Incentive Policy on Industrial CHP in Denmark

Mr. Jesper Koch, M.Sc Engineer
Danish Energy Agency

Synopsis

An economic incentive policy as a part of the “green taxes policy” is used by the Danish Government on natural gas fired and biomass fired industrial CHP.

Abstract

Growth of combined heat and power (CHP) within the industrial sector was up to 1993 rather limited mainly due to:

the relatively small number of industries having heavy energy consumption,
low Danish electricity prices,
unstable energy prices as well as changes in energy tax.

The introduction in 1993 of CO_2 taxes followed by "green taxes" in 1996 in the commercial and industrial sector resulted in considerable interest and numerous establishment of CHP in the industrial sector. Industrial CHP can give a considerable contribution of 3 - 4 per cent point to the fulfilment of the national target of 20 per cent CO_2 reduction by year 2005.

Major topics of the paper are:

Environmental benefits and contribution to the target in the Danish Energy 21 Programme.
Green taxes in the trade and industrial sector.
Incentives and subsidy structure in the green taxation policy
Industrial CHP competitiveness

1. Introduction

1.1. Background

Furthering the use of industrial combined heat and power (CHP)[1] can make an important contribution in the national energy programme as well as in the European climate strategy for reducing CO_2 emissions.

Utilization of CHP has a very great potential throughout the world in, for example, steam & electricity production in industry and heat and electricity production in district heating systems. Coal, natural gas, oil, different solid fuels and also biomass are used as energy sources. Estimates from 1994 and 1995 of the EEC countries indicate that CHP within the next 20 years may cover approx. 30 per cent or more of EEC power generation (Hammer 1996). It will imply a reduction of the CO_2 emission of approx. 15 per cent in EEC. An equivalent potential is found in Eastern and Central Europe.

Although CHP is arranged differently when used in either industrial CHP, small scale CHP in tertiary sectors or urban/community district heating schemes with CHP, these projects are from a life cycle consideration cost effective both as a means to reduce harmful emissions, including CO_2 and from a merely economic cost benefit point of view. The cost-effectiveness is primarily governed by physical site conditions and investment costs, cost of fuel supply, ability to export power to a nearby grid at attractive prices, maintenance costs and others. Crucial for establishing of CHP plants is reduction of the initial cost hurdle associated with the investment.

1.2. The Danish Government Objectives for reducing CO_2 Emissions

Denmark is among the heaviest CO_2-polluting countries in the world and therefore has an obligation to reduce her CO_2 emission. Like any other of the industrialized countries Denmark possesses resources to develop new and sustainable energy technologies. The Danish Government finds it beyond doubt that the risk of global climate change is a serious threat and calls for political action.

The Danish Government has therefore set the objective of reducing CO_2 emissions by 20 per cent by the year 2005 compared to the 1988 emission level. In figures it corresponds to a total reduction of 12 million tonnes (mt) from 60 mt to 48 mt. Furthermore, a long-term CO_2-emission target was described in the new energy action plan which the Danish Government presented in spring 1996 (DEA, 1995). The plan demonstrates that it may be technically and financially possible through a combination of energy-saving schemes, rationalization of energy systems and the use of renewable energy to halve the CO_2-emissions per capita by the year 2030.

A major instrument of the Danish CO_2-reduction policy is widespread extensions of CHP, mainly fired with natural gas, through policies involving economic incentives. Considerable CO_2-reductions are obtained when CHP production replaces electricity produced at coal-fired power stations.

1.3. Industrial Sectors

Since the beginning of the 1990’s the Danish CHP strategy involves other actors than the traditional energy suppliers. The new players on the CHP scene are the trade and industrial sectors. As a part of the CO_2-package, CO_2 taxes on trade and industry were introduced in 1993 together with subsidies for investment in energy efficiency, among these also investment subsidies for industrial CHP.

Up to 1993 extension of CHP within the industrial sector was rather limited. This was mainly due to the fact that Denmark only have a relatively small number of industries with heavy energy consumption. But also low electricity prices, unstable energy prices, and changes in energy tax together resulted in limited extension.

In 1996 the Danish Government launched “the package of green taxes” in trade and industry (Danish Government, 1995), thereby introducing a full recycling of taxes on energy consumption in combination with:

- energy efficiency voluntary agreements, with rebates on CO_2 taxes when companies enter into agreements,
- reduction of labour costs, and
- subsidies for investment in energy efficiency.

The purpose of the green package is to refund taxes on energy consumption in the industrial sector to industries that are willing to invest in, for example, combined heat and power production.

The CO_2 taxes followed by the “green taxes package” in 1996 in trade and industry, brought about considerable interest and establishment of numerous CHP facilities.

Today, installed electricity capacity in industrial CHP plants is more than 300 MW, mainly natural gas fired. With a actual development pace like the one we see today an installed capacity of 600 to 800 MW can be expected by the year 2005.

If industrial CHP develops as expected it will give a considerable contribution of *3 - 4 percentage points to the fulfilment of the objective of 20 per cent CO2 reduction* in the Danish energy programme.

If the expectations for district heating and industrial CPH are met, more than half of the objective of reducing CO_2 emissions by 20 per cent by the year 2005 will derive from utilization of CHP technology.

2. Potential of Industrial CHP

2.1. Energy Consumption in Trade and Industry

Gross energy consumption in trade and industry was 210 PJ in 1993, of which 155 PJ was for process and indoor heating, and 55 PJ was for electrical consumption. Table 2-1 shows energy distribution in trade and industry.

Table 2-1. Process and Indoor Heat Consumption in the Trade and Industrial Sector

Branche Year 1993	Gross Energy PJ	Distribution per cent	Electricity PJ	Proces/heat PJ
Agriculture	38,5	18	0,0	31,6
Recovery of Raw Product	3,8	2	0,0	3,5
Manufacturing	126,5	60	0,0	92,9
Building	6,2	3	0,0	5,1
Commercial	35,5	17	0,0	21,5
Total	210,5		0,0	154,6

2.2. Technical Potential

The attractiveness of industrial CHP will only become widely apparent if and when this technology can substitute for existing process- and indoor heating. The theoretical potential of industrial CHP in Denmark, which is heat in the temperature interval 0 - 400 ^{o}C is about 1/4 to 1/3 of the above mentioned process heat consumption. This corresponds to a “theoretical”, technical potential of 1700 MW_e (Danish Utilities, a.o., 1991).

The technical potential is estimated to approx. 1000 MW, mostly being natural gas fired. About 75 - 85 per cent of this potential is estimated to be covered by gas-turbine CHP, the rest of the potential covered by gas engines.

Compared to other countries Danish companies are not very energy intensive. Only about 120 Danish companies have energy consumption of more than 100 TJ. These companies account for about 75 per cent of total industry energy consumption. As for dimensioning only a few industrial CHP plants would be designed for 25 MW or more. Most of the potential is in the interval of 1 MW to 10 MW. The distribution of magnitude of industrial CHP is shown in figure 2-1.

2.3. Potential Based on Company Economies

A crucial point in a company’s decision to install CPH is the financial attractiveness. In general trade and industry requires relatively high return on investments. Minimum returns of 20 - 30 per cent are not unusual, especially in projects considered secondary in relation to the primary production. Industrial CHP projects are normally considered secondary investments.

In other words trade and industry will normally only find industrial CHP attractive when the simple pay back time is less than 3 - 5 years.

As mentioned earlier Danish companies are not very energy intensive and most of the potential is in the interval

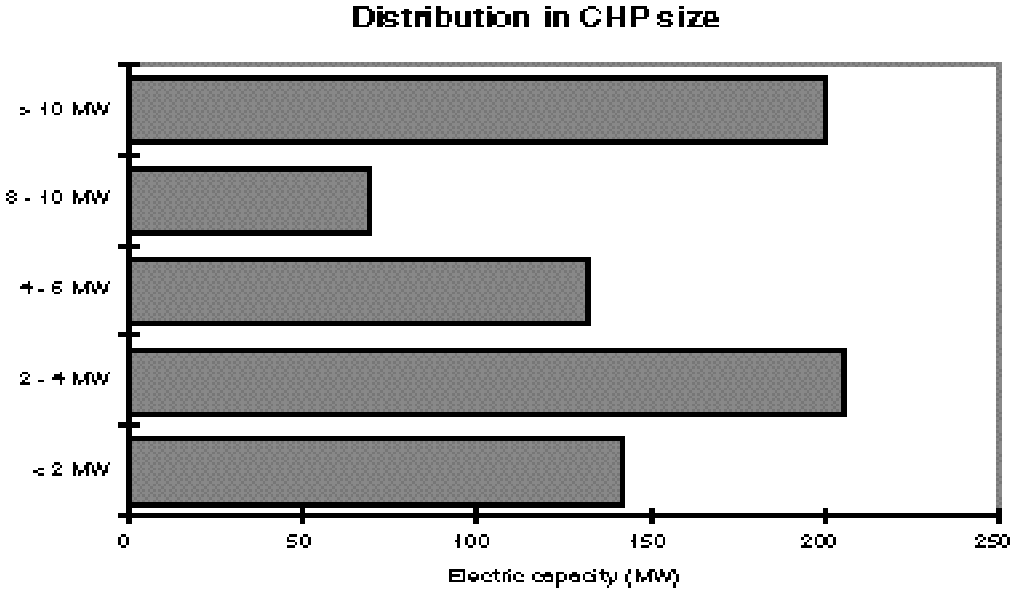


Figure 2-1. Distribution of Magnitude of Industrial CHP

of 1 MW to 10 MW. It has been experienced that the company economy of industrial CHP is in general not attractive. In Denmark recycling of subsidies raised from CO_2-levies are used as an instrument to provide favourable financial conditions for industrial CHP. Without subsidies or grants the simple pay back time would generally be more than 10 years. In other words the economical potential would generally be less than 100 MW, most of which would be coal fired, without subsidies in Denmark.

3. The Danish Incentive CHP Strategy for Industrial CHP

Economic incentives are used in Denmark in order to promote the extension of industrial CHP. This type of CHP is characterized by high cash-flow requirements and an inevitable need for short pay back periods of investments. In order to reduce pay back periods grants can be used as a CO_2-reducing tool. However, the government of Denmark sees grants for industrial CHP as funds well spent on industrial CHP because CO_2 is reduced in a very cost effective way. Therefore recycling of subsidies raised from CO_2-levies are used as an instrument to provide favourable financial conditions for industrial CHP.

3.1. Cost Benefit Estimates for CO_2 Emissions

The total cost of implementing industrial CHP must be compared to alternative investments in condensing power plants in the utility system because these investments can be saved. If heat only boilers for process or indoor heating in a company is worn-out investment in new heat only boilers also can be saved.

CHP, especially in community and industry, will usually provide economic benefits when assessed by a net present value calculation. This often renders “negative costs” to CHP as a CO_2 reduction measure, when comparing it to conventional separate condensing power systems and heat systems. In Denmark the level of the CO_2-tax has been set to 100 DKK per tonnes CO_2. This means that energy efficient technologies, which in principle can reduce CO_2 to a lower price than 100 DKK per tonnes CO_2 should be considered.

In figure 3-1 estimates of cost effectiveness of different CO_2 saving technology in Denmark is presented. It is seen that industrial CHP is very cost effective in reducing CO_2.

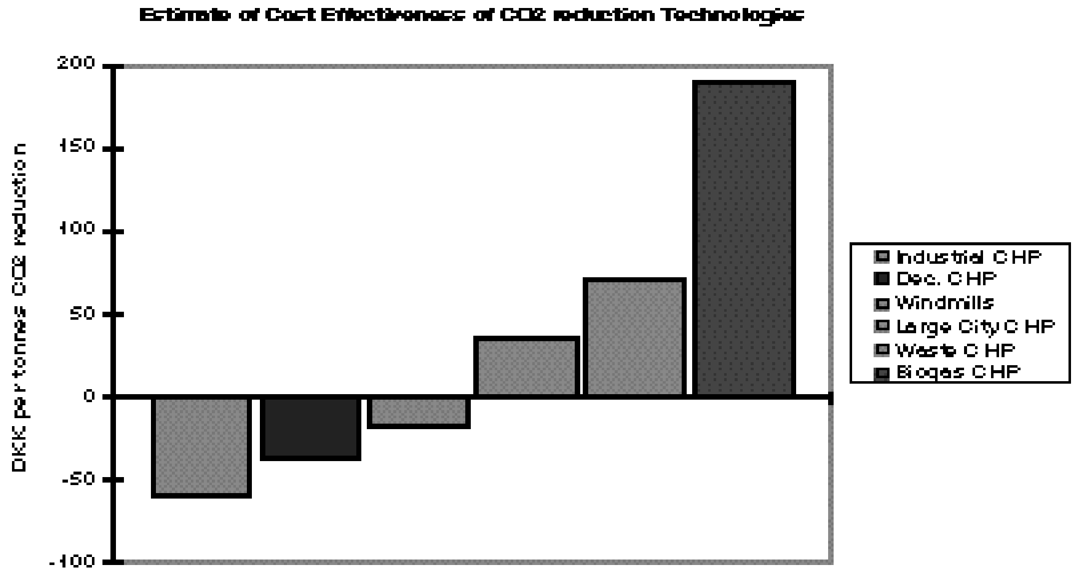


Figure 3-1. Cost Estimates for CO_2 Emission

3.2. Regulatory Objects

Regulations in connection with industrial CHP are made by the authorities in order to ensure CHP promotion. It is most interesting to focus on the topics - electricity prices, which effect the income to the industrial CHP and gas prices, which again effect CHP operating costs.

3.2.1. Electricity Price

Utility companies are obligated both to establish and pay connections to the industrial CHP and buy all the power production from the industrial CHP at electricity prices, based on the cost (i.e., no profit margin) value of electricity in utility companies.

Total long term avoided cost marked up for building condensing power plants, fuelling them etc. determines Danish electricity prices. Prices paid for CHP electricity vary by time and are found in three levels,

• peak hour production as the most expensive (condensing power plants)
• medium demand production, less expensive, and
• low demand production, least expensive (base load electricity production)

Therefore the electricity price is well known in advance and account for no barrier to industrial CHP.

3.2.2. Gas Prices and Taxes

In Denmark the CO_2-tax on electricity consumption is imposed on end-user level, but not on fuels used for electricity production. Therefore, when gas is used in CHP there is a distinction between gas used for electricity production and gas used for heat production. Gas used for electricity production is exempt from taxes while there is a duty on gas used for heat production.

Also the gas price is well known in advance and account for no barrier to industrial CHP.

3.3. Green Taxes on Trade and Industry

As mentioned earlier, green taxes on trade and industry were introduced in 1995. The philosophy behind the green taxes is to reduce rates on labour and raise rates on use of resources. Green taxes involve differentiated CO_2-taxes on fuel and electricity depending on its use for process purposes or indoor heating. Taxes on process purposes are maintained on a relatively low level - 3 to 90 DKK per ton CO_2 - in order not to reduce competitive power. Oppositely, taxes on indoor heating are rather high - 600 DKK per ton CO_2 - corresponding to taxes on domestic heating purposes. In addition SO_2-taxes are introduced on fuels and electricity. To distinguish between process and indoor heating companies are obligated to be able to amount measure for process and indoor heating.

It is important to notice that all the tax yield to the state is recycled to trade and industry mainly as investments grants when companies invest in energy efficiency appliances, for example industrial CHP.

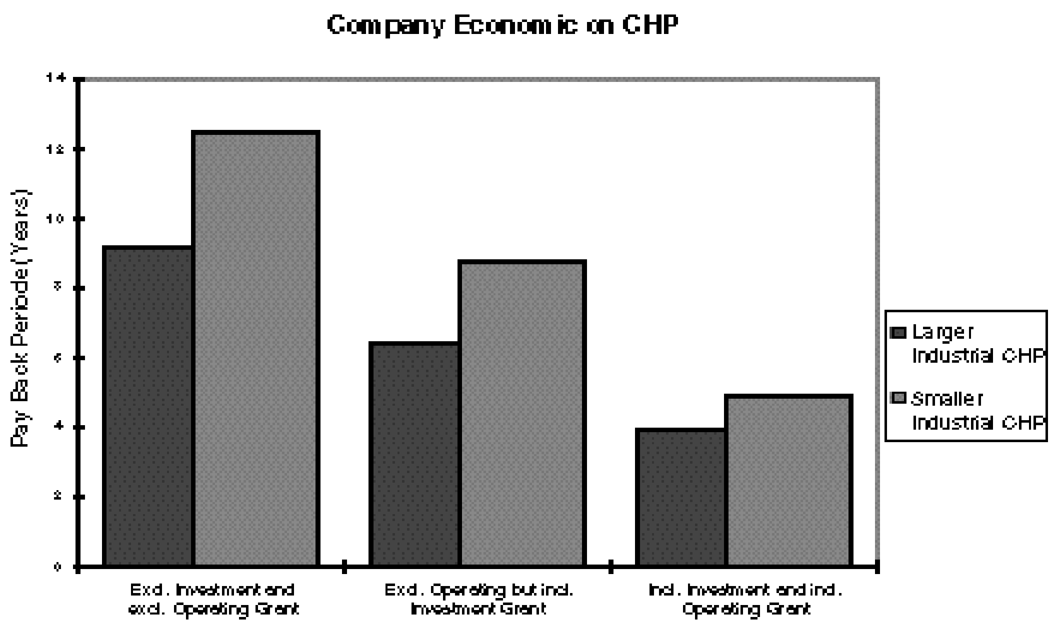
In the period from 1996 to 1999 the total amount of money returned to companies as investments grants is expected to be 2.6 billion DKK. During the same period Danish companies are expected to invest approx. 8 billion DKK in energy efficiency appliances. It is estimated that approx. 40 per cent of this total will be allocated to industrial CHP.

3.4. Economic Incentives

All CHP requires stable and favourable economic incentives. To promote industrial CHP two types of grants form part of the Danish CO_2 initiatives as a part of the recycling of subsidies raised from CO_2-levies:

- grant towards running cost specified as 70 DKK (≈ 9 ECU) per produced MWh electricity[2],
- investment grant on maximum 30 per cent of the total investment[3] in industrial CHP.

As mentioned earlier in this paper these two grants are necessary to provide a favourable and attractive economy. In figure 3-2 the company economics are shown for respectively a larger industrial CHP and a smaller industrial CHP. In both cases economics are presented as simple pay back period respectively excluding and including



grants.

Figure 3-2. Company Economy for Industrial CHP, Respectively Excluding and Including Grants.

From figure 3-2 it is obvious that for company economics, CHP will not be attractive without grants. Even with grants towards running costs only or investment grants only industrial, CHP economy is in general not attractive.

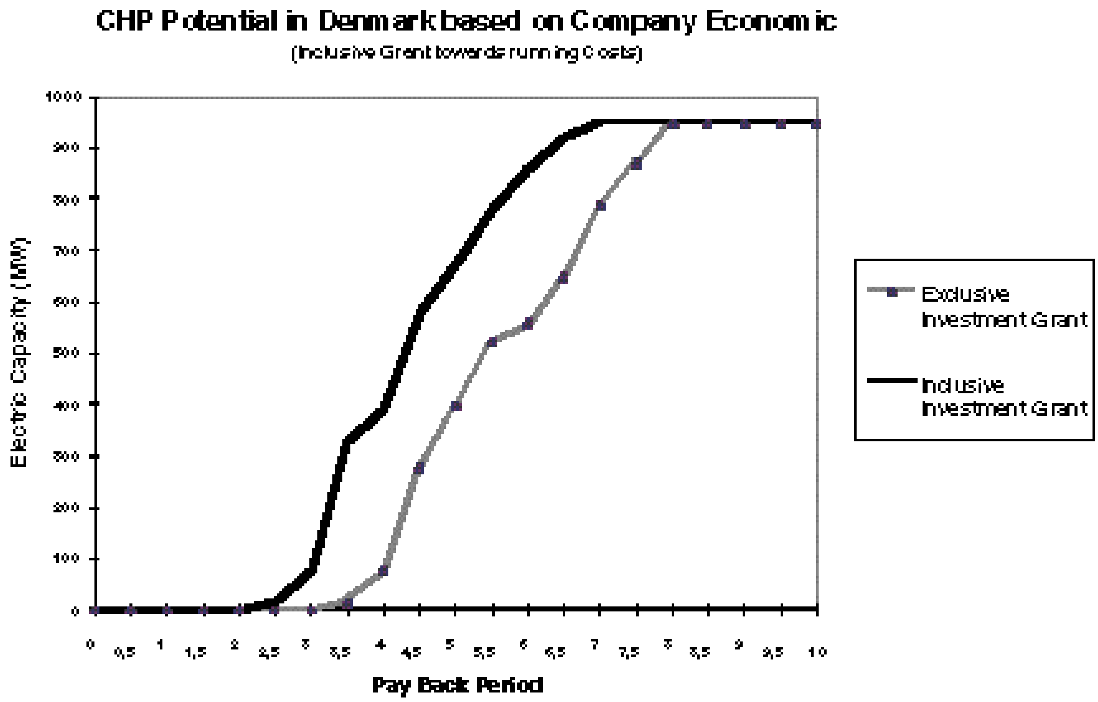
Only by subsidizing with both types of grants will company economics be favourable.
Under these circumstances the Danish Government has experienced great success, in generating widespread interest and extensions of industrial CHP.

3.5. The Potential and Contribution to the CO_2 Objective

In chapter 2 the technical potential of industrial CHP was estimated to be approx. 1000 MW. From this potential the company economic potential can be estimated. Please notice that company economic potential cannot be considered as a forecast of how much of the technical potential will be realized. A company’s decision whether or not to implement industrial CHP is influenced by other parametres in addition to the internal interest or pay back period. Company strategy, financing, development in energy prices etc. may be very important.

The expression “company economic potential” of industrial CHP means how many industrial CHP will be established with a certain probability. The company economic potential has been calculated (DEA, 1994) based on statistical information of energy use of Danish companies.

The calculation is based on energy consumption, data of investment, efficiencies, maintenance expenditure, gas- and electricity tariffs a.o. for companies with a heat demand of more than 20 TJ. For each company suitable for CHP the optimal configuration and size of CHP (steam turbine, gas turbine or reciprocating engine) has been calculated. Based on these calculations figure 3-3 shows the company economic potential of industrial CHP presented as a function of simple pay back period. The simple pay back period can only be considered as an indicator of



profitability.

Figure 3-3. Company Economy Potential of Industrial CHP

Please notice that the grant towards running costs - 70 DKK per MWh - contributes to the company economic potential. The company economic potential is shown respectively including and excluding the investment grant of 30 per cent of total cost. If solely grants towards running costs were given a company economic potential of approx. 350 MW could be anticipated. When investment grants are included it would not be unrealistic to anticipate a company economic potential of approx. 700 MW. Therefore only approx. half of this potential can be anticipated if investment grants are not included.

If 700 MW industrial CHP were to be established before year 2005 it would provide a reduction in CO_2 emissions of approx. 2 mt per year - corresponding to about 20 per cent of the total national CO_2 target.

From 1993 up to now nearly 200 MW of industrial CHP mainly natural gas fired has been established. About 100 - 150 MW was built up to 1993 without subsidies, mainly coal and oil fired.

Conclusion

Even though Denmark has a much less intensive energy structure compared to other European countries, Denmark has succeeded with an economic incentive policy as a part of the “green taxes policy”. The policy has resulted in great interest in industrial CHP. It is realistic to anticipate an extension of industrial CHP of approx. 700 MW which can give a contribution of 3 - 4 percentage point to the fulfilment of the national target of 20 percent CO_2 reduction by year 2005.

Reference

(1) Ture Hammer, 1996. CHP Programmes - Part of the Future EU Climate Strategy
(2) Danish Energy Agency, 1995. Danmarks Energifremtider.
(3) *Danish Government, 1995.* Erhvervene og Energien (also published in English)
(4) *Danish Utilities, Gas Companies and Danish Energy Agency, 1991.* Potentiale for Industriel Kraftvarme.
(5) *Danish Energy Agency, 1994.* Rapport fra Arbejdsgruppen vedr. Industriel Kraftvarme.

List of endnotes

[1] In this paper “industrial CHP” means Combined Heat and Power production in trade (commercial) and industry.

[2] Grant towards running cost will only be given for a period of 6 years respectively 8 years for industrial CHP less than 4 MW respectively larger than 4 MW. The limitation is introduced in order to avoid giving grants after the plant has been totally paid back.

[3] During the period 1996 to 1999 total spendable investment grant amounts to 2,6 billion DKK. It is expected that approx. 40 per cent of this amount will be stipulated to industrial CHP.