

# Chapter 6

## Combined heat and power

### Introduction

6.1 This chapter sets out the contribution made by Combined Heat and Power (CHP) to the United Kingdom's energy requirements. The data presented in this chapter have been derived from information submitted to the CHP Quality Assurance programme (CHPQA) or by following the same procedures where no information has been provided directly. The CHPQA programme was introduced by the Government to provide the methods and procedures to assess and certify the quality of the full range of CHP schemes. It is a rigorous system for the Government to ensure that the incentives on offer are targeted fairly and benefit schemes in relation to their environmental performance.

6.2 CHP is the simultaneous generation of usable heat and power (usually electricity) in a single process. The term CHP is synonymous with cogeneration, which is commonly used in other Member States of the European Community and the United States. CHP uses a variety of fuels and technologies across a wide range of sizes and applications. The basic elements of a CHP plant comprise one or more prime movers (a reciprocating engine, gas turbine, or steam turbine) driving electrical generators, with the heat generated in the process captured and put to further productive use, such as for other industrial processes, hot water and space heating or cooling.

6.3 CHP is typically sized to make use of the available heat<sup>1</sup>, and connected to the lower voltage distribution system (i.e. embedded). This means that unlike conventional power stations, CHP can provide efficiency gains by avoiding significant transmission and distribution losses. CHP can also provide important network services such as black start, improvements to power quality, and some have the ability to operate in island mode if the grid goes down. There are four principal types of CHP system: steam turbine, gas turbine, combined cycle systems and reciprocating engines. Each of these is defined in paragraph 6.34 later in this chapter.

### Government policy towards CHP

6.4 Good Quality CHP denotes schemes that have been certified as being highly efficient through the UK's CHP Quality Assurance (CHPQA) programme. The criteria used are in line with the requirements for high efficiency CHP set down in the EU Cogeneration Directive (2004/8/EC). A Good Quality CHP plant must achieve 10 per cent primary energy savings compared to the separate generation of heat and power i.e. via a boiler and power station. Only Good Quality CHP schemes are eligible for Government support.

6.5 There are a range of support measures to incentivise the growth of Good Quality CHP in the UK. These include:

- Exemption from the Climate Change Levy (CCL) of all fuel inputs to, and electricity outputs from, Good Quality CHP.
- Eligibility to Enhanced Capital Allowances for Good Quality CHP plant and machinery.
- Favourable allocations of carbon allowances under Phase II of the EU Emissions Trading Scheme (EU ETS)
- Business Rates exemption for CHP power generation plant and machinery.
- Reduction of VAT (from 17.5 to 5 per cent) on domestic micro-CHP installations.
- Extension of the eligibility for Renewable Obligation Certificates (ROCs) to energy from waste plants that utilise CHP.
- Increased support under the Renewables Obligation from with two ROCs allocated to the Good Quality electricity output of CHP fuelled by biomass.

<sup>1</sup> But not always, see paragraph 6.10. In such cases there is an impact upon the electrical capacity and electrical output classified as CHP.

- In April 2010 the Carbon Reduction Commitment (CRC) came into force. The CRC is a mandatory emissions trading scheme that will cover large, non-energy intensive business, currently not covered under other policy measures like Climate Change Agreements (CCAs) and the EU ETS. In the CRC, organisations covered will be required to purchase allowances to cover the CO<sub>2</sub> emissions from all fixed-point energy sources. This means that allowances must be purchased to cover the use of electricity, gas and all other fuel types such as Liquefied Petroleum Gas (LPG) and diesel. However, under CRC heat is zero-rated, meaning that allowances will not have to be purchased by a site to cover any imported heat. It is expected that this treatment will stimulate a growth in the heat market, and this will in turn incentivise the use of CHP. From 2013, the first capped phase will commence and allowances will be sold to participants by auction.

## International context

6.6 The EU-ETS commenced on 1<sup>st</sup> January 2005 and involves the trading of carbon emissions allowances. The purpose of the EU-ETS is to reduce emissions by a fixed amount at least cost to the regulated sources. Each year participants in the scheme are allocated a set number of allowances. At the end of each trading year allowances equal to the reported emissions must be given up. In the EU-ETS Phase I National Allocation Plan (NAP), the sectoral classification of CHP plant depended on the sector in which it was modelled in DTI's Updated Energy Projections (UEP) and the presence of CHP at an installation was not considered explicitly in their allocation calculations. The sector in which an installation is classified has an effect on the level of its allocation, because allocations are calculated on the basis of sectoral growth projections. It was argued that this method of allocation would have an impact on CHP because its future growth and emissions are different to those of non-CHP installations in Phase I sectors. For this reason the Government decided to create a specific sector for GQCHP in Phase II, to ensure that incumbent CHP plant would not be disincentivised and to ensure that investment in GQCHP would be encouraged by the implementation of Phase II. Phase II runs from January 2008- December 2012.

6.7 All sites wishing to be included in the CHP sector were required to submit to CHPQA in 2006. This was to enable the Qualifying Power Capacity (QPC) to be determined for all schemes, and was necessary to ensure that the correct number of allocations was made to individual sites in the CHP sector. A consequence of this was that a number of sites that had previously not submitted to CHPQA, on the grounds that there were no fiscal benefits to accrue to them from the CHPQA process, submitted to CHPQA for the first time in 2006. This made available for the first time accurate data on capacities and energy inputs and outputs for these schemes. Where corrections were necessary, they were made back in time and revised historical data incorporating these corrections were presented in the 2007 Digest. The details of these corrections were provided in paragraph 6.31 of the 2007 Digest which is available on the DECC Energy web site at

[www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx](http://www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx)

6.8 Phase III of EU ETS will run from 2013 until 2027. Under this Phase there will be no allocation made in respect of CO<sub>2</sub> emissions associated with the generation of electricity, including electricity generated by CHP. However, there will be an allocation made in respect of CO<sub>2</sub> emissions associated with the generation of heat. The allocation will be based upon harmonised benchmarks for heat production, and a heat generating installation will receive 80 per cent of the allocations determined using this benchmark, declining linearly to 30 per cent by 2020 and then to 0 per cent by 2027. At the time of writing the benchmark value(s) for heat have not been determined.

6.9 UK incentives for CHP have influenced developments and operations of CHP in Continental Europe. The value of the CCL exemption on Good Quality CHP electricity outputs can be realised by the sale of Levy Exemption Certificates (LECs) issued against CHP electricity outputs exported to the grid and consumed in the UK. This has encouraged CHP operators in France, Denmark Germany and Republic of Ireland to generate and export low carbon CHP electricity to the UK. In 2009 LECs were issued in respect of 2,424 GWh of Good Quality CHP electricity generated by over 60 overseas CHP schemes. This represents approximately 8 per cent of Good Quality CHP electricity consumed in the UK in 2009. Electricity generated by overseas CHP schemes are not included in figures given in this chapter.

## UK energy markets, and their effect on CHP<sup>2</sup>

6.10 Two major factors affecting the economics of CHP are the relative cost of fuel (principally natural gas) and the value that can be realised for electricity. Energy price trends that are applicable to CHP schemes differ depending upon the size and sector of the scheme. During the last few years there has been an improving trend in the viability of CHP due to an increase in the price of electricity relative to that of gas. This is known as the spark gap (i.e. the difference between the price of electricity and the price of the gas required to generate that electricity). Due to the long term nature of CHP investments long term trends in the spark gap need to be taken into account.

## Use of CHPQA in producing CHP statistics

6.11 The CHPQA programme is the major source for CHP statistics. The following factors need to be kept in mind when using the statistics produced:

- Through CHPQA, scheme operators have been given guidance on how to determine the boundary of a CHP scheme (what is regarded as part of the CHP installation and what is not). A scheme can include multiple CHP prime movers<sup>3</sup>, along with supplementary boilers and generating plant, subject to appropriate metering being installed to support the CHP scheme boundaries proposed, and subject to appropriate metering and threshold criteria. (See CHPQA Guidance Note 11 available at [www.chpqa.com](http://www.chpqa.com)). This point is relevant when considering the figures in Table 6D, where the power efficiencies, heat efficiencies and heat to power ratios stated in that table for 2009 are those of the scheme, which may not be just the prime mover.
- The output of a scheme is based on gross power output, ignoring parasitic loads (i.e. ignoring power used in pumps, fans, etc. within the scheme itself).
- The main purpose of a number of CHP schemes is the generation of electricity including export to others. Such schemes may not be sized to use all of the available heat. In such cases, the schemes' total electrical capacity and electrical output have been scaled back using the methodologies outlined in CHPQA. Only the portion of the electrical capacity and electrical output that qualifies as Good Quality is counted in this chapter. The remaining electrical capacity and electrical output are regarded as power only, and these are reported in Chapter 5 as part of 'Other Generators'. The fuel allocated to the power-only portion of the output is calculated from the power efficiency of the prime mover.
- The load factor presented in Table 6A is based on the Good Quality Power Output and Good Quality Power Capacity reported in this Chapter. For schemes that are scaled back, this load factor is likely to be smaller than the actual load factor (hours run) for the prime mover in these schemes. Between 2008 and 2009 there was a small fall in the load factor and a small increase in overall efficiency.

<sup>2</sup> Reference source for price trends is DECC's 'Quarterly Energy Prices March 2009. Table 3.1.3', available at [www.decc.gov.uk/en/content/cms/statistics/publications/prices/prices.aspx](http://www.decc.gov.uk/en/content/cms/statistics/publications/prices/prices.aspx)

<sup>3</sup> The CHP prime mover is the heart of a CHP system and is a mechanical machine which drives the electricity generator or develops mechanical power for direct use

**Table 6A: A summary of the recent development of CHP<sup>(1)</sup>**

	Unit	2005	2006	2007	2008	2009
Number of schemes		1,365	1,364	1,415	1,437	1,465
Net No. of schemes added during year (2)		29	-1	51	22	28
Electrical capacity (CHP <sub>QPC</sub> )	MWe	5,533	5,432	5,438	5,494	5,569
Net capacity added during year		137	-101	6	56	74
Capacity added in percentage terms	Per cent	2.5	-1.8	0.1	1.0	1.4
Heat capacity	MWth	11,499	11,208	11,068	10,887	10,755
Heat to power ratio (3)		1.96	1.86	1.84	1.89	1.83
Fuel input (4)	GWh	124,611	122,354	118,643	120,369	116,708
Electricity generation (CHP <sub>QPO</sub> )	GWh	28,830	28,733	27,846	27,901	27,777
Heat generation (CHP <sub>QHO</sub> )	GWh	56,445	53,411	51,314	52,778	50,721
Overall efficiency (5)	Per cent	68.4	67.1	66.7	67.0	67.3
Load factor (4)	Per cent	59.5	60.4	58.5	58.0	56.9

(1) All data in this table for 2005 to 2009 have been revised since last year's Digest.

(2) Net number of schemes added = New schemes – Decommissioned existing schemes

(3) Heat to power ratios are calculated from the qualifying heat output (QHO) and the qualifying power output (QPO).

(4) The load factor reported in this table is based on the qualifying power generation and capacity and does not correspond exactly to the number of hours run by the prime movers in a year

(5) These are calculated using gross calorific values; overall net efficiencies are some 6 percentage points higher.

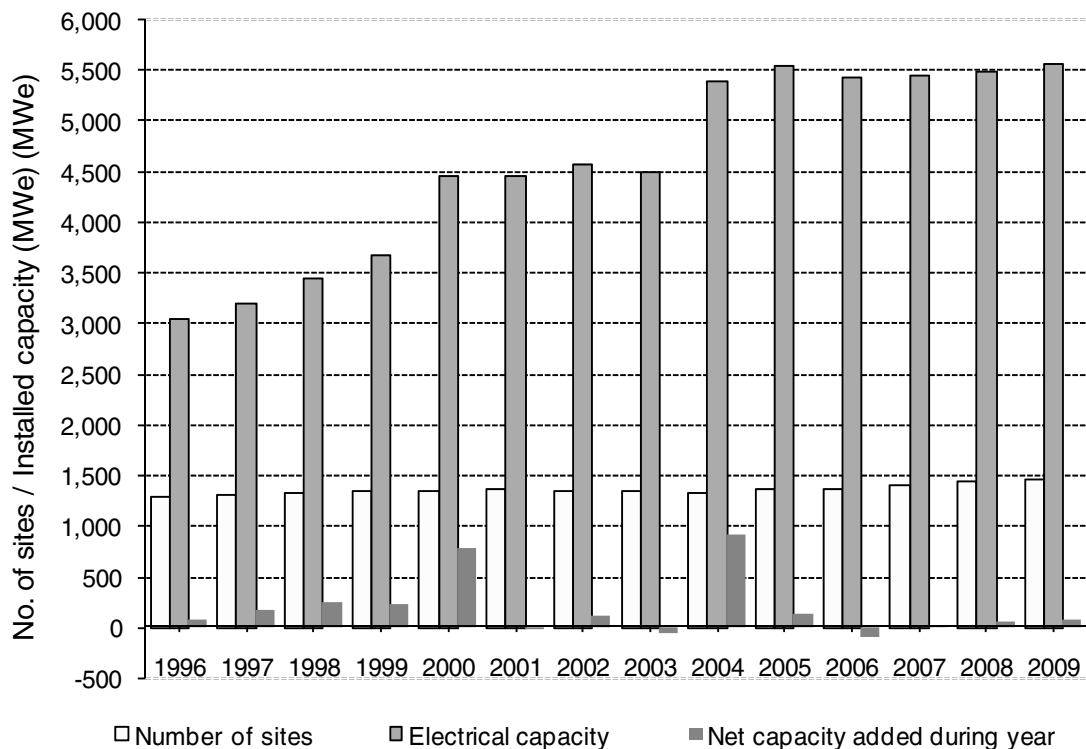
### Changes in CHP capacity

6.12 Chart 6.1 shows the change in installed CHP capacity over the last thirteen years. Installed capacity at the end of 2009 stood at 5,569 MWe. There was a net increase of 28 schemes between 2008 and 2009 and a net increase of 74 MWe in installed capacity.

### Installed capacity and output in 2009

6.13 During 2009 57 new CHP schemes came into operation. 29 CHP schemes that were operating in 2008 subsequently closed and did not operate in 2009. This resulted in a net increase of 28 schemes between 2008 and 2009.

**Chart 6.1: Installed CHP capacity by year**



6.14 In the current market conditions, a number of operators have chosen to mothball their CHP schemes rather than continue to operate. As these schemes are still able to operate they have been included in the capacity figures. At the end of 2009, there were 100 mothballed schemes with a Good Quality capacity of 91 MWe.

6.15 Table 6A gives a summary of the overall CHP market. The electricity generated by CHP schemes in 2009 was 27,777 GWh. This represents a little over 7 per cent of the total electricity generated in the UK. Across the commercial and industrial sectors (including the fuel industries other than electricity generation) electrical output from CHP accounted for around 15 per cent of electricity consumption. CHP schemes in total supplied 50,721 GWh of heat in 2009.

6.16 In terms of electrical capacity by size of scheme, schemes larger than 10 MWe represent over 83 per cent of the total electrical capacity of CHP schemes as shown in Table 6B. However, in terms of number of schemes, the largest share (81 per cent) is in schemes less than 1 MWe. Schemes of 1 MWe or larger, make up approximately 19 per cent of the total number of schemes. Table 6.5 provides data on electrical capacity for each type of CHP installation and the map on page 164 shows how these schemes are located around the country.

**Table 6B: CHP schemes by capacity size ranges in 2009**

Electrical capacity size range	Number of schemes	Share of total (per cent)	Total electricity capacity (MWe)	Share of total (per cent)
Less than 100 kWe	454	31.0	28	0.5
100 kWe - 999 kWe	738	50.4	190	3.4
1 MWe - 9.9 MWe	201	13.7	693	12.4
Greater than 10 MWe	72	4.9	4,657	83.6
<b>Total</b>	<b>1,465</b>	<b>100.0</b>	<b>5,569</b>	<b>100.0</b>

6.17 Seventy seven per cent of electrical capacity is now gas turbine based<sup>4</sup>, with about 85 per cent of this (66 per cent in total) in combined cycle mode. After combined cycle, reciprocating engines represent the second largest technology in terms of installed electrical capacity, closely followed by open cycle gas turbines, both with very similar individual shares of total installed capacity. Table 6.7 provides data on heat capacity for each type of CHP installation. Over the years there has been a clear downward trend in the capacity of back pressure and pass-out condensing steam turbines.

### Fuel used by types of CHP installation

6.18 Table 6.2 shows the fuel used to generate electricity and heat in CHP schemes, (see paragraphs 6.35 to 6.37, below for an explanation of the convention for dividing fuel between electricity and heat production). Table 6.3 gives the overall fuel used by types of CHP installation (which are explained in paragraph 6.34). Total fuel use is summarised in Chart 6.2. In 2009, 71 per cent of the total fuel use was natural gas, which is approximately the same proportion as was used in 2008. CHP schemes accounted for 8 per cent of UK gas demand in 2009 (see Table 4.3). Over the last few years the refineries sector has seen a decrease in the use of heavy fuel oil and an increase in the use of refinery gas and natural gas. This may be a reflection of the rise in the market value of heavy fuel oil over this same time period. A refinery selling rather than burning the heavy fuel oil it produces, and substituting this with lower value refinery gas and natural gas, the latter having increased in value less than fuel oil, would likely increase its revenue.

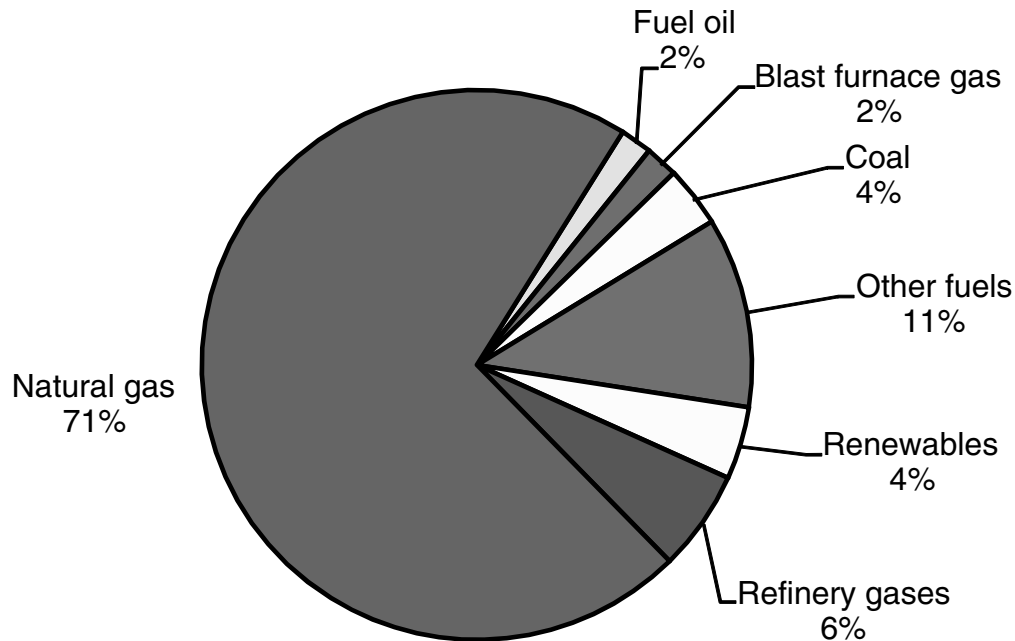
6.19 In 2009, there was a 5 per cent increase in the use of renewable fuels compared to 2008 (see Table 6.2). This increase was mainly due to increases in biomass and sewage gas, which saw an increase of 7 per cent and 20 per cent respectively. Renewable fuels surpassed the use of coal in CHP in 2008.

6.20 Non-conventional fuels (liquids, solids or gases which are by-products or waste products from industrial processes, or are renewable fuels) account for 23 per cent of all fuel used in CHP in 2009. Some of these are fuels that are not commonly used by the mainstream electricity generating industry, and some would otherwise be flared or disposed of by some means. These fuels, with the exception

<sup>4</sup> See table 6.5 Gas turbine and Combined cycle.

of some waste gases, will generally be utilised in steam turbines being fed by boilers. In almost all cases, the technical nature of the combustion process, and the lower fuel quality (lower calorific value of the fuel, high moisture content of the fuel, the need to maintain certain combustion conditions to ensure complete disposal etc.) will generally result in a lower efficiency. However, given that the use of such fuels avoids the use of fossil fuels, and since they need to be disposed of in some way, the use of these fuels in CHP provides environmental benefits.

**Chart 6.2: Types of fuel used by CHP schemes in 2009**

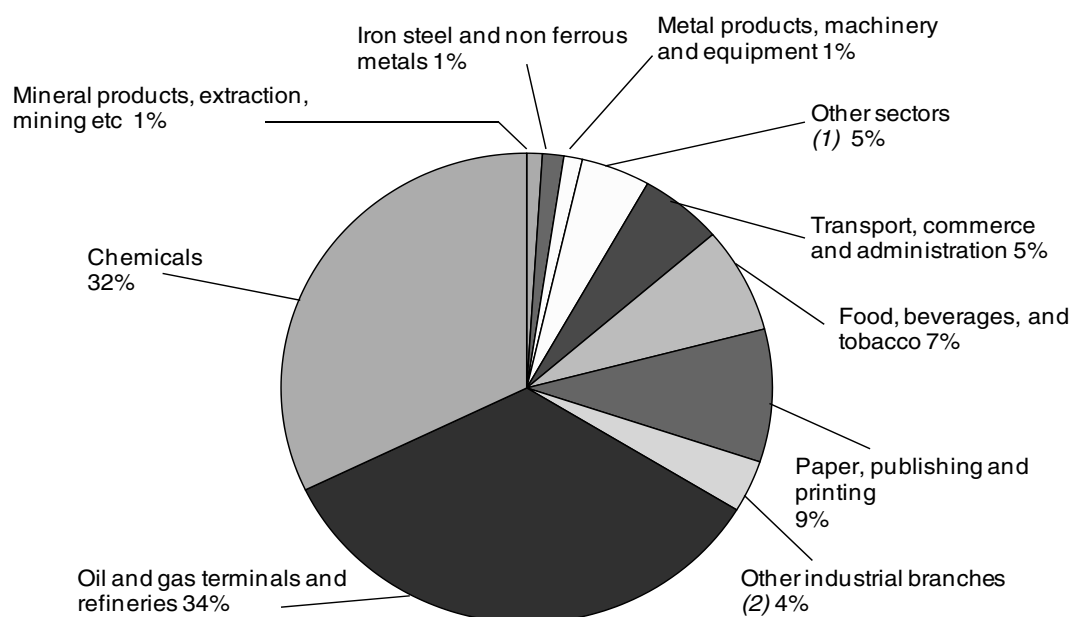


### CHP capacity, output and fuel use by sector

6.21 In this chapter of the Digest CHP is allocated to the sector using the heat, or, where the heat is sent to users in more than one sector, to the sector taking the majority of the heat. This method of assigning a CHP scheme to a sector was rigorously applied for the first time in DUKES 2008 and resulted in the movement of CHP schemes between sectors. One consequence of this was the removal of all schemes once allocated to the “electricity supply” sector and their distribution to other sectors. Full details of this reassignment are provided in paragraph 6.33 and Table 6J of DUKES 2008.

6.22 Table 6.8 gives data on all operational schemes by economic sector. A definition of the sectors used in this table can be found in Chapter 1, paragraph 1.58 and Table 1F:

- 343 schemes (90 per cent of electrical capacity) are in the industrial sector and 1,122, schemes (10 per cent of capacity) are in the agricultural, commercial, public administration, residential and transport sectors.
- Three industrial sectors account for about 75 per cent of the CHP electrical capacity – oil refineries (34 per cent), chemicals (32 per cent), and paper and publishing and printing (9 per cent). Capacity by sector is shown in Chart 6.3. In 2008 the chemicals sector had the largest share of CHP electrical capacity.

**Chart 6.3: CHP electrical capacity by sector in 2009**

(1) Other sectors include agriculture, community heating, leisure, landfill and incineration.  
 (2) Other industry includes textiles, clothing and footwear, and sewage treatment.

6.23 Table 6C gives a summary of the 1,001 schemes installed in the commercial sector, public sector and residential buildings. These schemes form a major part of the “Transport, commerce and administration” and “Other” sectors in Tables 6.8 and 6.9. The vast majority of these schemes are based on spark ignition reciprocating engines fuelled with natural gas, though the larger schemes use compression ignition reciprocating engines or gas turbines. The largest proportion of the capacity is in

**Table 6C: Number and capacity of CHP schemes installed in buildings by sector in 2009**

	Number of schemes	Electrical capacity (MWe)	Heat capacity (MWth)
Leisure	395	50.7	52.8
Hotels	244	34.8	40.9
Health	180	121.1	164.6
Residential Group Heating	39	27.8	59.8
Universities	42	50.4	83.8
Offices	20	16.7	12.0
Education	18	10.2	17.7
Government Estate	16	15.8	18.4
Retail	44	10.2	3.4
Other (1)	3	10.5	18.7
<b>Total</b>	<b>1,001</b>	<b>348.3</b>	<b>472.1</b>

(1) All schemes under Other are at airports

the health sector, mainly hospitals. Leisure and hotels account for nearly two-thirds of the total number of schemes but only about 25 per cent of the electrical capacity. Table 6.9 gives details of the quantities of fuels used in each sector.

## CHP performance by main prime mover

6.24 Table 6D gives a summary of the performance of schemes in 2009 by main prime mover type. Combined cycle gas turbines have the highest average operating hours at 5,348 hours per annum. The average for all schemes of 4,988 hours is nearly 2 per cent lower than in 2008 (5,078 hours - revised).

6.25 The average electrical efficiency is 24 per cent and heat efficiency 43 per cent, giving an overall average of 67 per cent, which is the same as in 2008 - revised (all measured on a gross calorific value (GCV) basis).

**Table 6D: A summary of scheme performance in 2009**

	Average operating hours per annum (Full load equivalent)	Average electrical efficiency (% GCV)	Average heat efficiency (% GCV)	Average overall efficiency (% GCV)	Average heat to power ratio
<b>Main prime mover in CHP plant</b>					
Back pressure steam turbine	4,763	11	62	73	5.4
Pass out condensing steam turbine	4,261	17	46	63	2.7
Gas turbine	4,920	21	50	71	2.5
Combined cycle	5,348	26	40	66	1.5
Reciprocating engine	3,591	27	42	69	1.5
<b>All schemes</b>	<b>4,988</b>	<b>24</b>	<b>43</b>	<b>67</b>	<b>1.8</b>

## CHP schemes which export and schemes with mechanical power output

6.26 Table 6E shows the electrical exports from CHP schemes between 2007 and 2009. Where a scheme that exports is Good Quality for only a portion of its capacity and output, the exports have been scaled back in the same way as power output has been scaled back (see paragraph 6.11, above). Exports accounted for about 25 per cent of power generation from CHP in 2009, but this may be an underestimate as reporting of exports remains voluntary under CHPQA.

**Table 6E: Electrical exports from CHP**

	2007	2008	GWh 2009
To part of same qualifying group (1)	931r	942r	564
To a firm NOT part of same qualifying group	3,522r	2,609r	1,471
To an electricity supplier	6,118r	5,668r	4,822
<b>Total</b>	<b>10,571r</b>	<b>9,218r</b>	<b>6,857</b>

(1) A qualifying group is a group of two or more corporate consumers that are connected or related to each other, for example, as a subsidiary, or via a parent or holding company, or in terms of share capital.

6.27 In 2009 21 large schemes also exported heat, some larger schemes to more than one customer. As Table 6F shows, together they supplied 8,127 GWh of heat in 2009.

**Table 6F: Heat exports from CHP**

	2007	2008	GWh 2009
To part of same qualifying group (1)	2,551r	3,672r	3,574
To a firm NOT part of same qualifying group	6,947r	8,388r	4,552
<b>Total</b>	<b>9,498r</b>	<b>12,059r</b>	<b>8,127</b>

(1) A qualifying group is a group of two or more corporate consumers that are connected or related to each other, for example, as a subsidiary, or via a parent or holding company, or in terms of share capital.

6.28 There are an estimated 12 schemes with mechanical power output. For those schemes, mechanical power accounts for around 5 per cent of their total power capacity (Table 6G). These schemes are predominantly on petro-chemicals or steel sites, using by-product fuels in boilers to drive steam turbines. The steam turbine is used to provide mechanical rather than electrical power, driving compressors, blowers or fans, rather than an alternator.

**Table 6G: CHP schemes with mechanical power output in 2009**

	Unit	
Number of schemes		12
Total Power Capacity of these schemes (CHP <sub>TPC</sub> )	MWe	4,221
Mechanical power capacity of these schemes	MWe	231

**Emissions savings**

6.29 The calculation of carbon emissions savings from CHP is important, given the substantial contribution that CHP can make to the Climate Change Programme. However the derivation of the savings is complex because CHP displaces a variety of fuels, technologies and sizes of plant. The methodology and assumptions used for calculating carbon emission savings are outlined in Energy Trends June 2003 ([www.decc.gov.uk/en/content/cms/statistics/publications/trends/trends.aspx](http://www.decc.gov.uk/en/content/cms/statistics/publications/trends/trends.aspx)) and the figures compare CHP with the UK fossil fuel basket carbon intensity and the UK total basket carbon intensity which includes nuclear and renewable generation. The carbon emission savings from CHP in 2009 as compared to the fossil fuel basket were 13.89 MtCO<sub>2</sub>, which equates to 2.49 Mt CO<sub>2</sub> per 1,000 MWe installed capacity. Against the total basket, in 2009 CHP saved 9.47 Mt CO<sub>2</sub>, or 1.70 Mt CO<sub>2</sub> per 1,000 MWe installed capacity. Corresponding figures for 2007 and 2008 are shown in Table 6H. It is worthy of note that from 2007 to 2009 the trend in carbon intensity of conventionally generated electricity for both the full mix and for fossil fuel only has been down, and this was particularly marked in the case of the full mix between 2008 and 2009.

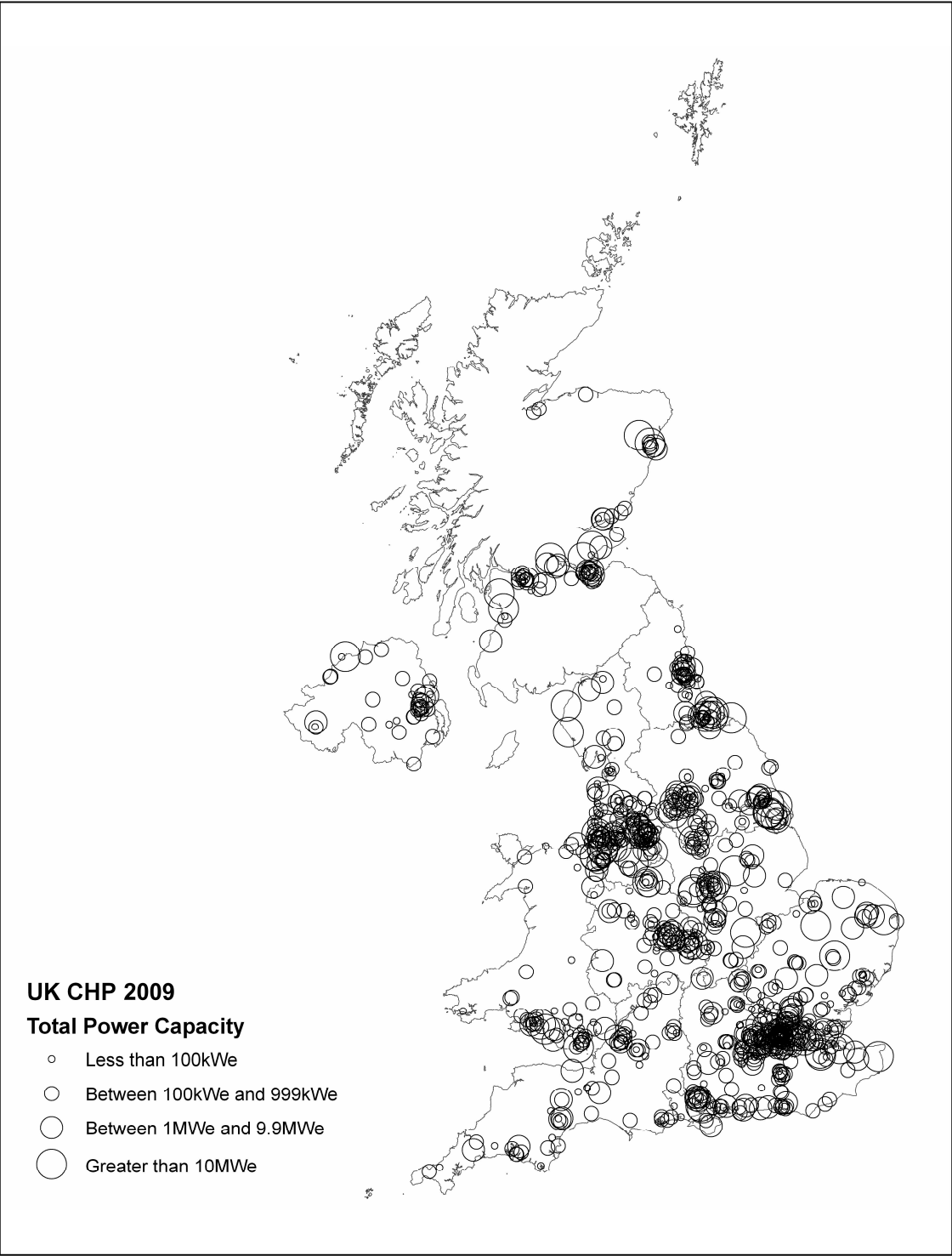
**Table 6H: Carbon dioxide savings due to CHP, absolute and per 1,000 MWe of installed good quality CHP capacity**

	2007		2008		2009	
	MtCO <sub>2</sub>	MtCO <sub>2</sub> /1000 MWe	MtCO <sub>2</sub>	MtCO <sub>2</sub> /1000 MWe	MtCO <sub>2</sub>	MtCO <sub>2</sub> /1000 MWe
Carbon savings against all fossil fuels	14.63	2.69	14.42	2.62	13.89	2.49
Carbon savings against all fuels ( including nuclear and renewables)	10.83	1.99	11.03	2.01	9.47	1.70

*Note: (1) The CO<sub>2</sub> savings in Table 6H assume that CHP generated electricity avoids the transmission and distribution losses associated with its conventionally generated equivalent. These losses are assumed to be 1.5% in the case of transmission losses and 6.0% in the case of distribution losses.*

*(2) The CO<sub>2</sub> savings quoted above for 2009 are based on preliminary CO<sub>2</sub> intensities, for that year, for the fossil fuel basket and the total fuel basket of conventional electricity generation. As such, they are subject to revision at a later date.*

# CHP schemes in the United Kingdom by power capacity, 2009



## Technical notes and definitions

6.30 These notes and definitions are in addition to the technical notes and definitions covering all fuels and energy as a whole in Chapter 1, paragraphs 1.26 to 1.61

### Data for 2009

6.31 The data are summarised from the results of a long-term project undertaken by AEA on behalf of the Department of Energy & Climate Change (DECC). Data are included for CHP schemes installed in all sectors of the UK economy.

6.32 The project continues to be overseen by a Steering Group that comprises officials from DECC, the Office of Gas and Electricity Markets (Ofgem), the Combined Heat and Power Association (CHPA) and the Office for National Statistics (ONS) all of whom have an interest in either the collection of information on CHP schemes or the promotion of the wider use of CHP in the UK.

6.33 Data for 2009 were based largely on data supplied to the CHPQA programme, by information from the Iron and Steel Statistics Bureau (ISSB) and from Ofgem “Renewables Obligation Certificates” (ROCs) information. Approximately 96 per cent of the total capacity is from schemes certified under the CHPQA programme, while about 1.2 per cent is from schemes covered by ISSB sources. Data for schemes not applying for CHPQA and not available from other sources were interpolated from historical data. These schemes account for about 0.9 per cent of total capacity. Since 2005, Sewage Treatment Works that do not provide returns to CHPQA in a format that can be used within these statistics, have been included based on ROCs information from Ofgem returns. The sewage treatment works data from this source accounts for approximately 2.2 per cent of total electrical capacity.

### Definitions of schemes

6.34 There are four principal types of CHP system:

- **Steam turbine**, where steam at high pressure is generated in a boiler. In **back pressure steam turbine systems**, the steam is wholly or partly used in a turbine before being exhausted from the turbine at the required pressure for the site. In **pass-out condensing steam turbine systems**, a proportion of the steam used by the turbine is extracted at an intermediate pressure from the turbine with the remainder being fully condensed before it is exhausted at the exit. (Condensing steam turbines without passout and which do not utilise steam are not included in these statistics as they are not CHP). The boilers used in such schemes can burn a wide variety of fuels including coal, gas, oil, and waste-derived fuels. With the exception of waste-fired schemes, a steam turbine plant has often been in service for several decades. Steam turbine schemes capable of supplying useful steam have electrical efficiencies of between 10 and 20 per cent, depending on size, and thus between 70 per cent and 30 per cent of the fuel input is available as useful heat. Steam turbines used in CHP applications typically range in size from a few MWe to over 100 MWe.
- **Gas turbine systems**, often aero-engine derivatives, where fuel (gas, or gas-oil) is combusted in the gas turbine and the exhaust gases are normally used in a waste heat boiler to produce usable steam, though the exhaust gases may be used directly in some process applications. Gas turbines range from 30 kWe upwards, achieving electrical efficiency of 23 to 30 per cent (depending on size) and with the potential to recover up to 50 per cent of the fuel input as useful heat. They have been common in CHP since the mid 1980s. The waste heat boiler can include supplementary or auxiliary firing using a wide range of fuels, and thus the heat to power ratio of the scheme can vary.
- **Combined cycle systems**, where the plant comprises more than one prime mover. These are usually gas turbines where the exhaust gases are utilised in a steam generator, the steam from which is passed wholly or in part into one or more steam turbines. In rare cases reciprocating engines may be linked with steam turbines. Combined cycle is suited to larger installations of 7 MWe and over. They achieve higher electrical efficiency and a lower heat to power ratio than steam turbines or gas turbines. Recently installed combined cycle gas turbine (CCGT) schemes

have achieved an electrical efficiency approaching 50 per cent, with 20 per cent heat recovery, and a heat to power ratio of less than 1:1.

- **Reciprocating engine systems** range from less than 100 kWe up to around 5 MWe, and are found in applications where production of hot water (rather than steam) is the main requirement, for example, on smaller industrial sites as well as in buildings. They are based on auto engine or marine engine derivatives converted to run on gas. Both compression ignition and spark ignition firing is used. Reciprocating engines operate at around 28 to 33 per cent electrical efficiency with around 50 per cent to 33 per cent of the fuel input available as useful heat. Reciprocating engines produce two grades of waste heat: high grade heat from the engine exhaust and low grade heat from the engine cooling circuits.

### Determining fuel consumption for heat and electricity

6.35 In order to provide a comprehensive picture of electricity generation in the United Kingdom and the fuels used to generate that electricity, the energy input to CHP schemes has to be allocated between heat and electricity production. This allocation is notional and is not determinate.

6.36 The convention used to allocate the fuels to heat and electricity relates the split of fuels to the relative efficiency of heat and electricity supply. The efficiency of utility plant varies widely: electricity generation from as little as 25 per cent to more than 50 per cent and boilers from 50 per cent to more than 90 per cent. Thus it is around twice as hard to generate a unit of electricity as it is to generate a unit of heat. Accordingly a simple convention can be implemented whereby twice as many units of fuel are allocated to each unit of electricity generated, as to each unit of heat supplied. This approach is consistent with the Defra Guidelines for Company Reporting on greenhouse gas emissions and for Negotiated Agreements on energy efficiency agreed between Government and industry as part of the Climate Change Levy (CCL) package. It recognises that, in developing a CHP scheme, both the heat customer(s) and the electricity generator share in the savings, reflecting the fact that more than three-quarters of CHP build in the last few years has been supplied under an energy services arrangement.

6.37 The assumption in this convention that it is twice as hard to generate a unit of electricity as heat, is appropriate for the majority of CHP schemes. However, for some types of scheme (for example in the iron and steel sector) this allocation is less appropriate and can result in very high apparent heat efficiencies. These, however, are only notional efficiencies.

### The effects on the statistics of using CHPQA

6.38 Paragraph 6.11 described how schemes were scaled back so that only  $CHP_{QPC}$  and  $CHP_{QPO}$  are included in the CHP statistics presented in this Chapter. This is illustrated in Table 6K. In 2008, 173 schemes have been scaled back. In 2007, 185 (revised) schemes were also scaled back.

6.39 In 2008, the power output from these schemes was scaled back from a total of 32,343 GWh to 8,612 GWh. The total fuel input to these schemes was 93,594 GWh of which 56,035 GWh was regarded as being for power only.

**Table 6K: CHP capacity, output and fuel use which has been scaled back in 2009**

	Units	
Number of schemes requiring scaling back		180
Total Power Capacity of these schemes ( $CHP_{TPC}$ )	MWe	6,622
Qualifying Power Capacity of these schemes ( $CHP_{QPC}$ )	MWe	2,588
Total power output of these schemes ( $CHP_{TPO}$ )	GWh	38,134
Qualifying Power Output of these schemes ( $CHP_{QPO}$ )	GWh	13,298
Electricity regarded as "Power only" not from CHP ( $CHP_{TPO} - CHP_{QPO}$ )	GWh	24,837
Total Fuel Input of these schemes ( $CHP_{TFI}$ )	GWh	109,987
Fuel input regarded as being for "Power only" use i.e. not for CHP	GWh	58,657

*\*This figure includes generation from major power producers*

### Exports of electricity and heat

6.40 The figures quoted in Tables 6E and 6F for exports of electricity and heat are based mainly on voluntary returns from schemes. As such, there is the potential for these figures to underestimate the

true situation. However, and in respect of exports of electricity, all schemes participating in CHPQA, exporting to the grid and participating in the Levy Exemption Certificate (LEC) scheme are required to identify a meter recording this exported electricity. Where a site meeting these criteria has not volunteered electricity export data this meter reading is used when compiling the data presented in Table 6E. In such cases all electricity read by this meter is assumed to be exported to an electricity supplier, via the grid. If this value exceeds the QPO for the scheme, then the quantity of exported electricity is amended to QPO. For all schemes, where a value of exported electricity is volunteered this figure is used when compiling the data presented in Table 6E.

This is the first time this approach has been adopted and is intended to improve the representative nature of the export data presented in Table 6E. The data presented for 2007 and 2008 in this edition of DUKES have been compiled on the same basis as for 2009.

Exports of heat, quoted in Table 6F, continue to be compiled on the basis of volunteered data only.

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## 6.1 CHP installations by capacity and size range

	2005	2006	2007	2008	2009
<b>Number of schemes (1)</b>	<b>1,365r</b>	<b>1,364r</b>	<b>1,415r</b>	<b>1,437r</b>	<b>1,465</b>
Less than 100 kWe	463r	462r	456r	457r	454
100 kWe to 999 kWe	639r	644r	687r	706r	738
1 MWe to 9.9 MWe	188	187	202r	202r	201
10.0 MWe and above	75	71	70	72r	72
					<b>MWe</b>
<b>Total capacity</b>	<b>5,533r</b>	<b>5,432r</b>	<b>5,438r</b>	<b>5,494r</b>	<b>5,569</b>
Less than 100 kWe	29	29	29	28r	28
100 kWe to 999 kWe	165r	166r	179r	182	190
1 MWe to 9.9 MWe	731	705	733r	711r	693
10.0 MWe and above	4,607	4,532	4,497	4,573r	4,657

(1) A site may contain more than one CHP scheme.

## 6.2 Fuel used to generate electricity and heat in CHP installations

	2005	2006	2007	2008	2009
					<b>GWh</b>
<b>Fuel used to generate electricity (1)</b>					
Coal (2)	1,559	1,797	1,750	1,856r	1,840
Fuel oil	1,617	1,552	892	887r	901
Natural gas	47,506r	46,864r	46,507r	46,130r	45,618
Renewable fuels (3)	1,414	1,783	1,742	2,373r	2,525
Other fuels (4)	10,411	10,801	10,300	10,100r	9,472
<b>Total all fuels</b>	<b>62,507r</b>	<b>62,796r</b>	<b>61,192r</b>	<b>61,346r</b>	<b>60,356</b>
<b>Fuel used to generate heat</b>					
Coal (2)	2,591	2,559	2,369	2,418r	2,357
Fuel oil	2,150	2,006	1,248	1,178r	1,284
Natural gas	41,145r	39,269r	38,515r	39,509r	37,526
Renewable fuels (3)	1,434	1,400	1,477	2,344r	2,456
Other fuels (4)	14,784	14,323	13,842	13,574r	12,729
<b>Total all fuels</b>	<b>62,104r</b>	<b>59,558r</b>	<b>57,452r</b>	<b>59,023r</b>	<b>56,352</b>
<b>Overall fuel use</b>					
Coal (2)	4,150	4,356	4,120	4,274r	4,197
Fuel oil	3,767	3,558	2,140	2,065r	2,185
Natural gas	88,651r	86,133r	85,022r	85,639r	83,144
Renewable fuels (3)	2,848	3,183	3,219	4,717r	4,982
Other fuels (4)	25,196	25,124	24,142	23,675r	22,200
<b>Total all fuels</b>	<b>124,611r</b>	<b>122,354r</b>	<b>118,643r</b>	<b>120,369r</b>	<b>116,708</b>

(1) See paragraphs 6.35 to 6.37 for an explanation of the method used to allocate fuel use between heat generation and electricity generation.

(2) Includes coke and semi-coke.

(3) Renewable fuels include: Biomass; sewage gas; other biogases; municipal waste and refuse derived fuels.

(4) Other fuels include: process by-products, coke oven gas, blast furnace gas, gas oil and refinery gas.

## 6.3 Fuel used by types of CHP installation

GWh

	2005	2006	2007	2008	2009
<b>Coal</b>					
Back pressure steam turbine	903	693	592	521	513
Gas turbine	44	-	43	29	-
Combined cycle	41	589	568	834r	832
Reciprocating engine	-	-	-	8	1
Pass out condensing steam turbine	3,162	3,074	2,916	2,881r	2,851
<b>Total coal</b>	<b>4,150</b>	<b>4,356</b>	<b>4,120</b>	<b>4,274r</b>	<b>4,197</b>
<b>Fuel oil</b>					
Back pressure steam turbine	463	207	138	140	185
Gas turbine	8	12	3	1r	2
Combined cycle	2,953	2,994	1,629	1,474r	1,472
Reciprocating engine	162	140	139	153	163
Pass out condensing steam turbine	182	206	232	297	362
<b>Total fuel oil</b>	<b>3,767</b>	<b>3,558</b>	<b>2,140</b>	<b>2,065r</b>	<b>2,185</b>
<b>Natural gas</b>					
Back pressure steam turbine	2,938	2,154	1,855	1,694r	1,757
Gas turbine	12,358	11,462	11,763	12,273r	11,386
Combined cycle	65,112	64,979	63,719	63,907r	61,865
Reciprocating engine	6,990r	6,409r	6,719r	6,903r	7,265
Pass out condensing steam turbine	1,254	1,128	966	863r	871
<b>Total natural gas</b>	<b>88,651r</b>	<b>86,133r</b>	<b>85,022r</b>	<b>85,639r</b>	<b>83,144</b>
<b>Renewable fuels (1)</b>					
Back pressure steam turbine	326	535	525	1,521	1,431
Gas turbine	30	26	10	-	-
Combined cycle	634	654	611	520r	562
Reciprocating engine	1,484	1,317	1,462	1,508r	1,820
Pass out condensing steam turbine	374	651	611	1,167r	1,168
<b>Total renewable fuels</b>	<b>2,848</b>	<b>3,183</b>	<b>3,219</b>	<b>4,717r</b>	<b>4,982</b>
<b>Other fuels (2)</b>					
Back pressure steam turbine	5,930	5,829	5,090	5,089	4,932
Gas turbine	4,040	4,125	4,024	3,514r	3,625
Combined cycle	11,436	10,516	10,837	11,274r	9,905
Reciprocating engine	58	57	51	36r	34
Pass out condensing steam turbine	3,731	4,597	4,141	3,761	3,705
<b>Total other fuels</b>	<b>25,196</b>	<b>25,124</b>	<b>24,142</b>	<b>23,675r</b>	<b>22,200</b>
<b>Total - all fuels</b>					
Back pressure steam turbine	10,559	9,418	8,199	8,966r	8,818
Gas turbine	16,480	15,625	15,843	15,817r	15,014
Combined cycle	80,176	79,733	77,363	78,009r	74,637
Reciprocating engine	8,695r	7,923r	8,371r	8,608r	9,283
Pass out condensing steam turbine	8,702	9,655	8,867	8,969r	8,957
<b>Total all fuels</b>	<b>124,611r</b>	<b>122,354r</b>	<b>118,643r</b>	<b>120,369r</b>	<b>116,708</b>

(1) Renewable fuels include: Biomass; sewage gas, other biogases, municipal solid waste and refuse derived fuel.

(2) Other fuels include: process by-products, coke oven gas, blast furnace gas, gas oil and refinery gas.

## 6.4 CHP - electricity generated by fuel and type of installation

GWh

	2005	2006	2007	2008	2009
<b>Coal</b>					
Back pressure steam turbine	99	77	63	57	52
Gas turbine	7	-	7	5	-
Combined cycle	3	136	120	172r	172
Reciprocating engine	-	-	-	1	0
Pass out condensing steam turbine	541	517	514	501r	503
<b>Total coal</b>	<b>650</b>	<b>730</b>	<b>704</b>	<b>736r</b>	<b>728</b>
<b>Fuel oil</b>					
Back pressure steam turbine	53	25	16	16	20
Gas turbine	2	3	1	0r	0
Combined cycle	636	618	316	303r	286
Reciprocating engine	50	47	47	51	53
Pass out condensing steam turbine	29	34	36	44	58
<b>Total fuel oil</b>	<b>769</b>	<b>727</b>	<b>417</b>	<b>413r</b>	<b>418</b>
<b>Natural gas</b>					
Back pressure steam turbine	235	172	142	122r	125
Gas turbine	2,697	2,464	2,701	2,704r	2,524
Combined cycle	17,381	17,600	16,952	16,715r	16,625
Reciprocating engine	1,778r	1,617r	1,688r	1,724r	1,907
Pass out condensing steam turbine	155	135	144	131r	273
<b>Total natural gas</b>	<b>22,246r</b>	<b>21,987r</b>	<b>21,626r</b>	<b>21,396r</b>	<b>21,455</b>
<b>Renewable fuels (1)</b>					
Back pressure steam turbine	36	70	71	215	196
Gas turbine	5	4	1	-	-
Combined cycle	43	60	21	10r	16
Reciprocating engine	416	387	445	460r	534
Pass out condensing steam turbine	34	109	115	212r	212
<b>Total renewable fuels</b>	<b>534</b>	<b>631</b>	<b>653</b>	<b>898r</b>	<b>959</b>
<b>Other fuels (2)</b>					
Back pressure steam turbine	684	641	593	628	604
Gas turbine	642	571	608	540r	555
Combined cycle	2,975	2,860	2,800	2,899r	2,567
Reciprocating engine	12	14	12	9r	8
Pass out condensing steam turbine	316	573	432	383	484
<b>Total other fuels</b>	<b>4,631</b>	<b>4,659</b>	<b>4,445</b>	<b>4,458r</b>	<b>4,218</b>
<b>Total - all fuels</b>					
Back pressure steam turbine	1,107	987	884	1,037	999
Gas turbine	3,354	3,041	3,318	3,249r	3,079
Combined cycle	21,037	21,274	20,209	20,098r	19,666
Reciprocating engine	2,256r	2,064r	2,193r	2,245r	2,503
Pass out condensing steam turbine	1,075	1,367	1,241	1,271r	1,530
<b>Total all fuels</b>	<b>28,830r</b>	<b>28,733r</b>	<b>27,846r</b>	<b>27,901r</b>	<b>27,777</b>

(1) Renewable fuels include: Biomass; sewage gas, other biogases, municipal solid waste and refuse derived fuel

(2) Other fuels include: process by-products, coke oven gas, blast furnace gas, gas oil and refinery gas.

## 6.5 CHP - electrical capacity by fuel and type of installation

	MWe				
	2005	2006	2007	2008	2009
<b>Coal</b>					
Back pressure steam turbine	32	26	28	20	19
Gas turbine	1	-	1	1	-
Combined cycle	0	18	20	26r	26
Reciprocating engine	-	-	-	1	0
Pass out condensing steam turbine	159	150	145	145r	144
<b>Total coal</b>	<b>193</b>	<b>195</b>	<b>194</b>	<b>193r</b>	<b>190</b>
<b>Fuel oil</b>					
Back pressure steam turbine	14	9	7	7	7
Gas turbine	0	0	0	0	0
Combined cycle	116	131	68	60	64
Reciprocating engine	16	16	16	16	16
Pass out condensing steam turbine	8	8	10	12	12
<b>Total fuel oil</b>	<b>154</b>	<b>165</b>	<b>102</b>	<b>94r</b>	<b>99</b>
<b>Natural gas</b>					
Back pressure steam turbine	74	61	47	37	39
Gas turbine	494	479	502r	531r	508
Combined cycle	3,045	3,015	3,029	3,002r	3,092
Reciprocating engine	506r	496r	522r	542r	547
Pass out condensing steam turbine	61	43	39	39r	65
<b>Total natural gas</b>	<b>4,180</b>	<b>4,095r</b>	<b>4,140r</b>	<b>4,150r</b>	<b>4,251</b>
<b>Renewable fuels (1)</b>					
Back pressure steam turbine	12	16	16	37	35
Gas turbine	1	1	0	-	-
Combined cycle	6	10	8	3r	3
Reciprocating engine	100	100	116	119r	130
Pass out condensing steam turbine	10	23	23	45r	45
<b>Total renewable fuels</b>	<b>129</b>	<b>149</b>	<b>163</b>	<b>203r</b>	<b>213</b>
<b>Other fuels (2)</b>					
Back pressure steam turbine	137	112	109	109	109
Gas turbine	111	113	119	114	118
Combined cycle	522	494	509	535	493
Reciprocating engine	4	4	4	3r	3
Pass out condensing steam turbine	103	105	99	93	93
<b>Total other fuels</b>	<b>877</b>	<b>828</b>	<b>840</b>	<b>854r</b>	<b>816</b>
<b>Total - all fuels</b>					
Back pressure steam turbine	270	225	207	210	210
Gas turbine	607	593	623r	646r	626
Combined cycle	3,688	3,668	3,635	3,625r	3,677
Reciprocating engine	626r	616	658r	681r	697
Pass out condensing steam turbine	342	330	315	333r	359
<b>Total all fuels</b>	<b>5,533r</b>	<b>5,432r</b>	<b>5,438r</b>	<b>5,494r</b>	<b>5,569</b>

(1) Renewable fuels include: Biomass; sewage gas, other biogases, municipal solid waste and refuse derived fuels.

(2) Other fuels include: process by-products, coke oven gas, blast furnace gas, gas oil and refinery gas.

## 6.6 CHP - heat generated by fuel and type of installation

	GWh				
	2005	2006	2007	2008	2009
<b>Coal</b>					
Back pressure steam turbine	713	504	442	373	367
Gas turbine	24	-	24	19	-
Combined cycle	7	170	155	237r	236
Reciprocating engine	-	-	-	4	0
Pass out condensing steam turbine	1,526	1,503	1,380	1,396r	1,363
<b>Total coal</b>	<b>2,270</b>	<b>2,177</b>	<b>2,002</b>	<b>2,028r</b>	<b>1,966</b>
<b>Fuel oil</b>					
Back pressure steam turbine	336	181	122	117	136
Gas turbine	4	5	2	1r	1
Combined cycle	1,560	1,568	901	789r	824
Reciprocating engine	55	43	44	49r	54
Pass out condensing steam turbine	85	90	101	131	162
<b>Total fuel oil</b>	<b>2,040</b>	<b>1,886</b>	<b>1,169</b>	<b>1,086r</b>	<b>1,177</b>
<b>Natural gas</b>					
Back pressure steam turbine	2,271	1,672	1,444	1,278r	1,304
Gas turbine	6,143	5,648	5,679	6,236r	5,763
Combined cycle	26,435	25,976	25,396	25,751r	24,341
Reciprocating engine	3,083r	2,842r	2,941r	3,094r	3,150
Pass out condensing steam turbine	696	611	507	402r	641
<b>Total natural gas</b>	<b>38,627r</b>	<b>36,750r</b>	<b>35,967r</b>	<b>36,761r</b>	<b>35,200</b>
<b>Renewable fuels (1)</b>					
Back pressure steam turbine	144	242	176	755	744
Gas turbine	16	14	5	-	-
Combined cycle	108	107	85	82r	77
Reciprocating engine	554	444	518	493r	639
Pass out condensing steam turbine	146	143	141	256r	256
<b>Total renewable fuels</b>	<b>968</b>	<b>949</b>	<b>924</b>	<b>1,586r</b>	<b>1,716</b>
<b>Other fuels (2)</b>					
Back pressure steam turbine	3,558	3,314	2,911	3,079	2,879
Gas turbine	1,973	1,962	1,891	1,734r	1,801
Combined cycle	4,841	4,209	4,562	4,811r	4,311
Reciprocating engine	24	23	22	11r	13
Pass out condensing steam turbine	2,145	2,141	1,867	1,681	1,658
<b>Total other fuels</b>	<b>12,541</b>	<b>11,649</b>	<b>11,253</b>	<b>11,317r</b>	<b>10,662</b>
<b>Total - all fuels</b>					
Back pressure steam turbine	7,022	5,912	5,094	5,602r	5,430
Gas turbine	8,160	7,630	7,601	7,990r	7,565
Combined cycle	32,950	32,030	31,100	31,669r	29,789
Reciprocating engine	3,715r	3,351r	3,525r	3,652r	3,857
Pass out condensing steam turbine	4,598	4,488	3,995	3,865r	4,080
<b>Total all fuels</b>	<b>56,445r</b>	<b>53,411r</b>	<b>51,314r</b>	<b>52,778r</b>	<b>50,721</b>

(1) Renewable fuels include: Biomass; sewage gas, other biogases, municipal solid waste and refuse derived fuels.

(2) Other fuels include: process by-products, coke oven gas, blast furnace gas, gas oil and refinery gas.

## 6.7 CHP - heat capacity by fuel and type of installation

	MWth				
	2005	2006	2007	2008	2009
<b>Coal</b>					
Back pressure steam turbine	200	152	160	127	122
Gas turbine	4	-	3	4	-
Combined cycle	1	14	16	19r	19
Reciprocating engine	-	-	-	1	0
Pass out condensing steam turbine	445	453	424	444r	432
<b>Total coal</b>	<b>649</b>	<b>619</b>	<b>604</b>	<b>595r</b>	<b>574</b>
<b>Fuel oil</b>					
Back pressure steam turbine	94	51	42	39	41
Gas turbine	1	1	0	0	0
Combined cycle	247	275	119	102r	111
Reciprocating engine	17	18	18	18	18
Pass out condensing steam turbine	23	23	28	36	39
<b>Total fuel oil</b>	<b>382</b>	<b>367</b>	<b>207</b>	<b>195</b>	<b>209</b>
<b>Natural gas</b>					
Back pressure steam turbine	457	364	348	289	295
Gas turbine	1,496	1,424	1,402r	1,381r	1,260
Combined cycle	4,267	4,252	4,431	4,391r	4,435
Reciprocating engine	690r	667r	661r	647r	643
Pass out condensing steam turbine	183	176	159	130r	140
<b>Total natural gas</b>	<b>7,091r</b>	<b>6,884r</b>	<b>7,001r</b>	<b>6,838r</b>	<b>6,774</b>
<b>Renewable fuels (1)</b>					
Back pressure steam turbine	44	47	45	45	40
Gas turbine	2	2	2	-	-
Combined cycle	16	17	16	16	17
Reciprocating engine	114	113	111	110r	110
Pass out condensing steam turbine	43	43	43	43	43
<b>Total renewable fuels</b>	<b>220</b>	<b>222</b>	<b>218</b>	<b>215r</b>	<b>210</b>
<b>Other fuels (2)</b>					
Back pressure steam turbine	437	397	380	380	381
Gas turbine	1,517	1,586	1,572	1,536r	1,577
Combined cycle	813	746	740	795	698
Reciprocating engine	5	4	4	4	4
Pass out condensing steam turbine	385	383	342	329	328
<b>Total other fuels</b>	<b>3,157r</b>	<b>3,116</b>	<b>3,039</b>	<b>3,044</b>	<b>2,988</b>
<b>Total - all fuels</b>					
Back pressure steam turbine	1,231	1,011	975	879	879
Gas turbine	3,020	3,013	2,980r	2,921r	2,837
Combined cycle	5,343	5,304	5,323	5,323	5,280
Reciprocating engine	826r	801r	794r	781r	775
Pass out condensing steam turbine	1,079	1,079	996	983	983
<b>Total all fuels</b>	<b>11,499r</b>	<b>11,208r</b>	<b>11,068r</b>	<b>10,887r</b>	<b>10,755</b>

(1) Renewable fuels include: Biomass; sewage gas, other biogases, municipal solid waste and refuse derived fuels.

(2) Other fuels include: process by-products, coke oven gas, blast furnace gas, gas oil and refinery gas.

## 6.8 CHP capacity, output and total fuel use<sup>(1)</sup> by sector

	2005	2006	2007	2008	2009
<b>Iron and steel and non ferrous metals</b>					
Number of sites	7	7	8	8	8
Electrical capacity	67	81	80	78	78
Heat capacity	285	285	285	285	285
Electrical output	238	520	367	349r	467
Heat output	1,765	1,812	1,718	1,592r	1,589
Fuel use	3,045	3,984	3,812	3,593r	3,569
of which : for electricity	609	1,426	1,096	1,024r	1,232
for heat	2,436	2,558	2,716	2,569r	2,337
<b>Chemicals</b>					
Number of sites	52	50	49r	47r	46
Electrical capacity	1,862	1,819	1,789r	1,814r	1,790
Heat capacity	3,994	3,920	3,818r	3,779r	3,756
Electrical output	9,832	10,082	9,398	9,619r	8,710
Heat output	18,282	18,311	17,111	17,926r	16,679
Fuel use	42,650	43,041	40,522	42,465r	39,716
of which : for electricity	22,193	22,548	21,343	22,128r	20,546
for heat	20,457	20,492	19,178	20,338r	19,170
<b>Oil and gas terminals and oil refineries</b>					
Number of sites	9	9	9	9	9
Electrical capacity	1,735	1,731	1,765	1,763	1,902
Heat capacity	3,677	3,677	3,677	3,677	3,677
Electrical output	9,957	10,040	9,940	9,823	10,649
Heat output	17,803	16,779	16,894	17,244	16,687
Fuel use	40,713	40,426	40,068	39,543r	39,700
of which : for electricity	21,306	21,679	21,429	20,884r	21,868
for heat	19,407	18,747	18,639	18,659r	17,832
<b>Paper, publishing and printing</b>					
Number of sites	30	26	26	26	24
Electrical capacity	655	619	535	556r	509
Heat capacity	1,350	1,217	1,182	1,169	1,106
Electrical output	3,840	3,394	3,062	3,074r	2,718
Heat output	7,977	6,770	6,137	6,386r	6,061
Fuel use	16,116	14,028	12,865	13,126r	11,694
of which : for electricity	7,795	6,927	6,388	6,374r	5,438
for heat	8,321	7,100	6,477	6,752r	6,256
<b>Food, beverages and tobacco</b>					
Number of sites	42	40	40	38r	41
Electrical capacity	408	408	424	404	406
Heat capacity	968	923	911	814	814
Electrical output	2,091	1,952	2,102	1,964r	1,968
Heat output	5,148	4,576	4,216	4,354r	4,356
Fuel use	9,381	8,604	8,542	8,368r	8,436
of which : for electricity	4,223	3,945	4,254	3,980r	3,979
for heat	5,158	4,659	4,288	4,388r	4,458

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## 6.8 CHP capacity, output and total fuel use<sup>(1)</sup> by sector (continued)

	2005	2006	2007	2008	2009
<b>Metal products, machinery and equipment</b>					
Number of sites	18	17	18	17	17
Electrical capacity	75	37	69	68	68
Heat capacity	57	38	57	56	56
Electrical output	175	146	174	206	182
Heat output	221	214	211	221	200
Fuel use	686	633	609	619	546
of which : for electricity	407	346	370	389	339
for heat	279	286	239	229	207
<b>Mineral products, extraction, mining and agglomeration of solid fuels</b>					
Number of sites	10	9	9	9	8
Electrical capacity	72	53	54	65	57
Heat capacity	216	215	215	205	178
Electrical output	223	175	182	156	139
Heat output	902	746	714	602	529
Fuel use	1,500	1,235	1,188	1,059	935
of which : for electricity	498	382	403	369	326
for heat	1,001	854	785	690	609
<b>Sewage treatment</b>					
Number of sites	124	124	160	161	182
Electrical capacity	125	129	146	147	159
Heat capacity	138	138	138	137	137
Electrical output	466	447	502	547	638
Heat output	615	519	589	610	790
Fuel use	1,662	1,548	1,676	1,915	2,258
of which : for electricity	999	983	1,056	1,227	1,399
for heat	663	565	620	688	859
<b>Other industrial branches (2)</b>					
Number of sites	7	7	7	8	8
Electrical capacity	44	44	41	41	41
Heat capacity	74	74	74	74	74
Electrical output	196	236	259	247	248
Heat output	330	392	387	348	342
Fuel use	712	866	936	884	865
of which : for electricity	390	481	545	527	519
for heat	322	385	390	357	346
<b>Total industry</b>					
Number of sites	299	289	326	323	343
Electrical capacity	5,041	4,921	4,902	4,937	5,011
Heat capacity	10,759	10,487	10,357	10,197	10,083
Electrical output	27,019	26,994	25,986	25,985	25,718
Heat output	53,044	50,118	47,977	49,284	47,233
Fuel use	116,465	114,365	110,217	111,572	107,721
of which : for electricity	58,419	58,718	56,884	56,903	55,647
for heat	58,047	55,647	53,333	54,669	52,074

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## 6.8 CHP capacity, output and total fuel use<sup>(1)</sup> by sector (continued)

	2005	2006	2007	2008	2009
<b>Transport, commerce and administration</b>					
Number of sites	593r	589r	597r	622r	633
Electrical capacity	260r	262r	281r	305r	305
Heat capacity	417r	409r	403r	384r	367
Electrical output	1,050r	972r	1,099r	1,192r	1,246
Heat output	2,022r	2,077r	2,121r	2,253r	2,190
Fuel use	4,455r	4,373r	4,702r	5,183r	5,181
of which : for electricity	2,261r	2,082r	2,376r	2,669r	2,743
for heat	2,194r	2,291r	2,326r	2,513r	2,438
<b>Other (3)</b>					
Number of sites	473r	486r	492r	492r	489
Electrical capacity	232	249	255r	252r	253
Heat capacity	323	311r	308r	305r	305
Electrical output	761	768	761r	724r	813
Heat output	1,380r	1,216	1,216r	1,242r	1,297
Fuel use	3,691r	3,617r	3,725r	3,614r	3,807
of which : for electricity	1,827	1,997	1,932r	1,774r	1,966
for heat	1,864	1,620	1,793r	1,840r	1,840
<b>Total CHP usage by all sectors</b>					
Number of sites	1,365r	1,364r	1,415r	1,437r	1,465
Electrical capacity	5,533r	5,432r	5,438r	5,494r	5,569
Heat capacity	11,499r	11,208r	11,068r	10,887r	10,755
Electrical output	28,830r	28,733r	27,846r	27,901r	27,777
Heat output	56,445r	53,411r	51,314r	52,778r	50,721
Fuel use	124,611r	122,354r	118,643r	120,369r	116,708
of which : for electricity	62,507r	62,796r	61,192r	61,346r	60,356
for heat	62,104r	59,558r	57,452r	59,023r	56,352

(1) The allocation of fuel use between electricity and heat is largely notional and the methodology is outlined in paragraphs 6.35 to 6.37.

(2) Other industry includes Textiles, clothing and footwear sector.

(3) Sectors included under Other are agriculture, community heating, leisure, landfill and incineration.

## 6.9 CHP - use of fuels by sector

	GWh				
	2005	2006	2007	2008	2009
<b>Iron and steel and non ferrous metals</b>					
Coal	-	-	-	-	-
Fuel oil	55	79	105	170	235
Natural gas	202	181	195	313r	277
Blast furnace gas	2,313	3,083	2,885	2,490	2,232
Coke oven gas	475	641	628	621	826
Other fuels (1)	-	-	-	-	-
<b>Total iron and steel and non ferrous metals</b>	<b>3,045</b>	<b>3,984</b>	<b>3,812</b>	<b>3,593r</b>	<b>3,569</b>
<b>Chemicals</b>					
Coal	2,804	3,395	3,372	3,653r	3,608
Fuel oil	145	292	153	137r	138
Gas oil	545	98	28	21r	11
Natural gas	34,987	35,330	33,359	35,056r	32,290
Refinery gas	1,132	1,181	1,181	1,181	1,181
Renewable fuels (2)	30	26	10	-	3
Other fuels (1)	3,006	2,719	2,420	2,417r	2,485
<b>Total chemical industry</b>	<b>42,650</b>	<b>43,041</b>	<b>40,522</b>	<b>42,465r</b>	<b>39,716</b>
<b>Oil and gas terminals and oil refineries</b>					
Fuel oil	2,910	2,844	1,606	1,466	1,464
Gas oil	111	80	122	112r	159
Natural gas	20,818	21,041	22,045	21,618	23,243
Refinery gas	4,011	4,651	5,583	5,703r	5,723
Other fuels (1)	12,863	11,810	10,711	10,644r	9,112
<b>Total oil refineries</b>	<b>40,713</b>	<b>40,426</b>	<b>40,068</b>	<b>39,543r</b>	<b>39,700</b>
<b>Paper, publishing and printing</b>					
Coal	683	595	437	402r	372
Fuel oil	308	3	0	12	-
Gas oil	73	188	22	20r	24
Natural gas	14,905	13,092	12,255	11,552r	10,182
Renewable fuels (2)	0	-	-	1,032	1,032
Other fuels (1)	147	150	151	108	83
<b>Total paper, publishing and printing</b>	<b>16,116</b>	<b>14,028</b>	<b>12,865</b>	<b>13,126r</b>	<b>11,694</b>
<b>Food, beverages and tobacco</b>					
Coal	578	338	238	156	194
Fuel oil	192	199	137	127	184
Gas oil	97	81	59	26r	36
Natural gas	8,473	7,965	8,100	8,052r	8,006
Renewable fuels (2)	-	1	2	7	18
Other fuels (1)	42	20	5	-r	-
<b>Total food, beverages and tobacco</b>	<b>9,381</b>	<b>8,604</b>	<b>8,542</b>	<b>8,368r</b>	<b>8,436</b>
<b>Metal products, machinery and equipment</b>					
Fuel oil	89	89	89	89	89
Gas oil	0	0	0	0	0
Natural gas	492	439	455	504r	431
Renewable fuels (2)	105	104	65	26r	26
<b>Total metal products, machinery and equipment</b>	<b>686</b>	<b>633</b>	<b>609</b>	<b>619r</b>	<b>546</b>

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## 6.9 CHP - use of fuels by sector (continued)

	GWh				
	2005	2006	2007	2008	2009
<b>Mineral products, extraction, mining and agglomeration of solid fuels</b>					
Coal	-	-	-	-	-
Fuel oil	-	-	-	-	-
Gas oil	-	1	0	0	3
Natural gas	1,231	964	919	767r	644
Coke oven gas	269	271	269	291	288
<b>Total mineral products, extraction, mining and agglomeration of solid fuels</b>	<b>1,500</b>	<b>1,235</b>	<b>1,188</b>	<b>1,059r</b>	<b>935</b>
<b>Sewage treatment</b>					
Fuel oil	53	41	48	62r	73
Gas oil	15	20	23	17r	18
Natural gas	112	145	118	181r	215
Renewable fuels (2)	1,483	1,341	1,487	1,654r	1,952
<b>Total sewage treatment</b>	<b>1,662</b>	<b>1,548</b>	<b>1,676</b>	<b>1,915r</b>	<b>2,258</b>
<b>Other industrial branches</b>					
Fuel oil	-	-	-	-	-
Gas oil	9	1	13	3	0
Natural gas	703	866	923	881r	865
<b>Total other industrial branches</b>	<b>712</b>	<b>866</b>	<b>936</b>	<b>884r</b>	<b>865</b>
<b>Transport, commerce and administration</b>					
Coal	44	-	43	29	-
Fuel oil	6	1	0	0	0
Gas oil	21	116	32	6r	10
Natural gas	4,382r	4,093r	4,451r	4,542r	4,527
Refinery gas	-	-	-	-	-
Renewable fuels (2)	2	162	176	605r	643
Other fuels (1)	-	-	-	-	-
<b>Total transport, commerce and administration</b>	<b>4,455r</b>	<b>4,373r</b>	<b>4,702r</b>	<b>5,183r</b>	<b>5,181</b>
<b>Other (3)</b>					
Coal	41	28	29	33r	24
Fuel oil	9	10	1	1	1
Gas oil	65	14	12	13	9
Natural gas	2,347	2,015r	2,203r	2,172r	2,464
Renewable fuels (2)	1,228	1,548	1,479	1,393r	1,307
Other fuels (1)	1	1	1	1	1
<b>Total other</b>	<b>3,691r</b>	<b>3,617r</b>	<b>3,725r</b>	<b>3,614r</b>	<b>3,807</b>
<b>Total - all sectors</b>					
Coal	4,150	4,356	4,120	4,274r	4,197
Fuel oil	3,767	3,558	2,140	2,065r	2,185
Gas oil	934	599	309	219r	270
Natural gas	88,651r	86,133r	85,022r	85,639r	83,144
Blast furnace gas	2,313	3,083	2,885	2,490	2,232
Coke oven gas	744	911	897	912	1,114
Refinery gas	5,143	5,832	6,764	6,884r	6,903
Renewable fuels (2)	2,848	3,183	3,219	4,717r	4,982
Other fuels (1)	16,060	14,699	13,287	13,170r	11,681
<b>Total CHP fuel use</b>	<b>124,611r</b>	<b>122,354r</b>	<b>118,643r</b>	<b>120,369r</b>	<b>116,708</b>

(1) Other fuels include: process by-products.

(2) Renewable fuels include: sewage gas, other biogases, municipal solid waste and refuse derived fuels.

(3) Sectors included under Other are agriculture, community heating, leisure, landfill and incineration.