

# ***Hazards in Transition of Gasfired Decentral and Industrial Combined Heat and Power to a Liberalized Market***

Jesper Koch  
Danish Energy Agency

## **1 - SYNOPSIS**

This paper describes the decentral and industrial CHP-sector's ability to meet the changing market conditions.

## **2 - ABSTRACT**

In Denmark the transition to the liberalized energy market is well under way. The superior objectives of the paper are:

- to introduce the future regulation of the electricity sector in Denmark,
- to identify and evaluate the conditions influencing the decentral and industrial CHP sector with special regard to the liberalization of the electricity market,
- to identify environmental consequences and threats of liberalizing the energy market.

It is not the expectation that decentral and industrial CHP will be able to compete on electricity price even if the subsidy of 70 DKK per MWh<sub>e</sub> (8,5 EURO per MWh<sub>e</sub>) for running costs is maintained. If independent cogeneration is forced into competition this may lead to a significant and unacceptable increase in heat prices. There will also be high risk that companies with industrial CHP permanently convert to use heat only boiler. These effects will cause a significantly increase of the national CO<sub>2</sub>-emission.

It is therefore the intention to proceed with the principles in the Electricity Supply Act no. 486 in which this kind of electricity production is given priority. This is expected to be carried out as long as the independent electricity production sector is too sensible to competition.

## **3 - INTRODUCTION**

The long-term CO<sub>2</sub>-emission target described in the Government's energy action plan Energy 21 (ref. no. 1) from spring 1996 demonstrates that it may be technically and financially possible to halve the CO<sub>2</sub>-emissions per capita by the year 2030. This is done by combining energy-saving schemes, by rationalizing energy systems, using renewable energy, and further extending combined heat and power plants.

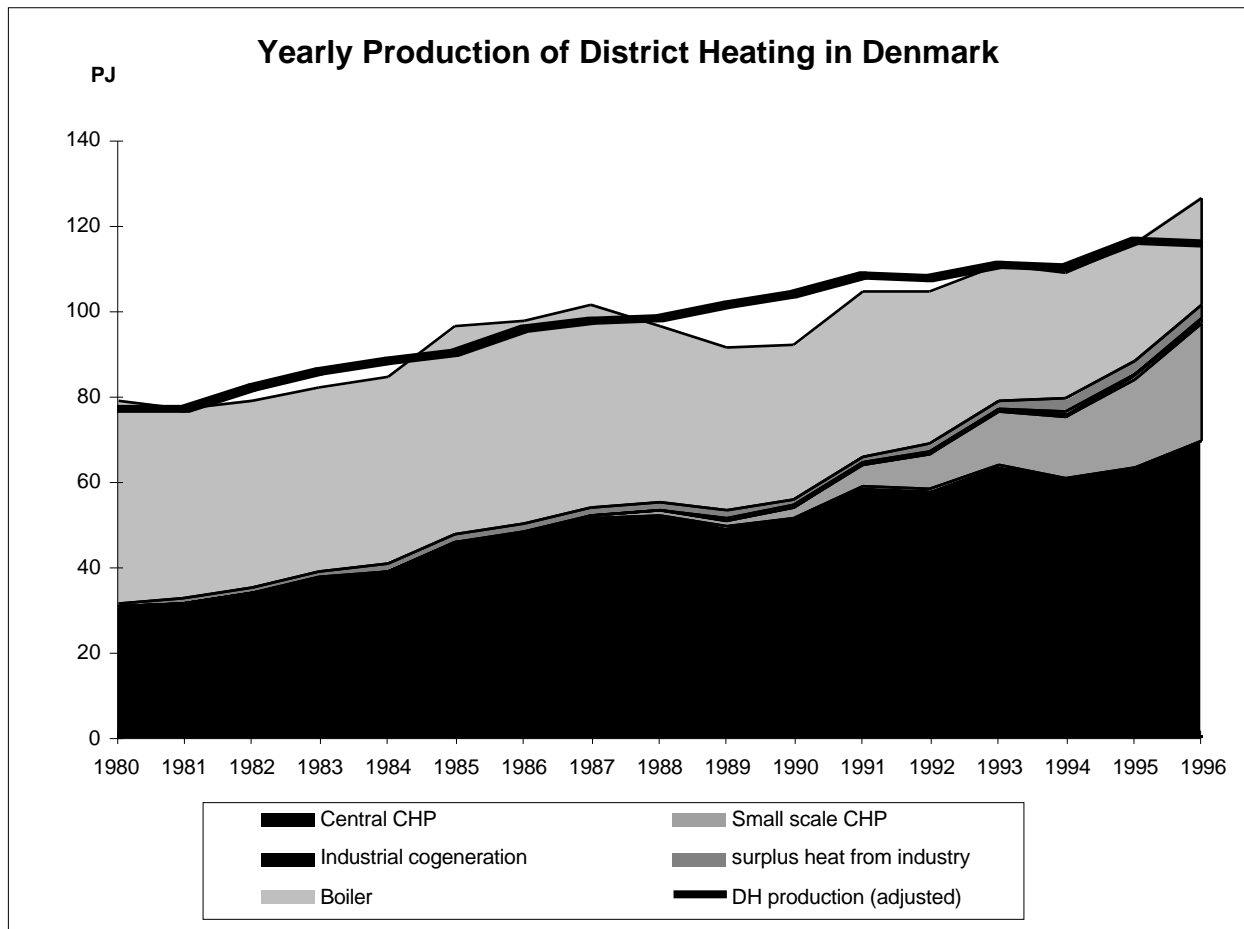


Figure 1 : Production of District Heating

The first Danish energy policy was formulated in 1976 with the aim of securing the energy supply. Since then the developing of combined heat and power (CHP)<sup>1</sup> has increased significantly. As shown in figure A above, now more than 50 per cent of the Danish electricity production and more than 80 per cent of the district heating production originates from CHP. This covers about 50 per cent of domestic heat demand.

Gross energy consumption has stagnated at about 815 PJ per year for the past three decades. This happens in spite of general economic growth of more than 60 per cent. The main reasons for this paradox are, firstly, the widespread extensions of CHP, secondly: substantial efforts on demand side, and thirdly: substantial efforts on renewable production technology. If we are to reach the ambitious CO<sub>2</sub>-reduction targets in the Danish energy policy, a continuous effort on above three fields seem fundamental.

The structural conditions of the Danish energy sector has up to now been based on regulation (and economic regulations) through the Electricity Act<sup>2</sup>, the Natural Gas Supply Act<sup>3</sup> and the Heat Supply Act<sup>4</sup>. Moreover, the regulation has also been widely based on voluntary agreements between the Government and the energy sector. Especially this has made a great contribution to promoting small- and large scale CHP-production. The combination of regulation and voluntary agreements has had a favourable effect on the ambitious, long-term

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1 Distinction in this paper between three types of combined heat and power production:  
 central CHP: Utility owned large scale plants in major cities supplying transmission district heating network  
 decentral CHP (small scale CHP): Municipality or co-operative owned medium scale supplying local district heating network  
 industrial CHP: Private owned supplying heat for industrial purpose  
 2 governing the development and structuring of the electricity sector  
 3 guidelines for construction and supplying from the gas network  
 4 frame for governmental and municipality planning of the heat sector

Danish energy planning because :

- regulations have kept energy prices constantly stable (apart from energy taxes) and
- the energy sector (gas, electricity and heat) has been able to plan with certainty for financing future projects through favourable tax exempted appropriations.

These conditions have therefore been fundamental for development of the monopoly structure of the natural gas network, of the district heating network and for development of the electricity sector's capacity.

Moreover, the structural framework – including to a high degree the regulation of the energy sector - has ensured protection of the consumer. Smaller consumers have been protected against cross subsidizing bigger (companies) consumers. Likewise, consumers linked to the combined heat and power systems have been protected against cross subsidizing of electricity consumers.

It is a fact that the existing structural framework has given advantages for the consumers and the energy production companies. It has also made ambitious environmental friendly energy planning possible.

However, transition to a liberalized energy market seems to create more advantages than disadvantages for the Danish energy sector.

The main reasons for liberalizing (ref. no. 2) the energy market are :

- that Scandinavia and internal EU electricity markets are gradually being opened to growing competition within the framework of the EU Directive.
- that the networks (transmission of electricity, gas and district heating) to a high degree have been developed and to some degree been paid back.
- that the non-profit monopoly structure may not have sufficient incentives to improve efficiency in productiveness – nor to create sufficient incentives to ensure economic rational planning of new production capacity<sup>5</sup>.

If the Danish Government is to give access to the market this must happen in a coherent and balanced way where

- Denmark's international environmental obligations are fulfilled
- heat and electricity consumers are efficiently protected, and
- the market is transparent and well organized.

It has been the intention to carry out the transition of the energy market to competition in to steps. In the first step the electricity sector will gradually open to market competition. Based on experiences of this process the next step will accomplish the natural gas sector<sup>6</sup> and the heat sector opening to market competition.

In Denmark the transition to the liberalized electricity market is now well under way and political negotiations are going on. The political approval of a new electricity act took place the third of March 1999.

## **4 - KEY ELEMENTS IN THE COMING REFORM ON THE UTILITY SECTOR**

The Danish electricity sector has gradually been introduced to competition through the operation of the Electricity Supply Act no. 486 of 1 of January 1998 (ref. no. 3). Today large industrial and network companies with an annual consumption of more than 100 GWh<sub>e</sub> have their free choice of supplier. As mentioned in the introduction a reform of the electricity sector is needed basically because the European markets are being opened to growing competition. Also the aim is to create incentives to rational economic planning in the utility sector. Moreover, the Government will not allow an increase of Danish coal fired electricity export due to Denmark's international environmental obligations.

The structure of the electricity sector will be divided into a monopoly and a commercial part (ref. no. 4). The distribution companies organization will be split in :

- transmission companies or system operators (natural monopolies) with responsibility of

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<sup>5</sup> This is the main reason that the total production capacity in the electricity sector is more than twice the maximum Danish electricity consumption.

<sup>6</sup> Access to the market for the gas sector is prepared but is supposed to be carried out after year 2000.

- securing the supply,
- coordinating several transmission functions (for example taking care of the high-prioritized electricity production from renewable and cogeneration technologies and initiating R&D functions).
- commercial companies operating in the market who has the obligation to offer electricity supply to all consumers at reasonable prices
- production companies operating electricity production on market conditions.

The purpose by separating the monopoly and the commercial activities in utility companies is to prevent cross subsidizing.

Denmark's international environmental obligations with subject to CO<sub>2</sub> emission is intended to be regulated by transferable quotas for utilities. It is the purpose to ensure that the utilities on one hand contribute significantly to reducing the CO<sub>2</sub> emission and on the other hand still be able to keep up the favourable trade with Norway and Sweden and other European countries.

The principles in Electricity Supply Act no. 486 will be continued in order to secure and give continuous incentives to further development of electricity from prioritized production plants. This means renewable energy, decentral and industrial CHP. Therefore Danish electricity consumers will be obligated to carry their proportionate share of publicly determined services including environmental benign electricity. The system operator will take care of the practical distribution of the services.

Finally there will be created a specific green market for electricity production from renewable energy sources in order to ensure a viable and cost-efficient developing in this sector. The principals will to a large extent be similar to the proposal from Netherlands concerning a green market. Cogeneration plants fired with renewable energy sources will be an actor at this green market together with wind turbines.

## **5 - DECENTRAL AND INDUSTRIAL COMBINED HEAT AND POWER IN LIBERALIZED MARKET**

As mentioned earlier more than 80 per cent of the district heating production is based on combined heat and power production (see figure A). In Denmark 16 utility owned central cogeneration plants produce about 70 per cent of the total production. Nevertheless, this paper will focus on natural gas fired decentral cogeneration plants owned by municipal or consumer co-operatives and private owned industrial cogeneration plants. The reason for this decision is that these independent cogeneration plants will be particularly economically sensible for changes in the framework structure. Moreover, more than 250 decentralized cogeneration plants and more than 100 industrial cogeneration plants have been built during the last decade and far most of them still have substantial repayment of the investments in network and production plants.

Especially for existing decentral and industrial CHP it is important to analyze which economic and structural framework is necessary in order to meet conditions in a liberalized market. This analysis is presented beneath.

### **5.1. Decentral Combined Heat and Power**

The ambitious regulation in the Heat Supply Act is the background for the widespread extensions of decentral CHP. Heat consumers have been forced to be connected to the district heating system. Municipalities have also been forced to convert from typical heat only boiler plants to cogeneration plants based on primarily socio-economic criterias.

This framework has created significant energy political and socio-economic benefits. The result is an extension of decentral CHP from less than 20 MW<sub>e</sub> in the mid-eighties to 1273 MW<sub>e</sub> in 1996 as shown in figure B (see ref. no. 5). Now the major part (950 MW<sub>e</sub>) is based on natural gas and waste (200 MW<sub>e</sub>).

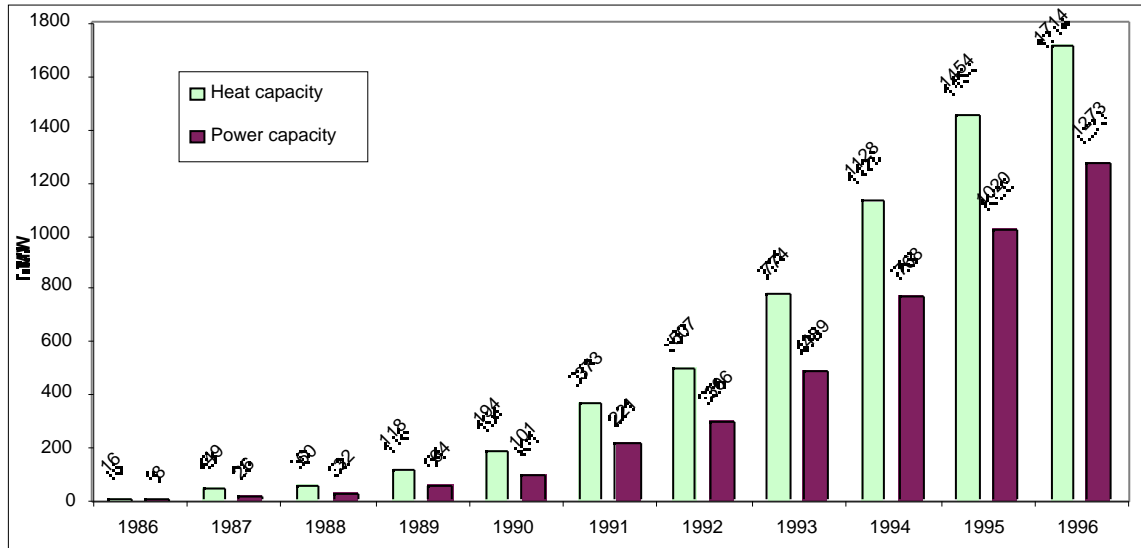


Figure 2 : Development of Decentral CHP for the Last Decade

Today in the framework, utility companies are obligated to buy the electricity production from the decentral and industrial CHP at electricity prices, principally based on the avoided cost of new utility production plants.

If the trade price of electricity decreases significantly, the natural monopoly of these networks may have a hazardous impact on the municipally owned cogeneration plants. The government can use Electricity Supply Act no. 486 to economically quarantine electricity produced under environment-friendly conditions. The great question is to which degree this possibility should be practiced. This highly depends on how sensible the overall economy is in the independent cogeneration plants.

As a reference, heat cost produced from decentral CHPs must not exceed heat cost produced from heat only boiler plants supplying district a heating network. Figure C shows the heat cost pr GJ from heat produced by a typical decentral CHP compared with a heat only boiler.

It appears that heat from decentral CHP typically can be produced 20 - 30 per cent cheaper than on a heat only boiler. Please notice that the value of electricity sold is most important for the economy. For example a decrease of 40 DKK per MWh<sub>e</sub> (5 EURO per MWh<sub>e</sub>) on electricity sale will increase the annual heat bill for heat consumers by approx. 1000 DKK (135 EURO). An average annual heat bill is about 9000 DKK (1250 EURO).

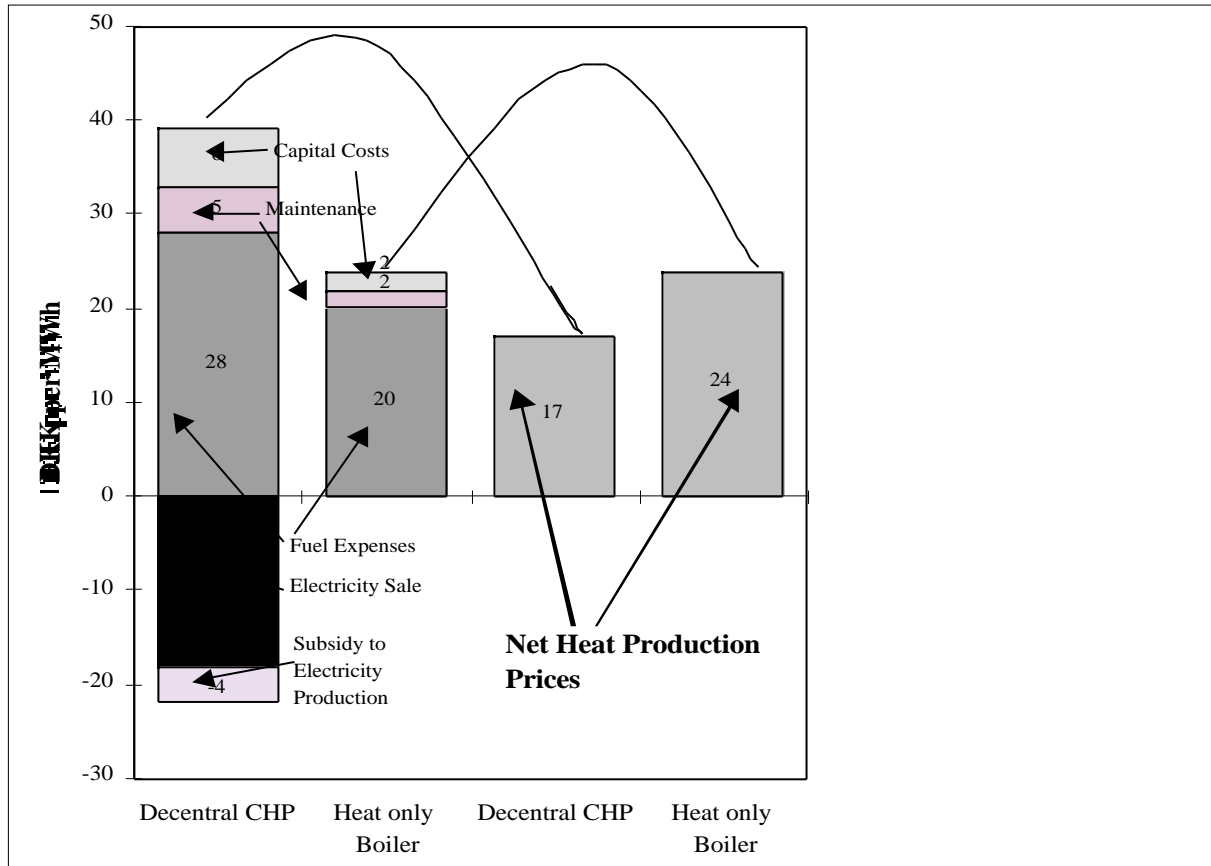


Figure 3 : Heat Production Prices in District Heating Network from Decentral CHP compared to Heat Only Boiler

Today the independent producers get an average of 380 DKK per MWh (50 EURO per MWh<sub>e</sub>) including the subsidy for running cost of 70 DKK per MWh<sub>e</sub> (8,5 EURO per MWh<sub>e</sub>). If the total electricity sales price was reduced to 310 DKK per MWh<sub>e</sub> (42 EURO per MWh<sub>e</sub>) the heat production price would increase to the same level as for the heat only boiler. The question is what will the electricity trade price be in the future.

We can only try to estimate the future electricity prices. Danish Energy Agency has tried to estimate the future electricity trade prices which is shown in figure D below. The estimate is based partly on the prices of Nordic Pool today and partly on an expected price increase when current surplus capacity is gradually being reduced. Please notice that Danish electricity production will only count for about 10 per cent of the total Scandinavian market.

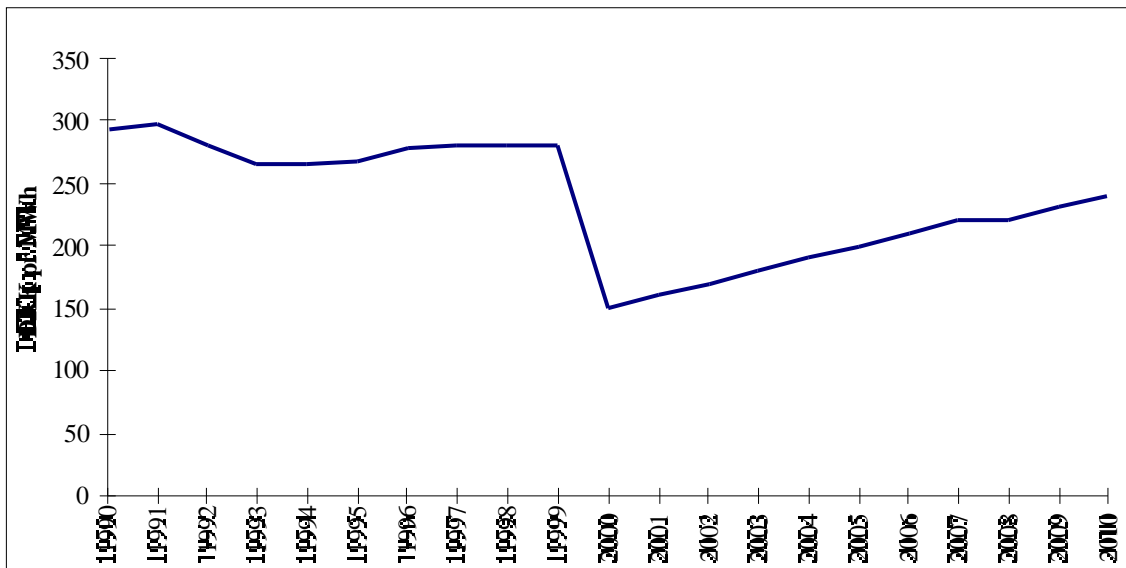


Figure 4 : Estimation of the future electricity trade price from (1999 to 2010) compared to average electricity production (+transmission) prices from utilities.

It is obvious that the heat production price of decentral CHP would increase dramatically if the electricity sales price would drop to a range between 150 - 220 DKK pr MWh<sub>e</sub> (18 – 28 EURO pr. MWh). A decrease of the gas price could soften the problem for the decentral CHP when the natural gas sector gets full access to the market. However, even if the net gas price (without taxes) would decrease to half of today's level the heat production price would still only reach that of heat produced by heat only boiler.

## 5.2. Industrial Combined Heat and Power Production

Extension of industrial CHP has reached about 350 MWe corresponding to half of the expected potential. However, only quite few industrial CHP have been planned since the subsidy for running cost was reduced from 100 DKK per MWh<sub>e</sub> (13 EURO per MWh<sub>e</sub>) to 70 DKK per MWh<sub>e</sub> (8,5 EURO per MWh<sub>e</sub>) in the beginning of 1997. There is no public request to force the development, as was the case with decentral CHP. Therefore the development has to be based on economically attractive means.

Like the decentral CHP the average electricity sales price from the independent producers today is about 380 DKK per MWh<sub>e</sub> (50 EURO per MWh<sub>e</sub>) including the subsidy for running cost of 70 DKK per MWh<sub>e</sub> (8,5 EURO per MWh<sub>e</sub>). Existing industrial CHP might stop their cogeneration production and instead use their old heat only boilers if the electricity sales would drop significantly.

For example, if the total sales electricity price is reduced to approx. 250 DKK per MWh<sub>e</sub> (33 EURO per MWh<sub>e</sub>) the heat production price would increase to the same level as for the heat only boiler. This level is too much above the expected future electricity prices.

## 6 - CONCLUSION

The analysis shows that decentral and industrial CHP will have great difficulty in competition on electricity prices even if the subsidy for running costs is maintained. If independent cogeneration is forced into competition there will be a great risk of a significant increase in heat prices. For example, heat consumers supplied from a decentral CHP will see an average increase of at least 5000 DKK per year (650 EURO per year). This is far from acceptable. There will also be a high risk that companies with industrial CHP will permanently convert to use heat only boiler and only use their CHP occasionally. These effects will cause a significant increase of the national CO<sub>2</sub>-emission.

It is therefore the intention to proceed with the principles in Electricity Supply Act no. 486 in which the electricity production will be prioritized. This is expected to be carried out as long as the independent electricity

production sector is too sensible to competition.

## 7 - REFERENCE

- (1) *Danish Government, 1996*. Danish Energy Action Plan Energy 21 (see WEB-address: [www.ens.dk](http://www.ens.dk) or [www.mem.dk](http://www.mem.dk) (English version))
- (2) *Danish Competition Authority, 1998*. Competition in the energy sector (Publication in Danish)
- (3) *The Ministry of Environment and Energy* Electricity Supply Act no. 486 of 1 of January 1998 ([www.mem.dk](http://www.mem.dk) only Danish version)
- (4) *Danish Energy Agency, 1998*. Main elements in the proposed electricity reform (draft version in Danish at WEB-address: [www.ens.dk](http://www.ens.dk))
- (5) *Danish Energy Agency, 1998*. Combined Heat and Power in Denmark (Publication in English)