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Energy efficiency and security of supply in district heating

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1. Introduction

In recent decades, increasing demand for energy, fluctuating oil prices, uncertain energy supplies and global warming made the EU-citizens to realize that secure and safe supplies of energy can no longer be taken for granted. It becomes obvious that improved energy efficiency can play a critical role in addressing energy security, environmental and economic objectives.

Security of energy supply has been widely debated, mostly in relation to the upstream (security of supply for specific geographical region or single country). However, it can be argued that one way to reduce the dependence from external energy sources, or the exposure to energy prices volatility and increase, is simply to reduce the demand for energy. Energy savings may thus be considered a policy priority when concerns for energy security are particularly strong. Thus, in order to fully understand how energy security affects the European society and how demand-side policies can be geared a detailed knowledge of energy intensities in the Europe member countries' sectors and of their potential for efficiency improvement is potentially very important.

The bulk of the analysis were described in the three previous deliverables, as they cover the vast majority of energy uses. This deliverable looks at a specific way of conveying energy, that is the distribution of heat (or, in summer, of cold as a substitute to air conditioning) produced by a central thermal unit to several final users in a given area by means of a grid of pipelines. This deliverable in particular highlights the possible contribution of district heating and cooling (DHC) and combined heat and power (CHP) in reducing emissions of carbon dioxide and increasing energy efficiency and security.

To this purpose, we will look at the available information on district heating in Europe to depict the current status in terms of energy indicators[1], the development potential of this technology and relevant policies and measures. Since the said available information is not homogeneous and of varying quality across member countries, deeper insights are obtained by means of specific case study on Italy and by applying the same innovative econometric approach used in other Deliverables of this WP to the data on "heat" of the IEA energy balances, here adopted as a proxy of district heating heat generation. Drawing on Arigoni Ortiz et al (2009) and Confindustria (2008), which focused solely on energy and carbon efficiency indicators, we check whether policies and measures that affect indicators of energy efficiency performance have an analogous effect on security of supply indicators, in the EU 15 countries, using an updated database.

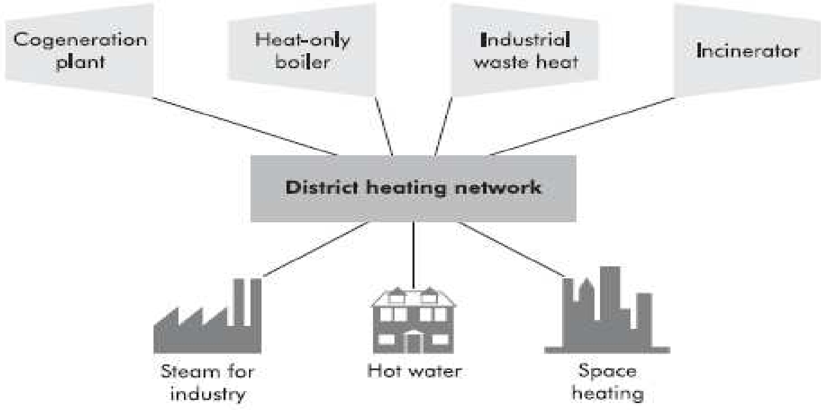
[1] Note that, due to the peculiarities of the sectors considered, it is not possible to use the same indicators of energy efficiency for all the subsectors. In particular energy intensity, that is, the ratio between energy consumption and value added, makes sense only for sectors yielding output measurable in value terms. In this case we computed an "heat intensity" for the whole economy, using heat generation and overall GDP.

DHC is an integrative technology that can make significant improvement to energy efficiency, since it combines the benefits of highly-efficient conversion processes and the use of surplus energy sources in order to reduce the use of imported fossil fuels to a minimum. In November 2006 the Energy Council identified district heating and cooling as one of the most energy efficient technologies available for the construction of new capacity.

District heating consists in a system of distributing hot water or steam from a central plant to individual buildings through a network of pipes, in order to supply space heating, domestic hot water and/or industrial process energy. In many processes, for example when electricity is generated or waste is burned, large parts of the energy are set free in the form of surplus heat.
The fundamental idea behind modern district heating is to recycle this surplus heat which otherwise would be wasted -from electricity production, from fuel and biofuel-refining, and from different industrial processes. The recycled heat is used to heat water which is transported to the customer via a well-insulated network of pipes. DHC systems can supply thermal energy to buildings directly (by circulating DHC water through the building) or indirectly by transferring energy to the building systems through a substation. In contrast, conventional on-site heating and cooling systems typically require combustion of fuel in a boiler and/or use of electrically-driven equipment to produce heating and/or cooling. DHC service eliminates the need for such on-site conversion by delivering hot water, steam and/or chilled water directly to buildings. City-wide district heating systems exist in Helsinki, Stockholm, Copenhagen, Berlin, Munich, Hamburg, Paris, Prague, Moscow, Kiev, Warsaw and other cities. Many systems supply a downtown district (such as in New York, San Francisco, Minneapolis, St. Paul, Seattle, Philadelphia and other cities) or a university, military base, hospital complex or industrial area.

While having an overall market share of less than 10 percent, the sector is particularly developed in North, Central and Eastern Europe with market shares of over 50 percent. In total, in Europe 5000 district-heating networks connect citizens to a variety of sustainable heat sources. About 1 EJ of District Heat is annually delivered to customers in the former EU-15 for a total value of about 11-12 billion euros. Further 1 EJ is annually delivered in the twelve new EU member states to a value of about 6-7 billion euros. Figure 1 depicts the typical supply and demand components of a district heating system.

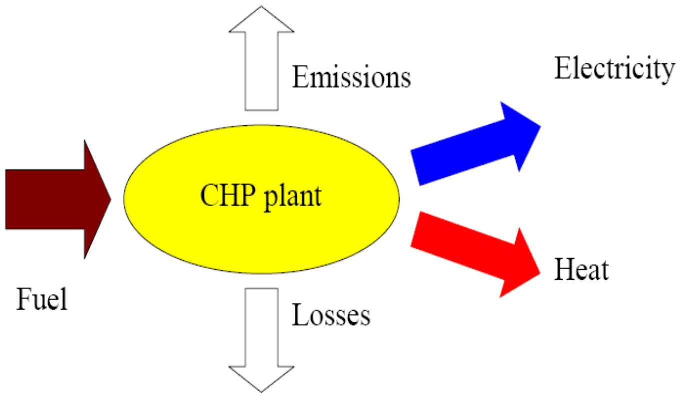
Figure 1 : Typical District Heating System



Source: IEA

In a district heating system the heat production sources can produce heat only or simultaneously produce heat and electricity. This system, called *Combined heat and power (CHP)* or *cogeneration*, consists of the simultaneous or sequential generation of electricity, mechanical shaft power, or both, in combination with the generation or steam, hot water or other forms of useful thermal energy. Figure 2 displays a general illustration of the CHP process.

Figure 2: General description of the five major flows of a CHP plant



Source: IEA, Promotion and Recognition of DHC and CHP Benefits in Greenhouse Gas Policy and Trading Programs May 2002

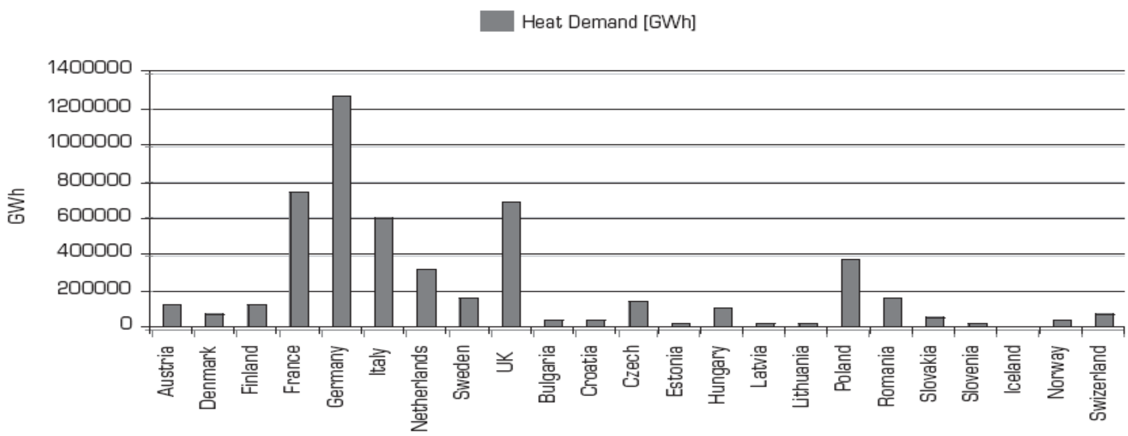
CHP is a general term that encompasses a wide variety of technologies including steam turbines, combustion turbines, reciprocating engines and fuel cells. The primary energy source can be a wide range of fuels, including biomass and fossil fuels, as well as geothermal or solar energy.
CHP heat can be used either for district heating or for industrial processes. DHC is important for implementing CHP because it expands the pool of potential users of recovered thermal energy beyond the industrial sector to include commercial, institutional and multi-unit residential buildings. The temperatures required by these users are relatively low, which allows CHP to operate at higher efficiencies compared to plants producing higher-temperature industrial process heat.

The rest of the deliverable is organized as follows. Section 2 looks at the demand for heat in the EU while section 3 looks at its supply. Section 4 explores the penetration of combined heat and power technologies in District Heating heat production. Section 5 considers the fuel mix used for District Heat production. Sections 6, 7, and 8 look at the potential impact of developing District Heating on, respectively, energy efficiency, energy security and carbon emission reduction. Section 9 focuses on a case study on the potential for district heating in Italy, Section 10 looks at the European policy framework for energy efficiency in District Heating. Section 11 reports the results of the econometric panel analysis of energy intensity and energy security. Section 12 concludes. Annex 1 lists support measures for the promotion of RES, District Heating and CHP in selected European countries.

2. Heat Demand

The following analysis focuses on a sub-set of EU-15 member states and New Member States (NMS-12)[2], where DHC systems are more widespread and data are hence available. The surveyed regions represents however more than 90 percent of the total EU and EFTA heat demands as well as of the district heat deliveries.
Starting with the total heat demand, in the EU more than 30 percent of final energy demand is related to heating purposes - space heating, warm water preparation and low-temperature industrial processes - mainly covered with imported fuels (gas and oil) or low-efficiency electricity.
The total heat demands in the surveyed European Union and EFTA countries represent 19.5 EJ or 5425 TWh, the total for EU and EFTA countries being 20 EJ. Figure 3 displays the total heat demands covering residential, industrial and service sectors for countries surveyed.

Figure 3: Total heat demands per countries, 2005

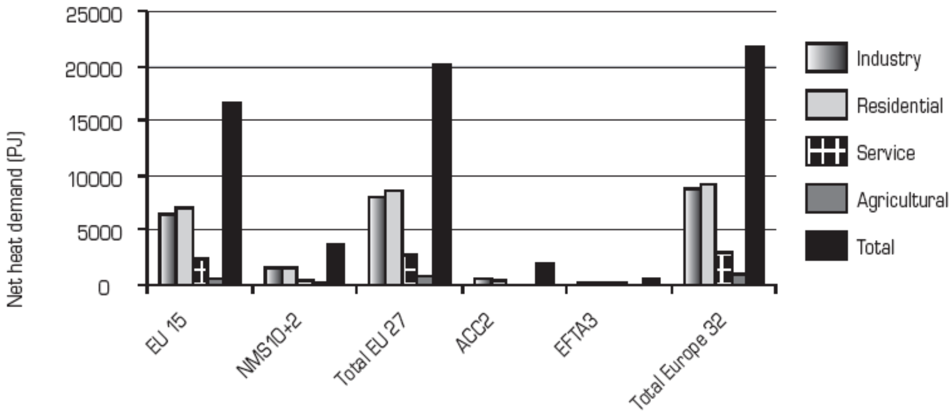


Source: Euroheat & Power (2007)

[2] The countries considered in the analysis are: Austria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Italy, Latvia, Lithuania, The Netherlands, Norway, Poland, Romania, Russia, Slovakia, Slovenia, Sweden, Switzerland, Ukraine, United Kingdom.

Germany registers the largest national share and represents a slightly less than one fourth of the total EU and EFTA heat demand. France also has a high heat demand, followed by UK, Italy and Poland. Regarding the distribution of the total heat demand by sectors and by aggregated regions, in EU member countries the heat demand for residential and industrial sector registers similar values, accounting for 43 and 39 percent respectively, while the service sector accounts only for 13 percent, followed by the agricultural sector with a 5 percent. (Figure 4). A slightly higher share of the residential sector with respect to the industrial one is registered in EU-15.

Figure 4 : Heat demands per sectors and regions

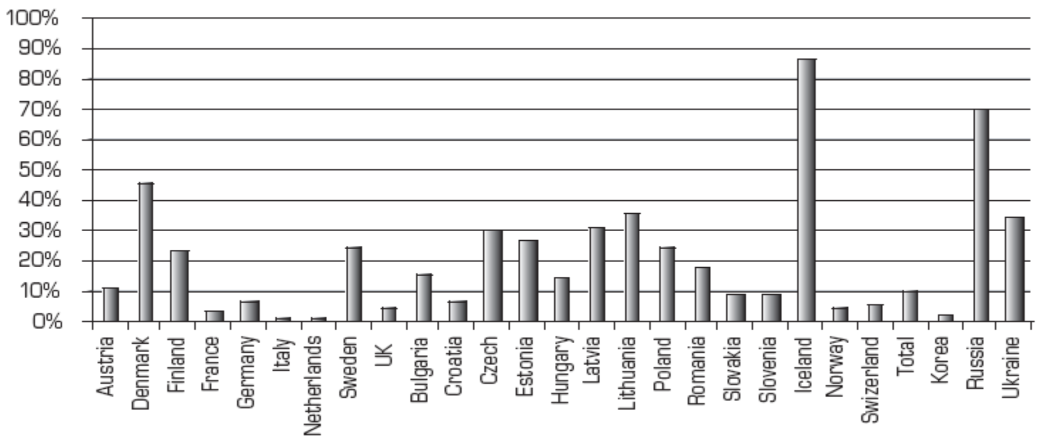


Source: Euroheat & Power (2007)

3. Heat supply by District Heating

The District Heating sector was developed traditionally in Central, Eastern and Northern European countries, due to the climate conditions characterized by cold and long winters. In addition, the diffusion of district heating in these regions has been promoted by some national energy policies, which considered district heating as a way to face the two oil crisis in ’70’s or they were focused on the reduction of primary energy supply for electricity by using CHP. However, district heating exists also in more Southern European countries such as Italy, France and more recently Spain.
District heating represents only a small fraction of the total heat market of the European Union, supplying 9.7 percent (2 EJ or 530 TWh) of the total heat end use in surveyed countries. Although in absolute terms more than half of the district heat deliveries takes place in EU-15 countries, the relative share of district heat in the heat market is higher in NMS-12, where it represents 21 percent of the total heat end use, while it accounts only for 7 percent in EU-15 member states surveyed.
Figure 5 shows the estimation of supplies of district heating in the total heat demands by countries.

Figure 5: Share of DH in the total heat demand, 2005



Source: Euroheat & Power (2007)

The highest share of district heat deliveries in the total heat demand is registered in Iceland, which shows a share of almost 90 percent. Within the EU-15, Denmark is the main user of DH deliveries (46 percent of total heat demand), followed by Sweden, Finland and Austria. Outside the EU-15, Russia district heat deliveries cover 70 percent of the total heat needs, followed by Lithuania and Ukraine.
District Heating continues to grow in Austria, Italy, Iceland, Norway and Sweden at high expansion rates.

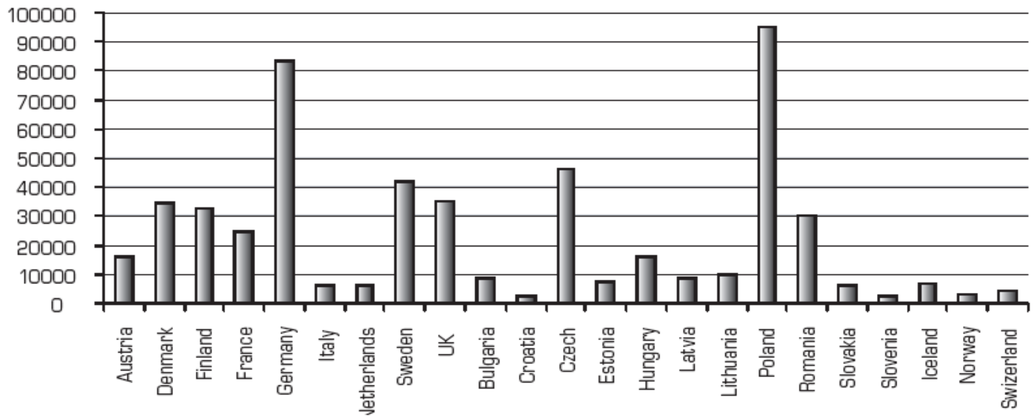
Looking at the DH demand by sectors, District Heating systems supply heat mainly to the residential sector. The countries with the highest share of residential heat consumptions covered by District Heat supplies are Latvia and Lithuania where 70 percent of the residential heat demands are delivered by District Heating, followed by Denmark with 60 percent, Finland, Sweden and Poland with 50 percent. Also the service sector in urban areas represents a significant section covered by DH, especially in Central and Eastern European countries.

Regarding the DH deliveries in absolute terms, the District Heat annually delivered to customers in the former EU-15 accounts for about 1 EJ, for a total value of about 11-12 billion euros. Further 1 EJ is annually delivered in the twelve new EU member states to a value of about 6-7 billion euros.

The District Heat production per countries is presented in the Figure 6. The countries with the highest District Heat produced in absolute terms are Poland (95000 GWh) and Germany (83340 GWh), followed by Czech Republic, Sweden, Denmark, Finland, UK and Romania.

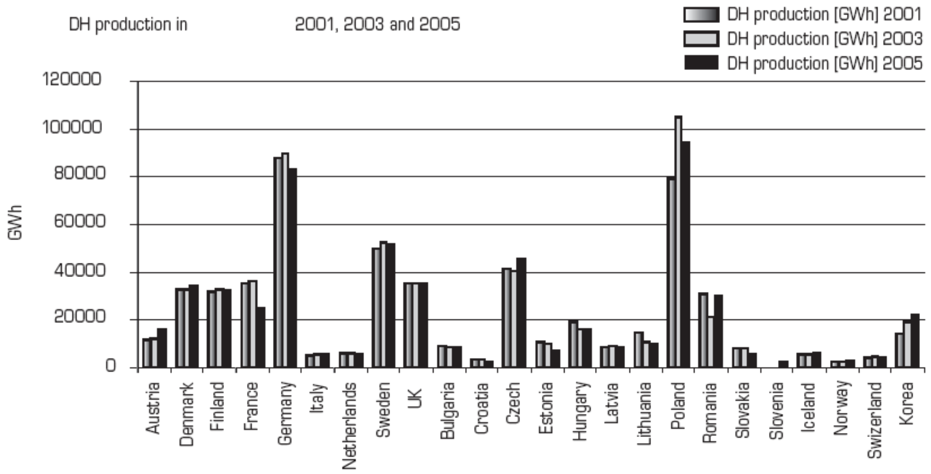
The evolution of District Heat production in various countries surveyed is presented in Figure 7. A significant growth continues to be registered in Austria, Italy, Iceland and Norway, within a range of more than 5 percent per year.

Figure 6: District Heat deliveries, selected countries, 2005, GWh



Source: Euroheat & Power (2007)

Figure 7: Evolution of DH production DH production in 2001, 2003 and 2005



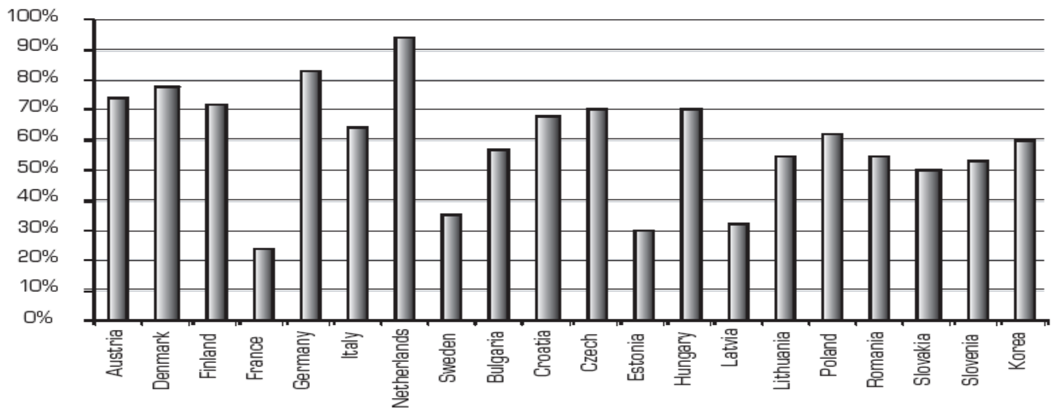
Source: Euroheat & Power (2007)

Recently, in most of Central and Eastern European there has been a noticeable reduction in energy production, due to energy efficiency measures especially in buildings, rehabilitation of the District Heating schemes and consequent energy savings on the demand side (change of behaviour triggered by the introduction of heat meters and relative high energy prices in view of average family incomes prevailing in those countries). However, this trend was compensated to a certain extent by the connection of new customers attracted by improved energy policy measures, increased efficiency of the systems and a customer-oriented approach from the side of the District Heating companies.

4. Penetration of Combined Heat and Power in District Heating

In EU-15 countries, the weighted average of CHP share in District Heat generation amounted to 64 percent during 2005. This share continues to be higher in the EU-15 than in NMS-12 countries. However, in Central and Eastern European the CHP share increased from 57 percent in 2003 to almost 60 percent in 2005, reducing the gap between EU-15 and NMS-12. Conversely, the CHP use in relation to the District Heating sector corresponds to approximately half of the total electricity and heat generated through CHP technology in EU-27. Figure 8 shows the share of CHP in the District Heating production.

Figure 8: CHP share in DH production, 2005



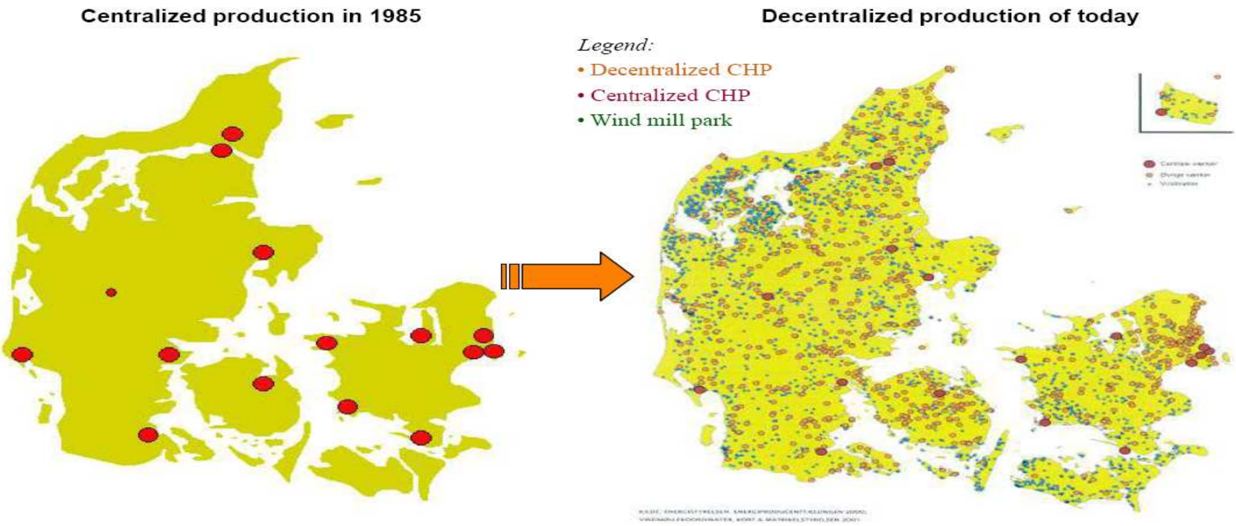
Source: Euroheat & Power (2007)

Among EU-15 countries, Netherlands and Germany account for the highest CHP share in District Heat generation, (95 and 83 percent respectively) mainly due to the existing support schemes in these countries. In France and Sweden instead, the use of CHP technologies in District Heat production is rather low. In Sweden the deliveries from CHP increased during last years mainly due to the commissioning of the Gothenburg CHP plant. However, the total CHP share remains relatively low given the high share of waste heat recovered from industrial processes. In France, the relatively low penetration of CHP should be seen in the context of the difficulties for independent producers to enter the national electricity market. Finally, in Central and Eastern Europe the highest percentage of CHP in District Heat is registered in Hungary and Czech Republic.

As to CHP capacity, the growth rate has been the strongest in the countries which have also had the strongest growth in district heating capacity. This suggests that operators who build new district heating schemes regard the deployment of CHP capacity as a rational and viable solution to enhance energy production and reduce overall costs.

Since Denmark is the country, among the EU-15,holding the highest share of DH in total heat demand, a more detailed analysis of the Danish DH market is perhaps instructive. Since 1985, Denmark have started a progressive shift from a centralized CHP production system to decentralized production (Figure 9) reaching a 60 percent of the heated area in all country supplied by district heating.

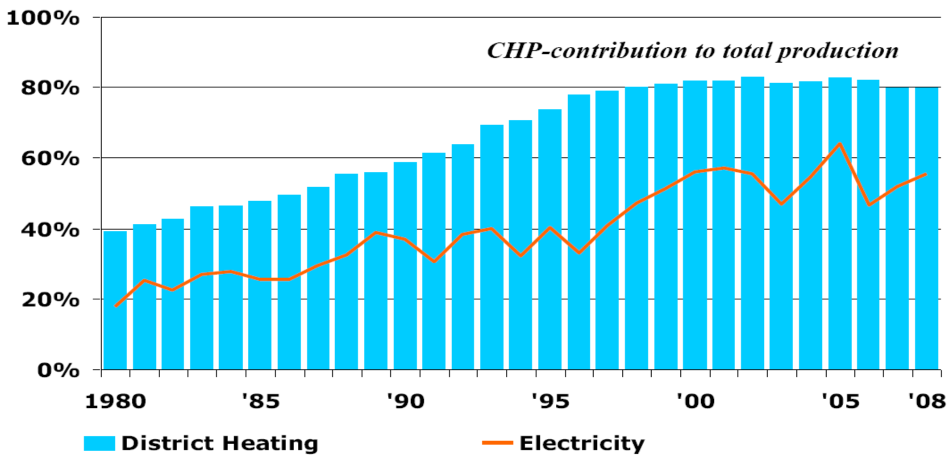
Figure 9: From Centralized to Decentralized CHP, Denmark



Source: DBDH (2009)

The proportion of CHP in Danish district heating production shows a stable increase reaching a share of 81 percent in 2008. The CHP proportion of electricity production is instead about 53 percent (Figure 10).

Figure 10: CHP Proportion of Electricity and District Heating Production, Denmark, 1980-2008



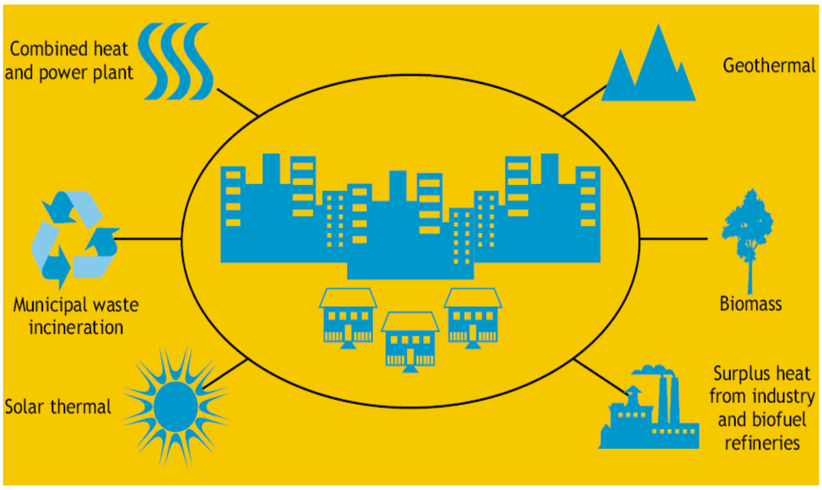
Source: Danish Energy Authority

5. Fuels Used for District Heat Production

District heating systems can use a variety of fuels and heat sources. Natural gas, coal, fuel oil, and renewable fuels such as biomass and waste products can all serve as fuel inputs for district heating boilers and cogeneration plants. Alternatively district heating systems can also recycle industrial waste heat. Moreover, some plants can operate on multiple fuels. For example, a heat plant might use biomass with supplementary gas or coal when temperatures are coldest, or natural gas with fuel oil as an emergency fuel.

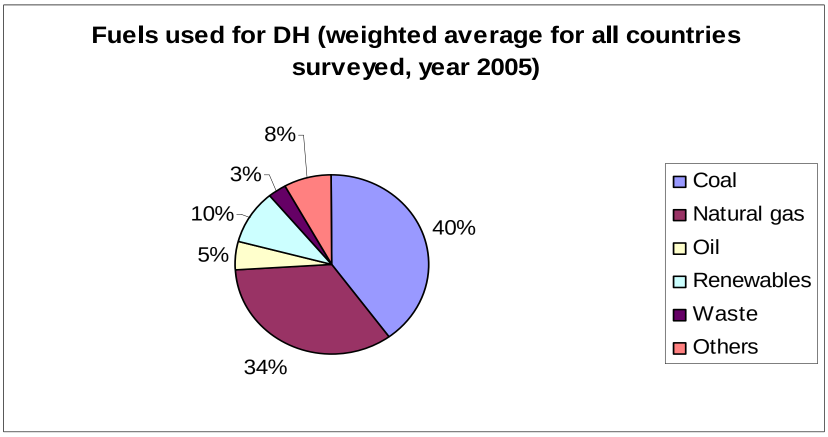
However, DH systems represent a crucial platform for the use of renewable energy sources (RES), waste and CHP technologies, as shown in Figure 11.
The share in the use of fuels for DH in the surveyed countries in Europe (EU and EFTA) for the year 2005 is shown in Figure 12. Considering the weighted average for all countries, coal is the fuel which registers the highest use in DH systems, accounting for 40 percent, followed by natural gas (34 percent) and renewables. However, it should be pointed out that the most of these fuels are used in Combined Heat and Power plants, implying a recycling of heat otherwise dumped into water bodies or in the atmosphere, with consequent gains in energy efficiency and reduction of environmental impacts. The use of renewables, of waste heat resulted from industrial process or use of waste incineration represents around 20 percent, with biomass and biofuels having a remarkable share of approximately 10 percent.

Figure 11: DHC as a flexible platform for CHP and renewable heat sources



Source: Froning, S. (2009)

Figure 12: Fuels used for DH in year 2005 (weighted average for all countries surveyed)



Source: Euroheat & Power (2007)

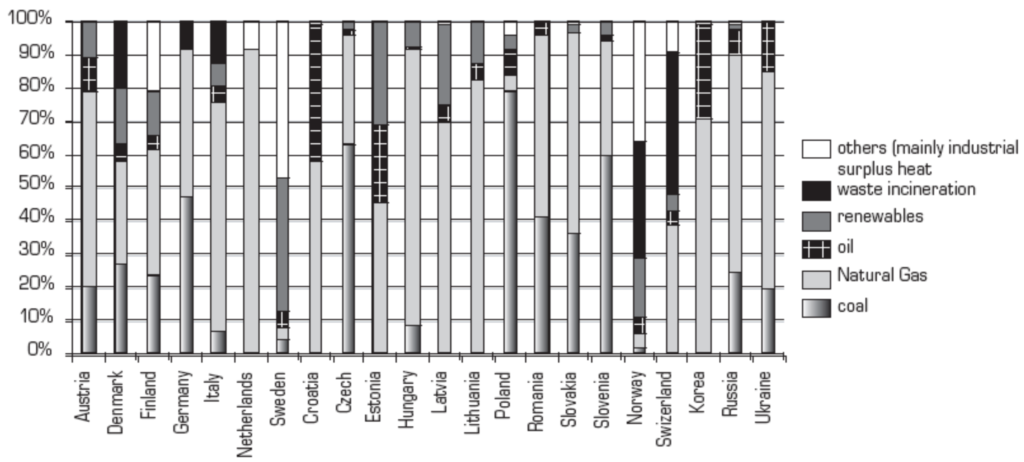
Looking at the general trend of the fuels used for DH in the period 2003 and 2005, a decrease in the use of coal and oil has been registered both in EU-15 and Central and

Eastern Europe, balanced by a slight increase in the use of natural gas and RES (+1%). The progressive substitution of coal with natural gas has been particularly pronounced in the EU-15 countries, where natural gas represents the dominant fuel, accounting for 33 percent of the total fuels. Furthermore, in the EU-15 region the share of RES increased from 13 to 14 percent in the same period.

These trends were triggered by environmental policies including the use of mechanisms such as emissions trading as well as the support measures towards small scale CHP units or increased use of RES.

Figure 13 shows the shares of fuels used for District Heating production by country. A proportion higher than 10 percent in the use of RES is registered in Austria, Denmark, Finland and Sweden and to a less extent in Italy. In the same countries this share rose during the period 2003 and 2005. Among the EU-15 countries, Austria, Italy and Netherlands rely mostly on natural gas supply for DH systems and an increase in the use of natural gas was registered in Austria and Germany. In CEE countries, Czech Republic, Poland and Slovenia use to a high extent coal, while Baltic countries - such as Hungary, Romania and Slovakia – register large shares of natural gas. Furthermore, the special situation of Iceland should be mentioned as 97 percent of the District Heating is based on the use of RES in the form of geothermal energy.

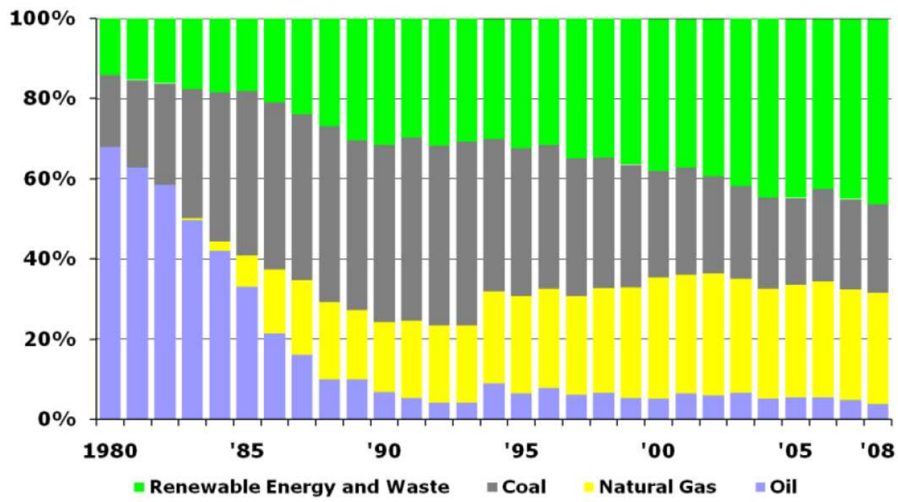
Figure 13: Fuels used for DH in surveyed countries, year 2005



Source: Euroheat & Power (2007)

Focusing on Denmark, in this country the fuel mix used for DH production has changed noticeably between 1980 and 2008. Figure 14 shows a declining trend in the oil share, falling from about 70 percent in 1980 to less than 10 percent in 2008. This decrease is balanced by an increase in the use of RES and waste - which reach together the share of about 50 percent in 2008 – as well as of natural gas.

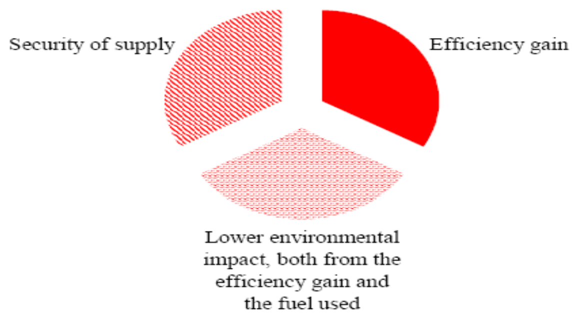
Figure 14: District Heating Production by Fuel, Denmark, 1980-2008



Source: Danish Energy Authority

Due to the high use of CHP technologies and RES, the DH systems could in principle contribute to improve energy efficiency and security. According to IEA (2002) the use of CHP and RES presents the following three major benefits: efficiency gain, lower environmental impact, and security of supply, as illustrated in Figure 15.

Figure 15: The three major benefits of CHP



Source: IEA, Promotion and Recognition of DHC and CHP Benefits in Greenhouse Gas Policy and Trading Programs, May 2002

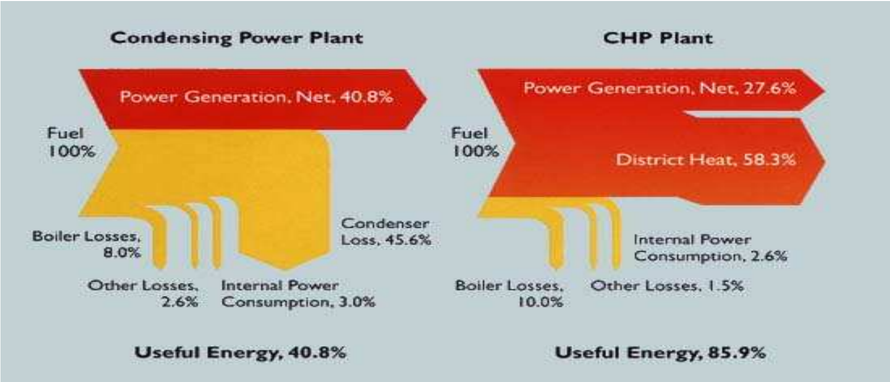
The efficiency gain could come from the higher conversion efficiency from CHP generation compared to separate generation of electricity and heat in condensing thermal power plants and local boilers for heating. The lower environmental impact is due to both the efficiency gain and the use of more carbon-lean fuels and renewable energy resources. Security of supply can be enhanced by CHP plants since they generate power in urban areas near consumer demands and with many small plants, which make them less vulnerable to major interruptions in supply.

6. Energy Efficiency

The European energy balance shows that more than half of the energy contained in

primary fuels is lost in conversion and transformation processes from extraction to end-use. From the annual energy supply of 63 EJ, more than 20 EJ heat are lost in power plants, oil refineries, and industrial processes. Part of these losses can be retrieved and distributed by district heating systems to heat urban buildings. Heat networks can largely contribute to improve efficiency by recycling the heat otherwise wasted, and substituting fossil fuels by recycled heat and locally-available renewable heat.
As shown in Figure 16, the average global efficiency of traditional fossil-fuelled power generation is about 40 percent. Roughly 2/3 of heat wasted during fossil-fuelled power generation and transmission/distribution account for an additional 9 percent of losses. By using the heat output from the electricity production for heating or industrial applications, CHP plants generally convert 75-80 percent of the fuel source into useful energy, while the most modern CHP plants reach efficiencies of 90 percent or more (IPCC, 2007). CHP plants also reduce transmission and distribution losses as they are sited near the end user. About 75 percent of district heat in Finland, for instance, is provided from CHP plants with typical overall annual efficiencies of 85–90 percent.

Figure 16: Comparison between conventional condensing power plants and CHP plants in the useful energy



Source: http://www.chp-info.org/

Table 1 shows the efficiency and capacity values of different CHP technologies.

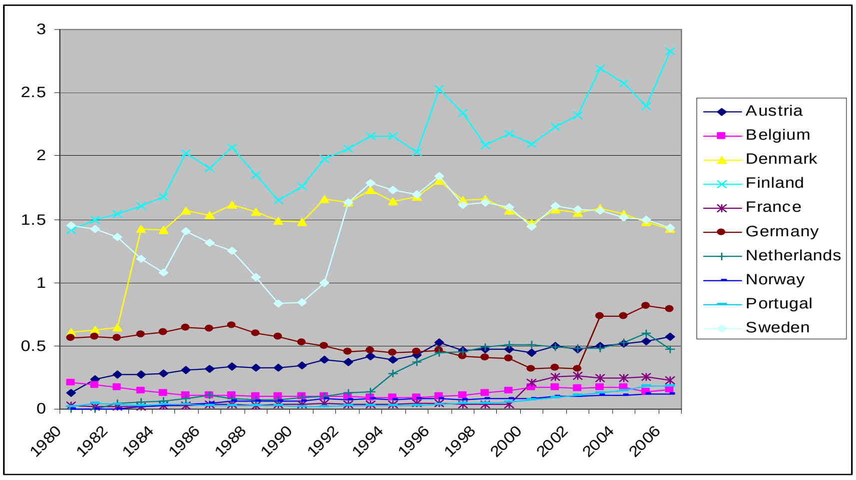
Table 1: Characteristics of CHP (cogeneration) plants

Technology	Fuel	Capacity MW	Electrical efficiency (%)	Overall efficiency (%)
Steam turbine	Any combustible	0.5-500	17-35	60-80
Gas turbine	Gasous & liquid	0.25-50+	25-42	65-87
Combined cycle	Gasous & liquid	3-300+	35-55	73-90
Diesel and Otto engines	Gasous & liquid	0.003-20	25-45	65-92
Micro-turbines	Gasous & liquid	0.05-0.5	15-30	60-85
Fuel cells	Gasous & liquid	0.003-3+	37-50	85-90
Stirling engines	Gasous & liquid	0.003-1.5	30-40	65-85

Source: IPCC (2007). Climate Change 2007: Working Group III: Mitigation of Climate Change

An international comparison of energy intensity indicators (EI) for a sub-set of EU-15 countries[3] is provided by Figure 17. The EI indexes for the District Heating sector are been estimated as energy use per unit of output. In particular, we have used data on energy production in the Heat sector as proxy of the heat provided by the DH sector to the overall economy[4], and GDP as indicator of economic activity. In a sense, this gives the amount of heat necessary to produce one dollar of output in the national economies considered, and thus can be regarded as an "heat intensity" indicator. It must be noted that this indicator differs from the standard energy intensity indicator in two was: first, the numerator is but a proxy of the variable we are interested in (namely heat production from district heating plants, see footnote 4). More importantly, the numerator is not a measure of *consumption* but of *production* of energy. Since exports of heat are non-existent, however, and heat losses along the pipelines are low, we expect quite a close correspondence between the two variables.

Figure 17: Energy Intensity Index, selected EU-15 countries + Norway, 1980-2006, ktoe/00$ppp



Source: Author's computation on data from IEA, EUROSTAT, OECD

Figure 17 shows an upward trend of the EI index for France, Netherlands, Finland and Austria, while the index remains rather stable in Belgium, Portugal and Norway during the period 1980-2006. Sweden and Denmark display an early increase in heat intensity followed by a decline from the mid-'90's. In Germany, after a period of slight decrease, the index starts to grow from the early 2000's. The high value in the EI index of Finland, Denmark and Sweden is explained by the large amount of energy consumed for heating purposes with respect to the relatively low total GDP, compared to the other countries surveyed.

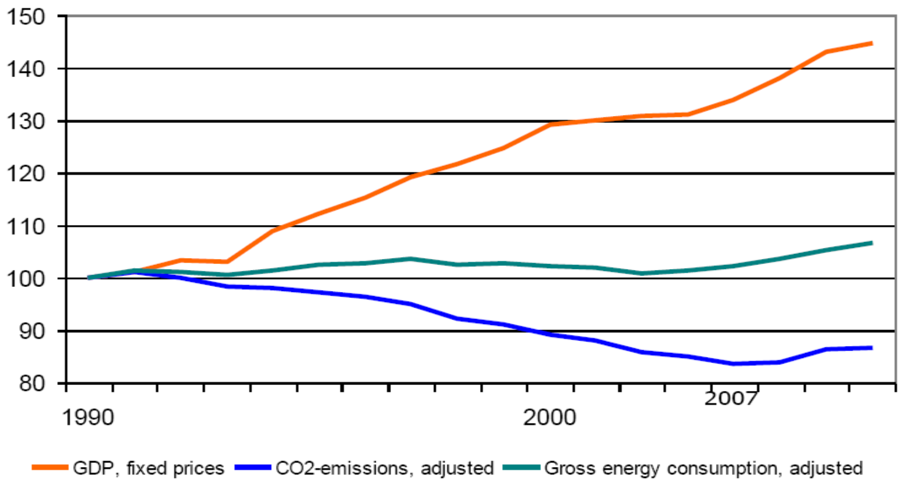
[3] The EU-15 countries are been selected on the basis of the availability of data for the entire period 1980-2006.

[4] According to the definitory notes to the IEA energy balances (IEA, 2008) "Heat permits the reporting of (a) the generation and consumption of heat for sale and (b) heat extracted from ambient air and water by heat pumps. The generation of heat for sale is reported as a transformation sector activity. Heat consumed at the point of production, which is generated from fuels reported elsewhere in the balance, is not reported. The fuels consumed for the production of heat are included in the quantities of the fuels shown as consumed by the final sectors".

District heating in transition economies tends to be less efficient than in Western Europe, North America and OECD Asia, although the significant improvements registered in recent years have made district heating systems more efficient than they were ten or fifteen years ago. Several factors contribute to the inefficiency: technical design, poor maintenance, worn out equipment, over dimensioned systems, lack of controls and insufficient insulation on heat pipelines. In Central Europe, the heavy reliance on coal also tends to be inefficient, though more and more systems are switching to burning natural gas or biomass.
The degree of efficiency does vary from country to country and between regions. For example, the new EU member countries have modernized many district heating systems in recent years using Western technologies. Nonetheless, there is wide room for improvement. The World Bank estimates that typical cogeneration plant efficiencies are around 70-75 percent in Eastern Europe, compared to 80-90 percent in Western Europe and the efficiency of older heat-only boilers is estimated at 60-80 percent.
Heat losses in production, distribution and end use in transition economies are also high compared to Western Europe. Cumulative heat losses from production through transportation to end-use are estimated to be between 35 and 77 percent in Central and Eastern Europe and the former Soviet Union. Heat transmission and distribution pipes suffer from external and internal corrosion, leading to frequent leakages. Moreover heat losses within buildings in Eastern Europe are usually 25 to 40 percent higher than the design values, according to World Bank estimates, and standards for design values are typically much less stringent than in the West.

Looking at the Danish DH system, considerable results have been achieved in terms of energy efficiency. Due to the increasing diffusion of DH and CHP systems, Denmark has experienced an increase in fuel efficiency from around 40 to 90 percent. In last 25 years Denmark's economy has grown nearly 80 percent with basically unchanged energy consumption. According to DBDH (2009) the substantial increase of the national energy efficiency provided by the district heating technology could be one of the major reasons for the energy consumption in Denmark to be constant despite the increase in GDP, as shown in Figure 18.

Figure 18: Trends in GDP, Gross energy consumption and CO_2 emissions, Denmark, 1990-2007



Source: Danish Energy Authority

During the same period, the share of RES in district heating has increased by 300 percent to a total share of about 46 percent. Currently, the 80 percent of district heating in Denmark is waste heat, or excess heat, from power generation at combined heat and power plants (CHP). In 2006, the district heating tariffs in some cities have fallen because heat production is based on other fuels than gas or oil. Moreover, due to these achievements, Denmark has turned into the only energy self-sufficient country in EU from being 98 percent dependent on imported fuel.

7. Energy Security

Regarding the energy security issue, DHC and CHP can play a key role in increasing the energy security among European countries by:

• Strengthening power grid reliability. By generating power close to the load centres, CHP avoids or reduces power transmission and distribution constraints.

• Reducing cooling-related peak power demand. Air conditioning is a big contributor to peak power demands. By supplying cooling through highly efficient electric chillers and non-electric, heat-driven chillers, district cooling could significantly reduce peak power demand.

• Shifting demand to off-peak periods. DHC can shift power loads to off-peak periods through thermal energy storage systems that store hot water, chilled water or ice at night for use during the day, or by shifting loads seasonally through aquifer or other long-term storage.

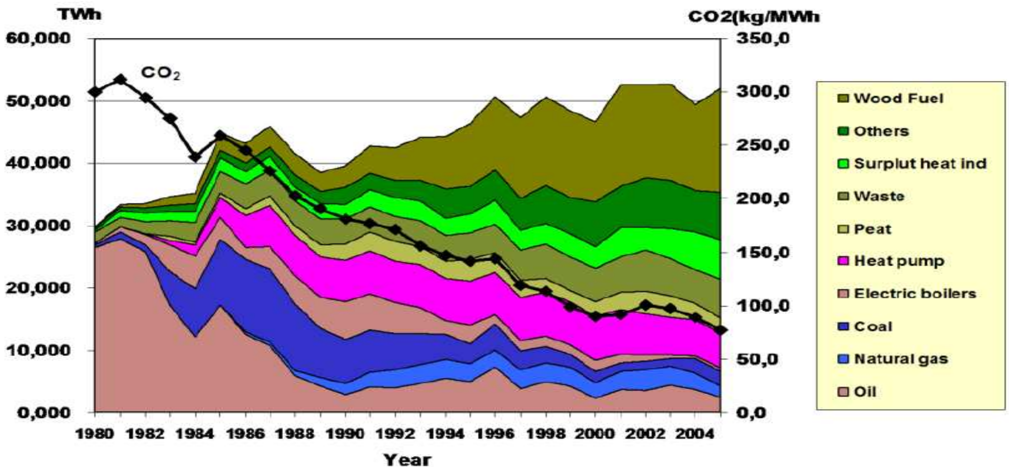
• Increasing fuel flexibility. DHC systems boost reliability and energy security by providing flexibility to use a variety of domestic resources like biomass or waste, thereby reducing the impact of supply and price variations.

Furthermore, district heating can affect international energy security because of its close link with natural gas in major gas-producing and transit countries. In Russia and Ukraine, natural gas is the main fuel for district heating. District heating tends to be less efficient in Russia and other transition economies than in OECD countries. This inefficiency is a significant reason behind the low cost-recovery of district heating tariffs: charging the full price could result in tariffs so high that they could harm the economy in the short run. The inefficiency and social welfare issues combined mean that it is difficult to raise district heating tariffs without a more comprehensive reform. Instead, natural gas is provided to domestic consumers, including district heating companies, at prices well below those charged for the same gas in Western Europe. This ongoing need for subsidized natural gas in the district heating sector will delay reform of natural gas transportation and distribution in Russia, and hence the development of stronger gas supply security. Gas sector reforms could facilitate exports from the lowest-cost producers, because these producers would likely have greater access to Russian gas pipelines (today such producers have almost no access to gas export pipelines). At the same time, until natural gas prices rise domestically, there is less incentive to boost investment in gas production (gas output in Russia has in fact dropped since 1991). The end result is less gas available for export and a gas monopoly in Russia. Constrained exports and monopolies mean higher prices for importing consumers and less choice of supply options everywhere, which harms energy security. Reforms both to the district heating sector and the natural gas sector therefore need to go hand in hand. Major gas transit countries, such as Ukraine and Slovakia, have experienced similar market distortions when gas transit revenue cross-subsidizes district heating and other forms of domestic gas consumption.

8. Emission Reduction

DHC has proven to be a major contributor to GHG reduction in many member countries and recognition of DHC's importance is growing. Many countries, indeed, are renewing their commitment to DHC as they find new ways to use the technology to reduce environmental impacts. According to the IPCC (2007), CHP has the environmental benefit of reducing 160–500 gCO_2/kWh, given a fossil-fuel baseline for the heat and electricity generation. In Sweden, where the share of district heat in residential market has reached over 50 percent, the benefits of DH in emission reduction have been significant. Figure 19 shows how the increase in the share of renewable and recycled heat led to a drop in CO_2 emissions between the period 1980-2005.

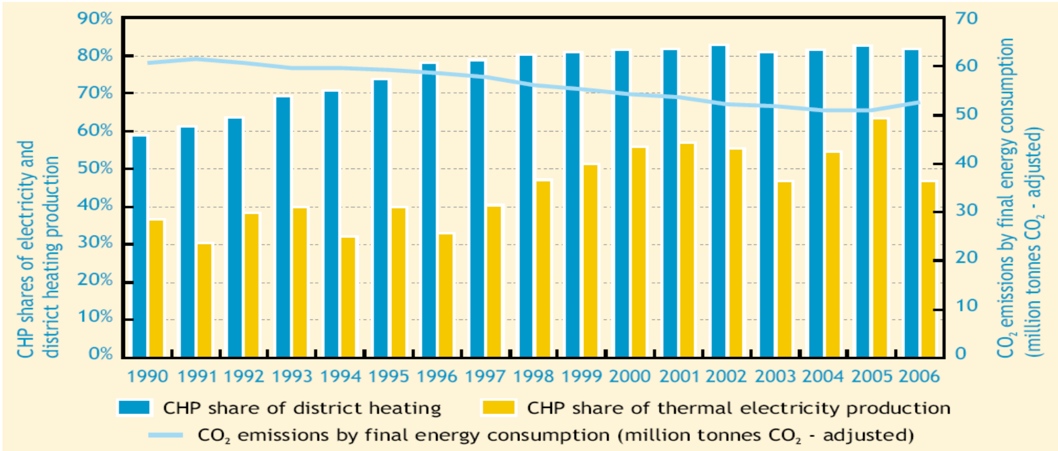
Figure 19: Improving resource-efficiency in DH and cutting emissions, Sweden, 1980-2005



Source: Swedish district heating association, 2008

Also in Denmark, which registers the highest share of DH in total heat demand, the increasing use of CHP/DHC has enabled the reduction of energy imports and GHG emissions simultaneously (Figure 20).

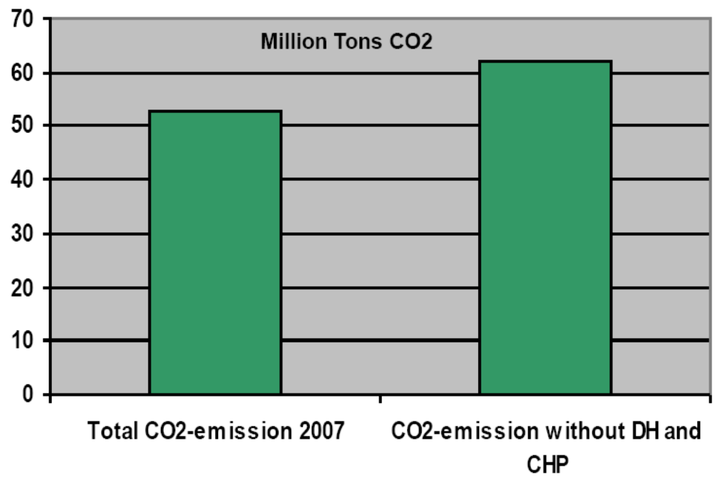
Figure 20: Increase in CHP capacity and reduction of CO_2 emissions in Denmark, 1990-2006



Source: IEA (2008), Combined Heat and Power: Evaluating the Benefits of Greater Global Investment, IEA/OECD, Paris

District heating and CHP technologies are the most important factors behind Denmark's CO_2- reduction. A recent estimate by the Danish Energy Authority compares the CO_2 emissions with and without District Heating and CHP (Figure 21). Denmark's CO_2-emission would have been 8-11 Million Tons higher without district heating and CHP, meaning a reduction of CO_2-emissions by 20 percent due to DH/CHP.

Figure 21: CO_2-reduction from DH and CHP, Denmark, 2007

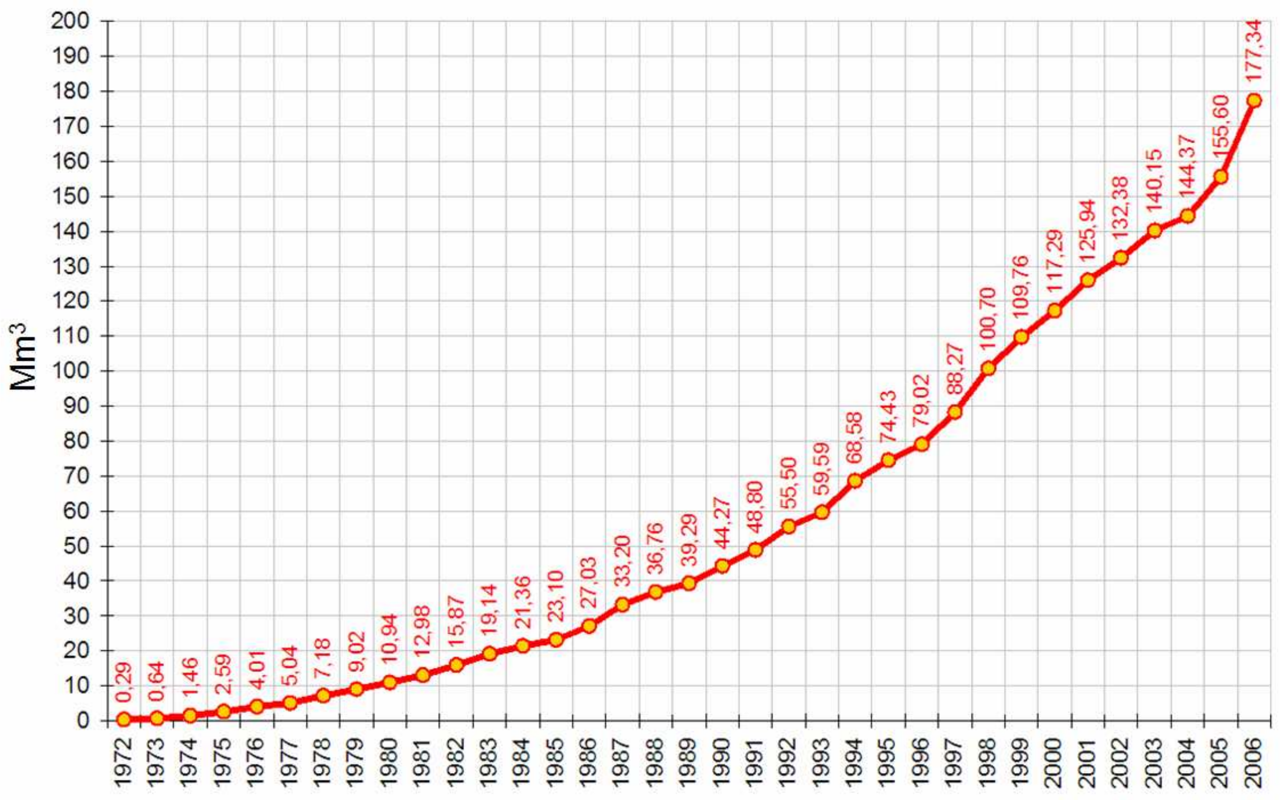


Source: Danish Energy Authority

9. Assessment of the development potential of district heating in Italy

The penetration of district heating in Italy showed a steady growth (see Figure 22), reaching a volume of served buildings of about 177 millions m^3 in 2006 (the last year for which aggregated data are available).

Figure 22: Volumes of buildings served by district heating in Italy (source: AIRU)



At the end of 2005, district heating was available in 57 Italian cities, where 87 networks were in operation, from the largest one in Brescia (305 km) to smaller ones with a length of a few kilometers. The total primary network length in 2005 reached 1667 km, with an end-user available thermal power of 5054 MW_{TH}.

The gross thermal power produced by district heating plants in 2005 was 6262 GWh_{TH}, with a combined gross electrical power generation of 5331 GWh_{EL}. The corresponding values net of network losses and of self-consumptions were 5500 GWh_{TH} and 5035 GWh_{EL}, respectively, i.e. 88% and 94%.

The development of district heating in the different Italian regions has been quite uneven, with five (out of twenty) regions (namely Lombardia, Piemonte, Emilia Romagna, Veneto and Trentino Alto Adige: see Figure 23) accounting for almost all the served volumes.

These data, together with the equally uneven distribution of the volumes of buildings served by district heating per inhabitant in the different Italian regions (see Figure 24), suggest that the potential for a further growth should be significant.

In the following, an assessment of the development potential of district heating in Italy till 2025 is reported (see Perego O., Marciandi M., 2008).

Figure 23: Volumes of buildings served by district heating in the different Italian regions in 2006 (source: AIRU)

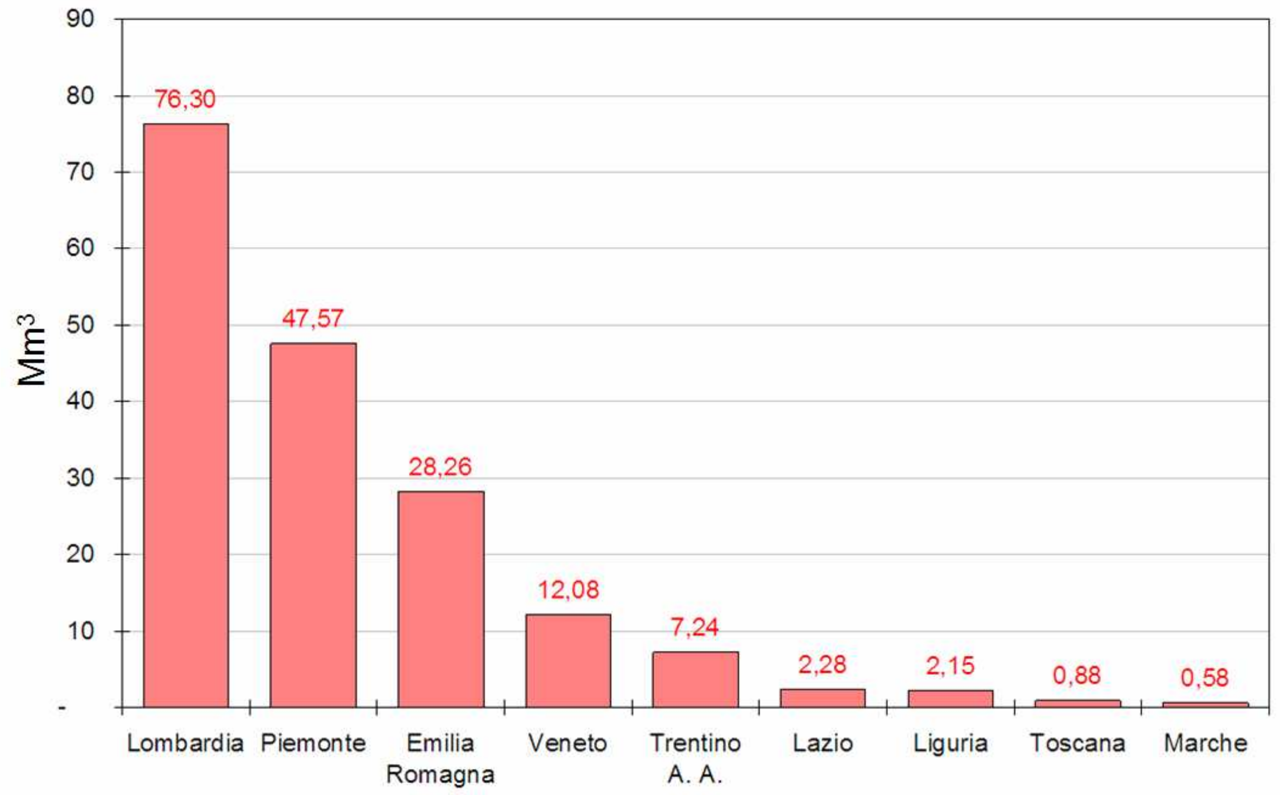
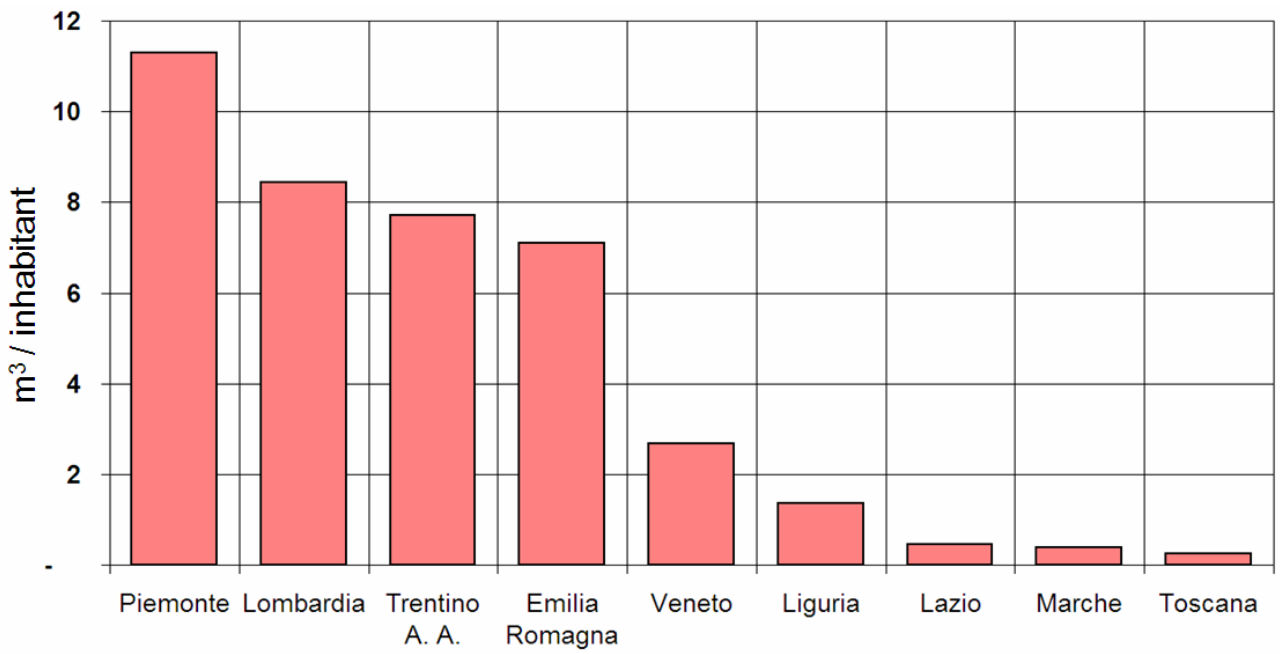


Figure 24 – Volumes of buildings served by district heating per inhabitant in the different Italian regions in 2006 (source: AIRU)



In particular, the cities located in the regions where winter climate is sufficiently cold to require space heating have been selected.
Then, a minimum threshold of 25000 inhabitants has been defined, to select only the cities whose size makes it reasonable to build a district heating network: according to the 2001 Italian census, this corresponds to 359 cities, accounting for 48% of the whole Italian population.
Subsequently, the volume of residential heated buildings located in such cities has been calculated (3049 Mm^3) and it has been distinguished among:

- buildings equipped with centralized heating systems (932 Mm^3), that are the most suitable for district heating applications,
- buildings equipped with autonomous heating systems (1778 Mm^3),
- buildings equipped with "other" heating systems (339 Mm^3: stoves, fireplaces, etc.), that have not been considered to assess the potential of district heating.

Moreover, it has been estimated that only 90% of the aforementioned buildings are located in high density areas, more suitable for development of district heating, therefore the resulting volumes to be considered are 2439 Mm^3.
Then, the volume of residential buildings that can *potentially* be connected to district heating networks has been calculated, taking into account:

- the buildings equipped with centralized heating systems,
- small-sized (with few floors) buildings equipped with autonomous heating systems, corresponding to 20% in province chief towns and to 30% in the remaining cities.

The result is about 1121 Mm^3.
Another factor to be taken into account is the *propensity* of people to connect to an available district heating network, that varies according to the type of heating system they already have.
The estimated percentages of conversion to district heating are the following:

- buildings equipped with centralized fuel oil-fired heating systems: 100%
- buildings equipped with centralized natural gas-fired heating systems: 75%
- buildings equipped with autonomous natural gas-fired heating systems: 50%

The application of this additional filter reduces the volume of residential buildings that can *really* be connected to district heating to about 788 Mm^3.
As for space heating in the tertiary sector, it has been estimated that for each m^3 connected to district heating in the residential sector, currently about 0.66 m^3 of buildings belonging to the tertiary sector are connected to the same network. In the longer term, this factor has been estimated to reduce to 0.5 m^3.
This means that the total *additional* volume that could be connected to district heating networks both in the residential and in the tertiary sectors is about 1091 Mm^3.
This value is a sort of *static* potential, evaluated on the basis of the picture that has been built starting from the most recent available data (mostly referring to 2004). To assess the potential till 2025, first of all it is necessary to estimate the evolution of the set of buildings that could be served by district heating.
To this aim, it has been calculated that, between 1995 and 2006, the annual growth rate of buildings in cities with more than 25000 inhabitants was 0.7%: this rate has been assumed also for the future years.
Moreover, for the new buildings the use of centralized natural gas-fired heating systems has been assumed.

Furthermore, the estimated percentages of conversion to district heating are assumed to grow over time. In particular, for buildings equipped with centralized natural gas-fired heating systems the percentages are assumed to be the following:

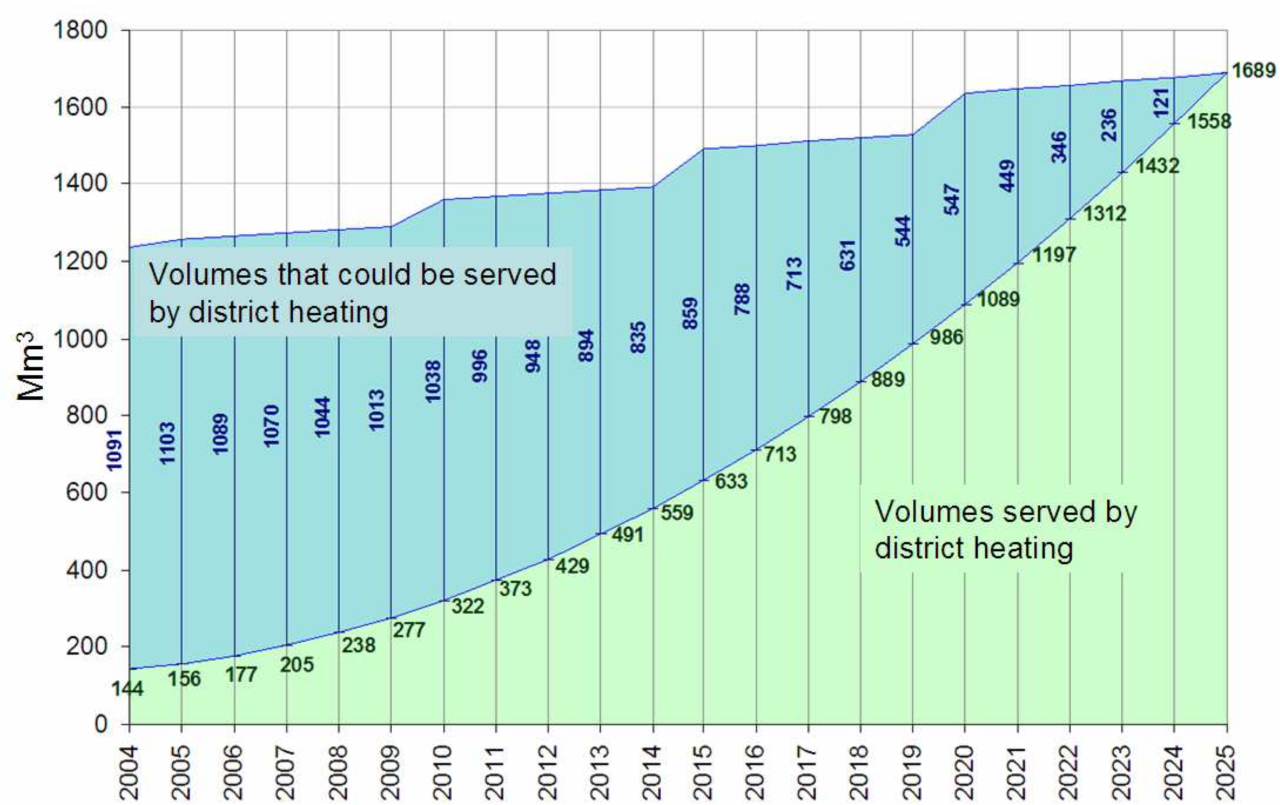
- in 2010: 80%
- in 2015: 90%
- in 2020: 100%

For buildings equipped with autonomous natural gas-fired heating systems the percentages are assumed to be the following:

- in 2010: 60%
- in 2015: 70%
- in 2020: 80%

Therefore, according to the aforementioned hypotheses, the evolution over time of the volumes of buildings served by district heating till 2025 (when the estimated potential is assumed to be saturated) is shown in Figure 25
The overall potential is therefore estimated to be about **1689 Mm^3**, that is about ten times the volumes of buildings served by district heating in 2006.

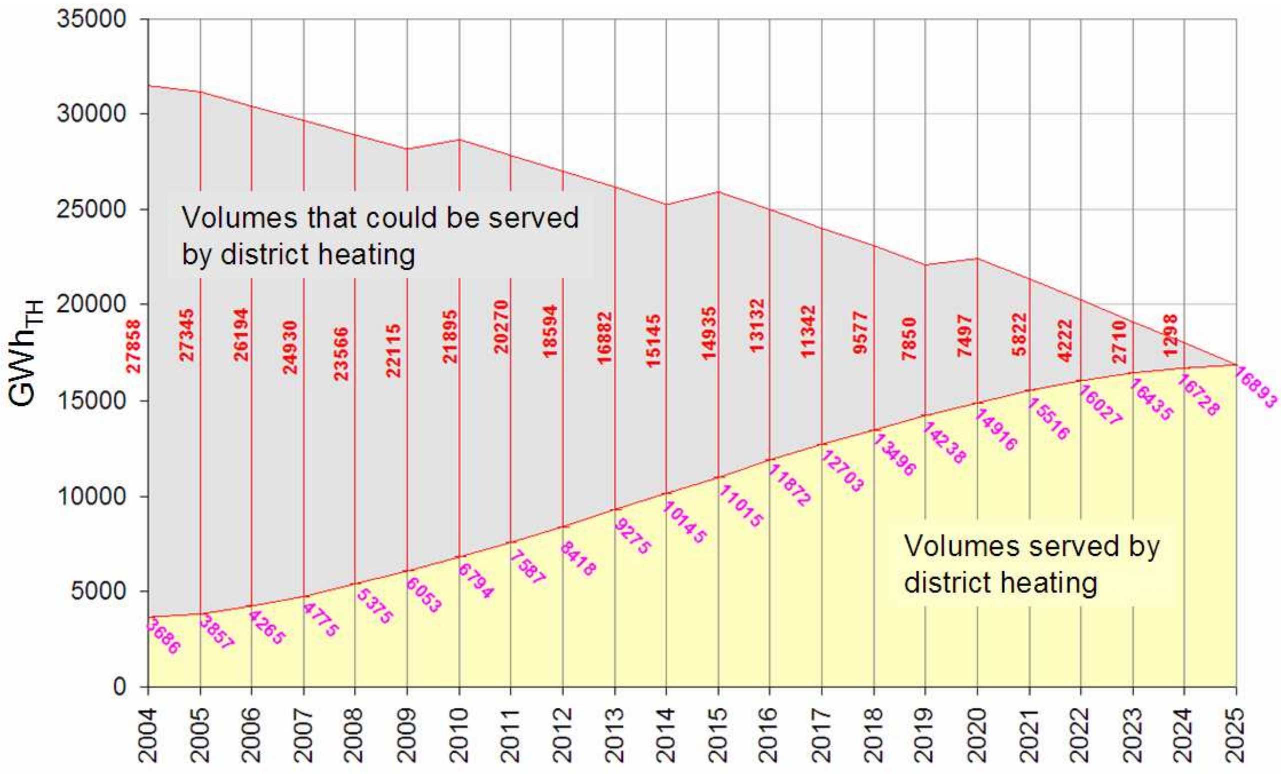
Figure 25: Evolution over time of the volumes of buildings served (and that could be served) by district heating till 2025 in Italy



In terms of thermal energy requirements, the average 2004 value was about 25.5 $kWh_{TH}/year/m^3$, while a new “class A” building should have a requirement lower than 10 $kWh_{TH}/year/m^3$.

Assuming that all the buildings can progressively increase their thermal efficiency according to a linear trend, so as to reach "class A" in 2025, the thermal energy requirements that can be supplied by district heating are shown in Figure 26 and in 2025 they amount to about 16.9 TWh_{TH}.

Figure 26: Evolution over time of the thermal energy requirements of buildings served (and that would be served) by district heating till 2025 in Italy



10. Policies and Measures to promote DHC and CHP in Europe

This section highlights the policies and measures at a European, national and local level which have a direct influence on District Heating and Cooling sector.

At a European level, the Buildings Directive (2002/91) specifies that the positive influence of DHC shall be included in the calculation of the energy performance of a building. Some countries indeed tend to focus solely on saving final energy in buildings, missing the potential to save fossil fuels by optimising the whole chain of energy production and delivery. In order to correctly take into account DHC in the computation of energy performance in buildings one needs to apply an integrated approach including the whole District Heating or cooling production and distribution system. In Germany, for instance, the Directive has been implemented by the Energy Saving Order, which sets the calculation of energy performance as a function of both the supply and demand side.

The Directive on Energy Services (2006/32) recognizes the contribution of DHC to the efficiency of the energy system outside the buildings, specifically mentioning District Heating and Cooling systems as energy efficiency improvement measures.

In 2004 the Cogeneration Directive (2004/8) entered into force to promote the use of cogeneration to increase energy efficiency and improve security of supply. The Directive does not include targets, but urges Member States to carry out analyses of their potential for high efficiency cogeneration. To date the implementation of the Directive was limited mainly at its translation into the national legislation without any further actions taken at a national level.

Regarding the use of renewable sources, heating and cooling will be under the attention of policy makers through the Directive 2009/28/EC on the promotion of the use of energy from renewable sources. According to the Directive, solutions aiming at improving resource efficiency across sectors (combined effect of CHP and RES, transfer of energy products which would be lost in one sector to another etc.) should be considered. Furthermore, strong incentives for developing District Heating and Cooling grids as efficient shortcut between renewable and surplus heat sources and the heating and Cooling demands should be provided.

The Emissions Trading Directive (2003/87) so far does not establish guidance on how to take into account specific technologies such as CHP generation and District Heating. When allowances were allocated on the basis of grandfathering, the efficiency advantages of CHP/DHC were not economically rewarded. In several countries, producers tended to reduce heat and power production in their own - highly efficient - CCGT plants and buy from the market.
In Austria, according to the National Allocation Plan II, approximately the same quantity of allowances as in first trading period has been allocated. The allocation principle is now changed to a benchmarking system. This can be a favourable allocation mechanism for efficient plants and therefore especially for CHP. In Finland, the emission trading scheme does not support the natural increase of District Heating, because the allowances are given for new plants instead of new customers. In addition to that, every new customer who changes his heating form from oil heating to District Heating, will likely decrease the overall emissions. According to the Euroheat & Power survey (Euroheat & Power, 2007), for the first trading period, 2005 - 2007, District Heating and CHP installations was allocated an almost sufficient number of CO_2 allowances, while the second Kyoto period, 2008-2012, will be substantially more difficult, with a deficit of allowances probably around 20 percent. In Germany for the second trade period (2008-2012), a benchmark system based on best available technique will be the only allocation mechanism for both old and new power plants. Furthermore the calculation will be based on historic production output for old and a production estimate for new plants.

Regarding the national legislative framework, the main driver for the process is the European Union and consequently few countries continue to cover the District Heating and CHP sectors with specific acts. Among the EU-15 countries, Austria has the Eco Power Act, which provides support for CHP and renewable energies. A District Heating law is enforced in Denmark from 1997, while Germany addresses District Heating

through secondary legislation and CHP sector through a support scheme. Finally, in Sweden, Finland and Denmark energy and environmental taxes systems ensure a good market position for District Heating systems.
An overview of various types of support measures use for the promotion of RES, District Heating and CHP in various countries is presented in the Annex I.

A recent study by IEA (IEA, 2008b) has identified a consistent set of policies that can be used to address the barriers faced by CHP and DHC systems. These individual policies have often proved to be most effective when combined in comprehensive CHP/DHC strategies implemented by a central policy department or agency. The policies are listed below:

1. Financial and fiscal support
2. Utility supply obligations
3. Local infrastructure and heat planning
4. Climate change mitigation (emissions trading)
5. Interconnection measures
6. Capacity building

Regarding the financial and fiscal support relevant to CHP, they include up-front investment support - such as grants and depreciation - operational support - such as Feed-in tariffs (FiT) and fuel tax exemptions - and R&D funding - like Government funding for fuel cells.
Examples of best practice in implementing financial and fiscal support measures can be found in Germany, Netherlands and Sweden. In Germany, Biogas CHP receives a FiT through the *Erneuerbare-Energien-Gesetz* (EEG) (2009), adding up to EUR c27.67 per kWh to the electricity price. This policy has been the main factor supporting biogas capacity growth from less than 200 mega watts of electricity (MWe) in 2000 to over 1 200 MWe in 2007.
In the Netherlands, CHP policies achieved over 4 Mt CO_2-eq. GHG emissions reductions in the 1990s. The EIA, a fiscal investment credit, achieved its share at a cost of EUR 9 per ton of CO_2-eq, while in Sweden, exemption from fuel and carbon taxes underlines the success of DHC development.

The Utility supply obligations (USOs) (also known as energy portfolio standards) are instead a market-based mechanism using certificate trading to guarantee a market for CHP electricity. They place an obligation on electricity suppliers to source a certain percentage of their electricity from CHP. The share of supply to be met by CHP can increase year-on-year, in step with policy targets. An example of best performance is represented by Belgium, where the region of Wallonia has implemented a USO that supports CHP plants with certificates based on CO_2 savings, rather than on electricity output.

Local infrastructure and heat planning is aimed at creating a rational framework for providing heat and cooling efficiently by identifying and linking demand and supply, and supporting the best energy sources available. Municipal governments in Denmark, for example, first assessed heat demand and supply options, then introduced restrictions on electric heating and power generation without heat recovery. At the same time governments supported R&D in emerging renewable CHP technologies to stimulate a transition to a low-carbon heat and electricity system. In Germany the *EEWärmeG*

(Renewable Heat Law), obliges building developers to use renewable technologies or CHP for heating in new buildings.

Looking at the interconnection measures, three main types of measures can be identified as follows:

- Interconnection standards, which provide clear rules for obtaining physical connection to the distribution/transmission network depending on connection voltage levels.
- Measures enabling grid access, that relate to the participation of CHP plants in the grid network.
- Incentives to network operators, which enable them to benefit where they may lose revenue by connecting CHP plants to their systems.

A successful implementation of such measures has occurred in the Netherlands, where the Dutch Net Code in the 1990s simplified connection rules, ensuring transparency and fairness in the connection process. The government set out the requirements and the utilities developed the code.

Finally, measures related to the capacity building can be undertaken in two ways:

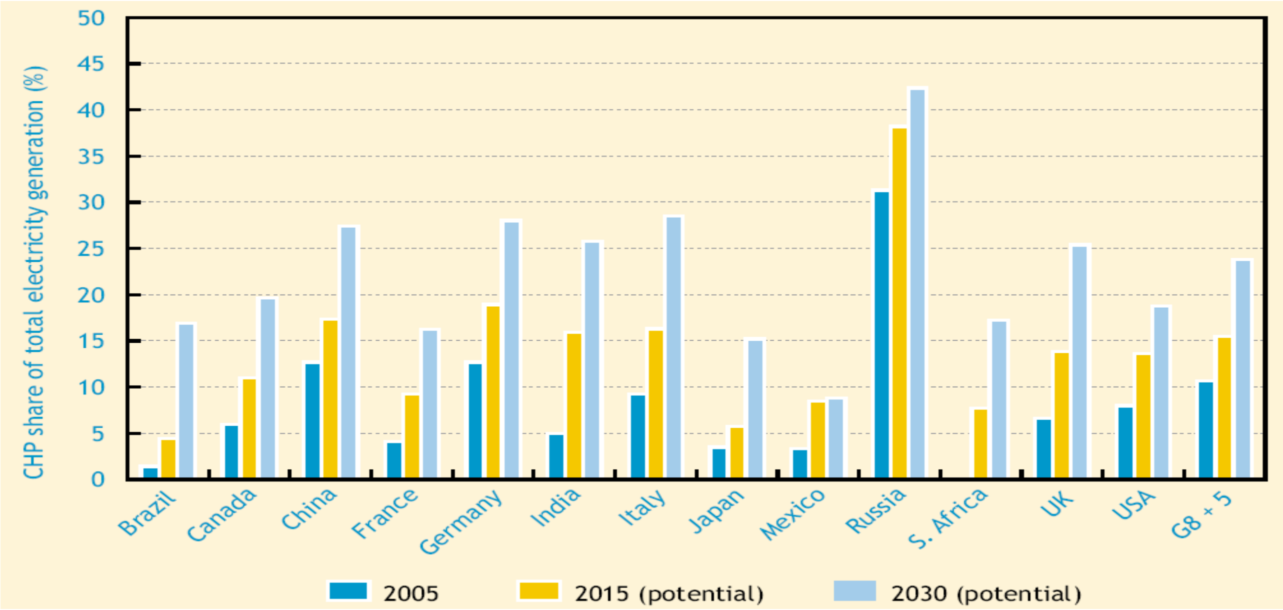
I. Raising the awareness of CHP, making known to potential users the benefits of CHP, through training programmes, active campaigning or the creation of a central CHP office or champion.

II. R&D funding, which supports the development of CHP technologies and applications towards market commercialisation.

An example of best practice is represented by the *KWK Modellstadt* implemented in Berlin, where, by producing free publications and newsletters, the initiative has been informing the inhabitants of Berlin of the benefits and potential of CHP. Moreover in the Netherlands, the Dutch CHP Agency (*Projektbureau Warmte-Kracht*) brought together government, industry and energy companies to identify opportunities, advise on policy and implement new projects. The Agency, set up to overcome the barriers that obstructed the development of CHP, played a key role in the CHP boom in the Netherlands in the 1980s and 1990s.

The CHP development potentials are huge worldwide, as demonstrated by a recent analysis by IEA (IEA, 2008c). Figure 27 shows the economic potential for CHP, for the G13 group of countries, in a policy scenario - the “IEA Accelerated CHP Scenario” - that mirrors policies used in some of the most successful CHP countries. By 2030, the CHP share of G13 electricity generation could rise from 10 percent to around 24 percent, if suitable policy regimes were to be introduced based on best-practice CHP policies. In China and India the CHP shares of electricity generation could rise to 28 and 26 percent respectively by 2030, from 13 and 5 percent respectively at the date of publication of that report. These results point to concrete opportunities to improve the use of DHC systems and CHP technologies in Europe.

Figure 27: Major economies' CHP potentials under an accelerated CHP scenario, 2015 and 2030



Source: IEA (2008c)

11. Panel Analysis

In this Section we illustrate the results of the panel analyses, whose general methodology has been described in sections 4 and 5 of Deliverable 5.8.1.
As mentioned there, our aim is to check whether the implementation of energy efficiency policies has had an effect in EU (EU15+Norway) countries on indicators of energy efficiency and security of supply. In particular we are interested in checking whether some policies had a sort of "double dividend" by having a positive effect on more than one of these indicators. Besides policy dummies, we also look at the effect of the macro drivers (GDP, prices, R&D, etc.). Note that, in contrast with deliverables 5.8.1, 5.8.2 and 5.8.4, due to data availability issues, it has not been possible to perform such analysis for carbon intensity for district heating.
In this section we analyse such effects for the European district heating sector, focusing on energy (heat) intensity and energy security.

The analysis described here bears two important differences with respect the analyses performed for the energy using sectors. First, the proxy we used , that is "heat" in the IEA energy balances is not a sector consuming energy, but rather an energy vector that can be used by various sectors for their heating needs. Thus the dependent variable "heat intensity" has not the same interpretation as energy intensity, although it is expressed in terms of a ratio of energy[5] to economic activity (GDP[6]). The second

[5] : IEA World Energy Statistics and Balances -Energy Balances of OECD Countries - Extended Balances Vol 2009 release 01
[6] OECD.Stat - *Gross domestic product (output approach) US $, constant prices, constant PPPs, OECD base year (2000), millions*

difference is the availability of data, much reduced in the case of heat. In particular, it has not been possible to compute the dependent variable for the following countries in the following years:

- Ireland: 1980 - 2006
- Italy: 1980 - 2003
- Luxembourg: 1980 - 1994
- The Netherlands: 1980 - 1981
- Norway: 1980 - 1982
- Spain: 1980 - 2006
- UK: 1984 - 1998.

11.1. Methodology

The goal of the analysis is to assess the economic variables which could have a significant effect in improving the heat intensity and energy security a and to identify the policies and measures (P&M) implemented in European countries which have been effective for the same purpose. A further goal is to compare the significant drivers resulting from regressions, in order to understand whether there are some factors which affect both energy intensity and energy security and if improvements in carbon intensity match with lower energy intensity.
In order to achieve these goals, we have chosen to apply econometric models which exploit the panel data format. The panel data analysis, indeed, allows us to combine cross-sectional data and time series data, obtaining a gain in the efficiency of estimates, thanks to the availability of a large amount of information.

The estimates are been conducted by regressing the energy intensity index (HI), and the energy security index (ES), on a set of explicative variables X (such as energy prices, GDP, R&D expenditure, etc.) and policy variables PM. The analysis therefore includes 2 general panel models, with alternative specifications for energy security[7], focusing on the EU15 countries and Norway between the period 1980-2006[8].
The econometric models have the following functional form:

$$HI_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMK_{it} + u_{it} \qquad (1)$$

$$ES_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMN_{it} + u_{it} \qquad (2)$$

Where *EI* is the Energy Intensity index and *ES* is the Energy Security index. The matrix X_{it} includes the explanatory variables related to economic structural changes, society and energy market. The variables PM_J, j=1,…,K, represent instead the policies included in the regression, which are dummy variables equal to 1 if the policy is in force in the *i-th* Country and *t-th* year.
The double pointer (*i*,*t*) shows the panel structure of the dataset. In particular the index *i*=1,…,N represents the country, while the index *t*=1,…,T refers to time. The parameters λ e β_j, *j*=1,…,K, are constant across countries and over time, while the parameters α_i

[7] Given the vast range of possible energy security indicators, we have tested a few alternative options.
[8] For the EE indexes the analysis focuses on the period 1980-2004.

change only with the country. The parameters α_I are known as fixed effects and capture the individual heterogeneity which characterize panel data models.
The individual heterogeneity is unknown, systematic and correlated with regressors. To solve this issue we chosen a fixed-effect model, where the individual heterogeneity is modeled by means of *country-specific* constants. Such models differ from random-effects models, where instead the individual heterogeneity is a random variable μ_I, included in the disturbance term, α_i=α e $u_{it} = \mu_i + e_{it}$.
The random-effect model implies the use of a random sample of individuals. We used instead a dataset where the selection of countries under scrutiny are not random, this makes the fixed-effects models more useful for our purpose than the random-effects models.
Models (1) and (2) are special cases of Seemingly Unrelated Regression equation systems (SUR), where the coefficients λ e β_j, vary across individuals. In a model where coefficients are indexed with i=1,…,N, the excess of parameterization implies issues in degrees of freedom and less efficient estimates of coefficients. Considering the high number of policies used in the regression, the fixed-effects model is preferable to a SUR system.
We have tested also one-year and two-year lags for all the P&M variables, and one-year lags for the main economic variables. The approach followed consisted in testing models which cover all macro-variables and policies, as well as their lags, cutting out variables with non statistically significant coefficients. This process has been made again until a set of significant explicative variables has been obtained.
Data concern observations on 16 countries (N=16) for 27 periods (T=27), related to 18 variables overall. We have created therefore 2 panel models, and we have proceeded by regressing each endogenous variable on the set of explicative variables in order to find statistically significant regressors.

11.2. Results

The main results are collected in Table 2

Heat intensity o increases with per capita GDP: here the size effect of larger dwellings that become affordable as income rises prevails on the availability of more efficient building techniques. In terms of policies only two cross cutting policies seem to impact beneficially this indicator: Legislative/Normative Measures and cooperative measures. Note however that the coefficient of the second policy variable is significant only at 95 % confidence level. Also the R-square for this regression is not impressive (0.2674).

Table 2. Panel analysis results

Heat intensity			Energy Security	
Variable	**Coefficient**		**Variable**	**Coefficient**
GDPppsCur	0.3021***		GDPppsCur	0.341***
Pmcct2	-0.13875**		Pmcct4	-0.00801***
Pmcct5	17375*		Pmcct5	-0.00703*
	-.		Pmcct7	-0.004064**
Cons	-2.361***		cons	-0.332***

Notes:
GDPppsCur: GDP per capita, PPP (current international $) (NY.GDP.PCAP.PP.CD), WDI

PMccT2:	P&Ms Cross-cutting - Legislative/Normative Measures
PMccT5:	P&Ms Cross-cutting - Co-operative Measures (lagged)
PMccT7:	P&Ms Cross-cutting - Non-classified Measure Types (lagged)

In terms of **energy security**, three alternative indicators have been tested: the ratio of gas consumption to GDP, the ratio of gas import to gas consumption and the ratio of gas imports to total exports. The latter yielded the best results in terms of goodness of fit (R-square =0.561).

Again increasing income per capita exposes to higher risks through increased dependence from external energy sources. Cross cutting measures appear to be effective, in particular financial measures, cooperative measures and general (non-classified) cross cutting measures. It must be noted that different measures were significantly effective when alternative indicators were used: for instance, in the case of the ratio of gas consumption to GDP, also cross-cutting with household-specific characteristics and General energy efficiency, climate change or renewable programmes proved effective.

In the case of the ratio of gas import to gas consumption, soft loans for energy efficiency, renewable energy and CHP in the tertiary sector proved effective. This case is worth noting because it has to do with measures specifically geared towards district heating technologies.

Despite that some measures proved effective and even one overlapping between energy intensity and energy security can be singled out in terms of a policy being effective on both indicators, the results do not appear to be very robust, as different policies appear to be effective on different energy security indicators. This may have to do with the smaller sample size compared to the full sample used in the previous deliverables.

12. Conclusions

This Deliverable summarizes SECURE’s findings on the role of District Heating and Cooling (DHC) for energy security and energy efficiency in the EU, highlighting the possible contribution of DHC and combined heat and power (CHP) in reducing emissions of carbon dioxide and increasing energy efficiency and security.

We looked at the available information on district heating in Europe to depict the current status in terms of energy indicators, the development potential of this technology and relevant policies and measures. We complemented such information with a specific case study on Italy and with an econometric analysis analogous to the one described in other Deliverables of this WP, checking whether policies and measures that affect indicators of energy efficiency performance have an analogous effect on security of supply indicators, in the EU 15 countries.

The District Heating sector was developed traditionally in Central, Eastern and Northern European countries, due to the climate conditions characterized by cold and long winters. District heating exists also in more Southern European countries such as Italy, France and Spain.

While having an overall market share of less than 10 percent, the sector is particularly developed in North, Central and Eastern Europe with market shares of over 50 percent.

In total, in Europe 5000 district-heating networks are operating. About 2 EJ of District Heat is annually delivered to EU customers to a value of about 17-19 billion euros. Within the EU-15, Denmark is the main user of DH deliveries (46 percent of total heat demand), followed by Sweden, Finland and Austria. District Heating continues to grow in Austria, Italy, Iceland, Norway and Sweden.

Due to the high use of CHP technologies and RES, the DH systems could in principle contribute to improve energy efficiency and security. According to IEA (2002) the use of CHP and RES presents the following three major benefits: efficiency gain, lower environmental impact, and security of supply. The efficiency gain could come from the higher conversion efficiency from CHP generation compared to separate generation of electricity and heat in condensing thermal power plants and local boilers for heating. The lower environmental impact is due to both the efficiency gain and the use of more carbon-lean fuels and renewable energy resources. Security of supply can be enhanced by CHP plants since they generate power in urban areas near consumer demands and with many small plants, which make them less vulnerable to major interruptions in supply.

The Italian case study showed that, although the fraction of the Italian territory realistically likely to witness an expansion of DH is limited to urban and sub-urban areas of Northern and Central Italy (where winter climate is sufficiently cold to require space heating), accounting to slightly less than half of the Italian population, the potential for further penetration to 2025 of this technology is substantial, up to ten times the volumes of buildings served by district heating in 2006.

The survey of the policy initiatives in the EU relevant for the support to District Heating, in particular in connection with the promotion of renewable energy sources and CHP has shown a remarkable level of activity both at the EU and at the national level, although there have probably been some dissonances between the first phase of the ETS (the main EU initiative in this field), and the specificities of the DH sector, due to the grandfathering of emission allowances.

Finally, our econometric panel analysis found that some measures proved effective, and even one overlapping between energy intensity and energy security can be singled out in terms of a policy being effective on both indicators. However, we warn that these results must be taken with a pinch of salt: they do not appear to be very robust, as different policies appear to be effective on different energy security indicators. As it was the case for the various energy consumption sectors analysed previously by this WP, the wider the scope of the policy the higher the likelihood that it will affect positively multiple targets: also in this case, cross-cutting measures seem to improve both energy efficiency and energy security indicators.

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Annex 1: Overview of support measures for the promotion of renewables, District Heating and CHP in selected European countries

Country	Measures for CHP	Measure for RES/District Heating	Types of measures
Austria	The feed-in tariffs are linked to CHP electricity a support scheme for existing fossil CHP plants (apart from subsidies for renewables).	Subsidy for biomass DH CHP Investments are subsidised depending on heat supplied with 15% to 30%. Subsidy on industrial buildings 30% subsidy on investments for DH systems when heat is 100% produced out of renewables, or 15% when the heat is produced by fossil fuels	Feed in tariff for CHP Investment grant funded as a percentage of investment costs for DH and RES in DH
Croatia	Premium price for CHP electricity For new capacities built priority should be given to CHP technologies		Premium price for CHP
Czech Republic	CHP electricity purchasing obligation for a stated price including a bonus for decentralized units Evaluation of the economical and technical possibility to install CHP units for capacities over 5 MWQ heat, and 10 MWE electric		Purchasing obligation for CHP
Denmark	A special regulation gives priority and ensures fixed prices for the back-pressure CHP and for all forms of renewable electricity production (wind, waste, bio fuels etc.) but the system changes towards market prices.	Municipalities may oblige a building to be connected to a DH network or to prevent it from disconnection. Electricity is forbidden to be used for heating purpose except the already connected buildings before the measure	Purchasing obligation for CHP and RES Obligatory connection for DH Prohibition of a technology
Finland		Energy taxation and refunds as subsidies especially for CHP based on renewables	Tax incentives

Germany	Feed in tariff especially for small scale CHP	- CHP installations are exempted from energy taxation on natural gas when their efficiency exceeds the 70% threshold. Heat as an end product is not taxed. - Low interest loans (with interest set for 10 years) aswell as partial debt release for new large scale biomass facilities	Feed in tariff Tax incentive for CHP and related DH use Low interest loans Debt release
Hungary	Purchasing obligation and feed in tariffs for CHP units <50 MW. The existing CHP heat potential is close to saturation, however the electricity production can be increased by 10-20%.	The CHP support is foreseen for units which are mainly DH units. The support is foreseen until 2010	Purchasing obligation and feed in tariff for CHP -threshold for capacity
Italy		Financial support is granted for the conversion if electrical water heaters into installations fuelled by RES	Conversion grant
Lithuania		The support scheme for electricity produced in CHP plant based on biofuel is also applied in Lithuania. This scheme is valid for plants where the ratio of nominal power and heat capacities is over 0.23 and the amount of renewable energy resources is not less than 70%	Purchasing obligation
Latvia	feed-in tariff for CHP capacities below 4 MW and using local fuels		Feed in tariff for small scale CHP Possible zoning in the municipalities for Dh and Natural gaS
Poland	Purchasing obligation for electricity and heat produced in CHP for capacities below 5MW		Purchasing obligation for CHP -small scale
Slovakia	Purchasing obligation for CHP electricity and renewable	Potential for biomass 75.6 PJ and use of geothermal energy considered	Purchasing obligation for CHP and RES Acknowledge of RES potential

Slovenia	CHP support - If the producer is qualified in high performing range than it has the right for primary dispatch of electricity and also the right for getting the premium price for produced electricity. The level of premium is set by the government		Purchasing obligation and Premium price
Sweden	Favourable taxation for CHP Potential for CHP -20TWh	Support to biomass and natural gas for CHP through taxation ensures the development of DH. Renewables support through green certificates for electricity	Tax incentives for CHP and biomass Green certificates

Source: Euroheat & Power (2007)