

Report of the Study Committee for Ecology

The Committee for Ecology has studied to what extent Combined Heat and Power have contributed to CO₂ reductions in the European Union and has determined the further CHP-potential for CO₂ reduction in the future.

Motivated by the promise of large energy efficiency gains and the potentials for reducing greenhouse gas emissions, the European Union has set the objective of doubling the produced amount of Combined Heat and Power (CHP) electricity from 9 to 18 % of the total electricity production by 2010 compared to 1994. Since the adoption of the strategy, outlined in the 1997 Communication »A Community Strategy to promote CHP and dismantle the barriers to its development« several policy initiatives have been proposed and adopted, which impact on the prospects for CHP. At the same time, there has been some degree of uncertainty about the actual level of CO₂ emissions, which CHP could facilitate in EU-15. The study at hand aims to make a step closer to the end of that debate.



Figure 1. Johann J. Hof from The Netherlands, chairman of the Study Committee for Ecology

Based on a detailed and coherent set of data, it determines the contribution of combined heat and power to CO₂ reductions. Different from many parallel studies, the study takes the technological development over the next decade into account. It considers a change towards cleaner fuels, both in condensing electricity production and in CHP plants. Further, it quantifies network losses - an often disregarded factor which nevertheless has an important impact on the emissions from electricity producing plants.

The Committee for Ecology has estimated by means of an extensive calculation model that if CHP production reaches 18 % of total electricity production by 2010, then CO₂ reductions from CHP will reach an annual level of 208 mln tons. When compared to only fossil fuelled electric power plants, the CO₂ emission reduction from CHP is more than 345 mln t in the year 2010. The findings of the report indicate that the Commission has underestimated the contribution that CHP will make to climate policy by 60 mln t CO₂. In its 1997 CHP strategy, the European Commission estimated that: »... CHP ... as replacement of existing electricity and heat production plants, could reduce CO₂ emissions by 150 mln t per year or approximately 4 % of the total EU CO₂ emissions in 2010.« The findings of the survey indicate that the European Commission should revise its figure.

The report also addresses the issue of the environmental benefits of CHP compared to those of the Combined Cycle Gas Turbine (CCGT) in power generation, and use of separate gas boilers for heating. The calculations clearly show that in terms of CO₂ reductions, combined heat and power, using the fuel mix in the market place, remains a stronger tool for CO₂ reduction than separate heat and electricity production

using gas only. If CHP was competing solely against CCGT in 2010, the result would still be a net reduction of 185 mln. tons CO₂ in favour of CHP. After all, even highly effective CCGT plants still generate approximately 40 to 45 % waste energy. The results are based on the premise that the CHP plants are operated at a high efficiency, around 80 to 90 % overall annual efficiency. Such direct competition between CHP and separate heat and electricity production is however no given thing. In fact, one could easily imagine that with the existing overcapacity of condensing power on the electricity market, and the resulting low electricity prices, the environmental performance of the electricity market will be much worse. During winter time, production of electricity is peaking. CHP plants are producing at their peak, so are the oldest hard coal and lignite plants, which also feature the highest emissions. If CHP production were to replace such types of plant, the calculations would come out very differently.

An 18 % penetration of CHP, avoiding only fossil plant would result in emissions reductions of 345 mln tons in 2010. This figure takes into account the gradual replacement of »dirty« plants with newer gas plants that is projected to take place. In the year 2000 the CO₂ reductions by CHP would stand at 235 mln t, even at the lower overall CHP penetration (11 %) compared to 2010.

The scenarios

The following scenarios have been taken into consideration:

1. CHP generated electricity replaces electricity produced with emissions corresponding to the average of plants running in the electricity sector, including nuclear and hydro
2. CHP generated electricity replaces only electricity produced in fossil fuel plants running in the electricity sector
3. CHP generated electricity replaces electricity from 55 % gas-fired combined cycle plants.

The calculations take into consideration two rough types of CHP:

- Localised CHP: This is combined heat and power located on-site or in a building of a single end-consumer of

heat. The owner can for instance be an industrial company or a company in the tertiary sector.

- District heating CHP: This is combined heat and power linked to district heating networks. In this case multiple heat consumers are connected to a heating grid.

It should be noted that this distinction is based on a loose observation of ownership, it does not need to imply any differences in technology. There can be, and there are, overlaps between these types of operators.

CHP electricity made out 6.9 % of total electricity production in 1990, divided on 4.5 % localised and 2.3 % district heating CHP. CHP electricity production reached 12 % of EU-15 electricity production in 1997. 8.4 % was in localised CHP and 3.6 % for DH CHP. Total production of CHP electricity was 268 TWh in 1997. By 2010, it is assumed that 7 % of all electricity in the EU will be come from district heating CHP and 11 % from local CHP.

Preliminary results

Scenario 1

CHP generated electricity replaces electricity produced with emissions corresponding to the average of plants running in the electricity sector, including nuclear and hydro power.

Table 1. CO₂ reduction in mln t in the EU if CHP replaces electricity produced with emissions corresponding to the average of plants running in the electricity sector

	1990	1997	2000	2010
District heating CHP				
CHP	20.8	39.7	47.8	74.8
Localised CHP	47.9	77.9	90.7	133.5
total CHP	68.7	117.6	138.5	208.3

In 1990, CHP has reduced CO₂ emissions by 69 mln t and in 1997 more than 11 mln t. In the year 2000 the number has risen to over 135 mln t. It can grow to more than 205 mln t per year when CHP electricity reaches its penetration of 18 % of total EU production.

The increase in the contribution to CO₂ reduction from CHP, takes place despite of the fact that a shift to cleaner fuels in condensing power plants has been foreseen over this period.

It is particularly important to stress that the scenario is not a realistic one, but has been done in order to allow comparison with other studies, which, seen from a CHP point of view are also not realistic. CHP will never replace

hydro power or nuclear power in the market place. This means that CHP generation will normally replace condensing power electricity based on fossil fuels. Generally, the results for CHP will come out better than indicated in this scenario.

If in the next ten years the foreseen fuel switch in condensing power stations and separate heat boilers towards cleaner fuels will not be realised, the CO₂ reduction by CHP would be as shown in table 2.

Table 2. CO₂ reduction by CHP if the foreseen fuel switch in condensing power stations and separate heat boilers towards cleaner fuels will not be realised

	2000	2010
District heating CHP	47.8	82.7
Localised CHP	90.7	149.1
total CHP	138.5	231.8

Scenario 2

CHP replaces electricity from the average fossil production unit in the market.

In 1990, CHP reduced CO₂ emissions by 131 mln t and in 1997 more than 205 mln t. In 2000 the number has risen to more than 235 mln t. By 2010, it has been assumed that the fuel and technology for condensing power units has changed, and the abated emissions accordingly. It is assumed that there will be 10 to 15 % less coal and 10 to 15 % more gas and waste/biomass combustion in condensing units by 2010. CHP would however reduce emissions by more than 345 mln t.

Table 3. CO₂ reduction in the EU in mln t if CHP replaces electricity from the average fossil production unit in the market

	1990	1997	2000	2010
District heating CHP				
CHP	50.7	80.7	93.6	136.4
Localised CHP	79.8	125.2	144.7	209.6
total CHP	130.5	205.9	238.3	346.0

The scenario analyses the result of a situation, where CHP replaces only fossil production of electricity, while leaving nuclear and hydro power untouched by any advance in CHP production. In this scenario, the contribution of clean gas plants will have increased significantly by the year 2010, replacing older types of coal plant. This is the reason for the relative decline in CO₂ reductions by CHP in 2010, relative to 2000.

If in the next ten years the foreseen fuel mix in condensing power generated and separate heat boilers remained the same, no switch towards cleaner fuels, the CO₂ reduction by CHP would be as shown in table 4.

It can be seen from table 4 that the relative decline between 2000 and 2010 will then not occur.

Table 4. CO₂ reduction by CHP if the foreseen fuel switch in condensing power stations and separate heat boilers towards cleaner fuels will not be realised

	2000	2010
District heating CHP	93.6	190.3
Localised CHP	144.7	264.5
total CHP	238.3	454.8

Scenario 3

CHP replaces electricity from gas fired combined cycle plant (with 55 % electrical efficiency)

Comparing CHP heat and power generation to a natural gas fired 55 % efficient combined cycle gas turbine (CCGT) plants on the electricity side (and normal diversified supply on the side of the separate heat boiler), is the »toughest« comparison in terms of environmental gains by CHP. CCGT plants feature very low emissions due to their overall high efficiency, and due to the low level of emissions in natural gas.

Table 5. CO₂ reduction in mln t if CHP replaces electricity from gas fired combined cycle plant

	2010
District heating CHP	69.7
Localised CHP	115.2
total CHP	184.9

The result of the scenario is however that CHP still will reduce CO₂ emissions by almost 200 mln t CO₂ by 2010.

The status

The outcome of this study is still preliminary and is now in the final process of an extra cross-check. Germany, Sweden, Denmark and Finland, have agreed on making parallel calculations with independent computer models and check whether or not the same calculation results will come up. If so, the report will be made final, expected to be published in May 2001.

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