Meeting cooling demands in SUMMER by applying HEAT from cogeneration

Deliverable 2.1

Framework Conditions

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1 Introduction

Within the past few years the amount of useful floor area being cooled and/or conditioned has increased, and based on national and international surveys this trend is going to continue also in the next years. This fact shall be illustrated by the subsequent figure.

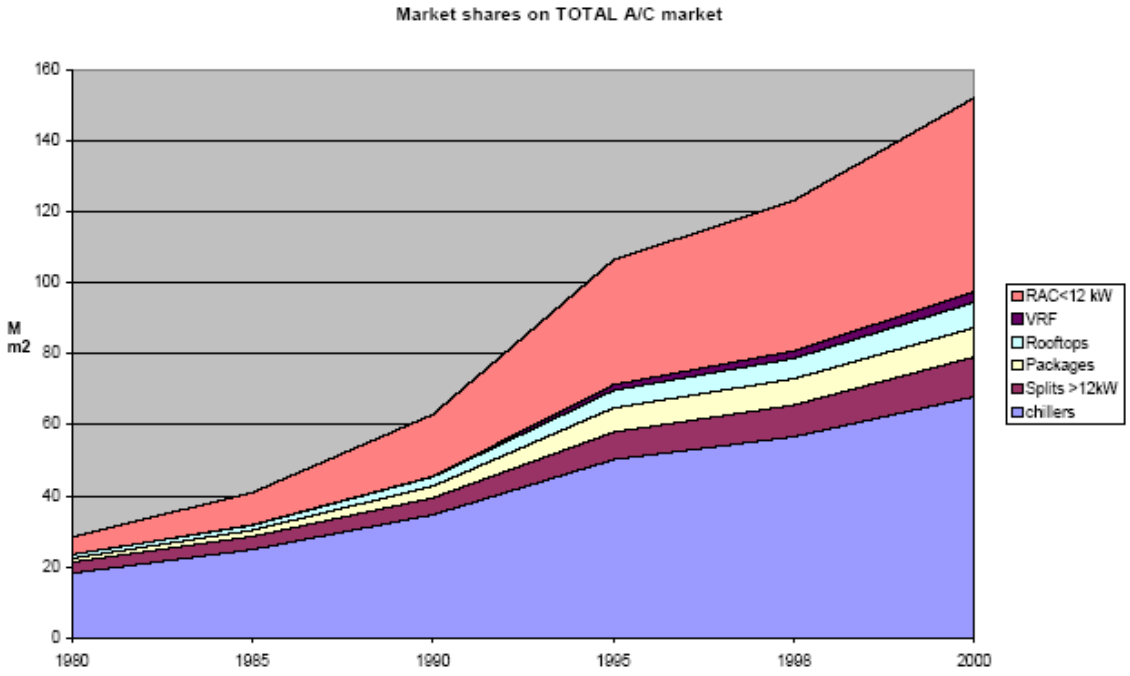

Figure 1: Useful floor area being cooled and/or conditioned [Mill. m2], EU 15

(Source: AUDITAC Study)

There are several reasons for this development. In any case, crucial factors are the constructive design, the usage of the building and increasing internal loads on the one hand as well as risen demand in comfort while climatic outdoor conditions are changing also in temperate latitudes and, of course, the quantitative increase of office and service buildings.

Assuming that the increasing cooling demand in buildings is mainly covered by conventional compressor chillers, this rise will also have an impact on the electricity grids and its upstream production facilities. The rise will intensify already existing problems in the energy supply like high peak loads in summer, additional dependency on imports and higher CO_2-emissions and problems concerning refrigerants.

In order to prevent this trend, it is naturally intended to reduce or even avoid any cooling demand in buildings by the design and constructive measures. For this purpose additional incentives are given by the European Directive on energy

performance of buildings. Besides, alternative approaches such as measurements for passive cooling or chillers driven with district heat offer the possibility to cover existing cooling demand.

When installing absorption chillers driven with district heat, there must be appropriate technical and economic conditions. At an holistic consideration of thermally driven absorption chillers including the upstream district heating network especially the technical conditions can adversely affect their application. The main issues are

- Low DH supply temperatures require larger-scale thermal chillers
- Small DH temperature differences between supply and return cause hydraulic bottlenecks and limit the feasible cold capacity
- An increase of the DH supply temperature causes additional heat losses in the network and losses in the electricity generation of CHP plants

Thus, an analysis always concerning the concrete single case study has to be carried out for an examination of the entire system. Cooling with district heat shall contribute to an efficient use of energy sources and to a reduction of CO_2-emissions compared to compressor chillers. Therefore, it is necessary that district heat can be generated with a low primary resource energy input (see also Figure 2). This can be achieved by the use of waste heat from cogeneration, in particular from those fired with renewable energy sources, and from waste incineration plants.

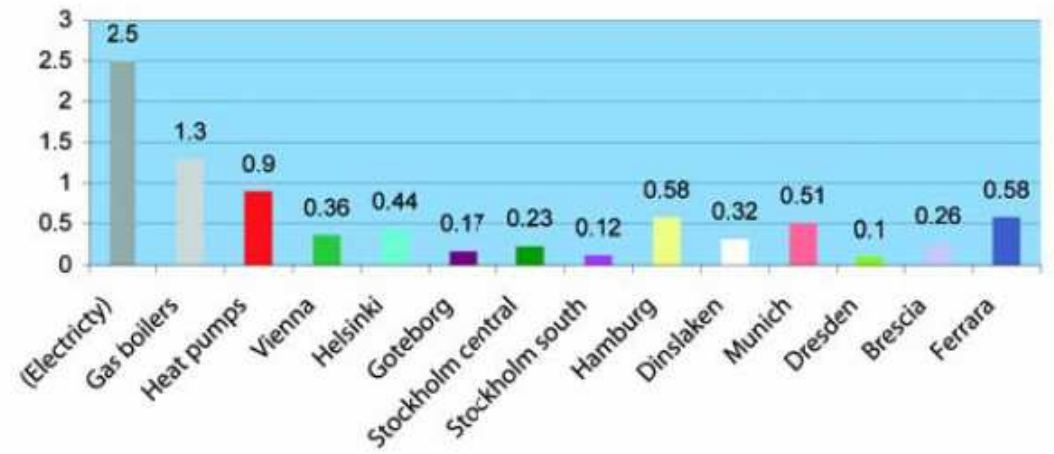

Figure 2: Primary resource factors of different district heating networks (ECOHEATCOOL Project)

The utilisation of the free heat capacities, which are in general available in summer, can contribute to a rise in efficiency and thus lead to a better profitability of the production facilities. Naturally, thermally driven chillers are in direct technologic and economic competition with conventional compressor chillers.

2 European political and legal framework

In Kyoto (Japan) in 1997 the European Union and its Member States committed to achieve an 8 % reduction in emissions of the greenhouse gases carbon dioxide, methane, nitrous oxide, fully and partly fluorinated hydrocarbons and sulphur hexafluoride in the period from 2008 to 2012 compared to 1990 levels. This target was differentially subdivided in the Member States.

Measurements to reduce the greenhouse gas emissions must also aim for the field of air-conditioning and cooling, because on the one hand climate relevant refrigerants are used and on the other hand the consumption of electric energy from thermal power plants contributes to the CO_2-exhaust.

In the European Union these central measures for climate and environment protection come along with provisions on energy efficiency, the promotion of renewable energy sources and the maintenance of the security of supply. In the following chapter some legal regulations concerning the field of cooling are described.

2.1 European legislation

2.1.1 Directive 2004/08/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market

Cogeneration is regarded as important means for the increase of energy efficiency and the reduction of greenhouse gases connected with it. The directive 2004/8/EG on the promotion of cogeneration based on a useful heat demand in the internal energy market[1] aims to create common and transparent basic framework conditions in order to promote and facilitate the implementation and operation of high-efficient (in the meaning of the directive) cogeneration systems based on a useful heat demand (inclusive of heat demand for thermally driven cooling units) and at primary energy savings taking into account the specific conditions in each Member State, in particular the ones of climatic and economic kind. Furthermore the Member States have to provide analyses of the national potential for the application of high-efficient cogeneration.

Nevertheless the directive does not state any binding targets nor any obligation to support energy from cogeneration. It is up to the Member States, if they introduce

[1] Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC
http://europa.eu/scadplus/leg/en/lvb/l27021.htm (08/2007)

or proceed measures of funding energy from cogeneration. The support of existing or future cogeneration systems must only comply with the requirements of the directive (e. g. high-efficient cogeneration, useful heat, primary energy savings). The standardisation of the definition for electricity from cogeneration as well as the unified calculation method for energy savings (for high-efficient CHP) can be seen as the main points of this directive.

2.1.2 The directive 2002/91/EG on the energy performance of buildings

The directive 2002/91/EG on the energy performance of buildings[2] aims to improve the energy performance of buildings taking into account climatic and local conditions as well as requirements on the indoor climate environment and cost effectiveness. Thereby, emphasis is put on measures of increasing the energy efficiency and of energy savings.

The Directive is set to promote the improvement of energy performance of buildings with the following requirements to be implemented by the Member States:

(i) the general framework for a methodology of calculation of the integrated energy performance of buildings;

(ii) the application of minimum requirements on the energy performance of new buildings;

(iii) the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation;

(iv) energy certification of buildings of new and existing buildings and

(v) regular inspection of boilers and of air-conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old and

In this Directive “air-conditioning systems” are defined as a combination of all components required to provide a form of air treatment in which temperature is controlled or can be lowered, possibly in combination with the control of ventilation, humidity and air cleanliness.

Referring to the air-conditioning and cooling in buildings and the activities set in the Summerheat project the Directive contains terms explicitly in Article 5 and 9 which are relevant for cooling applications in general and when considering the implementation of thermally driven cooling technologies.

In Article 5 an examination of alternative systems is stated. Precisely the technical, environmental and economic feasibility of alternative systems such as:

[2] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings

http://europa.eu/scadplus/leg/en/lvb/l27042.htm (08/2007)

(i) decentralised energy supply systems based on renewable energy,

(ii) CHP,

(iii) district or block heating or cooling, if available,

(iv) heat pumps, under certain conditions,

must be considered and taken into account for new buildings with a total useful area over 1000 m^2 before construction starts.

Article 9 prescribes, that Member States shall lay down the necessary measures to establish a regular inspection of air-conditioning systems of an effective rated output of more than 12 kW. This inspection shall include an assessment of the air-conditioning efficiency and the sizing compared to the cooling requirements of the building. Appropriate advice shall be provided to the users on possible improvement or replacement of the air-conditioning system and on alternative solutions.

The methodology for the calculation of the energy performance of buildings, which a general framework is given to the Member States for, will not be described here in more detail. Concerning the implementing of the Directive Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive at the latest on 4 January 2006.

2.1.3 Regulation (EC) No 842/2006 on certain fluorinated greenhouse gases

Global environmental effects need a common approach. In the European Union this fact is reflected by common laws. With respect to the aim of reducing the fluorinated greenhouse gases, which are part of the Kyoto protocol and therefore protecting the environment, provisions should be made for the prevention and minimisation of emissions of fluorinated greenhouse gases in this regulation, which enters into force directly in each member state. It does not deal with a prohibition of the use of fluorinated green house gases, but emissions shall be effectively reduced by higher requirements on the installation, control and maintenance of refrigeration equipment as well as on the training and certification of personnel and companies involved in activities provided for by this regulation. Naturally, thermally driven chillers stay in direct technologic and economic competition with conventional compressor chillers. Consequently, it seems to be appropriate also to analyse their framework conditions, since a change or tightening of them can have an influence on the decision for or against a certain system. For this reason the main criteria of this regulation shall be described.

Operators of stationary refrigeration and air-conditioning equipment, including their circuits, which contain fluorinated greenhouse gases shall, prevent leakage of these gases; and as soon as possible repair any detected leakage. Moreover operators shall ensure that the applications are checked for leakage by certified personnel according to the following schedule:

- applications containing 3 kg or more of fluorinated greenhouse gases shall be checked for leakage at least once every 12 months; this shall not apply to equipment with hermetically sealed systems, which are labelled as such and contain less than 6 kg of fluorinated greenhouse gases;
- applications containing 30 kg or more of fluorinated greenhouse gases shall be checked for leakage at least once every six months;
- applications containing 300 kg or more of fluorinated greenhouse gases shall be checked for leakage at least once every three months.

Operators of the applications containing 3 kg or more of fluorinated greenhouse gases, shall maintain records on the quantity and type of fluorinated greenhouse gases installed, any quantities added and the quantity recovered during servicing, maintenance and final disposal. They shall also maintain records of other relevant information concerning the operation, service and maintenance. Furthermore operators must ensure a proper recovery of these refrigerants.

In the regulation also an evaluation of the legal act itself is provided. By 4 July 2011, the Commission shall publish a report based on the experience of the application of this Regulation. Therein it shall be evaluated among others, if the objectives of this regulation can be met, whether maximum leakage rates for installations can be established and assessed, whether Community provisions concerning the global warming potential of fluorinated greenhouse gases should be amended taking into account technological and scientific developments as well as timescale constraints.

3 National political and legal framework

3.1 National policy

Since the first oil crisis in 1973, energy policy has occupied a relatively significant position in Denmark. Initially policies were directed towards the problem of security of supply, but gradually the focus has been brought to bear on domestic energy production (oil and gas, renewable energy etc.), on energy supply and distribution (natural gas, CHP etc.), and on energy savings (insulation, labelling schemes etc.). In addition, international sustainability targets – not least reduction of CO2 emissions – and economic considerations have had a significant role to play in recent years. Denmark has ratified the EU directive on greenhouse gas emission allowance trading and made it law. The government regards the emission allowance trading scheme as a vital element in the Danish climatic strategy.

In its latest energy policy proposal, *A Visionary Danish Energy Policy 2025,* of 19 January 2007, the Danish Government presented its proposals for the cost effective fulfilment of overall energy policy objectives for security of supply, environmental impact and competitiveness.

The proposal is founded on a forward-looking vision of Denmark in the long term being entirely independent of fossil fuels. With a view to realising its vision, the government has set the following targets prior to 2025:

- A minimum 15% reduction in the use of fossil fuels compared with today
- Preventing an overall increase in energy consumption, while sustaining economic growth. With this in mind, the energy saving initiative will be increased to 1.25% annually.
- The share of renewable energy must be increased to at least 30% of energy consumption by 2025.
- A doubling of publicly funded research and development into and demonstration of energy technology.

In order to achieve these ambitious targets the government has put forward a number of new energy saving and renewable energy initiatives along with initiatives aimed at new and more efficient energy technologies.

Danish energy consumption has remained constant since 1972 despite the more than doubling of GDP in the same period, thereby making Denmark the most energy efficient country in the EU.

The present energy saving measures was laid down in the energy saving agreement of June 2005, which involved the implementation of a number of initiatives to strengthen energy saving efforts.

The promotion of renewable sources of energy has always played a significant role in the Danish energy policy and it is crucial aspect of the government's future vision of fossil fuel-free energy supplies. Today, the primary sources of renewable energy are wind and biomass. A great deal of electricity and heating is also produced from waste.

3.1.1 District Heating and Cooling

District heating has high priority, and is considered an important prerequisite for fuel diversification and for obtaining energy efficiency through CHP.

Approximately 60% of all households are heated with district heat from district-heating plants and co-generation plants. About 80% of the DH is co-produced with electricity. Typically, the systems are very large and involve many players and public supply of heat is widespread.

As to *district cooling* the Danish Energy Authority prepared a report in June aiming at assessing the potential for district cooling and the current framework conditions[3]. The background the report is based on an increased interest among district heating companies towards district cooling and a request from the district heating sector to analyse current legal barriers.

The work with covering the potential is a.o. based on a questionnaire survey elaborated in cooperation with the Danish District Heating Association, and further a number of Danish district heating companies have contributed with feasibility studies on district cooling in their supply areas.

The report concludes

- District cooling has a potential in larger cities and industrial areas, depending on the local conditions.
- The potential energy savings connected with district cooling are relatively limited
- The district heating sector is positive towards producing district cooling
- The current Danish legislation permits private organisations to implement district cooling measures, while municipalities are not permitted. Many municipal district heating companies has indicated big interest for district cooling.

In the light of the current framework conditions the government is considering to allow municipal district heating companies to establish district cooling activities within companies that are economically separated from the district heating companies.

[3] Fjernkøling i Danmark. Potentilale og Regulering. Danish Energy Authority, June 2007.

3.2 National legislation

Beyond national priorities the whole framework of EU directives has influenced the Danish energy sector, yet many of the directives follow a direction, which, to some extent was already established in Denmark prior to the adoption at EU level.

Renewable energy, electricity and heating are covered by the consolidated versions of

- The Act on Electricity Supply N°286 of 20 April 20 05.
- The Heat supply act N°772 of 24 July 2000.

In addition to the above regulations, Denmark has created a comprehensive legislative framework promoting energy savings in all sectors of the economy.

3.2.1 The Electricity Market

The electricity market was liberalised in accordance with a decision of the Danish Parliament, the Folketing, at the end of the 1990s. This decision provided the foundation for the restructuring of the electricity sector and the opening of the electricity market and resulted in the adoption of the Act on electricity supply.

Subsequently, production and trading in electricity is subject to competition and the electricity grid and its operation are subject to public price regulation, and all users of the system may make use of this infrastructure.

Since 1. January 2003 all electricity costumers may purchase electricity in the open market and choose the supplier they prefer. Costumers who do not wish to exercise their free choice are assured electricity supplies. Special supply obligation companies offer electricity to all costumers at publicly controlled prices.

The demarcation between monopoly and areas of competition is clearly defined by the legal framework.

3.2.2 Support schemes available for CHP

Environmentally-friendly generation of electricity is eligible for subsidy, and includes production based on:

- wind
- biomass
- biogas
- waste
- natural gas
- solar energy
- wave

Around 6,000 plants in Denmark generate electricity. The subsidies, that some of them receive, usually depend on:

- fuel type
- size
- age of the plant

Existing plants with output over 5 MW are eligible for an individual subsidy corresponding to that received in the period 2001-2003. The subsidy is paid for 20 years from the date of the grid connection and for at least 15 years as from 1 January 2004.[4]

Plants of 5 MWe or under are eligible for a subsidy depending on when electricity production takes place. Combined with the market price, the subsidy ensures a tariff called three-tier tariff. At the end of 2006 the tariffs were approx. 21 øre/kWh at low demand, approx. 46 øre/kWh at high demand and approx. 61 øre/kWh at peak demand. The mean annual tariff is consequently approx. 35 øre/kWh.

Renewable electricity (apart from wind power) from existing plants are eligible for a subsidy that together with the market price will ensure a tariff of 60 øre/kWh for 20 years from the date of grid connection and for at least 15 years as from 1 January 2004. New renewable energy plants are eligible for a subsidy that together with the market price will ensure a tariff of 60 øre/kWh for 10 years and 40 øre/kWh for the following 10 years. Special rules for new biogas plants mean that this subsidy is only applicable to plants connected to the grid before the end of 2008 and up to a ceiling of 8 PJ for total biogas use in Denmark.[5]

The Danish Government reduced the tax burden on decentralised CHP plants. This relaxation corresponds to reduced costs by an average of DKK 1,000-1,500 per year for a normal house in a rural area.

As far as centralised electricity production (most large-scale plants are multi-fuel CHP installations) is concerned, the biomass agreement of 1993 forced central power stations to use biomass. This element of their production is eligible for a subsidy which when combined with market price ensures a tariff of 40 øre/kWh for a 10-year period.

3.2.3 Energy savings - EPBD

Denmark has for many years had fairly strict energy requirements in the building regulations, obligatory labelling scheme for buildings and obligatory inspection scheme for boilers. In relation to a.o. the EPBD Denmark has now tightened the energy requirements in the building regulations further and developed new labelling and inspection schemes.

[4] Danish Energy Authority, 2007.

[5] Ibidem

New energy requirements were issued 16. June 2005 and came into force 1. January 2006. The new energy requirements are not only an implementation of the EPBD, but also impose stricter energy performance requirements in accordance with Danish action plans for an increased 25 % energy saving in new buildings, compared to requirements before 1. January 2006.

In Denmark the implementation of the Energy Performance Building Directive, EPBD is the responsibility of the Danish Energy Authority and of the Danish National Agency of Enterprise and Construction [6].

In relation to EPBD a new Secretariat – FEMSEK[7] - was established from 1. January 2006 based on based on law no. 585 from 24. June 2005 "Law on promotion of energy savings in buildings"

FEMSEK is Secretariat for five schemes

1. Energy performance certificate of buildings,
2. Home inspection scheme (from 1. July 2006),
3. Inspection of boilers and heating systems,
4. Inspection of ventilation systems (from 2008-01-01) (not aircon)
5. Energy Management scheme for state-owned property.

An energy performance target is the main requirement for all types of buildings heated to at least 15 ℃. The target is based on th e supplied energy needed for operating the building. There are separate targets for housing (not including lighting) and non-domestic buildings (including lighting). An extra allowance to the basic target is given to non-domestic buildings with high ventilation requirements for IAQ purposes, high lighting requirements, long operation hours or large hot water demand.

For all type of buildings the new energy requirements also include two classes of low energy buildings. Class two has an energy demand of 75 % or less compared to a normal house, and class one has an energy demand of 50 % or less compared to a normal house. Low energy buildings may be exempted from connecting to public networks with natural gas or district heating, which is otherwise obligatory in some areas.

The new classification system will make it possible for building contractors to better promote low energy houses for the consumers, and the public will be able to demand that their new houses have a better energy performance than the minimum requirements specified in the Building Regulations.

[6] www.ens.dk, www.ebst.dk

[7] www.femsek.dk

The energy frame is supplemented by specific requirements for U-values, minimum boiler efficiency, pipe insulation, heat recovery, fan power, efficiency etc.

In the new energy labelling scheme buildings need an energy label:

- when they are new constructed,
- when they are sold,
- if rented out.

In the case of new buildings the building needs to have a sufficient energy label to fulfil the energy requirements in the building regulations to be granted a permit for use.

In the case of existing buildings being sold or rented out, the buildings must have an energy label of not more than 5 years old. This also applies to blocks of flats, where individual flats are rented out or sold. In blocks flats the labelling is done on the building, but with an individual sub label for each flat stating the heating demand. There are 14 classes on the labelling scale from A1 to G2, where A1 is the highest.

As mentioned above the present energy saving measures were laid down in the energy saving agreement of June 2005, These included the introduction of a new framework for energy saving measures to be taken by the utility companies, under which their energy saving obligations were almost tripled, and increased focus on energy savings in heating and energy savings in the public sector.

3.2.4 The District Heating and Cooling market

The local authorities are the central players in the public heat-supply. They develop heating plans and have responsibility for expanding district heating and for implementing any changes made necessary by amendments to the regulations in the Law on Heat Supply.

The Danish Energy Authority has set the general conditions for the establishment and operation of district heating. These conditions are intended to ensure that both cost-effectiveness and consumers' heating costs are taken into consideration.

The Danish Energy Regulatory Authority and the Energy Supplies Complaint Board monitor the district-heating sector and handle complaints regarding prices and conditions.

In general Danish municipalities have no legal basis for establishing *district cooling* activities, and if they do so they can be met by various sanctions.

The objective of the Danish Heat Supply Act is to promote the most socio-economic and environmentally friendly utilization of energy for heating buildings, supplying them with hot water and reduce the dependency of the energy system on oil. The supply of heat shall be organised with a view to promoting the highest possible degree of cogeneration of heat and power

This objective statement does not encompass *district cooling* and the law does not cover plants producing or distributing district cooling.

The law defines the kind of costs that can be covered by the district heating price, and this does not include costs for district cooling.

Consequently the Heat Supply Act does not include any regulation that determines whether a municipal or private operator can carry out district cooling activities in relation to district cooling.

If sector laws or any other laws do not regulate a certain activity, municipalities can under certain conditions and without a legal basis carry out this activity. This typically concern services of common interest made available to citizens. However, recent investigations of this regulation have stated that district cooling is not within the scope of such services.

Basically private operators are obliged to carry out certain activities, provided that no legislation prohibits this. And due to the fact that the Heat Supply Act and any other legislation does not prohibit private operators to establish district cooling activities they are allowed to do so.

However certain limitations must be taken into account, namely the heat supply act's regulation on heating costs, which means that it is not allowed to use money from heating supply activities to finance district cooling activities. Establishment of an independent Company operating district cooling activities could meet this barrier.

To overcome these barriers there is an on-going discussion among the Danish authorities and the district heating sector to change current legislation, e.g. in the form of an addendum to the Danish heat Supply Act.

The government is considering allowing municipal district heating companies to establish district cooling activities within companies that are economically separated from the district heating companies.

3.2.5 Regulation on bans and restrictions on HFC and PFC as well as on sulphur hexafluoride

National provisions were introduced by Order No 552 of 2 July 2002. The Order concerns hydro fluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).

It consists of a general ban on the import; sale and use of new products containing the above mentioned greenhouse gases after 1 January 2006 as well as a ban on the import, sale and use of these greenhouse gases, new and recovered, after 1 January 2006.

Cooling plants, with charges between 0.15 and 10 Kg are exempted

This Danish Order consists of more stringent provisions than Regulation (EC) No 842/2006 which contains a limited ban on the placing on the market since it only applies to products as listed in its Annex II.

The national provision on certain fluorinated greenhouse gases was notified to the Commission by letter of 2. June 2006 and approved by the Commission in December 2006[8].

[8] Commission Decision of 6. December 2006 concerning national provisions notified by Denmark on certain industrial greenhouse gases