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# Background Report on Implementing the Cogeneration Directive

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## Background Report on Implementing the Cogeneration Directive

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## EXECUTIVE SUMMARY

This report is prepared in support of the implementation of Article 11 of the Cogeneration Directive (2004/8/EC), which states that the Commission should periodically report on progress in implementing the Directive and its effects in terms of promotion of high efficiency cogeneration.

*Chapter 1* provides an introduction and overview of this progress report.

*Chapter 2* of this document analyses the potential for high-efficiency cogeneration in the EU and the progress towards realising that potential. The analysis is based on Member States' national reports, the templates with quantification of national potentials (as submitted by Member States in response to the Commission's request), external scenario data and technology parameters, and internal Commission analyses.

In total, the national reports and templates show a CHP (*Combined Heat and Power*, used interchangeably with the term *cogeneration*) growth potential corresponding to 335 TWh additional annual electricity generation by 2020, implying a 5.7% compound annual growth rate. Reaching this potential would increase CHP-based electricity production in the EU-27 from around 11% of total gross electricity generation in 2007 to around 21% in 2020. By 2020, this could lead to 15-25 Mtoe/y of primary energy savings, and 35-55 Mt/y of avoided CO<sub>2</sub> emissions. A further breakdown of the potential shows a clear shift towards lower-carbon fuels, as well as a decline of use of the conventional steam turbine cycle. Technical and economic parameters of national reports show some convergence. The economical potential identified is reasonably in line with economic reference scenarios. However, realising this potential may be challenging, because it requires more than tripling the historical annual growth rate of CHP output up to 2020. Moreover, a number of countries would need to achieve very large increases in CHP output, in order to realise the potential. Eurostat data shows that penetration of CHP in EU-27 has not significantly increased since 2004.

*Chapter 3* starts with a review of the progress in transposing the Directive into Member States' law, which –as the analysis shows – has been generally achieved. Second, it reviews the extent to which the Directive mandated reporting rules and procedures have been implemented; this is generally achieved but the process has suffered lengthy delays and six Member States still have one or more reports outstanding at the time of writing this report (Q1 2012). At the time of writing this report (Q2 2011) it reviews Member States progress in identifying and removing network connection barriers to cogeneration in the EU, where the reports are found to be of highly variable quality but progress has been made. Fourth, it reviews Member States progress in implementing Guarantees of Origin (GO) schemes for electricity from high efficiency cogeneration – where 11 Member States don't have and 16 have such schemes. Finally, it reviews cogeneration with district heating market issues, where it concludes that there is an extremely large scope for the increase of district heating with CHP, but that there are numerous barriers to its implementation.

*Chapter 4* is devoted to comparing the effect of the different support schemes promoting CHP. The aim of this analysis is to pinpoint which kind of supporting measures have been more effective in promoting CHP. This analysis looks into the average evolution of the cogeneration between two different periods of time (2002-2004) and (2006-2008) in all the Member States. The information used to assess the evolution of CHP comes from Eurostat

whereas the economical support offered to CHP by the supporting measures comes from the CODE Project (The Cogeneration Observatory and Dissemination Europe). As a conclusion of the analysis it can be said that there is no evidence that the Member States whose supporting measures include economical advantage to CHP projects have been more effective in promoting cogeneration than Member States not providing any economical advantage. Following the same approach it has been shown that the promotion of RES has not affected the promotion of CHP.

*Chapter 5* contains a summary of a Commission report that reviews the Reference Values. It broadly accepts the earlier methodology used to establish reference values in 2006; notes how the previous reference values for the period 2006-2011 compare with data on efficiencies of plant operating under realistic market conditions during the same period; and makes recommendations about future treatment of the issue of reference values.

*Chapter 6* assesses the impact of the EU Emissions Trading Scheme (EU ETS). During Phase I of the EU ETS quite a number of countries experienced unintended negative effects in the way CHP was treated, which did not contribute to its development in these Member States. During Phase II (2008-2012) of the EU European Trading Scheme improvements were made in how free emission allowances were attributed to CHP. In Phase I and II larger CHP units could be penalised compared to smaller CHP units (below 20 MW thermal power) since the latter were not included in the EU ETS. In Phase III (2013-2020) of EU ETS the allocation of emission allowances will attempt to remedy this, since focus will move from the heat producer to the heat consumer. Thereby the disadvantage that larger units could experience versus smaller units should disappear. When looking at the period 2002-2008 it is noticeable that many Member States have experienced a growth of CHP. However, it is not possible to judge how much of that can be attributed to the EU ETS, since the national support schemes in most cases contributed more to total cost reductions in the short term and effect of support schemes seems to have been minimal (See also Chapter 4).



## 1. BACKGROUND AND OVERVIEW OF THIS PROGRESS REPORT

The Cogeneration Directive (2004/8/EC) of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC is intended to promote cogeneration of heat and power (CHP) based on the perceived primary energy saving benefits and its contribution to European energy security.

One of the requirements of the legislation in Article 11 was that the Commission should periodically report on progress in implementing the Directive and its effects in terms of promotion of high efficiency cogeneration.

This report is an input to the Commission's assessment of the progress at the current time, on the different thematic elements of the cogeneration directive as required by Article 11 and other related matters.

Information is drawn from a variety of sources including Member States' reports, the scientific and technical literature, national and European trade associations and expert interviews.

It provides:

- An overview and critical assessment of the national potentials for high-efficiency cogeneration and Member States' progress towards realising the potential (Art. 11.1.a);
- An overview and analysis of the rules and procedures providing the framework conditions for cogeneration covering in particular network connection and access, guarantees of origin (GO) schemes, and heat market regulations issues (Art. 11.1.b);
- An overview of barriers and support schemes and an evaluation of to what extent the support schemes have contributed to the creation of stable conditions for investments in cogeneration (Art. 11.1.c);
- A review of the efficiency reference values for separate production on the basis of the current technologies (Art. 11.1.d);
- A preliminary assessment of the impact of the EU ETS and RES Directives on the development of cogeneration, (Art. 11.2, 1st paragraph);
- A preliminary assessment of the impact of EU internal energy market rules and other EU instruments<sup>1</sup> on the development of cogeneration (Art. 11.2, 1st paragraph);

Therefore, this document considers the following main questions:

---

<sup>1</sup> These instruments may include the gas security of supply Directive, Energy Services Directive (2006/32/EC), the Energy Performance of Building Directive (2002/91/EC and recast 2010/31/EU), the Integrated Pollution Prevention and Control Directive (IPPC, 96/61/EC, codified 2008/1/EC, and its recast industrial emissions directive (IED), the Large Combustion Plants Directive (2001/80/EC, also under recast by the IED), the Energy Taxation Directive 52003/96/EC, the Community Guidelines on State aid for environmental protection, the Energy labelling Directive (92/75/EEC and 2010/125/EC), the Eco-design Directive (2005/32/EC and 2009/125/EC), the SET-plan, FP7, European Industrial Initiatives, relevant Technology Platforms, Energy Efficiency and renewable energy initiatives, such as: the Covenant of Major, Concerto, Build-up, the IEE programs, Financing programs and facilities under the Cohesion and Structural Funds, by EIB, EBRD, etc.

1. What was the view taken by the Member States of the future potential of CHP?
2. At what state are Member States in implementing the Directive?
3. What progress have the Member States made in realizing CHP potentials?
4. What are the main barriers to implementation of CHP?
5. Did the Member States implement electricity network rules as required in the CHP Directive? – such as guaranteed transmission and distribution, priority dispatch at TSO level; rules for small scale and micro-CHP?
6. What has been the impact of the various support schemes on CHP growth?
7. What is the Commission's initial view of the impact on CHP of the EU ETS and RES Directives?
8. How should future Reference Values be reformulated?

Chapter 2 will address questions 1 and 3. Chapter 3 will address questions 2, 4 and 5. Chapter 4 will address question 6. Chapter 5 will address question 8. Chapter 6 will address question 7.

## **2. PROGRESS TOWARDS REALIZING NATIONAL POTENTIALS FOR HIGH-EFFICIENCY COGENERATION (ART. 11.1.A)**

### **2.1. Introduction**

Article 11(1)(a) of the Directive states that “[the progress report submitted by the Commission] shall consider progress towards realising national potentials for high-efficiency cogeneration referred to in Article 6”. This chapter addresses Article 11(1)(a), thereby answering the following main question: what do Member States think is the future potential for CHP, and have they made progress in realising that potential?

In order to answer this question, this chapter provides an overview and critical assessment of the EU potential for high-efficiency cogeneration. The overview is based on the national potentials identified by the Member States in the national reports that have been submitted to the Commission in accordance with Article 6(1) of the Directive. Furthermore, this chapter provides an assessment of the progress made by Member States in realising these potentials. The assessment is based on data from Eurostat and on the information provided by the Member States in accordance with Articles 6(1) and 6(3) of the Directive.

The structure of the chapter is as follows. First, Section 2.2 provides more details about the scope and methodology of the analysis. Next, Section 2.3 studies the EU heat market, which forms the basis for the overview of the cogeneration potential in Section 2.4. Section 2.5 provides a critical assessment of the cogeneration potential identified in the national reports of the Member States, while Section 2.6 gives an overview of the progress made in realising the national potentials. Finally, Section 2.7 summarises the conclusions of this chapter.

### **2.2. Scope and methodology of this analysis**

#### *2.2.1. Scope: Member State information included*

As mentioned above, the analysis of national potentials in this chapter is based on the national reports submitted by the Member States in accordance with Article 6(1) of the Directive. In addition, in order to ensure maximum comparability of the estimates submitted by different Member States, the Commission provided an electronic “template” to the Member States. In this template, Member States were requested to provide quantitative information about national cogeneration potentials, in a standardised format. Since the size of the cogeneration potential depends on the CO<sub>2</sub> emissions allowance price, the Member States were requested to complete the template for three different scenarios of CO<sub>2</sub> emissions allowance prices up to 2020. Eight Member States returned the template with the three scenarios as requested. Twelve Member States have returned the template with one or two scenarios. Hence, in total, 20 Member States have returned the template with at least one scenario. Out of the seven Member States that have not returned any templates, there are five Member States whose national reports contain sufficient information to infer the requested information on national potentials. For two Member States, information is lacking. An overview of documentation included in the analysis is given in Table 2.1. The eight countries that have provided 3 scenarios are Cyprus, Greece, Ireland, Italy, Netherlands, Poland, Slovakia, and Spain.

As a result of the above, the analysis in this chapter is based on input from 25 Member States (i.e. EU-27 excluding Luxembourg and Romania). These Member States represented 347

TWh out of a total of 353 TWh of electricity generated from CHP in the EU-27 in 2007, i.e. 98%.

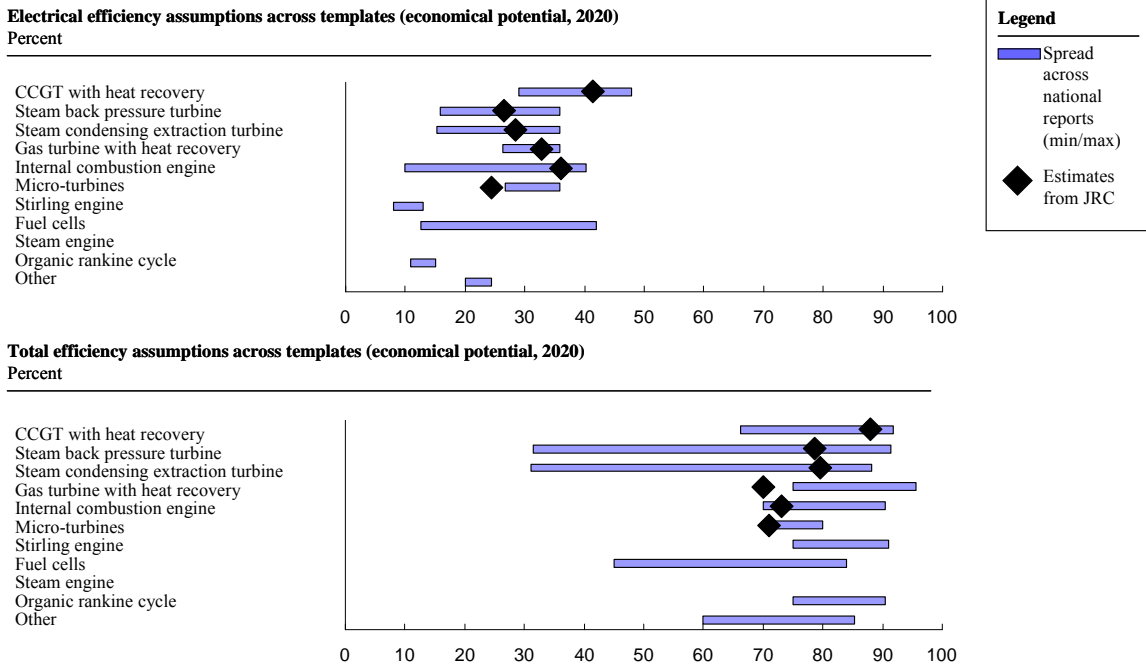
**Table 2.1: Overview of templates on national potentials and national reports used in the analysis of national potentials in this document**

	Member State	Template with at least 1 scenario submitted	Template with 3 scenarios submitted	No template submitted, but national report used for the analysis of potentials	Date of template	Date of corrections (if any)	Date of additional report or note submitted (if any)
1	Austria	Yes	No		14/02/2010		
2	Belgium	No	No	Yes			
3	Bulgaria	Yes	No		31/03/2010		
4	Czech Republic	No	No	Yes			
5	Cyprus	Yes	Yes				
6	Denmark	Yes	No		08/07/2010		
7	Estonia	No	No	Yes			
8	Finland	Yes	No		29/01/2010		
9	France	Yes	No		26/10/2010		26/10/2010
10	Germany	No	No	Yes			
11	Greece	Yes	Yes		17/05/2010		
12	Hungary	Yes	No		08/02/2010		
13	Ireland	Yes	Yes		17/05/2010		17/05/2010
14	Italy	Yes	Yes		25/05/2010		25/05/2010
15	Latvia	No	No	Yes			
16	Lithuania	Yes	No		29/01/2010		
17	Luxemburg	No	No				
18	Malta	Yes	No		28/05/2010		
19	Poland	Yes	Yes		22/11/2010		
20	Portugal	Yes	No		23/02/2010		01/06/2010
21	Romania	No	No				
22	Slovakia	Yes	Yes		11/02/2010	16/04/2010	
23	Slovenia	Yes	No				01/2010
24	Spain	Yes	Yes		22/02/2010		
25	Sweden	Yes	No		29/01/2010		
26	The Netherlands	Yes	Yes		16/04/2010		16/04/2010
27	UK	Yes	No		29/01/2010	12/02/2010	06/04/2010
	<b>Total</b>	<b>20</b>	<b>8</b>	<b>5</b>			

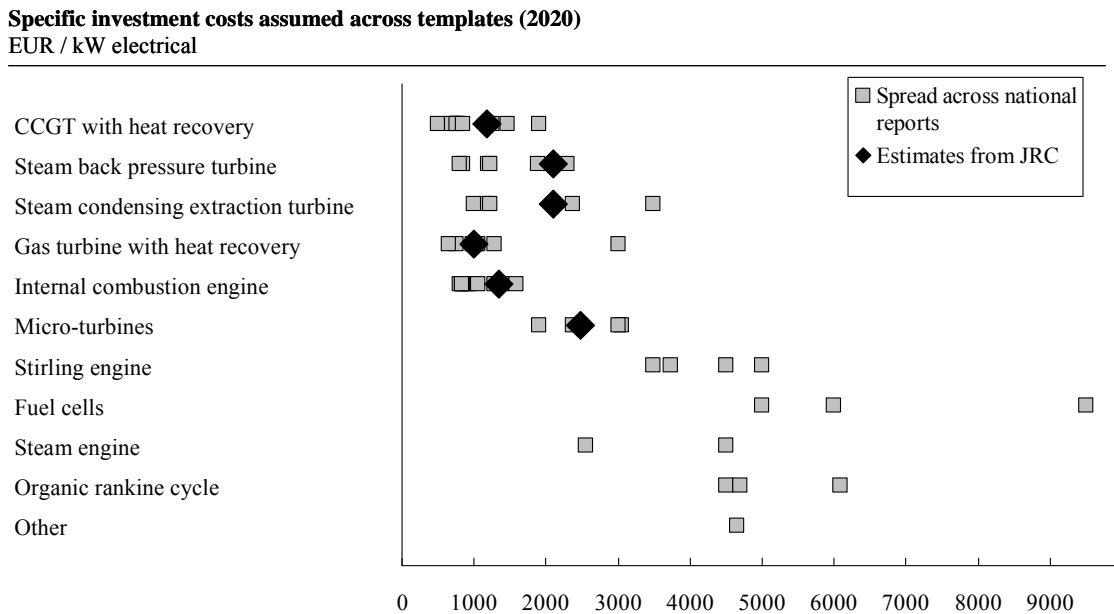
### 2.2.2. Convergence of efficiency and cost assumptions

Figure 2.1 and Figure 2.2 show the range of efficiency and investment cost assumptions used in the templates, as well as estimates of technological state-of-the-art provided by the JRC. Overall, the values show a certain level of convergence and are by and large in line with the JRC estimates. However, more agreement would be desirable.

**Figure 2.1: Efficiency assumptions compared across templates and with JRC estimates**



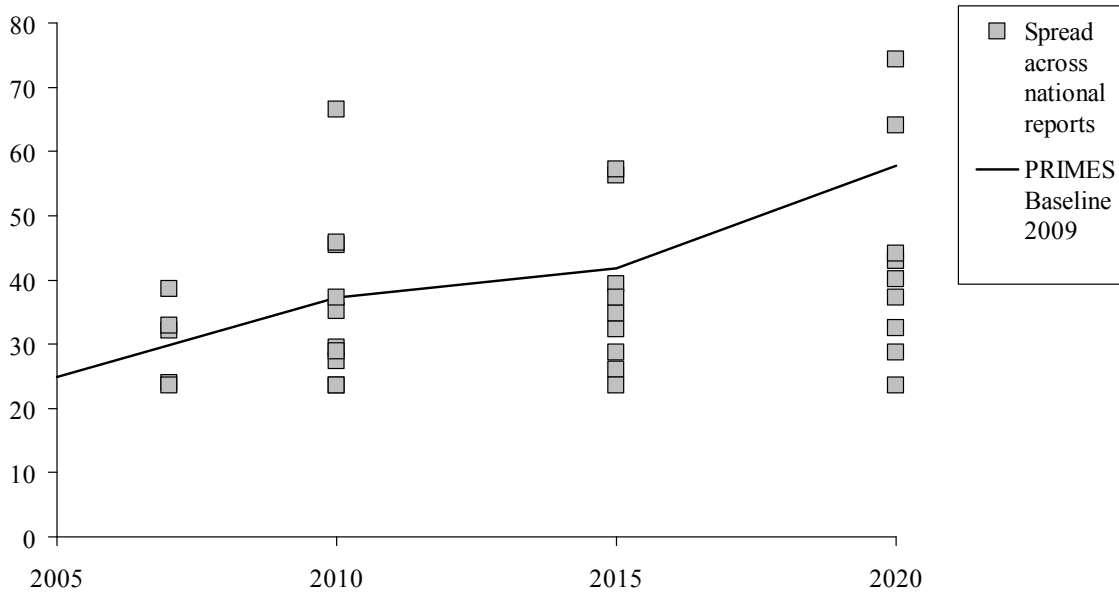
**Figure 2.2: Investment cost assumptions compared across templates and with JRC estimates**



### 2.2.3. Fuel price assumptions

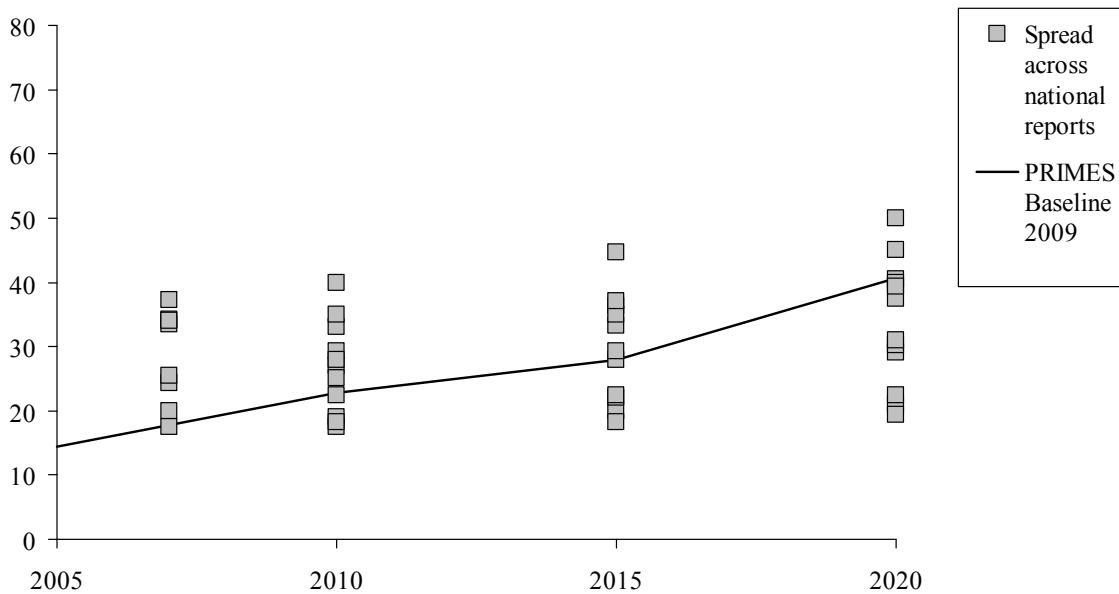
Similar to the above, Figure 2.3 and Figure 2.4 show examples of the fuel price assumptions made by Member States for their analyses of national potentials. The two figures deal with “oil and oil products” and “gas” respectively. The figures also show the corresponding assumptions from the PRIMES Baseline 2009 scenario. Differences between Member States may be due to national market conditions, or due to differences in the quality of fuels used (especially in the case of “oil and oil products”).

**Figure 2.3: Fuel price assumptions for oil and oil products, compared across Member States and with PRIMES Baseline 2009\* [EUR/MWh]**



\* PRIMES Baseline 2009 prices are converted to nominal prices using an assumed average inflation of 2% per year.

**Figure 2.4: Fuel price assumptions for gas, compared across Member States and with PRIMES Baseline 2009\* [EUR/MWh]**



\* PRIMES Baseline 2009 prices are converted to nominal prices using an assumed average inflation of 2% per year.

Assumptions for electricity and heat prices (i.e. output prices) are available only in a very limited subset of national reports, hence they are not described in this progress report.

#### 2.2.4. Methodological assumptions of this analysis

Since the national reports and templates deal with *high-efficiency* cogeneration only, the baseline numbers used in the national reports and templates are different from the statistics

recorded by Eurostat, which include *all* cogeneration, i.e. both high- and low-efficiency. In order to make the most productive use of the information available in the reports and the templates, a two-pronged approach has been used for the analysis in the remainder of the document. On the one hand, in order to put future potentials in the perspective of a comparable reference point, the information on existing CHP generation in the templates has been used as a reference when assessing potentials of individual Member States. On the other hand, in order to provide an insightful aggregate perspective on penetration of CHP at EU level, the Eurostat data have been used as a baseline for the overall assessment of the current situation.

Secondly, some countries interpret the concept of potential as being additional to the existing CHP capacity, while other countries include the existing CHP capacity as part of the potential. Therefore some potentials are lower than what is reported as existing CHP capacity in the same templates. Therefore, in this analysis, it has been assumed that these potentials are to be interpreted as additional to the existing CHP capacity. Regarding the other countries, it has been assumed that the potentials already include the existing CHP capacity.

Thirdly, whenever no technical potential was provided (or when the economic potential exceeded the technical potential), the technical potential is assumed to be the same as the economic potential.<sup>2</sup>

Fourthly and finally, in the event of discrepancies between the national reports and the templates, priority is given to the templates.

## **2.3. Overview of the heat market**

### *2.3.1. Sectoral breakdown of heat demand*

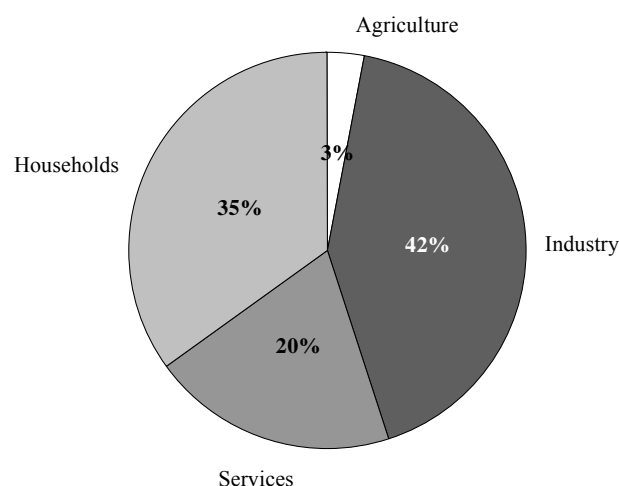
National reports from 15 Member States (Austria, Belgium (Flanders only), Bulgaria, Cyprus, Germany, Estonia, France, Greece, Spain, Finland, Lithuania, Luxembourg, the Netherlands, Poland and Slovenia) include a break-down of total heat demand by sector. It is noted that total heat demand includes demand satisfied both by cogeneration and by separate heat production. Cooling demand data is provided only by a very limited number of Member States and hence it is excluded from this analysis.

Figure 2.5 shows the overall break-down of heat demand into the main sectoral classifications of the economy (i.e. agriculture, industry, services and households), as derived from the 15 above-mentioned national reports. The percentage values per sector have been averaged across Member States on an unweighted basis, to prevent possible reporting inaccuracies in large markets from having a major impact on the end-result.

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<sup>2</sup> The technical potential is the maximum amount of CHP-based electricity production that is deemed possible, given the useful heat demand. The economic potential is the economically realisable technical potential under different economic scenarios.

**Figure 2.5: Break-down of total heat demand by sector, based on national reports from 15 Member States [Percent]**



The major heat markets are industry and households, which together represent close to 80% of the market. The remainder of the heat demand is almost completely attributable to the services sector, while the agricultural sector is small in relative terms.

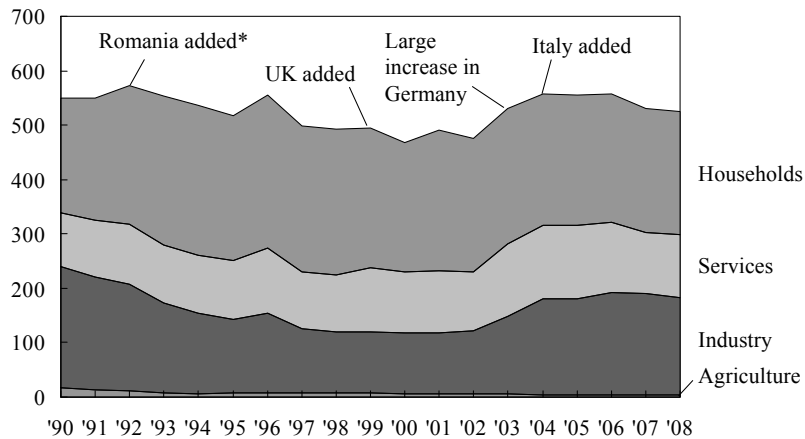
The resolution of the classification by sector varies per Member State: while all 14 above-mentioned Member States provide at least a break-down of heat demand into the main sectoral classifications of the economy, only a limited number of Member States provide data at a higher resolution. The analysis here of heat demand in the national reports is therefore limited to the main classification. To complement this analysis, the next section (2.3.2) studies Eurostat data of final consumption of derived heat, which provide a higher sectoral resolution.

### 2.3.2. *Historical evolution of the derived heat market*

Figure 2.6 shows the historical evolution of final consumption of derived heat in the EU-27, as reported by Eurostat. It is important to note that this includes only the heat *sold* to third parties and hence excludes all heat consumed by auto producers. The total number is therefore different from the total heat demand. As noted in the graph, the increases that take place in 1992, 1999, 2003 and 2004 can be attributed to statistical effects, most notably the inclusion of additional countries in the Eurostat analysis. If these increases are disregarded, a slightly declining trend can be observed. The break-down by sector shows that the decline takes place mostly in the industry sector (especially during the 1990s) while heat consumption in households and services has remained more or less stable. In 2008, total final consumption of derived heat by households represented 43% of the heat market, while industry and services represented 34% and 22%, respectively. Again, these numbers are different from Figure 2.5, because heat consumed by auto-producers is excluded.



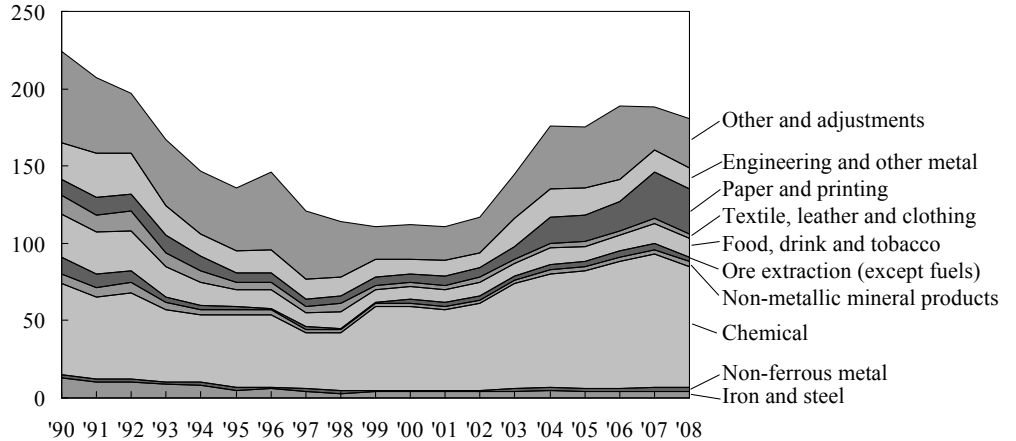
**Figure 2.6: Historical final consumption of derived heat, split by sector [TWh thermal] – Source: Eurostat**



\* Although Romania joined the EU only in 2007, Eurostat retroactively updated the statistics back to 1992.

Figure 2.7 provides a further break-down of heat consumption in industry. It can be observed that the decline is rather uniform across industries, except for the chemical industry and the paper and printing industry. The latter effects may however be related to the statistical effects mentioned above.

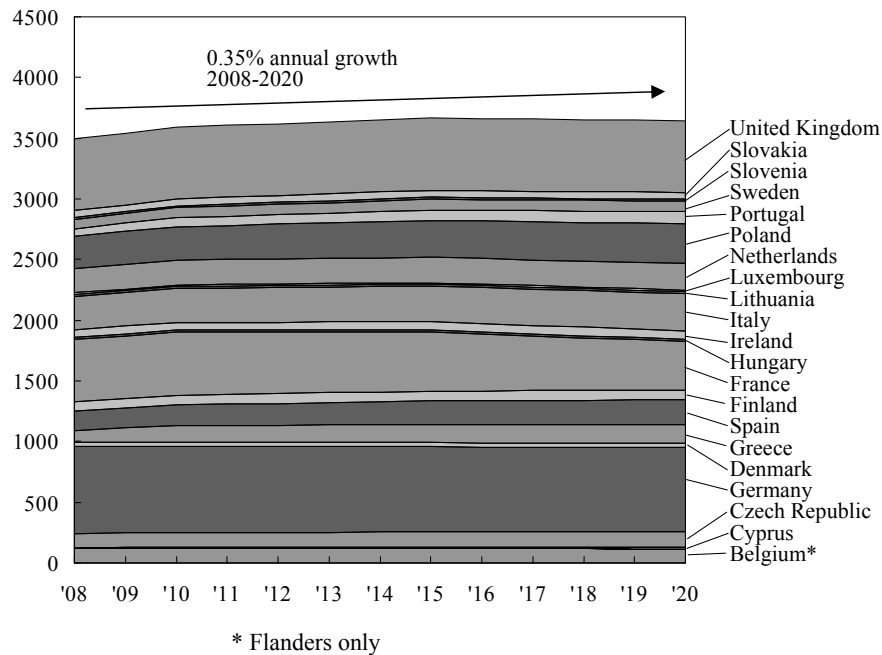
**Figure 2.7: Historical final consumption of derived heat in industry, split by subsector [TWh thermal] – Source Eurostat**



### 2.3.3. Heat demand forecasts

Templates and /or national reports from 21 Member States (Belgium (Flanders only), Cyprus, Czech Republic, Germany, Denmark, Greece, Spain, Finland, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Sweden, Slovenia, Slovakia and the United Kingdom) provide a forecast of total heat demand up to 2020. Figure 2.8 consolidates the forecasts of these Member States. It is noted that in cases where multiple scenarios are provided in the national report, this analysis uses the scenario that is called “main” or “reference” scenario in the national report. This may or may not correspond to one of the standardised scenarios provided in the templates (e.g. “15-15-15”). In the absence of a “main” or “reference” scenario, an unweighted average of available scenarios is used.

**Figure 2.8: Forecasted heat demand 2008-2020, based on templates and/or national reports from 21 Member States [TWh thermal]**



Aggregate heat demand evolves from 3495 TWh in 2008 to 3643 TWh in 2020. While the heat market is expected to grow slowly during the 2010-2015 period, overall a stabilisation or even a slight decline is expected after 2015. On average, this corresponds to a compound annual growth rate of 0.35% from 2008 to 2020. It is noted that the totals in Figure 2.8 are much larger than in Figure 2.6, which demonstrates that a large proportion of heat demand originates from auto producers.

The data underlying Figure 2.8 are shown in Table 2.2.

**Table 2.2: Underlying data of Figure 2.8**

Country	[TWh]				[PJ]				[Mtoe]			
	2008	2010	2015	2020	2008	2010	2015	2020	2008	2010	2015	2020
Belgium*	117	117	116	115	422	422	419	416	10	10	10	10
Cyprus	7	10	12	13	24	36	41	48	1	1	1	1
Czech Republic	118	121	127	132	424	435	457	474	10	10	11	11
Germany	719	712	701	689	2587	2563	2525	2479	62	61	60	59
Denmark	36	36	34	33	131	129	124	119	3	3	3	3
Greece	93	135	152	157	334	486	547	565	8	12	13	13
Spain	163	172	192	205	588	620	690	738	14	15	16	18
Finland	78	79	81	82	279	285	291	295	7	7	7	7
France	510	518	488	397	1836	1863	1755	1431	44	44	42	34
Hungary	16	16	17	18	57	58	59	65	1	1	1	2
Ireland	67	66	67	71	242	238	242	257	6	6	6	6
Italy	274	281	294	306	985	1012	1057	1103	23	24	25	26
Lithuania	15	16	17	18	56	57	60	63	1	1	1	2
Luxembourg	12	12	13	13	43	44	45	46	1	1	1	1
Netherlands	201	203	209	215	723	732	753	775	17	17	18	18
Poland	266	277	304	331	958	997	1093	1190	23	24	26	28
Portugal	64	74	87	98	229	265	313	351	5	6	7	8
Sweden	78	83	88	88	279	298	315	317	7	7	8	8
Slovenia	16	16	16	16	59	58	59	59	1	1	1	1
Slovakia	55	55	57	58	198	200	205	207	5	5	5	5
United Kingdom	591	591	595	588	2129	2129	2141	2116	51	51	51	50
<b>Total</b>	<b>3495</b>	<b>3591</b>	<b>3665</b>	<b>3643</b>	<b>12584</b>	<b>12927</b>	<b>13193</b>	<b>13115</b>	<b>300</b>	<b>308</b>	<b>314</b>	<b>312</b>

\* Flanders only

## 2.4. Cogeneration potential identified

### 2.4.1. Overview

Based on the methodological assumptions highlighted above, Table 2.3 provides an overview of the national potentials for CHP capacity, as derived from the documentation submitted by Member States. The table distinguishes between the technical potential and the economic potential, as defined earlier in this chapter. In particular, for the estimation of the economic potential, different scenarios for the price of CO<sub>2</sub> emissions allowances have been studied. For those Member States that have analysed multiple scenarios, the potentials are shown on separate lines in the table. Annual growth rates of the technical and economic potential of CHP capacity up to 2020, range from 0 to 42% and from -1 to 28%, respectively. Similar conclusions can be derived from Table 2.4, which provides an overview of the national potentials expressed in terms of CHP output.

**Table 2.3: Potential CHP capacity as derived from documentation submitted by Member States  
[GW electrical]**

Country	Scenario*	Present	Technical potential			Annual growth to 2020	Economic potential			
			2010	2015	2020		2010	2015	2020	Annual growth to 2020
Austria	15-15-15	0.924								
Belgium	15-15-15	1.908							1.515	
Bulgaria	15-15-15	0.657	0.669	0.777	1.259	5%	0.669	0.777	1.259	5%
Cyprus	15-15-15	0.000	0.016	0.162	0.308		0.013	0.079	0.150	
	15-25-25	0.000	0.020	0.164	0.308		0.017	0.099	0.188	
	15-50-50	0.000	0.024	0.166	0.308		0.020	0.119	0.226	
Czech Republic	15-15-15	5.273	23.865	27.266	30.634	14%	5.635	6.473	8.110	3%
Denmark	13-15-25	6.336	10.576	10.576	10.576	4%	6.376	6.349	6.532	0%
Estonia	15-15-15	0.150						0.397	0.397	
Finland	15-25-25	5.600					5.250	5.250	5.250	
France	15-15-15	6.336	35.345	34.835	30.340	14%	6.240	5.340	5.674	-1%
	15-50-50	6.336	35.345	34.835	30.340	14%	6.217	5.108	5.418	-1%
Germany	15-15-15	0.000								
Greece	15-15-15	0.052	1.190	3.019	4.857	42%	0.549	0.978	1.138	27%
	15-25-25	0.052	1.190	3.019	4.857	42%	0.549	0.990	1.154	27%
	15-50-50	0.052	1.190	3.019	4.857	42%	0.551	1.174	1.341	28%
Hungary	15-15-15	1.547	5.522	1.940	2.393	3%	1.592	1.647	1.707	1%
Ireland	15-15-15	0.290	0.490	0.630	1.310	12%	0.310	0.503	1.160	11%
	15-25-25	0.290	0.490	0.630	1.310	12%	0.310	0.503	1.160	11%
	15-50-50	0.290	0.490	0.630	1.310	12%	0.310	0.503	1.160	11%
Italy	15-15-15	7.060	40.880	40.587	40.297	14%	7.110	8.104	10.657	3%
	15-25-25	7.060	40.880	40.587	40.297	14%	7.110	9.858	10.878	3%
	15-50-50	7.060	40.880	40.587	40.297	14%	7.110	10.171	11.300	4%
Latvia	15-15-15	0.000								
Lithuania	15-15-15	0.000								
Malta	15-15-15	0.000	0.014	0.022	0.024		0.007	0.015	0.016	
Netherlands	15-15-15	12.870	23.971	22.570	24.338	5%	15.358	16.889	18.221	3%
	15-25-25	12.870	23.971	22.254	24.292	5%	15.358	16.841	18.751	3%
	15-50-50	12.870	23.971	22.502	24.178	5%	15.358	18.143	19.740	3%
Poland**	15-15-15	6.200	14.674	14.185	14.033	7%	12.783	12.130	12.033	6%
	15-25-25	6.200	14.674	14.185	14.033	7%	12.402	11.913	11.728	5%
	15-50-50	6.200	14.674	14.185	14.033	7%	12.022	11.696	11.652	5%
Portugal	15-15-15	1.399	2.917	3.442	3.867	8%	1.750	2.065	2.320	4%
Slovakia	15-15-15	0.077	2.714	4.200	4.766	37%	0.496	0.884	0.597	17%
	15-25-25	0.077	2.714	4.200	4.766	37%	0.496	0.889	0.619	17%
	15-50-50	0.077	2.714	4.200	4.766	37%	0.496	0.893	0.630	17%
Slovenia	15-15-15	0.335	1.238	1.275	1.417	12%	0.339	0.587	0.762	7%
Spain	15-15-15	3.761	8.651	9.162	8.646	7%	6.265	7.419	7.255	5%
	15-25-25	3.761	8.651	9.162	8.646	7%	6.265	7.265	7.112	5%
	15-50-50	3.761	8.651	9.162	8.646	7%	6.265	6.874	6.748	5%
Sweden	15-15-15	4.129	4.994	4.129	4.129	0%	4.994	4.580	4.429	1%
United Kingdom	15-15-15	5.469	47.003	48.274	50.958	19%	5.469	10.517	15.894	9%

\* The scenario refers to the CO<sub>2</sub> emissions allowances price assumed for 2010/2015/2020, expressed in EUR per tonne of CO<sub>2</sub>.

\*\* Poland supplied two cases for each scenario: one with hard coal and one with natural gas. This document uses the former, because it is the most conservative of the two cases.

**Table 2.4: Potential CHP output as derived from documentation submitted by Member States  
[TWh electrical]**

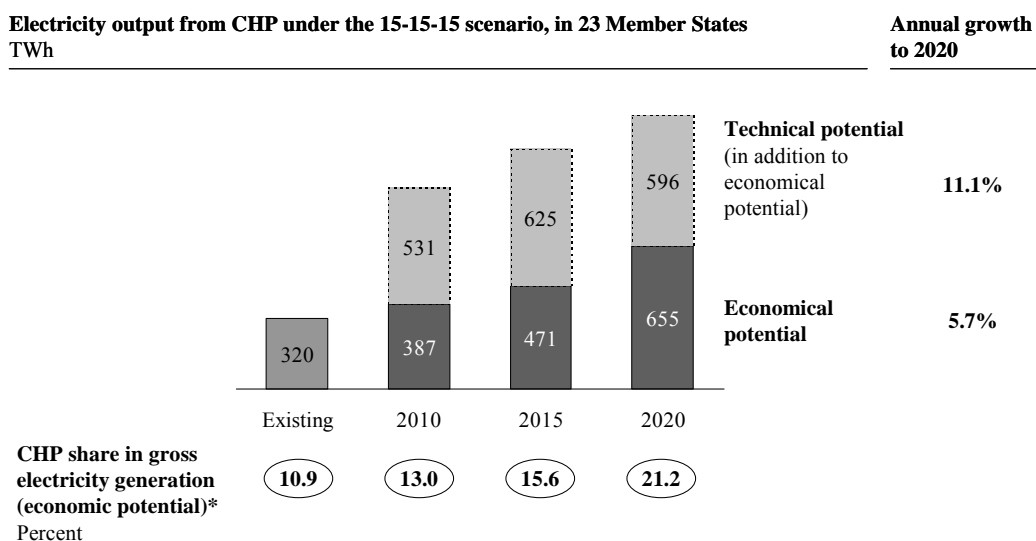
Country	Scenario*	Present	Technical potential			Annual growth to 2020	Economic potential			
			2010	2015	2020		2010	2015	2020	Annual growth to 2020
Austria	15-15-15	4.554								
Belgium	15-15-15	9.021							12.464	
Bulgaria	15-15-15	3.014	3.074	5.030	22.249	17%	3.074	5.030	22.249	17%
Cyprus	15-15-15	0.000	0.113	1.136	2.158		0.094	0.554	1.054	
	15-25-25	0.000	0.141	1.150	2.158		0.118	0.693	1.317	
	15-50-50	0.000	0.169	1.164	2.158		0.141	0.831	1.580	
Czech Republic	15-15-15	11.788	37.237	42.535	47.868	11%	12.636	14.365	17.419	3%
Denmark	13-15-25	22.900					23.323	21.917	24.910	1%
Estonia	15-15-15	0.000		4.000				2.100	2.100	
Finland	15-25-25	26.700					26.200	25.600	23.800	
France	15-15-15	21.645	133.973	130.140	111.669	15%	21.255	17.764	19.135	-1%
	15-50-50	21.645	133.973	130.140	111.669	15%	21.087	17.581	18.896	-1%
Germany	15-15-15	84.600							176.803	6%
Greece	15-15-15	0.121	8.340	21.155	34.040	54%	3.037	5.837	6.318	36%
	15-25-25	0.121	8.340	21.155	34.040	54%	3.039	5.960	6.369	36%
	15-50-50	0.121	8.340	21.155	34.040	54%	3.013	6.959	7.314	37%
Hungary	15-15-15	5.895	11.490	6.534	7.161	2%	5.595	6.095	6.131	0%
Ireland	15-15-15	1.820	3.420	4.120	9.040	13%	1.990	3.280	8.270	12%
	15-25-25	1.820	3.420	4.120	9.040	13%	1.990	3.280	8.270	12%
	15-50-50	1.820	3.420	4.120	9.040	13%	1.990	3.280	8.270	12%
Italy	15-15-15	22.990	133.708	133.914	134.133	15%	23.023	27.592	38.840	4%
	15-25-25	22.990	133.708	133.914	134.133	15%	23.023	35.322	39.818	4%
	15-50-50	22.990	133.708	133.914	134.133	15%	23.023	36.696	41.700	5%
Latvia	15-15-15	0.000								
Lithuania	15-15-15	0.000								
Malta	15-15-15	0.000	0.089	0.150	0.160		0.062	0.119	0.125	
Netherlands	15-15-15	61.470	102.107	100.933	109.801	5%	70.320	78.069	84.827	3%
	15-25-25	61.470	102.107	98.791	109.627	5%	70.320	76.833	87.043	3%
	15-50-50	61.470	102.107	100.677	109.194	5%	70.320	83.062	91.004	3%
Poland**	15-15-15	25.000	67.500	65.520	64.550	8%	58.800	55.800	55.350	7%
	15-25-25	25.000	67.500	65.520	64.550	8%	57.050	54.800	53.950	7%
	15-50-50	25.000	67.500	65.520	64.550	8%	55.300	53.800	53.600	7%
Portugal	15-15-15	5.407	13.197	17.819	22.348	12%	7.918	10.691	13.409	7%
Slovakia	15-15-15	0.070	4.885	7.979	9.656	46%	0.893	1.680	1.209	25%
	15-25-25	0.070	4.885	7.987	9.697	46%	0.893	1.691	1.259	25%
	15-50-50	0.070	4.885	7.993	9.719	46%	0.893	1.699	1.284	25%
Slovenia	15-15-15	1.106	4.731	4.903	5.541	13%	1.123	2.321	3.211	9%
Spain	15-15-15	19.870	45.675	46.686	45.979	7%	34.550	41.737	38.529	5%
	15-25-25	19.870	45.675	46.686	45.979	7%	34.550	40.819	37.764	5%
	15-50-50	19.870	45.675	46.686	45.979	7%	34.550	38.479	35.824	5%
Sweden	15-15-15	13.353	16.289	13.353	13.353	0%	16.289	14.986	14.448	1%
United Kingdom	15-15-15	27.911	239.885	390.729	412.455	23%	27.911	85.122	128.647	12%

\* The scenario refers to the CO<sub>2</sub> emissions allowances price assumed for 2010/2015/2020, expressed in EUR per tonne of CO<sub>2</sub>.

\*\* Poland supplied two cases for each scenario: one with hard coal and one with natural gas. This document uses the former, because it is the most conservative of the two cases.

Figure 2.9 provides a summary of the potential CHP output in the “15-15-15” scenario, i.e. a scenario in which CO<sub>2</sub> emissions allowance prices stay constant at 15 EUR per tonne up to 2020. 23 Member States have submitted data for this scenario (note that Denmark and Finland have submitted one scenario, but not this one). Under this scenario, the economic potential represents an increase in CHP electricity output from 320 TWh per year in the current situation<sup>3</sup> to 655 TWh in 2020, i.e. an increase by 335 TWh. The economic potential represents a 5.7% annual growth rate up to 2020, thereby increasing CHP penetration from 10.9% in 2007 (according to Eurostat) to 21.2% in 2020. The growth in technical potential is roughly twice the growth in economic potential.

**Figure 2.9: Graphical summary of potential CHP output**



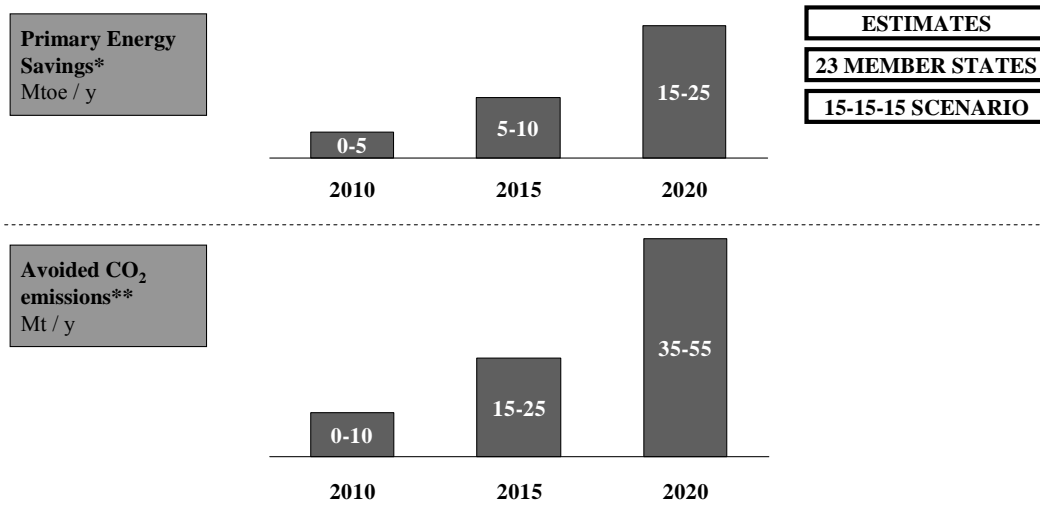
\* Estimation. For the column “Existing”, the 2007 figure from Eurostat is used (10.9). For the other columns, the ratio of CHP output (economic potential, from the Templates) after subtracting the existing 2007 CHPs, to total EU-27 gross electricity generation 2007, is added to the 10.9.

#### 2.4.2. Estimated impact on policy objectives

Figure 2.10 provides an estimate of the potential impact of the economic potentials – again under the “15-15-15” scenario – on two policy objectives of the EU: Primary Energy Savings (PES, as defined in the Directive) and avoided CO<sub>2</sub> emissions. The figure shows that the realisation of the economic potential would result in measurable energy savings and emissions reduction at EU level.

<sup>3</sup> As explained before, we use the national reports as a basis when assessing the national potentials, for the sake of comparability. The number 320 TWh is therefore a mixture of multiple base years (mostly 2007 and 2008), because different national reports used different base years. Furthermore, as pointed out before, this number does not correspond to Eurostat data of CHP penetration, most notably because the definitions are different (see Section 2.2.4).

**Figure 2.10: Estimates of Primary Energy Savings (PES) and avoided CO<sub>2</sub> emissions, corresponding to the identified economic potentials**



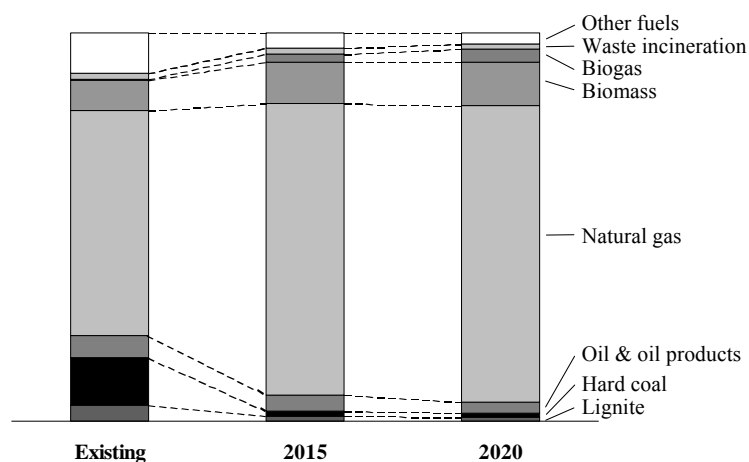
\* Primary Energy Savings are based on reference PES values (calculated according to Annex III of the Directive) for the future CHP technology mix indicated in the Templates. Since the resulting coefficient (in Mtoe/TWh<sub>e</sub>) has been applied at aggregate level, a large error margin applies.

\*\* Avoided CO<sub>2</sub> emissions are based on the Primary Energy Savings\* and reference CO<sub>2</sub> emissions for the future fuel mix indicated in the Templates. Since the resulting coefficient (in Mt CO<sub>2</sub>/Mtoe) has been applied at aggregate level, a large error margin applies.

### 2.4.3. Fuel and technology mix

Figure 2.11 and Figure 2.12 show the evolution of the fuel and technology mix, respectively, as projected in the economic potentials. In terms of fuel, there is a shift towards lower-carbon fuels. In terms of technologies, the conventional steam turbine cycle declines, internal combustion engines increase and CCGT (Combined Cycle Gas Turbine) maintains its significant share. It is noted that not all Member States have provided the full information, so the resulting graphs are an extrapolation.

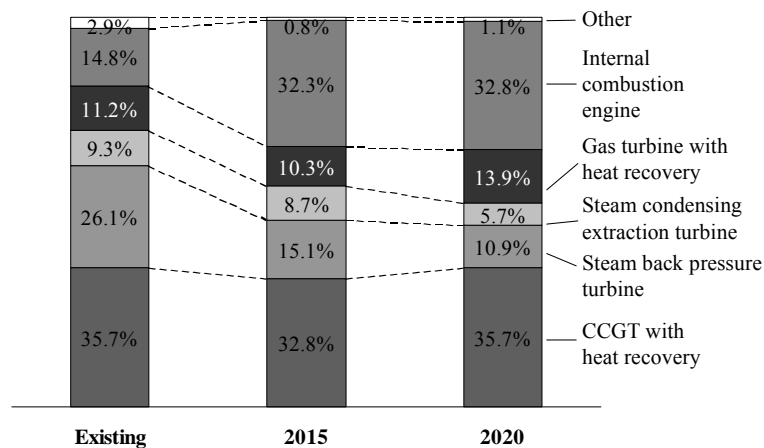
**Figure 2.11: Fuel breakdown of the economical potential CHP capacity (15-15-15 scenario, 23 Member States) [Percent]**



**Table 2.5: Underlying data of Figure 2.11**

	Existing	2015	2020
Other fuels	10.4%	3.8%	2.9%
Waste incineration	1.5%	1.6%	1.2%
Biogas	0.4%	2.1%	3.4%
Biomass	7.6%	10.6%	11.1%
Natural gas	58.0%	75.2%	76.5%
Oil & oil products	5.7%	4.1%	2.9%
Hard coal	12.3%	1.4%	1.0%
Lignite	4.2%	1.2%	1.0%

**Figure 2.12: Technology breakdown of the economical potential CHP capacity (15-15-15 scenario, 23 Member States) [Percent of TWh electricity generation]**

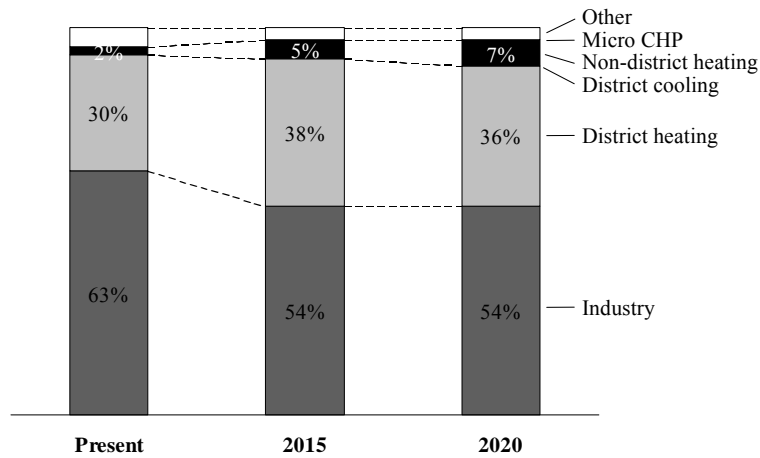


#### 2.4.4. Sectoral breakdown

Figure 2.13 shows the sectoral breakdown of the economic potential. The graph shows that industry and district heating are projected to remain the two main sectoral pillars of the cogeneration mix. Nevertheless, based on the aggregation of national potentials, it seems that more growth is expected in district heating than in industry, which is consistent with the decline in industrial heat demand observed in Figure 2.7. Non-district heating shows a substantial increase, while district cooling and micro-CHP remain very small.



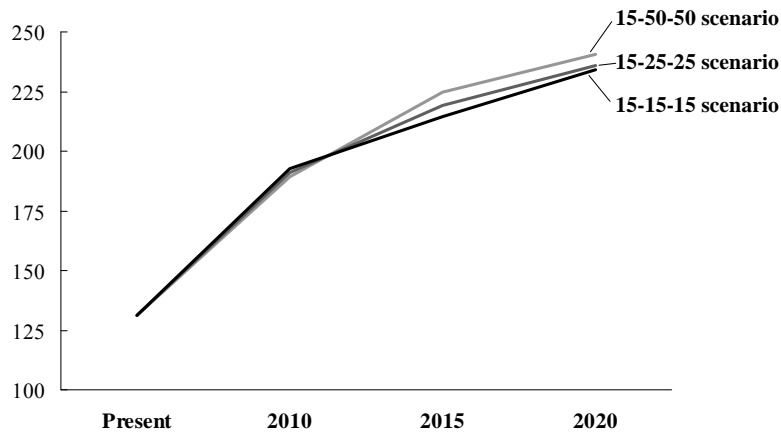
**Figure 2.13: Sectoral breakdown of the economical potential CHP capacity (15-15-15 scenario, 23 Member States) [Percent]**



#### 2.4.5. Impact of CO<sub>2</sub> price scenarios

Seven Member States have submitted templates with national potentials under three different scenarios of CO<sub>2</sub> emissions allowance prices, which allows for an analysis of the impact of CO<sub>2</sub> emissions allowance prices on the economic potential for CHP.

**Figure 2.14: Electricity output from CHP economic potential in 8 Member States\* under different scenarios for CO<sub>2</sub> emissions allowance price\*\* [TWh]**



\* Cyprus, Greece, Ireland, Italy, Netherlands, Poland, Slovakia, Spain

\*\* E.g., “15-25-25” refers to a scenario with a CO<sub>2</sub> price of 15/25/25 EUR per tonne in 2010/2015/2020.

From this figure, it can be concluded that the “15-15-15” scenario, which is the main focus throughout this document, is a conservative view of the CHP potential.

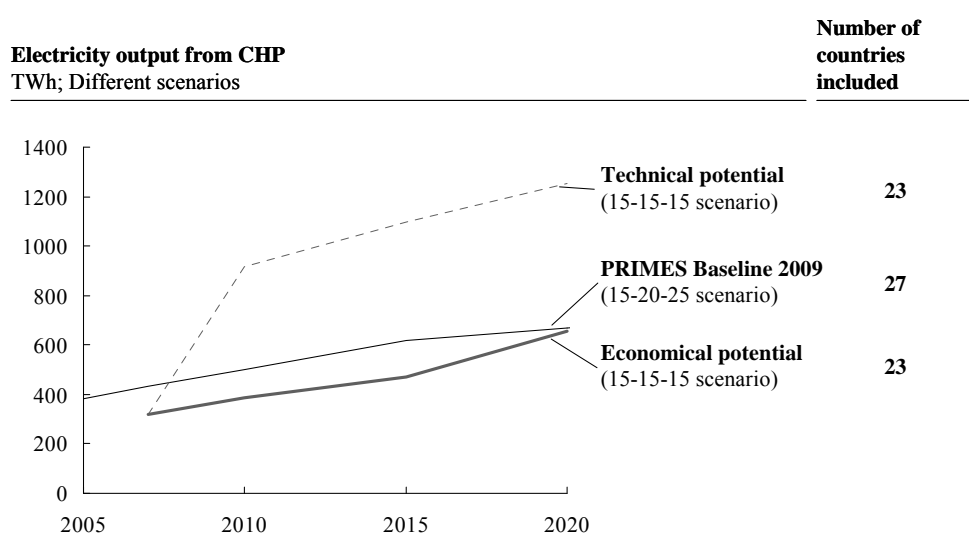
## 2.5. Critical assessment of the potential

This section provides a critical assessment of the national potentials (described above), by comparing the potentials with an EU-wide economic reference scenario, and by assessing the required growth rates at EU level and in individual Member States. Finally, this section also studies the progress made in terms of cogeneration penetration since the enactment of the Directive.

### 2.5.1. Comparison with economic reference scenario

Figure 2.15 shows again the technical and economic potential identified in Figure 2.9, and compares the results with the projected CHP output from the PRIMES Baseline 2009 scenario, which is a frequently used reference scenario in the context of EU policy-making. Attention has to be paid to the fact that the PRIMES scenario covers all EU-27 Member States, while the data on national potentials is only available for the 23 countries for which data is available for the “15-15-15” scenario. As mentioned before, it is noted that no information about potentials is available for Romania and Luxembourg, while Denmark and Finland have not provided the 15-15-15 scenarios. As a result, 23 countries are included in the graphs below. Overall, however, it seems that the economic potential is reasonably in line with the economic reference scenario.

**Figure 2.15: Comparison of economic and technical potential with economic reference scenario**



### 2.5.2. Required growth rates

While the economic potential is reasonably in line with an economic reference scenario at EU level, there may be challenges when considering the required growth rates, both at EU level and in individual Member States. First of all, at EU level, growth needs to accelerate significantly compared to the recent few years, in order to reach the economic potential. Figure 2.16 illustrates the step-change required: compared to an average annual growth rate of 1.6% observed between 2004 and 2008, the annual growth required to reach the economic potential by 2020 is 5.7% (as mentioned before), i.e. more than tripling the past growth rate.

**Figure 2.16: Illustration of increase in CHP growth rate required up to 2020 Source: Eurostat.**

**Electricity output from CHP in EU-27**  
TWh

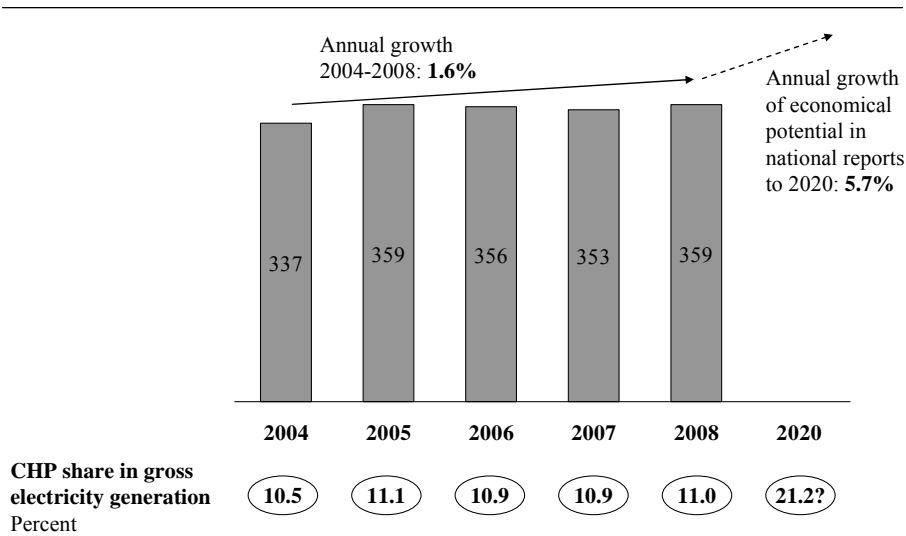
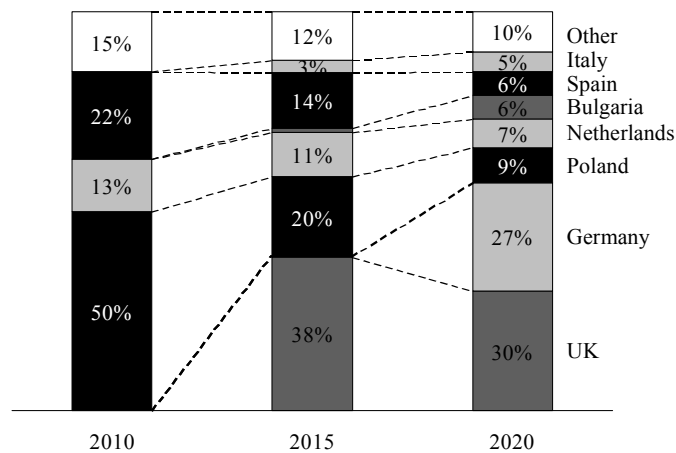


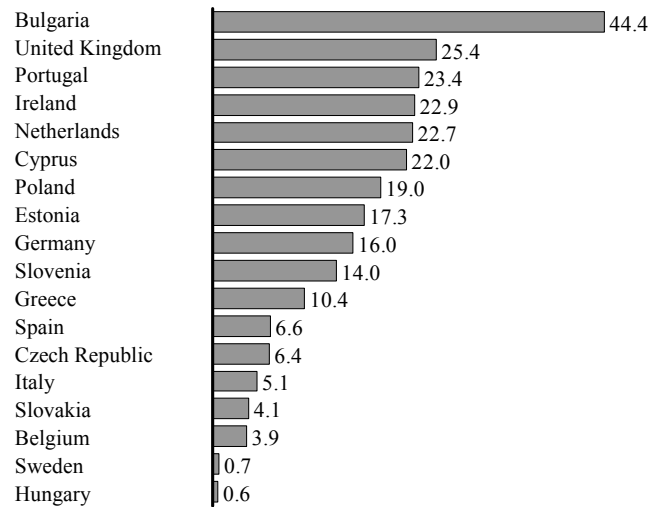
Figure 2.17 shows how the economic potential is distributed across 23 Member States. The figure shows only the increase in CHP output, i.e. the economic potential after subtracting the existing CHP output. One can observe a high concentration of CHP potential in a limited number of Member States. In particular, UK and Germany represent 57% of the potential by 2020, while five other countries account for another 33%.

**Figure 2.17: Breakdown of reported economic potential (after subtracting existing CHPs), in the 15-15-15 scenario (23 Member States) [Percent]**



The required increase in penetration of CHP up to 2020 is very large in some Member States, as illustrated in Figure 2.18. The required increase in penetration (measured in percentage points of total gross electricity generation) varies from around 0% up to 44.4%, with a sizeable number of countries requiring an increase in penetration of 20 to 25%.

**Figure 2.18: Increase\* from existing CHP output towards economical potential 2020 (15-15-15 scenario), divided by total gross electricity generation 2007 [Percentage points]**



\* Countries with zero or negative growth in CHP penetration are not mentioned in this graph.

## 2.6. Progress in realising the potential

As part of the Progress Report, Member States were asked whether they could already show progress in high-efficiency cogeneration – since the publication of the Directive on 21.02.2004 – which can be ascribed to either EU or national legislation and support schemes. Many countries report that it is too early to evaluate progress. Only few countries provide concrete evidence of increased penetration. The Progress Report of Bulgaria mentions that about 100 MW of new high efficiency cogeneration capacities have been put into operation since 2004. The Progress Report from Cyprus states that “*Cyprus can already show progress in cogeneration (four applications received since 2004). However the evaluation process is not completed yet for the year 2006 and thus we can not provide information if the investment proposal is high efficiency CHP. The progress is ascribed to the EU directive and the support scheme.*” The Progress report of Hungary provides an analysis of cogeneration over the period 2002-2007, thereby observing an increase in electricity production from cogeneration. The Progress Report of Lithuania mentions the start of the construction of a district heating cogeneration plant with 35 MW electrical capacity, as well as the modernisation of a boiler with 60 MW heat capacity. The Progress Report of the UK mentions that growth in CHP electricity since 2004 has been slow.

Eurostat data can be used to provide a more comprehensive answer to the question about progress since the introduction of the Directive 2004/8/EC. Figure 2.16 has already shown that the share of CHP penetration in gross electricity generation in the EU-27 has increased by 0.5 percentage-points: from 10.5% in 2004 to 11% in 2008. In absolute terms, electricity generation from CHP has increased by 22 TWh annually: from 337 TWh in 2004 to 359 TWh in 2008. As mentioned before, this corresponds to a compound annual growth rate of 1.6% per year. The trend is however not consistent across Member States. Table 2.6 summarises the evolution of CHP penetration in the EU’s Member States from 1994 to 2008. Overall, while some Member States increased penetration by more than 0.5 percentage-points (Belgium, Bulgaria, Germany, Ireland, Italy, Latvia, Lithuania, Luxembourg, Hungary, Netherlands, Portugal, Slovakia, Finland, Sweden), other Member States observed a decrease in penetration of more than 0.5 percentage-points (Czech Republic, Denmark, Estonia, Spain, France, Romania). It is noteworthy that CHP penetration levels in 2008 range from 0% to

46.1%, highlighting the large differences between each Member States' cogeneration situation.

**Table 2.6: Combined heat and power generation [Percentage of gross electricity generation] – Source: Eurostat**

	1994	1996	1997	1998	2000	2002	2004	2005	2006	2007	2008	Trend*
EU (27 countries)	:	:	:	:	:	:	10.5	11.1	10.9	10.9	11	=
EU (25 countries)	:	:	:	:	:	9.9	10.2	10.8	10.8	10.9	11	+
EU (15 countries)	9	9.4	10.1	10.9	9.6	9.2	9.5	10.2	10.1	10.3	10.3	+
Belgium	3.4	3.9	3.9	4.1	6.5	7.5	8.4	8.5	8.7	12.5	:	+
Bulgaria	:	:	:	:	:	:	7.3	6.1	6	9.4	10	+
Czech Republic	:	:	:	:	:	17.1	16.4	16.8	15.1	13	14.2	-
Denmark	54.5	54.6	59.9	62.3	52.6	49.1	50	52.1	40.7	42.8	46.1	-
Germany	9	6.8	6.7	7.5	10.6	9.8	9.3	12.6	12.5	12.2	12.5	+
Estonia	:	:	:	:	:	11	9.9	10.2	10.7	7.2	8.6	-
Ireland	1.5	1.9	2.3	1.9	2.4	2.5	2.6	2.4	5.6	6.3	6.2	+
Greece	2	2.1	2.2	2.1	2.1	1.9	1.5	1.7	1.7	1.6	1.9	=
Spain	5.3	7.7	9.8	11.2	9.2	7.8	7.9	7.8	7.2	7.1	7	-
France	1.8	1.9	2.1	2.5	3	4	4.1	4	3.2	3.2	3.1	-
Italy	11.4	12.9	16	17.3	8.3	7.4	8.1	9	9.8	10.3	9.5	+
Cyprus	0	0	0	0	0	0	0	0.3	0.3	0.3	0.3	=
Latvia	:	:	:	:	:	37.5	32	30.7	42.6	40.9	33.6	+
Lithuania	:	:	:	:	:	9.7	11.6	15.5	14.3	13.2	12.7	+
Luxembourg	:	:	9.5	22.5	17.7	7.9	10.6	10.1	10.9	9.9	11.9	+
Hungary	:	:	:	:	:	21.5	18.2	19.1	22.4	21.4	21.1	+
Malta	0	0	0	0	0	0	0	0	0	0	0	=
Netherlands	39.5	42.7	47.9	52.6	37.6	29.9	29.5	29.4	29.9	30.1	33.6	+
Austria	21.4	24.7	24.7	24.8	10.4	13.6	15.2	15.4	16.1	15.6	15.3	=
Poland	:	:	:	:	:	16	17	16.8	16	17.3	16.9	=
Portugal	9.9	8.2	8.6	8.4	10	10	11	11.6	11.6	12.3	11.9	+
Romania	:	:	:	:	:	:	26.4	26.2	18	10.7	9.6	-
Slovenia	:	:	:	:	:	5.9	6.4	7.3	7.4	7.2	6.7	=
Slovakia	:	:	:	:	:	17.5	15.3	15.3	27.6	25.6	24	+
Finland	30.9	32.5	33.3	35.8	36.4	38	34	38.9	34.9	34.4	35.6	+
Sweden	6.4	7.3	6.2	6	5.9	6.8	8.1	6.7	8	8.2	9.6	+
United Kingdom	3.6	4.3	4.9	5.2	6.1	5.4	6.7	6.8	6.3	6.4	6.4	=

\* Trend is based on the difference in penetration between 2004 and 2008 (or the latest number if 2008 is not available). A plus sign (+) indicates a growth in penetration larger than 0.5%. A minus sign (-) indicates a decrease in penetration larger than 0.5%. An equal sign (=) is used for all other cases.

## 2.7. Conclusion

This chapter has analysed the potential for high-efficiency cogeneration in the EU and the progress towards realising that potential. The analysis is based on Member States' national reports, the templates with quantification of national potentials (as submitted by Member States in response to the Commission's request), external scenario data and technology parameters, and internal Commission analyses.

In total, the national reports and templates show a CHP growth potential corresponding to 335 TWh additional annual electricity generation by 2020, implying a 5.7% compound annual growth rate. Reaching this potential would increase CHP-based electricity production in the EU-27 from around 11% of total gross electricity generation in 2007 to around 21% in

2020. By 2020, this could lead to 15-25 Mtoe/y of primary energy savings, and 35-55 Mt/y of avoided CO<sub>2</sub> emissions. A further breakdown of the potential shows a clear shift towards lower-carbon fuels, as well as a decline of conventional steam turbine cycle. Technical and economic parameters of national reports show some convergence, but more agreement would be fruitful.

The economical potential identified in the national reports seems reasonably in line with economic reference scenarios. However, realising this potential may be challenging, because it requires more than tripling the historical annual growth rate of CHP output up to 2020. Moreover, a number of countries would need to achieve very large increases in CHP output, in order to realise the potential. Eurostat data shows that penetration of CHP in EU-27 has not yet significantly increased since 2004.

### 3. OVERVIEW AND ANALYSIS OF THE RULES AND PROCEDURES PROVIDING THE FRAMEWORK CONDITIONS FOR COGENERATION INCLUDING NETWORK CONNECTION AND ACCESS ISSUES, GUARANTEES OF ORIGIN (GO) AND HEAT MARKET REGULATION ISSUES (ART. 11.1.B)

#### 3.1. The CHP Questionnaire

In order to fill in gaps in information a questionnaire was sent to all Member States during November 2010. Eleven detailed responses were received.

Four countries reported they had fully incorporated the Directive into law, 5 had made significant progress, and one made no response to this question.

Member States were invited to make comments as to how the Directive could be strengthened or improved, and a selection of key comments is included below. There was felt to be a clear need for market intervention to address the reluctance of free markets to invest in CHP-district heating (CHP-DH).

The Cogeneration Directives' 10% primary energy savings definition of high-efficiency cogeneration is clearly a difficulty for some of the older Eastern European systems who ask for this criterion to be relaxed.

##### 3.1.1. *Extract of significant Member States' comments:*

**Sweden:** The main problem is the demand for low temperature heat, especially in district heating and cooling, there should be a major incentive to extend the district heating/cooling networks in combination with CHP.

**Germany:** Cogeneration is dependant upon an appropriate useful heat demand. In order to encourage the development of cogeneration the Directive should put a focus on heat sinks, the industrial or public use of heat from cogeneration, for instance by utilizing district heating and cooling.

Investments in cogeneration and heat sinks for cogeneration (for instance district heating and cooling) are high and induce long payback periods. The market conditions however do not react favourably to long payback periods. In order to encourage cogeneration development the preservation, modernization as well as the building of new cogeneration plants and infrastructure for heat sinks needs to be incentivized in order to attract companies to invest and put up with these long payback periods. The Directive however should link to these programs and express the political will to help encourage the development of cogeneration through incentives.

**Austria:** The main problem is the demand for low temperature heat, especially in district heating and cooling, there should be a major incentive to extend the district heating/cooling networks in combination with CHP.

**Bulgaria:** The Cogeneration Directive enables support of cogeneration with new technologies, but restricts the modernization of plants placed in service more than 20 ago years under other economic conditions. Bulgaria would like to see a reassessment of the criteria for high performance in terms of annual fuel savings of "not less than 10% "of fuel in separate proceedings.

**Estonia:** The Directive has significantly increased the motivation to promote CHP, large and positive developments can be observed in Estonia.

**Ireland:** There are significant barriers, especially economic (particularly the spark gap<sup>4</sup>), and the structure of the Irish heat market.

**Cyprus:** The lack of a CEN-CENELEC<sup>5</sup> Standard is an obstacle for promotion of cogeneration. A clear methodology is needed on how to calculate high efficiency CHP electricity from different technologies and fuel types.

PES criterion is not the right one and new criteria based on energy efficiencies are more appropriate. The calculation of PES requires many assumptions which are theoretical and not realistic. For instance CHP outcome is compared with a theoretical one assuming that the production is done from the Best Available Technology (BAT) when the ideal case for the producer would be to use electricity from the local grid.

Broader definition of CHP is needed in order to cover cooling demand.

**Finland:** The promotion of CHP has been on the agenda of Finnish energy policy for decades and the share of CHP already is about on third of their electricity supply. Finland would like to see rationalization of the calculation methodology for high efficiency CHP electricity based on annex II of the existing directive.

**Greece:** Would like to see: a common reporting format, a common methodology for the measurement cogenerated electricity, a common procedures for measuring the cogenerated electricity at a CHP installation, and a common procedures for connection of CHP installations to the networks.

### 3.2. State of transposition of the Cogeneration Directive 2004/08/EC

All EU Member States have confirmed the transposition of the Cogeneration Directive into national law. This is summarised in the table below:

**Table 3.1: Member States' situation on transposition at 1 December 2009.<sup>6</sup>**

<i>Member State</i>	<i>Is transposition complete?</i>
Austria	Yes – but responsibilities for the GO* system on regional level have yet to be clarified
Belgium	Yes
Wallonia	Yes
Flanders	Yes
Brussels	Yes - but formal requirements for GOs are incomplete
Bulgaria	Yes – but formal requirements for GOs are incomplete, grid access priority is only up to 10 MW
Cyprus	Yes
Czech Republic	Yes
Denmark	Yes – but no priority connection, priority access only for decentralised plants
Estonia	Yes – but formal requirements for GOs incomplete, no priority grid

<sup>4</sup> The Spark Gap is the difference in financial value of a unit of gas and the value of the electricity which that unit could generate in a power station

<sup>5</sup> CENELEC is the European Committee for Electrotechnical Standardization and is responsible for standardization in the electrotechnical engineering field.

<sup>6</sup> Source: CODE Member State reporting under the Cogeneration Directive including cogeneration potentials reporting <http://www.code-project.eu/wp-content/uploads/2010/02/290110-CODE-European-summary-report.pdf>. Later updated from Commission sources.



	access & connection
Finland	Incomplete
France	Yes – but no priority grid access & connection
Germany	Yes
Greece	Yes – but GO system not operational, priority access only for production facilities up to 35 MW
Hungary	Yes
Ireland	Yes
Italy	Yes, but GO only above 50 MWh/a
Latvia	Yes – but formal requirements for GOs unclear, no priority grid access/connection
Lithuania	Yes but no priority grid access/ connection
Luxembourg	Yes – but GO system not precise
Malta	Yes
Netherlands	Yes – but no priority grid access/transmission
Poland <sup>3</sup>	Yes
Portugal	Yes
Romania	Yes
Slovak Republic	Incomplete, grid access to be clarified
Slovenia	Yes
Spain	Yes
Sweden	Yes – but no priority access/connection
United Kingdom	Incomplete

\* *GO = Guarantees of Origin schemes for electricity from high efficiency cogeneration*

Transposition into a national law does not necessarily mean that the provisions of the Directive are fully implemented or active in that Member State. There is frequently complexity in the detail of implementation into national law following the formal adoption and only when the full process is completed can the transposition be said to be complete.

To varying degrees it is clear that there are gaps in the implementation of the Cogeneration Directive through the absence of secondary or other legislation.

Due to the lack of progress in several Member States it is quite possible that full implementation at national level will not be concluded in all Member States until late in 2011: 7 years after the acceptance of the legislation by the European Parliament.

In conclusion, the Commission considers the implementation of the Directive to have been slow and still incomplete in some Member States.

### **3.3. Status of implementation of the Cogeneration Directive by EU Member States concerning analysis, administrative structures and reporting**

#### *3.3.1. Introduction*

Under the Cogeneration Directive the Member States are asked to assess their national potential for cogeneration and to carry out various enabling assessments (of barriers, support mechanisms, verification through guarantees of origin) and then update the Commission on progress towards achieving the potential.

### 3.3.2. *Member States' reports*

Member States were required to produce the following reports:

- Analysis of the national potential for cogeneration. Article 10(1) and Article 6(1)
- Review of barriers to the wider use of cogeneration. Article 10(1) and Article 6(2)c.
- Administrative and procedural situation. Article 10(1),
- Guarantees of origin. Article 10(1) and Article 5(3).
- Progress Report on Cogeneration Directive. Article 10(2), Article 6(3).

Only seven Member States based their reporting obligations under article 6(3) (Progress Report) on a questionnaire supplied by the Commission. The rest of the Member States delivered this report following their own structure. In general, Member States were free to choose the format of the reports with the content guided by the Directive and its Annexes. As a result the Member States' reports vary considerably in depth and content.

In general reporting by Member States under the Directive has been slow and was completed for all Member States only on 16 February 2011. Only 12 Member States have completed all reporting under the Directive more than two years beyond the last deadline. All Member States should have delivered a report on the national potential for cogeneration to the European Commission by the 21<sup>st</sup> of February 2007.

Few Member States have moved quickly to implement the Directive, or follow through the reporting steps. Legal proceedings against defaulting Member States were started by the Commission in May 2009. Germany and the Czech Republic stand out as Member States which fully embraced and moved forward on the Directive.

Reporting national potentials by Member States under the Directive has been slow.

#### 3.3.2.1 *Member States' progress in reviewing support mechanisms for the promotion of cogeneration*

The Cogeneration Directive required Member States to “review their progress against the objectives of the Directive, initially in 2007 and thereafter every four years” evaluating progress towards increasing the share of high efficiency cogeneration“. Member States tended not to give explicit accounts of support mechanisms but rather to include comments on the schemes during either their assessment of economic potential or during the first progress report.

Several Member States have modified their support schemes during implementation of the Directive. Notably Germany, Belgium, Spain, Greece, Slovenia and Luxembourg have consciously chosen to enhance support for cogeneration.

### *3.3.2.2 Member States' progress in identifying barriers to the greater promotion of cogeneration in the EU*

All countries have followed different approaches to identify the possible barriers. The scope of the analysis carried out by the Member States ranges from carrying out surveys among stakeholders, to an enumeration of barriers. In some cases this enumeration is accompanied by supporting measures to overcome them. In one case, (Lithuania), the analysis essentially is a statement that there are no legal, technical or financial barriers preventing further implementation of CHP. The Member State that has not provided an analysis of the barriers in their report is France. The rest of the countries discuss, to a greater or lesser extent, the barriers that they have found, despite the fact that some of them only considered one barrier (Hungary, Denmark, and Sweden).

### *3.3.2.3 Network Access Barriers*

Two broad categories of barriers can be distinguished:

**The ability to sell power and capacity at a reasonable price:** to be able to fund a generation project it is essential to have the ability to sell power, MWh, and capacity MW, at a reasonable price, and to know for a long period ahead what that price is likely to be. It is clear that for project developers not having this certainty, this is a major barrier to chp since without it funding is not possible, or if it is, not at a favourable rate. This difficulty has frozen out many independent small chp suppliers due to uncertainty in knowing what future power prices will be, which is an issue the big utilities do not have to be so concerned about.

**Impact of bureaucratic, procurement and general administrative barriers:** In many countries, discussions with contractors indicate that there are very subtle but significant barriers to implementation of sound energy saving policies such as chp. These can arise from onerous costly tendering processes, which deter developers from even bidding for small efficient CHP-DH schemes.

#### **Overall conclusion:**

From reading the Member States' reports on barriers and also applying the knowledge obtained from talking to persons working in the Member States, we can conclude:

- Barriers analysis by Member States is not well done
- Member States do not readily acknowledge barriers
- It is not clear whether they did anything to remove those barriers, and they are not in fact obliged to do that
- The Directive does not effectively address all the major barriers to CHP

### *3.3.3. Member States' progress in reporting on Guarantees of Origin (GO) schemes for electricity from high efficiency cogeneration*

All Member States have provided information on their scheme for Guarantees of Origin (GO). However, some Member States (Belgium (Flemish Region, Brussels Capital), Greece, Romania, Malta, Czech Republic) do not provide the information about the GO explicitly mentioned in article 5(3) of the Directive.

#### *3.3.4. Conclusions*

One of the main conclusions reached by the European Commission is that the discretion given to the Member States to choose the approach followed to prepare the reports requested in Article 10 makes it difficult to make a consistent comparison of many of the points asked for in Article 10. Given the gaps in the reports about the matters treated (or in some cases not treated) means that most of the conclusions already extracted are in fact about these gaps. Some of these gaps were due to differences in interpretation about the reporting requirements. A clear conclusion of that analysis was, and is, the recommendation to clarify the minimum content of the requested reports. An index of each report with clear guidelines of the content to be included appears to be of paramount importance.

### **3.4. Progress in removing barriers concerning electricity network connection and access rules**

#### *3.4.1. Introduction meaning of the term “barrier”*

This section looks only at the issue of progress in removing barriers to the implementation of cogeneration systems which arise from the process of physically connecting to the electricity network and any associated procedures. Information is largely drawn from the National Templates and the National Reports.

It should be borne in mind that the Directive does not define “barrier” very clearly – a barrier could mean an absolute ban on access to cogenerators, or it could merely mean a general difficulty or impediment. The Member States’ responses clearly reflect a range of interpretations of the term. Thus the information asked for and the information given by Member States does not allow a clear evaluation of to what extent cogeneration is impeded.

Thus while the barriers to access to the network – such as a ban on small cogenerators - may have been removed according to Member States’ reports, nevertheless, the procedures may still be problematic and may be perceived as barriers by new entrants.

Future reporting requests should address this issue, and give much clearer definitions of the term barrier and how the question is to be responded to.

#### *3.4.2. Barriers concerning Network Connection and Access Rules*

In the context of the Directive, there are two broad distinctions which can be made with regard to an analysis of any barriers around the areas of Network Connection and Access Rules:

**Price** - To what extent is a reasonable price received for 1) power – MWh, 2) capacity MW, sold into the network and 3) Charging – what charges are levied for connection and use of the system?

**Procedure** - How easy is it for a cogenerator to connect to the power network in terms of administrative procedures, permits, technical requirements and licenses, and what connection charges are made by the network owner/operator.

Whilst both of the above can be considered barriers to network access (and have been responded to as such by Member States), this section of the report only looks at barriers which are covered by the subsection above **“Procedures”**.

Procedure as above can be broken down into 3 broad categories:

1. Administrative / bureaucratic barriers – essentially form filling and waiting for approvals in the various steps and electrical protection requirements.
2. Administrative charges – fees / licenses etc.
3. Costs of making physical connections – cables, transformers, switchgear etc – both the costs themselves and who pays for them.

### 3.4.3. Results: Information taken from the reporting templates

Table 3.2 below summarizes whether or not responses were received from Member States through the original reporting template and, whether any information was received at all. Then this information is categorised as described above. It is noted that this involves a certain amount of judgment:

**Table 3.2 – Member States’ response on network issues - summary**

DATA SOURCE – Templates – Comments from Member States on Network Connection and Access Rules					
EU27	No information at all given on Network Connection and Access Rules	Some information given on Network Connection and Access Rules (which may not cover the narrow focus of this section)	Administrative procedure Network Connection and Access Rules	Administrative Costs Network Connection and Access Rules	Physical Connection Costs Network Connection and Access Rules
Austria		x			
Belgium		x			
Bulgaria	x				
Cyprus		x			
Czech Republic	x				
Denmark	x				
Estonia	x				
Finland		x			
France	x				
Germany	x				
Greece	x				
Hungary		x			
Ireland					
Italy		x	x		x
Latvia	x				
Lithuania	x				
Luxembourg	x				
Malta		x			
Netherlands		x			
Poland	x				
Portugal		x			
Romania	x				
Slovak Republic		x	x		

Slovenia	x				
Spain	x				
Sweden	x				
United Kingdom		x	x	x	x

Note: The important part of the table is the 3 right hand columns. An entry here means that there is a specific issue of network access which has been cited.

Only 3 countries report on barriers, but 15 countries made no comments.

Note, eight other countries whilst reporting on barriers did not cite network issues, instead the majority related to economic issues concerning the value of power. It is uncertain if this means that there exist network barriers or not. Clearly if governments keep power prices below actual costs, for whatever reason, then this will act as a barrier to commercial cogenerators who need to earn a commercial rate from any export. From the templates it is not clear to what extent network access barriers exist, or have been removed. A better method of reporting needs to be devised in the future.

#### 3.4.4. Results: Information taken from the Member States' country reports

The table below summarises the extent to which network barriers have been removed. An entry in the rightmost 3 columns implies that the Member State has enacted specific legislation as required by the Directive to overcome any network access barriers. An absence of an entry in this column may mean that the conditions prior to the Directive already met the requirement of the Directive. But this cannot be determined from the Member States' report.

**Table 3.3. Information in the Member States' reports regarding the extent to which network connection barriers have been removed.**

DATA SOURCE – National Reports - Network access rules - barriers						
EU27 Member States	No information given	Some information given	Existence of Network access barriers cited (in the narrow sense defined in this section)			Removal of, or prior non existence of, Network access barriers, or positive encouragement to connect, or specific transparent non discriminatory procedure cited
			Procedures	Admin fees	Connection costs	Procedures Admin fees Connection costs
Austria	x					
Belgium		x		x		x
Bulgaria	x					
Cyprus		x				x
Czech Republic		x				
Denmark		x				x
Estonia		x				x
Finland		x				x
France		x				x
Germany		x				x
Greece		x				x
Hungary		x				x
Ireland		x				x
Italy		x				x
Latvia		x				x
Lithuania		x				x
Luxembourg	x					
Malta		x				x
Netherlands		x				x
Poland		x				x
Portugal		x				x

Romania	x		x		
Slovak Republic	x		x		
Slovenia	x	x			
Spain	x		x	x	x
Sweden	x				
United Kingdom	x	x	x	x	

Note: An entry in the rightmost 3 columns implies that the Member State has enacted specific legislation as required by the Directive to overcome any network access barriers. Of course an absence of an entry in this column, may mean that the conditions prior to the Directive already met the requirement of the Directive. But this cannot be determined from the Member States' report.

It seems that at least 19 countries report that they have removed network access barriers (used in the procedural sense here) to CHP. However at least 2 countries, Sweden and Austria, which are known to have thriving CHP infrastructure have not reported any network barriers so it can also be assumed that in these countries there are unlikely to be significant network access barriers and that additional legislation is not needed. This may or may not be the case with other non reporting countries.

The National report from Hungary could be picked out as very clearly stating that the required legislation has been enacted giving non-discriminatory access to the grid. The same comment can be made for the National report for Italy however the barriers template to a large extent contradicts that Member State's national report.

### 3.4.5. *Costs of network reinforcement - deep charging and shallow charging*

When a cogenerator is connected to an existing power network, typically a transformer and switch gear is provided within the network at the new point of connection, and a power line run to the plant concerned. The network will make a charge for providing this *direct connection*. If the charge is solely for this *direct connection*, then this is referred to as *Shallow Charging*. However often it is the case that to receive an input of power then the network has to be strengthened beyond the point of *direct connection*, i.e. further potentially expensive upstream works may have to be carried out by the Network Owner itself to accommodate the generator. This could be a need to increase the power line size running to the point of direct connection and to increase other transformer sizes and power lines remote from the direct connection. If these elements are all charged to the cogenerator who requested the initial *direct connection* then this would be called *Deep Charging* and can be in some cases enormously expensive making the cost of connecting a small cogenerator uneconomic.

It can be argued that this is unfair to the initial cogenerator, because subsequent connectors would be able to use the reinforcement as well at no charge and the Network Operator may gain benefits as well – delayed reinforcement for example. Thus Deep Charging can be conceived of as a barrier. Some Member States for example, Flanders / Belgium, reports imply that such Deep Charging costs are borne or partly borne, by the network generally rather than levied on an individual cogenerator. This could be interpreted as a specific encouragement, going beyond what is needed, or, countries which do not offer such generous terms could be regarded as having a barrier to network connection, but this is not clear from the reports.

### 3.4.6. *Network studies*

Often Network Owners require a network study to be carried out prior to providing a cost for connection and re-enforcement and again this can be expensive and the outcome is uncertain – it may show that network reinforcement costs are so high that the scheme cannot go ahead. In some Member States (for example the UK) the full cost of the study is not paid unless the scheme is actually built. In other Member States the full fee has to be paid regardless. In yet others such as Spain, there is no fee. The state of these arrangements can be considered significant barriers but again this is not clear from the reports.

### 3.4.7. *Conclusion*

With the qualifications noted earlier, it seems that in general good progress has been made in terms of enacting legislation as required by the Directive to remove any network access barriers, but only a carefully thought out and well constructed survey including would be users, will give a clear unambiguous picture.

The two examples cited earlier show how difficult it is to make good judgments based on the Member States' reports only. Clearly future reporting on the Network Connection barriers issue require more specific questions (and prior definitions) to enable evaluation of the true situation and comparison of Member States' progress.

However it is clear that Member States do not fully recognise the correct discount rate to be used by governments in assessing infrastructure schemes such as CHPDH and do not make appropriate financial support to those schemes that meet these criteria. See later Heat Market section for a fuller discussion of this issue.

## **3.5. Guarantees of Origin (GO) schemes**

### 3.5.1. *Introduction*

The Directive requires that Member States shall, “...., ensure that the origin of electricity produced from high-efficiency cogeneration can be guaranteed according to objective, transparent and non-discriminatory criteria laid down by each Member State. They shall ensure that this guarantee of origin of the electricity enable producers to demonstrate that the electricity they sell is produced from high-efficiency cogeneration and is issued to this effect in response to a request from the producer”.

The potential uses of a GO system are:

- To enable final consumers to understand the origin of power purchased
- Proof of compliance with criteria for public support
- Accurate reporting of quantities of CHP generated power

### 3.5.2. *Results*

A detailed study of the state of implementation of these GO schemes is obtained in<sup>7</sup>.

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<sup>7</sup> The state of implementation of electricity disclosure and Guarantees of Origin across Europe. D1 of WP2 from the E-TRACL II project plus recent updates from other sources.



The report identifies 3 levels of implementation:

- **Incomplete level of implementation:** the system in place in the Member State is not yet fully operational.
- **Sufficient level of implementation:** the Member State has a fully operational system in place.
- **Advanced level of implementation:** the Member State has an advanced system in place

Based on these definitions, table 3.4 below was compiled by the authors of the original report.<sup>8</sup>

**Table 3.4: GO schemes across Europe<sup>9</sup> (No later information than this has been found.)**

<b>GO</b>	<b>Not fully operational</b>	<b>Fully operational</b>	<b>Advanced</b>
<b>EU-15</b>	Brussels-Capital FI GR IE LU PT but in legislation	AT DK ES FR GB IT – GO only required above 50 MWh/a NL DE SE	Flanders Wallonia
<b>EU-12</b>	BG CY but in legislation LV MT but in legislation EE	CZ EE LT SI PL HU RO SK	SI
<b>CH &amp; NO</b>	CH & NO 11 + Brussels- Capital	16	1 + Flanders and Wallonia

### 3.5.3. Conclusion

11 countries / provinces plus Brussels do not have a fully operational GO scheme, 16 do and 1 country and two provinces of Belgium have advanced systems.

<sup>8</sup> The state of implementation of electricity disclosure and Guarantees of Origin across Europe. D1 of WP2 from the E-TRACL II project plus recent updates from other sources.

<sup>9</sup> The state of implementation of electricity disclosure and Guarantees of Origin across Europe. D1 of WP2 from the E-TRACL II project plus recent updates from other sources.

### 3.6. Cogeneration with district heating / cooling – heat market issues

This section is designed to cover a range of considerations with respect to heat market issues. Some are specifically related to the Directive on Cogeneration, but broader issues regarding technology and practical issues are discussed and introduced as background information.

#### 3.6.1. Introduction

District heating with cogeneration has a large potential to cut carbon emissions across the Community and according to one study regarding the cost of carbon abatement in the Netherlands, Combined Heat And Power and District heating (CHPDH) was found to be one of the least cost solutions at 25 EUR per tonne CO<sub>2</sub>, lower than most building insulation, condensing boilers and wind power.<sup>10</sup> Work carried out by Orchard Partners London Ltd. in the UK.<sup>11,12</sup> arrived at similar conclusions.

Furthermore district heating also offers the flexibility of using waste industrial heat, geothermal heat and heat from waste combustion. The heat storages common in existing schemes also offer the facility to take and store surplus wind energy. CHP stations can provide balancing services to wind energy at very low cost. For these reasons CHPDH is seen as offering great potential in moving towards a low carbon society.

#### 3.6.2. Background – District heating and combined heat and power technology

DH – (District Heating) and DHC (District Heating and Cooling), consist of distributing heat to consumers using buried insulated water pipes. Hot (or cold water) is conveyed along them by pumping.

Consumers are connected to these pipes by a heat exchanger and heat (or cooling) thus provided. In some cases consumers are directly connected to the pipes. This leads to significant savings on capital especially in one-family houses, by the avoidance of the numerous heat exchangers, and allows increased efficiency since lower flow and water return temperatures can be used. These lower return temperatures means that there is a reduced loss of electricity output per unit of heat supplied. Lower water temperatures mean lower losses and the pipes can be installed without expensive expansion allowance that would otherwise be needed.

In the build up phase of a city's district heating network, heating is provided by local boiler houses. As the network extends it can be connected to a CHP station which provides both heat and power, or an electricity only power station modified for that purpose (the latter case for example occurs in the German city of Flensburg).

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<sup>10</sup> Boonekamp, P.G.M. (2004) Milieukosten, Rijksinstituut voor Volksgezondheid en Milieu (RIVM) and Energy Centre of the Netherlands (ECN)

<sup>11</sup> "Technology Strategy Board Retrofit for Future a study to minimise CO<sub>2</sub> emissions for typical UK housing comparing Combined Heat and Power District Heating with Insulation. March 2011" Orchard Partners, London. <http://www.claverton-energy.com/technology-strategy-board-retrofit-for-future-a-study-to-minimise-co2-emissions-for-typical-uk-housing-comparing-combined-heat-and-power-district-heating-with-insulation-march-2011.html>

<sup>12</sup> "Carbon footprints of various sources of heat – biomass combustion and CHPDH comes out lowest" – William Orchard. <http://www.claverton-energy.com/carbon-footprints-of-various-sources-of-heat-CHPDH-comes-out-lowest.html>

The initial heat only boilers are retained to meet peak loads and for standby during outage of any chp station or other heat source and to meet short term peaks during severe weather.

*3.6.3. Heat from a Combined Heat and Power station can be considered thermodynamically equivalent to a heat pump and to have low carbon or of low primary fuel content:*

Nordjylland 3, one of the worlds most efficient coal fired plants in Denmark can operate either as electricity only, or as a CHP station feeding heat to the city of Aalborg under the Liim Fiord to Aalborg some 15 km distant. At the CHP station when steam is diverted from the turbine to the district heating network the electrical output will drop. However some 5 – 6 kWh of heat become available for every unit of electricity lost. Note that the fuel consumption of the CHP station will remain constant. This ratio is known as the Z factor of the CHP.

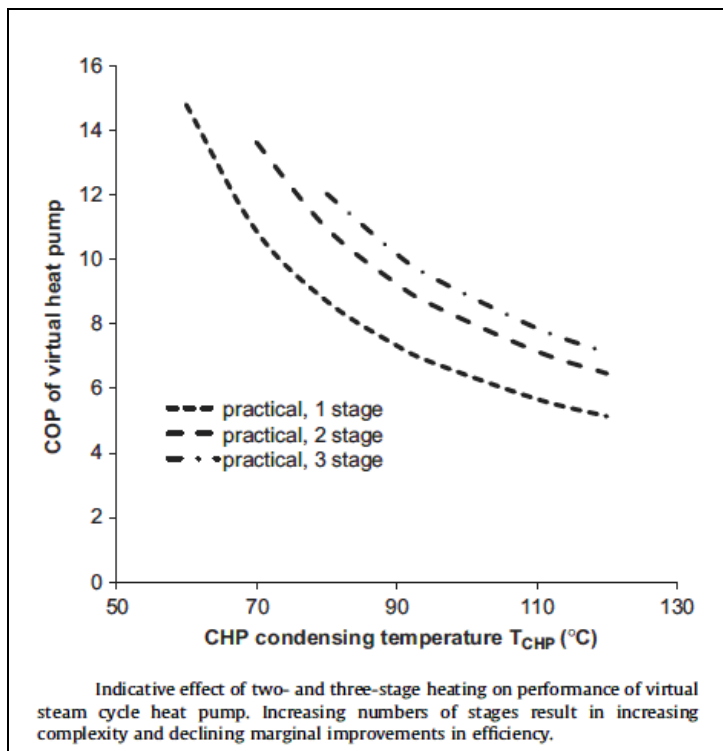
Thus Z can be considered to be comparable to the COP of a heat pump, and the CHP considered a virtual heat pump<sup>13</sup> where when 1 unit of electricity becomes unavailable in the heat pump, some heat is delivered. This is typically in the range 2 – 4 depending on conditions, usually about 3 for domestic units and thus CHP is nearly twice as effective than a heat pump.

The diagram below shows the theoretical ranges of Z factors or COPs potentially achievable by a large power station (the diagram is based on Drax in the UK, 500 MW coal). A Z of 5 - 6 is presently achieved at the Nordjylland power station but up to 10 can be achieved at some power stations, and theoretically even higher. As can be seen generally the lower the temperature at which the steam is condensed the greater the amount of heat recovered from a given power station and the higher the Z factor, ie the lower the reduction in power output. (This is why modern CHPDH networks have low heat supply temperatures of around 75C.)

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<sup>13</sup> Lowe, R.J., 2011. Combined heat and power considered as a virtual steam cycle heat pump, Energy Policy, 39 (9) 5528-5534.

**Figure 3.1: Theoretical Z / COP for a large 500 MW power station according to Lowe<sup>14</sup>**



At the CHP station as more steam is diverted and the power drops, it is important to note that the fuel consumption does not change. For analysis purposes, we can assume that in a perfect market, as the electrical output drops, another equally efficient coal fired electricity-only station increases its output to make up for the lost electrical output somewhere in the system. (Assuming a condensing coal station is on the margin which in Europe is generally the case). This means it is logical to allocate the extra fuel burn which occurs in the compensating electricity-only station to the heat provided by the CHP station – because it is the only extra fuel burnt by the system.

The table below<sup>15</sup> summarises the situation in terms of unit fuel burn per unit heat delivered for gas and coal stations based on this analysis:

<sup>14</sup> Lowe, R.J., 2011. Combined heat and power considered as a virtual steam cycle heat pump, Energy Policy, 39 (9) 5528-5534.

<sup>15</sup> “Smart Energy in Cities” Anders Dyrelund, market manager energy Rambøll (A leading Danish CHPDH consultancy)

Figure 3.2: Marginal fuel burn for different forms of heating.<sup>16</sup>

Cases		1	2	3	4	5	6	7
		Old coal extraction	Old coal backpres.	New coal extraction	Gas CC extraction	Gas CC backpres.	Gas engine	small Gas engine
Reference power condensing on the margin		Old coal	New coal	New coal	New gas	New gas	New gas	New gas
CHP heat	efficiency of plant	53%	53%	50%	41%	45%	52%	55%
CHP power	efficiency of plant	32%	32%	39%	49%	45%	38%	35%
<b>Total</b>	<b>efficiency of plant</b>	<b>85%</b>	<b>85%</b>	<b>89%</b>	<b>90%</b>	<b>90%</b>	<b>90%</b>	<b>90%</b>
<b>Power to heat ratio</b>		<b>0,60</b>	<b>0,60</b>	<b>0,78</b>	<b>1,20</b>	<b>1,00</b>	<b>0,73</b>	<b>0,64</b>
Ref heat		90%	90%	90%	90%	90%	90%	90%
<b>Ref power</b>	<b>central most efficient</b>	<b>40%</b>	<b>46%</b>	<b>46%</b>	<b>55%</b>	<b>55%</b>	<b>55%</b>	<b>55%</b>
Estimated marginal loss	from central plant	0%	0%	0%	0%	2%	4%	6%
Ref power	local plant	40%	46%	46%	55%	54%	53%	52%
Extraction CV		15%		14%	15%			
Saving of fuel to heat and power, EE directive		28%	22%	29%	26%	25%	23%	22%
<b>Marginal fuel consumption for heat from plant</b>								
Extraction of heat	MWh fuel/MWh heat	0,38		0,30	0,27			
Back pressure heat	MWh fuel/MWh heat	0,38	0,57	0,30	0,27	0,37	0,54	0,59
Heat only boiler	MWh fuel/MWh heat	1,11	1,11	1,11	1,11	1,11	1,11	1,11
<b>Heat pumps</b>								
Heat pump COP		300%	300%	300%	300%	300%	300%	300%
Marginal loss from central plant to individual		8%	8%	8%	8%	8%	8%	8%
Marginal efficiency for heat pump		110%	127%	127%	152%	152%	152%	152%
Marginal fuel consumption for heat pump		0,91	0,79	0,79	0,66	0,66	0,66	0,66
(Fuel consump. CHP)/(fuel consump. heat pump)		0,42	0,73	0,39	0,40	0,56	0,82	0,89
<b>Electric heating</b>								
Marginal efficiency for electric heating		37%	42%	42%	51%	51%	51%	51%
Marginal fuel consumption for electric heating		2,72	2,36	2,36	1,98	1,98	1,98	1,98
(Fuel consump. CHP)/(fuel consump. Elec. heat)		0,14	0,24	0,13	0,13	0,19	0,27	0,30

We can immediately see that:

Comparing a gas fired combined cycle plant (CCGT) with a gas boiler, then every unit of heat from CHP utilises 0.27 units of energy, whereas the boiler utilises 1.11 units, a factor of 4 higher. The heat pump utilises 0.66 units a factor of 2.44 higher. And electric heating utilises 1.98 a factor of 5 higher. Thus CHP heat is a very low energy / carbon content heat source.

This method of illustrating the energy efficiency of CHP, where it is seen that CHPDH has an energy content of ¼ that of the equivalent boiler is a much better method of indicating the savings than the normal method which is to compare primary energy savings. See next section.

### 3.6.4. The primary energy savings of CHP in the heat sector

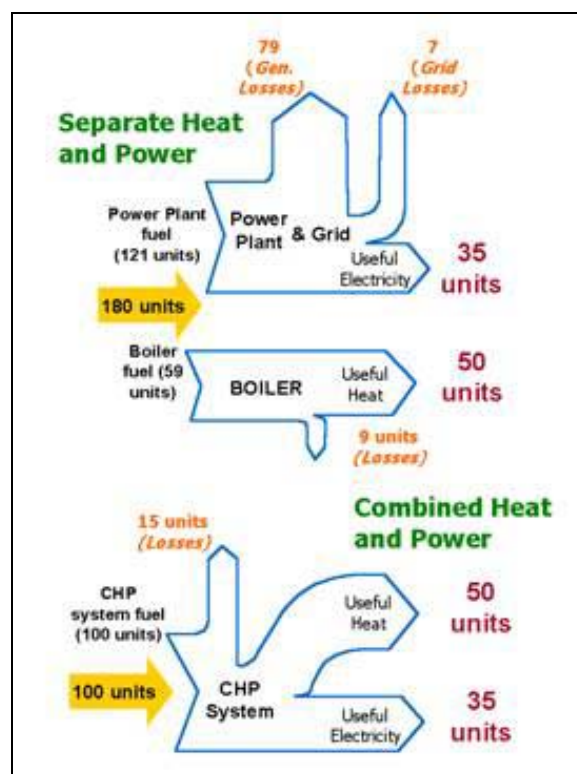
The standard method of indicating the carbon and energy savings potential of CHP is shown in the diagram below. The first two blue coloured diagrams illustrate primary energy flowing in from the left and going into a power station and a boiler to provide separate heat and electricity, - 35 units of electricity and 50 units of heat. Thus requires 180 units of input primary energy.

<sup>16</sup> “Smart Energy in Cities” Anders Dyrelund, market manager energy Rambøll (A leading Danish CHPDH consultancy)

If we generate the same 35 units of electricity and 50 units in a CHP unit, as in the lower blue coloured diagram, it turns out that we only need to use 100 units of primary energy. Thus this is a saving of 80 units in 180 or 44%.

Whilst this does illustrate energy savings, of this approach is that it adds together energy used to generate electricity and energy used for heating which are two quite separate types of energy. One is high quality high temperature energy used to fire the boiler, and the other is low temperature energy needed to heat buildings. All the energy savings arise in the heating sector where less boiler fuel is burnt.

**Figure 3.3: The primary energy saving and CO2 displacement benefits of CHP-DH ( Danish District Heating Association)**



### 3.6.5. Renewable energy and heat pumps compared to CHP

Providing the COP<sup>17</sup> for an electric heat pump is over 2.9, that is, one unit of electricity consumed will cause the pump to deliver 2.9 units of heat, EU governments can define some of the heat from electric heat pumps as renewable, and are thus able to receive subsidies for this source of heat and to promote them to help meet renewable targets even though they presently use fossil electricity in the majority of cases to deliver the heat as does CHP.

<sup>17</sup> COP - Coefficient of Performance - is the ratio of heat out of a heat pump divided by the electricity in

Because of this thermodynamic similarity between heat pumps and CHP, it could be argued that CHP should be given similar renewable status as is enjoyed by heat pumps or they should be treated on a comparable basis.

### 3.6.6. *Effect of temperature on heat pumps – potential stress on power grids*

The COP of Air Source Heat Pumps falls off dramatically as air temperature drops, which coincides with maximum building heat demand. This means that widespread use of heat pumps will significantly increase winter peak demand during extremely cold periods, not only due to the fall off in efficiency as air temperature drops, but also during these extremely low external temperatures, users will tend to resort to direct resistance heating which imposes severe stress on electrical networks and may cause additional expenditure on upgrading electrical distribution, transmission and interconnectors<sup>18</sup> as happened recently in France.

The UK's Energy Savings Trust field trials revealed that none of the heat pump installations had a higher COP than 2.5 and this means none were as good as simply burning gas according to Brian Mark of Mott Macdonald, a leading UK consultancy house. The reports state that industry average COP for a Ground Source Heat Pump (GSHP) is just 2.3. Also when a cold snap (<0 deg C) arrives the COP of main stream heat pumps drops considerably to around 1:1, little more efficient than electrical resistance heating.<sup>19</sup>

A further point often not considered, is that whilst it is well known that average losses on the grid and transmission systems are around 3% to 6% respectively, at peak times they are much higher proportionally. This is because the resistance of an electrical network is proportion to the square of the current passing through the wires and transformers – these are known as I<sup>2</sup>R losses. Thus at system peak, whilst the power may be 4 times the minimum load on the system that resistance can increase by a far greater factor and is likely to approach 20%. This again increases the stress on the power transmission and distribution system. See also later section *Precedents of coercion for environmental reasons*.

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<sup>18</sup> Karolin Schaps (Feb 14, 2012). "Germany powers France in cold despite nuclear u-turn". *Reuters*. <http://www.reuters.com/article/2012/02/14/europe-power-supply-idUSL5E8DD87020120214>.

<sup>19</sup> Journal of the Chartered Institute of Building Services Engineers, UK, CIBSE Feb 2012

### 3.6.7. Carbon footprint of CHPDH compared to heat only and heat pumps

CHPDH has one of the lowest carbon footprints of all heat sources, significantly lower than heat pumps.<sup>20</sup> This table below summarises the calculated footprints.

**Table 3.5: CO<sub>2</sub> Footprints for heat and energy supplies to buildings in descending order. (The below table reproduced by Courtesy of William Orchard Partners)**

The COP of a heat pump and the Z factor of CHP show the amount of heat made available per unit of electricity made not available from the power station for other uses. The numbers below are based on a heat network designed on a 75°C flow 30°C return to retrofit UK dwellings heated currently by gas boilers. Note 1: The carbon footprint of heat from CHP using electricity to upgrade heat (which is thermodynamically the effect of a CHP station) being rejected to environment is lower than heat from electric heat pumps extracting heat from the same environment. Note 2: The table follows cradle to final use convention for bio fuels signalling CO <sub>2</sub> emitted by the end use when the fuel is burnt . The method is superior to <i>cradle to grate</i> assumptions that do not allow optimization of CO <sub>2</sub> displacement. © William Orchard, Orchard Partners London Ltd william@orchardpartners.co.uk				
Heat supply options gross (higher) calorific value (CV) basis and efficiency (eff)	kg CO <sub>2</sub> eq./kWh per unit of Energy	Distribution losses		kg CO <sub>2</sub> eq./kWh Energy delivered
		Energy Average loss %	CO <sub>2</sub> Average loss kg	
Hydrogen fuel from electricity(coal) 80%(eff)	1.046			
Biogas burnt in 86% (eff) domestic boiler.				1.008
Electricity from coal 36%	0.837	10	0.084	0.920
Biogas as a fuel 40% (eff) conversion from biomass (Lund University Maria Berglund Pal Borjesson)	0.850	2	0.017	0.867
Biomass wood boiler 78% (eff).	0.436	5	0.022	0.458
Electricity from gas 48% (eff)	0.397	10	0.040	0.437
Biomass (dry wood) as a fuel	0.340			0.340
Air source heat pump COP 2.9 (Electricity from coal)				0.317
Coal as fuel	0.301			0.301
Old gas boiler 75% (eff)				0.255
New condensing natural gas boiler 86% (eff)				0.222
Heat micro CHP 1kWel 6% (el) (eff) 86% (eff) overall				0.212
Natural gas as a fuel	0.191	2	0.004	0.195
Heat pump good geothermal winter heat source, COP 4 electricity from gas.				0.109
Piped heat from gas fired condensing 500 kWel CHP 34.7 % (el) (eff) 86% (eff) overall	0.103	10	0.010	0.113
Piped heating from very large biomass CHP co fired with coal.	0.075	20	0.015	0.089
Piped urban district heating from coal fired CHP equivalent COP 12.7	0.066	20	0.013	0.079
Piped urban district heating from gas fired CCGT CHP equivalent COP 12	0.033	20	0.007	0.040
Electricity from wind, DTI "Future of Nuclear Power" page 49	0.020	10	0.002	0.022
Electricity from nuclear 0.006 to 0.026 DTI "Future of Nuclear Power" page 49	0.010	10	0.001	0.011
Piped district heat from nuclear fired CHP equivalent COP 10	0.001	20	0.000	0.001

### 3.6.8. CO<sub>2</sub> emissions of biomass

It is often assumed that because biomass withdrew carbon from the atmosphere when it grew its carbon emissions can be neglected when it is burnt. However when biomass is burnt it

<sup>20</sup> William Orchard Partners. 2009. <http://www.claverton-energy.com/wp-content/uploads/2009/02/footprinttaxheatforbuildings1.jpg>



undoubtedly emits CO<sub>2</sub> from the chimney. On this basis, there is a case that where appropriate, scarce biomass should be burnt in such a way as to maximise the amount of fossil carbon fuels displaced. This points towards its use in high efficiency CHPDH stations rather than local inefficient CHPDH because more high carbon heating fuel will be displaced. Furthermore, whilst coal is still used as a major component of power station fuel, the lowest CO<sub>2</sub> emitting route for biomass is to co fire the biomass in a large coal CHP plant, since these have the highest thermal efficiency and every unit of wood burnt displaces fully 1 unit of coal and its carbon footprint. This is the practice at the large Avedøre CHPDH station in Denmark.

### 3.6.9. Sizing ratio of heat boilers to chp

It is typical for the maximum heat output from a central CHP station to meet about half the annual maximum heat load on the network (that is the total heat load thermal power on the DH system occurring at the central heat supply point on the coldest day of the year) with the other half at that time being met by the peak boilers. In this arrangement, the CHP station will provide 90% of the heat given to the network over the year.

### 3.6.10. Heat storage

Heat storage in large hot water tanks is commonly provided and this decouples power production from heat production and significantly improves the economics of CHP plant by enabling them to generate on peak price periods and not when power prices are low, and facilitates their use in absorbing surplus wind energy. A 25,000 m<sup>3</sup> district heat accumulation tank is connected to the DH system for Norjyland 3 mentioned earlier.

**Figure 3.4: Heat storage tanks in connection with a multi-fuel Coal, natural gas, oil, wood chips, straw) 500 MWe cogeneration unit, Avedøre Denmark <sup>21</sup>**



<sup>21</sup> PowerGen Europe 2007 paper (ID-94).Heat Storages for CHP Optimisation. Jan de Wit,Danish Gas Technology Centre.Denmark

### 3.6.11. *Costs of new CHP power stations and conversions of electricity only stations+*

The extra cost of making a new power station CHP for District Heating compared to electricity only is relatively low – in the range 7 - 20%<sup>22</sup>. Existing power stations can be converted to CHPDH and this is thought to cost up to around 20 % of the original cost depending on the extent.<sup>23</sup>

We introduce two examples:

One conversion example is Barking, a 400MWe CCGT block. A new station would cost approx. 250 million Euros. A budget conversion cost was around 12 million Euro – that is about 5% of the initial capital cost to capture up to 100MW from a medium pressure steam header, with z-factor<sup>24</sup> of just under 5. This is for a station, which has around 350MW of low grade waste heat available (at around 35 °C). Full conversion to condensing / extraction turbine would be much more costly as it would require modifications to the low pressure section of the steam turbine. But costs for this are not available.<sup>25</sup>

Secondly the Amercentrale power station is an example of one conversion of an existing power station to CHP for heat distribution for the Amercentrale heat network. The heat network stretches from Amernet Geertruidenberg to Tilburg, Breda and surrounding villages. The power plant consists of 2 units together generating 1245 MW of power and 600 MW of heat generated for heating homes and greenhouses. The plant provides a large part of southern Netherlands of electricity and also supplies heat to the horticultural areas.

Other known cases of conversion of existing power stations include the Melnik – Prague conversion, and the Flensburg conversion.

### 3.6.12. *The heat transmission technology – maximum feasible distance from power station to city grid*

District heat can be economically transmitted over very long distances. Generally, the larger the quantity of heat the longer the economic distance. This is because for a constant insulation thickness percentage losses drop as the pipe becomes larger. (Losses are proportional to the diameter of the pipe, but water and energy transmission are proportional to the square of the diameter)

It has been calculated that the capital cost of taking a 2,000 MW heat output 140km, using 2 x 2m diameter pipes is about 0.35€/kWh for the delivered heat. Heat loss was 35 MW and the pumping losses 50 MW meaning the heat actually arrived warmer than when it left the power station<sup>26</sup>

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<sup>22</sup> ETSAP the investment cost per kWe is about 18% comparing a CCGT with a CCGT CHP. See <http://etsap.org> This is for the relative costs of chp plant compared to EQUIVALENT electricity only plant

<sup>23</sup> Discussions with manufacturers and consultants.

<sup>24</sup> The Z-factor refers to the rations of heat made available to the loss of power generated when a chp station starts to deliver useable heat.

<sup>25</sup> Alastair Young, Buro Happold. London. This is for the relative costs of chp plant compared to EQUIVALENT electricity only plant.

<sup>26</sup> Personal communication: W. Orchard

One of the longest one-way heat transmission pipelines in Europe is the Melnik-Prague feeder. The distance is almost 40 km to the Prague city gate and 64 km to the opposite city gate. It was started in 1996. Pictured below

**Figure 3.5: 60 km, 2 x DN 1200 pipe delivering 200 MW from Melnik to Prague DH<sup>27</sup>**



### 3.6.13. *Minimum size of CHPDH systems*

Various studies have shown that CHPDH can be economic in small groups of houses even as low as 50 modern detached dwellings, based on modern gas engine.<sup>28,29</sup> Many of the 600 main DH systems in Denmark in the image below have as few as only 100 dwellings attached. Denmark has a population of five million. However the smaller DH systems are often biomass heat-only. Very small biomass CHP-DH systems are often not considered optimal due to the low efficiency, so the preference is to ship the biomass to large central and more efficient CHP-DH according to some Danish experts.<sup>30</sup> Figure 3.6 shows the location of many of the Danish CH systems.

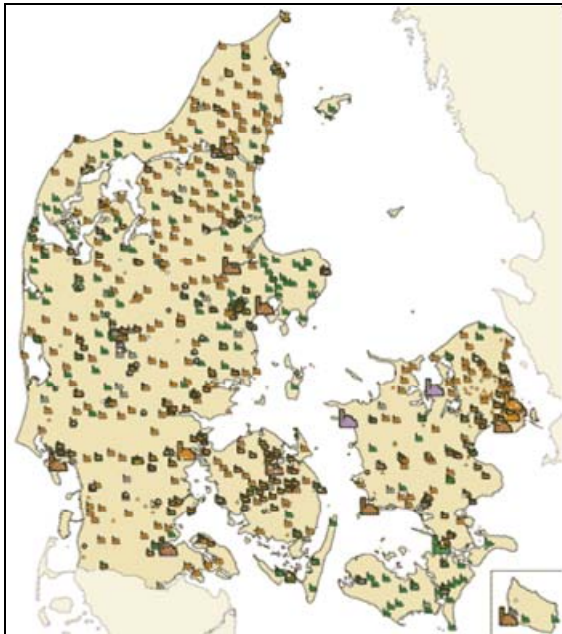
<sup>27</sup> Prague District Heating System. Application for 1st Global District Energy. Climate Awards <http://www.copenhagenenergysummit.org/applications/Prague,%20Czech%20Rep-District%20Energy%20Climate%20Award.pdf>

<sup>28</sup> ERG 036. A D.C.F. . analysis of a totem based district heating scheme. DC Andrews, RJ Lowe. Open university Energy Research Group, Milton Keynes U.K. August 1981.

<sup>29</sup> ERG 056 An Introduction to domestic micro-chp R.Everett and D.C. Andrews. Open university Energy Research Group, Milton Keynes U.K. September 1986

<sup>30</sup> Anders Dyrelund, market manager energy Rambøll (A leading Danish CHPDH consultancy)

Figure 3.6: Map of Danish DH systems.<sup>31,32</sup>



#### 3.6.14. Sources of heating and cooling

Heat or cooling for DHC can come from a variety of sources.

When waste heat from a power station is provided to heat (or cool) a large area of buildings, this is known as Combined Heat and Power District Heating - CHPDH. The heat or cooling for district heating and cooling can come from a variety of sources, not only large power station waste heat but also active solar, geothermal, gas or diesel engine waste heat in small sizes, industrial waste heat, heat only boilers (which can be biomass fuelled), and heat pumps (taking heat for example from the air, a river or the sea). Cooling of coastal cities or cities on lakes can utilize water from near the lake or ocean floor directly, giving no fuel cost apart from that needed for pumping.

District Cooling can also be achieved by connecting for example an absorption chiller (a device which takes heat and converts it into cooled water at an efficiency of about 95%) to the heat network, and this will convert the heat into cooling at the particular building. In some cases, conventional electrically powered chillers and absorption chillers fed by district heat can feed cold water into specific networks of cold water conveying pipes, this is quite common in the commercial centres of large cities – Helsinki being notable due to its Northern location.

Natural gas expander stations are a source of free cooling. Currently gas fired heaters warm the expanding gas, which effectively waste the free cooling.<sup>33</sup>

<sup>31</sup> Source: Danish Board of District Heating, [www.dbdh.dk](http://www.dbdh.dk).

<sup>32</sup> Less Is More, The Association of Conservation of Energy in Buildings, 2011, David Olivier.

<sup>33</sup> Natural gas is conveyed in pipes at high pressure up to 60 bar. (60 times atmospheric pressure) This is expanded down to low pressure – 25 millibar for delivery to consumers. This expansion creates significant cooling of the gas – up to 25 MW in some cases and to prevent the gas freezing the pipe work it has to be reheated using some of the natural gas. This heat could be provided by district cooling systems.

The system for heating or cooling chosen will depend on local circumstances. In Sweden, at Sundsvall Hospital, some summer chilling is centrally provided by snow recovered and stored from clearing roads in the winter.

In Iceland, geothermal heat is used to run power stations, with waste heat from the power stations heating the entire capital Reykjavik. In Sweden; e.g. Goteborg, much industrial waste heat is used. Denmark has several District Heating systems heated by solar energy.

According to national district heating statistics more than 80% of district heat used in the 27 European Member States is renewable and/or recycled heat from electricity production or cogeneration, waste-to-energy plants and industrial processes.<sup>34,35</sup>

### 3.6.15. *Developers of CHP*

In many cases developments are carried out by local municipalities and this is frequently the case in Denmark and Germany because these are less constrained by the need for high rates of return required by commercial enterprises. A typical example is that of the north German city of Flensburg where a district heating network was installed retrospectively and existing power stations converted to CHP by the local municipality.

Flensburg has a connection density of more than 90% (*of heat loads connected*). Work started on expanding the supply network as early as 1969. The city's own electricity only power station were converted in 1971 into a co-generation plant providing 170 megawatts of electrical and 800 megawatts of thermal output. Four reserve co-generation plants guarantee supply security.<sup>36</sup> Once developed systems are often then handed over to be run by private sector companies.

In Denmark, CHP systems are generally run as not-for-profit with the operators being allowed to make a guaranteed rate of return – much as per water companies in the UK. Under Danish heat planning certain areas are designated DH and others, the less dense ones gas. This ensures a high take up of CH and guaranteed profit for the operators. The tax policy on other fuels is also manipulated to achieve the aim of high take up rates in the DH areas.

### 3.6.16. *Cost of CHPDH heat compared to other heating technologies*

#### 3.6.16.1 *UK Studies*

Detailed studies carried out in Great Britain in 1979<sup>37</sup> showed that the overall cost of heat from CHPDH (ie including capital costs) competed with the existing heating fuel mix. Details have changed but in general the conclusion is likely to remain the same if the detailed exercise were to be repeated (fuel and power costs now are higher compared to capital costs at the time of the study and CCGTs are just as able to provide reject heat as the coal fired

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<sup>34</sup> District Heating and Cooling – Euroheat and Power 2009 Johannes Jungbauer

<sup>35</sup> Ecoheatcool 2006, Prof. Sven Werner et.al.

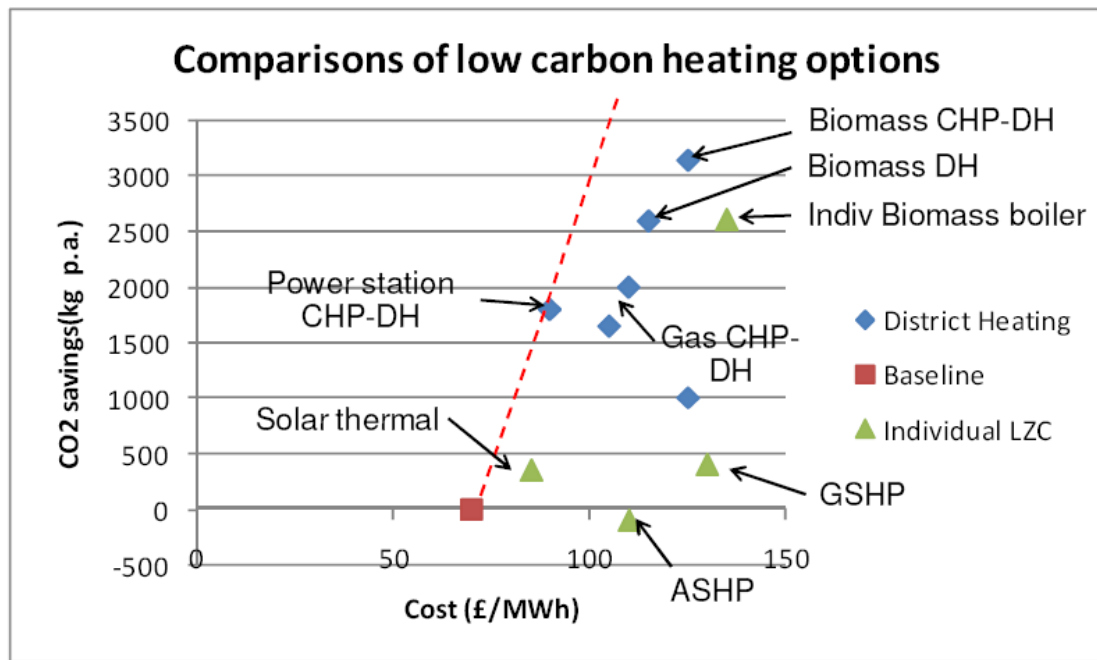
<sup>36</sup> <http://www.umweltbundesamt.de/produkte-e/beschaffung/energieversorgung/fernwaermeversorgung.html>

<sup>37</sup> Combined heat and electrical power generation in the United Kingdom – Energy Paper 35. HMSO 1979

stations on which the study was based). Piping and heat metering technologies have all improved reducing infrastructure costs.

The table below indicates the likely cost of heating from different low carbon energy sources in the UK<sup>38</sup>

**Figure 3.7: Comparison of low carbon heating options (derived from Poyry/AECOM)<sup>39</sup>**



### 3.6.16.2 IEA study

A study carried out by the IEA showed that for a representative city, (which happened to be UK, chosen as typical) a large scale city CHPDH was more cost effective overall than the option of an electricity-only CCGT<sup>40</sup>

### 3.6.16.3 Estimated heat costs based on the work of Dr Sven Werner<sup>41</sup>

It is quite difficult to make generalised statements about the cost of CHPDH since many local factors apply, however an estimate of the likely cost of heat can be made as follows. We use UK as an example as being typical of much of Europe, and costs and power station performance figures are readily available from the Department of Energy and Climate Change – DECC web site:

According to Dr Sven Werner a market share of 60% of the heating market in 83 European cities can be reached with an average distribution (the cost of the district heating network

<sup>38</sup> The potential costs district heating networks - A report to the Dept of Climate Change. Poyry, Faber Maunsell, AECOM. April 2009.

<sup>39</sup> The potential costs district heating networks - A report to the Dept of Climate Change. Poyry, Faber Maunsell, AECOM. April 2009.

<sup>40</sup> A comparison of distributed CHP/DH with large scale-CHP/DH. Report 8DHC – 05.01 IEA. Vienna, 2005

<sup>41</sup> Dr Sven Werner, Professor, Energy Technology, Halmstad University (Högskolan i Halmstad), SET, PO,Box 823, SE-30118 Halmstad, Denmark

allocated to each unit of heat output) capital cost of 1.6 €/GJ. Amortised over 30 years at 3% discount rate

1.6 €/GJ. = 0.58 €Cent /kWh for distribution piping etc. House connections are estimated to be the same as the costs of a domestic boiler by Werner and so can be neglected on the basis that boilers need replacing every 10 to 12 years and inspecting every year for gas safety reasons hence the costs roughly cancel out. Piping lasts for 30 years if operating at 120C and over 100 years if at 75C low temperature. We can **very roughly** estimate the cost of heat at a UK power station ( the data is readily available) gate at follows:

The UK gas prices at NBP (Notional Balancing Point) were estimated to be 2.35 €Cent/kWh (UK DECC and using an average efficiency of generation of 50%, the figure currently used by gas and power traders to estimate Spark Spread. This gives a fuel cost of power of 4.7€Cent /kWh.

For every kWh of heat generated by a CHP station as it shifts from electricity only to CHP assuming a Z factor of 5, 1/5th of a kWh of electricity is lost, therefore the heat cost can be estimated as around  $4.7/5 = 0.94$ €Cent /kWh. This gives a total CHPDH estimated cost in the UK of 0.58 (distribution) + 0.94 (fuel cost of heat) = 1.52 €Cent /kWh = 4.2€GJ (This neglects power station capex but these are small in comparison to fuel costs and should be allocated mainly to the electricity sector).

There will be other factors not considered such as metering, billing maintenance, back-up/peak boiler and fuels, losses (10% - 20%) but these are unlikely to add more than about 30%. So it can be estimated very roughly that total heat total amounts to:  $1.52 \times 1.3 = 1.96$  €Cent /kWh = 5.44 €/GJ.

Clearly operational costs and some profit for any commercial operator will need to be factored in.

For comparison, the current UK domestic gas cost from one supplier is 5.95 €Cent /kWh which when factored up by the boiler efficiency, 0.8 and converted to Euros is about 7.44 €Cent/kWh or 20.66 €/GJ.

From figures supplied by Dr Sven Werner the typical DH cost in Europe in 2008 was about 15€/GJ.

The foregoing estimation is given for illustrative purposes only - much more detailed and careful studies are carried out elsewhere<sup>42</sup>.

It also indicates, that since there is no widespread uptake of an apparently cheap source of heat then there are likely to be institutional and market failures present. These can only be addressed by government and some of these economic and financial issues are looked at later on in this section.

There are of course practical difficulties in digging up the streets of entire cities, however this has been done successfully in a number of completely new schemes which have been retrofitted to parts or all of some European cities. Flensburg which is a difficult to excavate and historic town is one example, and Stockholm, Frankfurt, and large parts of Denmark can also be cited.

### *3.6.17 Other benefits of CHPDH and centralised heating systems*

There are other significant benefits arising from CHPDH:

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<sup>42</sup> JRC - Background Report on EU-27 district heating and cooling potentials, barriers, best practice and measures of promotion



- CHPDH is in many cases likely to be the cheapest method of domestic building carbon reduction in existing and difficult to insulate buildings.<sup>43</sup>
- Waste heat from industries can be used.
- Geothermal heat can be used.
- Solar heat can be used.
- Imports of fuel and hence balance of payment deficits are all reduced.
- There is a reduced cost of not having to insulate or glaze house windows to such high specifications. (A paper from Orchard shows these are less cost effective than CHPDH<sup>44</sup>).
- The installation of the technology is labour intensive providing indigenous employment and using indigenous products.
- Centralised combustion is inherently more efficient.
- Centralised combustion is inherently safer.
- Centralised combustion is inherently less polluting with lower emissions due to better combustion and exhaust clean up and higher stacks.
- CHP plant offer inherent flexibility (that is their ability to increase or decrease electric output very rapidly without the kind of ramping losses experienced by electricity-only plant) make CHPDH schemes likely to be an essential part of any large increase in wind energy in Europe The large heat stores which are large insulated tanks of water common in Scandinavia enable the production of heat and electricity to be decoupled from the overall demand for electricity at grid level. Furthermore the storage tanks allow the absorption of excess wind energy as heat to be used later. The scope and impact on grid storage for one Member State is analysed here<sup>45</sup>
- It has been suggested by the Danish District Heating Association that the average selling prices were €10.000 higher for houses with district heating than for those without.

### 3.6.18 Problems with CHPDH and centralised heating systems

- A need to excavate and install pipes in already heavily congested city centre areas.
- Loss of choice for customers over heating method. Restriction of choice in heat supply and regulation To be commercially successful, District Heat needs a very high take up. If 50% of the houses passed choose not to take it, then the system is most unlikely to be profitable. So its success depends to

<sup>43</sup> Technology Strategy Board Retrofit for Future a study to minimise CO2 emissions for typical UK housing comparing Combined Heat and Power District Heating with Insulation. March 2011. Orchard Partners London. <http://www.claverton-energy.com/technology-strategy-board-retrofit-for-future-a-study-to-minimise-co2-emissions-for-typical-uk-housing-comparing-combined-heat-and-power-district-heating-with-insulation-march-2011.html>

<sup>44</sup> Technology Strategy Board Retrofit for Future a study to minimise CO2 emissions for typical UK housing comparing Combined Heat and Power District Heating with Insulation. March 2011. Orchard Partners London. <http://www.claverton-energy.com/technology-strategy-board-retrofit-for-future-a-study-to-minimise-co2-emissions-for-typical-uk-housing-comparing-combined-heat-and-power-district-heating-with-insulation-march-2011.html>

<sup>45</sup> Smart Heat Grids - The potential for District Heating to contribute to electricity demand management to facilitate renewable and nuclear electricity generation. Paper C92-EIC\_029 to Energy in the City Conference, LSBU, June 24th 2010. Paul Woods, MA MSc CEng FEI FIMechE MCIBSE  
Andrew Turton, PhD Sustainable Development Group, AECOM



some extent in restricting the choices of customers some of whom might prefer gas biomass or heat pumps. Investors will not like this unless they have a regulator willing to help in the restriction of choice and who are committed over the long term.

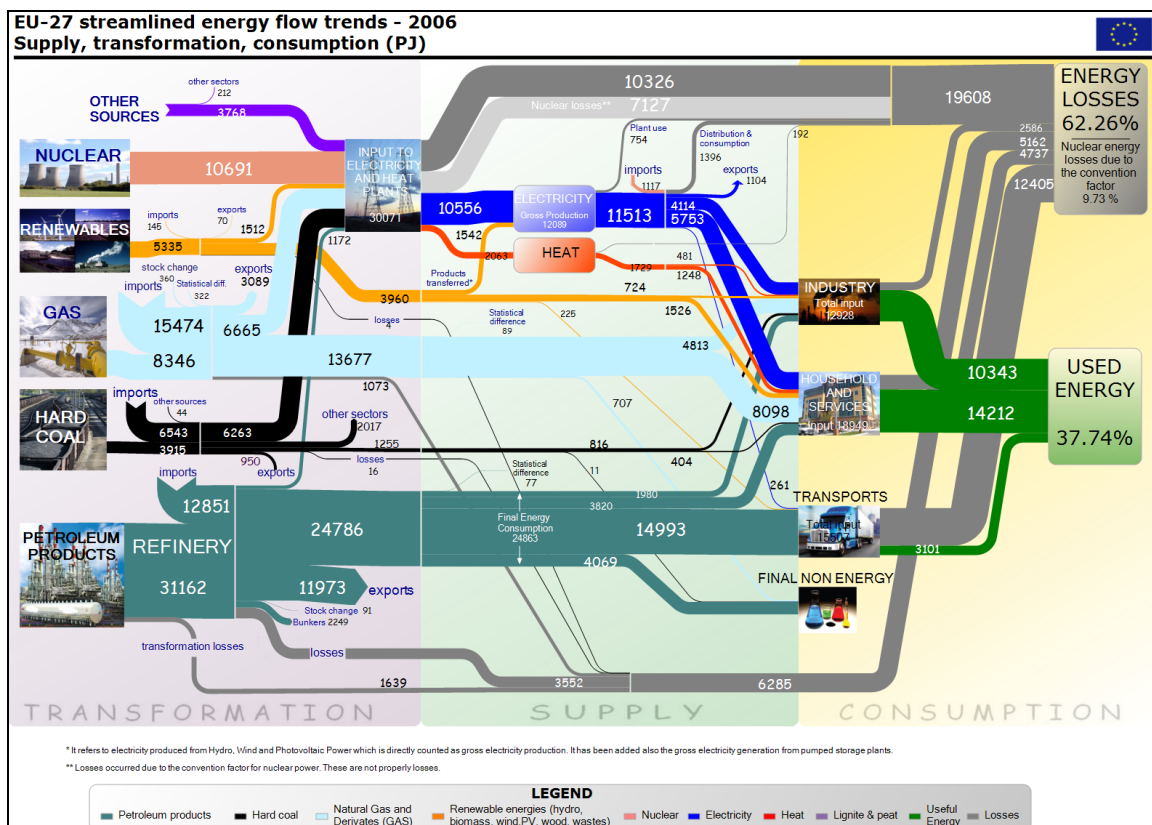
- Very high capital cost of heat network.

### 3.6.19 Estimate maximum potential of CHPDH from European Sankey<sup>46</sup> Diagram

(This section was introduced largely to familiarise readers with the broad picture of primary energy and waste energy flows through the European system)

We can make an estimation of the quantity of low temperature heat demand that could potentially be met with District Heating and CHP or other waste heat sources from the Sankey diagram in the next section. (Chapter 2 of this report analyses the heat market based on Eurostat statistics and National Reports)

Figure 3.8: Energy Flows in EU<sup>47</sup>



To get a very approximate idea of the potential for CHPDH, we can assume that half the end use of energy in Europe that is going to industry is used for low temperature heating. (The majority of the electricity in blue for industry will be for motors and or high temperature heating – melting etc) We can also estimate that 70% of the energy going to the Household and services (almost all the fuels, and a good part of the electricity) will be for heating and hot water. This gives a figure of 15,000 PJ/y = 4,100 TWh for low temperature heat demand which could potentially be met with power station or industrial waste heat. This is close to 50% of the end use of energy as defined by the Sankey diagram, an extremely large potential

<sup>46</sup> JRC Ispra  
<sup>47</sup> JRC Ispra

market for waste heat. Note that this figure is less than the total waste heat emitted from power stations – 19,600 PJ/a and about equal to other losses. Not all of this could be provided by power station or industrial waste heat in practice because there are inter-seasonal mismatch issues but this chart serves to very quickly indicate the scope of the potential.

A lot of the waste heat is at too low a temperature to be used for building heating, but the temperature can be upgraded to a useful level with significantly less of energy expenditure compared to the energy used by a boiler or a heat pump. (See

The very rough estimate here is in line with a very detailed analysis carried out by JRC which will be published in due course which gave 11,000 PJ per annum

A much more rigorous analysis of the potential which could be met by CHP is carried out in a later report<sup>48</sup>

### *3.6.20 Temporal persistence of heat loads*

The demand for building heating is unlikely to diminish to such an extent as to make CHPDH unfeasible, even with conservation measures, (See 2.3.3 Heat demand forecasts Fig.2.8) or disappear entirely as can be the case with industrial cogeneration when the plants are relocated abroad. This point is especially true in countries with badly-insulated buildings. Reductions in building heat loss can lead to warmer buildings, rather than to reductions in heat consumption; even after quite high insulation levels are added, a UK house may still have a heat load of 7,000-12,000 kWh per year rather than the previous 15,000-20,000 kWh/year<sup>49</sup>. The Open University report cited earlier<sup>50</sup> shows that even low energy houses can be so heated economically

### *3.6.21 Carbon savings*

An international study co-financed by the European Commission<sup>51</sup> confirms the possibility of saving an extra 400 million tons of CO<sub>2</sub> yearly (corresponding to 9.3% CO<sub>2</sub> reduction – thus more than the whole Kyoto target by doubling District Heating and Cooling across 32 European countries. As the preceding estimate shows the scope is probably far greater than a doubling.

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<sup>48</sup> JRC - Preliminary Report on EU-27 district heating and cooling potentials, barriers, best practice and measures of promotion

<sup>49</sup> Dr David Olivier, Olivier Associates, Personal Communication

<sup>50</sup> ERG 056 An Introduction to domestic micro-chp R.Everett and D.C. Andrews. Open university Energy Research Group, Milton Keynes U.K. September 1986

<sup>51</sup> (ecoheatcool see [www.euroheat.org/ecoheatcool](http://www.euroheat.org/ecoheatcool))

3.6.22 Background – present contribution of CHPDH

Figure 3.9: Shares of district heating used to satisfy heat demand in the residential and services and other sectors

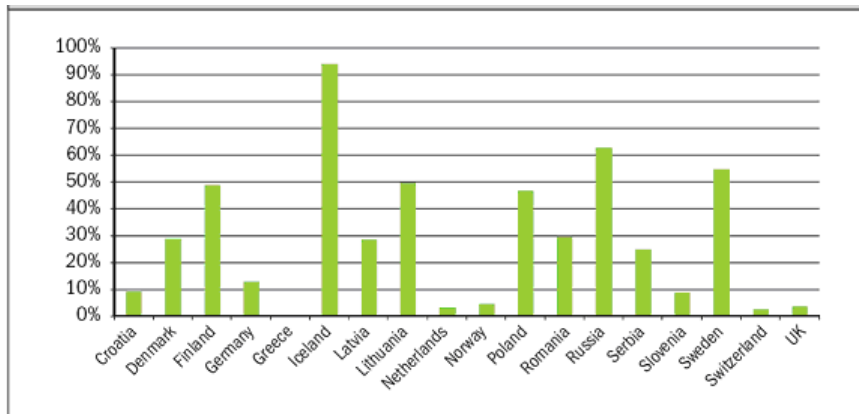
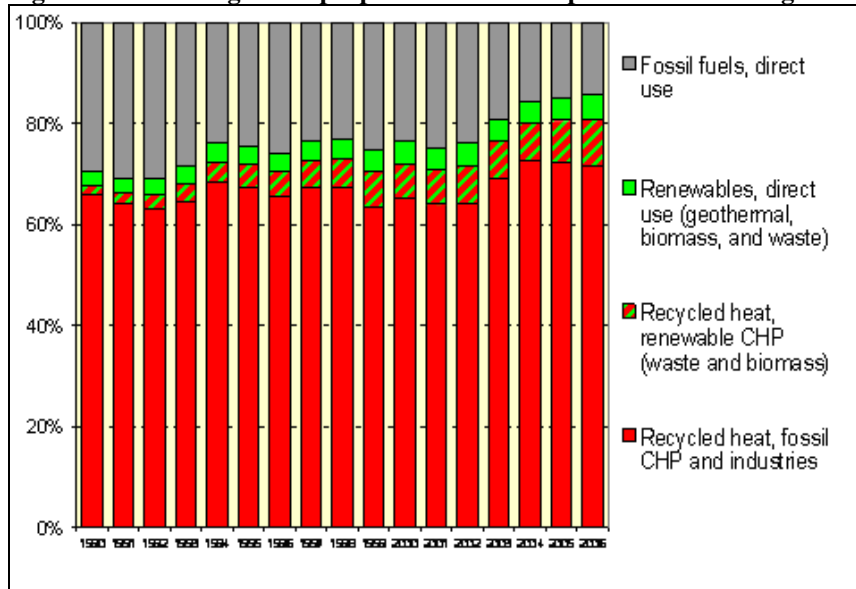


Figure 3.9 above, shows the percentages of the heat market satisfied by leading Member States users and EEA members of CHPDH (Combined Heat and Power with District Heating).<sup>52</sup> If all national district heating fractions were brought up closer to the leading practitioners’ levels, namely Iceland, Denmark and Finland, then this would represent a significant increase in CHPDH implementation.

3.6.23 Current sources of heat for District Heating in the EU27

The tables below show the origin of heat input into EU27 DH grids:

Figure 3.10: the origin and proportions of heat input into EU27 DH grids:<sup>53</sup>

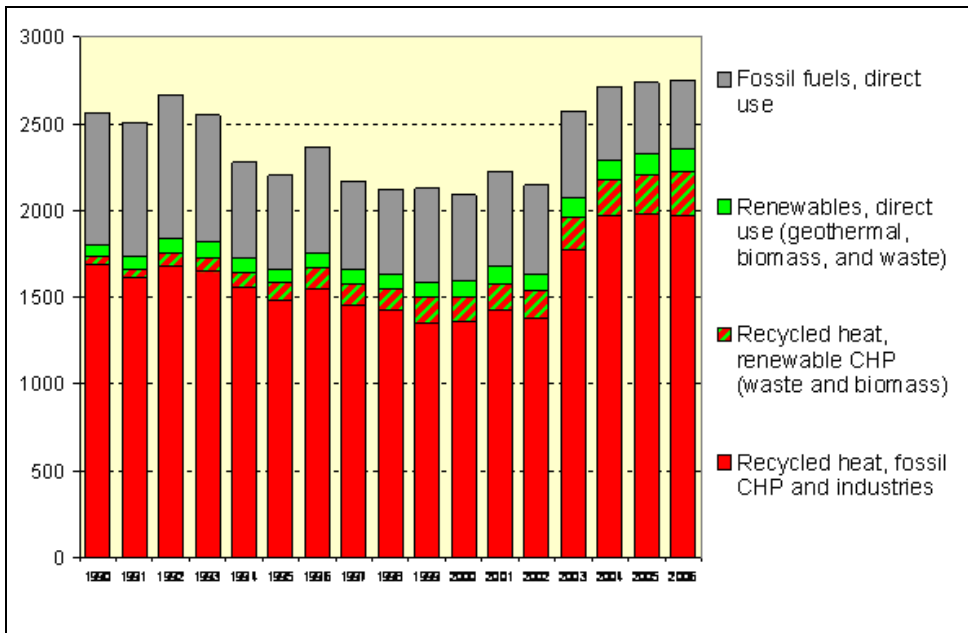


<sup>52</sup>

Source: District Heating and Cooling – Euroheat and Power 2009 Johannes Jungbauer Prof. Sven Werner; Halmstad University; based on IEA Energy balances 2008

<sup>53</sup>

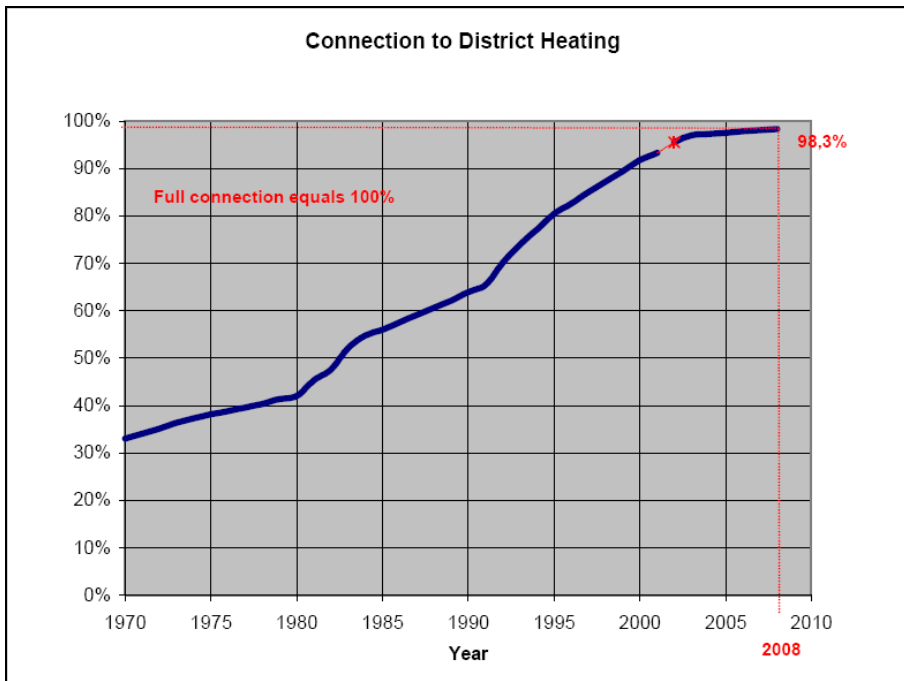
**Figure 3.11: the origin and quantities of heat input into EU27 DH grids<sup>54</sup>**



### 3.6.24 Potential growth rates of CHP DH

This can be considerable – the example below shows how quickly CHPDH can be built even in existing cities such as Copenhagen<sup>55</sup>:

**Figure 3.13: Rate of growth of connection to Copenhagen DH grids**



<sup>54</sup> Prof. Sven Werner; Halmstad University; based on IEA Energy balances 2008

<sup>55</sup> Global District Energy Climate Awards – Copenhagen District Heating System – Application 2009. Application for the ‘Global District Energy Climate Award’. Operated by Copenhagen Energy Ltd. Owned by the Municipality of Copenhagen

### *3.6.25 District Heating Regulation*

Regulation varies widely from country to country. In the UK there appears to be little regulation with prices being set by the operator which is usually ultimately the Local Authority. In other countries such as Denmark it is heavily regulated with Heat Planning undertaken and enforced by local municipalities. Danish heat suppliers are not permitted to make a profit; rates must be based on cost recovery, no more. (Note: this is in line with how water companies, and the power transmission and distribution companies, in England are financed and operated.)

In Eastern Europe many systems are owned by the Local Authority and prices are often regulated downwards for social reasons.

Many systems have been contracted out to companies such as Cofely District Energy, part of GDF Suez, Dalkia, Fortum, EON, and Vattenfall for example, but these are usually operated under license and control of the Local Authority.

### *3.6.26 Financial obstacles for district heating coupled with cogeneration – market failure*

CHPDH has to compete in modern liberalised markets with low investment cost heating systems such as direct electric heating, electric heat pumps, individual natural gas heating, oil fired heating, wood pellet heating (in approximate order of installation costs) All these systems suffer from higher running costs.

CHPDH has a high capital cost but low running costs. In the face of uncertainty developers will naturally tend to favour the low capital cost items unless there is some form of explicit encouragement; this will tend to occur even though on a theoretical basis, as shown earlier, the overall cost of heat from CHPDH is likely to be much less than that of a typical alternative.

Electric resistance heating is only low capital cost to the developer and the consumer, because the power stations, transmission and distribution have often been paid for at very low discount rates and over very long periods – mostly on written off assets. This works for the utilities because they can recoup costs on the sale price of energy.

Thus although it appears district heat offers a very low cost form of heating (in the appropriate locations) – but it would be wrong to conclude that the economics are so good that no market intervention is needed. There appear to be market failures which need to be addressed.

For this reason some jurisdictions notably Denmark have made heat planning compulsory whereby certain areas are mandated CHPDH only, on the basis that analysis shows it is the most cost effective heating method overall.

### *3.6.27 Market capital rates versus utility capital rates*

The high costs of initial investments, particularly for heat transport and distribution, have been identified as a serious obstacle to the expansion of district heating. Typically infrastructure projects such as water supply, waste treatment and electricity generation, whilst in the hands of governments and municipalities historically have tended to use a relatively low test discount rate of 3 to 6% real. Regulated private utilities in the UK such as water

companies pay rates of about 3-4%/yr for their money. Liberalized markets generally demand much higher returns, though, impeding the installation of such systems. At these former low rates of return then CHPDH is more economic than other options which explains the predominance of CHPDH in Denmark and parts of Germany where municipalities recognise the benefits and make funding available at these utility rates and over long periods and in suitable areas make it mandatory. Unless CHPDH is mandatory then it cannot compete because the uncertainty will necessitate investors seeking much higher returns.

### 3.6.28 Financial rates of return – what can actually be achieved over the long term?

Whilst private investors may expect high rates of return on individual projects, overall they do not achieve them on all projects since some inevitably under deliver or fail. The long term real rates of return that are in fact available to an economy – ie taking into account cyclic downturns - are quite low – about 3.5%. The UK Treasury in its Green Book advocates using a real discount rate of:

- 3.5%/yr for projects lasting up to 30 years
- 3%/yr for projects lasting 30-75 years

and somewhat lower rates for projects with even longer lifetimes.

The International Energy Agency (IEA) typically uses 3.5% to analyse energy infrastructure investments – see for example<sup>56</sup>

The final Report and Accounts of the CEGB (Central Electricity Generating Board - the old UK monopoly power utility) shows the "return on average net assets" in 1988/89 was 1.8%; in the previous year it was 2.26%. The target is given as 3.75%.<sup>57</sup>

Given that most of our energy infrastructure was created based on these low interested rates it is not unreasonable to expect governments, in a largely liberalised market to invest in or to create mechanisms to persuade private investors to do so. This may be for example to grant a monopoly by mandatory heat planning for CHP because over the long term they deliver the same rates of returns as markets taking into account “good” times and “bad” investment periods.

This may mean that they have to allow operators to charge higher rates by regulating prices – this is what happens now in other infrastructure projects. They are assessed at 3.5% and then subsequent operators are allowed to earn higher rates, via regulation of prices.

### 3.6.29 The requirement for management to focus on the core business

It is modern business practice to focus on the “core business”. A water company will invest in water treatment, a pharmaceutical company in a new drug plant or drug, an engine company will invest in better engine technology. The boards of these companies are well aware that long term real returns are low (3.5%) and are quite happy to invest in core business at these low rates of return, providing long term security is provided – and this can only come from governments, and financiers are happy to raise capital for these well run, long term sound business.

The water industry is a good example – after privatisation in the UK, many of the newly formed and inexperienced boards invested in peripheral businesses – investing in plumbing

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<sup>56</sup> A Comparison Of Distributed Chp/Dh With Large-Scale Chp/Dh. Report 8dhc-05.01. 2005  
<sup>57</sup> David Milborrow, Ex CEGB, Prinicpal Engineer in the Technology Planning and Research Division.

services, hotels, leisure centres and so on. All these business invariably lost money and were sold off and the boards pilloried by the City of London financial press for not sticking to core business.

It may therefore be unrealistic to expect power generating utilities or other energy providers to invest in CHPDH as it is not their core business.

### 3.6.30 Unfavourable fuel and power pricing

In several countries, heat prices are regulated to be lower than the actual production costs. Therefore, the district heating companies are not profitable and cannot afford to invest in the renovation of their facilities and networks which make these systems less efficient and more vulnerable to competition.

This particularly troubles the systems in some Eastern Europe countries, where DH is widespread in densely populated areas. Systems may be in bad condition for example with high heat losses. A large part of the population is low income and often live in dense urban areas. So social considerations may lead to regulation to keep heat prices low, without consideration of the effect on District Heat systems and its income and maintenance.

In some other countries social considerations lead to government intervention in energy markets without consideration for either socioeconomic or environmental effects, or for the effect on companies, investments and so on. This leads to government policies that keep gas prices to individual householders artificially low. In others the price of electricity is regulated to be a low value and this does not give sufficient income to the district heating company.

This is a major problem for district heating systems. If for social reasons heat prices are kept low then the part of the population having the higher ability to pay will also gain from lower prices. The practical answer according to Professor Werner is to separate energy and social policy. It becomes impossible to achieve energy efficiency gains as district heating, if social policy is more important than energy policy says Werner.

### 3.6.31 *Schemes in Eastern European states*

Eastern European states have often inherited poor (i.e. high average losses as compared to modern systems, poor technology) CHPDH systems from the old planned economy era. They have also often been allowed to fall into disrepair due to inadequate maintenance with the conditions of the pipes and heat and power generating apparatus being poor as a result. Many of these systems have no controls at the dwelling with customers being charged by floor area and thus have no incentive to conserve energy.

Overall the European heat losses in CPDH systems are estimated to be 14%,<sup>58</sup> with about 10% in West European (WE) networks and 20% in East European (EE) networks. However many EE systems have succeeded in lowering the heat losses such as in Riga where losses are now at 13% and according to some experts Riga can be seen as a model city for upgrading old Soviet DH systems. Today, they have better benchmarking parameters than many WE DH systems.

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<sup>58</sup> Dr Sven Werner, Professor, Energy Technology, Halmstad University (Högskolan i Halmstad), SET, PO,Box 823, SE-30118 Halmstad, Denmark

Many others have been successfully upgraded. A tentative classification<sup>59</sup> today would be:

**High degree of rehabilitation:** Estonia, Latvia, Lithuania, Poland, and former DDR in the current Germany.

**Medium degree of rehabilitation:** Czech republic, Slovak Republic, Hungary, and Slovenia

**Low degree of rehabilitation:** Bulgaria and Romania.

### 3.6.32 Market volatility and lack of stable forward power prices

The volatility of electricity price as reported in many of the national reports, makes it very difficult for new entrant CHP plants to get funding if they cannot go to a bank and say with any certainty what the power price will be and therefore what the returns will be 30 years ahead. Incumbent players do not face this difficulty because to a very large extent they know they will be able to control their income 30 years ahead because they have large captive markets of existing customers so in effect they can sell from their own power stations' output to their own customers. Churn is relatively low, and since all the large players EDF, EON, RWE etc have the same business model, which can be derived without explicit collusion they are all offering similar deals to final consumers.

One type of solution would be to require power companies as part of their license conditions to offer long-term buy back contracts – similar to the feed in tariffs which have been very successful for renewables. This is similar in which the UK Government is now talking about setting a minimum carbon price, which amounts to the same thing.

### 3.6.33 *The example of the water industry how market failure was addressed*

The water industry is an instructive example of how the market's failure to supply clean water and sewerage was addressed in 18<sup>th</sup> Century London. In the late 19<sup>th</sup> Century in London, and other major cities there were major epidemics of water borne disease and terrible odours. After much argument and debate the government very reluctantly provided the investment and the whole of London and progressively all other cities had sewers and water supplies laid on. It is clear that this could not have happened incrementally house by house under some far sighted free market entrepreneur. Widespread powers of road breaking and house entry etc had to be granted to a monopoly holder to ensure once the investor started he could be sure of 100% take up. The Metropolitan Water Board had to know in advance that they could invest on the basis that all customers would be connected. Subsequently the entity was privatised and sold off with enormous value creation.

Now it is clear that this was carried out by government decision and would not have happened by the operation of private capital alone, even though the crude sort of cost benefit analysis carried out earlier would have showed good net benefit in terms of the sale of water and sewage, reduced cost of ill health and death, reduced loss of working hours etc. To be successful it required everyone to be connected for the greater benefit of everyone.

This is the situation facing CHPDH in many countries. To be economic, CHPDH must get at least 60% of the heat market in a given area. (In many schemes in Denmark the uptake is

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<sup>59</sup> Dr Sven Werner, Professor, Energy Technology, Halmstad University (Högskolan i Halmstad), SET, PO,Box 823, SE-30118 Halmstad, Denmark



90%, and in the large ones close to 100%) Further more, it cannot grow incrementally street by street and house by house.

The situation is not exactly the same as for CHPDH. For water sewage etc there are no alternative technologies, but for heating there are, e.g. bio fuels, heat pumps, gas and electricity. However, if studies by government indicate that CHPDH is overall a technology they want, they may need to consider treating it in the way that the water industry was, giving it monopoly rights as is done in Denmark by the heat planning system, where certain areas are designated DH only.

The water companies in England, although privatised operate under a strict model of regulation. They are allowed to make about 6% real on capital employed, and have to submit detailed investment plans every 5 years – for cutting flooding, improving treatment and so on. In return for this, they are granted effectively an indefinite monopoly. This is a very successful model and could easily be applied to CHPDH.

It is noteworthy that water companies have virtually unlimited powers when it comes to their ability to lay pipes anywhere they choose if they deem it to be in pursuance of their license conditions.

#### *3.6.34 The creation of the UK National Grid*

This is another example of where market failure prevented the growth of an economic option, and this was recognised by government. They chose nationalization but nowadays other more efficient market solutions would be preferred.

Prior to 1920 power stations sprang up all over the UK and near towns and run by the municipality with a variety of different voltages, frequencies, ac/dc. etc It was widely recognised by technical experts that these small, inefficient stations could be replaced by fewer more efficient ones connected by an electricity grid. Due to the sharing of reserve capacities this required substantially less capacity overall than was required in the previous fragmented situation. No doubt the simplistic calculations showed that there was a hugely profitable enterprise but the market of itself did not start building the grid. It would not have been in the interests of the incumbent power station owners. Eventually the government took over, nationalised the industry and built the grid around 1925 onwards. This system has now been sold off creating huge value

#### *3.6.35 Precedents of coercion for environmental reasons*

There is ample precedent of coercion to deal with environmental issues and curtailment of heating fuel choice. During the 1950's London experienced intense particulate pollution known as smogs caused by particular weather conditions and the widespread burning of domestic coal, caused thousands of deaths. Following one particularly severe episode, the government of the day banned all coal and wood burning in major cities, declaring smokeless zones and limiting the number of open fires per house. This solved the problem in a few years. Interestingly in the light of earlier comments on heat pumps (*Effect of temperature on heat pumps – potential stress on power grids*), lack of foresight lead to another problem, and this was that to replace coal, electric fires were widely purchased and these imposed severer

peak loads on the grid system, resulting in widespread power failures, and lowering of grid voltage and frequency.

### 3.6.36 Summary of Member States' country reports with regard to district heating barriers

Euroheat report<sup>60</sup> on the country members views with regard to district heating barriers have been summarised in the Table 3.6 below:

**Table 3.6: District heating barriers as per Member States' reports**

EU27	High primary energy prices	Negative impact CO <sub>2</sub> emissions trading	Differential taxes applied to cogeneration / district heat	Difficulty in funding long payback period of heating network	Unfavourable cross pricing favouring individual gas users	Discriminatory building regulations and codes	Poor payment for power generated	Prices of heat held low for social reasons inhibiting investment
Austria	x							
Belgium								
Bulgaria								
Cyprus								
Czech Republic								
Denmark								
Estonia	x	x						
Finland								
France								
Germany	x			x				
Greece			x	x				
Hungary		x	x		x	x	x	
Ireland								
Italy							x	
Latvia					x			
Lithuania			x		x			
Luxembourg								
Malta								
Netherlands								
Poland		x						
Portugal								
Romania								
Slovak Republic								
Slovenia								
Spain								
Sweden		x				x		
United Kingdom								

### 3.6.37 Is barrier removal alone likely to promote significantly the growth of CHPDH?

The case of the United Kingdom can be cited, where there are few specific barriers to the installation of CHPDH and with a similar climate to Denmark and Germany, but which has very few district heating schemes and little definite planned change in this direction. In this Member State all the investment in energy infrastructure tends to be centred around new electricity only power stations either coal or gas and there is no heat planning. There is an obligation to consider CHP for the authorisation of new power plants however so far this has had little impact. Several cities (including London based on converting the existing Barking power station to CHP) are looking in detail at district heat systems and are conducting heat mapping however the consultants concerned indicate privately that without impetus and

<sup>60</sup> District Heating and Cooling – Euroheat and Power 2009 Johannes Jungbauer

priority from central government little will happen due to the lack of any means of financing these schemes. Thus the mere removal of barriers is unlikely to change this and this situation is likely to be the case in other Member States.

### *3.6.38 Support schemes and planning*

An additional approach to the removal of barriers to cogeneration and district heating, is the provision of positive encouragement by the use of legislative means. For example in Denmark, heat planning requires certain areas to only have district heating, and the construction of electricity-only power stations is virtually impossible since they will not receive planning permission. These kind of mandatory actions were cited as being the most effective by a survey of country partners of some 23 district heating promotional policies.<sup>61</sup>

### *3.6.39 Do energy statistics treat CHPDH in a useful way?*

According to Professor Werner,<sup>62</sup> when allocating primary energy supply and carbon dioxide emissions, the energy method widely used is as per Eurostat and IEA statistics. In this case the whole benefit of CHP is allocated to the electrical side, the whole benefit of industrial heat recycling is allocated to the industrial processes, and the whole benefit of waste-to-energy plants is allocated to waste management. Hence, the benefits of district heating is obscured says Werner and he claims that no international energy analyst can track the benefit of district heating, when analyzing international energy or emission statistics.

Logically he says it can be argued that the waste heat in all cases is decarbonizing the heating sector.

What is needed Werner says, are general allocation methods such as the Orchard proposal<sup>63</sup> where the energy saving from CHP is allocated to the heat side, and this more readily shows the real benefits of district heating and makes these benefits more transparent. This is a view held by many Danish experts consulted during the preparation of this report.

### *3.6.40 The long term – is CHPDH a technology with a future?*

CHPDH currently largely relies on waste heat from fossil fuel power stations and arguably can be seen as a technology with an uncertain future on that basis.

However, it should not necessarily be seen as a technology without a future which relies on high carbon fossil energy. It can be perhaps more properly viewed as a transition technology to a low carbon future

Also:

- 4 If CCS becomes widely implemented then the waste heat from these fossil fired stations can be used indefinitely.

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<sup>61</sup> Ecoheat4EU project contract D3.3

<sup>62</sup> Personal Communication. Dr Sven Werner, Professor, Energy Technology, Halmstad University (Högskolan i Halmstad), SET, PO,Box 823, SE-30118 Halmstad, Denmark

<sup>63</sup> <http://www.claverton-energy.com/the-orchard-convention-for-the-analysis-of-chp.html>

- 5 Other sources of heat such as geothermal, industrial waste heat, solar, waste  
combustion, can be readily incorporated for district heating.
- 6 The multi day heat stores associated with DH in Denmark, enable DH networks to  
offer enormous energy storage potentials for wind energy at a very affordable costs.
- 7 CHPDH can also readily supply back up and balancing energy to electrical grids with  
large amounts of wind energy.
- 8 Biomass combustion in CHPDH plants is superior to direct utilisation of biomass in  
individual boilers in terms of emissions and CO<sub>2</sub> reduction.
- 9 In high wind scenarios surplus wind energy can be used for heating purposes in  
district heating networks – this is already widely practiced in Denmark.
- 10 Central heat pumps, which are much more efficient than individual ones can extract  
heat from sea water, potentially power station exhaust stacks (thereby initiating  
condensing) and place it into district heating systems.
- 11 Waste heat from nuclear power stations can be incorporated into District Heating.
- 12 As an alternative to District Heating, the use of electricity for heating will require  
major investment in upgrading the electric generation and transmission and  
distribution networks. This is because the widespread adoption of heat pumps for  
heating will create a dramatic increase in winter peak electricity demands. The costs  
of this upgrading of power grids needs to be set against the cost of CHPDH  
networks.

### *3.6.41 Conclusion*

District heating offers the largest potential for the increase in cogeneration based on a heating demand that will not go away within the next 30 years (Figure 2.8, page 18). However the mere removal of perceived barriers is of its own unlikely to produce much exploitation of the very large potential.

It is one of the JRC's overall conclusion that CHPDH is seriously impeded by the lack of recognition that without being given the same sort of rights and privileges (monopoly, risk reduction by governments, price setting power) that other network operators already have, (water, gas and electric cables) then CHPDH will not fulfil its potential within the European Community.

Many administrations fail to evaluate the benefits of CHPDH using the correct discount rate for infrastructure which is 3.5%. It is not sufficiently recognised that this rate does not imply that the private sector needs to invest and expect this low rate of return. The role of administration's policy in this area is to identify good infrastructure projects (such as CHPDH which meet a 3.5% discount rate test), and then to manipulate the commercial environment to enable the private sector to make the much higher returns they require.

There are good technical grounds for seeing CHPDH as a good partner for high penetrations of renewable energy which add to the case for supporting CHPDH projects.

## 4 OVERVIEW OF SUPPORT SCHEMES

### 4.1 Introduction

This chapter presents an analysis carried out to investigate the effectiveness of the different supporting measures to promote cogeneration employed by various MS. The effect of the different support schemes in each country are also compared to pinpoint which kind of supporting measures have been more effective. The conclusions rely on an analysis carried out looking into the average evolution of the cogeneration between two different periods of time in the past (2002-04) and (2006-08) in all the Member States. To quantify the economical effect of the supporting measures in each country in the development of cogeneration the information of the cost benefits analysis carried out by CODE<sup>64</sup> has been used. Also the possible effect of the competition between the measures supporting combined heat and power and renewable energy sources is analysed.

### 4.2 Contributions and cost effectiveness of the support schemes for the creation of stable conditions for the promotion of investment in cogeneration, effect of the coexistence of different support schemes

This chapter presents the analysis carried out to study the influence of the various different support schemes in the development of CHP. In Table 4.1 information that that could have affected the evolution of cogeneration between two periods of time is introduced. The second Table contains the information that can be used to quantify the increase of cogeneration and other forms of generation.

As one senior industry insider put it “Today there is no lack of opportunity for companies to invest in energy infrastructure. Indeed a shortage of investment money is often cited as an issue. So in this case why would a company target its scarce resources at a difficult and new venture such as CHP rather than the simple quick to build known technology of a CCGT? Investment prioritisation is key for private companies – domestic CHP is extremely challenging unless mandated.”

The first two columns of Table 4.1 summarise the effects of the cost benefits analysis carried out by CODE<sup>65</sup>; this document gives for every Member State the effect on the payback period and the internal rate of return of cogeneration projects with and without supporting measures. This is analysed for several combined heat and power (CHP) projects (5 in total) that vary according the technology used, fuel consumed and size of the project (from 50 kWe to 66 MWe).

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<sup>64</sup> CODE (Cogeneration observatory and dissemination Europe). Work package 3. Comparison of member state approaches. Country overview of internal rate of return calculations.

<sup>65</sup> Ibid.

**Table 4.1. Combined economical effect of the supporting measures and different kinds of supporting measures.**

Column No	1	2	3	4	5	6	7	8	9	10
	Payback period without supporting measures	Payback Period with supporting measures	Variation of the payback period	Economical advantage per installed capacity	Capital cost per installed capacity	Type of support scheme: - see * below also				
	y	Y	$\Delta y$	$\Delta \text{€}/\text{kW}$	€/kW	Tax	Feed-in tariff	Cert	Grnt	Other
		afterPB	incPB	venEUR	capCOST					
Austria	3.08	3.07	-0.01	5.2	1082.3	0	1	0	0	1
Belgium	3.73	2.20	-1.52	203.4	1028.7	1	0	1	0	1
Bulgaria	8.46	5.84	-2.62	214.2	1522.0	0	1	0	0	1
Cyprus	1.66	1.66	0.00	0.0	1101.8	0	0	0	0	1
Czech Republic	6.23	3.93	-2.31	145.6	1545.8	0	1	0	0	1
Denmark	1.31	1.31	0.00	0.0	884.5	0	0	0	0	0
Estonia	3.16	3.16	0.00	0.0	887.5	0	0	0	0	1
Finland	2.93	2.93	0.00	0.0	1161.1	0	0	0	1	1
France	7.27	0.85	-6.42	919.8	849.7	0	1	0	0	1
Germany	1.70	1.55	-0.15	62.9	1109.8	0	1	0	0	1
Greece	3.46	2.25	-1.21	0.0	691.2	1	1	0	0	1
Hungary	6.76	6.76	0.00	0.0	1534.7	0	1	0	0	1
Ireland	4.50	4.50	0.00	0.0	1425.3	0	0	0	0	1
Italy	2.70	1.11	-1.59	465.3	872.0	1	1	0	1	0
Latvia	12.39	4.99	-7.40	179.8	1538.1	0	1	0	0	1
Lithuania	10.03	8.24	-1.79	33.6	1548.0	0	1	0	0	1
Luxembourg	1.24	1.24	0.00	0.0	659.7	1	0	0	0	1
Malta	1.84	1.84	0.00	0.0	752.3	1	0	0	0	1
Netherlands	8.12	6.38	-1.74	41.4	1178.8	1	1	0	1	1
Poland	11.33	5.43	-5.90	125.0	1780.9	0	0	1	0	1
Portugal	3.07	3.07	0.00	0.0	900.4	0	0	0	1	1
Romania	5.46	3.48	-1.98	266.7	850.1	0	1	0	1	0
Slovakia	6.34	5.81	-0.53	20.0	1534.4	0	1	0	0	0
Slovenia	6.74	3.16	-3.57	221.5	1208.8	0	1	0	0	1
Spain	6.36	3.06	-3.30	93.5	1040.9	1	1	0	0	1
Sweden	3.60	3.60	0.00	0.0	901.2	0	0	0	1	1
United Kingdom	4.85	4.11	-0.74	36.6	1072.3	1	1	0	1	0

**NOTE:** These last 5 columns contain a “1” as appropriate to indicate the supporting measures which apply. For example, a “1” in column 6 indicates the support measure provides a tax advantage compared with other forms of generation; in column 7 indicates a feed in tariff; in column 8 indicates the electrical generation from CHP receives a certificate, in column 9 indicates that the CHP facilities may qualify to get some sort of grant; in column 10 indicates some other kind of additional support.

Columns 1 and 2 give the average payback period before and after taking into account the supporting measures for the projects considered. To compute a single average for each country, the payback period of the five projects analysed are weighted. The weightings used<sup>66</sup> are the capacity percentage of overall generation of similar cogeneration facilities in each country. This average allows the analysis to combine the payback periods of the five projects into a single one, easing the analysis. The lower the value of the payback period the more interesting the project is. Projects with payback period lower than 2 years are very interesting for companies. The bigger the reduction in the payback period the more effective the supporting measures are. However, if this decrease still does not place the final payback period below a certain threshold, the decrease of the payback may be ineffective. This may be the case, for example, of Latvia in which the large decrease in the payback period -7.40 still does not manage to make the investment interesting (its final payback period of 4.99 years is still too high). In other cases, like in France, even with a smaller decrease in the payback period (-6.42 years) the final value of the payback period may make CHP projects very appealing. In spite of the fact that low payback periods are required by investors, they may not be enough to assure a positive investment decision. In other words, this criterion has to be satisfied but the final decision will also depend on many other factors or barriers (it is a necessary but not sufficient criterion).

Column 3 is the difference between the first two columns; it contains the variation (a decrease when the sign is negative) in years of the payback period as a result of the supporting mechanism. The weighted used of the payback period of the projects considered in the CODE project to obtain column 1 and 2 facilitates the analysis but on the other hand makes that that value does not correspond to any of the projects considered in the CODE project. In the same way, none of the CODE projects have had such decrease of the payback period given in column 3. Since the weighs used are the capacity percentage of overall generation of similar cogeneration facilities in each country, we are decreasing the importance on the payback period of schemes to promote projects that are not focus on promoting the existing CHP park in each country.

The columns 4 and 5 have been weighted in the same way as the first two columns. Column 4 contains the weighted average of the annual economical benefit offered by the supporting measures per capacity installed. This value is the average difference in Euros (weighted) of the net benefit of the CHP projects with and without the supporting measures divided by the capacity of the project. Therefore this value only deals with the difference of the cash flow of the projects with and without supporting measures. In other words it is only affected by the supporting measures that affect to the operational costs of the CHP. The fifth column is the weighted average cost of the capital investment per kW installed. The capital cost considered in the fifth column already has discounted the potential support to reduce the capital cost by some Member States. Again, when interpreting the values of these columns care should be taken. For example, in Austria the difference between the net benefit with and without support measures is 320 €/kWe for projects of 1MWe fuelled by natural gas, however, this kind of projects only represent approximate 1.63% of the installed capacity, and the rest of the projects considered in the CODE project do not receive any support. For this reason the weighted economical support given the fourth column is 5,2 €/kWe ( $320 \text{ €/kWe} * 1.63\% + 0\text{€/kWe} * 98.37\%$ ). In other words schemes that promote technologies/fuels with low presence in the CHP park of one particular Member State are penalised when obtaining the values of column 4 and 5.

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<sup>66</sup> Estimated from the EPIC database (Electricity production information & capacity) by ESAP (Energy System Analysis & Planning). [http://www.esap.be/epic\\_presentation.htm](http://www.esap.be/epic_presentation.htm)

Thus the first five columns of Table 4.1 are parameters that quantify the strength of the economical support, whereas columns 6 to 10, only contain qualitative information about how the support measure is implemented.

The first and second columns of the next Table, Table 4.2, give the average percentage of electricity production from CHP projects in two different periods of three years (from 2002 to 2004 and from 2006 to 2008). The values used to compute these averages come from Eurostat<sup>67</sup>. In the ensuing analysis, it will be assumed that the second period contains the effect of the supporting measures, whereas the first period does not. This may not be always the case, for example in Flanders and Germany the supporting measures have been in operation also during the first period of time considered. However, following this approach other considerations that can have influence in the development of cogeneration, such as the economical context, are similar for all countries. Also, considering several years in each period, annual abnormalities are smoothed (for example, the influence of uneven annual hydro electric productions are flattened). In order to contrast the evolutions of electrical generation from CHP with generation from renewable sources, three additional columns are included in Table 4.2. These last three columns are similar to the first three columns except the renewable energy production has replaced CHP production (this information has also been taken from Eurostat<sup>68</sup>). In these ratios the electricity produced from renewable energy sources comprises the electricity generation from hydro plants (excluding pumped storage), wind, solar, geothermal and electricity from biomass/wastes.

The increment of the share of generation from Renewable Energy Sources (RES) has been included to check whether or not the high development of RES has affected the development of CHP. That is, we will analyse the possible overlapping of both sets of support schemes (CHP and RES) checking if the measures designed to promote RES (not described here) have negatively affected the evolution of CHP.

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<sup>67</sup> Eurostat database. [http://epp.eurostat.ec.europa.eu/portal/page/portal/product\\_details/dataset?p\\_product\\_code=TSIEN030](http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/dataset?p_product_code=TSIEN030)

<sup>68</sup> Ibid.



**Table 4.2. Evolution of the percentages of electrical production from CHP and from renewable energy sources in two periods of time.**

Column number	1	2	3	4	5	6
	Annual average of electrical production from CHP	Annual average of electrical production from CHP	Increment in the share of CHP between the two periods	Annual average of electrical production from renewable sources	Annual average of electrical production from renewable sources	Increment in the share of renewables between the two periods
	2002-04	2006-08		2002-04	2006-08	
	%	%	Δ%	%	%	Δ%
	beforeCHP	afterCHP	incCHP	Before RENW	afterRENW	IncRENW
Austria	14.4	15.7	1.3	59.4	59.7	0.3
Belgium	8.0	10.6	2.7	1.9	4.5	2.6
Bulgaria	7.3	8.5	1.2	7.6	8.7	1.1
Cyprus	0.0	0.3	0.3	0.0	0.1	0.1
Czech Republic	16.8	14.1	-2.7	3.8	4.9	1.1
Denmark	49.6	43.2	-6.4	23.4	27.9	4.5
Estonia	10.5	8.8	-1.6	0.6	1.6	1.0
Finland	36.0	35.0	-1.0	24.6	27.0	2.4
France	4.1	3.2	-0.9	13.2	13.4	0.2
Germany	9.6	12.4	2.9	8.6	14.1	5.5
Greece	1.7	1.7	0.0	8.5	9.1	0.6
Hungary	19.9	21.6	1.8	1.3	4.6	3.3
Ireland	2.6	6.0	3.5	4.9	9.8	4.9
Italy	7.8	9.9	2.1	14.6	14.9	0.3
Latvia	34.8	39.0	4.3	40.6	38.4	-2.2
Lithuania	10.7	13.4	2.8	3.2	4.3	1.1
Luxembourg	9.3	10.9	1.7	2.7	3.8	1.0
Malta	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	29.7	31.2	1,5	5.0	8.1	3.1
Poland	16.5	16.7	0.2	1.9	3.5	1.6
Portugal	10.5	11.9	1.4	27.2	28.8	1.6
Romania	26.4	12.8	-13.6	28.3	28.9	0.6
Slovakia	16.4	25.7	9.3	15.3	16.2	0.9
Slovenia	6.2	7.1	1.0	25.5	25.2	-0.3
Spain	7.9	7.1	-0.7	18.0	19.3	1.3
Sweden	7.5	8.6	1.2	44.3	51.9	7.6
United Kingdom	6.1	6.4	0.3	3.1	5.1	2.0

The capital cost per installed capacity in Table 4.3 is the weighted average of the values given by CODE<sup>69</sup>. The weightings used<sup>70</sup>, are the capacity percentage of similar cogeneration facilities in each country. The smaller the capacity of the facility the more expensive per kW installed the facility is. Therefore, this capital cost per installed capacity represents the investment needed to increase the cogeneration using the same kind of technologies already in use in that country.

<sup>69</sup> CODE (Cogeneration observatory and dissemination Europe). Work package 3. Comparison of member state approaches. Country overview of internal rate of return calculations.

<sup>70</sup> Estimated from the EPIC database (Electricity production information & capacity) by ESAP (Energy System Analysis & Planning). [http://www.esap.be/epic\\_presentation.htm](http://www.esap.be/epic_presentation.htm)

The sudden decrease in the share of generation from CHP in Rumania is more related to a change in the methodology to compute generation from CHP from 2007 than with a real change in the penetration of CHP. However, this country also has suffered from other important pressures discouraging CHP production. It comes from a situation in which at the beginning of the 90's the CHP share in generation was 40% due to a high heat demand from an industry that afterwards vanished, and from 2000 to 2004 many thermal energy consumers stopped using the services of centralised systems and thermal energy demand in the residential sector also fell significantly<sup>71</sup>.

The first kind of analyses carried out is to compare whether the influence of the two different groups of countries according to its supporting measures make any difference to the evolution of cogeneration or not. In the first group of countries we have placed all Member States whose supporting measures do not have any effect at all in the economical cost of the cogeneration projects, the second group are the rest of countries. To easily visualize this we rearrange in Table 4.3 the information contained in Table 4.1 and 2 (sorting it by the decreased offered by the supporting measures to the payback period).

In the first group of countries, those whose supporting measures do not include any economical advantage to CHP projects, there are two of the countries with higher generation from CHP (Denmark and Finland), 43% and 35% respectively. Both countries suffer from a decrease of electricity generation from CHP. In the case of Denmark this decrease of 6.4 % is the second biggest decrease of all Member States. In Denmark the total electricity production in both periods of time hardly changes. The increase in the share of wind generation is 3.1%, more than half of the total increment in the share of RES (4.5%). Since the decrease of the share of CHP (6.4%) is higher than the increase in the share of RES (4.5%), the CHP is losing ground not only due to the increase of RES.

We now perform a statistical analysis known as a contrast to test the difference between two means. This involves splitting the data from the MS into several different groups according to various "explanatory" variables which could have influenced the growth in CHP and comparing the mean of the groups using a statistical method. The statistical method used enables us to say, with a certain degree of confidence whether or not the explanatory variables we used to split the original data are likely to be responsible for any difference.

The first explanatory variable that we use to divide the growth in CHP of member states into two groups is the variation of the payback period between the two periods of time (the column headed incPB in table 4.3 gives this information). Therefore, the two groups contain the increase of the share of electrical production coming from CHP over the two periods of time of the Member States (this variable is called incCHP in table 4.3). But, one group is formed with the values of incCHP of Member states in which there is a decrease of the payback period (explanatory variable) and the other group will contain the values of incCHP for the Member States in which there is no change in the Payback period.

We then perform a statistical contrast to check whether or not the means of both groups are statistically different. The conclusion is that there is no statistical evidence to state that both means are different (with a confidence of 95%). If these means had been different, this difference would have been due to the explanatory variable (variation of the payback period).

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<sup>71</sup> RO Report Art 10. Report, submitted pursuant to the provisions of Directive 2004/8/EC, concerning evaluation of the promotion of cogeneration in Romania.

The same can be repeated to compare the means of the two groups for

- (i) the average increase of the share of electrical production coming from RES (incRENEW),
- (ii) for the average value of electrical production from RES in the second period of time (afterRENEW)
- (iii) for the average value of electrical production coming from CHP in the second period of time (afterCHP).

That is, when we split each of the former variables into two groups (according to the value of the change of the payback period) and we compare the means of both groups the result is that both means are indistinguishable.

We can repeat the process using each of the rest of the potential explanatory variables - columns 6 to 10 of table 4.1 - to again form two groups of values for each of the variables incCHP, incRENEW, afterRENEW and afterCHP in turn. The difference from the previous comparisons is that now we use each of the potential explanatory variables instead of the change in the payback period to split those variables.

The results are the same. There is no statistical evidence to say that any of the different ways in which these variables (that measure the evolution of CHP or RES) can be split produce means that are different. Therefore, it can be said that there is no evidence that the Member States whose supporting measures include any economical advantage to CHP projects have been more effective in promoting cogeneration than the rest of the countries. However this conclusion should be read with care since it is based on information coming from the CODE project. Thus, this analysis suffers some inevitable problems due to the need to select a concrete number of CHP projects and technologies. Since only five cases were analysed in the CODE project, some technologies/fuels were necessarily excluded. For example, none of those 5 projects used biofuels, and therefore, it is not possible to analyse the effect of support schemes that only favour this kind of fuel, as it happens in Sweden. Therefore, Sweden in this analysis appears in the group of countries that do not support CHP when this is not completely true (it should be read that Sweden does not support economically any of the fossil fuel projects analysed in the CODE project). Moreover, in the CODE project, it was not always possible to complete the information of those projects in all the countries, therefore, the quality of the information provided is not the same for all the countries.

Also, it is noteworthy that, the analysis carried out in this chapter measures the evolution of the cogeneration between two periods of time comparing the percentage of electrical production from CHP. However, the variation in the production may have been due to schemes aimed at operating existing CHP capacity in different way, without changing the capacity installed, or may have been due to a variation in the installed capacity, keeping constant the load factor of CHP existing facilities. In this analysis both effects are undistinguishable. Also, the size of the different national electrical systems play a role. For a Member State with a relative small electrical system (in terms of electrical production), one individual new big facility (CHP or of other kind) may be the responsible for most of the variation of the electrical production, as it happens in Ireland. Nevertheless, and acknowledging that the casuistic may very broad among the 27 Member States, with the approach followed in this chapter we are trying to see the forest more that distinguishing among individual trees.

Notwithstanding the potential shortcomings that it has, we consider the information provided by the CODE project to support the European Commission to assess the strength and effectiveness of the supporting measures very valuable and thorough.

If the promotion of the CHP by the support schemes has not been very effective (the electrical generation from CHP has risen a total of 0,5% between the two periods of time considered) is due to the lack of effectiveness of the support schemes to overcome the barriers that they face. It is noteworthy to underline that despite the fact that these barriers are “analysed” by the Member States in their reports about their National Potentials, no country carried out an analysis about the ability of their support schemes to deal with those barriers. In the meeting of the committee on cogeneration (art. 14 Directive 2004/8/EC) on 2<sup>nd</sup> December 2010 in which the analysis of the barriers carried out by the JRC in the synthesis report was presented, the representative of the United Kingdom stated that the complexity of an analysis of this kind was out of the reach of the National Authorities and was not required by the Directive. It can be understood that is even more out of the reach of the EU Commission to deal with this kind of analysis for the 27 Member States. However, the JRC has tried to relate those barriers<sup>72</sup> reported by the Member States and the evolution of the share of electrical production from CHP following the same approach that has been presented so far in this chapter.

To carry out this analysis the increase of the electrical generation in perceptual terms (incCHP) of countries have been considered again for two different groups. In one group are the values of incCHP of countries reporting about one specific barrier in their National reports and in the other group are the values of the countries that do not mention that barrier. For all barriers considered there is no statistical difference between the means of both groups (for an interval confidence of 95%). However, relaxing a little bit the requirements, the barrier “Lack of promotion” appears to be like a potential factor to distinguish about both groups of values of incCHP (The p-value obtained is 0,07). This means that if the groups of incCHP had been formed at random, in 7% of the cases the difference between the means of incCHP would had been similar to the one observed when the groups are formed using the barrier “Lack of promotion”. But since in this analysis we have used 14 different barriers, the probability of obtaining at least one apparent relationships by pure chance is quite high (63,8%). Thus, the result of the analysis carried out in this chapter about of the effects of the barriers reported by the Member States on the evolution of CHP is not conclusive.

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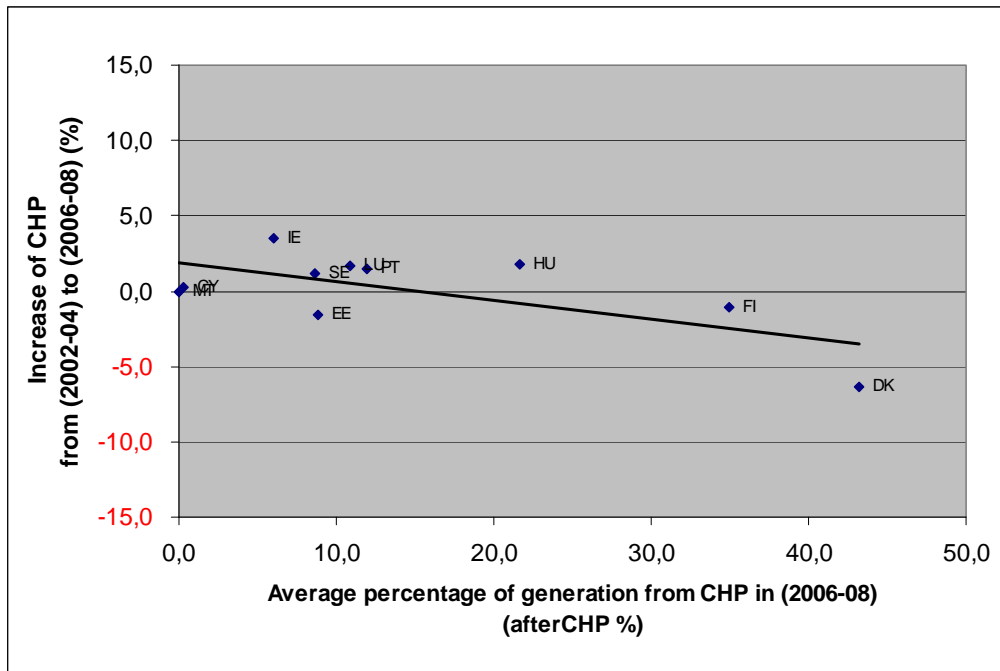
<sup>72</sup> The barriers used in this analysis come from the “Final Synthesis Report – Part I: Draft synthesis report on the progress in implementing and promoting cogeneration, based on the Article 10 national reports. Part I. Deliverable 1.1.a within the framework of the Administrative Arrangement on Cogeneration between DG ENER and JRC

**Table 4.3. Variation of the payback period, economical advantage offered by the supporting measures, capital cost per capacity installed and increment in the shares of electrical production coming from CHP and renewables in the two periods of time considered.**

Country	Abrev.	Increment Payback period	Economical advantage per installed capacity	Capital cost per installed capacity	Increment of the share of CHP	Increment of the share of renewables
		y	€/kW	€/kW	%	%
		incPB	venEUR	capCOST	incCHP	incRENEW
Cyprus	CY	0	0	1101.8	0.3	0.1
Denmark	DK	0	0	884.5	-6.4	4.5
Estonia	EE	0	0	887.5	-1.6	1.0
Finland	FI	0	0	1161.1	-1.0	2.4
Hungary	HU	0	0	1534.7	1.8	3.3
Ireland	IE	0	0	1425.3	3.5	4.9
Luxembourg	LU	0	0	659.7	1.7	1.0
Malta	MT	0	0	752.3	0	0
Portugal	PT	0	0	900.4	1.4	1.6
Sweden	SE	0	0	901.2	1.2	7.6
Austria	AT	-0,01	5.2	1082.3	1.3	0.3
Germany	DE	-0,15	62.9	1109.8	2.9	5.5
Slovakia	SK	-0,53	20.0	1534.39	9.3	0.9
United Kingdom	UK	-0,74	36.6	1072.3	0.3	2.0
Greece	EL	-1,21	0	691.2	0	0.6
Belgium	BE	-1,52	203.4	1028.7	2.7	2.6
Italy	IT	-1.59	465.3	872.0	2.1	0.3
Netherlands	NL	-1,74	41.4	1178.8	1.5	3.1
Lithuania	LT	-1,79	33.6	1548.0	2.8	1.1
Romania	RO	-1.98	266.7	850.1	-13.6	0.6
Czech Republic	CZ	-2,31	145.6	1545.8	-2.7	1.1
Bulgaria	BU	-2.62	214.2	1522.0	1.2	1.1
Spain	ES	-3.30	93.5	1040.9	-0.7	1.3
Slovenia	SI	-3.57	221.5	1208.8	1.0	-0.3
Poland	PL	-5.90	125.0	1780.9	0.2	1.6
France	FR	-6.42	919.8	849.7	-0.9	0.2
Latvia	LV	-7.40	179.8	1538.1	4.3	-2.2

However, the statistical analysis of the information provided in Tables 4.1 4.2 gives several facts worth mentioning. For the countries for which their supporting measures are not translated into any economical effects, (or to put it another way, for the countries whose supporting measures do not alter the Payback period of cogeneration projects –incPB=0-), there is a trend to decrease the share of electricity generated from CHP for the countries with higher penetration of cogeneration. However, this trend is governed by only three countries (Estonia, Finland and Denmark).

**Figure 4.1. Trend of the evolution between the two periods of time considered (from 2002-04 to 2006-08) of the percentage of electrical production from CHP in the countries whose supporting measures are not translated into an economic effect (incPB=0), or put it another way, evolution of the percentage of electrical production from CHP in the countries whose supporting measures do not alter the payback period of the cogeneration projects.**



According to this relationship it can be stated that countries in which the CHP was more developed (and among which their supporting measures do not include any economical advantage) are the ones in which CHP has suffered higher decreases between the two considered periods. That is, without economical supporting measures, the countries with well developed CHP systems tend to suffer bigger decreases of CHP than the rest of the countries.

The opposite trend is observed for the countries with supporting measures able to decrease the payback period (in this case Romania is an outlier). In this case, the increase of CHP has been bigger in those countries that already had high CHP penetration. So following the same reasoning as in the previous paragraph: with support measures that improve the economical values of CHP projects, the countries with well developed CHP systems tend to increase their share of CHP more than the rest of the countries.

**Figure 4.2. Trend of the evolution of the percentage of electrical production from CHP between the two periods of time considered in the countries whose supporting decrease the payback period of CHP projects – incPB<0 - ).**

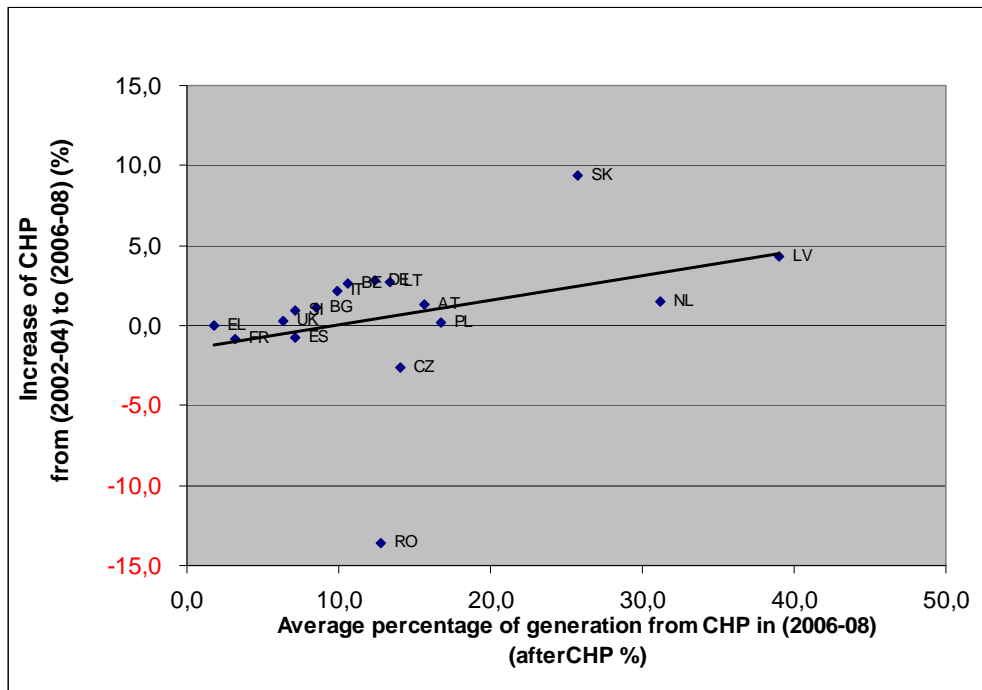


Figure 4.3 illustrates how the evolution of CHP has coexisted with the increase of the fraction of renewables in the generation of electricity. The first observation that stands out is that for almost all countries, between the two periods considered, renewable energy has increased its share in electricity production whereas the same cannot be said for CHP; there are many countries in which CHP has decreased (irrespective of the value of the payback period). Both increases (or decreases) do not appear to be related. Some of the countries whose supporting measures for CHP are not translated in economical terms (PB=0) (IE, DE, SE) had a steep increase in renewables; in one of these countries DK the increase in renewables happened with a big decrease of electrical energy from CHP. This may be because Denmark already is an exporter of power and may find it easier to decrease fossil generation during high wind periods when there is an excess of power on the Danish grid.

Another way to analyse the overlap of CHP and RES can be by comparing the increase in the share of RES in two sets of countries. The first group formed by countries in which the share of generation from CHP decreased (Romania, Denmark, Czech Republic, Estonia, Finland, France and Spain), and the second group formed by countries in which the share of CHP increased. The average increase in the share of RES in the first and in the second group are so similar (1.59% and 1.76%) that this drives us to conclude that, in general terms, the development of RES has not influenced the development of CHP.

Other factors which complicate any comparison between the growth in RES and CHP are some CHP is renewable in nature – for example the use of district heating based on wood fuel combustion. In the United Kingdom for example it is common to co-fire waste biomass in electricity only power stations, thereby increasing RES but not CHP, whereas in Austria, there is much combustion of waste biomass in CHP district heating schemes.

Another factor is that the EU has binding targets for Renewable Energy, but not for CHP.

In several ways it is easier to increase renewable generation than CHP – the dominant RES in Europe is wind energy and this simply requires the developer to locate a site and gain the various permits – there are vast areas to choose from and some will inevitably be successful. On the other hand, CHP is much more restricted and must be applied to either cities or industries – clearly the barriers to changing a whole city to CHP district heating are of a different order, than obtaining permission for a wind farm. Support schemes for RES are tailored on a country by country basis to ensure the targets are met – but support for an industrial CHP scheme requires the commitment of a large industry as well and this may not be forthcoming, since the owners will be looking at other issues – investment, long term survival and location of the industrial plant etc.

It is clear that CHP with or without district heating is a much more problematic investment case than a simpler investment in RES – unless the governments such as in Denmark or Germany have already taken policy decisions to strongly support such investments.

**Figure 4.3. Percentage of increase of electrical generation from CHP vs. increase in generation from renewables.**

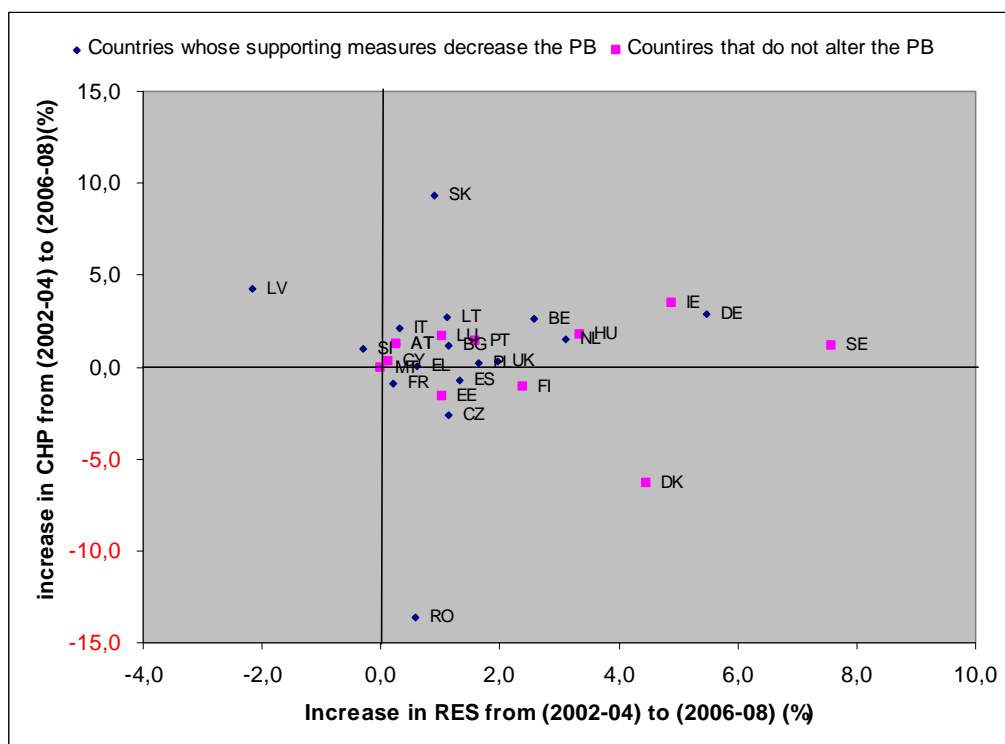
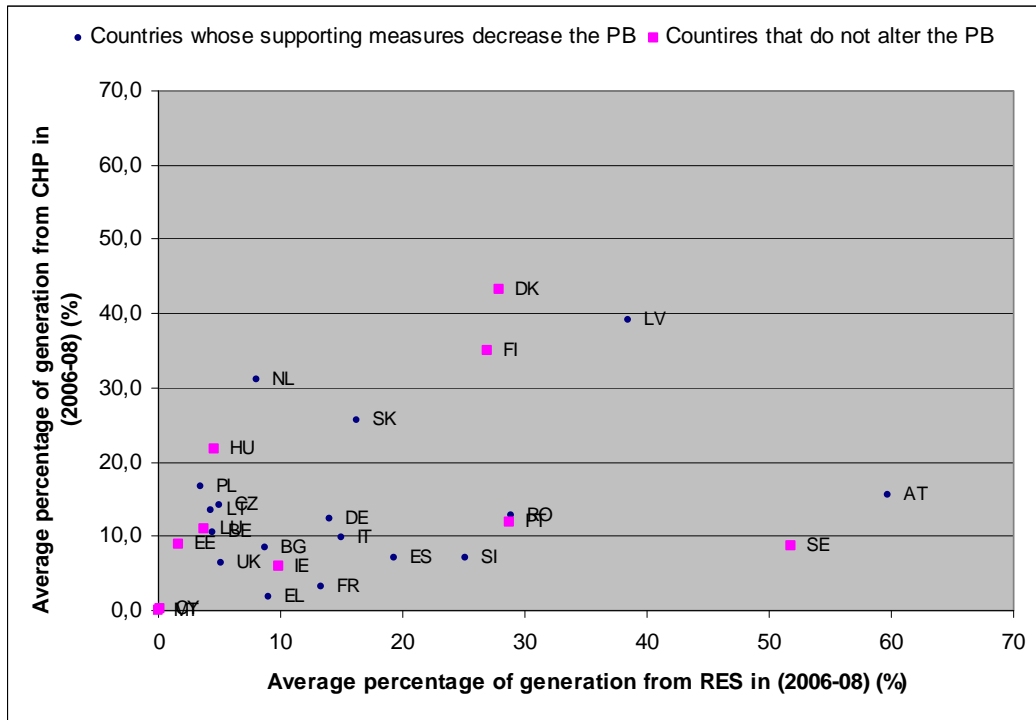


Figure 4.4 helps to complement the relationship between the total percentage in the last of the two periods of electrical energy coming from CHP and renewables. It shows countries with a high presence of renewables, low presence of CHP (SE, AT), countries with both technologies highly present in their generation systems (DK, FI, LC) and the rest of the countries. There are countries present in all groups with and without supporting measures.



**Figure 4.4. Annual percentage of electrical generation from CHP vs. generation from renewables**



### 4.3 Conclusion

The analysis carried out in this chapter clearly highlight that there is no evidence that the Member States whose supporting measures include any economical advantage to CHP projects have been more effective in promoting cogeneration than the rest of the Member States. This general lack of effectiveness prevents us of further comparison between supporting measures. Also, MS that start with high penetration of CHP in their national systems are more sensitive to the removal or extension of their supporting measures. The possible overlap with the promotion of RES has been checked, the conclusion is that the promotion of RES has not affected significantly the promotion of CHP.

## **5 REVIEW OF THE HARMONISED EFFICIENCY REFERENCE VALUES FOR THE SEPARATE PRODUCTION OF HEAT AND POWER ON THE BASIS OF THE CURRENT TECHNOLOGIES.**

### **5.1 Introduction**

Article 4 of Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC mandates the use of harmonized efficiency reference values for separate production of electricity and heat for the purpose of determining the efficiency of cogeneration in accordance with Annex III of the Directive. The same article stipulates that these harmonised efficiency reference values:

- shall be differentiated by relevant factors, including year of construction and types of fuel
- must take into account data from operational use under realistic conditions, cross-border exchange of electricity, fuel mix and climate conditions as well as applied cogeneration technologies, in accordance with the principles in Annex III
- will be reviewed for the first time on 21 February 2011 and every four years thereafter.

In application of the Directive, Commission Decision 2007/74/EC of 21 December 2006 established harmonized reference values for the period 1996-2011, as well as correction factors for separate electricity production.

The JRC has reviewed the harmonized reference values adopted in 2006 and in particular: (i) reassessed the methodological approach made in 2006 for setting harmonized reference values, and, (ii) compared the harmonised reference values for the period 2006 – 2011 with data from operational use during the same period under realistic conditions. The results of this review will contribute to the formulation of a new Commission Decision that will establish new harmonized reference values, which will be applicable until 2015.

### **5.2 Review of the methodology**

The JRC confirms in general the technical ‘interpretation’ of the articles of the Directive, which are relevant to the establishment of harmonized reference values, as made in 2006. In particular, it is pointed out that:

- The term ‘harmonised’ means that the same reference values apply to all Member States. It is stressed however that harmonisation can only be ensured when reference values are established based on a statistically significant and hence large set of operational data from plants across most (if not all) Member States. This dataset must be representative of the actual market conditions, the range of plant sizes in operation and of the wide range of business models of plant operators across Europe.
- Plants that benefit from special arrangements to operate at high efficiencies should not be considered for the establishment of reference values, since such operational conditions cannot be duplicated by other similar plants under normal market conditions.
- Defining ‘year of construction’ as ‘year of first plant operation’ allows for the transparent application of the reference values, as the year of first plant operation is unambiguous and publicly available information.

- Fixing the reference values for plants older than 10 years on the reference value of a plant of 10 years of age reflects the spirit of the Directive to promote energy savings by encouraging old power plants to be retrofitted to improve their efficiency performance.
- Correction factors for the average climatic situation in each Member State should continue to be applied. A major factor determining actual plant performance is both the cooling-water supply temperature to the condenser and ambient air temperature. Based on a recent IEA report that looks in detail at power generation from coal<sup>73</sup>, 1°C increase in cooling water temperature results in a 0.2% decrease in power plant efficiency. Moreover, cooling-water temperature tends to be influenced by ambient temperature. Changes in ambient temperature also affect the performance of other parts of a power plant. The reducing boiler heat losses as ambient temperature increases will tend to be offset by worsening cooling system performance. Overall, the IEA report has proposed that, where required, a nominal correction to efficiency of 0.15% per 1°C change in ambient temperature should be applied to coal plants. The IEA report also concludes that similar effects should be expected in gas turbine plants, without however providing a quantification of this effect. The correction factor proposed by the 2006 expert report is very similar with that proposed by IEA, taking into account the range of fuels considered in the Commission Decision. The difference in the correction factor (0.05% per 1°C), at least for coal plants, is expected to have only a small influence on the corrected harmonized reference values.
- No correction should be applied for altitude and relative humidity. Atmospheric humidity and pressure have a practically insignificant effect in power plant performance, which is also difficult to quantify.
- Correction factors for avoided grid losses should continue to be applied. The JRC considers that the correction factors for avoided grid losses at the present time are the same as those proposed in the expert report. It is noted that electricity grid losses in Member States differ significantly; therefore, any definition of common “correction factors for avoided grid losses” for all EU would be an approximation. Grid losses in the transmission network varies from 1% to 2.6% (on the basis of gross electricity generated), while losses in the distribution grid are much higher ranging from 2.3% to 13.5%<sup>74</sup>. These figures represent average electricity losses and depend on grid architecture and voltage levels in each country. The average values in Annex IV of the Decision are within the above-mentioned ranges. It is also noted that grid losses in the EU Member States have not changed significantly<sup>75</sup> and the electricity grid architecture did not see fundamental changes in its topology in the recent years. Consequently, the correction factors for avoided grid losses established in 2006 are still valid today. Moreover, the JRC recommends that correction factors for avoided grid losses should also apply to wood fuels and biomass.
- The procedure, which had been adopted in 2006 for the setting of future reference values via flat line projections of the latest reference values established using operational data, offers regulatory stability, which allows investment in the cogeneration sector.

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<sup>73</sup> IEA, Power generation from coal, measuring and reporting efficiency performance and CO2 emissions, Paris, 2010.

<sup>74</sup> Energie Baden-Württemberg AG, public consultation on “Treatment of Losses by Network Operators”, 2008

<sup>75</sup> See for example: Department of energy & climate change, Digest of United Kingdom energy statistics 2010  
Latvenergo, Annual Report 2007. Commission de régulation de l'énergie, Activity Report 2009 and Activity Report 2006

- Only one reference period must be distinguished for the separate production of heat.

The JRC also notices the following shortcomings, which should be addressed in a potential recast of the Cogeneration Directive:

- There is some vagueness with regards to measuring and reporting plant efficiency under realistic market conditions. Insofar, it has not been agreed whether reference values refer to net or gross efficiencies (measured at the plant's fence or at the generators terminals respectively) and the length of the time period of plant operation when efficiency must be measured and reported.
- There is no obligation for plant operators to report plant efficiencies and the operating conditions under which they are measured.
- There is no transparent, consistent and consented methodology for the setting of reference values from operational data in an unambiguous manner.

### 5.3 Review of reference values

As the Directive stipulates, the review of reference values must take into account data from operational use of plants under realistic conditions. It is thus imperative to distinguish between the design efficiency and the actual operational efficiency of a plant.

Every power plant has its maximum design efficiency, the value of which is determined by the size of the plant, the quality of fuel used, the technology employed (including pollution control technologies) and the local environmental conditions, such as ambient air and cooling water temperature. This maximum design efficiency is typically guaranteed by the power plant constructor under base-load conditions, i.e. when the plant operates at constant rate at full nameplate capacity.

Under realistic operational conditions, the efficiency of any fossil fuel power plant is inferior to its design efficiency. The main reasons for this are:

- Fossil fuel power plants do not generally operate as base-load, even when they are first commissioned. The rapid penetration of renewables that are intermittent by nature and receive dispatch priority and the downturn of economic activity have forced fossil fuel power plants to operate at partial loads to a greater extent due to the decreased electricity demand. This has adverse effects in power plant efficiency performance. In this respect, an IEA report<sup>76</sup>, which looks in detail at the efficiency of coal plants, provides details on the impact of reduction of operating load on efficiency. For example, the efficiency of a subcritical coal plant is reduced by about 2 percentage points when the operating load drops to 70% of the design maximum continuous rating and by about 4% in supercritical plants. The JRC has actual operating data from natural gas combine cycle plants that also demonstrate that a reduction of operating load to 70% leads to a 3 percentage-point efficiency reduction. Moreover, in a recent report, IEA<sup>77</sup> describes a state-of-the-art natural gas combined cycle plant, which operates in the UK, the efficiency of which is 58% at full nominal load but drops to 54% at 40% load. It is expected however that in an environment of reduced electricity demand, newer plants will operate at higher load factors than older similar plants in the same power plant fleet, since they are more efficient and hence more cost competitive.

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<sup>76</sup> Ibid. footnote 22.

<sup>77</sup> IEA, Fossil Fuel-Fired Power Generation: Case studies of recently constructed coal- and gas-fired power plants, 2007.

- Fossil fuel power plants, especially natural gas plants of the combined cycle gas turbine (CCGT) type, may suffer measurable efficiency reductions, up to 1 percentage point annually, due to fouling of key components.

It must be stressed that data on plant efficiency under realistic operational conditions cannot be found in the open literature. Such information provides an insight into plant operations and on the operating company's business models, hence their publication could conflict with competition rules or compromise the competitiveness of the plant operator. Therefore, information on the operating performance of plants has become commercially sensitive and in many cases is considered proprietary. As a result, such information can only be provided by the plant operators themselves and/or by national regulatory authorities.

To overcome this issue for the purpose of review of the reference values, the European Commission requested from the Member States data on efficiencies of recent electricity-only and heat-only plants under realistic market conditions. In particular, a questionnaire was sent by DG ENER on 28 October 2010, requesting the Member States to inform the Commission on operational gross<sup>78</sup> efficiencies achieved by electricity-only and heat-only plants that started operating after 1 January 2006, according to fuel type and year of operation.

The response to the Commission's questionnaire was relatively poor, as only 14 Member States returned it completed. Some of these Member States provided the requested information on a confidential basis while others did not identify by name the individual power plants for which operational efficiencies were reported. It is noted that a very small number of plants for which information was received is operated with a fuel mix; nevertheless no information on the share of each fuel was provided for these cases. In consequence, the JRC assigned these plants to the primary fuel used. Regrettably, not all the provided information could be used for the review of harmonised reference values for a variety of reasons, such as:

- Some Member States were unable to report the efficiencies for all plants they mentioned in the questionnaire.
- For a number of electricity-only plants some Member States provided estimates or nameplate efficiencies rather than efficiencies under actual operating conditions. This could also be the case for a number of heat-only plants.
- A Member State provided information on a cogeneration plant instead of an electricity-only plant.
- A Member State provided information on peaking electricity-only plants, which operate at very low capacity factors.

Such information was not further considered in the analysis. Usable data for the purpose of the review was received for 39 electricity-only plants with a total capacity of about 2.5 GW. The provided information relates to 9 different fuel types out of the 16 specified in the Commission Decision.

The reported data from the Member States for electricity-only plants should be contrasted with the actual capacity that entered in operation in the EU during the same period. According to databases available in the JRC, 50.4 GW of electricity-only power plant capacity has come into operation in the EU from 1 January 2006 to 31 December 2010. Out of this total, 9.0 GW uses solid fuels or waste, 3.9 GW uses oil and 37.5 GW uses gaseous fuels (of which 99.9% is natural gas). Solid-fuel based capacity is mostly based on coal (1.1 GW hard coal, 2.6 GW lignite/soft coal, 0.3 GW peat, 2.0 GW unspecified coal), but includes

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<sup>78</sup> Measured at the generator's terminals.

also 1.1 GW of wood-based capacity and 1.0 GW of biomass-based capacity, while 0.8 GW of capacity operates on waste.

It is evident that the data provided by the Member States refer to only a small fraction of the total capacity that entered into operation in the same period (5% of total capacity and 2% of natural gas capacity). It is also noted that for some fuel types a very limited set of data was received. For example, a single data point was provided for the following fuel types for electricity-only plants: coal, lignite, agricultural biomass and biofuels. The lack of or limited availability of data has a detrimental effect on the review process with consequent implications for the setting of reference values for the period 2011-2015, as will be described in Section 5.4.

Information was received for 103 heat-only plants with a total capacity of about 1100 MW, which relate to 5 fuel types. However, 87 of these plants are located in a single Member State, where conditions are considered untypical for the rest of Europe. The analysis of data for heat-only plants was further complicated by the lack of a clear description of system boundaries. For example, the Member State mentioned above informed the JRC that some of the heat-only facilities which were reported were condensing and others had heat pumps to enhance efficiency, without however identifying the specific technology used by each heat-plant mentioned in the questionnaire. The JRC is of the view that data from plants that use heat pumps should not be used for the review of the reference values. Consequently, due to the difficulties identified above, i.e. lack of representative data from across the EU and some uncertainty over a large part of the data received, the JRC considers that a meaningful analysis, as envisaged in the Directive, cannot be carried out.

#### **5.4 Reference values – key findings**

The key findings of the above mentioned study can be summarised as follows:

- The data collected by the European Commission from the Member States is too limited in terms of cumulative capacity per fuel type, geographical coverage and plant size, to ensure the proper review of reference values and the establishment of new reference values. The collected information does not represent a statistically important dataset that reflects actual market and operating conditions, plant sizes and the wide range of business models of plant operators, which exist across the EU.
- The operational efficiencies of electricity-only plants deployed in the period 2006-2011, as reported by the Member States, are broadly comparable with the harmonised reference values for the same period.
- There is no clear link between the efficiency of heat-only plants and the time they entered in operation. This confirms the assumption made in the 2006 expert report, which had led to the consideration of a single reference period for the reference values of heat-only plants.
- The efficiency values of heat-only plants provided by the Member States, but overwhelmed by data from a single Member State (84% of the data pool), are different from the reference values; and in most cases are higher. Nevertheless, it is not possible to identify the cause of this discrepancy since the dataset used in this analysis is not representative of the whole European situation. The JRC is of the opinion that the data collected refer mostly to District Heating systems where condensing operation is possible, which is unlikely to be the case for the majority of boilers installed in Europe. Further work is necessary to establish if this is a valid hypothesis.

- The correction factors relating to the average climatic situation and for avoided grid losses should continue to be applied. Moreover, the correction factors for avoided grid losses should also apply to wood fuels and biomass.
- The adopted reference values for the period 2006-2011 should not be modified *a posteriori* as an outcome of this review, in alignment with the spirit of the Directive to offer a stable economical and administrative environment for promoting investments in cogeneration.

## **6 ASSESSMENT OF THE IMPACT OF OTHER EU POLICIES ON THE DEVELOPMENT OF COGENERATION**

### **6.1 Introduction**

This section discusses the impact of other EU policies on the development of cogeneration, and in particular the impact of the EU ETS and the RES Directives. A discussion about other EU instruments impacting cogeneration is also held, e.g. Energy End-use Efficiency and Energy Services, Energy Performance of Buildings, Covenant of Mayors.

### **6.2 Preliminary assessment of the impact of the EU ETS Directive on the development of cogeneration**

#### *6.2.1 Introduction and background*

The EU Emission Trading System (ETS) was initiated in January 2005<sup>79</sup>. From then on large emitters of CO<sub>2</sub> were required to monitor and report annually the amount of CO<sub>2</sub> which they emit. To neutralise annual irregularities in CO<sub>2</sub>-emission levels that may occur during a particular year, emission allowances were given out for a sequence of years at once, a so-called trading period. Installations got the emission allowances from the NAP (National Allocation Plan) during Phase I and II, which is decided by each country's authorities. Besides receiving allocation, an operator may purchase or sell EU ETS emission allowances and international trading credits. The underlying idea is that low-carbon technologies will be promoted by penalising carbon emissions. In practise this happens when the price of carbon emissions is factored into new investment decisions.

At about the same time as the EU ETS Directive was adopted also other Directives on carbon capture and storage and renewables came into force. More about the influence of the Renewables (RES) Directive will follow in Section 6.4 and a discussion about other relevant EU policies can be found in Section 6.3.

#### *6.2.2 Characterization of CHP*

CHP plants are generally more efficient, but subject to more constraints than separate installations for heat and power generation. Heat generation from a CHP plant will always be accompanied with electricity production and vice versa. Electricity is easy to transport for long distances at low costs, but heat needs to be produced locally and can only be transported relatively short distances, i.e. some kilometers. Consequently, a heat generation unit is always connected to the end user, but the electricity is normally fed to the public grid. In other words the CHP installation will have to compete with for instance a boiler on the heat market and on the electricity market with more flexible power plants. Heat from a CHP can only be cheaper than from a boiler if its costs are offset by the earnings from its electricity generation, due to the fact that a CHP is a more complex and expensive installation.

The heat demand of industrial CHP is typically base load meaning that heat and electricity is produced continuously. Since the prices on the electricity market are set by the marginal

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<sup>79</sup> Emissions Trading System (EU ETS), available at webpage: [http://ec.europa.eu/clima/policies/ets/index\\_en.htm](http://ec.europa.eu/clima/policies/ets/index_en.htm).



running costs of power plants needed to meet the grid demand of electricity, the prices during periods with low electricity demand are in most Member States set by conventional coal power and nuclear power plants, operating at low variable cost due to low fuel prices. The base load electricity production comes from nuclear power for example Finland, France, and Sweden, whereas coal power plants provide base load in for instance Denmark, Poland, and the UK. During high electricity demand the marginal running costs are set by peaking natural gas power plants with higher variable costs.

### *Phase I (2005-2007)*

During Phase I most allowances were given out for free. The EU ETS included about 12000 installations representing approximately 40% of the CO<sub>2</sub> emissions of the EU. The allocation to different sectors was based on historical emissions and sector growth projections (known as grandfathering). It covered combustion installations exceeding 20 MW used for example at production and processes of ferrous metals, mineral industry (cement, glass and ceramics), and pulp, paper and board activities. In 2008 one third of the installations covered by the scheme had a thermal output of between 20-50 MW which contributed with about 2% of the overall CO<sub>2</sub> emissions. Installations with emissions of more than 500 000 tonnes of CO<sub>2</sub> accounted for 7% of the total number of installations, but they were responsible for more than 80% of total emissions<sup>80</sup>. Member States had flexibility in their approach when preparing their NAPs and as a result there were divergent decisions taken.

At that time CHP installations were not considered explicitly in the allocation calculations. Almost all countries made some allocations for CHP through the category of New Entrants, but in most Member States the allocation to CHP was not ring-fenced. New Entrants is a reserve of emission allowance rights used for new power installations. The sector of industry in which the CHP plants was classified had an effect on its allocation of emission rights, due to the fact that allocations were based on sector growth projections. In Germany for instance, a dual benchmark method was used. A dual benchmark method means that emission rights were calculated for both electricity and heat separately and then these rights were allocated for free to CHP. On the other hand in the UK the NAP did not differ between heat and electricity production, which made CHP uncompetitive during this phase<sup>81</sup>. In Austria a bonus was received if 5% primary energy saving was achieved compared to separate production of heat and electricity. The non high-efficiency CHP was treated as electricity generators only.

At the beginning of Phase I the price of emission allowances increased more or less steadily to its peak level in April 2006 of about €30/ton of CO<sub>2</sub>, but then the price fell in May 2006 to under €10/ton following news that some countries gave too generous emission caps to their industries. The price continued to decline resulting in a trading price of €0.10 in September 2007.<sup>82</sup>

### *Phase II (2008-2012)*

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<sup>80</sup> European Environment Agency, Application of the Emissions Trading Directive by EU Member States — reporting year 2008, EEA Technical report No 13/2008, ISSN 1725–2237

<sup>81</sup> Knecht, F., Cogeneration in Europe: The impact of the emissions trading scheme, 3rd annual cogeneration congress in Spain, 2004

<sup>82</sup> European Union Emission Trading Scheme, available at: [http://en.wikipedia.org/wiki/European\\_Union\\_Emission\\_Trading\\_Scheme](http://en.wikipedia.org/wiki/European_Union_Emission_Trading_Scheme)

The Phase II coincides with the first commitment period of the Kyoto protocol. A linking directive allowed using Kyoto certificates as a compliance tool within the EU ETS. The scope of ETS was expanded significantly during Phase II, e.g. aviation emission will be included from 2012. The emissions allowances permitted in Phase II were cut to 6.5% below the 2005 level.<sup>83</sup>

In Phase II the term ‘high efficiency CHP’ was implemented through the CHP Directive in all Member States. This means that to qualify as a New Entrant CHP under EU ETS a primary energy saving of at least 10% compared to separate heat and electricity production should be achieved. Identified disadvantages that CHP experienced in some Member States of Phase I were adjusted. A standard efficiency per technology reflecting the median size of existing plants in each technology group was used and a load factor for each technology was adopted too, reflecting the historic load of a particular type of CHP. In the UK a separate sector for high-efficiency CHP was created.

The carbon price within Phase II increased to over 20 €/ton CO<sub>2</sub> in the first half of 2008, then it decreased to 13 €/ton CO<sub>2</sub> in the first half of 2009, and on 1 December 2010 about 15 €/tonne. In terms of CO<sub>2</sub> emission reductions, the number of allowances had decreased by 11.6% in 2009 compared to 2008<sup>84</sup>. The decline in prices was mainly due to reduced output in the energy intensive sectors as a result of the recession. Projections indicate that there will be a surplus of allowances during Phase II as well. This means that the impact of the crisis will have consequences lasting several years since allowances can be carried over also into the Phase III in 2013.

### *Phase III (2013-2020)*

The Phase III will run for eight years, which is a longer period compared to the first and second trading periods. It is expected to ensure more predictability in the prices of emission allowance rights, which is expected to be more advantageous for long-term investments into low carbon technology.

For Phase III (01/2013 – 12/2020) a number of changes have been proposed, including for example:

- Setting of an overall EU cap, with allowances then allocated to EU members,
- Tighter limits on the use of offsets to international schemes,
- Moving from grandfathering of allowances to an auctioning system, with some free allocation.

The total quantity of allowances issued from 2013 is 2.4 billion and then it will decrease linearly by a factor of 1.74% per year<sup>85</sup>. From then onwards Member States shall auction allowances which are not allocated for free. No free allocation shall be made to electricity generators, except for some special cases<sup>86</sup>, e.g. electricity produced from waste gases.

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<sup>83</sup> European Commission, EU action against climate change – The EU Emission Trading Scheme, 2008, ISBN 978-92-79-12255-2

<sup>84</sup> European Commission, COM(2010) 265 final on Analysis of options to move beyond 20% greenhouse gas emission reductions and assessing the risk of carbon leakage, 2010

<sup>85</sup> European Commission, Climate Action, available at: [http://ec.europa.eu/clima/policies/ets/cap\\_en.htm](http://ec.europa.eu/clima/policies/ets/cap_en.htm)

<sup>86</sup> Mentioned in: Knecht, F., Cogeneration in Europe: The impact of the emissions trading scheme, 3rd annual cogeneration congress in Spain, 2004

Industries which are in risk of “carbon leakage”, i.e. industries that could move their operations outside of the EU will have special conditions with free allocation phased out slower. Also, free allocation shall be given to district heating as well as to high efficiency cogeneration, for economically justifiable demand, in respect to the demand for heating and cooling. From 2013 the same linear factor (1.74%) for phasing out the total free allocation of such installations will be used.

For each sector and subsector, a benchmark shall be calculated for products rather than for inputs. The starting point has been an average of greenhouse gas emission performance of the 10% most greenhouse gas efficient installations in 2007 and 2008. The heat benchmark is applicable for heat consumption processes where a measureable heat carrier was used. This includes emissions related to production of heat used for production regardless of whether the measureable heat was produced on site or not.

Free allocation in non-special sectors will be phased out quicker than the reduction of 1.74% of the ETS cap. In 2013 they also start from 80% free allocation of emission allowances, then reducing linearly to 30% in 2020, and finally arriving at no free allocation in 2027. Also, high-efficiency CHP and district heating and cooling is included in this more rapid reduction.

### 6.2.3 Findings

The following areas will be discussed in our analysis of the implementation of CHP due to the effect of the EU ETS: 1. Economics of CHP in the framework of ETS, 2. Size of installations included in the EU ETS, 3. Impact on corporate behaviour by ETS, 4. Future of ETS. Finally we make some short conclusions.

#### 6.2.3.1 Economic discussion concerning EU ETS and CHP

Generally speaking, rising prices of CO<sub>2</sub> emission allowances results in a higher share of heat demand for which it is profitable to apply CHP. On the other hand the higher prices increase the incentives for energy saving technologies, e.g. more insulation of buildings, which reduces demand. However, studies show that the former effect is more important than the latter for the potential of CHP.<sup>87</sup>

From the start of Phase I until today, there has been great volatility of the prices of CO<sub>2</sub> emission allowances, i.e. ranging from €0.1/ton to €30/ton. As a consequence it has been difficult for investors to estimate the value of future CO<sub>2</sub> emission allowance savings from employing CHP. Since investors prefer security when making decisions, price swings have possibly had an inhibiting effect on investments in CHP. Moreover, in the course of the different phases of EU ETS the allocation for CHP has changed, which also created an additional risk. Nevertheless, investors in CHP obviously have a longer time horizon for this type of decisions. As the EU ETS develops with time and the cap is reduced the performance of the scheme will probably stabilize. However, a degree of uncertainty will remain for some years to come.

High efficiency cogeneration plants are by definition expected to save at least 10% primary energy as compared to separate generation of electricity and heat. A simple comparison of two examples shows how costs are reduced by employing CHP:

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<sup>87</sup> European Environment Agency, Application of the Emissions Trading Directive by EU Member States — reporting year 2008, EEA Technical report No 13/2008, ISSN 1725–2237

1. If no free allocation of emission allowances for CHP is used, and when comparing the benefit of CHP on the same fuel basis, like for instance for natural gas, the reduction of CO<sub>2</sub> emissions per MWh is 203 kg \*10% = 2.03 kg<sup>88</sup>. At a price of €20/ton CO<sub>2</sub> this is a saving 0.406 €/MWh compared to separate heat and electricity production.
2. If CHP gets 100% free allocation of emission allowances from the EU ETS the savings would be 4.06 €/MWh.

In the Member States the real advantage through EU ETS of CHP lies somewhere between the two examples made above. Today it is closer to the example with more free allocation, but this will reduce with time.

It remains difficult to judge how large influence the EU ETS has had compared to the national support schemes. Given the large price swings of CO<sub>2</sub> emission allowances since their introduction this could indicate that the EU ETS has been of less importance than the national support schemes until now. A higher price for emission allowances in the future would naturally increase the weight of the EU ETS. In many countries the implementation of CHP in the EU ETS did not work perfectly as exemplified in the Section 6.2.2 describing Phase I of EU ETS above. The rules of the EU ETS sometimes made CHP disadvantageous even though the intention was to the contrary. For example in Phase I some countries already used double benchmarking in order to compare cogeneration in a just way, e.g. in Germany. But also here problems had occurred when allocation of allowances was made based on benchmarking data in the sense that some plants received too few emission allowance rights. If the assumed load factor was lower than the normal operating hours of a CHP, the plant would not receive sufficient allowances. This way CHP was penalised.

In Phase III of the EU ETS the free emission allowances for CHP and DH will be rapidly phased out. This will put CHP and DH under increasingly disadvantage relative to boilers, which do not fall under EU ETS. As mentioned above free allowances given to district heating in 2020 are only 30% and completely phased out in 2027. This problem could possibly be solved by a carbon tax on the non-EU ETS sector. Another problem in Phase III is that the benchmark is against a single fuel, i.e. natural gas. This puts for example district heating networks in Eastern Europe, which often use coal, at jeopardy since they cannot easily change fuel<sup>89</sup>.

Another aspect is how CHP benefits from the higher electricity prices through the cost of CO<sub>2</sub>. Today electricity prices are usually calculated on a long term basis. The power generation mix in many Member States includes renewables and nuclear power, which have no CO<sub>2</sub> cost to pass on. Therefore, in practise CHP cannot pass on 100% of the CO<sub>2</sub> cost savings to customers at all times in all Member States.

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<sup>88</sup> DEFRA, Guidelines to DEFRA / DECC's GHG Conversion Factors for Company Reporting version 2, 2009

<sup>89</sup> Euroheat & Power, Euroheat & Power on the current discussions regarding the implementation of the Directive 2009/29/EC, available at:  
[http://www.euroheat.org/Admin/Public/DWSDownload.aspx?File=%2fFiles%2fFiler%2fdocuments%2fpositionpapers%2fEuroheat\\_\\_\\_Power\\_on\\_ETS\\_21062010\\_final.pdf](http://www.euroheat.org/Admin/Public/DWSDownload.aspx?File=%2fFiles%2fFiler%2fdocuments%2fpositionpapers%2fEuroheat___Power_on_ETS_21062010_final.pdf)

#### 6.2.4 Size of installations impact on CHP

Trading of emission allowances is limited to installations of thermal capacity above 20 MW during Phase I and II. Small cogeneration plants, boilers and electricity generators therefore have an advantage since they do not need to buy additional certificates. In the past and present phases, the CHPs in the range of 20 to 40 MW thermal power have to compete with heat and electricity installations that fall outside of the EU ETS. New entrants with a heat demand just below 20 MW might have been discouraged from replacing their boiler with CHP units.

In Phase III one intends to shift focus to the consumer of heat where possible. All units providing heat and electricity to a factory consuming more than 20 MW thermal power will fall within the EU ETS. In cases where this can be established the disadvantage for larger CHP plants seems to have been removed. However, in cases like the district heating sector the competition from boilers falling outside the EU ETS is still difficult for CHP.

Also the former disadvantage for district heating appears to have been removed since free emission allowances can be given to residential units.

So in conclusion, as mentioned in the paragraphs above in Phase I and II there was a problem with so-called “internal leakage”, i.e. smaller units were chosen instead of larger ones to avoid the emission allowances. In Phase III this seems to have been partially resolved since the focus is now on the heat consumers, but in cases where this cannot be established the disadvantage of CHP still remains.

#### 6.2.5 Impact on corporate behaviour

Several studies show that EU ETS is impacting corporate behaviour. A survey covering 517 European companies, government bodies, industry associations, market intermediaries and NGOs showed that in 2005 about half of the studied companies already took into account the value of CO<sub>2</sub> allowances and more than 70% intend to do so in the future. Half of the companies said that ETS is one of the key issues in long-term decisions. They claim that the EU ETS has strong or medium impact on decisions to develop innovative technology. The industries where the ETS is one of the key issues in long-term decision making were steel, pulp & paper and power generation<sup>90</sup>.

However, the same surveys say that companies seek clarity and long-term stability regarding rules over longer periods. This would ensure a stable climate of investments and the renewal of asset portfolios. The main reason is that asset lifetimes in capital-intensive industries are between 20-60 years with construction times spanning several years.

Lately the events in the financial markets have limited the availability of capital and increased risk aversion among investors. The power market has also suffered from this. In these circumstances investors might prefer the lowest capital cost investment options like an industrial boiler or an electricity generator instead of a CHP.

#### 6.2.6 Future of ETS

As mentioned above in Phase III the free allocation of emission allowances will be given to district heating as well as to high efficiency cogeneration, for economically justifiable

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<sup>90</sup> European Commission et al., Review of EU Emissions Trading Scheme - Survey Highlights, 2005

demand, in respect of the production of heating or cooling. In 2013 80% of free allowances can be given to CHP. Thereafter, the total allocation to such installations in respect to the production of heat shall be reduced by a linear factor of 1.74% per year.

The new allocation methods in Phase III put CHP temporarily at an advantage compared to fossil fuelled electricity generators, since the latter have to pay for all their emission allowances. However, CHP free emission allowances will be phased out rapidly (30% in 2020) and totally disappear in 2027. Focus will move to the heat consumer instead of the producer in the Phase III of the EU ETS so the disadvantage that larger units had versus smaller ones earlier partially disappears, see Section 6.2.3.2 for more information.

### *6.2.7 Conclusion on CHP in the ETS*

During Phases I and II the EU ETS have been tested and improved. Initially the allocation of allowances for CHP was not explicitly foreseen in all Member States, but taken into account as New Entrants in the ETS. During Phase II improvements have been made for the EU ETS and for CHP as well. The allocation of allowances has been improved. The disadvantage that CHP experienced during Phase I is less in Phase II. In Phase III of EU ETS one attempts to improve it further since focus will move to the heat consumer instead of the heat producer. Thereby the disadvantage that larger units could experience versus smaller units below 20 MW thermal power partially disappears. However, some new restrictions will have severe implications for CHP. The rapid phasing out of free allowances for CHP and DH will put it at a disadvantage against smaller and more flexible facilities falling outside of the EU ETS. This problem could be resolved by taxing CO<sub>2</sub> emissions of non-EU ETS sectors. For CHP and DH the benchmark made on natural gas boilers only will place coal-fired CHP and DH at a disadvantage. In for example Eastern European countries problems arise for district heating systems designed for coal use. A longer transition period to use natural gas would be advisable.

From the start of the EU ETS the price of emission allowances have fluctuated greatly. During Phase I the cap for allowances had been set too generously in many Member States, which when revealed made the price of emission allowances collapse. During Phase II, the credit crisis and slow down in the economy have reduced emissions of CO<sub>2</sub> and hence its price. These instabilities have not provided the confidence and investment security in the EU ETS system that investors would prefer. On the other hand according to surveys a majority of companies already take the ETS into account when making investment decisions. Also, at the price levels of emission allowances experienced from the start of the EU ETS until now have been too low significantly impact the total cost of a power or CHP plant since it adds only a few percentages to the cost per MWh.

The exclusion of plants below 20 MW thermal power during Phase I and II of the EU ETS have probably made some companies opt for buying an industrial boiler and to purchase the electricity from the market instead of investing in CHP. As mentioned above, in Phase III this problem appears to have been partially resolved since focus has moved to the heat consumers. However, the problem of disadvantage to CHP partially persist for heat systems where the heat consumer or producer cannot easily be established

When looking at the period 2002-2008 it is distinguishable that many Member States have experienced a growth of CHP. However, since national support schemes in most cases contributed much more to the total cost reductions in the short term, it appears that the EU

ETS has not had a significant positive impact on the growth of CHP. In fact, due to reasons mentioned above with CHP being at disadvantage it appears more likely that the EU ETS had a negative impact on the growth of CHP and DH in several Member States.

### **6.3 Preliminary assessment of the impact of EU internal market rules and other EU instruments on the development of cogeneration**

The Directives on CHP, RES, EU ETS and the other EU instruments feed into and change the functioning of the EU internal market. Some of the EU instruments presented below are designed either to promote the development of cogeneration together with other low carbon technologies or in energy saving measures, whereas other instruments influence cogeneration indirectly. In this section, at first it is discussed how the EU internal electricity market influences the development of cogeneration. Then brief discussions on how other EU instruments have affected the development of cogeneration will follow.

#### *6.3.1 Introduction and background*

The EU internal market rules have as the objective to allow people, goods, services and money to move as freely within the European single market as they do within one country. Hundreds of laws to sweep away technical, regulatory, legal and bureaucratic barriers have been implemented in the legislation of the Member States from 1993.

The internal market in electricity has been progressively implemented since 1999. New Directives on the internal electricity market has followed in 2003 and 2009. In line with the general EU internal market rules, it aims to deliver a choice for all consumers of electricity, to create new business opportunities and to stimulate more cross-border trade, in order to achieve efficiency gains, competitive prices, and higher standards of service, and to contribute to security of supply and sustainability. Nevertheless, even though this has been in progress for more than ten years the internal electricity market is still fragmented.<sup>91</sup>

Some areas have been indentified previously as barriers that concerns cogeneration, these are<sup>92</sup>:

- Discriminatory network access
- Barriers when changing supplier
- Guarantee of Origin for high-efficiency cogeneration
- Investment incentives
- Liberalisation of electricity market

A short description of the problems and a discussion to how it affects the development of cogeneration follows.

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<sup>91</sup> European Commission, Directive 2009/72/EC concerning common rules for the internal market in electricity, 2009, available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0055:0093:EN:PDF>

<sup>92</sup> Ibid.

There are still obstacles to the sale of electricity on equal terms. In particular non-discriminatory network (in terms of electricity sales) access and an equally effective level of regulatory supervision does not exist in each Member States<sup>93</sup>. It has been tried to rectify the problem with discriminatory network access in Member States through legislation. An identified central issue to eliminate is the vertical integration of network and electricity operators. This is to avoid the inherent risk of discrimination not only in the operation of the network but also in the incentives for network operators to invest adequately in new network capacity<sup>94,95</sup>. Even though this was addressed in the Directive of 2003, it did not lead to effective unbundling. In 2007, the European Parliament referred to the unbundling as the most efficient way to promote investments in infrastructure in a non-discriminatory way with fair access to the network for new entrants and transparency in the market. In 2009 it was agreed that Member States should be given a choice between ownership unbundling and setting up a system operator or transmission operator which is independent from supply and generation interests.<sup>96</sup>

Cogeneration plants probably experience the same problems as other new entrants on the electricity market regarding network access. The legislation is in place in most Member States, but the issue with the non-discriminatory network access is still an unresolved in some countries as network access barriers can be very subtle due to the ability of the incumbents to manipulate markets in an opaque way<sup>97</sup>. However, a complete judgement cannot be made here since all Member States have not commented on barriers to network access in their National reports. Possibly this reflects that it is a minor problem. More discussions about network access can be found in Chapter 3.

The basic concepts of the internal energy market have become embedded in terms of the legal framework and institutional arrangements, so a customer can choose their own supplier(s). However, at the same time the competition in some Member States is weak, which limits the options consumers have in practice<sup>98</sup>. It has been noted in the British Press for example that the profit margins of all the majors per customer have continued to rise significantly even during a recession indicating at least tacit collusion.<sup>99</sup>

Directive 2004/8/EC on CHP says that a Guarantee of Origin (GO) for high-efficiency cogeneration must be demonstrated by the producer, similar as for renewable electricity. This would give the consumers the possibility of rewarding more energy efficient means of

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<sup>93</sup> Ibid.

<sup>94</sup> Ibid.

<sup>95</sup> Directive 2003/54/EC, concerning common rules for the internal market in electricity and repealing Directive 96/92/EC, available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32003L0054:EN:HTML>

<sup>96</sup> European Commission, Directive 2009/72/EC concerning common rules for the internal market in electricity, 2009, available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0055:0093:EN:PDF>

<sup>97</sup> Personal Communication Keith Munday, Ex head of trading at National Power.

<sup>98</sup> European Commission, Prospects for the internal gas and electricity market, COM(2006) 841, available at [http://ec.europa.eu/energy/energy\\_policy/doc/09\\_internal\\_gas\\_and\\_electricity\\_market\\_en.pdf](http://ec.europa.eu/energy/energy_policy/doc/09_internal_gas_and_electricity_market_en.pdf)

<sup>99</sup> Energy Giants Profits Continue to Soar. Independent Newspaper 19<sup>th</sup> January 2011. <http://www.independent.co.uk/news/uk/home-news/energy-giants-profits-continue-to-soar-2188407.html#>



electricity and heat production. The GO should have been implemented in 2007, but in several Member States the progress has been slow. In 2009 it had only been fully implemented in about half of the Member States<sup>100</sup>. Today there are still 7 countries which have not fully implemented the GO, see Section 3.2.

CHP may have had some benefit from the GOs in the Member States where it has been implemented since customers sometimes prefer the positive environmental aspects of more efficient energy production. It can also have an added value for marketing reasons for consumers. Nevertheless, there are no statistics to support this assumption and it should be recognised that many customers might prefer renewable instead of high-efficiency cogenerated electricity.

### 6.3.4

#### *Incentives for new investments*

One objective for a well-functioning internal electricity market is to provide producers with the appropriate incentives for investing in new power generation, including in electricity from renewable or more energy efficient energy sources.<sup>101</sup>

The overall market conditions are also important, since an expanding electricity production market is an incentive for new investments by itself. When studying the EU27 electricity market, it can be seen that during the years 2000 to 2007 the final electricity consumption increased by 13.6% and from 2007 to 2015 it is expected to increase by 5.2%<sup>102</sup>. According to EUROSTAT total gross electricity generation has increased by 11.5% from 2000 to 2007<sup>103</sup>. Thus, the growth of electricity generation capacity has grown at an appropriate or somewhat lower rate than total electricity consumption rate. One can also conclude that the growth of electricity production in EU27 has provided opportunities for new entrants, including CHP, to establish themselves.

Since the liberalization of the electricity market in 2003 the total gross electricity generation grew by 4.9% until 2008. Table 6.1 illustrates how different types of electricity production have changed in EU27 as well as in Member States during the period 2003 to 2008 (in parenthesis shows the total gross electricity generation of 2008). Electricity production from natural gas has grown in the majority of countries, but with most significant addition in absolute terms in Spain (82.2 TWh) and Italy (53.4 TWh). In absolute numbers, the most wind power capacities were added in Germany (21.7 TWh) and in Spain (20.1 TWh). Hard coal has lost the most power generation capacity followed by nuclear power.

Analysing the growth data of different electricity generation types in the Member States of EU27 and comparing with the Trend of CHP from Table 2.5 do not give a hint at how likely a country is to develop CHP. Moreover, a similar analysis of the initial electricity generation mix relative to the Trend of CHP from Table 2.5 does not point to how likely a country is to develop CHP either.

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<sup>100</sup> Fiddoch, F., Prospects of cogeneration in Europe, available at <http://www.powergenworldwide.com/index/display/articledisplay/370331/articles/power-engineering-international/volume-17/issue-9/features/prospects-for-cogeneration-in-europe.html>

<sup>101</sup> European Commission, Directive 2009/72/EC concerning common rules for the internal market in electricity, 2009, available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0055:0093:EN:PDF>

<sup>102</sup> International Energy Agency, World Energy Outlook 2009, ISBN: 978 92 64 06130 9

<sup>103</sup> EUROSTAT, available at: <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home>

**Table 6.1: Growth of different electricity generation types in EU Member States<sup>104</sup>. Total electricity production of 2008 in parenthesis.**

	<b>Hard coal, TWh</b>	<b>Natural gas, TWh</b>	<b>Nuclear, TWh</b>	<b>Wind, TWh</b>	<b>Hydro, TWh</b>	<b>Trend CHP, Table 2.5</b>
EU27	-81.7 (543)	210.0 (775)	-58.6 (937)	74.4 (119)	20.9 (359)	=
Austria	1.4 (5.5)	0.1 (11.2)	- (0)	1.6 (2.0)	5.4 (40.7)	=
Belgium	-4.1 (5.5)	3.0 (24.6)	-1.8 (45.6)	0.5 (0.6)	0.4 (1.8)	+
Bulgaria	1.5 (6.1)	0.6 (2.4)	-1.5 (15.8)	0.1 (0.1)	- (3.2)	+
Cyprus	- (0)	- (0)	- (0)	- (0)	- (0)	=
Czech Rep.	0.1 (5.8)	-0.3 (2.9)	0.7 (26.6)	0.2 (0.2)	0.6 (2.4)	-
Denmark	-7.8 (17.5)	-2.8 (6.9)	- (0)	1.4 (6.9)	- (0)	-
Estonia	- (0)	- (0.7)	- (0)	0.1 (0.1)	- (0)	-
Finland	-10.4 (8.5)	-2.7 (11.2)	0.2 (23.0)	0.2 (0.3)	7.5 (17.1)	+
France	-1.8 (24.4)	2.5 (21.9)	-1.6 (440)	5.3 (5.7)	4.0 (68.8)	-
Germany	-17.7 (125)	17.4 (75.9)	-16.6 (148)	21.7 (40.6)	2.5 (27.0)	+
Greece	- (0)	5.8 (13.8)	- (0)	1.2 (2.2)	-1.2 (4.1)	=
Hungary	0.3 (0.6)	3.3 (15.2)	3.8 (14.8)	0.2 (0.2)	- (0.2)	+
Ireland	-1.0 (5.2)	3.0 (16.1)	- (0)	2.0 (2.4)	0.3 (1.3)	+
Italy	4.3 (43.1)	55.4 (173)	- (0)	3.4 (4.9)	3.0 (47.2)	+
Latvia	- (0)	0.5 (2.1)	- (0)	- (0)	0.8 (3.1)	+
Lithuania	- (0)	-0.5 (2.0)	-5.6 (9.9)	0.1 (0.1)	- (1.0)	+
Luxembourg	- (0)	-0.2 (2.4)	- (0)	- (0)	- (1.0)	+
Malta	- (0)	- (0)	- (0)	- (0)	- (0)	=
Netherlands	-3.1 (23.5)	8.4 (63.4)	0.2 (4.2)	2.9 (4.3)	- (0.1)	+
Poland	-0.8 (83.9)	0.7 (3.2)	- (0)	0.7 (0.8)	-0.5 (2.7)	=
Portugal	-3.3 (11.2)	7.5 (15.2)	- (0)	5.3 (5.8)	-8.8 (7.3)	+
Romania	- (0.1)	-1.2 (9.9)	6.3 (11.2)	- (0)	3.9 (17.2)	-
Slovakia	-1.1 (2.5)	-0.8 (1.6)	-1.1 (6.3)	- (0)	0.6 (4.2)	+
Slovenia	- (0.5)	0.1 (0.5)	1,1 (6.3)	- (0)	1.1 (4.0)	=
Spain	-20.1 (48.7)	82.2 (122)	-2.9 (59.0)	20.1 (32.2)	-17.8 (26.1)	-
Sweden	-2.3 (0.5)	- (0.6)	-3.5 (63.9)	1.3 (1.3)	15.6 (69.2)	+
UK	-13.0 (125.3)	27.9 (177)	-36.2 (52.5)	5.8 (7.1)	3.3 (9.3)	=

Incentives for CHP exist in the Member States through the national support schemes and the implementation of several Directives like for instance the CHP, RES and EU ETS. From 2004 and onwards there is a noticeable positive trend in increased European CHP capacity and its share of the electricity market<sup>105</sup>, but the progress varies greatly between different countries, see Section 1.4.3 for more info. Some countries report that the incentives have not been sufficient to make a difference in expanding the use of CHP.

<sup>104</sup> EUROSTAT, available at: <http://ec.europa.eu/eurostat>

<sup>105</sup> Eurostat, Combined Heat and Power Generation, available at <http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tsdcc350&plugin=0>

Initially the liberalisation of the electricity market led to some efficiency improvements in energy supply and delivered savings to customers. However, later wholesale electricity and gas prices increased. Among the causes for higher price levels include higher primary fuel costs, the ongoing need for investment and the extension of environmental obligations, including the EU ETS, as well as the development of renewable energy sources. A continued lack of competitive pressure and high levels of concentration in wholesale markets have also been acknowledged to contribute to higher prices, as well as a lack of market transparency.<sup>106</sup>

The liberalisation of the energy markets in itself has had a negative impact on CHP, since the focus on price and short term profits have increased. CHP competes with boilers or electricity generators, which both require lower investment costs and are more flexible in their operation. However, the transposition of laws in the Member States based on discussed Directives support the CHP. In most Member States the national schemes have created more satisfactory conditions than previously for investing in energy efficient technologies but these are still not adequate. This is supported by the slow overall growth of CHP's share of the European electricity market and the stated desire of the large utilities to continue to build electricity only power stations, even in countries where CHP and district heating have been shown to be economic by detailed studies<sup>107,108</sup>

Apart from the Directives described in the section above there have been several EU instruments in which CHP is partially or indirectly affected. To simplify the discussion we have classified these EU instruments in three categories according to their primary objectives:

1. Energy efficiency/savings
2. Pollution reduction
3. Technology improvements

Discussions on how the development of CHP has been affected by these initiatives can be found after the presentation of each category.

#### *Energy efficiency/savings*

The EU instruments below are categorized as energy efficiency/saving. Some general information about the Directive is given, and then more specifically concerning the CHP.

- **Energy End-use Efficiency and Energy Services<sup>109</sup>** – the objective of this Directive is to make the end use of energy more economic and efficient by: (1) establishing indicative targets, incentives and the institutional, financial and legal frameworks needed to eliminate market barriers and imperfections which prevent efficient end use

<sup>106</sup> European Commission, Prospects for the internal gas and electricity market, COM(2006) 841, available at [http://ec.europa.eu/energy/energy\\_policy/doc/09\\_internal\\_gas\\_and\\_electricity\\_market\\_en.pdf](http://ec.europa.eu/energy/energy_policy/doc/09_internal_gas_and_electricity_market_en.pdf)

<sup>107</sup> Marshall, L. W., 1977. District heating combined with electricity generation in the United Kingdom. HMSO.

<sup>108</sup> Marshall, L. W., 1979. Combined Heat and Power electricity generation in the UK. HMSO.

<sup>109</sup> European Commission, Directive (2006/32/EC) on Energy End-use Efficiency and Energy Services, available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0064:en:pdf>

of energy; (2) creating the conditions for the development and promotion of a market for energy services and for the delivery of energy-saving programmes and other measures aimed at improving end-use energy efficiency.

- CHP is mentioned as one of the means for eligible energy efficiency improvement measure in the residential and industrial sectors, however, with the restriction that these cannot already be accounted for in other specific measures.
- **Energy Performance of Buildings<sup>110</sup>** - The objective of this Directive is to promote the improvement of the energy performance of buildings, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.
  - For new buildings with a total useful floor area over 1 000 m<sup>2</sup>, a Member State shall ensure that the technical, environmental and economic feasibility of alternative systems such as district heating and cooling and CHP are considered. The same is valid for existing buildings (>1000 m<sup>2</sup>) that will undergo major renovations.
  - A recast of the same directive was published in 2010<sup>111</sup>. It stipulates that Member States shall take necessary measures to ensure that minimum energy performance requirements for buildings are set at cost-optimal levels using a comparative methodology framework<sup>112</sup>. In the recast, cogeneration and district heating remain among the energy saving measures that must be considered. From 2021 Member States shall ensure that all new buildings are near zero energy buildings and from 2019 shall all new public building be near zero buildings. Member States shall also stimulate refurbishment to near zero energy buildings. The useful floor area of public buildings for which this directive applies is above 500 m<sup>2</sup>, and in 2015 above 250 m<sup>2</sup>. The more stringent conditions of energy efficient buildings will reduce heat demand, but at the same time CHP remains a cost-efficient and environmentally friendly mean to provide the heat still needed.
- **Community Guidelines on State aid for Environmental Protection<sup>113</sup>** - this Directive is designed to remedy or prevent damage to our physical surroundings or natural resources, or to encourage the efficient use of these resources. Energy-saving measures and the use of renewable sources of energy as action to protect the environment are also included.
  - Cogeneration is presented as the most efficient way to produce heat and electricity simultaneously. So, state aid can be granted to reach environmental targets. However, total aid cannot exceed 60% of the eligible investment cost. For SMEs additional assistance of 10-20% can be granted. Aid intensity for district heat cannot exceed 50% of eligible investment costs, but for SMRs it could increase to 60-70%. The eligible costs are extra investments necessary to realise energy efficient cogeneration or district heating.

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<sup>110</sup> European Commission, Directive (2003/91/EC ) on the energy performance of buildings, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:001:0065:0065:EN:PDF>

<sup>111</sup> European Commission, Directive (2010/31/EU) on the energy performance of buildings (recast), <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF>

<sup>112</sup> Ibid

<sup>113</sup> European Commission, Notice (2008/C82/01) on community guidelines on state aid for environmental protection, available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2008:082:0001:0033:EN:PDF>

- The above mentioned guidelines offer the possibility to Member States to provide extensive support to CHP. This should give them the freedom to design support measures suitable to meet their own targets.
- **Energy Labelling**<sup>114</sup> - Labelling and standard product information of the consumption of energy and other resources by household appliances.
  - CHP is not mentioned explicitly in this directive.
- **Eco-design**<sup>115</sup> - Establishes a framework for the setting of Community Eco-design requirements for energy-related products with the aim of ensuring the free movement of such products within the internal market. It contributes to sustainable development by increasing energy efficiency and the level of protection of the environment, while at the same time increasing the security of the energy supply.
  - CHP is not mentioned explicitly in this directive.
- **Covenant of Mayors**<sup>116</sup> - The EU Climate Action and Energy Package, which commits Member States to curb their CO<sub>2</sub> emissions by at least 20% by 2020. This is important since 80% of the European population lives and works in cities, where up to 80% of the energy is consumed. Signatories of the Covenant of Mayors contribute to this policy objective through a formal commitment to go beyond the 20% target through the implementation of their Sustainable Energy Action Plan. European Commission are adapting and creating specific financial mechanisms to help local authorities fulfil their commitments<sup>117</sup>.
  - Local and regional governments can promote local energy production and the use of renewable energy sources by giving financial support, e.g. CHP using biomass.
- **CONCERTO**<sup>118</sup> – A European wide initiative proactively addressing the challenges of creating a more sustainable future for Europe’s energy needs. There are a total of 58 communities in 22 projects participating, each working to deliver the highest possible level of self-supply of energy. The focus is primarily on demonstrating the environmental, economic and social benefits of integrating renewable energy sources together with energy efficiency techniques
  - Several communities report on that they are employing CHP, e.g. Apeldoorn (NL), Lambeth (UK), Copenhagen (DK). Often these systems are fuelled with biogas.
- **Build-up**<sup>119</sup> - European web portal for energy efficiency in buildings.
  - District heating is mentioned extensively.
- **Intelligent Energy Europe**<sup>120</sup> – An EU tool for funding project proposals to move towards “a more energy intelligent Europe”.
  - There are several funded projects that concerns CHP and DHC like for example CODE, D-PLOY, ECOHEATCOOL, and BIO-HEAT, Ecoheat4EU.
- **European Regional Development Fund** - <sup>121</sup> has been amended to support sustainable energy in the housing sector, providing a further boost to investment in this sector.

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<sup>114</sup> European Commission, Directive (92/75/EEC) on indication by labelling and standard product information of the consumption of energy and other resources by household appliances, available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0075:EN:HTML>

<sup>115</sup> European Commission, Directive (2005/32/EC) on Eco-Design, available at: [http://www.energy.eu/directives/l\\_19120050722en00290058.pdf](http://www.energy.eu/directives/l_19120050722en00290058.pdf)

<sup>116</sup> Covenant of Mayors, available at: <http://www.eumayors.eu/>

<sup>117</sup> Ibid

<sup>118</sup> CONCERTO, available at: <http://concertoplus.eu>

<sup>119</sup> Build-up, available at: <http://www.buildup.eu/home>

<sup>120</sup> Intelligent Energy Europe, [http://ec.europa.eu/energy/intelligent/index\\_en.html](http://ec.europa.eu/energy/intelligent/index_en.html)

Principally the energy efficiency instruments have had a positive impact on the development CHP. For example, through the Energy End-use Efficiency and Energy Services Directive the Member States have committed to make efforts to achieve a savings target figure of 9% by 2016. A means to reach this target is recognized to be by increased use of industrial CHP and district heating. For most instruments mentioned above the efficiency gains that cogeneration delivers are recognised. A possible negative long-term impact on CHP could be the use of more energy efficient buildings, which reduces the need for heat. Some studies show that beyond a modest point, CHP is significantly cheaper than extra insulation in terms of energy saving.<sup>122</sup>

Overall, the category of energy efficiency and savings instruments support the development of CHP. It is estimated to continue to have a significant impact on the development of CHP as industry and cities strive for optimal means to provide heat and electricity.

### *Pollution reduction*

The following EU Instrument is categorized as ‘Pollution reduction’:

- Industrial Emissions Directive (IED)<sup>123</sup> – is a recast of seven Directives related to industrial emissions, i.e. IPPC, Large Combustion Plants Directive, the Waste Incineration Directive, the Solvents Emissions Directive and 3 Directives on Titanium Oxide. The objective of IED is to achieve significant reduction of harmful emissions across the EU, in particular through increased use of Best Available Techniques (BAT). Permit conditions for combustion plants should be reconsidered regularly with new BAT conclusions. In references <sup>124</sup>, <sup>125</sup> the cogeneration type of plants is classified as a BAT. Moreover, a combustion plant may be exempted from compliance with the emission limit values and rates of desulphurisation provided that a number of conditions are fulfilled, e.g. thermal power less than 200 MW, the plant was put in operation no later than November 2003, and at least 50% of useful heat is delivered as steam or hot water to public network for district heating. It is also stated that heat generated by waste co-incineration plants shall be recovered as far as practicably possible as heat, steam or power.

The recast of IED will provide significant support for CHP. The importance of IED is mainly through its support of BAT, which CHP is classified as. It also gives less restrictive emission rules for CHP plants below 200 MW thermal power.

### *Technology improvements*

The following EU Instruments are categorized as technology improvements:

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<sup>121</sup> European Regional Development Fund, available at: [http://ec.europa.eu/regional\\_policy/funds/feder/index\\_en.htm](http://ec.europa.eu/regional_policy/funds/feder/index_en.htm)

<sup>122</sup> “Zero Carbon Hub Consultation - Retrofit for the Future” The effect of low CO2 piped heat supply on the optimum level of fabric insulation and options for decarbonisation of domestic hot water supply and ventilation loads November 2011.

<sup>123</sup> European Commission, Industrial Emissions Directive, available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:EN:PDF>

<sup>124</sup> European Commission, Reference document on Best Available Techniques for Energy Efficiency, Feb 2009, available at: [ftp://ftp.jrc.es/pub/eippcb/doc/ENE\\_Adopted\\_02-2009.pdf](ftp://ftp.jrc.es/pub/eippcb/doc/ENE_Adopted_02-2009.pdf)

<sup>125</sup> European Commission, Reference documents on Best Available Techniques for Large Combustion Plants, July 2006, available at: [ftp://ftp.jrc.es/pub/eippcb/doc/lcp\\_bref\\_0706.pdf](ftp://ftp.jrc.es/pub/eippcb/doc/lcp_bref_0706.pdf)

- **SET-Plan**<sup>126</sup> and **European Industrial Initiatives** – SET-Plan aims to increase research to reduce costs and improve performance of existing low-carbon technologies, and thereby encourage the commercial implementation of these technologies. The SET-Plan is implemented by European Industrial Initiatives (EII), which are joint large scale technology development projects between academia, research and industry. The goal of the EIIs is to focus and align the efforts of the Community, Member States and industry.
  - CHP is not an independent EII. However, the European Industrial Bioenergy Initiative (EIBI) studies the use of renewable CHP. The Smart Cities Initiative has not been launched yet, but CHP would play an important role there too.
- **European Biofuels Technology Platform**<sup>127</sup> - actively engages with biofuels stakeholders (researchers, academia, civil societies, industry), EC-funded research projects and initiatives, related to the European technology platforms and global biofuels organisations in a wide range of activities relevant to the RD&D of sustainable advanced biofuels in Europe
  - In the implementation plan of the European Industrial Bioenergy Initiative (EIBI), one of the studied pathways is high efficiency heat and power generation through thermochemical conversion (e.g.:  $\eta_{el} > 45\%$ ). The heat would be used to produce synthetic fuels from forest and agricultural residues, waste wood, and energy crops. The main technology challenges are to develop biofeedstock compatible materials and high share of power production. Other challenges within the value chain are energy and carbon efficiency and investment efficiency.<sup>128</sup>
- **Renewable Heating & Cooling Platform**<sup>129</sup> - brings together stakeholders from the biomass, geothermal and solar thermal sector, including the related industries, to define a common strategy for increasing the use of renewable energy technologies for heating and cooling.
  - The platform aims to coordinate European, national, regional and local RD&D programs in the renewable heating and cooling sector. It should establish effective public-private partnerships and be the interface between the EU and Members States.<sup>130</sup>
- **District Heating and Cooling PLUS Technology Platform**<sup>131</sup> - participates in the Renewable Heating and Cooling European Technology Platform mentioned above. The DHC+ platform aims to increase cooperation and improve synergies between existing renewable and heating and cooling technologies. The DHC+ platform contains projects like Ecoheat4eu which has its focus on national legislation for DHC. Ecoheat4cities is also relevant since it aims to support the implementation of the RES directive with regard to DHC components. Finally, the project called Urban Planners with Renewable Energy Skills (UP-RES) looks at phasing out non-technological barriers currently preventing the market penetration with heating and cooling services.

<sup>126</sup> European Commission, Communication (COM(2007)723final) on a European Strategic Energy Technology Plan (SET-PLAN), available at: [http://ec.europa.eu/energy/res/setplan/doc/com\\_2007/com\\_2007\\_0723\\_en.pdf](http://ec.europa.eu/energy/res/setplan/doc/com_2007/com_2007_0723_en.pdf)

<sup>127</sup> European Biofuels Technology Platform, available at: <http://www.biofuelstp.eu/>

<sup>128</sup> European Industrial Bioenergy Initiative, Implementation Plan 2010 – 2012, Nov 2010, available at: [http://ec.europa.eu/energy/technology/initiatives/doc/implementation\\_plan\\_2010\\_2012\\_eii\\_bioenergy.pdf](http://ec.europa.eu/energy/technology/initiatives/doc/implementation_plan_2010_2012_eii_bioenergy.pdf)

<sup>129</sup> Renewable Heating & Cooling Platform, available at: <http://www.rhc-platform.org>

<sup>130</sup> Ibid

<sup>131</sup> District Heating and Cooling PLUS Technology Platform, available at: <http://www.dhcplus.eu>

Since many of these instruments have been launched recently they are not considered to have made a significant impact on the development of CHP yet. Nevertheless, it should be recognised that the instruments concerning technology improvements of CHP likely could have an important impact on the development of more efficient CHP in the longer term. Increased performance of renewable CHP and more efficient use of district heating will increase the interest from utilities and investors.

### 6.3.7 *Conclusion*

The European instruments related to energy efficiency improvements have had a positive influence on the development of CHP. Often the documents describing these instruments mention CHP explicitly as a mean to save primary energy and their incentives are aligned, e.g. the Energy End-use Efficiency and Energy Services Directives. Overall, the category of Energy efficiency and savings instruments support the development of CHP and it is estimated to continue impacting the development of CHP as industries and cities search for more energy efficient means to provide their heat and electricity needs.

The Industrial Emission Directive (IED) which concerns pollution reduction is a recast of seven Directives. The IED promotes Best Available Technologies (BAT) to reduce pollution in the power generation industry. Since cogeneration is a BAT, it will incentivise utilities to invest in CHP. District heating plants below 200 MW thermal power, fulfilling some conditions like for instance that more than 50% of energy is used for heat production, will have less stringent pollution emission restrictions. This puts them at an advantage compared to pure electricity generators. Finally, cogeneration reduces pollution due to its better primary energy use.

The EU policy instruments of the category technology improvements have only been launched recently. Thus, they are not considered to have made a significant impact on the development of CHP until now. Nevertheless, these instruments will likely become important for the development of CHP in the longer term, since increased performance of CHP and more efficient use of district heating will result in increased interest in these technologies.

## **6.4 Preliminary assessment of the impact of RES Directive on the development of cogeneration**

### 6.4.1 *Introduction and background*

The first Directive on Renewables<sup>132</sup> followed the White Paper from 1997<sup>133</sup> on renewable energy sources, which had set a target of reaching 12% of primary energy consumption from renewables for the EU15 in 2010. The first RES Directive contributed to the package of measures needed to comply with EU's commitments under the Kyoto Protocol. The second RES Directive<sup>134</sup> was adopted in 2009 and entered into force in 2010. It contains a legislative

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<sup>132</sup> European Commission, Directive 2001/77/EC promotion of electricity produced from renewable energy sources in the internal electricity market, available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:283:0033:0033:EN:PDF>

<sup>133</sup> European Commission, Energy For the Future: Renewable Sources of Energy, White paper, 1997, available at [http://europa.eu/documents/comm/white\\_papers/pdf/com97\\_599\\_en.pdf](http://europa.eu/documents/comm/white_papers/pdf/com97_599_en.pdf)

<sup>134</sup> European Commission, Directive 2009/28/EC on promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF>



framework to enable renewables to reach 20% of the European energy mix by 2020. The second RES Directive obliges each Member State to adopt a national renewable energy action plan, which lays out the measures to achieve their national targets of renewable energy sources consumed in transport, electricity, and heating and cooling in 2020. Each Member State had to submit their national action plans by June 2010. At the time of the writing of this deliverable 24 out of 27 national action plans had been submitted and published<sup>135</sup>.

Already in the White paper the heat and cooling sector was recognized for its potential to utilise renewable energy, since heat constitutes 50% of the primary energy use in Europe. Nevertheless, the first RES Directive was mainly focused on renewable electricity and biofuel for the transport sector. In 2003 the second European Climate Change Progress report<sup>136</sup> it was recognized that the market penetration of RES-H (RES Heating) was at very different levels in the Member States. Issues like target setting, rules for support schemes, monitoring and reporting, harmonisation of standards for installations, and certification were not covered by the RES Directive at that time. A number of reasons for the diverse progress in the Member States were suggested, for instance the availability of renewable resources, government support (or lack of) or incentives, knowledge and experience of good practice and perceptions of biomass heating/other RES-H.<sup>137</sup> Also in 2007, the development was highly uneven between Member States, indicating that national policies had been uneven in their uptake and incorporation of EU policies. Powerful policies existed in some Member States to create investor confidence in RES, in others they had been sensitive to changing political priorities. In other words, the weak EU regulatory framework at that time for using renewables in heating and cooling had lead to progress is mainly a few committed Member States.<sup>138</sup>

According to the projections of the national action plans for 2020 the largest contribution of renewable energy comes from electricity (RES-E). The second largest contribution is from renewable heating and cooling (RES-H/C) and finally renewable transport (RES-T) is projected to contribute the least to the overall renewable target.

#### 6.4.2

#### *Examples of RES support schemes*

It is for the Member States to design the RES support schemes according to their needs and objectives. Table 6.2 illustrates some selected examples of the large variety of schemes existing in EU27. In addition to these, the EU ETS is designed to provide support for both CHP and renewables.

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<sup>135</sup> European Commission, National Renewable Action Plans, 2009, available at [http://ec.europa.eu/energy/renewables/transparency\\_platform/action\\_plan\\_en.htm](http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm)

<sup>136</sup> European Commission, Second ECCP Progress Report Can we meet our Kyoto targets?, 2003, available at [http://ec.europa.eu/clima/documentation/eccp/docs/second\\_eccp\\_report.pdf](http://ec.europa.eu/clima/documentation/eccp/docs/second_eccp_report.pdf)

<sup>137</sup> European Commission, Second ECCP Progress Report Can we meet our Kyoto targets?, 2003, available at [http://ec.europa.eu/clima/documentation/eccp/docs/second\\_eccp\\_report.pdf](http://ec.europa.eu/clima/documentation/eccp/docs/second_eccp_report.pdf)

<sup>138</sup> European Commission, Renewable Energy Road Map Renewable energies in the 21st century: building a more sustainable future, 2007, available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0848:FIN:EN:PDF>

Table 6.2: Examples of support measures in different Member States<sup>139</sup>.

Measure	Description	Country example
Investment Grant	Funding granted for a certain percentage of the investment costs of an installation.	Austria A program for the promotion of biomass district heating in rural areas provides investment support of up to 40% of total installation costs. For new CHP plants a maximum of 10% of the investment costs is covered.
Conversion Grant	Conversion to a more desirable type of energy production is promoted.	Italy Financial support is granted for the conversion of electrical water heaters into those fuelled by renewable sources.
Tax incentive	Tax on emissions	Sweden Taxation exists on CO <sub>2</sub> , Sulphur and NO <sub>x</sub> . Emissions produced by biofuels are exempted.
Low Interest Loan	Low-interest loans provided for investments.	Germany Low-interest loans with the interest rate set for 10 years are provided for new large-scale biomass facilities.
Purchasing Obligation	Consumers or grid operators are obliged to have a certain percentage of their energy supply provided through renewable or efficient sources.	Austria Grid operators are obliged to accept electricity from renewables sources and allocate it through to the customers. End consumers pay for this through an additional charge.
Voluntary Agreement	Support is provided when a subject enters into a voluntary energy savings agreement.	The Netherlands Dutch authorities provide (partial) energy tax cancellation when a company enters into a voluntary energy savings agreement with the government.
Certificates	Tradable certificates are introduced to boost the best available technologies in efficiency.	Belgium Certificates are acquired for avoided CO <sub>2</sub> emitted by fossil fuels.
Obligatory Connection	Buildings may be obliged to connect or prohibited to disconnect from a network.	Denmark Municipalities may, in principle, oblige a building to connect to a district heating network or to prevent it from disconnecting.
Liberalization	Taking away market distorting regulations may result in benefit for CHP and district heating when those	Finland For strong and effective CHP, the liberalized market allows for the achieving the complete system's

<sup>139</sup> ECOHEATCOOL – A Euroheat & Power Initiative, Work package 6, 2006, available at [http://www.euroheat.org/Files/Filer/ecoheatcool/documents/Ecoheatcool\\_WP6\\_Web.pdf](http://www.euroheat.org/Files/Filer/ecoheatcool/documents/Ecoheatcool_WP6_Web.pdf)

**are fully efficient.**

**natural efficiency.**

### 6.4.3

### *Cogeneration using renewable energy*

The implementation of renewable CHP is still uneven in the Member States<sup>140</sup>. This can also be noticed when reading the National reports on the RES Directive from 2007. In these only 60% of the Member States reported on renewable cogeneration. However, more was reported on heating using biofuels. Due to the lack of abundant and specific data concerning renewable cogeneration, heating using biofuels is discussed below in order to have a point of reference. This is relevant since heating from biofuels includes renewable CHP too. Table 6.3 illustrates the share of renewable sources for final energy consumption of heat during the years 2006-2008.

**Table 6.3: Share of renewable sources in final energy consumption for heat<sup>141</sup>.**

	<b>2006 [%]</b>	<b>2007 [%]</b>	<b>2008 [%]</b>
<b>EU27</b>	<b>10.3</b>	<b>11.5</b>	<b>11.9</b>
<b>Austria</b>	<b>23.4</b>	<b>26.0</b>	<b>26.0</b>
<b>Belgium</b>	<b>3.8</b>	<b>3.7</b>	<b>4.1</b>
<b>Bulgaria</b>	<b>14.9</b>	<b>14.1</b>	<b>15.0</b>
<b>Cyprus</b>	<b>8.4</b>	<b>10.6</b>	<b>11.3</b>
<b>Czech Rep.</b>	<b>9.7</b>	<b>11.7</b>	<b>11.2</b>
<b>Denmark</b>	<b>25.2</b>	<b>28.0</b>	<b>29.1</b>
<b>Germany</b>	<b>5.5</b>	<b>8.5</b>	<b>8.4</b>
<b>Greece</b>	<b>12.5</b>	<b>14.5</b>	<b>14.3</b>
<b>Estonia</b>	<b>30.8</b>	<b>32.5</b>	<b>35.7</b>
<b>Finland</b>	<b>40.2</b>	<b>40.8</b>	<b>42.0</b>
<b>France</b>	<b>12.1</b>	<b>12.6</b>	<b>12.9</b>
<b>Hungary</b>	<b>7.7</b>	<b>9.0</b>	<b>8.4</b>
<b>Ireland</b>	<b>3.3</b>	<b>3.5</b>	<b>3.3</b>
<b>Italy</b>	<b>3.6</b>	<b>3.4</b>	<b>5.5</b>
<b>Latvia</b>	<b>42.6</b>	<b>42.4</b>	<b>43.0</b>
<b>Lithuania</b>	<b>25.7</b>	<b>25.5</b>	<b>28.0</b>
<b>Luxemburg</b>	<b>1.7</b>	<b>1.8</b>	<b>2.0</b>
<b>Malta</b>	<b>2.6</b>	<b>3.1</b>	<b>3.4</b>
<b>Netherlands</b>	<b>2.2</b>	<b>2.3</b>	<b>2.3</b>
<b>Poland</b>	<b>11.1</b>	<b>11.4</b>	<b>11.3</b>
<b>Portugal</b>	<b>34.0</b>	<b>35.6</b>	<b>37.8</b>
<b>Romania</b>	<b>18.2</b>	<b>20.1</b>	<b>22.8</b>
<b>Slovenia</b>	<b>18.6</b>	<b>20.4</b>	<b>19.3</b>
<b>Spain</b>	<b>11.4</b>	<b>11.3</b>	<b>11.7</b>
<b>Slovakia</b>	<b>4.6</b>	<b>6.5</b>	<b>6.4</b>
<b>Sweden</b>	<b>58.8</b>	<b>61.9</b>	<b>63.1</b>
<b>United Kingdom</b>	<b>0.9</b>	<b>1.0</b>	<b>1.1</b>

<sup>140</sup> ECOFYS et al., Renewable Energy Country Profiles, 2008, available at <http://isi.fraunhofer.de/isi-de/publ/download/isi08b33/progress-renewable-energy-countryprofiles.pdf>

<sup>141</sup> Eurostat, 30/11, Renewable energy indicators, 2010, available at [http://epp.eurostat.ec.europa.eu/cache/ITY\\_OFFPUB/KS-QA-10-030/EN/KS-QA-10-030-EN.PDF](http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-QA-10-030/EN/KS-QA-10-030-EN.PDF)

Countries with the most significant increase of renewable heat production are Denmark, Estonia, Germany, Portugal, Romania, and Sweden. For countries having no or slight increase of renewable heat, one can probably conclude that they had limited increase of renewable CHP too. Countries belonging to this category were Belgium, Ireland, Luxemburg, Netherlands, Poland, Spain and the UK. However, it cannot be excluded this assumption is untrue in some cases, e.g. other renewable heat has decreased and renewable CHP increased.

It is notable that in the UK, large electricity only power stations such as Drax import large amounts of biomass from Europe and then burn it at relatively low efficiency. Arguably better effect could be achieved by constructing local district heating combined heat and power stations and burning the material therein.

The share of biomass heat has grown from 556 TWh (47.81 Mtoe) in 1997 to 649 TWh in 2005 in the EU27.<sup>142</sup> From 2006 to 2008 the renewable heat increased from 10.3% (683 TWh) to 11.9% (789 TWh) of the total final energy consumption for heating<sup>143</sup>. From this the CHP plants using biomass contributed 56 TWh of the renewable cogeneration in 2008<sup>144</sup>. As can be seen in Table 6.2 high shares of renewable heating can be seen in Scandinavia, the Baltic States, and Portugal. This is mainly due to the use of wood in households and industry and is in part due to the ready local supply of such materials<sup>145</sup>. The share of renewable energy for district heating in the EU (geothermal, solar, combustible, and waste incineration) represented 14% in 2003<sup>146</sup>. 68% of this amount was provided by cogeneration plants. Biomass contributed with about half of the fuel supply.<sup>147</sup>

Below will follow some examples of Member States, which belong to the group with noticeable progress in heating using biofuel.

#### *Austria*

Biomass is the most important source for renewable heat in Austria. This is related to the widespread traditional use of biomass heating. Austria increased biomass heat use from 27.0 TWh in 1997 to 33.7 TWh in 2005. The share of renewables in the final energy consumption for heat increased from 23.6% in 2006 to 26% in 2008<sup>148</sup>.

In 2003 cogeneration was included in the Green Electricity act at federal level. Since then the implementation of biofuelled cogeneration has been over target in the period 2002 to 2007. The most important form of subsidies exists at federal level as investment support for biomass heating systems. For such plants there is a possibility for fixed feed-in tariffs for electricity only. New plants are required to have an annual fuel efficiency of at least 60%.

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142 Fraunhofer et al., *EmployRES - The impact of renewable energy policy on economic growth and employment in the European Union*, 2009, available at [http://ec.europa.eu/energy/renewables/studies/doc/renewables/2009\\_employ\\_res\\_report.pdf](http://ec.europa.eu/energy/renewables/studies/doc/renewables/2009_employ_res_report.pdf)

143 Eurostat, 30/11, *Renewable energy indicators*, 2010, available at [http://epp.eurostat.ec.europa.eu/cache/ITY\\_OFFPUB/KS-QA-10-030/EN/KS-QA-10-030-EN.PDF](http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-QA-10-030/EN/KS-QA-10-030-EN.PDF)

144 Eurostat, 56/2010, *Renewable energy statistics*, 2010, available at [http://epp.eurostat.ec.europa.eu/cache/ITY\\_OFFPUB/KS-SF-10-056/EN/KS-SF-10-056-EN.PDF](http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-SF-10-056/EN/KS-SF-10-056-EN.PDF)

145 Eurostat, 56/2010, *Renewable energy statistics*, 2010, available at [http://epp.eurostat.ec.europa.eu/cache/ITY\\_OFFPUB/KS-SF-10-056/EN/KS-SF-10-056-EN.PDF](http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-SF-10-056/EN/KS-SF-10-056-EN.PDF)

146 ECOHEATCOOL - Reducing Europe's consumption of fossil fuels for heating and cooling, 2006, available at [http://www.euroheat.org/Files/Filer/ecoheatcool/documents/Ecoheatcool\\_Results\\_Web.pdf](http://www.euroheat.org/Files/Filer/ecoheatcool/documents/Ecoheatcool_Results_Web.pdf)

147 Ibid.

148 Eurostat, 30/11, *Renewable energy indicators*, 2010, available at [http://epp.eurostat.ec.europa.eu/cache/ITY\\_OFFPUB/KS-QA-10-030/EN/KS-QA-10-030-EN.PDF](http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-QA-10-030/EN/KS-QA-10-030-EN.PDF)

The standard reimbursement rate amounts to 25% of the investment costs and it can be increased to 40% if certain sustainability criteria are fulfilled.

### *Czech Republic*

During the years 1997 to 2005 the total production of energy from biomass grew from 4.4 to 16.6 TWh. The share of renewables in the final energy consumption for heat increased from 9.7% in 2006 to 11.2% in 2008<sup>149</sup>. The existing district heating infrastructure is considered sufficient in order to meet the 2020 target. New heating systems may be developed primarily in smaller towns where a suitable renewable energy source (biomass or biogas) is available in sufficient quantities.

Czech Republic uses feed-in prices, and if applicable a special surcharge applies to CHP production. However, they report that it has proven not to be sufficiently high to persuade investors to use CHP from renewable energy sources. There has also been an investment aid of about 25% of the total investment costs.

### *Denmark*

The growth of biomass cogeneration increased from 6.9 TWh in 1997 to 10.6 TWh in 2004. The share of renewables in the final energy consumption for heat increased from 25.2% in 2006 to 29.1% in 2008<sup>150</sup>. In Denmark district heating is already extensively used and about half of the electricity is generated by cogeneration. Local authorities promote conversion from natural gas to biomass. In 2009 almost half of the Danish district heat was produced from biomass and organic waste.

Subsidies are given for biomass installations and for biogas used for cogeneration. Heat production using biofuels is exempted from taxes. A subsidy of €1 cent/kWh exists for electricity from CHP, which applies to electricity from waste, natural gas and biogas. Large-scale, centralized CHP using biomass or biogas receives extra subsidy of €8 cent/kWh paid by customers. If biogas and natural gas are used together the surcharge is €3 cent/kWh.

### *Germany*

In Germany the biomass heat increased from 48.5 TWh in 1997 to 59.8 TWh in 2004. The share of renewables in the final energy consumption of heat increased from 5.5% in 2006 to 8.4% in 2008<sup>151</sup>. The growth of biomass fuelled CHP amounted to 23% per year in the period 2004-2008<sup>152</sup>.

The rapid growth is due to improved conditions introduced by the 2000 Renewables Energy Act (EEG)<sup>153</sup>, the EEG amendment in 2004, and the 2001 Biomass Act, which together provided enhanced subsidies for construction and use of renewable raw materials, for new technologies or CHP operation. An updated EEG<sup>154</sup> came into force in 2009. Also the Combined Heat and Power Act came into force on the same day (not only RES). The latter also promotes construction and development of heating networks. If the heat comes from RES sources it can receive funding from additional schemes.

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<sup>149</sup> Ibid.

<sup>150</sup> Ibid.

<sup>151</sup> Ibid.

<sup>152</sup> ETSAP – Biomass for Heat and Power, May 2010, available at <http://www.etsap.org/E-techDS/PDF/E05-Biomass%20for%20HP-GS-AD-gct.pdf>

<sup>153</sup> Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz -EEG), available at <http://bundesrecht.juris.de/bundesrecht/eeg/gesamt.pdf>

<sup>154</sup> Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz -EEG), available at [http://bundesrecht.juris.de/bundesrecht/eeg\\_2009/gesamt.pdf](http://bundesrecht.juris.de/bundesrecht/eeg_2009/gesamt.pdf)

## *Sweden*

Electricity production from renewable energy sources within the certification scheme amounted to 14.2 TWh in 2008 compared to 6.5 TWh in 2002. The share of renewables in the final energy consumption for heat increased from 58.8% in 2006 to 61.9% in 2008<sup>155</sup>. In Sweden district heating is the predominant form of heating in the main towns in 245 of the country's 290 municipalities. About 50% of the national heating requirements are met by district heating. In 2008 biofuel provided 71% of the total energy supply for remote heating.

Instruments which promote cogeneration and district heating from renewable energy is an exemption of biofuels from a CO<sub>2</sub> tax, the electricity certificate scheme, and the EU ETS.

### *6.4.4*

### *Conclusions on RES Directive*

The implementation of renewable CHP appears to be uneven in the EU27. In the National reports of the RES Directive from 2007 only 60% of the Member States commented on their progress concerning renewable CHP, which suggests that the remaining 40% had limited progress.

The Member States' incentives to promote renewable CHP vary greatly, which affected their implementation effectiveness. Other important parameters have shown to be the geographic location of a country and its renewable resource base. For example, biomass-based CHP or power generation have high penetration in regions with an abundance of wood resources or agricultural residue. Other countries gain from having a long tradition of using district heating, which also simplifies the transition to renewable CHP.

Other Directives work in parallel with the RES and the Cogeneration Directives, like for instance the Energy Performance of Buildings Directive (EPBD). It requires that new buildings and major renovations of buildings above 1000 m<sup>2</sup> shall study the feasibility of alternative systems, e.g. CHP. In the recast of EPBD the size limitation has been removed and architects and planners will be requested to consider the optimal configuration of improvements in energy efficiency, e.g. insulation, use of renewable energy, and district heating and cooling when constructing or renovating buildings. Although increased insulation of buildings reduces the heat demand, studies indicate that CHP is a more economically effective method to increase energy efficiency. Therefore CHP will remain an important technique to reach the optimal configuration with regard to energy efficiency. Finally, the actual incentives given in these specific Directives are to a large extent dependent on their implementation in the Member States. The EU ETS trading scheme is another driver to introduce renewable CHP, since both CHP and renewable fuel receive larger allocation of free allowances.

In conclusion, in some countries there have been significant progress with the implementation of renewable CHP and other countries the progress is much less. As has been described it is difficult to make a definitive judgement on how much the RES directive has affected the implementation of renewable CHP due to that: 1. not much information given in National Reports on renewable CHP, 2. other Directives and the available renewable resource base also influence significantly. However, it is clear that in countries where good incentives have been put in place like for instance in Germany and Denmark the growth of renewable CHP has been significant.

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<sup>155</sup> Eurostat, 30/11, Renewable energy indicators, 2010, available at [http://epp.eurostat.ec.europa.eu/cache/ITY\\_OFFPUB/KS-QA-10-030/EN/KS-QA-10-030-EN.PDF](http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-QA-10-030/EN/KS-QA-10-030-EN.PDF)

## ANNEX A

### LIST OF RELEVANT LEGISLATION.

**In most cases the titles of these documents have been translated and so therefore any potential user should refer to the documents in the original language.**

#### A.1. AUSTRIA

- Austrian Federal law on the promotion of CHP (KWK-Gesetz), issued by National Council on the 8<sup>th</sup> August 2008.
- Act to Amend the laws of renewable energies in the electricity sector and amending related legislation (Renewable Energy Act, EEG 2009)
- Law to promote renewable energy in heating (Renewable Energy Sources Act - EEWärmeG) (07/08/2008)
- Energy Tax Act (EnergieStG) (15/07/2006)
- Electricity tax law (StromStG) (24/03/1999)
- Federal Act providing new rules on the organisation of the electricity sector (EIWOG). Entering into force (01/12/1998). Latest amendment (08/08/2008).
- Electricity Services Act 2005 (30/11/2005)
- Steiermark's Electricity Industry and Organisation Act 2005, (16/08/2005)
- Law on the regulation of the electricity system in Burgenland (Burgenland electricity sector Act, 2006 - Bgld EIWG 2006) (05/12/2006)
- Law of 7 February 2007, changing the Tyrolean Electricity Act of 2003 (24/04/2007)
- State law, with the Upper Austrian. Electricity Industry and - Organisation Act 2006 and the Upper Austrian. Electric power transmission Act 1970 is amended (Upper Austrian Electricity Industry Amendment of 2008) (29/08/2008)
- Act under which the law of reorganization of the electricity-zitätswirtschaft (Wiener Electricity Industry Act 2005), Gazette No. 46/2005 as amended Gazette No. 7 / 2007 (22/02/2008)
- Act under which the Carinthian Electricity Industry and Organisation Act is changed (05/08/2008)
- Law of 13 February 2007, with the Styrian Electricity Industry and Organisation Act 2005 - Styria. ELWOG is amended in 2005. (20/04/2007)
- Law of 13 February 2007, with the Styrian Electricity Industry and Organisation Act 2005 - Styria. ELWOG 2005 and the Styrian electric power transmission Act amended in 1971 (20/04/2008)
- Law of 17 December 2008, amending the Salzburg Provincial Electricity Act 1999 (National Electricity Law Amendment 2008) (24/03/2009)
- Law amending the Burgenland Electricity Services Act of 2006. (08/07/2009)
- Vorarlberg's Act to amend the Electricity Industry Act (23/08/2005)
- Austrian Federal law, by which the Electricity Industry and Organisation Act, the Gas Industry Act, the Energy Powers Act 1982, the oil Stockholding and Registration Act 1982, the Energy Regulatory Authority Act, the Federal Law against Unfair Competition 1984 and the Competition Act are amended (energy Security of Supply Act 2006) (27/06/2006)

## **A.2. BELGIUM**

### **Walloon Region**

- Law on the promotion of CHP: Besluit van 30 November 2006
- Decree of 4 July 2002 the Walloon Government on the promotion of Green Electricity.
- March 4, 2004. - Government Decree amending the Decree of the Walloon Government of July 4, 2002 on the promotion of green electricity (MB of 22.03.2004, p. 16112). This decree was repealed by the AGW of 30 November 2006.
- Walloon Government Decree adopting various measures for promotion of electricity produced from renewable energy sources or cogeneration (01/01/2008)
- April 12, 2001. - Decree on the organization of the regional electricity market (MB, 01/05/2001, p. 14118). This decree was amended by: - the decree of December 19, 2002 - Decree of 18 December 2003 - the decree of February 3, 2005 - the decree of October 4, 2007.
- March 30, 2006. - Order of the Walloon Government on public service obligations in the electricity market (BS, 27/04/2006, p. 22143). This order was amended by the AGW of 31 August 2006; the AGW of December 6, 2006.
- December 13, 2006. Ministerial Decree establishing the procedure for determining the primary energy sources used to generate electricity. (BS, 22/12/2006, p. 73884). This order was amended by AMRW of December 20, 2007
- March 12, 2007. - Ministerial Decree determining the procedures and the Code of metering electricity produced from renewable energy sources and / or cogeneration

### **Flemish Region**

- F. 2006 - 4835 [C - 2006/36349] July 7, 2006. - Flemish Government Decree promoting the production of electricity by CHP of quality. (01/12/2006)
- [C - 2006/36904] 6 October 2006. - Ministerial decision on the establishment of reference efficiencies for application of the conditions for quality CHP (01/12/2006)
- Decision of the Flemish Regulator for the Electricity and Gas on January 24, 2006 regarding the establishment of the detailed technical rules on the use of green as a guarantee of origin and amended on March 31, 2006 October 17, 2006. Public Limited Comp-2006.
- Decree on the organization of the electricity market. 17.07.2000
- Decree containing various provisions relating to environment and energy (20/06/2006).
- Annex 1 BESL2006-5. Explanation of reporting the aggregated data reduction in Article 3 of BESL2006-5 on the commitment of the detailed technical rules on the use of guarantees of origin.
- Annex 1-Public Limited Comp 2006-5. Explanation of reporting the data on the quantity of electricity from renewable sources by supplier, according to Articles 2 and 3 of the Public Limited Comp-2006-5 regarding the establishment of the detailed technical rules on the use of guarantees of origin.

### **Brussels-Capital Region**

- F. 2004 - 4263 [C - 2004/31512] October 12, 2004. - Ministerial decision to establish the calculation code referred to in Article 2 of the decision of the Government of



Brussels-Capital Region 6 May 2004 on the promotion of green electricity and cogeneration quality

- F. 2004 - 2435 [C - 2004/31315] May 6, 2004. - Government Decree of the Brussels Capital Region for the promotion of green electricity and cogeneration quality
- F. 2007-85 [C - 2006/31640] December 14, 2006. - Ordinance amending the ordinances of 19 July 2001 and 1 April 2004 on the organization of the market for electricity and gas in the Brussels-Capital and repealing the ordinance of 11 July 1991 concerning the right to a minimum supply electricity and the order of 11 March 1999 establishing measures for the prevention of disconnection of gas for domestic use (1) (09/01/2007).
- F. 2007 - 3740 [C - 2007/31377] July 19, 2007. - Government Decree of the Brussels-Capital determining the procedures for granting security labels of origin, specifying the obligations on providers and amending the Decree of 6 May 2004 concerning the promotion of green electricity and quality cogeneration

### **A.3. BULGARIA**

- Energy Act. Promulgated in the State Gazette No. 107 of 9 December 2003, amended in the State Gazette No. 18 of 5 March 2004, amended in the State Gazette No. 18 of 25 February 2005, amended in the State Gazette No. 95 of 29 November 2005, amended in the State Gazette No. 30 of 11 April 2006, amended in the State Gazette No. 65 of 11 August 2006, amended in the State Gazette No. 74 of 8 September 2006
- ORDINANCE № 16 - 27 of 22 January 2008 on the conditions and procedure for the assessment of availability and estimated potential of the resource to produce energy from renewable and / or alternative energy sources. With effect from 01.01.2008 issued by Ministry of Economy and Energy. Prom. SG. issue 11 of 5 February 2008.
- ORDINANCE № 16 - 28 of 22.01.2008 on the content, terms and how to provide information produced, bought and sold quantities of energy from renewable and alternative energy sources and produced, bought and sold quantities of Biofuel Issued by the Minister of Economy, publ. SG. 11 of 5.02.2008, in force from 1.01.2008
- ORDINANCE №35 on the Regulation of Prices of Electricity (31/07/2007) amending the regulation of electricity prices (02/03/2004)
- ORDINANCE № RD-16-267 of 19.3.2008 on the calculation of the amount of electricity produced by combined heat and power. Issued by the Minister of Economy, publ. SG. 37 of 8.04.2008.
- Ordinance to issue certificates of origin for electricity produced from Renewable Energy. Adopted by Decree № 18 of 28.01.2009, promulgated. SG. 10 of 6.02.2009
- Ordinance to issue certificates of origin for electricity produced from res or by the CHP (title. - SG. 10 of 2009). Adopted by Decree № 110 of 14.05.2007, promulgated. SG. 41 of 22.05.2007, am. and supplemented. No. 10 of 6.02.2009
- Ordinance 332 on the Content, Structure, Terms and Procedure for the provision of the information required under European Community law in the field of Energy to the Institutions of the EU Community (11/12/2006)

### **A.4. CYPRUS**

- Law on the Promotion of Cogeneration and Heat (29/12/2006), Number 174 (1) 2006, issued by publication in the Official Gazette of the Republic number 4105 on 29/12/2006.
- A Regulated market electricity law of 2003. Number 122(I) 2003, issued by publication in the Official Gazette of the Republic under Article 52 of Constitution.

- The Market Regulation on Electricity (Amendment) Act of 2004, Number 239 (I) 2004. Ordinance amending on the regulation of electricity market law of 2003. (05/11/04)
- The Market Regulation on Electricity (Amendment) Act 2005. Number 143 (I) of 2005 Ordinance amending on the regulation of electricity market law, amendment in 2006
- Law amending the regulation of the electricity market law, number 173(1) 2006, 29.12.2006

#### **A.5. CZECH REPUBLIC**

- Decree No. 439/2005 Coll., which provides details of how to determine the amount of electricity from combined heat and power generation and determining the quantity of secondary energy sources (10/11/2005)
- Decree on electricity market rules and other conditions No.541/2005 Coll.
- No. 180/2005 Coll. ACT of 31 March 2005 on the promotion of electricity production from renewable energy sources and amending certain acts (Act on Promotion of Use of Renewable Sources) (31/03/2005)
- Act No. 158/2009 Coll. amending Act No. 458/2000 Coll. on business conditions and public administration in the energy sector and amending certain Acts (Energy Act), as amended, and amending some laws Act No. 158/2009 Coll. amending Act No. 458/2000 Coll. on business conditions and government in power sector (04/06/2009)
- Decree No. 344/2009 Coll. Details of how to determine the high-efficiency combined heat and power based on a useful heat and electricity from the determination of secondary energy sources (09/10/2009)
- Government Regulation No. 42/2006 Coll. amending Government Regulation No. 25/2003 Coll. laying down technical requirements for new hot-water boilers fired with liquid or gaseous fuels, as amended by Government Regulation No. 126/2004 Coll. (20/02/2006)
- Act No. 670/2004 Coll. amending Act No. 458/2000 Coll. on business conditions and public administration in the energy sector and amending certain Acts (Energy Act), as amended (30/12/2004)
- Government Regulation No. 25/2003 Coll. laying down technical requirements for new hot-water boilers fired with liquid or gaseous fuels (11/02/2003)
- Act No. 458/2000 Coll. on business conditions and public administration in the energy sector and amending certain Acts (Energy Act) (29/12/2000)
- Act No. 406/2000 Coll. on energy management (29/11/2000)

#### **A.6. DENMARK**

- Electricity Supply Act, Number 286, (20/04/2005)
- Heat Supply Act. Number 347 of 17 May 2005 (VFL)
- Order Number 146 of 16 February 2007 on Guarantees of origin for electricity from cogeneration 16/02/2007 (Bekendtgørelse om oprindelsesgaranti forelektricitet fra højeffektiv kraftvarmeproduktion).
- Guidelines for issuing guarantees of origin for electricity from cogeneration (version 1, from 1. 07 2007)
- Order on the labelling of electricity for consumers. Executive Order No. 145 of 02/16/2007

#### **A.7. ESTONIA**

- Electricity Market Act. RTI, 15/03/2007, 23, 120

- Description of supporting mechanism for renewable and efficient cogeneration electricity producers
- Regulation on Efficient cogeneration requirements (RTL 16.05.2007, 41, 696)

#### **A.8. FINLAND**

- Law on the excise taxation of specific fuels 30.12.1996/1260 Investment support for biomass based CHP-plants
- Act No 1129 on certification and notification of the origin of electricity, 19 December 2003.
- Government Decree No 1357 on certification of the origin of electricity , 30 December 2003.
- Government Decree on Notification of Origin of Electricity (233/2005)
- Government Decree No 97 amending the Government Decree on Certification of Origin of Electricity (19/02/2010)

#### **A.9. FRANCE**

- Consolidated Cogeneration Law : Arrête du 31 juillet 2001 consolidé au 23 août 2005
- Law No. 2005/781 of 07/13/2005 of the program laying down guidelines of energy policy.
- Decree No. 2006-1118 of 5 September 2006 on guarantees of origin of electricity produced from renewable energy sources or cogeneration.
- Order of 8 November 2007 made under Article 2 of Decree No. 2006 - 1118 of 5 September 2006 concerning guarantees of origin of electricity produced from renewable energy sources or cogeneration.

#### **A.10. GERMANY**

- Act to promote combined heat and power, Official Journal 49, 31/10/2008 (KWKG 2009)
- Law for Renewable Energy (Renewable Energy Sources Act - EEG). ), last revision of 25/10/2008.
- Second Act establishing new rules of the energy law of 7 July 2005. Federal Law Gazette 2005 Part I No. 42 (EnWG 2005)

#### **A.11. GREECE**

- Law on Generation of electricity using RES and High-Efficiency CHP and other provisions. 22 December 2005, Number 3468/2006
- Law on promotion of CHP and other Provisions (2009), Number 4734, 28/02/2009
- Ministerial Decree on a methodology for calculating the co-generated electricity from high efficiency CHP (2009)
- LAW No. 3851. Accelerating the development of RES to address climate change and other provisions. June 4, 2010.
- LAW No. 3734. Promotion of cogeneration of two or more useful forms of energy regulation issues related to the hydroelectric project of Mesochora and other provisions. January 28, 2009
- LAW No. 3426. Accelerating the liberalization process electricity market. 22 December 2005

#### **A.12. HUNGARY**

- Governmental decree No 389/2007. (XII. 23.) on obligatory off-take and purchase price of electricity generated from waste or from renewable energy sources, or by CHPG (not notified)\
- Decree 56/2002 on the purchase rules and price establishment of the electricity subject to the obligation of acceptance
- GKM decree 110/2007 on the calculation method of the electricity and consumable heat amounts in high efficiency CHPG (not notified)
- Act LXXXVI of 2007 on electricity (not notified)
- Decree 36/2002 on supplying certain data relating to the operation, functioning and use of the electricity system.
- Act CX/2001 on electricity in a harmonised structure including government decree 180/2002 on its implementation.

#### **A.13. IRELAND**

- Electricity regulation act, 1999
- Renewable Energy Feed in Tariff (RE-FIT - 2006)
- Energy (Miscellaneous Provisions) Act 2006(Commencement of Section 6) Order 2009
- S.I. 299 of 2009 Electricity Regulation Act 1999 (Appointment of Person to Calculate Power to Heat Ratios of Combined Heat and Power Units) Order 2009
- S.I. No. 298 of 2009 Energy (Miscellaneous Provisions) Act 2006 (Commencement of Section 6) Order 2009
- Calculation of 2007 Fuel Mix Disclosure Figures. Decision Paper and Response to Comments Received. CER/07/215. 13 November 2007

#### **A.14. ITALY**

- Legislative Decree 8 Feb. 2007, No 20. Implementation of Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC (G.U. No 54, March 6, 2007).
- Decree-Law of 18 June 2007, No 73, concerning urgent measures for the implementation of Community provisions on the liberalization of energy markets. Published in the Official Gazette No. 188, August 14, 2007
- Decree of 6 November 2007. Approval of technical procedures for the issue of guarantees of origin of electricity produced by cogeneration. (OJ No 275 of 26.11.2007)

#### **A.15. LATVIA**

- Electricity Market Law. 2005, Official Journal 82, 25/05/2005
- Regulations regarding Electricity Production in Cogeneration. Cabinet Regulation No. 921 Adopted 6 November 2006.
- Regulations regarding Electricity Production from Renewable Energy Resources. Cabinet Regulation No. 503. Adopted 24 July 2007.
- Provisions for electricity production and pricing of electricity generation in cogeneration. 17.03.2009. Cabinet Regulation Nr. 221

#### **A.16. LITHUANIA**

- Law on electricity 20 July, 2000, No. VIII –188.
- Revised version of the Law on Electricity as of 10 July 2004 No. IX-2307, (10/07/2004)

- Resolution on the approval of the National Energy Strategy No IX-1130 (16/10/2002)
- Resolution on the approval of the National Energy Strategy No X-1046 (26/01/2007)
- Resolution adopting legal acts necessary for the implementation of the electricity act, 1474 (12/12/2001)
- Order no. 4-224. Order amending the procedure for the purchase of electricity from CHP producers (15/06/2004)
- Order no. 4-206 "Process for approving the guarantee of origin certificates for electricity produced by high-efficiency co-generation ". Lithuanian Minister of Economy in 2008 19 May
- Order no. 1-26 revising Order No. 19. 4-206 about the process for approving the guarantee of origin certificates for electricity produced by high-efficiency co-generation
- Order no. 4-388 Conditions and procedure to connect to existing utilities facilities (networks, equipment, systems) to electricity consumers, manufacturers of energy facilities (networks, equipment, systems)
- Order no. 4-516 Plan for the development of co-generation (13/11/2008)
- Amendment Act to the Law on the Heat Sector No. X-1329 (11/12/2007)
- Order no. 4-123 On the purchase of electricity from combined heat and power producers (05/04/2008)
- Order Nr.380. Legislation necessary for Approval of the implementation of the Law on Electricity (29/12/2001)"
- Order no. 4-485 law required by the implementation of order no. 380 Law on Electricity
- Order no. 4-495 "List of identification of the public interest in the electricity sector" (04/01/2007)
- Resolution approving orientations for the development of the heat sector, 307 (25/03/2004)
- Resolution No. 665 amending Resolution No. 307 about policies for the development of the heat sector (19/07/2008)
- Order no. 4-253 amending order no. 326 about the Procedure and conditions to connect to existing utilities facilities (networks, equipment, systems) to power of consumers, manufacturers of energy facilities (networks, equipment, systems) (27/06/2008)
- Order no. 1-115 implementing the European Parliament and Council Directive 2004/8/EC on the promotion of cogeneration based on useful heat demand in the domestic energy market and amending Directive 92/42/EEC (18/07/2009)
- Law on the heat sector. IX-1565 (28/05/2003)

#### **A.17. LUXEMBOURG**

- Grand Ducal Regulation of 30 May 1994 concerning the production of electrical energy using renewable energy or cogeneration.
- Grand-Ducal Regulation of 22 May 2001 the introduction of a compensation fund under the organization of the electricity market.
- Law of 1 August 2007. Organization of the electricity market. Act of 1 August 2007.
- Law of August 5, 1993 concerning the Rational Use of Energy. Law of February 22, 2004 establishing a scheme to protect environment, rational use of energy and production energy from renewable sources.
- Law of Feb. 18, 2010 (not notified) on a system of aid for environmental protection and rational use of natural resources.

#### **A.18. MALTA**

- Subsidiary Legislation 423.22. Electricity Regulations. 16<sup>th</sup> December, 2004.
- Malta Resources Authority Act. (Cap.423). Cogeneration Regulations, 2007, 19/01/2007.
- Subsidiary Legislation 423.38, Guarantees of Origin of Electricity from High Efficiency Cogeneration and Renewable Energy Sources Regulations, 23 February 2010.

#### **A.19. NETHERLANDS**

- Act of July 2, 1998, establishing rules regarding the production, transmission and supply of electricity (Electricity Act 1998)
- Regulation of the Minister of Economy of June 6, 2003, WJZ No. 3019622, establishing implementing regulations on research installation, measurement and issuance of certificates with respect to electricity generated by CHP (Scheme Certificates cogeneration Electricity Act 1998)
- Annex 3, pertaining to Section 6a, the second paragraph of the regulations for certificates CHP Electricity Act 1998. Emission factors dioxide fuel used
- Regulation of the Minister of Economic Affaires of April 6, 2006, No. WJZ 6021274, amending the Cogeneration certificates scheme Electricity Act 1998 relating the closing of certificates.
- Regulation of the Minister of Economic Affaires of April 30, 2007, No. WJZ 7054690, amending the Guarantees of origin renewable electricity and Conditions CHP certificates. Electricity Act 1998 in connection with issuance of guarantees of origin and CHP certificates for individual production facilities behind a connection.
- Regulation of the Minister of Economic Affaires of June 12, 2006, No. WJZ 6043503, amending the CHP certificate scheme Electricity Act 1998 relating to the extension of the deadline for submitting a mandatory measurement report for the first quarter of 2006.
- Regulation of the Minister of Economic Affairs of 18 August 2006, No. WJZ 6053384, amending the control plant certificates Electricity Act 1998 associated with the identification of further requirements for issuing licenses for generating electricity cogeneration
- Regulation of the Minister of Economic Affairs of 14 September 2007, No. WJZ 7105952, on rules for the implementation of guarantees of origin for electricity generated in a plant for high efficiency heat and power cogeneration facility (Regulation on guarantees of origin for electricity generated in a plant for high efficiency heat and power cogeneration facility).

#### **A.20. POLAND**

- Law of 2 April 2004 - Energy Law and Environmental Act - amending the Energy Law of 10 April 1997
- Law of 12 January 2007- Energy Law and Environmental - amending the Energy Law of 10 April 1997
- Order 1314 of 26 September 2007 on the method of calculating the data contained in the request for a certificate of origin from cogeneration and obligation to obtain and present to redeem these certificates, payment of fees and the requirement to validate surrogate data on the amount of electricity produced in cogeneration
- Regulation 1846 on the essential requirements relating to the energy efficiency of new hot-water boilers

#### **A.21. PORTUGAL**

- Decree-Law n°. 23/2010 of 25 March (setting the rules applicable to the combined heat and power) (25/03/2010)
- Law n°. 19/2010 Amendment, of the Decree-Law No. 23/2010 of 25 March, which establishes the legal and remuneration applicable to electrical and mechanical energy and useful heat produced from cogeneration, transposing into national law Directive No 2004/8/EC of the European Parliament and the Council of 11 February. (23/08/2010)

#### **A.22. ROMANIA**

- The Electricity Law. No. 13/2007
- Decision 219 on the promotion of cogeneration based on a useful heat demand, (23/03/2007)
- Decision 1461 approving the procedure for issuing guarantees of origin for electricity produced in high efficiency cogeneration (4/12/2008)

#### **A.23. SLOVAKIA**

- Act 107 of 7 February 2007, amending Act No. 276/2001 Coll. on Regulation in Network Industries and amendments to certain other acts as amended, and amendments to certain other acts
- Government regulation of 4 July 2007 laying down rules for the electricity market
- Act 656 of 26 October 2004 Energy and consequential amendments
- Act 283 of the 2 July 2008 amending Act. 656/2004 on Energy and amending some laws.
- Regulation of the power distribution of 27 August 2007, establishing the scope and structure of eligible costs, determination of reasonable profit and background information to set prices in electricity and supplementing income. Regulation of the power distribution of 27 of June 2007, establishing the scope and implementation of price regulation in distribution companies.
- Ordinance 124 of 30 March 2005, which lays down rules for operation of the electricity market
- Law no. 599/2009 Z. which implements certain provisions of the Act on the promotion of renewable energy and highly efficient cogeneration (31/12/2009)
- Law no. 309/2009 Z. On the promotion of renewable energy and highly efficient cogeneration and amending some laws. (29/07/2009)
- Law no. 79/2006 Z. establishing the details of technical requirements to force hot water boilers fired with liquid or gaseous fuels and their conformity assessment procedures. (11/02/2006)
- Law no. 69/2006 Z. which amends Slovak Republic Government Order no. 433/2000 Z. Laws establishing the details of technical requirements for efficacy and conformity assessment procedures for hot-water boilers fired with liquid or gaseous fuels

#### **A.24. SLOVENIA**

- Act Amending the Act on the method of determination of the individual production sources of electrical energy and method of their presentation
- Act Amending the Energy Act (EA-C) of June 27, 2008. No. 003-02-6/2008-16

- Decree on the requirements to be met for obtaining the status of qualified electricity producer, number 3885.
- Regulation on issuing guarantees of origin for electricity, Number 5543, 04/01/2006
- Consolidation of 9 March 2007 of the Energy Act , which includes:
  - Energy Act - EZ (Official Gazette of RS, no. 79/99 of 30 9th 1999)
  - Revision of the Energy Act - EZ (Official Gazette RS, no. 8 / 00 of 31 first in 2000)
  - Law on State Administration - ZDU-1 (Official Gazette of RS, no. 52/02 of 14 6th 2002)
  - Construction Act - PGI-1 (Official Gazette of RS, no. 110/02 of 18 12th 2002)
  - Law Amending the Law on Energy - EA-A (Official Gazette of RS, no. 51/04 of 7 5th 2004)
  - Law Amending the Law on Energy - EZ-B (Official Gazette of RS, no. 118/06 of 17 11th 2006) and
  - revision of the Act Amending the Energy Act - EZ-B (Official Gazette of RS, no. 9 / 07 of second in 2007).
- ACT As regards the setting of the individual sources of electricity production and mode of their presentation
- Rules amending the order on efficiency requirements for new hot water boilers 63/2007

#### **A.25. SPAIN**

- Royal Decree 616/2007, of 11 May on the promotion of cogeneration.
- ORDER ITC/1522/2007, 24 May, establishing the regulation of the guarantee of origin of electricity from renewable energy sources and high efficiency cogeneration.
- CIRCULAR 2 / 2007 of 29 November, the National Energy Commission, which regulates the implementation and management of the guarantee of origin of electricity from renewable energy sources and high efficiency cogeneration.
- Royal Decree 661/2007 of 25 May, regulating the activity of production special regime electricity.
- Royal Decree 436/2004 of 12 March, establishing the methodology for updating and systematization of the legal and economic framework for electricity production in the special regime. (Effective until June 1, 2007)

#### **A.26. SWEDEN**

- The Electricity Act (1997:857) amended up to and including SFS 2008:265
- Regulation (2003:120) on electricity certificates
- Law on guarantees of origin for high-efficiency cogeneration and renewable electricity issued on 11 May 2006. SFS 2006:329
- Guidance on the origin of electricity (revised 2008-06-26)
- Swedish Energy Agency's Regulation on Guarantees of origin for electricity from cogeneration and renewable energy, 2006:8 01/01/2007
- Regulation on Guarantees of origin for electricity from cogeneration and renewable energy, 2006:331, 01/07/2006
- Mandatory provisions and general recommendations on efficiency requirements for new boilers powered by liquid or gaseous fuels of the National Board of Housing, Building and Planning (BFS 1997:58)

#### **A.27. UNITED KINGDOM**

- Energy Act 2008



- Climate Change Act 2008
- Enhanced Capital Allowances (ECA)
- Climate Change Levy (CCL) exemption (1/04/2001)
- Renewables obligation (RO)
- The Guarantees of Origin of Electricity produced from high-efficiency Cogeneration Regulations (Northern Ireland) 2008
- The Boiler (Efficiency) (Amendment) Regulations 2006
- The Guarantees of Origin of Electricity Produced From High – efficiency Cogeneration Regulations 2007

Legal Notice N. 12 of 2010. Electricity Authority Act 2003 Electricity (High –efficiency cogeneration) Regulations 2010



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## Abstract

This report is prepared in support of the implementation of Article 11 of the Cogeneration Directive (2004/8/EC), which states that the Commission should periodically report on progress in implementing the Directive and its effects in terms of promotion of high efficiency cogeneration. It analyses the potential for high-efficiency cogeneration in the EU and the progress towards realising that potential. The analysis is based on Member States' national reports, the templates with quantification of national potentials (as submitted by Member States in response to the Commission's request), external scenario data and technology parameters, and internal Commission analyses. It reviews the progress in transposing the Directive into Member States' law, which –as the analysis shows – has been generally achieved. Second, it reviews the extent to which the Directive mandated reporting rules and procedures have been implemented; this is generally achieved but the process has suffered lengthy delays and six Member States still have one or more reports outstanding. It compares the effect of the different support schemes promoting CHP. The aim of this analysis is to pinpoint which kind of supporting measures have been more effective in promoting CHP. It contains a review of the Reference Values. It assesses the impact of the EU Emissions Trading Scheme (EU ETS). It presents a number of recommendations that should be considered for improving the effectiveness of the Directive. It is not included in this report but will be sent separately.

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