Market for Solar District Heating

by

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Market for Solar District Heating

WP2 – European Market Study

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SUMMARY

The annual European market for solar heat is of the order of 2-3 GW_{th} (3-4 million m^2 solar collector areas) and the utilized solar heat amounted to 15-20 TWh in 2010. The business as usual case is an average market growth of about 10% per year.

The main market comprises small systems (3-10 kW_{th}) for single family houses, predominantly systems for DHW with an increasing share of systems for DHW and space heating and cooling. Only about 1% of the market comprises large systems (>350 kW_{th}).

There are so far poor incentives and few European market actors with respect to solar district heating, which is a major barrier for more solar district heating in Europe. Thus, solar heat grows faster outside district heating systems than inside. The opposite situation should appear, since solar collector installations inside district heating systems have competitive advantages.

Early stage engagement is a vital condition for obtaining future market shares and solar district heating has received high attention in Denmark during recent years. This has resulted in an emerging market for solar district heating among Danish district heating companies with new contractors and decreasing solar heat costs.

The total annual heat demand suitable for solar heat, i.e. domestic hot water and space heating in residential and commercial buildings and low temperature heat in industries, is estimated to 4 715 TWh (17 EJ) in 2006. The annual delivery of heat (mostly district heat) amounts to 556 TWh (2.0 EJ) in EU27, which corresponds to about 12% of the total low temperature heat demands.

Solar heat may be able to contribute with 200 – 580 TWh/a, or 4 – 25% of the total low temperature heat demand, in 2030. Based on the assumption that district heat will keep its market share and that solar heat will reach the same market share inside district heating systems, solar district heat may contribute with 20 - 58 TWh/a, or 4 – 10% of the total use of district heat, in 2030.

The combination of solar heat and local use of biomass is a rather straight forward solution where solar heat is used in the summer period and biomass is used in the winter period. The potential use of solar heat in large district heating systems, with recycled or waste heat, requires the development of new business models, e.g. based on customer choices.

Key words:
Solar heating, district heating, solar cooling

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INTRODUCTION

This report about the ”Market for Solar District Heating” (D2.3) is the 3rd out of 3 reports within SDHtake-off WP 2 – Market and policy assessment. The 1st report ”Success factors in Solar District Heating” (D2.1) identified and described success factors and lessons learned, the 2nd report ”Boundary Conditions and Market Obstacles for Solar District Heating” (D2.2) identified and described specific national boundary conditions, while this report is a more in depth study on the potential market for SDH.

Executive Summary

The annual European market for solar heat is of the order of 2-3 GW_{th} (3-4 million m^2 solar collector areas) and the utilized solar heat amounted to 15-20 TWh in 2010. The business as usual case is an average market growth of about 10% per year.

The main market comprises small systems (3-10 kW_{th}) for single family houses, predominantly systems for DHW with an increasing share of systems for DHW and space heating and cooling. Only about 1% of the market comprises large systems (>350 kW_{th}).

The cost for solar heat varies from competitive with traditional systems to several times higher than the alternative depending on local circumstances, type of financing and type and size of installation.

The market study is based on three scenarios: Business as Usual (BAU), Advanced Market Deployment (AMD) and Full R&D and Policy (RDP), as defined by Weiss and Biermayr (2010).

The total annual heat demand suitable for solar heat, i.e. domestic hot water (DHW) and space heating in residential and commercial buildings and low temperature heat in industries, is estimated to 4 715 TWh (17 EJ) in 2006. The BAU scenario assumes the same heat demand as in 2006, while the AMD and RDP scenarios assume reduced use of heat demand, to 3 990 TWh (-15%) and 3 270 (-31%) in 2050, due to increased energy efficiency measures.

The result is that solar heat may contribute with 200 TWh/a (BAU) – 580 TWh/a (RDP) in 2030. The corresponding shares of the total heat demand are 4 % (BAU) - 25 % (RDP).

The annual delivery of heat (mostly district heat) amounts to 556 TWh (2.0 EJ) in EU27 and district heat covers about 12%, or about 387 TWh (1.4 EJ), of the total heat demands in residential and service sector buildings of the order of 3 200 TWh (11.5 EJ).

The latest future projection published by EC DG Energy (EC, 2010) foresees a growth for district heating with about 60 % until 2030. However, it is possible to double or triple the deliveries with respect to available heat resources and current market conditions.

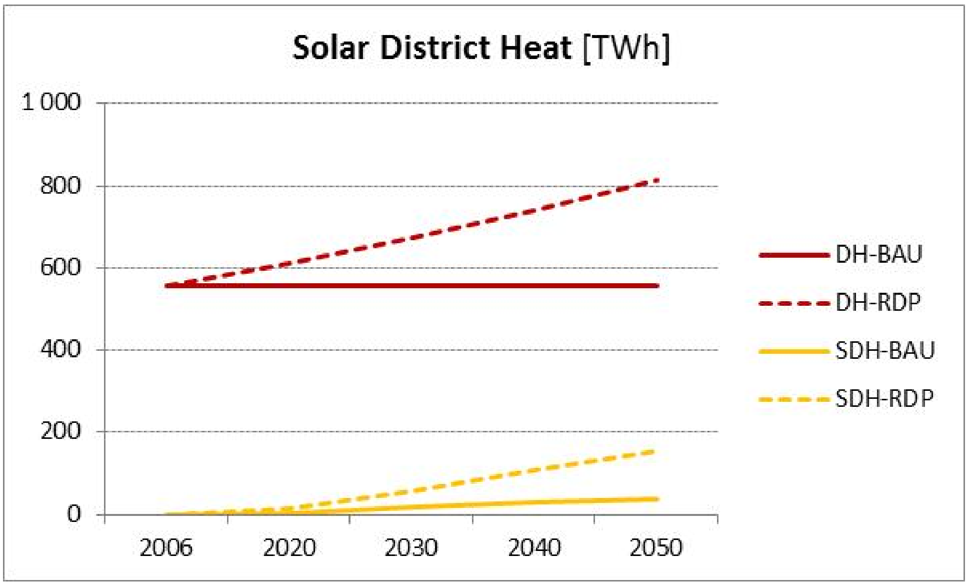
The main focus of district heating is to gather community heat flows of residual or excess heat from CHP, waste incineration, and industrial processes. Another focus is to utilise renewable heat locally, especially in small district heating systems. About 100 district heating systems utilise directly geothermal heat, mostly in Iceland and France. Several hundred systems utilise biomass locally. Fossil fuels are also directly used for peak and back-up purposes.

The combination of solar heat and local use of biomass is a rather straight forward solution where solar heat is used in the summer period and biomass is used in the winter period.

However, there is an embedded conflict between heat recycling and use of renewables in (large) district heating systems during the summer period. During summers, when solar heat is available, most large district heating systems have surpluses of recycled heat from CHP, waste incineration, and industrial excess heat. If solar heat should be used in large district heating systems, the solar and district heat communities must find a suitable business model that will solve this embedded conflict.

The potential use of solar heat in district heating systems is estimated by two scenarios; **A** - where solar district heat is assumed to have the same development as solar heat in general; **B** - where it assumed that sooner or later solar heat in district heat will catch up the market development outside of district heating.

The result for scenario A is that solar heat may contribute in district heating with 1.2 TWh/a (BAU) – 3.4 TWh/a (RDP) in 2030. The corresponding solar shares of district heating are 0.2 % (BAU) – 0.6 % (RDP).



Potential development of solar district heat (SDH) in relation to the total use of district heat (DH) for Scenario B.

The result for scenario B is that solar heat may contribute in district heating with 20 TWh/a (BAU) – 58 TWh/a (RDP) in 2030. The corresponding solar shares of district heating are 4 % (BAU) – 10 % (RDP).

The main conclusions from this brief market report concerning solar district heating are:

- Solar district heating is a small, undeveloped part of the heat market. Only 1% of the solar collector surface is currently connected to district heating systems. Hence, solar heat grows faster outside district heating systems than inside. According to our analysis, the opposite situation should appear, since solar collector installations inside district heating systems have competitive advantages. Early stage engagement is a vital condition for obtaining future market shares.
- Latent conflict exists in (large) district heating systems between heat recycling (secondary energy supply) and direct use of renewables (primary energy supply). This conflict can be solved by customer choices according to a new business model.
- Few European market actors with respect to products, contractors and buyers are a major barrier for more solar district heating in Europe.
- However, solar district heating has received higher attention in Denmark during recent years. This has given an emerging market for solar district heating among Danish district heating companies with new contractors and decreasing collector costs.
- Solar heat has the technical potential to make a major contribution to the share of renewables in district heating. Depending on the general conditions for the further development of solar and district heat, solar district heating may amount to between 1 and 58 TWh (4 and 210 PJ) in 2030.

Readers guide

Chapter SOLAR HEATING comprises a description of the development, present status and future prospects for solar heating.

Chapter DISTRICT HEATING comprises a description of the development, present status and future prospects for district heating.

Chapter SOLAR DISTRICT HEATING comprises a description of the development, present status and future prospects, including barriers and possibilities, to use solar heat in future district heating systems.

SOLAR HEATING

This chapter comprises a description of the development, present status and future prospects for solar heating.

Solar heat markets

Solar heat is one out of three renewable heat alternatives: bio energy, geothermal energy and solar heat. Solar heat is still covering a small part of the heat demands in Europe (<1%), but it has grown to an industry sector of considerable size within one decade.

The annual European market for solar heat is of the order of 2-3 GW_{th} (3-4 million m^2 solar collector areas) and the utilized solar heat amounted to 15-20 TWh in 2010. The business as usual case is an average market growth of about 10% per year.

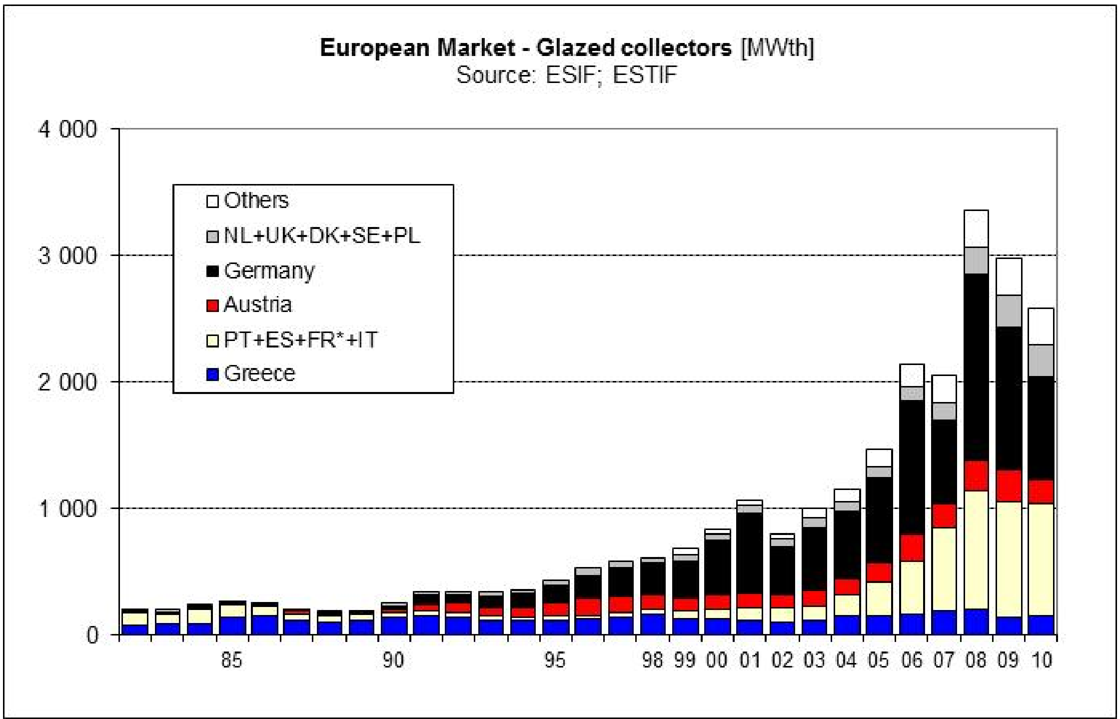


Figure 1. Market development for glazed solar collectors in Europe 1982-2010.

The development of the European solar heat market is dependent on a number of different measures like governmental subsidies and regulations. It is further strongly related to the general development in the heating sector, which in turn is related to the development in the building sector. Major changes in large markets related to subsidy schemes (Germany) and major declines in the building sector (Spain) had a strong influence on the poor development during the last three years. See Figure 1.

Solar heat positions

Market development

Historically the first small markets developed in South-Europe. The markets started to take-off in Austria and Germany in the 1990s and recent market developments occurred in Spain and Italy. The main market comprises small systems (3-10 kW_{th}) for single family houses, predominantly systems for DHW with an increasing share of systems for DHW and space heating and cooling. Only about 1% of the market comprises large systems (>350 kW_{th}).

The market for large systems has however increased in recent years (Figure 2), especially in Denmark, with >20 plants with a nominal thermal power of >1 MW. All together there are now >150 plants with a nominal thermal power >350 kW (average 1.6 MW) in operation. A large part of the large systems are built in block and district heating systems, while the rest are built in connection to multifamily buildings, hotels, commercial buildings, sport centres and industries.

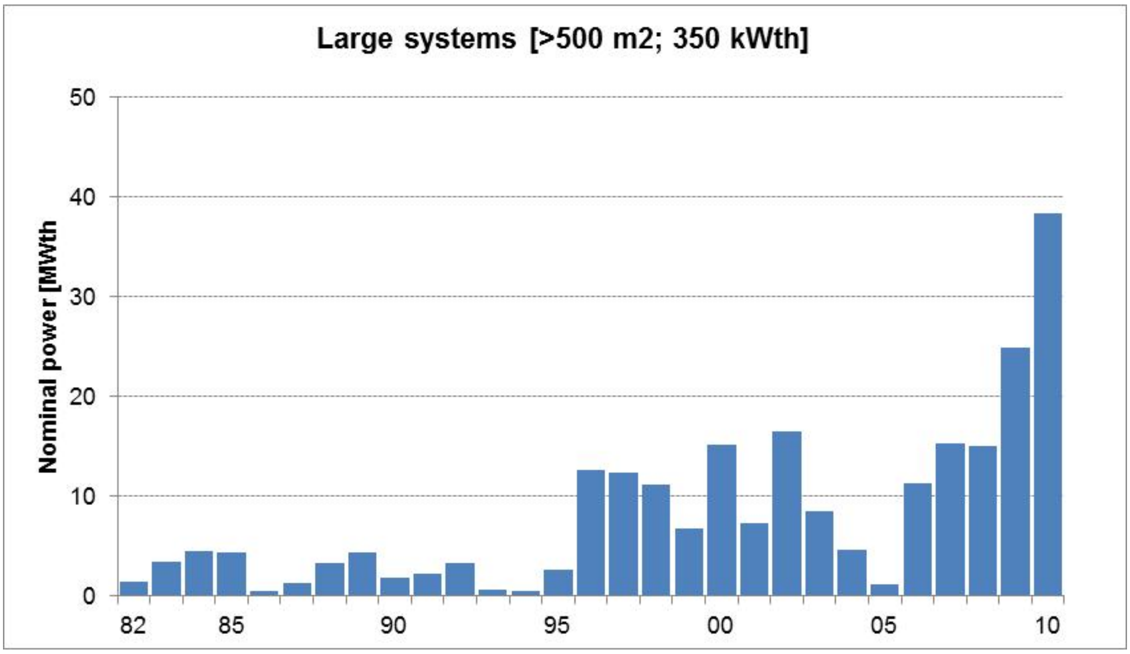


Figure 2. Market development for glazed solar collectors in large systems 1982-2010.

Historically the first large systems were developed in misc. demo projects in the 80’s in North-Europe (Sweden) where block and district heating had large market shares. The development was then transferred to Denmark, Austria and Germany in various demo projects in the 90’s.

Large systems show lower specific costs than small systems, but large systems are usually competing with lower alternative costs than small systems, especially if they are built and operated by utilities. The recent development is related to the fact that solar heat is competing with gas fired boilers in small Danish district heating systems.

Solar collector development

The early developments of small systems were based on rather small collectors (typically 2-3 m^2) based on copper absorbers. The early developments of large systems were based on the development of large module collectors (10-20 m^2) based on aluminium absorbers (easier to handle in large collectors). The present trend is that aluminium absorbers are becoming common also in small collectors (due to cost and environmental aspects).

Figure 3. Solar DHW (thermosifon) system on a single family house (Solahart/ESTIF).

Figure 4. Solar DHW (pumped) system on a single family house (Gasokol/ESTIF).

Figure 5. Mounting of a large module FPC[1] on ground (Dalenbäck).

Figure 6. Multifamily building with large roof module FPC (Dalenbäck).

The collector industry started out with more or less handmade collectors in small companies. Today there are a large number of companies manufacturing solar collectors using robots to put together the modules. The largest European collector manufacturer has a capacity of about 1 million m^2 of collectors per year.

The early developments covered flat plate collectors (FPC) as well as evacuated tube collectors (ETC). At present FPC dominates the European market, while ETC dominates the Chinese market, which is by far the largest collector market in the world. The large systems with ground-mounted or roof-mounted collectors are dominated by FPC, but ETC is commonly used in connection to process heat and solar thermal cooling, where the lower heat loss coefficient of ETC is regarded as an advantage.

[1] Flat plate collector

Large system development

The early insights regarding solar heating told us that we need large solar systems and seasonal storage if solar heat should be able to cover considerable parts of the heat demand in Northern Europe. The early developments of large systems were thus often connected to demonstration of “large” seasonal storages, especially in Sweden.

In order to achieve reasonable investment costs most seasonal storage types have connection to the ground, e.g. water-filled pits, rock caverns and buried tanks or the ground itself (using U-pipes to charge and discharge). The difficulty to use thermal insulation on all boundaries is compensated by size as the relation between envelope area (which determines the heat losses) and volume decreases with size.

A favourable development for solid biomass (wood chips) made seasonal storage of solar heat to replace oil less interesting in Sweden, and the development turned to large combined solar and biomass heating plants with short-term storage. This type was also developed in Denmark and Austria, while countries with less biomass, e.g. Germany, have continued the development of large systems with seasonal storage. Large systems in other countries involve misc. solar heating and cooling applications in connection too large buildings, industries and sport centres, etc.

Figure 7. Solar district heating plant in Marstal, DK (Marstal Fjernvarme).

The so far largest solar district heating plant, with a nominal thermal power of >13 MW, is built for the city of Marstal in Denmark (Figure 7). An extension with more collectors and a seasonal storage, to cover >50% of the heat demand, is under construction.

Performance and cost developments

The optical efficiency of most solar collectors is close to the technical limit, while the thermal losses of collectors, as well as the solar system performance, still can be improved. The heat gained by solar collectors varies between low 200 and high 700 kWh/a.m^2 collector area depending on available solar radiation and type of application. Large systems gain around 400 kWh/a.m^2 in most applications in Northern Europe.

The sale prices for small solar DHW systems (incl. auxiliary heater) vary a lot between different countries, from low 1 000 Euro (Greece) to high 6 000 Euro (Switzerland). Related costs for combi-systems vary from low 5 000 Euro (e.g. Austria) to high 14 000 Euro (Switzerland). The corresponding area specific costs vary thus from low 200 Euro/m^2 (simple thermosiphon DHW systems) to high > 1000 Euro/m^2 (advanced pumped combi-systems). One reason for the large differences is that solar systems are sold in different ways in different countries; another reason is that different subsidy schemes will influence the price in different ways (EC-project NEGST).

The costs for large systems vary less between different countries as they usually require about the same components and are built by contractors. The area specific cost (excl. VAT) for large systems (incl. short-term storage) are in the range from 300 to 600 Euro/m^2 (SDH).

The resulting cost for solar heat varies from competitive with traditional systems to several times higher than the alternative depending on local circumstances, type of financing and type and size of installation.

Legislative Conditions

All renewable energy sources require considerable areas to transform the energy into useful heat (and/or electricity). Small solar heating systems manage in general with available areas on buildings (roofs, facades, etc.) while finding or designing a suitable place for the collector array is a key issue related to large systems. An advantage with solar district heating systems is that it is possible to place the collector array in the most suitable place in connection to the district heating system.

The placing of solar collectors on buildings may need permission from the local building office. In some cases the placing of solar collectors on buildings may be restricted, e.g. if it is old and protected buildings.

The placing of solar collectors on ground need permission from the land owner and may need permission from the local building office. The possibilities to place solar collectors on the ground depend to a large extent on the planned use of the land and the price of the land. In some cases the placing of solar collectors on ground may be restricted, e.g. if it is planned for buildings.

So, far the majority of large systems in Germany, Austria and most other European countries have collector arrays placed on roofs, while the majority of large systems in Denmark and Sweden have collectors placed on ground. The requirement for areas is further discussed in the following section.

In some large systems utilities own and operate solar collector arrays placed on buildings owned by other parties, this type of arrangements require the development of suitable agreements. Another case that requires suitable agreements is if an ESCO builds a plant and sells the heat to a customer. Large systems built and operated by utilities and/or estate owners on the own premises and/or own buildings are usually less complicated.

There may also be cases when a third party wants to build and operate a system using an existing district heating system for distribution of the heat to its customer. This option requires the legal possibility to have a third party access to the district heating network.

The placing of a large storage on or in ground requires misc. permissions depending on the type of storage. In some cases the placing of large storages may be restricted, e.g. if it is in a place with special ground water conditions and/or restrictions.

Participating Countries

Common for more or less all European countries is that we have seen a rather strong market development in the last decade. Five countries are studied more in detail within the SDH project: Germany, Austria, Denmark, Italy and Czech Republic. Figure 1 shows the market development in Austria and Germany, two of the large markets in Europe. Figure 8 shows the market development in Denmark, Italy and Czech Republic, where Italy is one of the large markets in Europe.

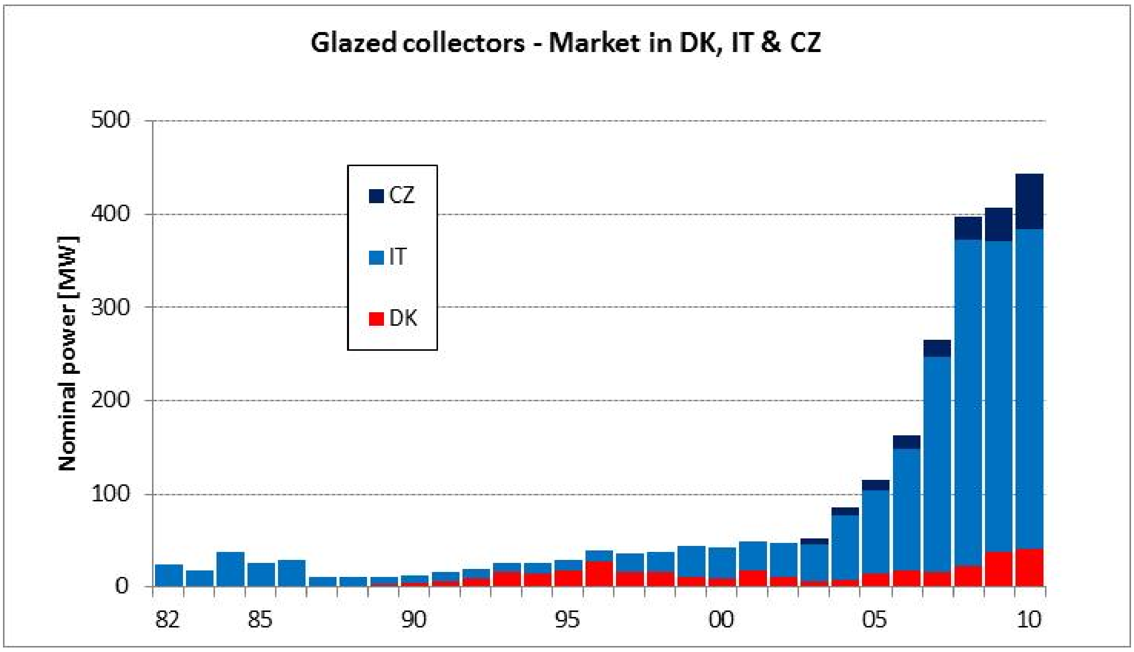


Figure 8. Market development for glazed solar collectors in DK, IT & CZ 1982-2010.

Italy had a small market development already in the late 70's together with Spain and Greece. Denmark and many other European countries (incl. Austria and Germany) showed initial market developments in the 90's, while the main market development in the Czech Republic has occurred in recent years.

If we study the development of large systems (>500 m^2, >350 kW$_{th}$), Denmark stands out from all other countries, having installed 50% of the total collector area in large systems in Europe.

Table 1 shows some basic data for the five countries studied more in detail. Germany has by far installed the largest amount of solar collectors, close to 14 million m^2. Denmark has by far the largest share of large systems (around 30%) in relation total installed, while Czech Republic shows the strongest market development, i.e. installed in 2010 in relation to total installed, followed by Italy.

Table 1. Market data for five countries end 2010 (ESTIF, SDH).

Collector area [m^2]	Total installed	Installed in 2010	Total installed in systems >500 m^2	Average area in systems >500 m^2
Austria	3 836 000	280 000	29 000	1 500
Czech Republic	308 000	86 000	1 800	600
Denmark	525 000	58 000	170 000	6 800
Germany	13 824 000	1 150 000	39 000	1 900
Italy	2 672 000	490 000	4 600	1 200

In end 2010, there were about 150 large systems (>500 m^2, >350 kW$_{th}$) with a total collector area of 340 000 m^2 (aver. 2 250 m^2, 1.58 MW$_{th}$ per system), out of which 50%, i.e. 170 000 m^2 (aver. 6 810 m^2, 4.78 MW$_{th}$ per system), are installed in Denmark.[2]

Austria

The solar heat market is well established in Austria which has the highest amount of solar collectors per inhabitant in Europe (>300 m^2 per 1 000 inhabitants). Austria is further unique in the aspect that the export of solar collectors is larger than the domestic market.

The solar heat market is as in most countries dominated by small systems, but the share of large systems is higher than in most other countries. The development of large systems was pioneered and is still dominated by one actor that operates all over the world. Most of the large systems in Austria are operated by an ESCO. Several Austrian collector manufacturers offer collectors for large systems.

Czech Republic

The solar heat market is developing in the Czech Republic, from <10 000 to >90 000 m^2 per year within less than 10 years, mainly based on imports. The local industry is not yet established, the market is dominated by small systems and there is a restricted experience from large systems.

Denmark

Denmark differs from all other European countries as the market development is based on large systems. The development of large systems was pioneered by domestic actors

[2] It should be noted that the corresponding collector area in large systems in Denmark had increased to 240 000 m^2 in July 2012.

based on initial collector developments in Sweden. The present development of large systems involves a number of domestic actors driven by local utilities.

Germany

The solar heat market is well established in Germany, where a number of established companies in the heating industry have considerable market shares and exports. The solar heat market is as in most countries dominated by small systems. The development of large systems is pioneered by a few domestic actors within an RD&D program.

Italy

The solar heat market is developing in Italy, from <50 000 to >400 000 m^2 per year within less than 10 years. The market is dominated by small systems, there is a growing domestic industry, but there is a restricted experience from large systems.

Future Prospects

The most comprehensive study of the future prospects for solar heat in Europe was carried out by Werner Weiss, AEE, and Peter Biermayr, Vienna University of technology, on behalf of ESTIF and presented in 2009 (Weiss and Biermayr, 2009).

The study defines three scenarios: Business as Usual (BAU), Advanced Market Deployment (AMD) and Full R&D and Policy (RDP). The total annual heat demand suitable for solar heat, i.e. DHW and space heating in residential and commercial buildings and low temperature heat in industries, is estimated to 4 715 TWh in 2006. The BAU scenario assumes the same heat demand as in 2006, while the RDP scenario assumes reduced use of heat demand, to 3 270 TWh (-31%) in 2050, due to increased energy efficiency measures.

The result is shown in Table 2. Solar heat may contribute with 200 TWh/a (BAU) – 580 TWh/a (RDP) in 2030 and possibly with 390 TWh/a (BAU) – 1 550 TWh/a (RDP) in 2050. The corresponding shares of the total heat demand are 4 % (BAU) – 15 % (RDP) and 8 % (BAU) - 47 % (RDP), respectively. Figure 9 illustrates the potential solar heat (HT) coverage in relation to the low temperature heat demand (LT-DEM) for the two scenarios BAU and RDP from Tabell 2.

Table 2. Future potential for solar heat in EU-27 (Weiss and Biermayr, 2009).

		Solar [TWh/a]	Demand [TWh/a]	Solar share [%]
2006		**8.5**	4 715	0.2
2020	BAU-RDP	**38 - 155**	4 715 – 4 297	0.8 – 3.6
2030	BAU-RDP	**198 - 582**	4 715 – 3 787	4.2 – 15.4
2050	BAU-RDP	**391 – 1 552**	4 715 – 3 271	8.3 – 47.4

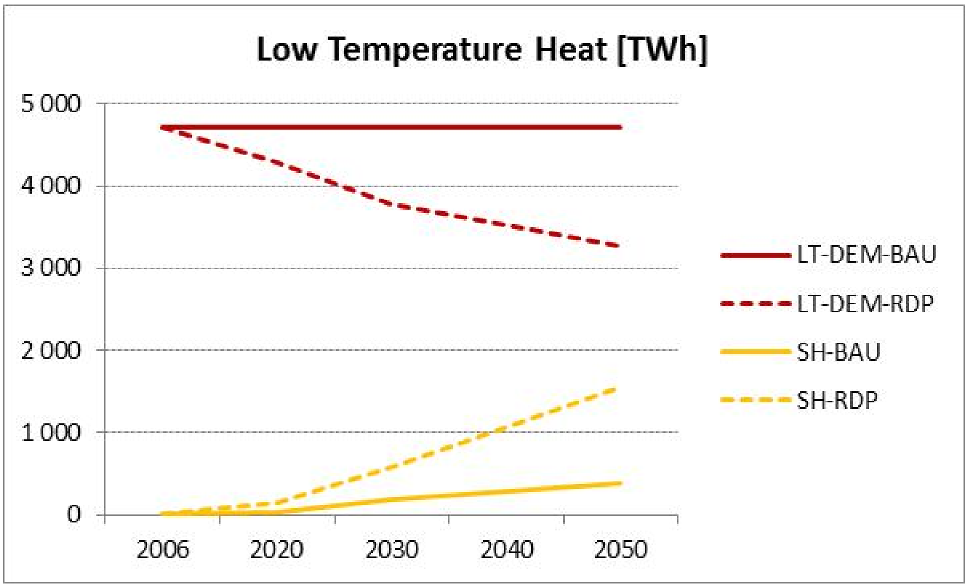


Figure 9. Future EU-27 potential for solar heat (SH) in relation to the low temperature heat demand (LT-DEM) for the two scenarios BAU (lines) and RDP (dotted lines).

The potential study is based on detailed studies for five countries: Austria, Denmark, Germany, Poland and Spain, extrapolated to EU-27. The main results for Austria, Denmark and Germany are presented in the following Tables 3 to 5.

The potential study is based on similar assumptions for all three countries and the results are rather similar for all three countries. Although the BAU scenario presents a large potential development it is clear that an (AMD or an) RDP scenario is required in order to have a considerable solar coverage of future heat demands.

Table 3. Future potential for solar heat in Austria (Weiss and Biermayr, 2009).

		Solar [TWh/a]	Demand [TWh/a]	Solar share [%]
2006		**0.97**	108	0.9
2020	BAU-RDP	**3.3 – 9.9**	108 - 100	3 - 10
2030	BAU-RDP	**5.6 – 16.5**	108 - 86	5 - 19
2050	BAU-RDP	**6.6 – 26.3**	108 - 66	6 - 40

Table 4. Future potential for solar heat in Denmark (Weiss and Biermayr, 2009).

		Solar [TWh/a]	Demand [TWh/a]	Solar share [%]
2006		**0.13**	72	0.2
2020	BAU-RDP	**0.4 – 1.1**	72 - 64	0.5 - 2
2030	BAU-RDP	**1.5 – 4.8**	72 - 54	2 - 9
2050	BAU-RDP	**3.8 – 15.2**	72 - 47	5 - 32

Table 5. Future potential for solar heat in Germany (Weiss and Biermayr, 2009).

		Solar [TWh/a]	Demand [TWh/a]	Solar share [%]
2006		**3.0**	980	0.3
2020	BAU-RDP	**14.7 – 43.4**	980 - 881	1.5 - 5
2030	BAU-RDP	**37 - 116**	980 - 779	3.8 - 15
2050	BAU-RDP	**58 - 232**	980 - 675	6 - 34

BSW[3] in Germany has recently (June 2012) presented a Road map for solar heat (”Fahrplan Solarwärme – Strategie and Maßnahmen der Solarwärme-Branche für ein beschleunigtes Marktwachstum bis 2030”). It outlines the prospects to have an increase from at present 10 GW (about 5 TWh/a) in 2010 to 70 GW (about 35 TWh/a) solar heat in 2030. This is in line with the BAU scenario presented by Weiss and Biermayr (2009) and makes the AMD and RDP scenarios look rather optimistic.

IEA has recently (June 2012) presented a Technology Roadmap for Solar Heating and Cooling. The roadmap envisages development and deployment of 16.5 EJ (4 583 TWh; 394 Mtoe) solar heating annually, more than 16% of total final energy use for low temperature heat, and 1.5 EJ solar cooling annually, nearly 17% of the total energy use for cooling, in 2050. This is about twice the BAU scenario presented by Weiss and Biermayr (2009).

Table 6. Required collector area in the BAU, AMD and RDP scenarios in 2050 in relation to available areas for solar collectors (Weiss and Biermayr, 2009).

Area [Mm^2]	BAU	AMD	RDP
AUSTRIA			
Collector area	16	44	66
Suitable roof			139
Suitable facade			52
0.2 % of land			167
DENMARK			
Collector area	10.9	29	43.4
Suitable roof			88
Suitable facade			33
0.2 % of land			431
GERMANY			
Collector area	165	438	662
Suitable roof			1296
Suitable facade			486
0.2 % of land			714

[3] Bundesverband Solarwirtschaft – www.solarwirtschaft.de

A major concern is if there is enough space to reach a high coverage of the existing heat demands with solar heat. Table 6 shows the required collector areas to fulfill the RDP scenario in 2050 together with available roof and façade areas, as well as in relation to land area.

A comparison between required collector areas and available areas shows that even a very ambitious scenario as the RDP scenario is likely to be possible from a space point of view.

DISTRICT HEATING

This chapter comprises a description of the development, present status and future prospects for district heating.

Heat Market Conditions

The heat supply for residential and service sector (non-residential) buildings in Europe is dominated by heat originating from the use of fossil fuels, mostly natural gas and fuel oils, as presented in Figure 10. Heat (mostly district heat) and electricity have the same market share, about one eight each. District heat considers urban demands and is dominated by heat recycling from thermal power generation and waste incineration. Electricity is used in resistance radiators and in electric water heaters, mostly in storage units for use of night charging. Combustion renewables (bioenergy) are mostly used for rural demands. Solar and geothermal heat supplies have currently only minor market shares.

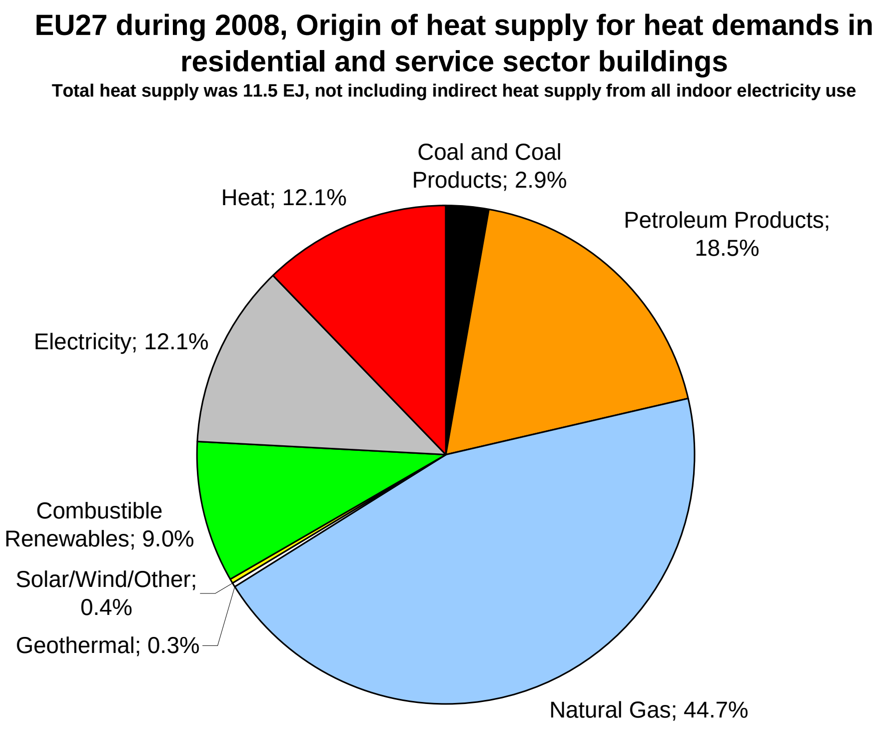


Figure 10. Estimation of the total final heat demand and its composition for residential and service sector buildings in EU27 during 2008. Data sources: Mainly IEA (2010), but complemented with other sources and own estimations of boiler conversion efficiencies.

With respect to climate change, energy dependency, and resource efficiency, fossil fuels can be punished by excise taxes as carbon or energy taxes. This punishment will facilitate the competition from low carbon alternatives as renewable and district heats. However, the national customs to punish fossil fuels varies considerably in Europe.

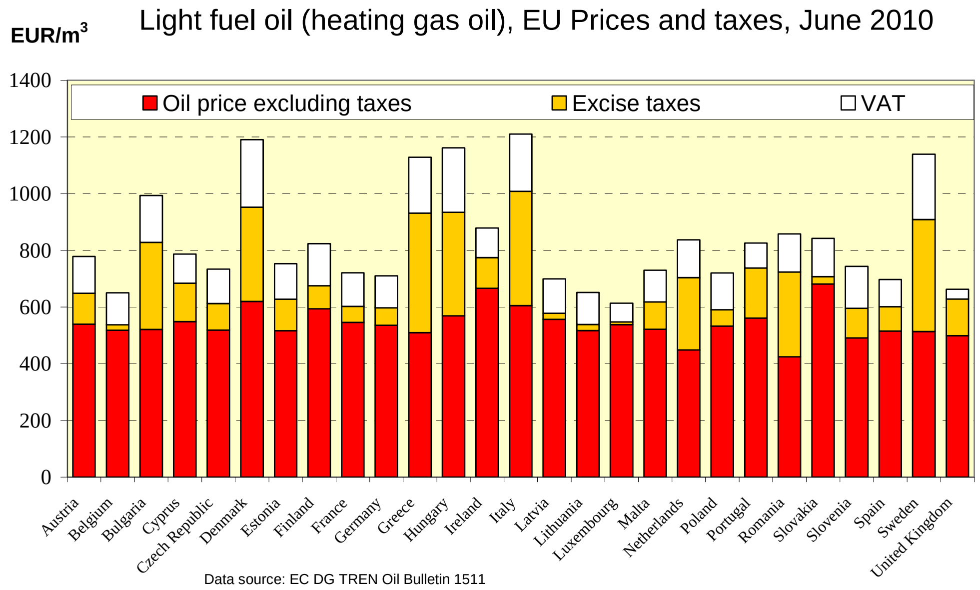


Figure 11. Overview of total retail oil prices in the EU27 countries divided into three components: Without taxes, excise taxes, and VAT. Excise taxes include mostly energy and carbon taxes.

An example is presented in Figure 11, where the taxation of light fuel oil is summarised for the EU27 countries in June 2010. Examples of countries with taxation are Denmark, Greece, Hungary, Italy, and Sweden. Low taxation is applied in Belgium, Latvia, Lithuania, Luxembourg, Slovakia, and United Kingdom. Hence, it is more easy to replace light fuel oil with renewable or district heat in the high taxation countries compared to the low taxation countries.

District Heat Positions

Currently, about 6000 district heating systems are in operation in Europe. Most of them are shown in the European map in Figure 12. The market share for district heat varies very much from country to country. The highest national market shares with over 40% of the building stock are found in Denmark, Sweden, Finland, Poland, Estonia, Latvia, and Lithuania. Medium market shares between 10% and 40% are the situation in Germany, Austria, Slovenia, Hungary, Bulgaria, Romania, the Slovak Republic and the Czech Republic. Low, but significant market shares appear in Netherlands, Luxembourg, France, and Italy. Very few and almost no district heating systems can be found in Belgium, United Kingdom, Ireland, Portugal, Spain, and Greece. The total heat deliveries within the European Union were about 2 EJ (556 TWh) during 2008.

District heat prices follow the national heat price levels set by the international fossil fuel price level as a base with addition of the national excise taxes. Since the national taxation varies, according to the preceding discussion, the national heat price level varies also. Hence, the national district heat prices vary considerably as shown in Table 7. The highest district heat prices are found in countries with high taxation of fossil fuels, since high taxation gives the possibility of creating extensive district heating systems.

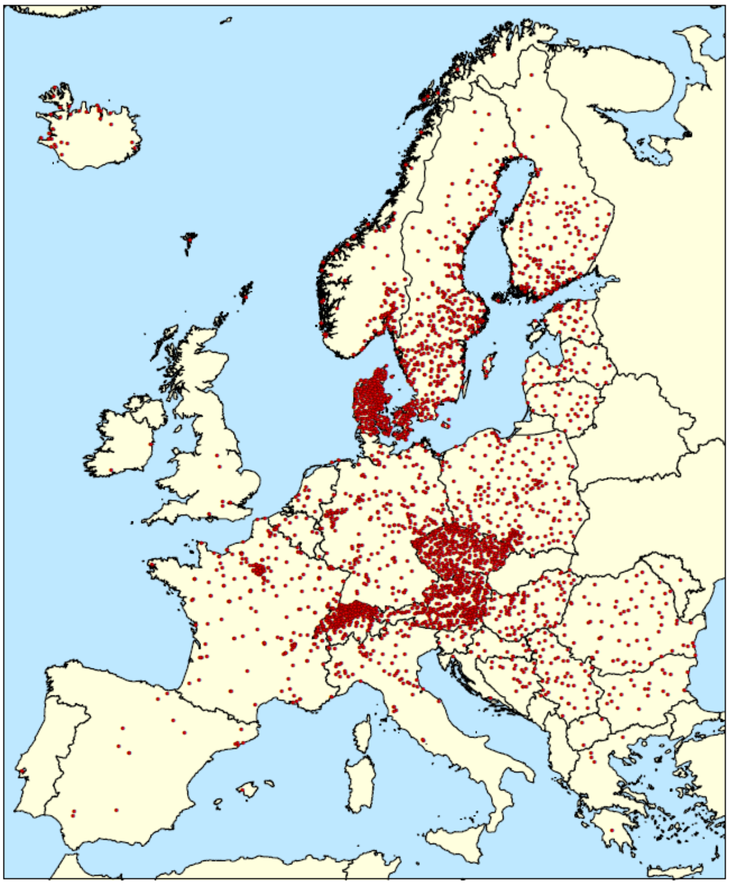


Figure 12. European map with district heating systems identified in various countries. Source: The European DHC database at Halmstad University. The systems in the Slovak republic are currently missing in the database.

Table 7. National average prices 2000-2008 in €/GJ for district heat delivered to customers excl VAT. Source: Sven Werner. 10 €/GJ ~ 36 €/MWh.

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Austria	14,4	14,9	15,0	15,0	15,6	16,1	17,0	17,5	18,0
Denmark	17,2	16,5	17,8	17,5	17,4	17,5	17,7	18,0	
Finland	7,9	8,3	8,6	8,6	8,9	9,4	10,0	10,4	11,8
France	10,8	11,4	11,9	11,9	11,9	12,5	13,5	14,0	
Germany	12,5	13,9	13,7	13,9	14,1	15,5	16,6	16,5	19,3
Italy	15,9	16,7	15,9	16,7	16,7	17,9	19,2		
Netherlands	10,4	10,7	10,7	11,6	12,4	13,4			
Sweden	13,0	12,2	12,8	13,7	14,3	14,4	14,9	15,1	15,5
United Kingdom	6,9	6,7	7,3	6,6	4,4	4,4	4,4	4,2	4,8
Czech Republic	8,4	9,4	10,4	10,1	10,5	12,0	13,3	14,2	
Estonia	5,8	5,9	6,1	6,1	6,6	6,6	7,5		
Hungary	7,2	6,8	9,5	9,4	8,6	9,8	9,6		
Latvia	9,4	9,5	9,3	8,7	8,9	8,7	10,1	11,9	17,1
Lithuania	8,4	9,2	9,4	9,3	9,1	9,1	9,6	11,1	14,4
Poland	6,9	8,0	8,1	7,3	7,3	8,3			
Slovak Republic	8,2	9,7	10,5	9,9	10,4	11,6	13,9		
Slovenia	7,5	9,8	9,4	9,0	8,5	9,2			
Bulgaria	4,3	4,4	5,6	6,1					
Romania	3,8	4,2	5,1	5,9	6,6	5,0			
Croatia	6,0	6,2	7,3	7,2	7,4	7,7	8,0	8,3	8,3
Iceland	4,6	4,1	4,9	5,0	5,5	6,3	5,5	5,5	
Norway	10,5	12,9	14,0	14,5	13,7	15,9	18,4	17,0	19,4
Switzerland	10,6	11,1	11,4	12,0	11,0	12,1	12,3	11,8	13,9

The fundamental idea of district heating is summarised in Figure 13. The traditional focus has been to gather community heat flows of residual or excess heat from thermal power generation, waste incineration, and industrial processes. Another focus has been to utilise renewable heat locally, especially in small district heating systems. About 100 district heating systems utilise directly geothermal heat, mostly in Iceland and France. Several hundred systems utilise biomass locally. Fossil fuels are also directly used for peak and back-up purposes.

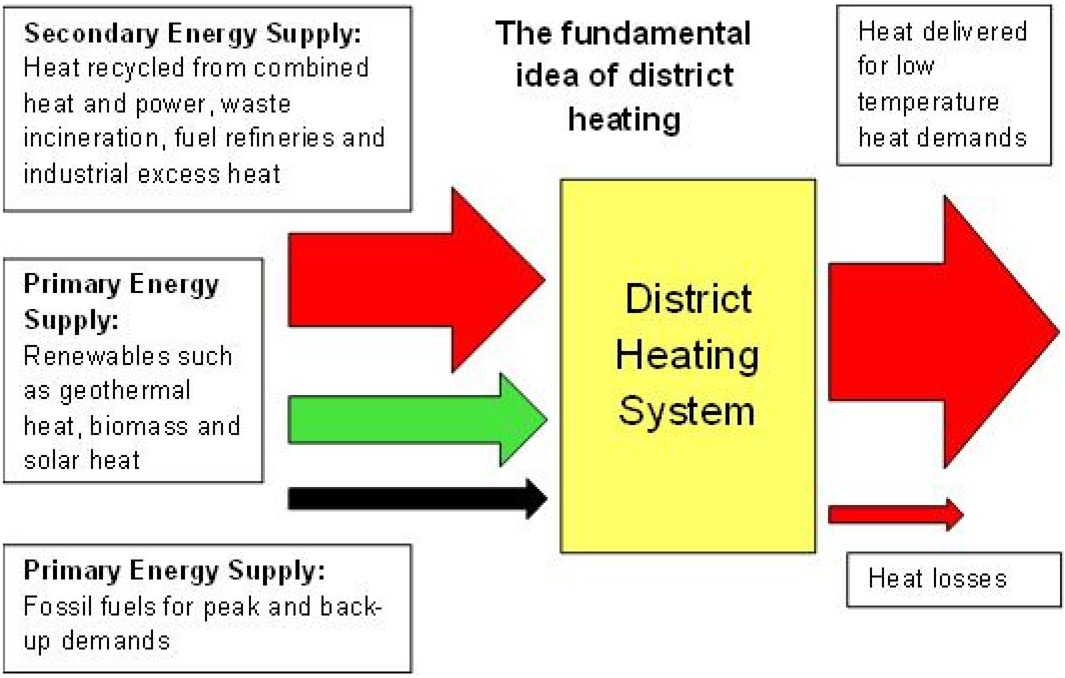


Figure 13. The basic energy flows in a district heating system.

The composition of the EU27 district heat supply divided into four main groups is presented in Figure 14. The composition during 2008 was 65% from recycling from fossil input into CHP and industries, 10% recycling from renewable input into CHP, 5% direct use of renewable, and 16% direct use of fossil fuels. Hence, the primary use of fossil fuels in district heating systems is low, but the secondary use from fossil fuel supply to mainly CHP plants is high.

Use of more solar heat supply into district heating systems is classified as direct use of renewables. The best would be if more solar heat could replace direct use of fossil fuels in order to maximise the community benefits. However, these fossil fuels are mostly used during the winter, giving a very low possibility for this replacement, since solar heat (without seasonal storage) has low availability during winters. More solar heat can only replace heat recycling in (large) district heating systems with CHP, giving very low pay ability for more solar heat. An increased use of wind power and solar PV may however change the conditions to operate CHP in summer as it has been shown in Denmark.

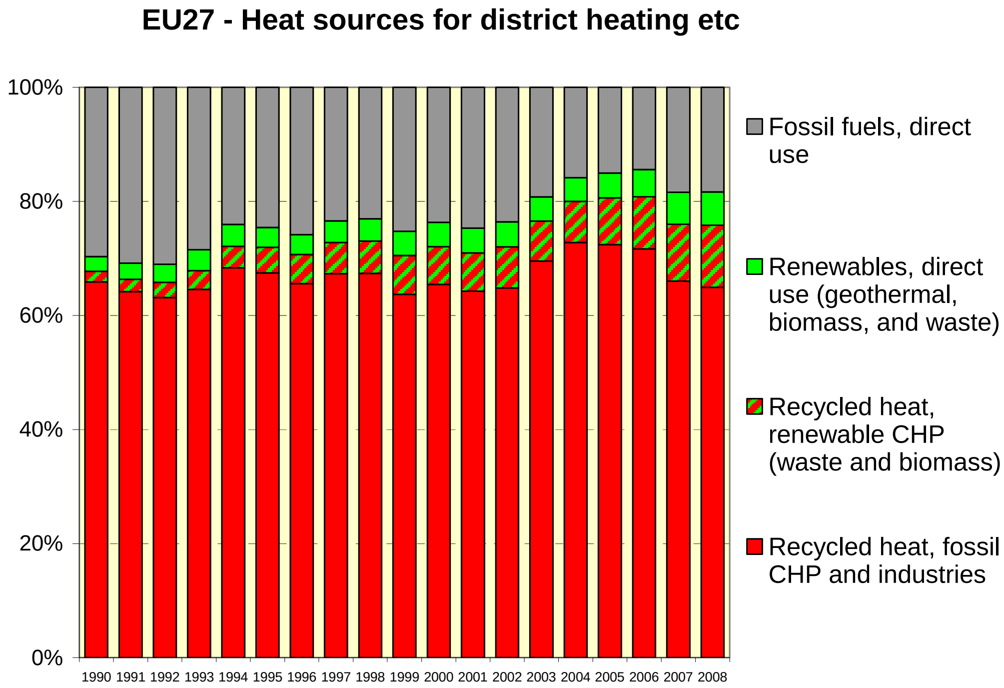


Figure 14. Composition of heat sources for the EU27 district heating systems 1990-2008. Data source: IEA (2010).

Hereby, Figure 13 reveals the embedded conflict between heat recycling and use of renewables in district heating systems. This is especially valid between solar heat supply and heat recycling during the summer. During summers, when solar heat is available, most large district heating systems have surpluses of recycled heat from CHP, waste incineration, and industrial excess heat. If more solar heat should be used in large district heating systems, the solar and district heat communities must find a suitable business model that solve this embedded conflict.

Legislative Conditions

National legislation

The legislative conditions for district heating systems have recently been analysed for 14 European countries in Ecoheat4EU, a project during 2009-2011 within the Intelligent Energy for Europe (IEE) program.

The number of relevant legislative frameworks concerning district heating and cooling are summarised in Table 8 by countries. In all, 13 typical groups of legislation were identified. The number of reported legislation differs from country to country. For France, 13 different legislative frameworks were reported, while two countries (Denmark and Sweden) only reported one legislative framework each, which were the national district heating acts. Three countries (Spain, Italy, and United Kingdom) reported that they had no legislative framework at all for district heating and cooling.

The main focus is on district heating in these legislative frameworks. Only Denmark reported a specific district cooling act, but as a support measure and not as a legislative framework.

The main national Energy act contains the major market rules for district heating and cooling in 5 countries (The Czech Republic, Finland, Croatia, Lithuania, and Norway). More specific district heating acts appear in Germany (AVBFernwärmeV), Denmark, Croatia, Lithuania, Romania, and Sweden. Price regulation legislation has been implemented in The Czech Republic, Croatia, and Romania. Price regulation also exists in Denmark, but the corresponding legislation can be found in the Danish district heating act. Germany has no price regulation, but reports an act that gives some restricting and exclusive market rules for district heat pricing: The AVBFernwärmeV in regards to price clauses. Other relevant acts are energy efficiency, renewable, environmental, taxation, planning, competition, and public utility acts together with national energy policies being the umbrellas for all energy legislation. Only Germany reports important municipal codes enforcing mandatory heat planning.

Table 8. Number of relevant legislative frameworks by country and legislative group. Source: (Werner 2011a)

Count of Legislative group	Country														
Legislative group	CZ	DE	DK	ES	FI	FR	HR	IE	IT	LT	NO	RO	SE	UK	Grand Total
01 Energy act	1				1		1			1	1				5
02 District heating act		1	1				2			1		2	1		8
03 Heat price regulation	1	2					3					4			10
04 No legislative framework				1					1					1	3
05 Energy efficiency act		2		1		3						3			9
06 Renewable act	1	2													3
07 Environmental act	4	1				2						1			8
08 Taxation act	1	1			1	2									5
09 Planning act		1			1	2					1				5
10 Competition act					1										1
11 Public utility act						4						1			5
12 National policies	1							4				1			6
13 Municipal & regional policies		1													1
Grand Total	9	11	1	2	4	13	6	4	1	2	2	12	1	1	69

The overall conclusions are that very different approaches to district heating and cooling legislative frameworks are implemented in the 14 European countries and that national legislations are more elaborated in countries having a tradition for using district heat.

Support measures

Support measures were in the Ecoheat4EU project classified into four main groups, reflecting the different characteristics in each group:

1. **Burden measures**: A tax or fee burden is generally applied for use of fossil fuels or emissions of fossil carbon dioxide. This burden will give opportunities for non-fossil energy options and higher energy efficiencies as DHC systems.
2. **Financial support**: A governmental, a regional or a municipal investment grant or operation support can be given to promising future market solutions currently having low or zero market shares. The financial support is given in order to facilitate the wider use of the requested technology.
3. **Market control**: Market supervision and control may decrease the risk for market abuse, giving customer more confidence to use the technology. This is

especially valid for natural monopolies with heat planning and mandatory connections to district heating.

4. **Planning:** Extension of district heating systems contains some considerable financial risk, since both heat supply and distribution capacity must be installed before more customers are connected. Installed capacity without customers constitutes the risk. Planning measures can reduce this risk by harmonised extensions.

In all, 23 different subgroups of support measures were reported in the national answers to the Ecoheat4EU enquiry: 3 burden measures, 11 financial supports, 3 market controls, and 6 planning measures. These 23 subgroups with their characteristics are presented below by each main group. No specific support program for solar district heating was identified.

Table 9. Support measures within subgroups according to country. Source: (Werner 2011a).

Count of Support subgroup	Country														
Support subgroup	CZ	DE	DK	ES	FI	FR	HR	IE	IT	LT	NO	RO	SE	UK	Grand Total
1 Burden - Carbon tax			1								1		1		3
1 Burden - Emission trading system									1		1				2
1 Burden - Energy tax			1								1				2
2 Support - Favourable loans		1					1								2
2 Support - Feed-in tarif, renewable electricity		1						1		1					3
2 Support - Investment grant, CHP		1						2							3
2 Support - Investment grant, DH connection		1	1		1								1		4
2 Support - Investment grant, DH distribution		2		1		1			1	1	1	2		1	10
2 Support - Investment grant, renewables		2					1	1			1		1		6
2 Support - Operation support, CHP incl FIT	1								1	1		2			5
2 Support - Operation support, renewables									1						1
2 Support - Social support for poor customers										1					1
2 Support - Tax deduction, CHP														2	2
2 Support - Tax deduction, DH					1	1			1	1	1				5
3 Market control - Consumer complaints board			1				1				1				3
3 Market control - Price regulation			1												1
3 Market control - Third party access										1					1
4 Planning - Building regulations								1			1			1	3
4 Planning - CHP planning			1											1	2
4 Planning - Heat planning & zoning, DH		1	2	1		1			1	1	2			1	10
4 Planning - National energy policy	11	2	1				5				1				20
4 Planning - Renewable planning		1						1	1		1			2	6
4 Planning - Waste planning & landfill bans			1								1				2
Grand Total	12	12	10	2	2	3	8	6	7	7	13	4	3	8	97

The main conclusions from the Ecoheat4EU project concerning support schemes characteristics were:

- Strong focus on generation measures in the typical measure groups reported, but distribution measures became stronger when number of measures reported are summarised.
- Planning and financial support measures dominate.
- Support measures are more directed towards district heating than to district cooling, revealing that district cooling do not have the same policy attention as district heating.

Best practise support measures

For the selection of best practise support measures within the Ecoheat4EU project, a voting procedure was performed in May 2010 among the various country partners. From the full list of support measures identified from the summary of the country reports, each country had to rank the 10 support measures, which were preferred in each country. The voting procedure was organised with ranking from 1 to 10 with 1 being the measure rated the best. During the voting analysis, the ranking values were changed to reversed order, with 10 being the measure rated the best, in order to get an additive scoring system.

Table 10. Final ranking list of the 12 best practise support measures elected by the 14 country partners in this project. Source: (Werner 2011b)

Rank	Top 12 support measures	Short description of the support measure	Sector dimension
1	Planning – Heat planning and/or zoning	Strategic energy planning, probably at municipality level. May include encouraging or even enforcing particular energy solutions (zoning). Currently applied in Germany, Denmark, Spain, France, Italy, Lithuania, Norway, and United Kingdom.	Distribution
2	Support – Investment grant, DH distribution	Financial support for district heating pipes through provision of grant, probably from government, but other sources also possible. Currently applied in Germany, Spain, France, Italy, Lithuania, Norway, Romania, and the United Kingdom.	Distribution
3	Planning – National energy policy	The framework, within which relevant legislation, possibly including measures on this list, may be framed. Currently applied in the Czech Republic, Germany, Denmark, Croatia, Lithuania, and Norway.	Planning
4	Support – Operation support, CHP including feed-in tariff	Supporting CHP through regulatory means, one prominent example being by means of a Feed In Tariff or a CHP bonus. Currently applied in the Czech Republic, France, Italy, Lithuania, and Romania.	Generation
5	Support – Investment grant, DH connection	Financial support for connecting customers to existing mains network through provision of grant, probably from government, but other sources also possible. Currently applied in Germany, France, Denmark, Finland, and Sweden.	Demand
6	Burden – Carbon tax	Implementing a tax penalty on fossil fuels proportional to its fossil carbon emissions. Applicable to all energy systems (energy efficient approaches like district heating would prosper). Currently applied in Denmark, Norway, and Sweden.	Generation
7	Support – Favourable loans	Providing low interest loans to finance the capital cost of establishing, extending or refurbishing district heating. Currently applied in Germany and Croatia.	All
8	Support – Investment grant, CHP	Financial support for CHP through provision of grant, probably from government, but other sources also possible. Currently applied in Germany and Ireland.	Generation
9	Support – Tax deduction, DH	Implementing a tax benefit for district heating schemes. Currently applied in Finland, France, Italy, Lithuania, and Norway.	Distribution

Rank	Top 12 support measures	Short description of the support measure	Sector dimension
10	Planning – Building regulations	Using existing regulatory framework to encourage deployment, and to ensure unnecessary barriers are removed. Currently applied in Ireland, France, Norway, and United Kingdom.	Demand
11	Support – Investment grant, renewables	Financial support for renewables through provision of grant, probably from government, but other sources also possible. Currently applied in Germany, France, Croatia, Ireland, Norway, and Sweden.	Generation
12	Planning – Waste planning & landfill bans	Promoting in a strategic way disposal of waste, so that the energy can be recovered and put to use in district heating schemes. Currently applied in Denmark and Norway.	Generation

The final result from the voting procedure is presented in Table 10. All identified support measures received votes, except for two measures: The emission trading system and operation support for renewables (as green certificates). The overall impression is that the voting outcome gave high prioritisation for planning measures together with investment grants as financial support.

Participating Countries

Austria

Residential heat supply was dominated by fossil fuels (natural gas, fuel oils and some coal) with a total market share of 48% for the 2009/2010 situation. The corresponding market share for district heat was 21%, similar to the market share of 20% for direct use of biomass. The remaining heat supply came from electricity, solar heat, and heat pumps.

During 2009, district heat was delivered to industrial (16%), service sector (50%), and residential customers (34%), adding up to the total delivery of 63.5 PJ (17.6 TWh). The Austrian district heating sector has had high growth rates during the last years. The heat deliveries have increased with 49% since 2000, mainly by the introduction and expansion of small district heating systems using biomass as main fuel. About 730 companies supply district heat in more than 1000 systems. The market shares in large urban agglomerations are 60% in Linz, 36% in Vienna, 30% in Klagenfurt, and 26% in Graz.

The heat supplied during 2009 came from recycled heat from fossil input (41%) and from renewable input (24%), while the direct use was 17% from renewables and 18% from fossil fuels.

Czech Republic

Residential heat supply was during 2008 dominated by 45% natural gas, 30% district heat, and 15% biomass, mostly in rural areas. The remaining market shares constituted of coal stoves and some electric heating.

During 2009, district heat was delivered to industrial (29%), service sector (24%), and residential customers (47%), adding up to the total delivery of 93.1 PJ (25.9 TWh). At the end of 2009, 777 licenses were issued by the Energy Regulatory Office for heat generation and heat distribution with 2109 price locations.

The heat supplied during 2009 came from recycled heat from fossil input (63%) and from renewable input (1%), while the direct use was 4% from renewables and 32% from fossil fuels. Hereby, the energy supply composition in the Czech Republic is one of the most fossil-intensive among the European district heating sectors.

Denmark

Residential and service sector heat supply was dominated during 2009 by district heat (53%) as counted by net heat use according to Energistyrelsen in Denmark. The corresponding market share for fossil fuel boilers was 26%. The remaining heat supply came from direct use of renewables (17%) and electricity (4%). The development since 1960 is presented in Figure 15. With respect to European conditions, Denmark has a very high share of district heat. This position is shared with Sweden, Finland, Estonia, Latvia, Lithuania, and Poland.

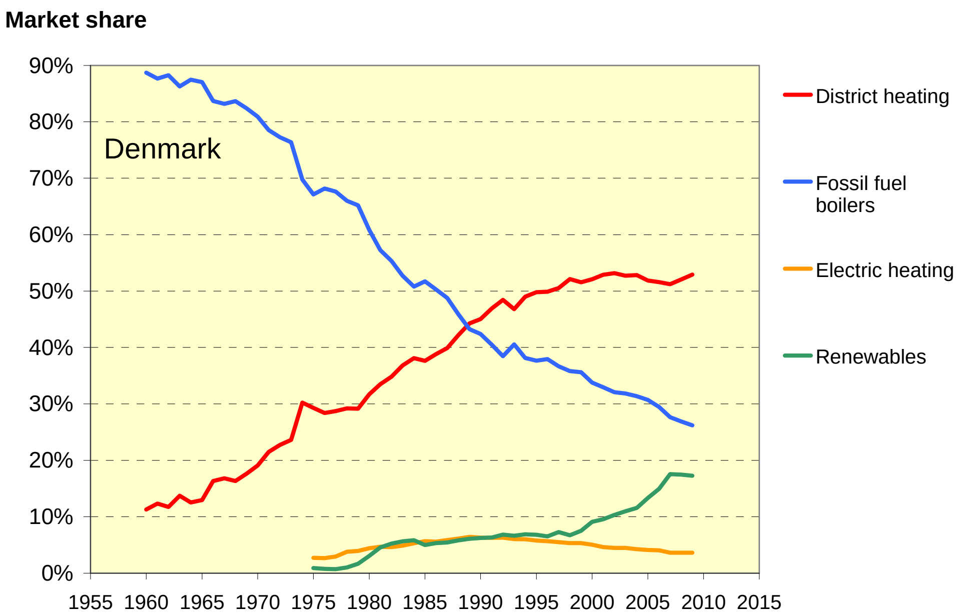


Figure 15. The development of composition of heat supply for residential and service sector demands in Denmark 1960-2009.

During 2009, district heat was delivered to industrial (8%), service sector (29%), and residential customers (63%), adding up to the total delivery of 100 PJ (28.8 TWh). The heat supplied during 2009 came from recycled heat from fossil input (41%) and from renewable input (24%), while the direct use was 25% from renewables and 10% from fossil fuels. Hence, the total renewable share reached 49%.

Germany

Residential heat supply was dominated by fossil fuels (natural gas, fuel oils and some coal) with a total market share of 80% in the latest micro-census for 2006. The corresponding market share for district heat was 13%. The remaining heat supply came from electricity (4%) and direct use of biomass (3%).

During 2009, district heat was delivered to industrial (34%), service sector (26%), and residential customers (40%), adding up to the total delivery of 446 PJ (124 TWh). Hence, Germany has the largest district heating sector within EU27. The heat supplied during 2009 came from recycled heat from fossil input (80%) and from renewable input (10%), while the direct use was 2% from renewables and 8% from fossil fuels.

Italy

Residential heat supply is dominated by the use of fossil fuels as natural gas (70%) and fuel oils (15%). District heat has a market share of only 2%.

The Italian district heating sector is mostly located in the Northern part of the country, having considerable heat demands during the winter. The two largest systems are located in Torino and Brescia. Delivered heat has had a high growth rate during recent years. Heat delivered to customers has increased with 75% since 2000.

During 2009, district heat was delivered to industrial (5%), service sector (35%), and residential customers (60%), adding up to the total delivery of 24 PJ (6.7 TWh). The heat supplied during 2009 came from recycled heat from fossil input (53%), while the direct use was 29% from fossil fuels. The total renewable share reached 18%, both direct use and heat recycled.

Future Prospects

The current district heat deliveries of about 2 EJ/year are delivered to industries (31%), residential buildings (46%), and service sector buildings (23%). The latest future projection published by EC DG Energy (EC, 2010) foresees a growth with about 60% until 2030. See Figure 16. However, it is possible to double or triple the deliveries with respect to available heat resources and current market conditions. According to (Persson & Werner, 2011), the population densities are rather high in the European cities, giving low capital costs for further heat distribution.

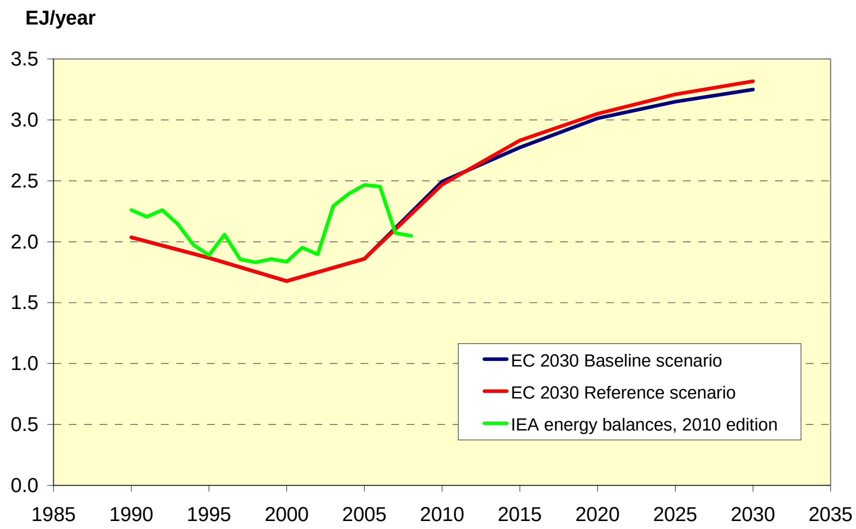


Figure 16. Recent and future development of district heat deliveries within EU27 until 2030 according to EC (2010). The corresponding development from the IEA energy balances (IEA, 2010) has been added for comparison. Discrepancy and annual variability reflects more statistical errors rather than actual changes.

SOLAR DISTRICT HEATING

This chapter comprises a description of the development, present status and future prospects, including barriers to use solar heat in future district heating systems.

Early Initiatives

Overall

The first large-scale solar heating plants were built >30 years ago and the first large-scale solar cooling plants were built >10 years ago. Figure 17 shows the number of plants with >500 m^2 (>350 kW nominal thermal power) of solar collectors built from 1979 to the middle of 2011.

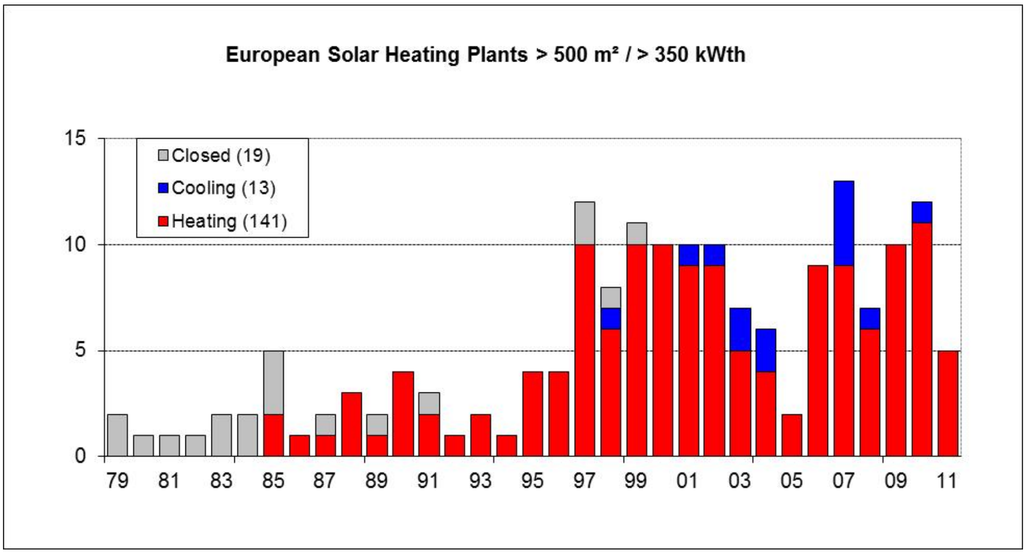


Figure 17. Number of large-scale solar heating plants built 1979-2011.

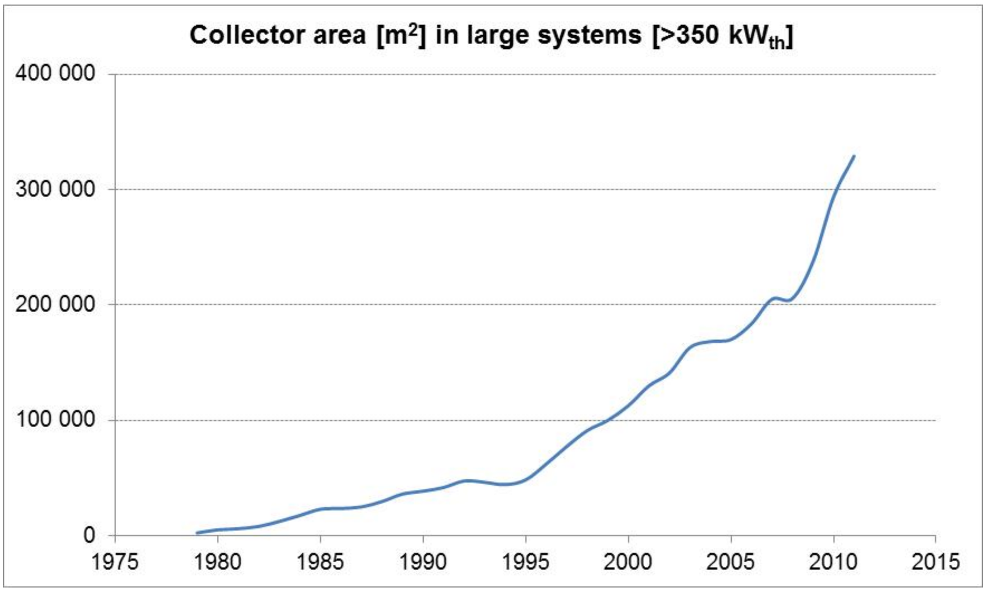


Figure 18. Accumulated colletor area in large-scale solar heating plants 1979-2010.

The main development occurred from end 90's when new large-scale systems were built in several countries. The early plants had varying collector areas, but new plants have increasing collector areas, especially in Denmark, so the market for large-scale solar collectors is increasing since 2007 although the number of plants per year still is rather modest. Figure 18 show the accumulated collector area in plants with >500 m^2 (>350 kW_{th}) up to the middle of 2011.

Sweden

The first Swedish large-scale solar heating plants were built within a Swedish RD&D program. The first two plants, both with seasonal storage, were put in operation 1979 and 1980. One plant comprised 1 320 m^2 of parabolic trough collectors (PTC) mounted on ground in combination with 5 000 m^3 of water in an insulated water tank in a small block heating system for 52 detached houses. The other comprised 2 900 m^2 of roof-integrated collectors on 50 row houses in combination with heat pumps and 10 000 m^3 of water in an insulated rock pit.

These early plants were later followed by a number of plants with especially developed large module flat plate collectors (FPC) mounted on ground in connection to small existing district heating systems by utilities. Figure 19 shows the pioneering plant with 4 300 m^2 of large module ground mounted solar collectors built already in the early 1980's in Lyckebo, Sweden.

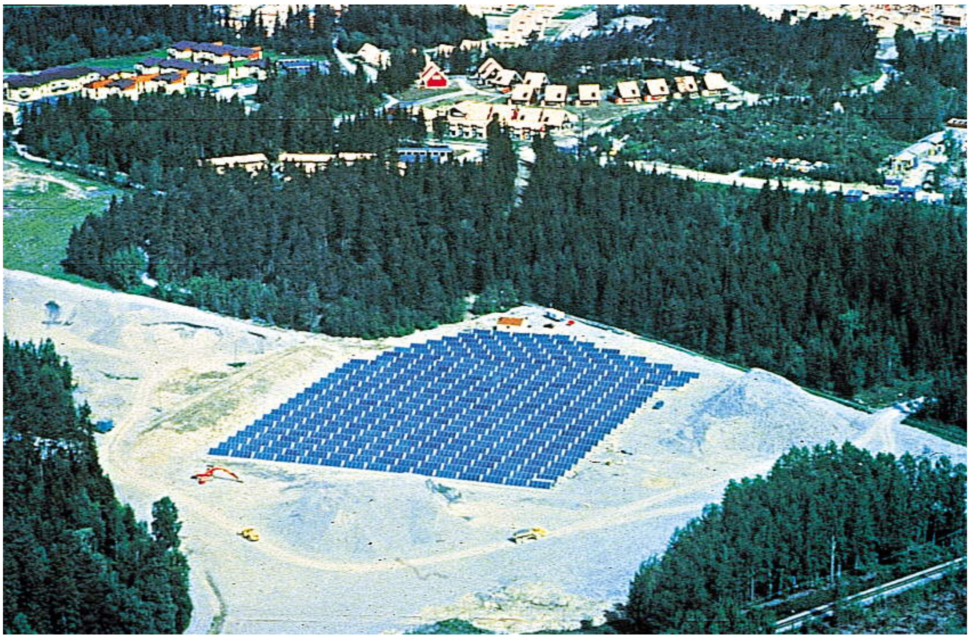


Figure 19. Large module collector array in Lyckebo, Sweden (1982).

The very positive development of biomass (e.g. wood chips) and the phase out of oil in Swedish district heating systems the last 20 years has slowed down the interest to develop solar district heating plants by utilities. The large share of district heating for residential, as well as for service and commercial buildings, has on the other hand created a demand from building owners (e.g. housing companies) to be able to apply solar heating systems.

Thus the recent developments comprise a number of distributed solar heating systems connected to district heating, out of which some with >500 m^2 solar collectors (350 kW_{th}).

Denmark

The first Danish large-scale solar heating plants were built in small existing district heating systems in end 1980's. The first two plants, both without storage (i.e. using the district heating network as storage), were put in operation 1988. Both plants comprised large module flat plate collectors (from Sweden), 1 000 m^2 and 3 000 m^2 respectively, mounted on ground.

The positive development of wind power (and sometimes very low electricity prices) together with a large number of CHP plants running on (heavily taxed) natural gas have created a large interest from thermal utilities to use buffer heat storages and solar heat. These conditions have created a very positive market for large-scale solar heating systems with several new plants, with decreasing specific investment costs, built each year since 2007.

Germany

The first German large-scale solar heating plants using roof integrated collectors were built in the early 1990's. Three larger plants, all with seasonal storages, were put in operation 1996-97. More or less all large-scale German plants are built with roof integrated collectors in connection to the establishment of new residential building areas, and the interest from thermal utilities to use solar heat in existing district heating systems is low, mainly due to a high share of low cost recycled heat from CHP.

Austria

The first Austrian large-scale solar heating plants using roof integrated collectors were built in the late 1990's in connection to small biomass plants. Four larger plants, all with a direct connection to an existing district heating system (in Graz), were put in operation 2002-2009. The majority of collectors are mounted on roofs. The present situation is a bit better than in Germany, but the interest from thermal utilities to use solar heat in existing district heating systems is low, mainly due to a high share of low cost recycled heat from CHP in existing systems.

Others

A number of large-scale heating plants have also been built in The Netherlands from the mid 1980's and the first large-scale solar cooling plant was built in Greece in the late 1990's.

Ownership and Business Models

The fact that the solar heat cost mainly comprises annual capital costs. This is a major advantage as it means that the solar heat cost is fixed during the lifetime of the plant unlike other types of heat supply where the heat cost varies with market variations for the fuels used. However, it is also a major disadvantage as it introduces a large risk, especially for investors with so far less confidence in the technology.

The problem with the risk to invest can be overcome by forming Energy Service Companies (ESCO) with the required confidence and knowledge, that can finance, build and operate the plants. Unless the main district heating provider is involved in the ESCO, this requires a kind of third party access to the district heating network. The solar heat can either be sold to the district heating operator or to a customer by using the district heating system to transfer the solar heat. A number of Austrian plants are already implemented based on the ESCO concept and there is a potential to transfer this concept to other countries.

The cost for solar heat is usually compared to the competing operational cost (heat cost) in a district heating system, based on the fact that solar heat in most cases mainly can replace heat from fuels summer and not heat and power during design conditions. This makes the cost effectiveness of the investment questionable from the district heating provider point of view if low cost heat alternatives are available (recycled heat from CHP, waste heat from industry or heat from waste incernation).

The solar heat cost is on the other hand more competitive with the cost that the district heating customer has to pay for district heat, usually considerably higher than the operational cost, which makes it interesting to implement the solar system on the customer side. There are already a number of pioneering examples in this direction that have to be developed further (net-metering in Sweden and EON in Hamburg).

The conflict between heat recycling and solar heat can further be solved by consumer choices in district heating contracts. Beside ordinary district heat, solar heat can be offered with a separate pricing. The customers that can afford the solar heat price can subscribe a certain share of their heat demand to be solar heat. The heat provider should then assure that they can provide solar heat during a year according to aggregated shares. The more solar heat shares ordered by interested customers, the more solar collector surfaces have to be installed. Since a district heating system have many customers, the probability that some customers will subscribe for solar heat shares is high.

Technical Interaction

The technical interactions between large solar collector areas and district heating systems consider temperature levels, temperature variations, and heat storage.

The temperature levels for district heat distribution vary from system to system. The lower supply temperature, the higher conversion efficiency can be obtained in solar panels. The current average supply and return temperatures in the Swedish district heating systems are about 84 and 48ºC, respectively. The solar district heating system in Marstal in Denmark had during 2009 an average supply temperature of 74ºC and an average return temperature of 36ºC. This temperature level can be considered as best practise in the third generation of district heating systems. With future implementation of the fourth generation of district heating technology, heat distribution temperature of 50-60ºC and 20-25ºC can be foreseen. These lower distribution temperatures will increase the conversion efficiencies for solar collectors considerably compared to the current situation.

Both supply and return temperature should not have too large variations with respect to low cycle fatigue of the steel pipes carrying the heat carrier in heat distribution networks. Hereby, the control method for solar heat supply should be constant supply temperature and variable flow in order to match the variable solar irradiation. The flow should be withdrawn from the return pipe and delivered to the supply pipe. This control method gives somewhat lower conversion efficiencies compared to another control method using constant return flow with a variable temperature addition to the return temperature. However, this latter control method, giving large variations in the return temperature after the solar heat supply, is very dangerous with respect to low cycle fatigue and should absolutely be avoided.

When the solar heat supply is large compared to the heat demand connected, a heat storage is needed in order to cover all heat demand variations. The heat storage manages the absence of correlation between demand variations and solar irradiation variations. Heat storage is not needed when the solar heat supply is small compared to the demand. This situation is prevailing when a district heating is supplied initially with solar heat. Hence, less investments is initially required in order to supply solar heat to a district heating system compared to an individual building. This is the main conclusion in (Begerow & Holler, 2010). Another conclusion from the Western harbour area in Malmö, Sweden is that if a building should be equipped with own roof solar collectors, the solar heat should be delivered to the district heating network. Hence, the customer substation will be the interface for both solar and district heat. This solution reduces the demand for a specific interface including heat storages between the solar collectors and the building heating system. Hereby, the lowest additional investment for initial solar heat supply is obtained by cooperation with the district system. This is a very important conclusion.

Barriers to SDH

This topic is treated more in detail in ”Boundary Conditions and Market Obstacles for Solar District Heating” (SDH D2.2).

The general legislative framework, as well as the support measures for district heating, is very different within Europe. There are varying and week (legislative, financial, etc.) support for solar district heating. There are varying and weak national, regional and local (legislative, etc.) requirements for renewable heat in new buildings and there are varying and weak national, regional and local (legislative, etc.) requirements for solar heat in new buildings. There are varying restrictions regarding available areas for solar collectors.

Furthermore, there are few actors involved in the development and poor capacity for planning, design and construction of solar district heating systems. The interest to demonstrate solar district heating and to reduce the use of fossil fuels (natural gas) in district heating, are the major driving forces for continued efforts to realize more demonstration plants. There is however a need to improve national requirements and incentives to enhance the interest to demonstrate solar district heating for enhanced knowledge transfer and capacity building.

Low cost for waste heat (industry, CHP) together with the lack of requirements, financial incentives and actor capacity, in combination with high initial costs for the solar system, are major threats for the development. Furthermore, many existing district heating systems have rather high heat distribution temperatures which results in reduced performance of connected solar collectors.

Increased use of wind power and solar PV power may however change the competition with heat from CHP plants in the future, but initial incentives to build demonstration plants are necessary in order to overcome initial barriers and encourage local actors, especially in countries without large-scale solar heating systems.

There are also differences in costs for land, as well as differences in costs for solar collector systems due to the lack of experienced contractors in several countries.

The main interest and the possibilities to develop solar district heating is mainly shown in Denmark and Austria, which for the time being have the best conditions related to incentives, as well as actor capacity.

Future Prospects

Current use of solar district heating is about 0.3 PJ (100 GWh) in Europe, representing only 0.015% of all heat generated annually in district heating systems. The share of solar heat in district heating (0.015%) is thus less than one tenth of the share of solar heat in relation to the total potential low temperature heat demand (0.2% according to Table 2).

The potential use of solar heat in district heating systems is estimated by two scenarios; **A** - where solar district heat is assumed to have the same development as solar heat in general; **B** - where it assumed that sooner or later solar heat in district heat will catch up the market development outside of district heating.

Table 11. Future potential for solar district heat in EU-27 – Scenario A.

		Solar [TWh/a]	DH [TWh/a]	Solar share [%]
2006		**0.05**	556	0.01
2020	BAU-RDP	**0.22 – 0.91**	556	0.04 – 0.16
2030	BAU-RDP	**1.16 – 3.42**	556	0.21 – 0.61
2050	BAU-RDP	**2.30 – 9.13**	556	0.41 – 1.64

Table 11 shows the potential development of solar heat in district heating – Scenario A - with the assumption that district heating will keep the present market volume (2 000 EJ, 556 TWh, about 12% market share of the potential low temperature heat demand) and that solar heat would keep the present market share in district heating (about 1% of the solar heat market) and have the same potential development in district heating as presented in Table 2 (Weiss and Biermayr, 2010).

The potential for solar heat in district heating in Scenario A would thus be 0.22 - 0.91 TWh (0.8 – 3.3 PJ) in 2020 and 2.30 - 9.13 TWh (8 – 33 PJ) in 2050. This assumption is likely a pessimistic one as it is realistic to believe that solar heat in district heating at least to some extent will catch up with the potential development of solar heat in general.

There are two national studies that include solar district heating. A Danish study by Aalborg University and Ramböll (Varmeplan Danmark, 2008) on behalf of Dansk Fjernvarme, recommends to introduce 2 million m^2 of solar collectors in district heatings systems until 2030 and another 2 million m^2 solar collectors until 2050. This corresponds to 0.7 TWh/a and 1.4 TWh/a of solar district heat only in Denmark, i.e. larger numbers in relation to what Scenario A gives for all of Europe. The BSW roadmap (Fahrplan Solarvärme, 2012) estimates the potential for solar district heating in Germany to 1.2 GW and for process heat to 15 GW in 2030. This corresponds to 0.6 and 7.5 TWh/a, i.e. larger numbers than the Scenario A gives for all of Europe.

Table 12. Future potential for solar district heat in EU-27 – Scenario B.

		Solar [TWh/a]	DH [TWh/a]	Solar share [%]
2006		-	556	-
2020	BAU-RDP	**3.8 – 15.5**	556	0.7 – 2.8
2030	BAU-RDP	**19.8 – 58.2**	556	3.6 – 10.5
2050	BAU-RDP	**39.1 - 155**	556	7.0 – 27.9

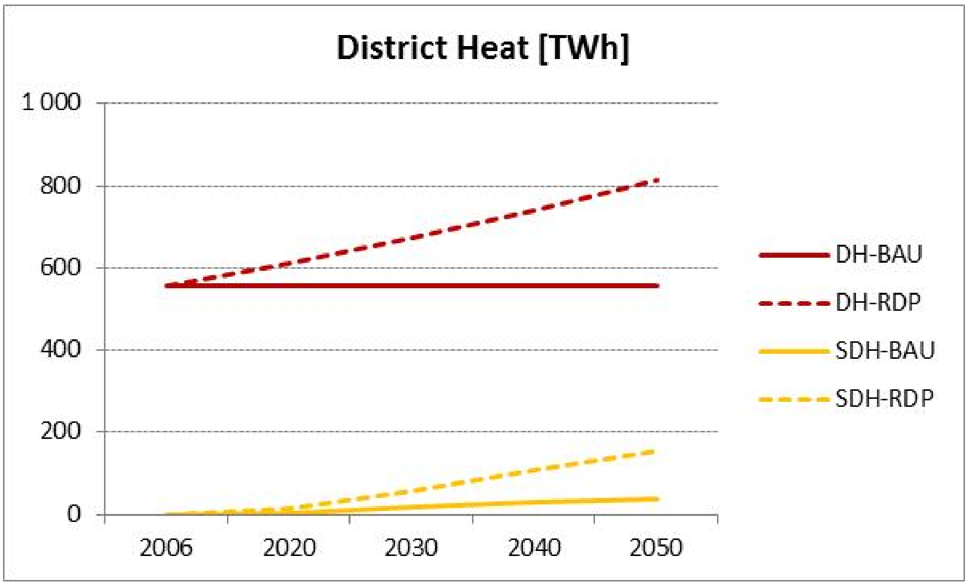


Figure 20. Potential development of solar district heat (SDH) in relation to the total use of district heat (DH) for Scenario B in Table 12. DH-RDP assumes an increase of about 10% per decade.

Table 12 shows the potential development of solar heat in district heating – Scenario B - with the assumption that district heating keep the present market volume (2 000 EJ, 556 TWh, about 12% market share of the potential low temperature heat demand) and that 10% of the potential development of solar heat is allocated as district heat based on the potential development presented in Table 2 (Weiss and Biermayr, 2010).

The potential for solar heat in district heating in Scenario B would thus be 3.8 – 15.5 TWh (13.7 – 55.8 PJ) in 2020 and 39 - 155 TWh (140 – 558 PJ) in 2050. This assumption is likely an optimistic one as it is assumes a very strong development of solar heat in district heating to catch up 100% with the potential development of solar heat in general during the next 10 years.

A very positive development for district heating, i.e. a doubled or a tripled market within the coming decades, will likely increase the amount of solar heat but reduce the solar share of solar heat in district heating.

Figure 20 shows the potential development of solar district heat (SDH) in relation to the total use of district heat (DH) for Scenario B. Included is also an RDP-scenario for district heat, here assumed that district heat will increase with about 10 % per decade.

CONCLUSIONS

The main conclusions from this brief market report concerning solar district heating are:

- Solar district heating is a small, undeveloped part of the heat market. Only 1% of the solar collector surface is currently connected to district heating systems. Hence, solar heat grows faster outside district heating systems than inside. According to our analysis, the opposite situation should appear, since solar collector installations inside district heating systems have competitive advantages. Early stage engagement is a vital condition for obtaining future market shares.
- Latent conflict exists in (large) district heating systems between heat recycling (secondary energy supply) and direct use of renewables (primary energy supply). This conflict can be solved by customer choices according to a new business model proposed in this report.
- Few European market actors with respect to products, contractors and buyers are a major barrier for more solar district heating in Europe.
- However, solar district heating has received higher attention in Denmark during recent years. This has given an emerging market for solar district heating among Danish district heating companies with new contractors and decreasing collector costs.
- Solar heat has the technical potential to make a major contribution to the share of renewables in district heating. Depending on the general conditions for the further development of solar and district heat, solar district heating may amount to between 1 and 58 TWh (4 and 210 PJ) in 2030.

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