The case of CHP in Denmark
- and perspectives to other countries

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1. Introduction

Denmark is the best performing European country in CHP development. According to statistics from the Danish Energy Agency, cogeneration has a share of 50% of the electricity production. A rough estimate indicates national CO_2 emission reductions of 7-10 Mt per year, when compared to separate production of heat and power. This is more than one tenth of total CO_2 emissions in the country (being approx. 60 Mt per year during the 1990s).

The huge CHP coverage is the result of two to three decades of persistent governmental and local policies.

Today, most of the Danish CHP potential seems utilised. Limited further potentials may be found in the industrial sector and by substituting outdated CHP stations with new high-efficient ones.

The conditions of this development have been very particular, especially when the energy markets are transformed. Nevertheless, elements may be generalised and combined with experience from other successful countries. To this end, Denmark has been very keen both nationally and on an EU level in promoting and maintaining CHP in its role as an important 'no-regret' option in climate policies, and in making room for CHP in electricity and gas market regulation.

EU has envisaged that it is possible to double CHP share of electricity market from 9% to 18% before 2010. This will lead to remarkable reductions in CO_2, CHP being perhaps the most important single contribution to GHG reductions. Corresponding options are at hand in Central and Eastern Europe and CIS, and probably in most Annex I countries.

But it is still a question to which extent the countries will take the necessary measures to utilise these options.

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2. The success story

So, how did this success story happen? Four important factors have helped:

- Existence of district heating network. This is something in common with other countries in the North of Europe and Central and Eastern Europe.

- Oil crisis at the beginning of the 70s. In 1973 Denmark was highly dependent on oil from abroad (93% of the entire fuel supply in the country). The willingness of the government to support CHP started with the purpose of ensuring security of supply. Nowadays, Denmark is self sufficient in oil and gas.

- Later on, during the 80s, environmental concerns played a major role in the continuing process, thus introducing natural gas, biomass, and waste as fuels in small scale CHP.

- From 1990, climate policies became the key driver, and extensive CHP schemes are now finalised. CHP is on the threshold of finding a major role in energy market and global climate policies.

The method used by the Danish government to promote CHP has been a combination of strategic work, regulation, economic incentives, voluntary agreements with the energy sector and other actors, and local energy planning. This combination has been evolving over the years. Three types of CHP exist in Denmark and their development has been chronological: First the large scale CHP in cities, next small and medium scale in district heating communities, and lately industrial CHP.

3. Large scale CHP with district heating

The use of CHP in the city-wide district heating schemes started to be developed in Denmark at the beginning of the century, but on a major scale during the 80s after the oil crisis. Condensing heat from existing and new central CHP stations was utilised in city-wide schemes and even connecting several cities and communities by heat transmission pipelines.

The main boost was the introduction of the heat planning system. Through this system, cities were divided into areas suited for district heating and areas more suited for individual supply of natural gas. District heating was made a local natural monopoly exempted from competition (natural gas or electric heating). Local municipalities, district heating utilities and power companies were heavily engaged in this, and economic (as subsidies, taxation, investment grants, etc.) and regulatory incentives (as governmental and municipal powers to regulate power stations and zoning of district heating) supported the implementation.

Denmark's ten major cities have city-wide district heating schemes where most of the heat (95%-98%) is produced in large coal- or gas-fired CHP plants and waste incineration CHP plants. All extra costs, investment and operating costs, as well as lost electricity production, have been paid by the heat consumers, who in turn have gained most of the advantages of the saved fuel costs. Taxation and subsidy schemes have also supported the development of these systems.

The upcoming opening of electricity trade will affect the large CHP by fluctuating electricity prices, which subsequently may impact district heat economies. The transformation of pricing, burden-sharing and taxation structures are being considered at the moment.

Furthermore, the large CHP stations will be subject to strict qouta for CO_2 emissions from electricity production according to the electricity market reform from spring 1999. The CHP stations' quota may benefit from relief from heat fuel savings.

Large-scale CHP stations are expected to remain competitive in a European electricity market. At the same time, new CHP capacity may rely on natural gas and renewable fuels, and even integrated solutions with geothermal plants may be on their way. This will open opportunities for further reductions of CO_2.

4. Small-scale CHP with district heating

In Denmark, small-scale CHP are the schemes which are outside the centrally supplied areas. The largest has a capacity of 99 MWe (supplying the town Viborg), but many of them range from 0.5-10 MWe and supply small communities and institution-buildings. Most of them are natural gas-fired with a rather high power-to-heat ratio.

The first boost came in 1986, when the Parliament adopted a decision for the electricity sector to implement 450 MWe of small scale CHP based on indigenous fuels (natural gas, waste or biomass), first part of the programme being demonstration projects. Due to disputes and reluctance from the electricity companies, major parts of the programme was delayed, and municipalities and local utilities wanted to take part in the programme.

This delay paved the way for subsequent development in a new Parliament decision in March 1990 to expand the capacity to 1.400 MWe (including industrial CHP). The development of the natural gas network was closely linked to the programme. The decision was based on both socio-economic considerations and climate policies. CHP as the primary CO_2 emission reduction means was integrated in the energy strategy 'Energy 2000'.

The new programme opened for municipalities, industry and local consumers to participate along with the electricity sector. This 'deregulation' showed up to be very helpful. The programme was supported by heat supply planning, by close regulation of size, location and choice of CHP fuel and technology, and by economic incentives in taxation, subsidies, and in gas prices and electricity tariffs.

The 1.400 MWe programme has now been implemented almost to its full extent. The investments in the programme have been of the magnitude of approx. 1,5 billion Euros. The emission reductions may be loosely assessed to amount to 4 Mt per year. Small scale CHP is exempted from the CO_2 qouta regulation.

5. Industrial CHP

Denmark has little energy intensive industry, and industrial CHP developed later than district heating CHP. After March 1990, new subsidies and electricity tariffs paved the way for new gas-fired industrial plants, and this was further stimulated by a comprehensive green taxation and subsidy scheme. The government launched a programme to release an estimated potential of 400 MWe. This programme had a very promising start. It was realised that subsidy and tariff incentives were most favourable, and government down-sized incentives. This meant an almost full stop to further CHP construction in industry, also in the light of upcoming competition in electricity prices, etc. Later on, the programme has restarted as an outcome of voluntary agreements in the green taxation scheme for industry, and the potential has been re-assessed to amount to 670 MWe.

6. CHP development in Europe

EU policies in CHP have existed since 1979. The first recommendation on promoting CHP by starting national co-operative work with energy sector and municipalities was adopted in the council of ministers. In 1988, a recommendation on the protection and encouragement of small power producers (less than 25 MWe) was also adopted, and several member countries have since set up certain privileges for this group.

CHP gained new momentum after 1990 when a number of countries carried out national programmes utilising modern gas CHP. Especially UK, Netherlands and Denmark had adopted this policy, taking CO_2 reductions into consideration. But also other countries as Spain, Italy, Portugal and France have opened the door for gas-fired CHP, while countries as Sweden and Finland looked into biomass CHP.

This momentum was created in the early phases of energy market transformation. In the later phases of the liberalisation negotiations, it became uncertain how for CHP to proceed. It is probably not incorrect to claim that the role of CHP, as well as renewable energy, is far from being perfectly defined until now, in spite of market directives for both electricity and gas, and in spite of many dedicated discussions and decisions in the council of ministers.

But CHP was also taken up from the environmental side, and in the preparations for the Kyoto meeting, CHP was out-mapped as a major element in the EU 'no regret' package. It was considered that CHP could cover 30-40% of future electricity demand, and that this would lead to reductions of approx. 10% of CO_2 emissions in EU.

The EU work also considered which policies and measures to implement. First of all, it was observed that

- CHP policies should be tailored to the fact that it is an integrated technology dependant on fuels, electricity and heat supply;
- District heating, local heat consumers and industry are three distinct applications of CHP, each with its own preconditions to policies and measures.

Consequently, CHP policies must start on a comprehensive strategic level, governments defining targets and space for the CHP, its fuels and sales of heat and electricity. This

strategy should also take the necessary action to stop misleading development as e.g. erosion of district heat markets and construction of surplus condensing power capacity.

The integrated requirements of CHP have also lead to an unpleasant and repeating work of identifying all the possible barriers to this technology, as lack of awareness and tradition, obstructive monopolistic behaviour, and time-consuming bureaucracy.

7. Perspectives

The design of CHP policies and measures could consist of a 'recipe' for each application of CHP:

- Both *EU and national targets* are necessary. Only few countries have defined such targets, though they have a quantified GHG reduction obligation.

- The real *CHP potential* must be analysed in depth for integrating the '3 Ms', i.e. all three market categories: fuel, electricity, heat. This work should not be underestimated (EU has now spent 10 years analysing it with sparse results), and many lessons could be learned from e.g. Denmark and the Netherlands.

- The *market frameworks* for all of the '3 Ms' must be supportive. Gas prices must be competitive at all times, electricity market must allow for CHP electricity at fair long-term conditions, heat market should be guaranteed and protected as a natural monopoly, etc.

- Governments must know their duties in setting *regulation, prices, taxation, investment grants, etc*. E.g., according to proposals in the EU large combustion plant directive (LCPD), no new condensing power capacity can be approved by Governments for efficiency and environmental reasons. Instead CHP should be established and located as the best technology. Taxation and pricing could be progressive, giving premiums to low-emission energy.

- The construction CHP stations must be well organised if ever to happen. Local actors as *industry, municipalities, suppliers of fuels, heat and electricity*, and other parties, must be involved. Organisation may be stimulated by *local planning* processes and consumer involvement, task forces and *joint ventures*, etc.

- In the *operational phase*, CHP must be given the right stimuli to maximise production and interact with other sources of 'cleaner' energy.

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References:

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2. CHP Programmes - part of the future EU Climate Strategy. Ture Hammar, Danish Energy Agency, May 1997.