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CHP STATISTICS AND IMPACTS OF THE GAS DIRECTIVE ON THE FUTURE DEVELOPMENT OF CHP IN EUROPE (CHP STAGAS)

Publishable SUMMARY Report

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Abstract

This document is a so-called Publishable Summary report of the SAVE project 'CHP statistics and Impacts of the Gas Directive on the future development of CHP in Europe'. It gives a summary of the objectives, analysis and results of the project. The CHP STAGAS project exists of two parts. A statistical Part A and a market and policy analysis oriented Part B. Part A deals with Collection of CHP statistics and Part B describes the Impact of the Gas Directive on the future development of CHP in Europe. The key objective of Part A was collecting CHP statistics with a similar new method for all EU Member States, Norway and Iceland. This is highly important because previously there did exist a wide diversity in data collection methods in Europe. Using one method is a prerequisite for precise monitoring and comparison of the developments of CHP in Europe using the Eurostat and Member State statistics. The objective of Part B was an analysis of the current and future competitive position of CHP in the European electricity and heat markets and moreover the impacts of the liberalisation of the gas and electricity markets and the required policy support in the Member States and in Norway. The project was conducted from January 2001 till June 2002. Since Part A and B were conducted in parallel some of the results are not influenced by the outcomes of the other part. As a reminder we emphasise that the new CHP Directive proposed by the Commission entitled 'Directive of the European Parliament and of the Council on the promotion of co-generation based on a useful heat demand in the internal market' was published very shortly after the ending of this study, namely on 22 July 2002. Therefore we have not included or referred to it. Nevertheless the two final reports of the CHP STA, respectively of the CHP GAS project together give a good overview of the historic developments and of future policies to successfully stimulate the development of CHP in Europe.

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1. INTRODUCTION

This chapter contains two paragraphs. The first paragraph presents some backgrounds of the European context of CHP. The second paragraph describes the activities conducted in both sub-projects of CHP STAGAS.

1.1 Background

The first initiatives of the European Commission (EC) regarding the development of Combined Heat and Power (CHP) resulted in the formulation of an industrial expert group in 1974 [77/714/EEC]. A Council Recommendation in 1988 [88/611/EEC] set out policy principles to remove legal and administrative obstacles to CHP development. In 1997 the European Commission published a Community Strategy to promote combined heat and power and to dismantle barriers to its development [COM(97) 514].

The main objective of this Community Strategy is to ensure needed co-operation between the all involved parties in order to dismantle barriers to the development and application of CHP. These involved parties include the European Community, the Member States (MS), end-users of heat and power and utility providers.

The CHP strategy proposes an indicative target of 18% CHP of the total electricity generation by the year 2010, which means twice as much as the current share of 9% in 1994.

In its resolution[1] on the CHP strategy the Council confirmed that the indicative target might guide increased efforts at all levels. In its report[2] on the CHP strategy the European Parliament (EP) suggested an indicative target share for CHP of at least 25%. However in April 2000 the recent Action Plan on energy efficiency[3] of the EC, reaffirmed its commitment to an indicative CHP target of 18% in 2010.

The EC recognises that the success of its CHP strategy depends upon a combination of mutually reinforcing measures at both Community and MS levels and that the strategy should be consistent with any existing MS policies. A complicating factor in developing promotion policy for CHP is the current implementation of the EU Directives for the electricity and gas market.

The gas market will be liberalised in accordance with the implementation in the MS of the EU Gas Directive (Directive 98/30/EC, COM (2001) 125 final). The question arises whether the liberalisation will benefit or hamper CHP production in the future. Two opposite developments can already be observed in the EU. In the UK, the liberalisation of the gas market resulted in much lower gas prices and a boost in CHP in recent years because partly condensing power production on CCGTs was banned for several years.

However in the Netherlands, the gas market liberalisation seems a threat for the future CHP development, since the special CHP tariff is abandoned and the new transport tariff system for gas appears to be unfavourable for (especially small-scale) CHP. In addition, Article 18 of the EU Directive on the liberalisation of the gas market (Directive 98/30/EC) allows MS to impose a

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1 Council resolution of 18 December 1997 on a Community strategy to promote combined heat and power.

2 Report on the Communication from the Commission on a Community strategy to promote combined heat and power (CHP) and to dismantle barriers to its development, Committee on Research, Technological Development and Energy, 23 April 1998.

3 Action Plan to Improve Energy Efficiency in the European Community, COM (2000) 247 final.

threshold for CHP regarding their eligibility and thus may deprive them from access to cheaper gas.

To enable the identification of CHP related developments within Member State and to enable the comparison between different Member States a certain standard on EU-level for gathering and processing data on CHP is essential. Moreover comparability is essential to enable the detection of barriers for CHP and to monitor the effects of certain (policy) measures taken by authorities or other actors in order to create improved conditions for CHP.

1.2 Project description CHP STAGAS

The project CHP STAGAS consists of two sub-projects both relevant for progress monitoring of CHP and meeting the CHP production targets in Europe. The first subproject (Part A, 'STA') concerns the 'CHP Plants statistics project 2000', with the objective to ensure the statistical monitoring of the CHP generation in the European Union. The other subproject (Part B, 'GAS') focuses on analysing the impacts of the implementation of the EU Gas Directive and electricity markets liberalisation in general on the development of CHP in the European Union, Norway. The next paragraphs give some more details of the objectives and scope of the two subprojects.

Part A: CHP statistics

This study concerned the following objectives:

- Applying a common approach, the so-called Protermo methodology, for collecting CHP data in the Member States and Iceland. This to improve CHP statistics in MS and Iceland for monitoring and benchmarking the CHP penetration in the European.
- Creating a appropriate infrastructure for the future collection of CHP data in EU MS.
- Assisting the agencies in the Member States in establishing systems for CHP data collection on a regular basis.
- Integrating the CHP statistics into the overall energy statistics system of EU and MS.

Part B: Impacts of Gas Directive and liberalisation electricity markets on CHP

Regarding the analysis of impacts of Gas directive and liberalisation on the economic viability and penetration of CHP we should realise that CHP has developed differently in the different MS within Europe. For different reasons, CHP has flourished in Denmark, Finland and the Netherlands whereas it is hardly penetrated in France, Ireland, Norway and Greece. We describe some of the success factors for CHP production. In some MS the accessibility and tariffs for natural gas have played an important role in the success of CHP. For instance in the Netherlands, CHP was benefiting from favourable gas tariffs where in addition gas was amply available. On the other hand, the poor gas infrastructure has hampered the development of CHP in Greece so far. In Austria, the gas tariffs have been unfavourable for independent CHP producers. In Sweden and Finland, the tax regimes are unfavourable for CHP. Another critical success factor are the government support schemes. A positive example of these support schemes can be found in Denmark where they have significantly supported the penetration of CHP/district heat, cooling (DHC). So the objective of Part B study is to assess more precisely the causes of lack of progress in enhancing the share of CHP in European countries and particularly to assess the role of the EU Directives and deregulation process in gas and electricity markets. So the main objectives of the study in Part B were:

- assessment of the different investment conditions in MR regarding CHP, barriers and incentives,
- analyse effects of liberalisation of gas and electricity markets on the economic viability of CHP production,
- calculate the economic feasibility of different gas-fired CHP technologies in the EU,
- formulate policy recommendations to create incentives for CHP investments.

The following two chapters summarize briefly the main assumptions, results and conclusions of this CHP study. For the full background and details of the project we refer to two final reports submitted to DGTREN in 2002. A final report concerning 'CHP statistics in Europe', Final report, CEREN, November 2002 and another final report entitled 'Impacts of the Gas Directive on the Future development of CHP in Europe', final version, ECN, May 2003.

The structure of the Summary report is as follows. Chapter 2 summarises the aggregated (per country over period 1994-2000 in tables and figures) results of the data collection, Part A of the project. Thereafter Chapter 3 summarises the assumptions, analysis and results of Part B of the project, entitled 'The impacts of gas and electricity market liberalisation on the future developments of CHP in the Europe'.

2. CHP STATISTICS: PART A OF PROJECT

2.1 Objectives and approach

Objectives

The CHP statistics have been systematically collected by Eurostat starting from 1994, which is the reference year for the target, of doubling the share of the CHP electricity generation from 9 till 18% in the total electricity generation by 2010. One of the main purposes of collecting the CHP statistics is to monitor the achievement of this target. The importance of promoting CHP has been recognised in the Member States, and national legislation has been created or updated to encourage CHP production. Over the years per country different definitions for the CHP production have been implemented. The definitions of CHP in the national legislation for exemptions from tax levy are often designed to maximise environmental benefits of the CHP production and are therefore often accepted as guideline for collecting data. Consequently the definitions of CHP can vary significantly across the Member States, depending on local conditions and policy framework. As a consequence the comparison of the environmental benefits of different CHP units per country can also be a rather complex task. The fuel used, the size of the unit, the choice of the reference scheme and the operational limits for example by low heat demand are to be accounted for in the calculations.

In the present CHP STA study the new Protermo methodology is applied for the collection of harmonised CHP statistics in all MS of the EU and Iceland. The methodology enables a better separation of the real CHP production from the total generation at a production unit level. Under certain conditions the electricity generated is considered to be completely stemming from CHP generation, whilst in some other cases the portion of the CHP electricity in the total electricity generation is calculated. The currently applied new method can be further improved by better defining the threshold, above which the electricity generation of a CHP plant is considered completely CHP electricity. Implementing this threshold would result in even more harmonised CHP statistics in MS than collected up to now.

So the CHP generation statistics include by default two types of data gathering, namely a data part, which is measured (total electricity generation) and the part, which is calculated (CHP electricity generation). The method applied to distinguishing between CHP and non-CHP electricity has an impact on the share of calculated amount of CHP generation from the total generation in CHP plants. The calculation part of data has a tendency to decrease the objectivity of the total of collected statistics, because calculations tend to be an approximation of reality.

Therefore the tuning of the methodology should be conducted extremely carefully to keep these statistics unbiased, transparent, simple and most of all comparable across the EU Member States and other European countries. The threshold for defining the need for scaling back the electricity generation should be selected in order to avoid excessive calculations and secure that these statistics to be collected in the future are also as unbiased and objective as possible.

However the purpose of applying the new Protermo methodology is not to define CHP production eligible for tax levy exemption. On the contrary, the data are collected for statistical purposes in order to provide comparable CHP statistics across the EU. The demand for comparable statistics at the EU level excludes the possibility of using national methodologies. Member States may, however, continue to publish national figures based on their own national methodologies, but obviously, these data will not be comparable across the EU.

This study concerned the following objectives:

- applying a common approach, the so-called Protermo methodology, for collecting CHP data in the Member States and Iceland. This to improve CHP statistics in MS, Norway and Iceland for better monitoring and benchmarking the CHP penetration in the European,
- creating an appropriate infrastructure for the future collection of CHP data in EU MS,
- assisting the agencies in the Member States in establishing systems for CHP data collection on a regular basis,
- integrating the CHP statistics into the overall energy statistics system of EU and MS.

Approach

Thermal energy is converted into electricity in conventional thermal power stations with a relatively low efficiency. The amount of generated electrical energy is around 30 - 40% of the energy content of the fuel consumed, and even in the most modern power plants it is still below 60%. The rest of the thermal energy is emitted into the environment. The principle of the combined heat and power production (CHP) is to use the remaining heat from the power generation for example for heating buildings or in industrial processes as process heat. A lot of primary energy can be saved by this simultaneous production of heat and power. The amount of overall losses is reduced to around 10 - 20% of the used fuel, depending on generation technology.

A power plant, which is equipped with heat recovery facilities in connection with electricity generation, is called a CHP plant. From the statistical point of view the simplest approach is to consider all the electricity and useful heat produced in these plants as CHP production. However, there are special features in CHP production, which complicate the collection of the statistics. First, a power plant has mostly several units, which haven't all the possibility for recovering the heat too. Therefore the collection of the statistics has to be carried out on a production unit basis. There might be some supplementary heating in addition to the CHP heat production. This supplementary heat can be produced for example in an extra boiler, completely separate from the CHP process. This supplementary heat has to be subtracted from the total heat generation of the plant. Also the fuel used to generate this heat has to be subtracted from the total fuel consumed.

There are flexible units, where the produced heat to power ratio is adjustable during the production process. The flexible units can be operated in a fully CHP mode, or they may also run without any heat recovery at all, depending on the current demand for heat and electricity. Variable heat loads are typical for district heating plants, whilst in industry the ratio between heat load and electricity generation is generally more stable.

Units with a possibility for only partial heat recovery are analogous to district heating plants concerning the statistical aspects of the study and the generated electricity is usually not completely CHP related. For example a large unit with a condensing extraction steam turbine, with a 500 MW_e electrical output and 10 MW_{th} heat recovery is certainly a CHP unit, but only a small portion of the generated electricity is a result of simultaneous heat and power production. The vast majority of the electricity generated in these types of units must not be considered as CHP production. The units with low heat production compared to electricity generation are called marginal CHP units. Consequently the adopted method for collecting CHP statistics must be able to cope with all the variable technical and operational features of CHP production in order to separate the CHP generation from the total production in a consistent and accurate manner. However, there are also other important boundary conditions to be accounted for in defining the appropriate methodology.

The previously conducted statistical surveys, e.g. by Eurostat, are used as a reference in this data collection study. The definitions remain unchanged, except some minor modifications outlined above. The Member States are requested to supply the aggregate data information in the form of completed tables, which are presented in Annex 1 of the Final report of Part A, which also contained the applied CHP definitions, see references. This Annex 1 contains also information on the capacity and production of operational units by type of cycle, also on the fuel input and the number of units, which are collected. The gross figures are reported in separate columns from the calculated CHP figures.

The following six types of CHP technology were considered to be relevant and representative for the data gathering:
- combined cycle
- steam back-pressure turbine
- steam condensing extraction turbine
- gas turbine with heat recovery
- internal combustion engine
- others.

2.2 Main Results

In the next paragraphs we present the final results of the CHP data collection study in terms of interesting final outcomes per country. Shown are different trends and developments from 1994 till 2000 for CHP plants per country for electricity production, capacity etc.

2.2.1 Cogeneration in the EU in 2000

First an overview of CHP electricity and its share in the overall electricity production per EU country in 2000 is presented below in Table 2.1.

Table 2.1 *CHP electricity production and share in gross electricity generation in EU in 2000*

Member state	CHP electricity [GWh]	CHP electricity in total electrical production [%]
Austria	6,408	10.4
Belgium	5,445	6.5
Denmark	18,971	52.2
Finland	25,510	36.4
France	16,280	3.0
Germany	60,836	10.6
Greece	1,137	2.1
Ireland	576	2.4
Italy	23,030	8.3
Luxembourg	208	17.7
Netherlands	43,153	48.2
Portugal	4,375	10.0
Spain	20,706	9.2
Sweden	9,075	6.2
United Kingdom	23,053	6.1
EU-15	258,763	10.0

The CHP electricity production in the EU in 2000 is 259 TWh, which represents 10.0% of the total electrical production in the EU. However the average ratio is the result of very contrasted situations from one country to another. For more disaggregated observations a classification of the member states in three groups of countries can be made, namely:
- The first group composed by Denmark, Finland and Netherlands in which CHP electrical production is high, exceeding 35% of their total production.

- The second group composed by Belgium, France, Greece, Ireland, Sweden and United Kingdom in which CHP electrical production is low, less than 7% of their total electrical production.
- The third group composed by Austria, Germany, Italy, Luxembourg, Portugal and Spain in which CHP electrical production is between 8% and 18% of their total electrical production.

2.2.2 Development of electricity and heat capacity

The operational hours per plant differ per climate and industrial conditions prevailing in a country and therefore also the installed capacities of the CHP plants per produced volume of electricity per CHP plant can differ per country. The figures on the installed capacities per output are presented in Table 2.2. Note that the gross electricity generation capacity in the EU countries (except for Finland and UK for which only CHP generation figures were available from previous years) has increased by 30%, in the period 1994 - 2000, from 64 to 88 GW.

In the same period, the heat capacity has increased to a lesser extend, namely from 151 till 177 MW, thus by about 17%, which can be explained by the strong growth of combined cycles and internal combustion engines producing more electricity and less heat per plant than the average existing installations.

Table 2.2 *Installed capacities of co-generation in period 1994-2000 [MW]*

Member State	1994*		1996		1997		1998		2000		
	Electricity	Heat	Electricity	Heat	Electricity	Heat	Electricity	Heat	Electricity	Gross	Heat
Belgium	728	3085	630	3048	721	3254	797	3189	1512	1540	4324
Denmark	5214	9180	5489	9581	5946	10152	7027	10999	5885	8796	10336
Finland	4085	12669	4256	13721	5018	14397	5097	14778	5502	6713	14800
Germany**	26183	46563	22542	40728	20666	41263	22160	35869	18747	18747	40755
Ireland	67	339	82	401	87	327	114	464	118	118	459
Luxembourg	na	na	na	na	31	61	98	204	45	45	119
Netherlands	6148	12055	6809	13673	8358	16558	8500	16912	9092	9116	12671
Sweden	2808	8480	2837	9407	3063	10627	3205	12440	3857	3857	13907
United Kingdom	3042	14765	3525	15189	3694	15651	3842	15338	6460	10632	10350
Austria	3246	6001	3134	7257	3409	7284	3416	7346	2879	3971	6347
France	2920	11190	3170	11531	3346	13405	3485	18837	4861	5276	17849
Italy	6328	17507	8034	19430	9519	20577	9802	23337	11994	12215	27814
Spain	1533	4706	2279	4275	3016	5130	3558	5313	3457	4961	11726
Portugal	991	4188	961	4292	921	4297	965	3978	923	1025	4196
Greece	218	562	218	552	218	552	257	709	706	706	910
Sub-total EU	*63511*	*151290*	*63975*	*153085*	*68013*	*163535*	*72323*	*169713*	*76037*	*87719*	*176563*
Norway	na	na	na	na	na	na	na	na	23	23	90
Iceland	na	na	na	na	na	na	na	na	76	106	350
Total	63511	151290	63975	153085	68013	163535	72323	169713	76136	87848	177003

(na: Non available)

* The Germany figures are for 1995.

** Figures for Germany are the gross capacity.

The increase in the electrical capacity from 1994 to 2000 is very large in the following countries: Spain and Greece: +224%; United Kingdom: +112%; Belgium: +111%; Italy: +93%; France: +81%; Denmark: +69%. The Netherlands and Ireland record also significant increases in the CHP electricity capacity, above 45% each. In Sweden and Finland, the increase is also substantial, 37% and 35% respectively.

Despite a decrease in absolute terms, namely 29%, still the largest total electricity capacity of the CHP generation 1994 - 2000 is reported in Germany. These developments are shown in Figure 2.1 and Figure 2.2, see table below.

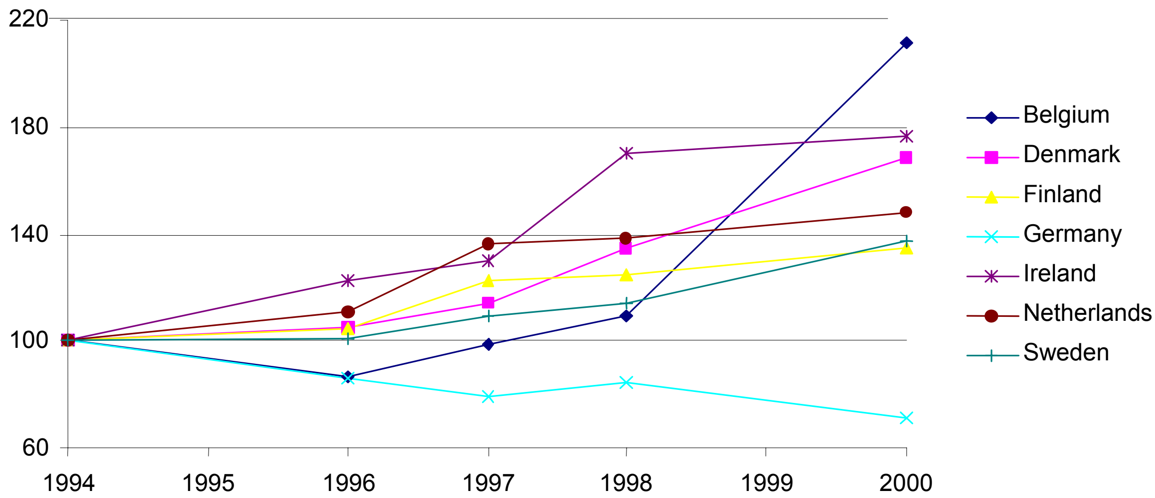


Figure 2.1 *Development of capacities of co-generation by Member State (Belgium, Denmark, Finland, Germany, Ireland, Netherlands, Sweden), development index 1994-2000*

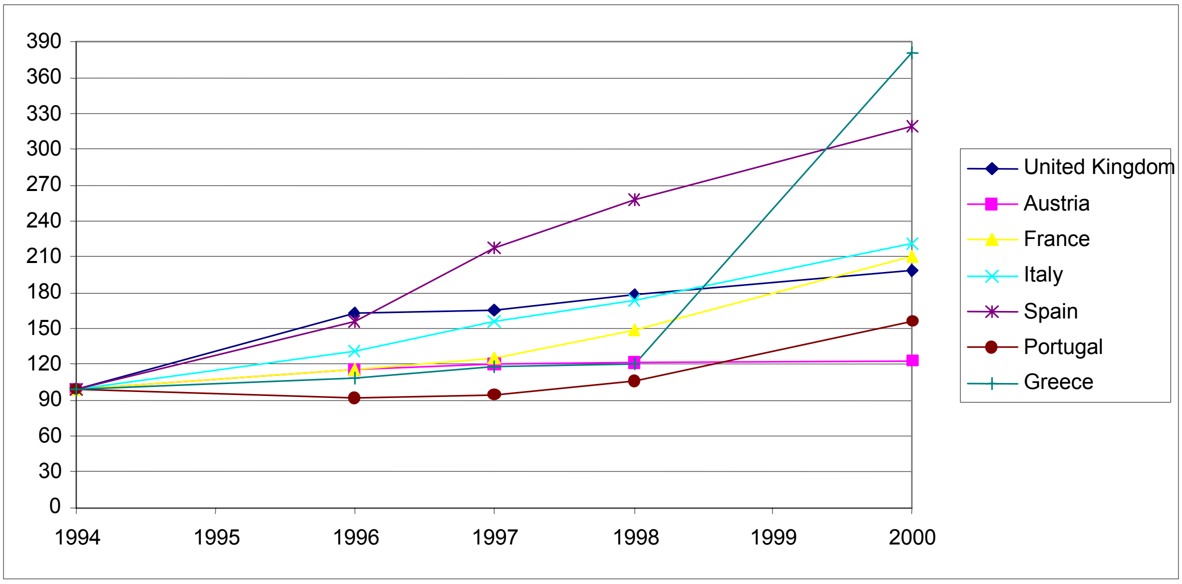


Figure 2.2 *Development of capacities of co-generation by Member State (United Kingdom, Austria, France, Italy, Spain, Portugal, Greece), development index 1994-2000*

2.2.3 Development of gross electricity production of CHP plants

It is also interesting to show the developments of the gross electricity production by CHP plants per country in the past period. See Table 2.3 for an overview.

Table 2.3 *Gross electricity generation by CHP plants 1994-2000*

Member State	1994[(1)]	1996	1997	1998	2000[(2)]
Belgium	2437	3729	3636	4113	6567
Denmark	21874	29260	26562	25591	29293
Finland	20312	22536	23049	25128	25510
Germany	47752	37817	36834	41770	60836
Ireland	259	357	457	404	576
Luxembourg	na	na	102	320	208
Netherlands	31543	36410	41502	47835	48367
Sweden	9257	10361	9301	9544	9081
United Kingdom	11619	18909	19290	20759	23053
Austria	11721	13539	14025	14268	14441
France	8506	9864	10663	12660	17952
Italy	26477	34670	41243	45990	58668
Spain	8537	13390	18567	21916	27200
Portugal	3111	2845	2949	3288	4863
Greece	819	886	968	981	3122
Sub-total EU	*204224*	*234573*	*249166*	*274567*	*329740*
Norway	na	na	na	na	101
Iceland	na	na	na	na	849
Total	204224	234573	249166	274567	330690

(1) German figures 1994 are based on 1995 data.
(2) The Finland & UK figures of 2000 based on data before 2000.

The gross electricity production in CHP plants (except for Finland and UK for which only CHP production data are available of years before 2000), increased from 204 TWh in 1994 to 330 TWh in 2000 (+62%). The strongest increases took place in the following countries:

- Greece +281%
- Spain +212%
- Belgium +169%
- Italy +122%
- France +111%
- United Kingdom +106%

In Figure 2.3 these trends are shown for all countries over the recent period 1994-2000.

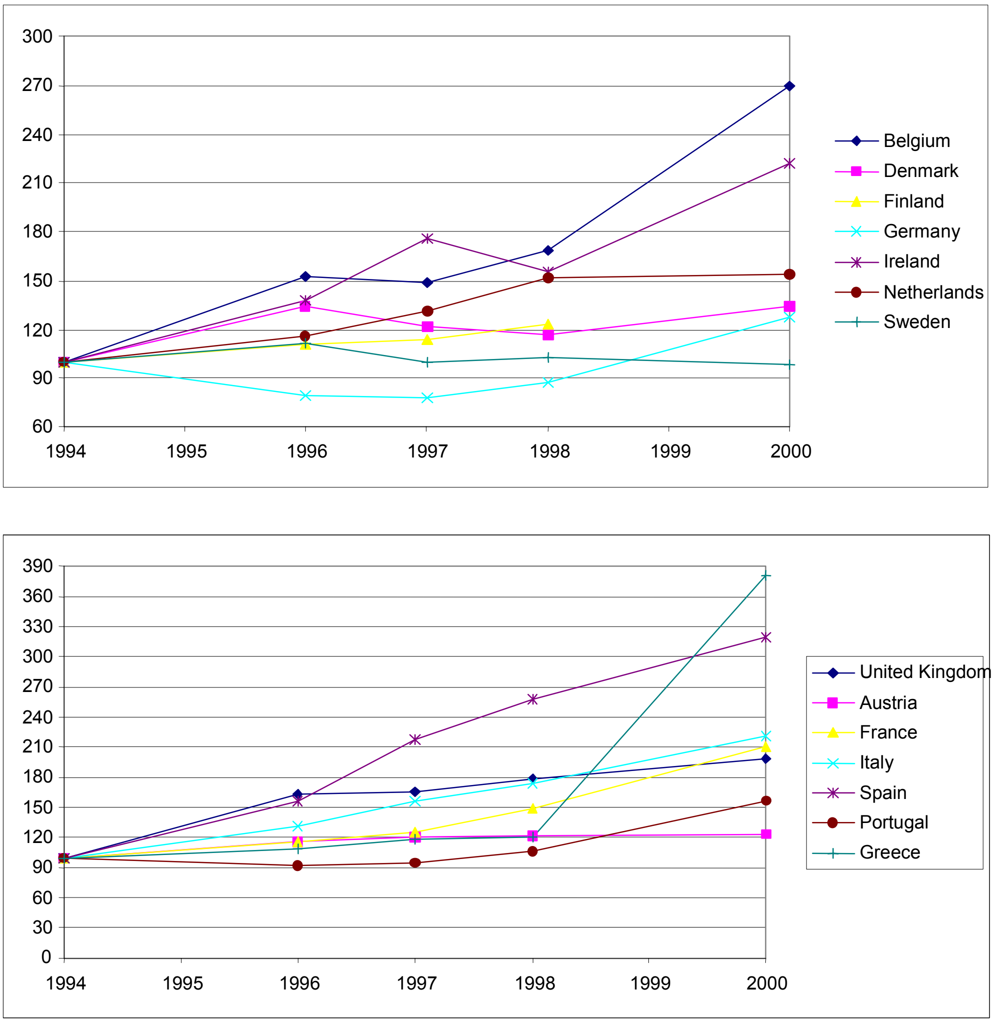


Figure 2.3 *Development Gross electricity production in CHP plants 1994-2000*

2.2.4 Development of heat production in CHP plants

The heat produced by co-generation in the 17 countries for the period 1994 - 2000 is shown in Table 2.4. The heat production has increased by 12% between 1994 and 2000 in these countries. In fact, it increased from 1994 to 1997 and then changed very little from 1997 to 2000. The largest increase in relative terms is recorded to Greece (+111%) in front of France (+91%) and Spain (+79%). The increase is also significant in Portugal (+38%), Denmark (+26%), Belgium (+21%) and Ireland (+15%). Germany, Sweden, Austria, Italy and Finland show a stabilisation or de-crease in their CHP heat production. Despite of the stabilisation in production in Germany, it is still largely the largest CHP heat production before Finland, Netherlands, France, Italy and United Kingdom.

Table 2.4 *Heat production in CHP plants 1994-2000*

	CHP Heat [TJ]				
Member State	1994	1996	1997	1998	2000
Belgium	38969	32194	37102	38029	47013
Denmark	92387	119116	116296	119717	116494
Germany	446886	362984	345510	340761	451825
Ireland	3930	5827	4670	4861	4537
Luxembourg	na	na	563	2197	1418
Netherlands	171026	206443	223511	238765	232668
Finland	256402	264236	274385	269439	251484
Sweden	124471	138690	144785	155751	121290
United Kingdom	205564	229261	224557	202165	205763
Austria	79178	101637	88599	81467	69214
France	116565	128788	154746	170670	222628
Italy	253675	296266	367071	397796	215571
Spain	91509	104508	141770	141321	164996
Portugal	46916	48080	51813	50799	55709
Greece	5490	6612	7460	7472	11560
Sub-total EU	*1932968*	*2044642*	*2182838*	*2221210*	*2172171*
Norway	na	na	na	na	1205
Iceland	na	na	na	na	4343
Total	1932968	2046638	2182838	2221210	217719

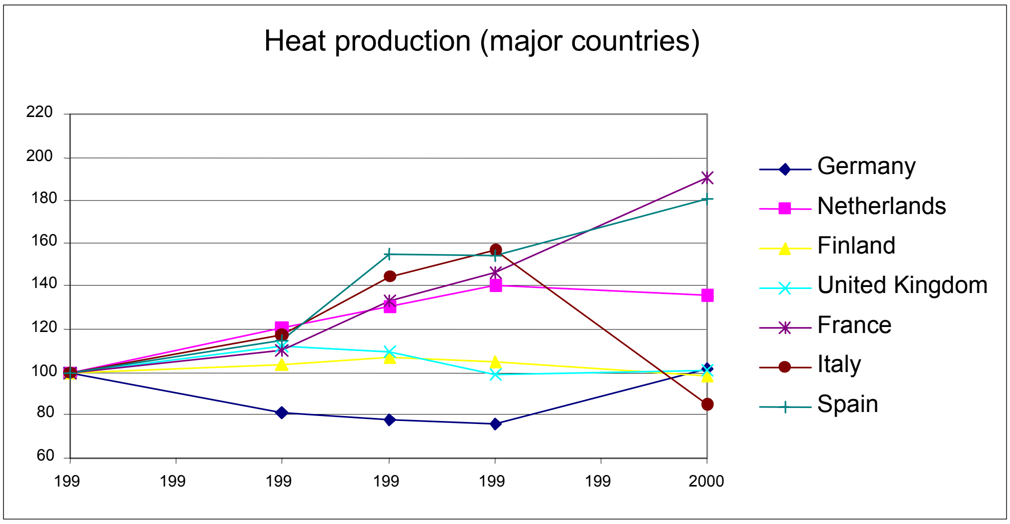


Figure 2.4 *Development of heat production of co-generation by Member State (Germany; Netherlands Finland; United Kingdom; France; Italy, Spain) in 1994-2000*

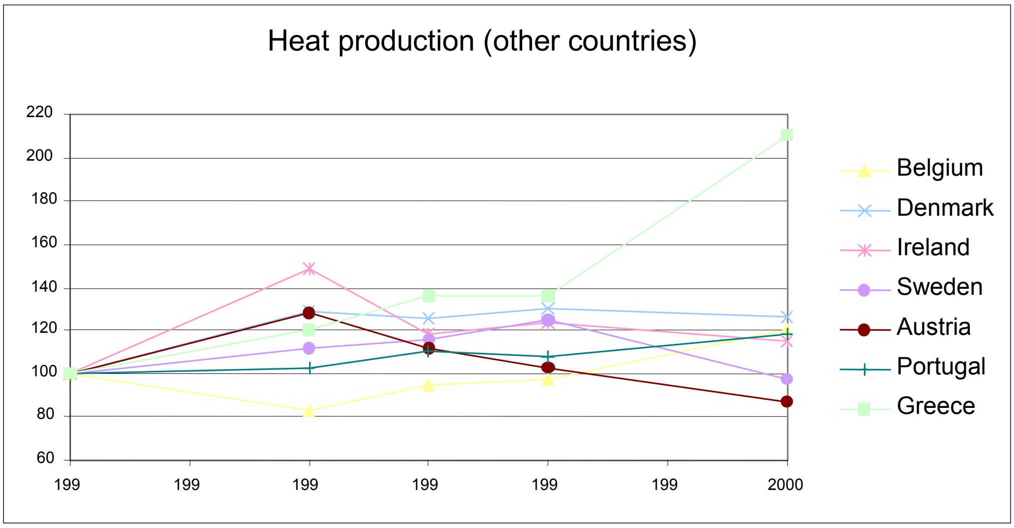


Figure 2.5 *Development of heat production of co-generation by Member State (Belgium, Denmark, Ireland, Sweden, Austria, Portugal, Greece) in 1994-2000*

2.2.5 Development of gross electricity generation in CHP plants per sector

The structure of the energy demand per economic sector, and the share of CHP in the public sector or industry differ per country. In one country more than 80% of the CHP electricity is produced in public power stations, e.g. in Denmark and Belgium. But this share is less than 10% in Italy and in the United Kingdom and even 0% in Spain. On the whole, the EU share is 59% for auto-producers mostly in industries and 41% for supply to the public sector consumption.

Results show that in Belgium, the CHP production in the public sector is multiplied by a factor 5, in the period 1994 - 2000 (and by 16 in France), and it has decreased by the auto-producers. In fact, the public supply authorities now manage some of auto-producers installations.

In nearly all the sectors of the economy there is production of electricity, but the CHP electrical production is mainly concentrated in three industry sectors:

- the chemical industry 60 TWh (28%)
- the paper and printing industry 39 TWh (18%)
- the refineries 30 TWh (14%).

The importance of CHP in these sectors is partly explained by their relative large need for 'heat at low temperature' in the form of steam.

2.2.6 Development of gross electricity production in the CHP plants per technology

Next it is interesting to show the role of different CHP technologies in the different countries. In Table 2.5 we give an overview.

Table 2.5 *Gross electricity generation in CHP plants by technology 1994-2000*

EU-15	1994[(2)]	1996	1997	1998	2000
Combined cycle					
Gross Electricity production [GWh] [(1)]	31176	61260	85238	90309	111762
Heat production [TJ]	178886	320430	404073	464688	428181
Steam: total backpressure turbine					
Gross electricity production [GWh][(1)]	72265	67562	65905	63844	78957
Heat production [TJ]	1195969	1098197	1106941	1063291	1032921
Steam: condensing turbine with heat extraction					
Gross Electricity production [GWh][(1)]	73539	67103	62572	64190	62126
Heat production [TJ]	359085	379465	388100	368086	292870
Gas turbine with heat recovery					
Gross Electricity production [GWh][(1)]	19999	22121	25068	30993	36898
Heat production [TJ]	154820	166544	183283	212813	224426
Internal cumbustion engine					
Gross Electricity production [GWh][(1)]	8491	15093	19741	24362	34986
Heat production [TJ]	42046	75924	97950	110112	154138
Others					
Gross Electricity production [GWh][(1)]	242	705	289	164	5008
Heat production [TJ]	2162	4082	2491	2221	39633

(1) Gross electricity production, except for Finland and UK (CHP production)
(2) German figures are relative to 1995

Steam turbines cover almost 43% of the gross electrical production and 59% of the heat production. In the period of 1994 till 2000 experienced a strong growth of combined cycles (+259%) and of internal combustion engines (+312%), especially between 1994 and 1996, but on the other hand, a stabilisation in the capacity of steam turbines as CHP option.

2.3 Summary and other trends

Situation in 2000

CHP electricity generation in the EU in the year 2000 is estimated at 269 TWh, which represents 10% of total electricity generation and 19% of conventional thermal generation. This production is made up of installations having an efficiency exceeding 75% or it is a part of the production of the less efficient installations. The development of the gross electricity generation is more relevant, is namely 364 TWh.

Another important observation is that CHP electricity production is mainly concentrated in the following countries:

- Germany 61 TWh or a share of 23%
- Netherlands 43 TWh or a share of 16%
- Spain 27 TWh or a share of 10%
- Finland 25 TWh or a share of 9%
- United Kingdom 23 TWh or a share of 9%
- Italy 23 TWh or a share of 9%
- Denmark 22 TWh or a share of 8%.

Development between 1994 and 2000
It seems that the Gross electricity production (except for Finland and UK for which only CHP production data are available) has increased from 205 TWh in 1994 to 330 TWh in 2000 (+ 62%). This strong increase is mainly due to the growth of CHP in the following countries:

- Greece +281%
- Spain +212%
- Belgium +169%
- Italy +122%
- France +111%
- United Kingdom +106%.

Furthermore the CHP electrical capacity is estimated to be around 77 GW_e in 2000. It has continuously increased from 64 GW_e in 1994 to 77 in 2000. CHP heat capacity is estimated to be around 177 GW in 2000. So it slightly but continuously increased from 151 GW in 1994 to 177 GW in 2000 (a growth of +17%). CHP heat generation is estimated to be around 2200 TJ in 2000, and increased from 1994 (1900 TJ) to 1997 (2000 TJ) and then it changed very little from 1997 to 2000.

The total energy consumption of CHP is 4874 PJ in 2000. It has increased by 34% from 1994 to 2000. The structure of fuel mix continues to follow a trend away from using solid and liquid fossil fuels and increased use of natural gas. Notable by the way is that the share of solid and liquid fossil fuels has dropped from 43% in 1994 to 31% in 2000, while the share of natural gas increased from 30% in 1994 to 46% in 2000. The renewable energies consumption of CHP also increased in this period, from 420 PJ to 580 PJ, with stagnation in the period from 1998 to 2000. This is probably caused by a change of definition of renewals (only the bio-degradable part of the municipal solid waste is asked to be included in the questionnaires for renewals in 2000).

CHP plants under construction
Finally the results of the questionnaires on plants under construction are presented. A summary of CHP plants currently (in 2000) under construction is presented below in Table 2.6.

Table 2.6 *CHP units under construction in EU in 2000*

	Gross electrical capacity [MW]	Number of units	Capacity under construction/ installed capacity [%]
Belgium	75	39	5
Denmark	486	5	5.5
Germany	0	0	
Ireland	4	11	3
Netherlands	0	0	
Finland	429	9	8
Sweden	70	2	26
United Kingdom	2719	26	26
Austria	0	0	
France	1384	201	26
Italy	240	13	2
Spain	639	72	13
Portugal	0	0	
Greece	145	22	20
Luxembourg	-	-	
TOTAL EU	6195	404	7

From Table 2.6 it becomes clear that a number of 400 CHP units were under construction in 2000 in the EU. These units have a gross electrical capacity of around 6,200 MW, and are representing about 7% of the actual electrical capacity.

But note that the situation varies greatly from one country to another, i.e.:

- No announced construction reported for Germany, Netherlands, Austria, Portugal and Luxembourg.
- Announced construction for 719 MW in the United Kingdom and 1.384 MW in France, representing each about 26% of the already in the respective country installed CHP capacity.

Clearly the developments in CHP capacity is largely influenced by the liberalisation process of and recent energy price developments in the European gas and electricity markets. The topic, of the conditions for and the 'willingness' to invest' in CHP plants is the key issue discussed in the next chapter of this report.

3. IMPACTS OF GAS DIRECTIVE ON CHP: PART B OF PROJECT

3.1 Objectives

The primal objective of the study is to assess the impacts of the implementation of the EU Gas Directive (98/30/EC) and liberalisation of gas and electricity market on economic viability and therefore development of combined heat and power production in general terms and specifically for all the 15 individual MS and for Norway. As currently more than 50% of all CHP plants in Europe are gas-fired units, and most of new CHP build are gas-fired plants, the gas price is an important factor for the cost effectiveness and further expansion of CHP in Europe. The establishment of an internal gas market will clearly affect the gas prices within the different Member States and this will influence the profitability of CHP and therefore the further expansion of CHP and meeting the EU targets. However it has also become clear that the liberalisation of the electricity markets in the member states and Norway are highly relevant for the profitability of CHP electricity and operations therefore also the impacts of the electricity Directive on the markets in MS will be assessed. Finally it should be emphasised that MS have all a different pace of implementation of the two Directives and also different policies that can facilitate or hamper the investments in CHP.

Therefore the study objectives are:

- Evaluation and comparison of the different investment conditions regarding CHP in the different MS. This by identifying the barriers to & incentives for promotion of CHP.
- Analysation of effects of the liberalisation of the gas and electricity market, e.g. prices, access to grid in order to assess the economic viability of CHP production and investments in the MS individually and the EU as a whole.
- Construction of a database containing all relevant policies and other market conditions, which influence the competitive position of CHP per MS in the European Union.
- Assessment of economic feasibility of most relevant gas-fired CHP options per country under different policy, gas and electricity market conditions foreseen in the next ten years.
- Formulating (policy) recommendations to mitigate barriers and create policies to create incentives to enhance the economic viability of CHP in MS.

3.2 Methodology and approach

The study contained the following tasks:

- Review of current situation influencing the underlying market conditions and economic viability of CHP in all EU MS and Norway, resulting in an assessment of all relevant supportive policies, barriers and trends in prices and regulations in the relevant gas & electricity markets.
- Collect all elements of the attractiveness of the CHP option in the EU MS and Norway and store these in a database. Thereafter the database for respectively electricity and gas market contains an inventory of CHP barriers, policy measures and incentive schemes currently in place in EU MS and Norway.
- Model analysis of the cost-effectiveness and viability of different relevant standard gas-fired CHP technologies under different conditions relevant for an investment decision. This by calculating the Internal Rate of Return (IRR) for six relevant CHP gas-fired technologies, under different load and capacity (scale) conditions, and through comparing effects of different policy packages (compared with a reference situation) on the IRR. This for all different European countries.

- Assessment of the improvement, if any, of the competitive position of the six different gas-ired CHP technologies and formulation of policy recommendations for countries to improve the investment conditions and economic viability of CHP in the next ten years.

3.3 Gas Directive and Market EU

Currently the single most important aspect of gas market policies in the EU is the establishment of the internal market for natural gas. During the discussions for the preparation of the EU Gas Directive (Directive 98/30/EC), which was adopted by the European Parliament and the Council in June 1998, individual countries already began to take steps towards liberalisation of their national gas markets and are expected to do so in the next years. Member States have to take care that the Directive is implemented into their national laws by 10 August 2000. The Directive basically takes over the principles of the Directive on electricity (Directive 96/92/EC) earlier launched. This means the regulation of access to the system, reciprocity, subsidiary and the gradual opening-up of the market, while taking account of the specific features of the natural gas market.

3.3.1 Opening-up of the gas market

Member States will specify eligible customers, meaning those customers inside their territory, which have the legal capacity to contract for natural gas undertakings. Member States will take the necessary measures to ensure that at least the following customers are designated as eligible customers:

- All gas-fired power generators are eligible. Member States may introduce a threshold for the eligibility of combined heat and power producers in order to safeguard the balance of their electricity market.
- Other customers who consume more than 25 million cubic metres (mcm) of gas per year (on a consumption site basis) are also indicated as eligible.

The definition of eligible customers must result in a market opening of at least 20% of the annual national gas consumption. This percentage will increase to 28% five years after the Directive becomes active, and to 33% after ten years. The percentages come with thresholds for eligible customers, other than gas-fired power generators, of 25 mcm, 15 mcm and 5 mcm per year on a consumption site basis.

Table 3.1 *EU gas market opening*

		1998 (2000)	2003	2008
Power producers		all	all	all
Other final customers	[m^3]	> 25 million	> 15 million	> 5 million
Minimum opening	[%]	20	28	33
Optional maximum opening	[%]	30	38	43
EU average	[%]	33.3	36.7	42.5
Latest estimate	[%]	70 by August 2000		80

Source: Geil, CEC presentation 1999.

3.3.2 Organisation of access to the system

For the organisation of access to the gas network system Member States may choose between two procedures (negotiated access or regulated access), which must operate in accordance with objective, transparent and non-discriminatory criteria.

- Negotiated access (nTPA): natural gas companies and eligible customers inside or outside the territory covered by the system can get access to the system by negotiating with the

relevant natural gas undertaking. The natural gas undertaking will be required to publish its terms for use of the system annually.
- Regulated access (rTPA): Natural gas companies and eligible consumers have the right to access the system on the basis of published tariffs and/or other terms and obligations for use of that system.

For the independent use of storage facilities (that is independent from using the network system) there are no provisions in the Directive. It is argued that the use of storage is always related to the use of outlet pipelines, it cannot be viewed as separate from the network.

3.3.3 Derogations of Gas Directive

For Member States and natural gas undertakings it is possible to apply for derogation of the Gas Directive. The following exceptional situations may be qualified for derogations:
- If a natural gas undertaking encounters serious economic and financial difficulties because of its take-or-pay commitments (some of their customers could decide to purchase their gas elsewhere), it may ask derogation from the requirement to allow access to the system by third parties.
- If a Member State is not connected to the interconnected system of any other Member State and has only one main external supplier (i.e. a supplier having more than 75% market share).
- If a Member State is an emergent market (or has a geographically limited area that is emerging), which will experience substantial problems when adopting the Directive, with a view to encourage investments.

The derogation may also be granted in case of capacity constraints of the network. The Member States are obliged to establish a dispute settlement entity in their country, to which one can turn for appeal on these derogations. The Member State and/or European Commission may grant the derogation. The derogations can only be temporary and may not disturb the functioning of the common market.

3.4 Electricity market liberalisation and CHP in EU

An indicator of openness of the electricity market to CHP is that the conditions for connection of CHP to the grid are transparent and non-discriminatory, unless direct support schemes are the norm. The existence of a standardised formula or tariff would be an indication of openness. The lack of published criteria for network access hampers the entrance of new generators. The last column of Table 3.2 shows that in most countries there is no clear, transparent information available about the connection costs, even though a high nominal degree of competition has been achieved in terms of market opening. Except in the Netherlands, UK and Norway, information does not exist on the cost of connecting to the state owned grid. The connection fee is generally dependent on voltage level.

In the absence of any standard conditions, a new entrant will normally have to pay for the necessary installations for connection from his property to the grid. Table 3.2 clearly shows that the conditions for CHP have not improved in parallel to the progression of the market liberalisation. There are no specific provisions for CHP in the Electricity Directive. Left to the initiative of the member states, CHP is being promoted, but usually not in a transparent and non-discriminatory way. The main factors, which this survey has prodded for compliance with CHP promoting policy, point to a lack of coherency in the CHP directed measures (see also next subsection on EU policies for CHP).

Table 3.2 *Status figures for CHP and liberalisation, 2001*

	Market opening [%]	Complete opening [%]	CHP share of production[4] [%]	Remaining cap. at peak/total cap. [%]	Calculation of connection costs
Austria	100	2001	25	25	Not specified
Belgium	35	2007	5.9	5.7	Not specified
Denmark	90	2003	>50	5.3 of total Nordel cap.	Not specified
Finland	100	1997	32	5.3 of total Nordel cap.	Not specified
France	30	None	5	79	Calculated for the individual connection, parameters unknown. Estimation is 0.2 €ct/kWh
Germany	100	1999	7.5	6	Not specified
Greece	34	None	1.7	23	For small plants: paid by investor
Ireland	28	2005	1.9	25	Not specified
Italy	30	None	18	5.6	Not specified
Luxembourg	56	None	3.7 (of cons) 58.5 (of own prod.)	42	Not specified
Netherlands	32	2004	52.6	2	One time charge plus annual administrative fee, varies with voltage level.
Portugal	25 (consumers) +8 (distributors)	None	8	18.5	Not specified
Spain	54	2003	12	9	Not specified
Sweden	100	1998	6	5.3 of total Nordel cap.	Not specified
United Kingdom	100	1998	5.8	12.7	Connection fee applies for new connections, for system use and modifications to agreements. The fee is dependent upon size, type and location of the applicant's scheme.
Norway (non-EU)	100	1997	<<1	5.3 of total Nordel cap.	Set by utility, individual pricing. For households applications Euro 375.

Source: CHP STAGAS project electricity database.

Another important factor (barrier) is the licensing of the building of new CHP capacity. One might consider that the authorisation procedure is more flexible to the choice of technology for new capacity than the tender procedure. The widespread opting for the authorisation procedure should however testify certain preference for change. A fast track procedure for smaller generators could even more facilitate a restructuring of the electricity system. In fact the new Austrian electricity law provides such a fast track procedure.

[4] The share of CHP production as a percentage of the total electricity generation depends to a large extent on the calculation methodology of electricity produced by CHP. Eurostat has recently adopted a general methodology called the Protermo method, of which the application will reduce the share of CHP electricity in some countries.

3.5 EU policies on Combined Heat and Power

3.5.1 Policy background

Within recent policy developments in the EU two trends can be observed that favour the specific position of CHP. The first trend shows a steady rise of CHP on the EU energy policy agenda. This trend is confirmed by the increasing probability of the issuance of a CHP Initiative for a CHP Directive in the near future. The second trend concerns the efforts made towards a further policy integration. Examples are the integration of environmental aspects and sustainable development into EU energy policy, the integration of energy efficiency in Community policy, the integration of climate change objectives in sectoral policies and the integration of the environmental policy in external policy. In energy policy this leads to stronger emphasis on energy conservation, energy efficiency, renewable energy and the internalisation of external costs on the one hand and the inclusion of these elements in other policies on the other.

Currently, major policy objectives in the field of energy, which have a bearing on the economic viability of CHP are to:

- Reduce energy intensity until 2010, by one percentage point per year over and above that which would otherwise be realised, see (COM (1998)246 final, 'Energy efficiency in the European Community - Towards a strategy for the rational use of energy'); 'Action plan to improve Energy Efficiency in The European Community' COM (2000)247 final.
- Increase the share of renewals in energy consumption to 12% in 2010, mentioned in the (COM(1997)599 final, Renewable energy sources - White paper for a Community strategy and action plan and Directive on Renewables 2001/77/EC.
- Increase the contribution of CHP to electricity generation to 18% in 2010, see COM (1997) 514.
- Reduce the emissions of greenhouse gases by 8% relative to 1990 levels in the period 2008-2012 (Kyoto Protocol).

It goes without saying that the increased application of CHP contributes to all of these four Community targets. Regarding the general Community policy objectives of security of supply and the internal energy market, which are also significant for the position of CHP, follows below a very brief overview of relevant documents.

Security of energy supply

This topic is covered in COM(2000)769 final, Towards a European strategy for the security of energy supply. In this Green Paper, worries are expressed about the high and increasing dependency on external energy suppliers (50% today, 70% in 2030) and the predicted failure to meet the Kyoto targets. As a consequence, scope for policy solutions on the supply side will become increasingly difficult. Hence the emphasis is put on Demand Side Management (DSM).

Environmental protection and climate change

Important themes in this policy track are: pollution prevention, the European Climate Change Programme (ECCP), emissions trading, and sustainable development. The promotion of renewable energy sources and the use of CHP are evidently linked to this policy track. Key documents are:

- Council Directive 96/61/EC (1996), concerning Integrated Pollution Prevention and Control (IPPC).
- [COM (2000)88], 'EU policies and measures to reduce GHG emissions. Towards a European Climate Change Programme (ECCP)'.
- Directive (1988) 0609, 'Large Combustion Plant Directive'.
- Green paper on emissions trading and ensuing draft Directive.
- [COM (2001)31], Communication on the 6th environment programme of the European Community Environment 2010: Our future, Our Choice.

The latter document reaffirms the 18% CHP target for the year 2010 and calls for the introduction of incentives to promote CHP. Also it is interesting to recall that CHP fired on the basis of biomass or landfill gas is categorised as renewable energy. Annex I to Council Directive 1999/39/EC states the obligation to collect landfill gas from sites receiving biodegradable waste. In case the collected gas cannot be used to produce energy, it has to be flared. On the other hand, electricity produced using such gas would be considered as electricity from a renewable source.

Completion of the internal energy market
The latest Commission proposals for accelerated liberalisation as contained in [SEC(2001)438], Completing the internal market and [COM(2001)125] final, the proposal amending directives 96/92/EC and 98/30/EC concerning common rules for the internal market in electricity and natural gas, do consider the possible influence of liberalisation on the position of CHP and renewals and recognise the possibility that these may need additional measures and stresses the need for close monitoring. The EU electricity Directive offers, in Article 8, the possibility to Member States to give priority to CHP plants when the system operator is dispatching generating installations. In many Member States this possibility has been translated into a purchase obligation. Under Article 20 (1) Member States are obliged to take necessary measures to enable independent producers and auto - producers to negotiate access to the system so as to supply their own premises and subsidiaries in the same Member State or in another Member State by means of interconnected system. These obligations promote the development of CHP. The natural gas Directive is, according to the Commission, expected to increase the availability of gas at more competitive (read lower) prices and in this manner contribute particularly to the economic viability of gas-fired CHP plants for production of electricity. However note that due to other factors the gas prices have increased last years.

3.5.2 Combined Heat and Power in EU legislation

The key document in the field of CHP related policy is the communication from the Commission to the Council and the European Parliament ([COM(1997)514] final), entitled 'A Community strategy to promote combined heat and power (CHP) and to dismantle barriers to its development'. This document outlines some basic principles on strategies in this area and has lead to the acceptance in 1997 of a Council Resolution on a Community strategy to promote combined heat and power. Note that a CHP EU Directive is currently in preparation, see [COM(2002)415] final.

In general, the Council has accepted the usefulness of an indicative target of a doubling of CHP in the Community by the year 2010, thus raising the use of co-generation to 18% of EU electricity production. But it stresses that the main responsibility in this area lies with the Member States. At the same time, it notes that additional measures might still be needed to support CHP, and it emphasises that the Community and the Member States should actively promote CHP by stimulating this market and removing barriers to the market.

According to Article 9 of the Resolution 'measures to promote the use of combined heat and power could include, among other things:
- increased use of existing Community programmes within the budgetary limits,
- encouraging negotiated agreements with industry and in the service sector,
- internalisation of external costs and environmental benefits,
- financial and/or fiscal instruments, if appropriate,
- monitoring the impact of the liberalisation of the Community's energy markets,
- measures encouraging market participants to buy energy produced from CHP plants,
- arrangements to promote district heating and cooling schemes,
- measures to support research and technological development.

Article 10 expresses the Council's belief that 'the liberalisation of the energy markets and the internalisation of external costs and environmental benefits should take into account the development of combined heat and power under fair market conditions, but that measures might still be needed to support combined heat and power, including district and industrial heating and cooling, and to make sure that it is not discriminated against'.

Table 3.3 *Overview of actions taken on EU level for supporting CHP*

Definition of action	Current status and timetable	Comments (financing, impact, etc.)
a. Legislative measures		
Large Combustion Plants Directive. Proposed amendment Dir. 88/609.	Has been discussed in Council on 10/09/01	No cost for EU budget. Feasibility studies. CHP a priority.
Member States to promote CHP through national actions.	New proposal 2000	No cost for EU budget. Possibly in the Amended Directive 93/76/EEC .
Reform of agricultural policy and production of biomass for use in CHP.	Proposals under debate	Cost calculations not yet available.
b. Programmes		
Projects promoting CHP in industry, the domestic and tertiary sectors, the power sector and the heating sector in many Community and national programmes.	Ongoing	Includes 5th Framework Programme and Energy Framework Programme (SAVE).
Use of Structural Funds. Member State proposals according to amended regulations.	Under discussion 2000-2006	
c. Other action		
Co-ordination of Commission activities concerning CHP. Ad hoc working group for information exchange.	New initiative	No additional cost
Follow-up groups for the transposition of Directives 96/92 (Internal electricity market) and 98/30 (Internal gas market), to avoid obstacles to CHP.	Ongoing	No additional cost
CHP Statistics (data collection). Monitoring of CHP penetration in the European energy market.	Ongoing	EUR 100 000 per year
Directors-General for Energy Committee. National programmes for the promotion of CHP discussion.	Proposed in 2000	No additional cost
Actions supporting cross-border strategies for promotion of CHP at regional level (with energy authorities, utilities, CHP producers, etc.).	New initiative	Cost of studies and pilot actions to be made available.
Promotion of CHP through public and technology procurement initiatives.	New initiative	Costs of studies and pilot actions to be made available.

The basic ideas about the direction into which CHP should further develop are also reflected in the action plan to improve energy efficiency in the European Community [COM(2000)247] final.

Among the initiatives to strengthen and expand existing successful EE policies and measures, CHP is prominently mentioned. It is also recalled that the proposed revision of the Council Directive 88/609/EEC (on large combustion plants, see below) will require that new plants apply CHP where feasible, making provisions for the use of biomass and promoting efficient production with fossil fuels. The building sector and the transport sector are targeted as sectors in which the greatest gains can be realised. Also Section 5 of the Action Plan to improve energy efficiency in the European Community contains actions focused on CHP, which are listed in Table 3.3. These initiatives promoting for increased use of CHP installations will cover a range of sectors, including industry, the domestic and tertiary sectors, the power sector and the heating sector. The target for wider use of CHP will be pursued by legislative measures, higher priority in programmes, and a number of other actions to improve co-ordination of promotional activities, market monitoring, etc. In section 6 of the Action Plan additional measures of a more general nature are recommended, see Table 3.4 for a summary.

The proposal for a revision of Directive 88/609 on the limitation of emissions of certain pollutants into the air from large combustion plants contains a new reference to CHP in Article 7. 'In new plants for which the licence is granted on or after 1 January 2000 the competent authorities shall ensure that there is provision for the combined generation of heat and electricity where this is technically and economically feasible. To this end, the Member States shall ensure that operators examine the possibilities of locating the installations on sites with a heat requirement.' In order to prevent a potential conflict between the promotion of CHP and RES and measures taken by Member States, that might be interpreted as state aid, the Community guidelines on State aid for environmental protection, whose validity has been extended up to the end of 2007, clarifies to what extent investment and operational aid to undertakings in the field of CHP will be allowed.

In the draft Directive on energy performance of buildings [COM(2001) 226] final, potential savings of energy used in the building sector for heating, hot water, cooling and lighting are estimated to be cost-effective for about 22% to the year 2010. District heating (DH) and cooling networks and CHP for individual buildings and groups of buildings are mentioned as a means to help improve a building's overall energy performance. Increased use of CHP in the building sector could make a major contribution to meeting the indicative Community target of doubling the total share for CHP electricity production to 18% by 2010. Article 4 of the draft Directive states 'for new buildings with a total surface area over 1000 m2, the Member States shall ensure that the technical, environmental and economic feasibility of installing decentralised energy supply systems based on renewable energy, CHP, DH or, under certain conditions, heat pumps, is assessed before the building permit is granted'.

3.6 Taxes and Stimulation measures

Finally an overview of current most relevant taxes and other CHP influencing measures are derived from the project database on measures in EU MS and summarised in Table 3.4. The overview of the fuel taxes (with a focus on gas) in the different countries show that seven countries (Finland, Greece, Ireland, Luxembourg, Norway, Portugal and Spain) do not have a fuel tax on gas or a similar kind of tax. The tax regimes between the other nine countries differ significantly in height and in structure. Seven countries use their fuel taxes on gas to stimulate CHP by introducing an (partly) exemption. The last column of Table 3.4 summarises other stimulation measures for CHP in the countries, also it appears with a focus on gas related stimulation measures). From this information, together with the tax exemptions, it is clear that within five countries no direct stimulation measures for CHP are effective (Finland, Greece, Ireland, Luxembourg and Norway). It also shows that the general stimulation policies on CHP between the different MS are quite diverse, but the mainly concern subsidising (i.e. lowering) gas prices, electricity prices and the investment costs.

Table 3.4 *Overview of the taxes and stimulation measures in the different countries in 2001*

Country	Fuel taxes	Stimulation measures: Tax exemptions	Stimulation measures: Other measures
Austria	4.2 €ct/m^3	• Power generators including CHP and DH[5]	Yes: Each province has possibilities to support CHP.
Belgium	1.1 €ct/m^3 consumption < 0.11 mln m^3		Yes: Rebate on gas tariff
Denmark	• 2.95 €ct/m^3 CO_2 tax households • Lower CO_2 tax for industry and commercial. • 26.31 €ct/m^3 energy tax for households	• Power generators. • CHP for the gas used for electricity production.	• Electricity produced by gas-fired CHP. • Electricity sold to the grid receives a premium.
Finland	None		
France	12.6 €ct/m^3 consuming > 53 mln m^3	• New CHP and DH plants for a period of 5 years	
Germany	• 3.8 €ct/m^3 • large industries 1.4 €ct/m^3	CHP with utilisation rate of 70%	See new law (17)
Greece	None		
Ireland	None		
Italy	• Consumption tax with zonal price system ranges from 17.33 - 1.24 €ct/m^3 • plus regional additional tax ranges between 0.51 and 3.09	• A reduction of regional additional tax for CHP	• Investment subsidies at local level.
Luxembourg	None		Attractive buy-back tariffs
Netherlands	• 0.1 €ct/m^3 < 10 mln m^3; 0.6 €ct/m^3 > 10 mln m^3. • Plus eco-tax with zonal pricing system up to 1 mln m^3 ranges from 12 to 1 €ct/m^3.	• Power generators including CHP and DH. • Eco-tax exemption only for CHP and DH	• Investment subsidies for CHP. • CHP electricity for own consumption is exempted from eco-tax on electricity. • Premium for electricity sold to the grid.
Norway	None		Under discussion
Portugal	None		Investment subsidies for gas infrastructure
Spain	None		CHP premium for electricity linked to the price of gas
Sweden	• 2.64 €ct/m^3. Plus CO_2 tax of 13.6 €ct/m^3. • for large industries CO_2 tax is 4.7 €ct/m^3. • 0.38 €ct/m^3 additional tax for gas-fired CHP		
United Kingdom	0.7 €ct/kWh as Climate Change Levy	• Good quality CHP has full exemption climate change[6]. • Non-licensed CHP smaller than 500 kW have total exemption	Investment subsidies for small-scale CHP

Source: CHP stagas project gas database

[5] However each kWh produced by gas-fired generation is taxed at 0.7 €ct.
[6] For a complete overview see Annex for new German law on support on CHP and certification rules.

3.7 Assumptions for Evaluation economic feasibility of CHP options

3.7.1 Key parameters

The key question of this project is to determine the profitability of investments in new CHP plants and the continuation of the viable operation of existing plants in a future setting where gas and electricity markets are more competitive, but including the notion that large country difference will still persist in the next years. Using the Internal Rate of Return (IRR) as proxy for the profitability (cost-effectiveness criterion) of investments in and current operation of CHP plants, the COWI model EnergyPro was used to calculate the IRR of different cases per country. Thereby it is necessary to realise that the profitability of CHP depends on technology characteristics such as investment costs and efficiency, developments in three energy markets where CHP inputs and outputs are relevant, namely the gas, heat and power market and finally policy measures to support CHP. In this section the key investment parameters and other assumptions for calculating the IRR, of six selected gas-fired CHP technologies (cases) per country are discussed.

Below in Table 3.5 follows an overview of relevant parameters for the calculation of the profitability of CHP. So the values of these parameters are influencing profitability of the CHP plant and therefore the decision to invest or not.

Table 3.5 *Parameters that are of influence on the profitability of CHP*

COSTS
• Natural gas prices • Maintenance and operational costs (variable and fixed) • Amortisation costs of investments in CHP and if applicable in heat distribution facilities • Interest on investment • Grid connection costs • Costs of backup from grid (commodity + transmission costs) • Taxes
REVENUE
• Value heat supply (based on reference boiler) • Electricity sales (or in case of own consumption: value of avoided purchases) • Avoided network and system costs • Possible avoided taxes (as stimulation) • Revenue from other supporting policies (such as subsidies and tax exemptions)
TECHNOLOGY
• Efficiency of (joint and single) product/output • Start-up time • Operational use of CHP and load balancing • Reliability of operation • Load factor demand • Load factor supply (fuel/technology)
OTHER
• Availability of natural gas

Clearly the values of the costs and revenue parameters have the largest impact on the economics of and therefore the incentive to invest in CHP. The key factors influencing the values of these parameters are the gas, electricity and heat prices, which depend on a number of ‘external’ factors that are characterised by (expected) emerging competitiveness of these markets in Europe, tax policies and energy world markets in the next ten years. Only those parameters that have a significant effect on the IRR and vary under different policy (measures) regimes are used as input for the CHP model calculations. Generally a minimum IRR of 10% is required for considering an investment economically viable, but of course this requirement can vary and depends strongly on other external factors influencing the economic climate of such an investment.

3.7.2 Selected CHP cases

For the current study six most relevant gas-fired CHP cases have been selected for further investigating of their cost effectiveness in the different Member States. For the representative ness of the technologies, see also overviews of statistics on CHP in Chapter 2.These six cases of five different technologies are:

- Steam turbine using back pressure,
- Steam turbine using condensation and extraction,
- Gas turbine with heat recovery,
- Gas engines,
- Combined cycle, a large and small-scale capacity type.

For example in the industrial CHP in the Netherlands (with a total capacity of 3900 MW_e), the most prevailing technology is currently the combined cycle with a capacity exceeding 100 MW_e. This is followed by the combined cycle between 40 and 100 MW_e and the gas turbine with a capacity between 10 and 25 MW_e. Besides these industrial technologies, gas engines are often applied in the Dutch horticulture. The total capacity of gas engines in the Netherlands amounts to 1500 MW_e and the individual units are mostly smaller than 1 MW_e.

Next step is determine the average efficiencies, maintenance costs etc of these six 'model CHP plants'. It is assumed that these types of scale of technologies (plants) are also representative for current and in the future to build CHP plants in the individual Member States and Norway. Obviously, the distribution of the total CHP capacity of these model plants can and will differ for each Member State.

Table 3.6 shows the six model plants with their corresponding capacities and efficiencies. A distinction has been made between efficiency of existing and new plants. Due to innovation efficiencies of certain technologies have increased and will continue to do so in the next ten years. The scope for innovation differs between technologies. For example the traditional steam turbine is more or less at the end of its developments, but for the combined cycle a significant efficiency increases have been observed in the last few years and are to be expected in the next years.

Table 3.6 *Technical characterisation of the six model plants*

Model plant	Electric capacity [MW_e]	Total efficiency [%]		Electric efficiency [%]	
		Existing	New	Existing	New
Steam turbine using back pressure	10	90	91	13	13
Gas turbine	10	81	85-88	31	33
Combined Cycle	40-50	65	85-88	20-45	38-50
Combined Cycle	200-250	80	90	38-50	38-55
Gas engine	0.5	82	85	33	35
Gas engine	5	85	85	38	38-40

The parameters investment, operation and maintenance costs dependent on the type of technology and are shown in Table 3.7, which defines these cost parameters for the six model plants. Besides these technical and financial characteristics it is assumed that units applied for district heating have 4,500 to 5,000 operational hours per year and the industrial based units 6,500 to 7,000 hours.

Table 3.7 *Financial characterisation of the six model plants*

Model plant	Electric capacity	Investment	Operation and Maintenance	
			Fixed cost	Variable
	[MW_e]	[€/kW_e]	[€/kW_e]	[€ct/kWh]
Steam turbine using back pressure	10	1425	18	0.25
Gas turbine	10	1100	36	0.30
Combined Cycle	40-50	825	14	0.17
Combined Cycle	200-250	500	7	0.10
Gas engine	0.5	825	0	1.20
Gas engine	5	900	0	0.90

3.7.3 Definition of reference (scenario) and policy (packages) variants

For defining the parameter values in the model representing a reference situation the current commodity prices relevant for CHP plants and the 'existing values' of the technology parameters were used. Thereby including some current trends in commodity prices per country. But for identifying effective policies to improve the IRR of a CHP investment, key objective of the study, the impacts of these policy measures must be compared with the IRR found in the reference situation, without these policies, for each CHP case in a country.

To conduct such a sensitivity analysis and assess the effects of different types of policies on the economics of CHP plants, three policy variants were defined on the basis of the overview of barriers and stimulating policies earlier collected during the project (for the description of these barriers and opportunities per Member State see Annex A of the Final report of Part B, CHP GAS, entitled 'Description of the project databases'). The three policy packages constitute a scenario variant compared with the reference scenario and are a selection of the most relevant and stimulating actions to remove barriers and provide incentives to CHP in a consistent combination.

The policy packages were defined as follows:

- 'General policies' - general measures indirectly influencing CHP profitability- these include limiting risks for CHP investors, improves access to distribution and transmission networks, energy taxes, binding climate change policies and transparent regulations. In general, these measures should create a level playing field for CHP in the liberalised energy market but without special policies for CHP. It is assumed that CHP will have to compete on the energy markets, but on a level playing field with large scale production of electricity, thus on with similar conditions as incumbent large power producers. General measures include also internalisation of environmental externalities etc.
- 'Gas oriented policies' - policy measures related to gas markets – these include symmetric implementation of electricity and gas Directives and transparent regulations and access to the gas networks. The asymmetric liberalisation of the electricity and gas market caused many barriers for CHP producers faced with competitive (low) electricity prices on one hand and high gas prices on the other. This scenario will put redress this situation on both markets, enabling fairer competition for CHP producers.
- 'CHP specific policies' - policy measures include measures specifically supporting CHP - these include feed-in tariffs, tax exemptions, subsidies and removal of all administrative barriers. CHP will receive a special treatment above other regular electricity producers.

These measure, which are categorised into three packages, make up three final alternative scenario variants for specifying input values for the CHP profitability calculations. To use these scenarios as an input for the profitability calculations with the model they need to be 'translated' into values of the relevant model parameters for the IRR calculations, see also the Final CHP gas report. In fact the estimated impacts of each individual measure on these parameters is subsequently summed up to arrive at a total impact of each complete policy package. However, note that these measures will not have a same effect (impact) in each Member State. For example the point of departure regarding existing energy and CHP policies differs largely for each Member State. Finally this leads to price projections for both natural gas and electricity within each individual Member State and Norway and relevant market segment, see Final report Part B.

Only those incentives are included that can have a real influence on the short-term parameter values. These concern measures of a financial and regulatory nature like:

- financial measures consist of taxes, subsidies, premiums and feed-in tariffs.
- regulatory measures consist mainly of network procedures (ensuring fair access to electricity and gas networks).

3.7.4 Gas and electricity price projections for reference scenario and variants

It is generally assumed that liberalisation of markets will lead to lower electricity prices, particularly if the electricity is produced by a single large scale plants, which are also competing on the spot market with electricity from technologies such as CHP. Together with the abolishment of other existing supporting policy measures for CHP in different MS these lower electricity prices lead to unfavourable market conditions for CHP outputs.

The price formation on the market for natural gas relevant for CHP is even more complex. As there are fewer competitors on the supply side of the gas market and it is very hard for new competitors to enter this market, it is often assumed that gas prices are and will be determined by a so-called oligopolistic behaviour of companies and generally these prices are significantly higher than the competitive prices. On the other hand in most MS gas prices are still strongly linked or influenced by the oil price developments and an important question rises when will gas competition, induced by liberalisation, develop to the extent that it predominates the linkage to the oil price.

Undoubtedly the key factors for investing in new CHP plants in the next ten years are the gas and electricity commodity prices as faced directly by CHP plants, because these are directly and largely relevant for the profitability of an investment in CHP. For the model calculations is assumed that gas is the prevailing input fuel of CHP and the heat prices are directly related to the gas prices in the MS and this price is set by a standard boiler.

First step was assessing the reference values of gas and electricity prices see the Final report. Next step was to establish for each measure a certain absolute level of impact in terms of percentage increases or decreases compared to the reference scenario values. The estimation of this specific level is of course very sensitive to discussions. It is however not meant to determine the exact level of impact, as this will be an impossible exercise. The three scenarios should be seen as a kind of structured sensitivity analysis of policy measures compared with the reference scenario conditions of CHP investments.

Figure 3.1 below shows for each of the three policy scenario variants, the range of relative changes of the three key parameters (gas wholesale prices, electricity wholesale prices and the IRR requirements). The range is set by the minimum and maximum impacts over all Member States and Norway.

From this graph it can be concluded that the measures included in the scenario variant ‘General’ have no influence on the wholesale price of natural gas in one of the MS. For some of the countries the overall package of measures contained by this scenario have a lowering impact on the wholesale electricity price, whereas for other countries these measure will increase the electricity prices. The electricity prices will at most be lowered with 5% compared to the reference scenario. The second policy scenario variant, ‘Gas’, which consists for a large part of measures and policies that should increase gas-to-gas-competition by improving the access to the gas network and making the gas transportation tariffs more cost reflective than they are nowadays. The relative changes of the gas prices in this scenario (Figure 3.1) show that this increased gas-to-gas-competition is assumed to result into lower gas prices. It is also assumed that the transportation tariffs within MS and the EU will become more transparent and this will lower the IRR requirement of potential investors as a consequence of more confidence and certainty about the market. The third policy variant ‘CHP’ in Figure 3.1, containing measures that are more evenly distributed among the three parameters, comprises policy measures related to specific CHP support. One of the measures is for example remunerating CHP for network losses, which are reduced by decentralised CHP plants connected to the lower voltage grid. This does not effect the over wholesale price for electricity but it does increase the electricity sales price for these CHP owners.

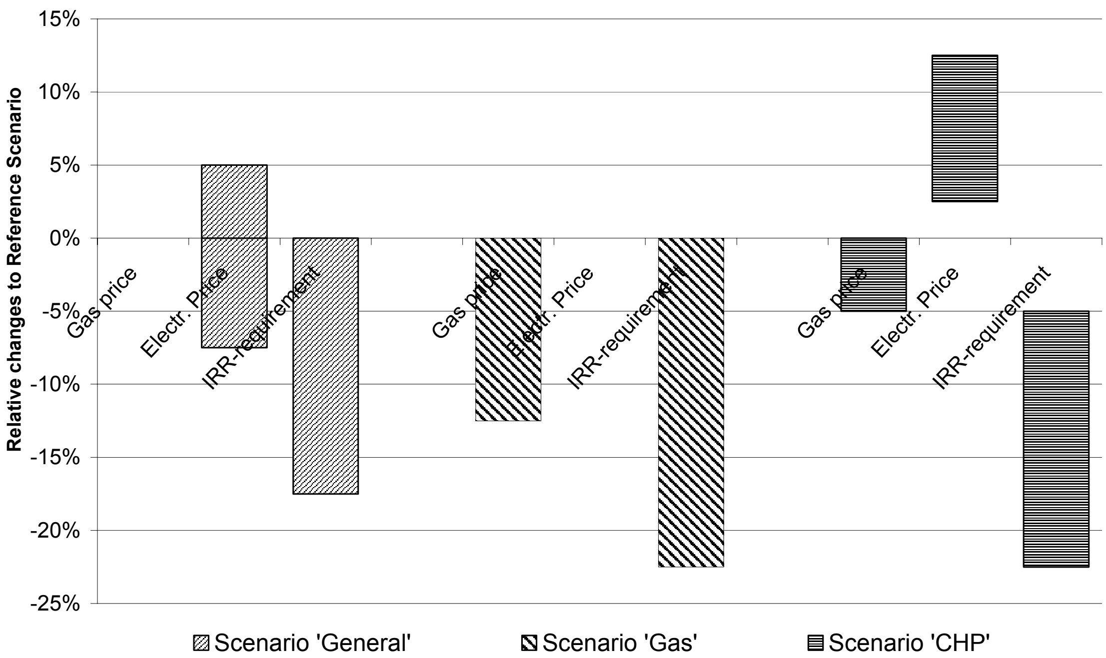
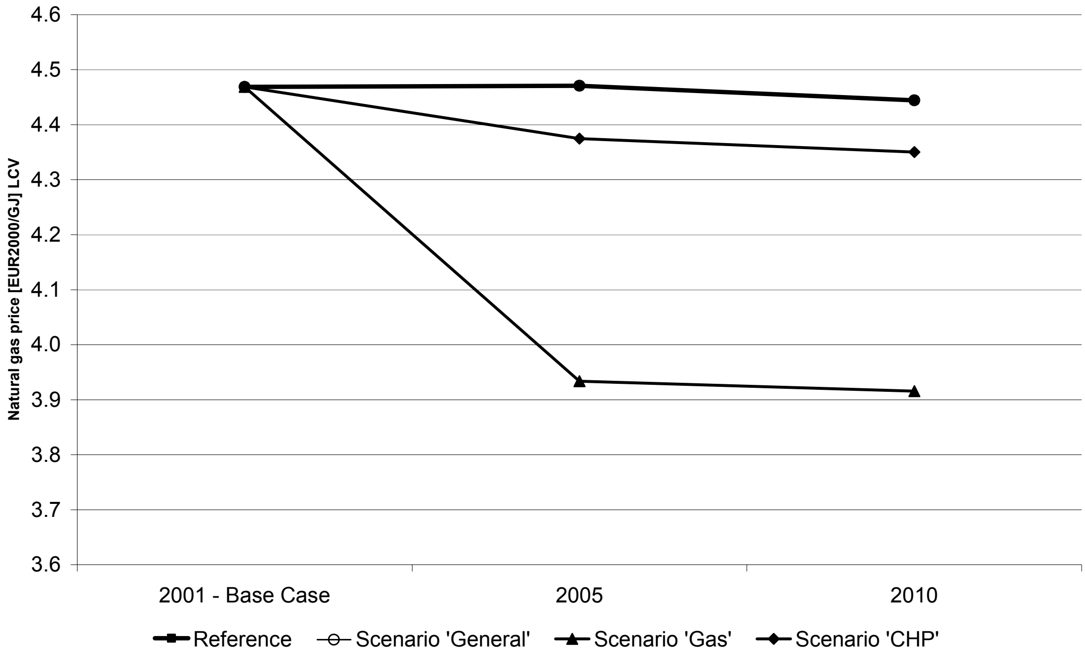


Figure 3.1 *Range of relative changes to the reference scenario for three of the parameters*

Gas wholesale prices trends
For all three scenarios the natural gas prices are calculated for the year 2005 and 2010. Figure 3.2 shows the trend of the average natural gas prices over all Member States and Norway. Gas prices per country are available from the Final report of CHP GAS study. For the ‘Gas’ scenario the average natural gas price within Europe is assumed to decrease considerably in the next years due to increasing competition, with the exception of the UK where today competition is already established.

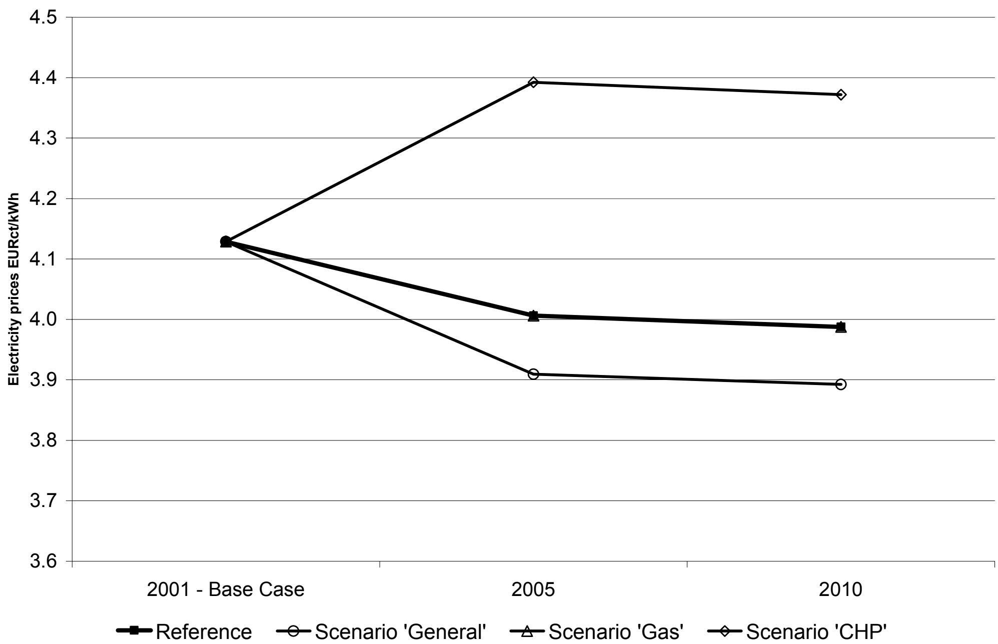
Electricity price trends
The relative impacts of the measures on the electricity prices for the different scenarios are also translated into absolute values. Regarding electricity two consumer types are distinguished: large and medium industrial consumers. As the effects are almost similar, this section only

shows the results for the large industrial consumers. The distinction is used within the final IRR calculations.



Note: In Reference and general gas prices are similar.

Figure 3.2 *Average natural gas price over all countries for each of the scenarios [EUR2000/GJ] based on low calorific value*[7]



Note: In Reference and general gas prices are similar.

Figure 3.3 *Average electricity price over all countries for each of the scenarios based on large industrial consumers [€ct/kWh]*

[7] This is a non-weighted average of the (estimated) natural gas prices in Europe

Figure 3.3 shows that the ‘Gas’ scenario variant has no effect on the electricity wholesale prices. This scenario is largely based on measures taken to remove barriers on the gas market. The scenario ‘CHP’ contains several measures that increase the valuation of the produced electricity by CHP, which is clearly shown in Figure 3.3. The ‘General’ scenario that is mainly based on measures enhancing the liberalisation of the electricity market, creating a level playing field even lowers the average electricity price. But this does not apply for all individual MS in the same degree because some countries experienced already fierce competition driving electricity prices down (i.e. UK, Germany) and others are still at the beginning of this process such as Italy and France.

3.8 Impact of policies on IRR of CHP per Member States

3.8.1 Impacts current policies

The Nordic countries, Finland, Norway and Sweden are characterised by low electricity prices. In addition natural gas is taxed within these countries and there is no exemption from this tax for CHP. Due to this combination of low electricity prices and taxed natural gas, the IRRs in these countries for CHP are generally very low. In Figure 3.4 and Figure 3.5 this is illustrated by the IRR values for the averaged size Combined Cycle (CC 50 MW). Both figures show by the IRR that for CC 50 MW the "CHP policy scenario variant" contains effective policies. Note that in Figure 3.4 and Figure 3.5 the assumed number of hours the CHP plant is operated and in the use of electricity (own consumption vs. sales part of produced electricity to the grid) is deferring.

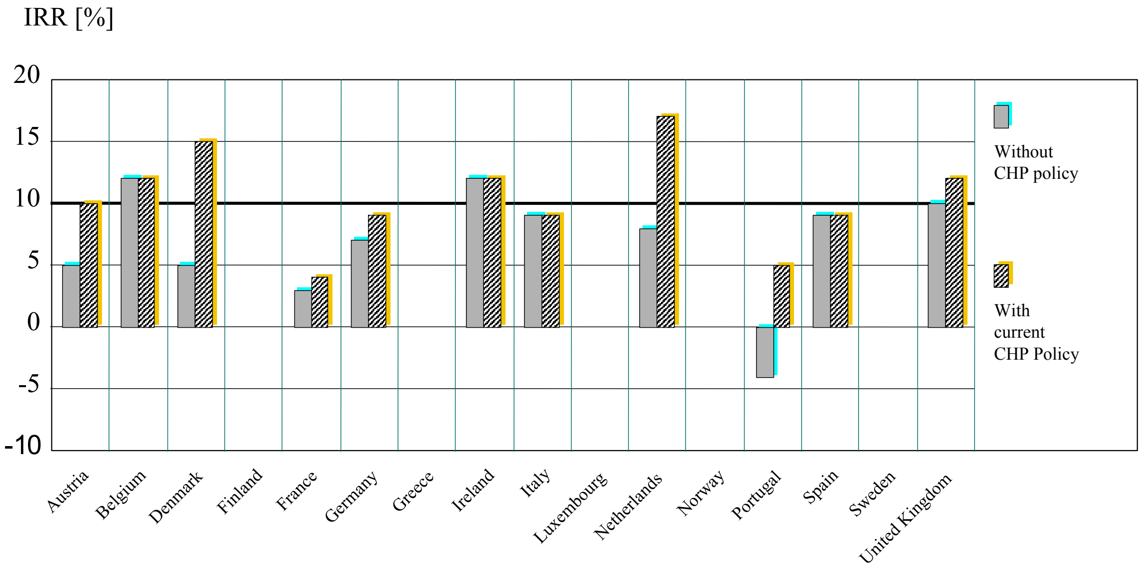


Figure 3.4 *Overview consequences current CHP policy on IRR of CC 50 MW 7000 hours, with own consumption of all electricity produced - 2001*

If CHP policy is in force, four Member States (Denmark, Netherlands, Portugal and Spain) apply a premium to CHP electricity sold to the grid. The value of this premium differs per country, but still in most countries this measure for stimulating CHP is quite effective. Figure 3.5 shows that in Denmark and in the Netherlands the IRR lies above the 10%-requirement due to their CHP policy. Within Spain and Belgium there is no specific CHP policy in force, but in both countries the electricity consumption is taxed. In both countries this tax makes CHP profitable when the electricity is applied for own consumption.

For Austria a large difference in IRR exists between the example of selling to the grid and using the electricity for own consumption. In Austria the electricity prices are relatively high, both electricity and gas are taxed and CHP is exempted from this gas tax. These three aspects make the industrial CHP with own consumption of electricity produced an economically feasible option.

Of course the influence of the level of the energy prices remains of great importance for the IRR. For example in Greece, which has relatively high natural gas prices, none of the CHP model plants is feasible. Whereas in Ireland, having no CHP policy, CHP is a profitable option due to the high electricity prices.

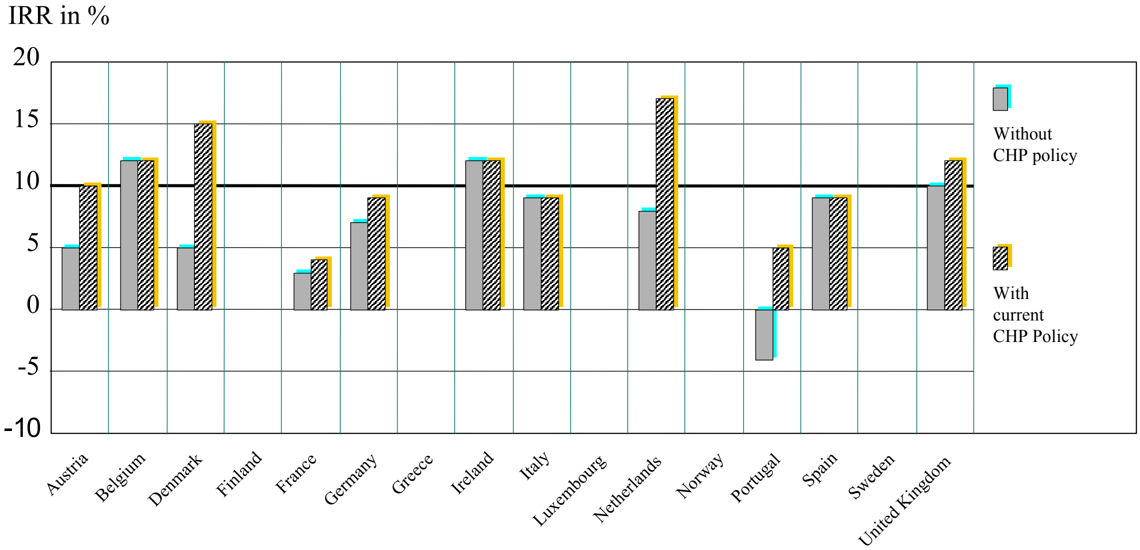


Figure 3.5 *Overview consequences current CHP policy on IRR of CC 50 MW 5500 hours, with allowing electricity sales to grid - 2001*

3.8.2 Impacts of the policy variants on IRR of Combined Cycle 50 MW

In this summary all results for all cases calculated per country cannot be present. These can be found in the Appendix B of the Final report (see CD-ROM provided with this report). For illustrating our results we selected the model plant defined as a new Combined Cycle of 50 MW in different modes of application, own consumption or sales back to the grid of electricity and 7000 hour/year versus 5500 hour/year of operation. This technology and four cases proved to be the most profitable compared to other cases and are also the most interesting cases for investment in the next years in most MS.

Combined Cycle invoked for industrial application

Figure 3.6 shows the internal rate of returns based on the 2001 prices of the reference scenario (Ref. 2001), based on the 2010 prices of the reference scenario (Ref. 2010) and based on the 2010 prices of the alternative scenario policy variants: 'General', 'Gas' and 'CHP'. The prices include the current CHP policies and possible new policies included in the different policy scenarios.

The IRR in the 2001 reference case represents the point of departure. Continuing the current policies at EU level and at individual MS level, IRRs are assumed to go to the level shown at the reference 2010. This is of course based on the assumptions made within the reference scenario. This level will be taken as a reference (or point of departure) to be used for comparing the impacts of the IRRs of the three alternative policy scenarios.

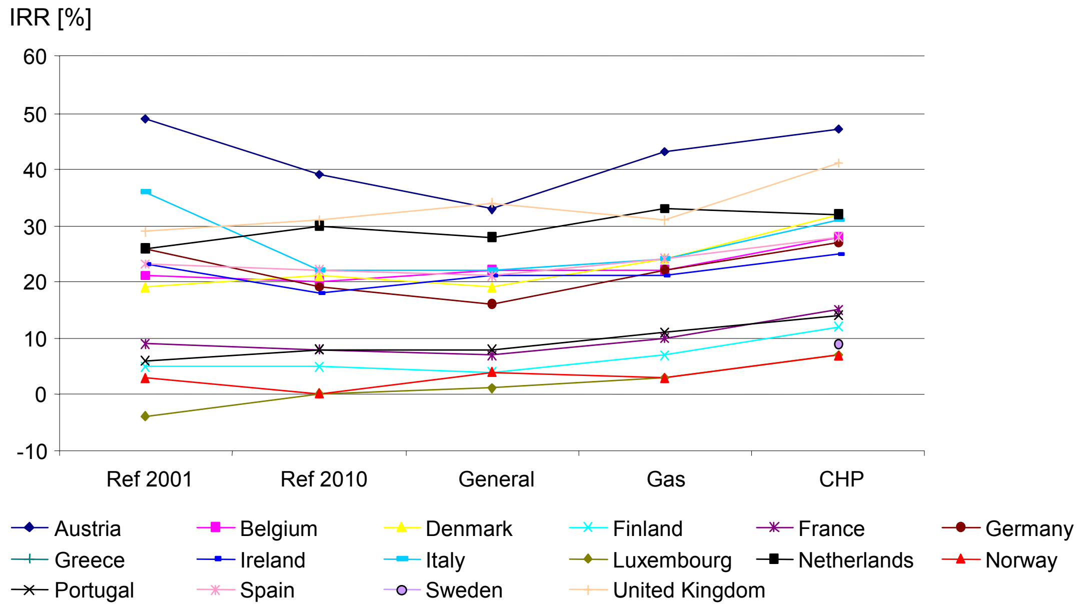


Figure 3.6 *IRR of a new Combined Cycle 50 MW, 7000 operation hours, own consumption, including current CHP policy, for all scenarios*

Clearly the 'General' policy variant has a certain effect for CHP in the countries Belgium, Denmark and Ireland. For Denmark this effect is negative as it shifts the IRR below 20%. The 'General' scenario consists of removing the barriers as regards limited competition on electricity market by speeding up the liberalisation process, facilitating the network procedures, and making the transmission tariffs more cost reflective. These measures will contribute to a decreasing electricity price, lowering the profitability of CHP. On the other hand this scenario assumes that CHP can exploit some opportunities as it contributes to the security of supply and a EU tax on electricity is assumed to come into effect for which CHP is exempted. This last measure contributes to a higher valuation of produced electricity for own consumption. In Denmark however this measure is already present in the current, reference situation, hence this positive effect of the 'General' scenario does not apply to Denmark.

In both Belgium and Ireland the IRR increases to a level above 20%. In both countries this increase results from the introduced EU tax on electricity for which CHP electricity used for own consumption is exempted. In Belgium an additional increase of the valuation of electricity is induced by the internalisation of environmental externalities, which is assumed to be effective within Belgium.

The 'Gas' policy scenario focuses on enhancement of the gas-to-gas-competition between and within the different countries driving gas prices for CHP down. Developing the gas infrastructure within some countries, improving network procedures and creating a level playing field could reach this. Both in France and Portugal this results into lower gas prices, which for these countries contributes significant to a higher cost effectiveness of the CC. In the United Kingdom gas-to-gas-competition has already developed so this scenario has no influence on gas prices in the UK. In some other countries, for example in Denmark, Finland, the Netherlands and Norway, wholesale gas prices are already relatively low in the reference situation, so in those countries the 'Gas' scenario effects the gas prices only minimally. Oppositely Greece is characterised by extreme high gas prices because of an underdeveloped gas market. For Greece it is assumed that gas-to-gas-competition shall not develop to the same extent as in other MS in the next ten years.

Comparing the 'CHP' policy variant with the reference situation, investments in a CC 50 MW under the given operational assumptions, have become attractive in three additional countries;

Finland, France and Portugal. The 'CHP' policy scenario consists of measures related to specific CHP support. This scenario includes for example the assumption that a CHP certificate trading system, tax exemptions (if not present yet), investment subsidies and less financial measures such as setting a national target will become in place. In Finland and Portugal the introduction of an exemption on gas tax for CHP has a positive effect on the profitability as it increases competitiveness of the CC in relation to (large-scale) electricity production units. In France a gas tax exemption was already in force, here the introduction of a CHP certificate trading system could also stimulate a higher profitability of CHP.

Summarised it could be concluded that for larger CHP (50 MW CC) applied for industrial processes and in case the electricity can be used for own consumption:
- The 'General' policy variant has only a limited effect on the actual investment conditions and among the countries it shows divergent (negative or positive) effects on IRR values.
- The 'Gas' policy variant especially affects the investment climate in MS where current gas prices are on an average EU-level and gas-to-gas competition can be achieved through extra regulating the gas market. Of course in MS where the gas infrastructure still needs to be developed the effects of gas prices are marginal.
- The 'CHP' policy variant stimulates via the electricity revaluation and the gas market prices (higher IRR) CHP. Consequently it could enhance the CHP investments in MS with both a less mature gas market and a mature gas market.

Figure 3.7 below shows similar results of the Combined Cycle of 50 MW at 7,000 load hours but now with all the produced electricity sold back to the grid. The differences in IRR between these two cases (own consumption vs. exporting back to the grid) stems purely from the valuation of the by CHP produced electricity. The CHP electricity used for own consumption is valued according to the electricity market end-use prices, as the CHP owner avoids these costs by producing its own electricity. These market end-use prices consist of the commodity (wholesale) price, transportation costs and perhaps an electricity tax.

In case of exporting to the grid, the electricity general yields only the market price i.e. the wholesale price of electricity. This market price is lower compared to the avoided costs of own consumption. Figure 3.4 and Figure 3.5 already demonstrated that indeed the IRR (without any additional support) is lower when exporting electricity to the grid is assumed and possible.

In several MS however, special measures have been taken to support and improve the value of the exports of CHP electricity to the grid. An example is the obliged purchase of CHP electricity by distribution companies and the special feed-in tariff for CHP. Another issue, which is assumed in one of the proposed 'CHP' measure packages, is the remuneration of net losses, which would stimulate production units (like small CHP) that needs to feed in to the lower voltage distribution networks. This would contribute to create a more level playing field for CHP versus large scale power production.

This special support for exporting electricity to the grid is of importance as the consumption of electricity at the CHP production location itself is often of a limited volume. This can hampers the building of an optimal size of the CHP plant. If the plant is designed to the total heat demand, the electricity production often exceeds the demand for electricity at the location, due to a lower heat/electricity ratio of the plant than the demand ratio at the location[8]. To utilise the environmental advantages of CHP optimal the CHP plant should preferably be designed to meet the useful heat demand. Aiming at this optimal coverage of heat demand by CHP, the price for exporting CHP electricity to the grid should at least cover the integral production cost.

[8] A second factor which hampers 100% consumption of electricity is the non-simultaneously of electricity and heat demand.

In the 'CHP' variant also measures are included that give electricity exports to the grid a premium on the electricity sold to the grid (i.e. fixed feed-in tariff), a remuneration of net losses (as CHP feeds in on a low voltage level), and a remuneration of reducing grid investments. This last measure is assumed to become effective in all MS in the next years and causes the increasing trend in the IRR lines observed in Table 3.7.

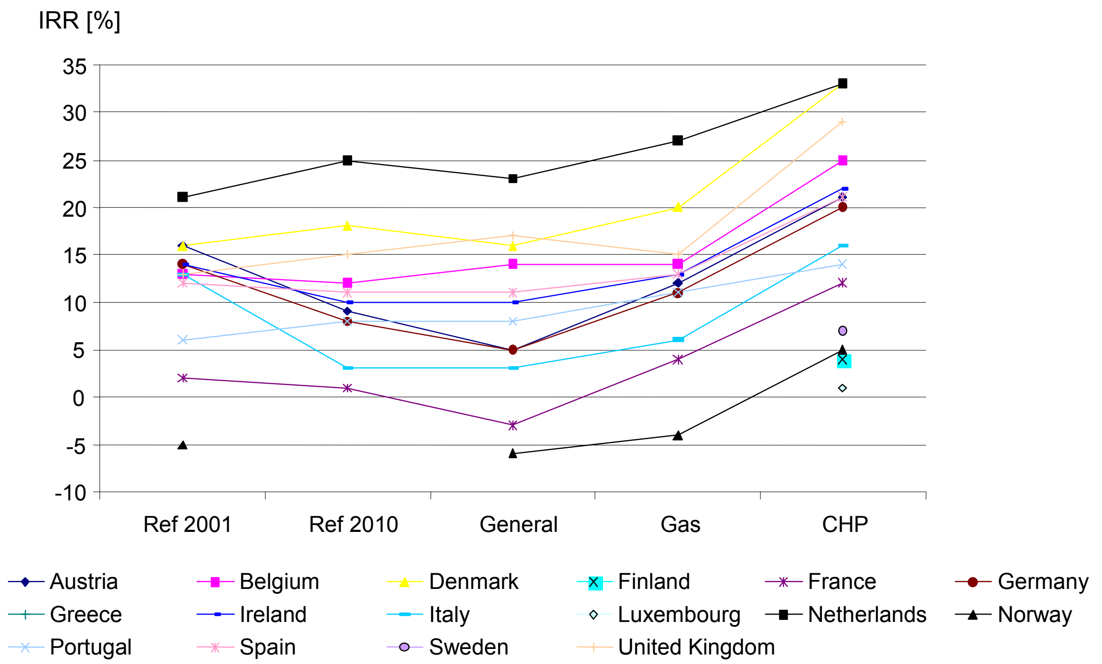


Figure 3.7 *IRR of a Combined Cycle 50 MW, 7000 hour/year, with sales back to grid, including current CHP policies, for all scenarios*[9]

Furthermore from the calculations it shows that the 'General' policy variant has only a small effect on the IRR value in the countries when the electricity is sold to the grid instead of used for own consumption. The EU tax exemption has no effect for these cases. For a few MS (Denmark, UK and the Netherlands) a system of GHG emission trading and in Belgium the internalisation of environmental externalities is assumed and shows to be effective. These opportunities counterbalance more or less the decrease of the electricity price due to more competition assumed in this scenario. After 2010 these mechanisms are assumed to have also an effect in the other MS, but this is beyond the time frame of the current analysis.

For the countries such as Germany, France and Austria the increased electricity market competition creates a major impact for IRR of CHP, by decreasing the profitability considerably, see Figure 3.7. It should also be noted that the increased competition will not only lower the electricity price but will presumably also hamper the opportunities for new entrants to enter the market.

The 'Gas' scenario has clearly a more positive effect on the calculated IRR due to lower gas prices as competition increases on the gas market. It shows that in this scenario the IRRs in Austria, Germany, and Portugal are lifted from below the 10% to the range between 10 and 20%. In some other countries, for example in Belgium, Denmark, the Netherlands, wholesale gas prices are already relatively low in the reference situation, so it is assumed that the 'Gas' scenario effects gas prices only a limited way in these countries. The gas prices in Austria, Germany and Portugal equal the current relatively European averages and for these countries a decrease in gas prices provides a relevant stimulus for CHP, making it more profitable.

[9] Extreme-negative IRR values (smaller than minus 10%) are not indicated in the figure.

Summarised it could be concluded that for larger CHP plants (50 MW CC) applied for industrial processes and if all electricity produced is sold to the grid:

- The 'General policies' have no effects on the investment climate. For some countries these have even a negative effect due to a lower electricity prices. In Denmark, UK, the Netherlands and Belgium if a system of emission trading and internalisation of environmental externalities becomes effective and (partly) this might partly cancels out the effect of a lower wholesale electricity price.
- The 'Gas policies' have a positive effect on the investment climate for CHP. Again it can be concluded that the scenario especially stimulates CHP in those countries where the gas market is just to become mature (Austria, Germany). Again in Greece deregulation of the gas market is not sufficient to stimulate CHP on the short term simply because restructuring and developing that market will take more than a decade. So in the short term gas prices will remain too high. Also in Luxembourg CHP remains unprofitable because of relatively limited competition on the gas market, but particularly due the low electricity prices in Luxembourg.
- The specifically 'CHP oriented policies' have a very positive impact on the IRR values of gas-fired CHP technologies. The IRR values of electricity supplies to the grid approach the IRR values of the cases with 100% own consumption. The measures contained within this scenario are much more focussed on stimulating electricity production to the grid. Hence the scenario has relatively more impact on the IRR of this case. The remuneration of avoided net costs is assumed to have an effect in all countries except in the Netherlands as there the measure is already in place. The scenario also includes a general agreement of a fixed feed-in tariff within EU, which gives a small impulse to the Dutch IRR values. In Belgium the introduction of a CHP certificate system (assumed in this scenario) might give an additional impulse to CHP.

Combined Cycle applied for District Heating

Note that the cost-effectiveness of District Heating it is assumed that all electricity will be sold to the grid and the system borders are assumed to lie at the CHP plant. This means that the costs of the district-heating network are not included in the present model evaluation. The question is whether a CHP plant or a boiler is more cost-effective in supplying heat through the (existing) district-heating network to consumers. The only difference between the previous cases is the number of full load hours, as the heat demand for spatial heating is assumed to have a more seasonal character. So due to lesser number of load hours (5500 hours), less output is generated and sold although the fixed costs of such an investments are equal. Clearly the IRR values for these DH cases will be lower than the previous industrial cases.

Although the evaluation of a DH heating by CHP plants compared to an industrial CHP plant seems similar, one should be aware of the fact that the potential for district heating largely depends on the capacities and availability of a heating distribution network. If such a network is not in place, one should also include in the costs the investments into the heating network.

3.8.3 Conclusions from the IRR calculations

From the IRR calculations it can be concluded that the 'General' scenario policy package has hardly any influence on improving IRR. Comparing the impacts among the different Member States the 'General' scenario shows different results. For some countries the scenario even has a negative impact (Austria, Germany, Netherlands, Denmark). The scenario includes mainly measures to increasing the transparency on the European electricity market and consequently increasing competition in these energy markets. For a lot of countries this implies (is assumed) lower electricity prices compared to the prices that currently prevail in the market.

The 'Gas' scenario contains measures that should decrease market barriers in the gas markets. The main focus of these measures is increasing transparency regarding the regulations of the gas market and the networks. This covers the enhancement of network procedures, facilitating access and connections to the network and therewith developing a mature gas-to-gas-competition in the EU. It is assumed that these measures altogether will bring forward lower natural gas prices. The IRR calculations show that for most countries this 'Gas' scenario increases profitability of gas-fired CHP to a moderate extent. The measures in the 'Gas' scenarios push the IRR values in some MS to just above the minimal IRR requirement of 10%.

The comparison of the two technology types demonstrates that technologies with a higher heat/electricity-ratio are less sensitive for variations in the gas price. Hence the 'Gas' scenario has less impact on CHP technologies with a higher heat/electricity ratio.

From comparing the IRRs of the 'CHP' scenario with the IRRs found for the Reference scenario, it is clear that this 'CHP' policy scenario has a significant impact on the profitability of CHP in almost all countries. This can mainly be ascribed to the increased valuation of electricity produced by CHP, which applies to al countries. The increased valuation is a result of measures such as the remuneration of reduced net losses, avoided transmission net costs and establishing a fixed feed-in tariff for CHP electricity sold back to the grid.

An overall conclusion from the analysis is that there are countries where the IRR is always at an acceptable (more than 10%) level (Denmark, Netherlands and UK) and countries where CHP is never feasible (Greece, Luxembourg, Norway and Sweden) according to the calculated IRR. Simply explained because in Luxembourg and Greece the gas prices are too high and in Norway and Sweden competition on the electricity market is very strong, leading towards extreme low electricity prices.

In general the situation of completely own consumption of CHP electricity the IRR values are higher and thus CHP is more profitable than when CHP part of the electricity is exported back to the grid. In order to make optimal use of the environmental benefits of CHP and also for increasing the security of supply on the electricity markets, CHP policy should specially focus on stimulating CHP units, which are dimensioned on the local site heat demand. As a consequence exporting electricity to the grid has to be lucrative for CHP too of course. The 'CHP policy' scenario includes several stimulation measures that are concentrated on these electricity exports. Note that these measures also would make District Heating based on CHP a more robust option against changing market conditions. Still the results show that industrial based CHP plants are more profitable than CHP for DH. Again this is mainly due to the generally lower amount of operational hours for CHP in a DH context and the revenues (tariffs for) from sales of electricity produced to the grid compared with purchasing electricity directly from the national power grid.

3.9 Recommendations and Epilogue

In this report that summarises the calculation results of the evaluation of economic viability of gas-fired CHP plants, based on calculated IRR values, we focused on the promising CHP plant option, namely the Combined Cycle 50 MW. By comparing the IRR values of the reference situation with the IRRs resulting from the different policy (packages) variants for the different CHP cases, one gets a reasonable impression of the relevance of some policies to effectively push the IRR value upwards to an minimally attractive level for investors in the different countries. In this summary report the focus was on the new Combined Cycle of 50 MW with varying the application of the technology, operational hours and the utilisation of the by CHP in excess of local demand produced electricity. In the evaluation of these results one should be aware of the fact that only quantitative effects to CHP can be taken into account in this model based financial analysis. A sufficient internal rate of return does not automatically result into new investments, as there can be other obstacles due to difficulties regarding for example license procedures, selling electricity to the grid or the availability of natural gas. This project concentrates purely on the effects of different policy scenarios on the internal rate of return. Below the CHP policy recommendations per country are formulated, which are based on the previously presented IRR calculations.

3.9.1 Recommendations per country

Austria

Currently electricity prices are relatively high, but the opening up of power market, overcapacity and presents of large low short run marginal costs hydro capacity lead for CHP to increasingly competitive prices of electricity. So improving access of CHP to grid (remove administrative & tariffs barriers) and particularly allowing CHP a premium to grid deliveries will slightly improve the CHP profitability but not sufficiently for CHP with sales to the grid. However the profitability of CHP plants with all 'heat & power' produced consumed at the local CHP site, will certainly be enhanced due to a gas tax exemption already in place. However, the outlook for CHP is still dim, except for specific small-scale CHP technologies for own consumption.

Belgium

Next to abolishing the national monopoly on power generation and transmission and real opening up of the electricity market to new entrants such as CHP, energy taxation and CHP premium and internalisation policy are effective policies to increase IRR and promote investing in CHP and are therefore strongly recommended. Recently a Green, respectively CHP certificate system was adopted in Belgium. Specific 'CHP policy' included measures even could drive IRR to higher values than 20%, if sales to the grid are possible. So if recommended policies such remuneration of avoided grid losses costs, feed in tariffs etc are introduced one might expect more CHP investments to emerge in Belgium.

Denmark

Tax exemption and premiums for CHP electricity sold back to the grid are currently a great incentive and already in place. More CHP specific measure although effective to enhance the economic viability of CHP, will probably not lead to any expansion of current capacity due to the currently existing 'over-capacity' of heat and electricity production from other technologies in the next years.

Finland

Irrespective of the stimulating policies such as premiums on CHP electricity sales to grid and tax exemption for gas purchases and also removal of barriers such as non-transparent connection procedures, the CHP investments are not becoming sufficiently profitable. Therefore it is not expected that CHP capacity will expand much. Also the under-developed gas grid and heating grid systems limits expansion of CHP.

France

Starting point should be to lessen the dominant position of EDF and remove all barriers to new entrants of the electricity market. Thereafter introduction of an energy (internalisation of) tax, premium for CHP electricity sales to grid and certificate trade for CHP will improve profitability and thus the scope for CHP substantial. Adopting CHP specific measure on top of that will favour CHP investment climate largely.

Germany

Recommended are, next to tax exemption, which is already in place, a wider application of the measures such as put a premium on sales of CHP electricity back to the grid, remuneration of avoidance of grid losses etc. This could certainly lead to substantial expansion of CHP investments, but only if transparency of regulatory framework and fair access to the grid for small-scale CHP producers is assured.

Greece
Currently there is limited scope for gas-fired CHP. So enhancement of the access to and expansion of the gas grid is a first priority. But this fast expansion of the gas grid and thus of CHP in the next years is not expected.

Ireland
Relative high electricity prices seem to favour CHP. However the low dispersion of gas network, limited ‘high intensity’ of heat demand at relevant locations hamper scope for CHP. This is regrettable because introduction of energy tax (with exemption for CHP) might certainly lead to IRRs higher than 20% as calculations demonstrate. So policies in the ‘General policy’ variant type of incentives can only be beneficial for small units (for own consumption producing CHP) for producing heat to the demand in industries. Recommended is therefore to increase the accessibility to gas for IPP’s and CHP plants.

Italy
First priority seems more stability, transparency in the regulatory framework and easier access to gas networks. Next step should be to enhance profitability of the investments in CHP by allowing the sale of excess electricity to the grid, remuneration of avoided grid losses, allow for premium to grid deliveries and internalise environmental benefits to CHP. So far only CHP for own use seems profitable.

Luxembourg
Over capacity in electricity production discourage all scope for effectiveness of measure. Otherwise tax exemptions and premium for feedback to the power grid with CHP deliveries together with energy taxation will be still insufficient to raise the IRRs to acceptable levels.

Netherlands
With all policies in place IRRs are generally in an acceptable range (higher than 10%). Nevertheless given the current huge imports of Green electricity and therefore ‘over-capacity ‘ in electricity supplies CHP capacity will probably not expand further in the near future.

Norway
Very low electricity prices scared off all investments in CHP up till now and will do probably also in the next years. All measures identified and applied in calculations to other countries cannot improve the IRR values for Norway to acceptable minimally required (10%) IRR values for an investor.

Portugal
Tax exemption for gas to CHP for plants delivering electricity to the grid is very effective as a first step but still insufficient to reach acceptable IRR values. Needed is a further lowering of the gas price to CHP (so stimulate gas-to-gas competition), which could lead to viable CHP investments, if CHP capacities are dimensioned for own local use of produced heat and power Also recommended are CHP specific measures such as remuneration avoidance of grid losses in case of making profitable CHP options with a need to sales of CHP electricity to the grid. If these policies are in place one can expect thereafter that CHP capacity can increase substantially.

Spain
The barriers of relative low electricity prices and limited development of gas grid should be overcome firstly before expansion of CHP is possible at all. But if fulfilled, the IRRs of CHP investments are expected to rise between 20 and 10% and therefore might lead to CHP investments in the future. After putting in place measures like gas tax exemptions and fair grid access and tariffs for sale of electricity to grid, IRRs might even further increase.

Sweden
Low electricity prices, even if all measures are in place, lead to far too low IRRs for CHP. So no expanding CHP development is expected in the next years.

UK
NETA now 'discriminates' against CHP with regulatory policies. These barriers should be removed first. Measure such as remuneration avoided grid losses, internalisation environmental benefits etc. will certainly enhance the economic viability of CHP, because calculated IRR values rise to levels between 10 till 20%. Thus investments in CHP can be expected if reasonable CHP incentives are in place. Note that is new regulatory framework these incentives are included.

3.9.2 Epilogue

Generally it should be stressed that the model calculations clearly demonstrated that countries with tax exemptions for gas delivered to gas-fired CHP plants and tax on electricity supply to consumers have a sufficiently favourable investment climate for CHP. Consequently the scenario variant 'CHP specific measures', containing these measures, has the most positive impact on the profitability of CHP. So these measures are for most countries strongly recommendable.

Another importantly step forward would be the introduction of methods to internalise external costs (social and environmental) in the prices of electricity and heat. This might provide also strong improvement of the IRR of gas-fired CHP plants. But much of the positive impact will depend on the specifics of the regulations and how it is applied. For example a carbon tax that taxes fuel for on-site use, but excludes electricity generation in power stations is not helpful in this respect. Where as a carbon tax on all type of fuel at the source is more helpful instrument for promoting CHP and so would be a carbon credit system.

Also an important measure in this set of measures is the labelling of CHP. Clearly labelling CHP and the trading in these certificates, could lead to advantages for the economics of CHP. Eligible CHP plants are awarded certificates in proportion to their energy (heat and electricity) production. Each unique certificate is concrete evidence of CHP energy production by CHP of a guaranteed 'quality' and 'type'. Thus the CHP operator would have two main types of product electricity and heat and CHP certificates. CHP certificates are sold to generate a revenue stream. The value of the certificate naturally depends on the demand for CHP certificates. Demand can be categorised into voluntary demand and mandatory (or incetivsiced) demand. Voluntary demand envisages CHP certificates being used as a mechanism for Green electricity consumers to CHP electricity. For example, CHP and renewables, could be sold together to green electricity consumers as a mixed CHP and renewables 'green tariff'. The extent of this demand is currently unknown, but it is likely to be small - a subset of the current niche market for voluntary consumption of renewables.

In summary some form of mandatory, or incentivised demand is therefore a key part of a CHP certificate system design. The most common approach for CHP is to set an obligation on electricity suppliers or consumers to buy a certain quantity of certificates. Another approach (e.g. in the Netherlands) is to offer a tax break linked to certificates.

Last year great progress have been made in the development of these CHP certificate trading systems in some MS and also in the discussion on the by the European Parliament and the Council of Ministers proposed CHP Directive 'On the promotion of cogeneration based on a useful heat demand in the internal energy market'. After the 2nd reading on 18th December 2003 the next and final hurdle to be taken seems the further precision of and agreement on the calculation methods and definitions to be used by the Member States to identify promotional measures to high-efficiency cogeneration. So the perspectives of CHP in Europe could be improved in the next years.

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