Benefits with more District Heating and Cooling in Europe

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Abstract
The future possibilities of more district heating and cooling in Europe have been assessed within the Ecoheatcool project, supported by the European Intelligent Energy programme. Doubling district heat sales and improved heat generation would increase the overall energy efficiency, increase security supply by lower import dependence, and decrease the carbon dioxide emissions. Increasing the market share of district cooling would also increase energy efficiency, decrease carbon dioxide emissions, and reduce summer congestion in electricity distribution. Furthermore, the 10 important strategy recommendations from the project are presented.

Résumé
Bénéfices de davantage de chauffage urbain et de climatisation centralisée en Europe
Les possibilités futures de davantage de chauffage urbain et de climatisation centralisée en Europe ont été estimé dans le projet Ecoheatcool, soutenu par le programme « Energie intelligent – Europe ». Un doublement du vente de chauffage urbain et une production de chaleur améliorée augmenteraient l’efficacité énergétique générale et la sécurité d’approvisionnement énergétique, grâce à une dépendance d’importation plus petite, et baisseraient les émissions de dioxyde de carbone. Une part de marché élevée de climatisation centralisée augmenterait aussi l’efficacité énergétique, baisserait les émissions de dioxyde de carbone et réduirait le surchargement de la distribution électrique en été. En outre, les 10 recommandations stratégiques importantes du projet sont présentées.
**Introduction**

Euroheat & Power performed the Ecoheatcool project during 2005-2006 as coordinator with participation from 12 partners. The project was supported from the European Intelligent Energy programme. The objective was to assess the overall community possibilities from an expansion of district heating and cooling (DHC) in Europe with respect to the current European energy policy. 32 European countries were the target area for the study: EU25 (the European Union after the 2004 enlargement), four accession countries (Romania, Bulgaria, Turkey, and Croatia), and three EFTA countries (Iceland, Norway, and Switzerland). Romania and Bulgaria entered into the EU in 2007.

For analyses, 2003 was chosen as reference year and base information about each country were gathered from the IEA Energy Balances and relevant Eurostat databases. The focus was to analyse commercial heat deliveries (mainly district heat) and other energy supply within the electricity and net heat demands in the industrial, residential, and service sectors. Hence, the project had a pronounced demand perspective.

The Ecoheatcool project has published six subject reports:

- The European heat market, [1]
- The European cold market, [2]
- Guidelines for assessing the efficiency of district heating and cooling systems, [3]
- Possibilities with more district heating in Europe, [4]
- Possibilities with more district cooling in Europe, [5]
- Project recommendations, [6]

These reports can be downloaded from the project website, [4](http://www.ecoheatcool.org). This paper gives a short overview of the major project findings. All amounts of energy, electricity, and heat are expressed with multiples of Joule, the international standard unit for energy since 1960. The highest prefix used is Exa, equal to $10^{18}$.

**The European energy balance**

The total energy balance for the target area during 2003 is presented in Figure 1. The various steps in the energy supply are divided into three different added bars: Total primary energy supply, Total final consumption and Estimated final end use.

The total primary supply of 81,1 EJ contains the total calorific value of all fuels and other energy amounts supplied to satisfy the total energy demand. The second added bar contains all energy commodities used by all community sectors. The difference between the two first added bars reflects what occurs in the energy transformation sector, including power generation, oil refining, central heat generation for district heating systems, and distribution losses in electricity and heat distribution systems. The bar diagram reveals that all hydro and nuclear resources and most of the coal was used for generating electricity, while most of the petroleum products, natural gas, and combustible renewables are transferred directly to the final energy consumers in the different community sectors. The total heat losses from the energy transformation sector were huge, 23,8 EJ, corresponding to 29 % of all primary energy supply. Most of this heat was lost in thermal power generation due to low conversion efficiencies. So higher conversion efficiencies in thermal power plants would considerably reduce the energy supply for electricity generation and the associated carbon dioxide emissions.
For final consumption, 10.7 EJ electricity and 2.0 EJ heat (mainly district heat) were delivered. These amounts correspond to 18 and 3.4% of the total final energy consumption of 57.3 EJ.

The third added bar contains the estimated final end use of heat for various purposes, electricity for power and lightning, and finally power for overcoming friction, speed change, altitudes, and air resistance in transportation. Heat amounts to more than 20 EJ, while electricity use was 10.4 EJ, since some electricity was used for transportation purposes. Also in this third step, the heat losses were huge from high temperature industrial processes, heat generation in local boilers, and conversion losses from engines in vehicles.

The major conclusion from this simple energy balance analysis is that the huge total heat losses correspond to more than half of the total energy supply. A future European energy system must reduce these losses in order to increase the energy efficiency, reduce the carbon dioxide emissions, and increase the security of supply. The heat sector in general and the district heat sector in particular could contribute to meet these objectives, by recycling existing heat losses in the energy system to satisfy local heat demands on the European heat market.

![Energy Balance Chart](chart.png)

**Figure 1. The energy balance for the 32 countries during 2003 divided into primary supply, final consumption and estimated end use for all energy services demanded.**

**The European heat market**

In Figure 2, the total net heat and electricity end use are presented for the whole target area by the three major sectors. The use of natural gas for heat and the use of electricity dominate in all three sectors, having total market shares of 33% each. This gives a combined market share of 66%. Commercial heat deliveries, as district heat, has only a total market share of 6.0%.

The total financial burden from the net heat and electricity use for all end users including national taxes but excluding VAT was 3.7% of the GDP in 2003. The total net heat and electricity costs amounted to 120 billion EUR for the industrial sector and 270 Billion EUR for the residential, service, and agricultural sectors, corresponding to 1.1% and 2.6% of the total GDP.
Figure 2. The estimated final end use of electricity and net heat with origin of supply during 2003 for the industrial, residential, and service sectors.

District heat is mainly used for covering heat demands for space heating and hot water preparation in the residential, service, and industrial sectors. Furthermore, some district heat is also used in the industrial sector for low-temperature process heat demands. The district heat is distributed in more than 5000 networks containing 142000 km trench length of transmission and distribution pipes.

District heating have reached high, almost saturated market shares in 8 countries: Iceland, Denmark, Finland, Sweden, Poland, Estonia, Latvia, and Lithuania, but some expansion is still possible. The annual growth rates are high (6-10%) in Norway, Austria, Italy, and Turkey, indicating favourable national conditions for district heating. Three important large countries with respect to the overall European energy balance have no significant growth of district heat: Germany, France, and United Kingdom.

The European cold market

The total cooling demands were estimated to 0.5 EJ in 2000 for the EU15 area. The saturation rates were 27% in the service sector and 5% in the residential sector. The current market share for district cooling is almost 2%, corresponding to district cold deliveries of about 9 PJ/year. Currently, about 100 district cooling systems exist in European high dense city centres and commercial areas. Most of them are located in France, Sweden, Germany, and Italy.

The fundamental idea of district cooling is to use natural cooling resources as deep lake water or seawater, surplus heat as input to large absorption chillers, or surplus cooling resources as importing LNG terminals.

The space cooling demands are increasing rapidly now in most European countries, due to higher availability and increasing pay ability. The future space cooling demand in 2020 was forecasted to be 2.4 EJ, with a saturation rate of 60% in the service sector and 40% in the residential sector. A district cooling market share of 25% would give district cold deliveries of 0.6 EJ/year.
The primary resource perspective

The main conclusion from the Ecoheatcool guidelines for assessing the efficiency of district heat and cooling systems is that a proper assessment must be based on the primary resource perspective. This conclusion is based on the fact that the total consumption of primary energy resources is the denominator in defining the energy efficiency and the import dependence quantifying the security of supply. The carbon dioxide emissions are also related to the primary energy supply.

By shifting from end use heat savings to the measure of all primary energy savings, and by moving from building-bound analyses to a broader energy system perspective, the guidelines offer a valuable tool for policy-makers to benchmark the competing technologies on the heating and cooling market. Given the fact that 74% of the European population live in urban areas, and that industries with heat demands are close to these areas, the Ecoheatcool guidelines provide valuable information about the role of district heating and cooling in further increasing the European energy efficiency and security of supply.

Possibilities with more district heating

The total net heat demand for the industrial, residential, and service sectors in 2003 was estimated to 20.8 EJ for the target area. The additional possible potential for district heat sales was estimated to 6.8 EJ/year, which is 3.4 times higher than the current district heat sales of 2.0 EJ/year. Hence, no limitations appear with respect to available heat demands for expansion of the European district heating systems.

According to [7], the fundamental idea of district heating is to use local fuel or heat resources without alternative use (the five strategic resources) in order to fulfil appropriate local customer heat demands (the service) by using a heat distribution network as a local market place (the tool). Internationally, the five strategic resources are normally identified as combined generation of heat and power (CHP), waste incineration (also known as waste-to-energy), industrial surplus heat, geothermal heat, and fuels difficult to handle directly in buildings (as unrefined biomass).

The more than 5000 European district heating systems fulfil the fundamental idea of district heating to a high degree, since the 2003 key figures were:

- 78% share of recycled and renewable heat in total district heat generated
- 68% came from combined heat and power plants
- 14% of total renewable share, which is higher than EU target of 12% for 2010
- 7% biomass share, from several hundred systems using biomass in their energy supply (Sweden has a 42% share)
- 1% geothermal share, from about 100 systems using geothermal heat completely or partially, mostly in Iceland and France

The volumes of the five strategic heat source options (CHP, waste incineration, surplus heat, geothermal heat, and combustible renewables) are summarised in Figure 3 and compared to the current volumes of district heat generated.
Available sources and corresponding heat flows during 2003 in EJ/year for the target area of 32 countries

Figure 3. Summary of the five strategic district heat sources with the current contributions to the district heat generated during 2003 in the target area of 32 European countries. The picture contains some double counting since some heat from biomass and waste are generated in CHP plants.

The conclusion from Figure 3 is that the total available potential for the five strategic resources are about 200 times higher than the current district heat deliveries and about 20 times higher than the current total net heat demand for the industrial, residential, and service sectors in the target area. The highest potential appears for geothermal heat, but the available heat resources from CHP and biomass are also significant. Hence, no limitations appear with respect to available strategic fuel and heat sources for more district heating in Europe.

Doubling the European district heat sales, by increasing the district heat share from 6 to 12% in all end use of net heat and electricity, and improvement of the current heat generation will give the following benefits for the 32 countries:
Higher energy efficiency: Reduction of primary energy supply with 2,1 EJ/year, which is equal to the current primary energy supply of Sweden

Higher security of supply: Reduction of the import dependence with 4,5 EJ/year, which is equal to the current primary energy supply of Poland.

Lower carbon dioxide emissions: Reduction of 400 million tons/year, corresponding to 9 % of the current emissions in target area. This estimated reduction is equal to the current emissions of France from fuel combustion.

These benefits have the same magnitude as the market share for district heat in the target area, revealing that the use of primary energy resources for district heating is very limited. The corresponding carbon dioxide emissions for district heat delivered are also very low, actually 51 g/MJ below zero, since new electricity from CHP plants are replacing existing coal condensing power plants in the European electricity market. These results prove the crosscutting abilities of district heating in the European energy balance.

Possibilities with more district cooling

The following benefits will be obtained, if the European district cooling systems could increase their current market share from 2 % in 2000 to 25 % in 2020 for all end use of space and process cooling etc:

Higher energy efficiency: Reduction of primary energy supply with 0,5-0,6 EJ/year, which is equal to the current primary energy supply of both Latvia and Lithuania.

Lower electricity demand: Reduction with 0,2 EJ/year, which is equal to the current electricity supply in Portugal. This reduction will reduce future summer congestion in electricity distribution, since the reduction appears during summer peak hours.

Lower carbon dioxide emissions: Reduction of 40-60 million tons/year, corresponding to about 1 % of the current emissions in the target area. This reduction is equal to the current emissions of Sweden from fuel combustion.

The benefits were estimated from a comparison with the baseline of no growth of existing district cooling systems.

Project recommendations

The 10 strategy recommendations to policy-makers from the Ecoheatcool project concerning the European heating and cooling markets are:

1. End use demands: Heating and cooling markets need more attention and be systematically addressed by European legislation.
2. Urban areas: Heating and cooling policies should prioritise action in urban areas
3. Local conditions: Policies need to carefully address issues related to establishing production facilities and infrastructure planning.
4. Statistics: EU and national governments need to ensure better monitoring of local heating and cooling markets in cooperation with professional associations to enable proper analysis and policymaking.
5. Resource efficiency: The impact of all legislative measures and energy investments must be evaluated from a primary resource perspective.
6. **DHC Policies:** Barriers exist in form of inadequate legal frameworks. DHC must be systematically integrated in and promoted by adequate policies as one of the most effective tools to reduce the fossil fuel consumption in Europe.

7. **DHC Improvement:** Policies should prioritise market stabilisation, financing system rehabilitation and give incentives for system improvement. Social dimension must be considered and distortions disadvantaging DHC and its customers avoided.

8. **DHC expansion:** Policies need to consider DHC as important tool to optimise energy use and should prioritise expansion and establishment of new DHC systems in markets that are not yet mature.

9. **Allocation:** The benefits and costs related to the use of renewable energy sources and CHP should be properly allocated between parties to enable fair return on the infrastructure investment.

10. **Research and Dissemination:** Research programmes should target actions to cut costs for DHC equipment; EU should provide a long-term framework for benchmarking and transfer of best knowledge / legislative practice.

**Conclusions**

District heating and cooling systems are important parts of the European energy system with respect to energy efficiency, security of supply, and environmental impact, since they reduce and substitute fossil primary energy supply with local heat and cold sources available.

The two major advantages with district heating systems are that they can recycle heat surpluses from the existing energy system and can be early options for renewables as biomass, geothermal heat, and solar heat.

The two major advantages with district cooling systems are that they utilise free cooling and surplus heat resources for cooling purposes and that they will reduce future summer congestion in electricity distribution.

**References**


