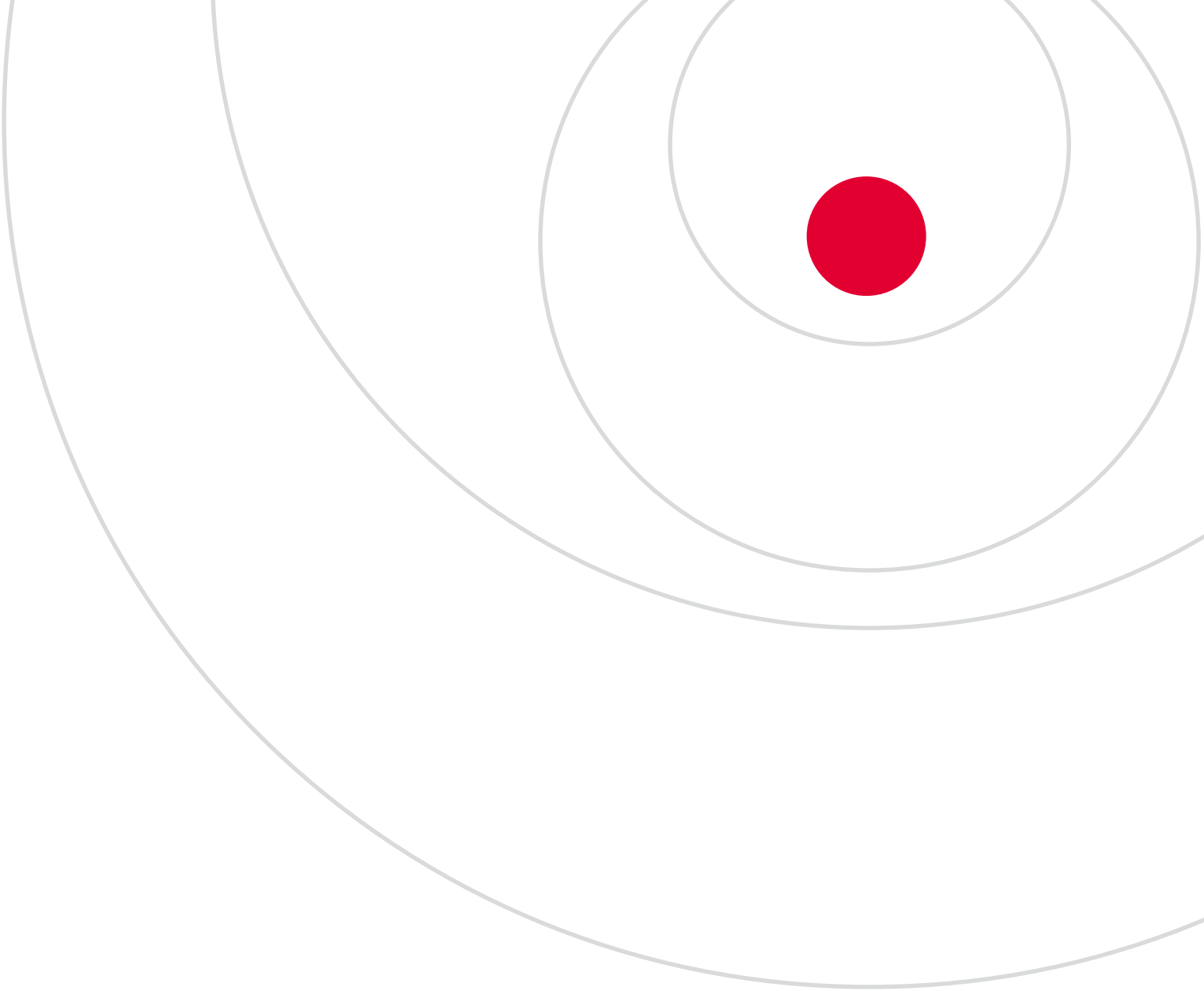


White Paper on District Heating and District Cooling Solutions in an Environmental Perspective

September 2007

”A sustainable energy supply is imperative for a safe financial future of the continent.”

- Angela Merkel, German Chancellor

”I say the debate is over. We know the science, we see the threat, and the time for action is now.”

- Arnold Schwarzenegger, Governor of California

”We have the opportunity and potential to create an oil-free future today, it is potentially right around the corner - and, more often than not, the technology is already here.”

- John Kerry, 2003

”Europeans need to save energy. Europe wastes at least 20% of the energy it uses”

- European Commission, 2006

”The good news is, we have everything we need now to respond to the challenge of global warming. We have all the technologies we need, more are being developed.... But we should not wait, we cannot wait, we must not wait.”

- Al Gore

By doubling the district heating in EU-15, CO2 emissions could be reduced by 9.3% for the EU-15 countries

- Conclusion from Ecoheatcool 2005

”Globally, district heating reduces existing CO2 emissions by 3-4%”

- International Energy Agency, 2002

-An industry information paper prepared by COWI, Danfoss, Grundfos and LOGSTOR

September 2007

1 Executive Summary

- If nothing is done to mitigate CO2 emissions an increase by 50% in 25-30 years is estimated
- EU has announced 20% in their 2020 plan. Purpose of bringing the level of renewable energy in the EU up to 20% - and thereby lower the CO2 emissions
- Improved **energy efficiency** is an important key in lowering CO2 emissions
- Today, the EU-32 countries are **wasting at least 38%** of the energy- primarily on account of inefficiencies
- With increased use of district energy a lot of the energy wasted today could be distributed to the consumers
- District heating is only supplying around 6% of the heat demand today in EU-32 – **enormous potential for improvement**
- District energy is a proven and available technology
- District energy allows for a multiple range of energy sources to come into play – hence there are **no technical limitations** to the roll-out of district energy
- The success of district heating in both Denmark and Sweden is to a great extent a function of **the right political framework**
- At the EU level the political framework should promote district energy – by necessary and reasonable **requirements for efficiency of energy production**
- **Doing more with less is an actual option**

2 Introduction

On global scale politicians, businesses and consumers are increasing their focus on energy consumption, supply and security of supply.

While it is obvious that the industrialised world cannot function without consumption of energy there is now evidence the emissions of CO2 into the air will potentially lead to global warming. Hence, focus is now directed towards the challenge of an increased or flat demand for energy while at the same time lowering CO2 emissions.

In a global business-as-usual scenario where nothing is done to mitigate CO2 emissions, the Swedish power and heat supply company, Vattenfall, has estimated that the CO2 emissions will increase from an estimated 40 Gt in 2002 to about 60 Gt in 2030 – a 50% increase.[1]

Global focus on energy consumption, supply and security in combination with CO2 emissions

There are many ways of looking at the energy industry and its related industries. First of all, there is the perspective of dependence on energy imports and security of supply, which are clearly political issues at the high end of the agenda. Secondly, there are the overall macroeconomic considerations of energy prices, which are frequently discussed, as oil prices appear to indicate an upward trend. Thirdly – and perhaps most importantly in a global setting – there is the growing consciousness of energy consumption impacts on the environment, specifically CO2 emissions and global warming. Interestingly enough, the latter seems to be on the agenda across the scale, from the political agenda over the businesses, and right to the consumers.

There is a strong commitment in many places of the world to lower CO2 emissions – and it is being formulated and implemented rapidly.

Around us there are numerous examples from the micro to the macro level that the issue is at the very top of the agenda;

- In Sweden, CO2 certificates were being sold for Christmas presents in 2006
- There is now a demand for “green” taxis in New York to improve air quality and lower emissions
- The Al Gore “effect” across US and Europe
- The EU target of 20% renewable energy in the total energy consumption in 2020

1 www.vattenfall.com/climate
- ”Vattenfall’s Global Climate Impact Abatement Map”

2.1 Purpose of the White Paper

The purpose of this White Paper is to illustrate and clarify the advantages of district heating and district cooling (together referred to as district energy) in terms of achieving substantially higher energy efficiency across the EU member countries. This will ultimately fulfil not only the 20% in 2020 target as set forth by the EU Commission, but also set the scene for an increased understanding and wider acceptance of district energy. As such, the paper is mainly concerned with the energy used for generating electricity, heat and cooling.

2.2 Addressing the EU target "Saving 20% by 2020"

In October 2006 the European Commission presented its Energy Efficiency Action Plan.

"Europeans need to save energy. Europe wastes at least 20% of the energy it uses. By saving energy, Europe will help address climate change, as well as its rising consumption, and its dependence on fossil fuels imported from outside the Union's borders."

Basically, there are two ways of addressing the target of lower CO2 emissions. One is lowering the overall primary energy consumption, i.e. to make better and more efficient use of the fuels that we consume on our way to deliver energy in various forms (electricity, including cooling, or heat basically) – as identified and pointed out by the European Commission in 2006. The other way of lowering CO2 emissions is to use other forms of raw input into our energy generation, i.e. to use more CO2 neutral "raw materials", such as biomass or wood pellets for example.

The "easiest" way of reducing CO2 emissions is simply to lower the energy consumption by becoming much more effective

In relation to the two ways described above, the EU target actually does not seem achievable if we do not improve our efficiency in the transformation of the primary energy sources into the consumer friendly means of energy – electricity and heat. The European Commission also made this point in 2006.

"Energy efficiency is crucial for Europe: If we take action now, the direct cost of our energy consumption could be reduced by more than €100 billion annually by 2020; around 780 millions tonnes of CO2 will also be avoided yearly"

Also from a macroeconomic point of view there are strong arguments for working together towards the target since it is clear that the enterprises of tomorrow will be those able to provide solutions directed at improved energy efficiency both from existing as well as new technology. As such, a focused effort to reach the target will have positive spill over effects on employment, know-how and exports of technology from the EU and the individual countries focusing on development of energy efficiency.

There are major benefits to the countries and regions, which will develop strong competences in energy efficiency

3 Energy supply and consumption

Generally speaking, energy is used for mainly three things;

- Generation of electricity
- Generation of heat
- Transport of people and goods

The energy used for the transport sector is not analysed here since it is another story and another focus area requiring other measurements than those of electricity and heat generation.

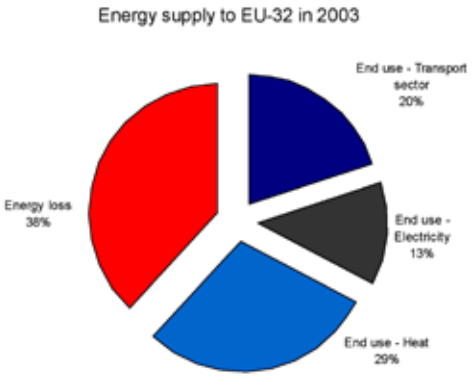
Focusing on Europe – and more particularly on the EU-32 countries – energy supply and consumption is highlighted by the following statistics: [2]

- Total primary energy supply of **81,1 EJ** (Exa Joule) calorific value
- Total energy for end use is **50,2 EJ**, which is used as either electricity, heat or for transportation purposes

Out of the 81,1 EJ supplied to the EU-32 countries some 30,9 EJ are actually lost This means that there is a total loss of energy supplied to the EU-32 countries at 38%. This number may even be at the low end because the transport sector is included in the statistics. With the data available for the time being it is not possible to separate the energy all the way from the primary supply and thereby look at the end use versus the primary supply. However, there is reason to believe that the loss may be a great deal higher than 38% as reported here.

More than one third *of the energy supplied to the EU-32 countries in 2003 was lost and never delivered to the end user of the energy*

Another important part of the energy supply is the dependency between countries. A number of European countries for example are strongly dependent on imports of oil and gas from countries outside the EU. This dependency is potentially a political issue, which for sure will influence regional politics from time to time. Obviously, this is not only an issue for the EU as a region – it also applies to a number of other countries and regions from around the world, and because of the importance of energy supply from an economic point of view, it is a crucial component of a country's political power.



Dependency of energy supply across borders is an important political issue

2 Ecoheatcool 2005, www.ecoheatcool.org.
All data based on statistics from 2003.

4 Reducing loss of energy

The waste of energy of at least 38% as illustrated in the previous section is in some contrast to the energy policy of Europe – as communicated in early 2007.

Energy efficiency is identified by the European Commission as the "most immediate element" of our common energy policy

"An Energy Policy For Europe"
COM(2007) 1 Final – Brussels, January 10, 2007

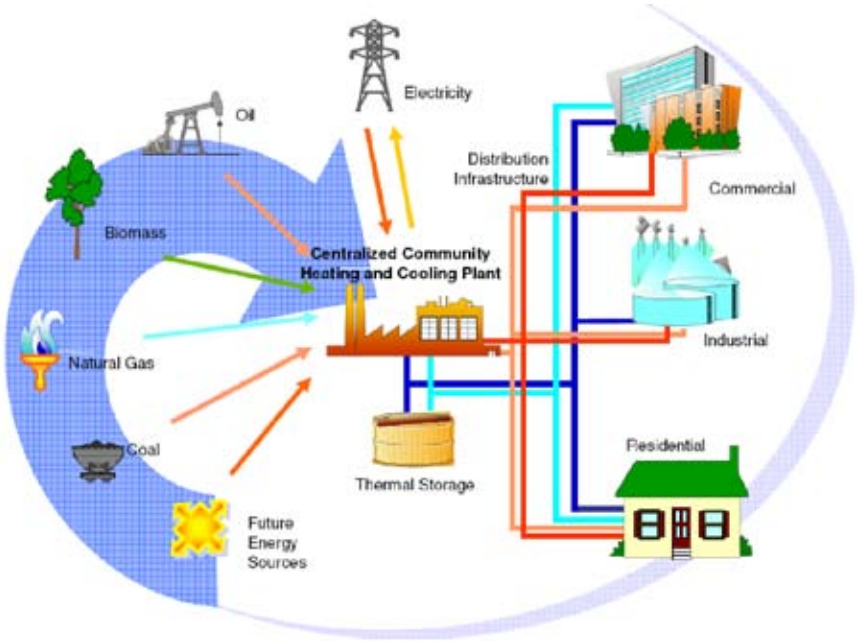
"To achieve the strategic energy objective…..means transforming Europe into a highly energy efficient and low CO2 energy economy, catalysing a new industrial revolution…", p.5

"For Europe's citizens, energy efficiency is the most immediate element in a European Energy Policy. Improved energy efficiency has the potential to make the most decisive contribution to achieving sustainability, competitiveness and security of supply", p.11

4.1 The idea of district energy

Considering the waste of energy, it is worth recalling that the fundamental idea of district energy today is to make use of local fuel, heat or cooling sources. Often, these sources would have otherwise been wasted. This is all possible by utilising an efficient local distribution network of insulated pipes, which provide for a cheap and reliable heat or cooling source once established. In the very best of scenarios the district heating or district cooling system is fuelled by energy from waste materials, e.g. from households and/or industries.

The graphics from the US-based District Energy St. Paul in Minnesota illustrates the flexibility and principles of district energy.



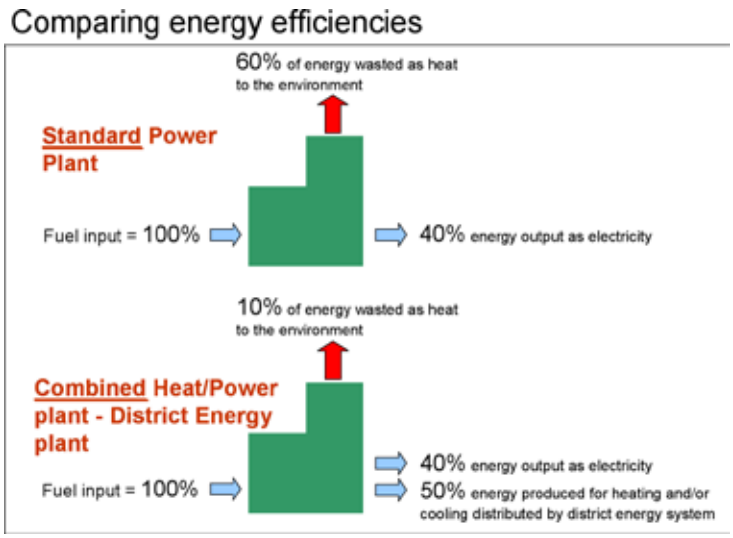
As can be seen from above the district energy system is very flexible in terms of fuel / energy source, it is able to serve numerous customers at the same time and last but not least it has the potential of storing the energy (thermal storage).

Referring to the section above on Europe's energy consumption, the energy lost could be substantially reduced with an increased use of district heating and district cooling. A large part of the loss comes from the **single-purpose plant**, which is designed to produce only electricity. The alternative to this is the **cogeneration plant** where both electricity and heat is produced. This is also referred to as combined heat and power (CHP) generation. In this process, heat is actually a "waste-product" of electricity production.

There are substantial efficiency differences between single-purpose and cogeneration plants

From an environmental point of view the heat that is wasted in the single-purpose plant is around 60% and it is important to bear in mind that this heat could have actually been used either to substitute electricity-based heat in a residential home, in the industry where it would have potentially replaced local low-efficiency boiler-generated heat or perhaps it could have been used to generate cooling in a district cooling system where it could have replaced electricity consuming conventional air condition.[3] The difference of efficiencies is illustrated below and is based on actual Danish figures.

…around 60% of the energy is wasted in single purpose plants



3 Data is based on numbers from the Danish district heating systems. As reported by DFF (www.dff.dk)

In essence, district energy is offering i) a unique way of utilising surplus heat from the existing energy system, and ii) an early and easy option of introducing more renewable energy into the energy system.

As such, this sector can be exploited as a common carrier, which enables the use of sustainable energy sources in the system, and in this way build an efficient energy sector that paves the way for local and regional initiatives with whatever energy source one might have available.

District energy systems are in essence a common carrier for a wide range of energy sources

The common carrier technology is easily accessible, known, very energy efficient and completely flexible on the energy source used.

…and a well-known and proven technology

5 Potential of increasing District Energy

Large district energy networks can be supplied by a number of energy sources; waste incineration, combined heat and power generation as well as surplus heat from industrial production. By connecting the network to these energy sources a number of various fuels and energy sources are brought into play, such as coal, oil, natural gas, solar power, geothermal heat, waste and biomass. Basically, any energy source can be used to supply heating and cooling to the network – multiple energy sources can even be used simultaneously.

District energy is flexible when it comes to the energy source

Adding the fact that among some large energy suppliers there is a vision to utilize both solar- and geothermal sources as well as bio fuels only underlines the potential of reducing CO2 emissions by using more district energy.

An important common denominator and an absolute key point is that all of the above mentioned benefits and use of resources are to be made available to the public through a common distribution system, which is already in most of the EU countries a mature and well-known technology.

Also, it is important to stress that district energy systems are not "yesterday's technology". On the contrary, they offer an economically feasible and attractive move away from fossil fuels by means of heat recovery, use of bio fuels, waste materials, solar power and even geothermal power – to name a few.

Focusing on district cooling only, it is worth noting that;

- ***District cooling is 5-10 times more efficient than traditional cooling solutions – mainly electrically powered AC systems***

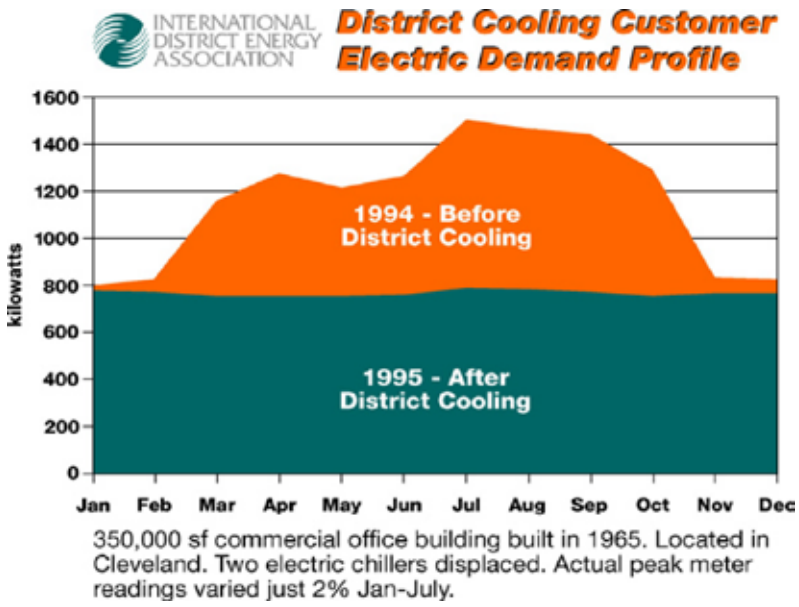
- ***25% district cooling in Europe would give electricity savings of 50-60 TWh savings…***

- ***…which translates into some 40-60 million tonnes CO2 / year***

Another important feature of district cooling is that it takes off the load on the existing electricity supply. Quite often this is a most attractive offer since electricity supply in many parts of the world is under high pressure during warm summers where demand for cooling from conventional electricity powered air conditioners is high.

In the US, the International District Energy Association (IDEA) analysed the effect of a district cooling system being put into operation in Cleveland, Ohio. The graphic below illustrates how the peak demand for electricity was completely removed. The benefits of removing peak demands from the electricity grid are obvious in terms of efficiency of plants, limited need for stand-by plants, closure of inefficient plants, etc.

District cooling takes the load off the existing electricity grid



The facts for district heating are that,

- ***60 % of the Danish demand for heat is supplied by district heating and more than 50% of the electricity and heat distributed comes from cogeneration plants***
- ***The 2003 average of 11% cogenerated electricity varies substantially across Europe from 2% to up to 50% - and this compares to the EU directive target of 18%***
- ***At the end of the 1990's it was estimated that district heating was reducing global CO2 emissions by 3-4% (7-900 million tons)***

District heating is already part of reducing CO2 emissions

5.1 Option of storing energy in district energy systems

When comparing the district energy system to other ways of supplying either heat or cold there is one important difference that stands out. It is the potential of storing large sources of energy with a relatively small storage loss.

The alternative to district energy is often electricity based heat or cold – ie. the source of the heat or cold is electricity. Electricity, unfortunately, cannot be stored in a meaningful amount when it comes to supplying heat or cold to industrial or commercial buildings, for example.

District energy can be stored to even out times of high/low demand

However, this is not only possible when using district energy – it is actually being done today.

Thereby, the district energy system actually holds the potential of being the accumulator of surplus energy – which is an immediate problem in today's wind power generated electricity. In other words, any surplus electricity, which may be generated according to nature's seasonality (wind or hydro), could effectively be transferred to the district energy system where it would be stored as either heating or cooling and used later (when there is no surplus of electricity).

5.2 Estimate of reduction in CO2 emissions

Assuming that the current 6% district heating share of the EU-32 countries would double to 12%, the following effects have been estimated:[4]

The beneficial effects from district energy on CO2 emissions have been proven and quantified

- ***Lower import dependency of 4.5 EJ – or the equivalent of Poland's energy supply***
- ***Improved energy efficiency leading to a reduction of the primary energy supply of 2.1 EJ – or the equivalent of Sweden's energy supply***
- ***Reduction of 400 million tons CO2 per year – or the equivalent of the emissions from fuel combustion in France***

4 Ecoheatcool Work package 4

6 Summing Up

Based on years of experience in many countries, especially the Scandinavian ones, there is strong evidence that district heating and district cooling are economically advantageous, extremely reliable and - perhaps most importantly - environmentally safer than other solutions being employed today.

Promoting combined heat and power generation (CHP) is the single biggest solution to the EU target of reducing CO2 emissions by 20% and increasing the renewable share of energy to 20%.

Denmark and Sweden are among the most energy-efficient societies in the world and there is a wide range of competences and expertise knowledge related to energy efficiency, especially CHP.

To a large extent the political framework is the key – it is simply necessary and reasonable to set up requirements for efficiency of energy production within the EU. The requirements must be followed up by enforcement and possibly also support, in order to promote efficiency.

By acting now, there is every chance that we can lead the way towards a “greener” society where the increased demand for energy is fulfilled by actually using less energy sources. “Doing more with less” is not only the title of the EU Commission’s paper on energy efficiency, it is an actual and realistic option….

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