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Combined Heat and Power (CHP) electricity generation in the EU-25 in 2002 totalled 299.2 TWh, 9.9% of total gross electricity generation.

Highlights

Germany was the largest CHP electricity producer at 56.2 TWh, while Denmark had the largest share of CHP in total gross generation, 49.1%. Finland and Latvia have shares of 38.0% and 37.5% of CHP electricity, respectively.

At 163.1 TWh, Public supply plants produced more than half of the CHP electricity, while industrial plants generated 136.1 TWh.

The paper and printing industry (37.7 TWh), the chemical industry (32.0 TWh) and refineries (24.0 TWh) were the largest industrial CHP electricity generators. More than two-thirds of CHP electricity in industry was generated by these three sectors.

In 2002 EU-25 CHP heat generation reached 2844 PJ. The largest producer was Germany with more than 19% of the EU-25 total.

The main fuel consumed in cogeneration was natural gas which accounted for 40% of the total fuel combustion in CHP plants. The share of hard coal and derived products was 19%.

CHP electricity generation and capacity by Member State

EU-25 CHP electricity generation was 299.2 TWh in 2002, corresponding to 9.9% of total electricity generation. The EU-15 produced 247.7 TWh of CHP electricity, which was 9.2% of total EU-15 gross electricity generation. New Member States contributed to the EU-25 increase in CHP electricity generation.

Germany, the Netherlands and Finland are the main EU-25 producers of CHP electricity representing nearly 40% of CHP electricity production. Germany alone produced more than 56 TWh of CHP electricity.

Denmark, Finland and Latvia are the leaders when considering CHP as a percentage of total electricity generation. In Denmark the CHP share is nearly half (49.1%) of electricity generation, while in Finland and Latvia the share is about 38%.

The EU-25 installed capacity of CHP plants in 2002 was about 92 GW, when taking only CHP electricity capacity into account. The highest electrical capacity for CHP generation is reported in Germany (26.4 GW), followed by the Netherlands (6.7 GW), and France, Poland, the United Kingdom and Finland are about 6 GW.

CHP Electricity generation, GWh	EU-25	EU-15	BE	CZ	DK	DE	EE	EL	ES	FR	IE	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	SI	SK	FI	SE	UK	
Combined cycle	70148	66736	176	854	3827	10594	0	0	5654	0	0	6890	-	0	0	167	1032	-	16298	2579	662	0	0	863	8640	198	11713	
Steam : backpressure turbine	94772	78038	2261	4471	2303	30868	530	230	2954	6009	74	5224	-	113	153	0	1226	-	1246	2617	7817	1188	384	2040	13183	8522	1359	
Steam : condensing turbine	55010	27108	316	7418	7610	0	366	0	696	1206	0	3427	-	1238	1573	0	156	-	828	2993	14217	999	385	2549	5175	1101	2797	
Gas turbine with heat recovery	46362	43823	2990	102	1496	7841	0	826	4783	11101	405	4253	-	1	0	0	1981	-	5230	13	307	669	54	94	1317	110	2988	
Internal combustion engine	28005	27180	427	219	4055	2463	43	0	5269	4262	145	1205	-	139	0	123	345	-	5070	320	0	1642	49	29	134	45	2020	
Others	4866	4781	0	0	0	4663	0	0	0	0	0	0	-	0	0	0	0	-	0	0	0	104	1	84	0	14	0	
Total CHP electricity generation	299163	247667	6170	13064	19291	56228	939	1057	19316	22578	624	20999	-	1491	1726	291	4741	-	28673	8521	23003	4603	873	5659	28448	9990	20877	
of which																												
Public supply	163096	126089	4374	9391	16665	33292	834	0	0	11470	0	9304	-	1450	1705	0	4336	-	19715	3532	15424	2349	564	3302	18000	5664	1725	
Autoproducers	136067	121578	1797	3673	2625	22936	105	1057	19316	11108	624	11695	-	41	21	291	405	-	8958	4990	7579	2255	309	2357	10448	4326	19152	
Share of total electricity generation, %	9.9	9.2	7.5	17.1	49.1	9.6	11.0	1.9	7.8	4.0	2.5	7.4	-	37.5	9.7	7.9	21.5	-	29.9	13.6	16.0	10.0	5.9	17.5	38.0	6.8	5.4	

Table 1: CHP electricity generation and capacity in EU-25 in the year 2002

CHP Heat production, TJ	EU-25	EU-15	BE	CZ	DK	DE	EE	EL	ES	FR	IE	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	SI	SK	FI	SE	UK	
Combined cycle	346400	332144	821	4405	15739	45564	0	0	38807	0	0	35378	-	0	0	1278	5516	-	88155	12299	2509	0	0	1825	35717	2198	56187	
Steam : backpressure turbine	1420642	1165375	25897	75627	34113	391653	7561	5215	43275	161871	1740	78492	-	3389	3396	0	27997	-	38041	40556	109442	25179	7696	20159	193242	102433	23688	
Steam : condensing turbine	567326	265467	5097	72343	42514	0	3574	0	7876	22380	0	44337	-	8654	12096	0	2445	-	12159	28369	192924	18258	6571	3254	37759	10198	36520	
Gas turbine with heat recovery	324978	310500	13995	697	9636	56862	0	4208	38638	61627	3038	32015	-	7	0	0	9601	-	56146	99	2702	4079	312	1160	7066	1876	12124	
Internal combustion engine	141899	136819	2142	1872	20660	13824	169	0	31610	17549	624	6283	-	450	0	819	2139	-	26616	1796	0	3744	193	257	520	206	10425	
Others	42922	39983	0	0	0	36844	0	0	0	0	0	0	-	0	0	0	0	-	0	0	0	3104	35	2904	0	35	0	
Total CHP Heat production	2844166	2250285	47954	154944	122661	544744	11304	9423	160206	263426	5403	196505	-	12500	15492	2097	47698	-	221118	83119	307577	54364	14806	29559	274304	116946	148014	
of which																												
Public supply	1191630	848274	26578	101354	95967	257309	9095	0	0	80870	0	62607	-	11798	14478	0	38121	-	113016	25844	137823	14947	6131	24555	109199	54334	7604	
Autoproducers	1652536	1402011	21376	53590	26694	287435	2209	9423	160206	182557	5403	133898	-	702	1014	2097	9577	-	108102	57275	169754	39417	8675	5004	165105	62612	140410	

CHP Heat capacity, MW	EU-25	EU-15	BE	CZ	DK	DE	EE	EL	ES	FR	IE	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	SI	SK	FI	SE	UK
Combined cycle	24501	22488	127	683	1155	4456	0	0	2864	0	0	1431	-	0	0	111	305	-	6941	1013	702	0	0	323	1682	153	2555
Steam : backpressure turbine	121212	92597	2488	9753	2626	34677	863	477	5275	14776	334	7147	-	362	275	0	2975	-	2481	2591	8294	2244	487	5606	10408	5711	1362
Steam : condensing turbine	53289	21809	780	10178	4825	0	669	0	423	1833	0	3070	-	846	2026	0	379	-	1019	2217	15658	1409	695	1025	2632	1556	2046
Gas turbine with heat recovery	19864	18945	615	99	607	3858	0	385	1966	4570	182	1492	-	3	0	0	556	-	3278	9	158	254	13	90	569	65	1095
Internal combustion engine	11470	11045	232	203	1392	1526	9	0	1804	1786	33	625	-	20	0	248	126	-	2281	117	0	219	15	52	74	29	678
Others	5805	4360	0	0	0	4142	0	0	0	0	0	0	-	0	0	0	0	-	0	0	0	204	1	1444	0	14	0
Total	236136	171243	4243	20916	10605	48659	1541	861	12331	22965	550	13765	-	1231	2301	359	4341	-	16000	5946	24812	4331	1211	8540	15365	7527	7736

Table 2: CHP heat generation and capacity in EU-25 in the year 2002

CHP heat generation and capacity by Member State

The total CHP heat production in EU-25 for 2002 was 2 844 PJ or 790 TWh, which is more than 2.6 times higher than electricity production (299 TWh).

CHP heat capacity in 2002 was greatest in Germany (48.7 GW) followed by Poland (24.8 GW), France (23.0 GW) and the Netherlands (16.0 GW).

The highest production was in Germany (545 PJ), Poland (308 PJ) Finland (274 PJ) and France (263 PJ). Those countries produced nearly half (49%) of the CHP heat in EU-25.

CHP generation and capacity by type of technology

There are five basic types of technology in CHP generation. Plants with steam backpressure turbines generated 32% of CHP electricity and nearly half of CHP heat in EU-25. Combined cycle plants generated 23% of CHP electricity and 12% of CHP heat. The contribution of plants with steam condensing turbines in CHP electricity generation was 18%, but they produced more CHP heat than combined cycle plants with a share of 20%.

Combined cycle plants have the largest share of CHP electricity generation in the Netherlands (57%), Luxembourg (57%) and the UK (56%) followed by Italy (33%) and Spain (29%).

Gas turbines with heat recovery dominate CHP electricity generation in Greece (78%) and Ireland (65%), but their share is high also in Belgium (48%) and Hungary (42%).

The share of CHP electricity generated in plants with steam backpressure turbines is highest in Sweden (85%).

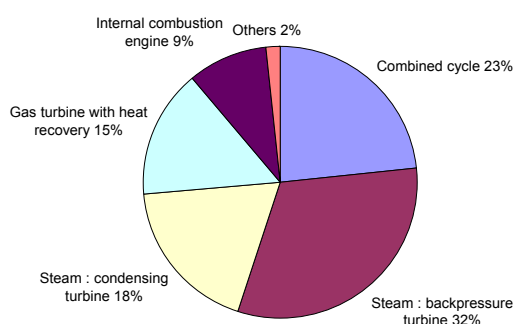


Figure 1: CHP electricity generation in the EU-25

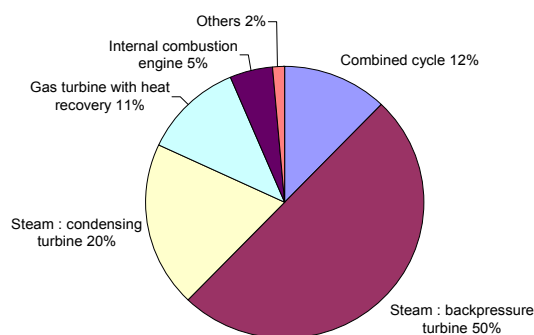


Figure 2: CHP heat generation in the EU-25

CHP electricity generation in the new Member States is dominated by steam condensing-extraction turbines. Their share is highest in Lithuania (91%) and Latvia (83%), but also high in Poland (62%) and the Czech

Republic (57%). Of EU-15 countries, the largest share of steam condensing-extraction turbines is in Denmark (39%) and Austria (35%).

CHP generation and capacity by economic activity

More than half of CHP electricity (163 TWh) was produced in public supply plants, while industrial plants recorded electricity generation of 136 TWh.

On the other hand, autoproducers produced more CHP heat than public supply plant, 1653 PJ (58%) compared with 1192 PJ (42%).

Sector	Maximum CHP Capacity		CHP Production		Fuel Input TJ(NVC)
	Electrical MW	Heat MW	Electricity GWh	Heat TJ	
Public supply	53043	115108	163097	1191630	3486203
Autoproducers	38591	121028	136067	1652536	3001355
of which					
Mining and agglomeration of solid fuels	1857	2085	2583	29474	70221
Extraction of crude oil and natural gas	88	178	494	3837	9864
Coke ovens	94	705	618	13007	17577
Refineries	4487	16563	24043	262004	469749
Iron and steel industry	1425	6432	3456	32762	100828
Non-ferrous metals	191	914	596	9164	19501
Chemical industry	13300	26074	31997	399024	730431
Non-metallic mineral products	483	1045	2599	20453	43429
Extraction	167	312	982	7073	13723
Food products, beverages and tobacco	3918	19099	12456	163958	271952
Textile, clothing and leather	601	2636	2249	22707	44595
Paper and printing	7469	32185	37677	532951	888065
Metal products, machinery, equipment	652	2005	2094	17236	35859
Other industrial branches	1040	2962	3841	38923	80201
Transport	71	78	252	1019	3687
Services, etc	1522	3310	6009	46699	103547
Other	1223	4442	4121	52244	98125
TOTAL	91634	236136	299164	2844166	6487558

Table 3: CHP in the EU-25 by economical activity in 2002

High CHP production in public supply plants is typical in countries with a well-developed district-heating network. This is the case in nearly all new Member States, but also in Denmark, Belgium, Finland, Germany and Sweden where more than half of the CHP electricity was generated in public supply plants in 2002.

Nevertheless there are countries with a 100% share of autoproducer plants: Spain, Greece, Ireland and Luxembourg. The United Kingdom also has a high share of autoproducer plants (92%).

The largest industrial CHP electricity generators were the paper and printing industry (37.7 TWh), the chemical industry (32.0 TWh) and refineries (24.0 TWh). Over two-thirds of the CHP electricity in industry was generated in these three sectors. In CHP heat generation, the most important sectors are also the paper and printing industry (32%), the chemical industry (24%) and refineries (16%).

Fuel consumption in CHP generation

In 2002 most of the fuel was consumed in CHP plants with steam backpressure turbines (36%) and in plants with steam condensing-extraction turbines (26%), whilst 20% of the fuel for cogeneration was consumed in combined cycle plants.

Natural gas is the main fuel used in EU-25 accounting for 40% of the total consumption. However, hard coal (19%) and lignite (8%) remain important fuels in CHP generation. The share of renewable energy sources is around 10%. The share of liquid fuels is 8% of the total fuel consumption.

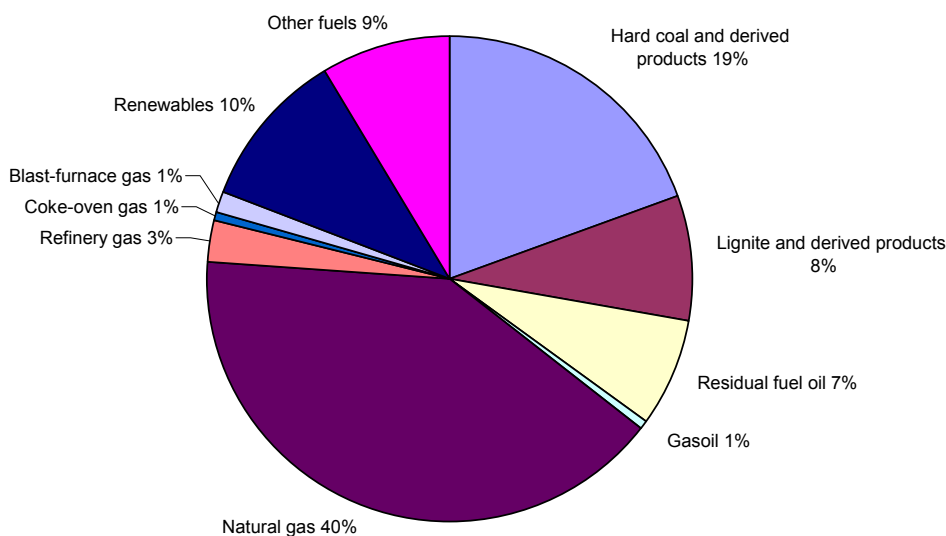


Figure 3: Fuel input to CHP plants in the EU-25

Hard coal, lignite, and their derivatives were used preferentially in the new Member States. The share of solid fossil fuels was as high as 84% in Poland and in Slovenia and 81% in the Czech Republic. In the EU-15 the share of solid fossil fuels was largest in Denmark (46%).

Liquid fuels are the most widely used fuel in cogeneration in Portugal (45%). In Sweden and Finland renewable energy sources accounted for 56% and 41% of fuel consumption in CHP units, respectively. Natural gas was the most common fuel in nearly all other countries in CHP generation.

Type of cycle, TJ(NCV)	EU-25	EU-15	BE	CZ	DK	DE	EE	EL	ES	FR	IE	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	SI	SK	FI	SE	UK
Combined cycle	1314526	1246063	4082	18037	35947	96209	0	0	84192	0	0	396788	-	0	0	2041	26665	-	247421	41275	14158	0	0	9583	76825	3571	257712
Steam : backpressure turbine	2306411	1827958	44475	130470	49069	652958	12989	8774	74589	223909	2617	114399	-	4697	4894	0	39266	-	48593	73913	166181	40555	54034	65922	293795	163214	37099
Steam : condensing turbine	1715440	822244	13973	262998	195705	0	15267	0	16713	39322	0	144054	-	16644	30884	0	4902	-	123033	100272	338388	27036	10650	213462	67030	17412	77694
Gas turbine with heat recovery	645587	613211	33403	1551	17800	98104	0	9689	82470	136701	5925	63054	-	12	0	0	21385	-	93602	175	6347	8514	620	2461	13928	2778	47068
Internal combustion engine	407768	338898	5169	3221	40805	28363	414	0	94083	45072	1514	16129	-	1357	0	1476	4522	-	56091	3939	0	17561	616	462	1358	438	26900
Others	97827	69787	0	0	0	64498	0	0	0	0	0	0	-	0	0	0	0	-	0	0	0	5182	41	27999	0	107	0
Total	6487558	4976440	101102	416277	339326	940134	28669	18463	352047	445004	10056	734424	-	22710	35778	3517	96760	-	568739	219574	525074	98847	65961	319889	511213	187520	446474
of which																											
Hard coal and derived products	1264916	699579	2855	89717	156913	264888	0	0	8103	17550	805	5872	-	0	0	0	375	-	100627	26106	441685	0	10145	23415	80041	14722	21095
Lignite and derived products	533032	191843	0	248246	0	90461	17719	0	0	1102	0	0	-	945	0	0	9693	-	0	14233	0	0	45095	19491	79763	6285	0
Residual fuel oil	474384	385724	6922	7394	14020	25325	130	3074	43091	37871	0	116148	-	2192	6244	0	5914	-	20378	9808	49893	44295	1925	14867	13593	37902	13297
Gasoil	34683	34418	622	111	217	10010	0	0	8069	1352	0	8479	-	0	0	19	21	-	23	136	0	19	15	118	834	3623	1016
Natural gas	2625021	2409510	68895	25155	100721	409987	9722	3388	225538	222700	7590	438192	-	19460	27659	3499	72685	-	380846	94337	20505	12946	5263	35062	114506	10049	316315
Refinery gas	183323	182032	0	765	2455	12245	0	8083	24302	39858	546	33570	-	0	0	0	0	-	23305	14667	0	2841	0	527	744	2344	17071
Coke-oven gas	42854	22598	362	6755	0	2234	0	0	2253	0	0	10358	-	0	0	0	320	-	513	3671	9031	0	0	4150	0	78	3129
Blast-furnace gas	91427	74228	8851	8907	0	6432	0	0	0	1385	0	25629	-	0	0	0	2774	-	8530	7980	0	0	0	5518	1692	4278	9451
Renewable	673205	654077	10195	5234	35448	34849	1098	352	32746	97779	0	27529	-	113	446	0	907	-	7431	45965	0	38737	3518	7812	210786	104862	7397
Other fuels	564714	322431	2400	23994	29552	83703	0	3564	7944	26509	13	68647	-	0	1429	0	4071	-	27087	2672	3860	9	0	208929	9254	3377	57701

Table 4: Fuel consumption in CHP plants in EU-25 in 2002, TJ

Type of cycle, %	EU-25	EU-15	BE	CZ	DK	DE	EE	EL	ES	FR	IE	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	SI	SK	FI	SE	UK
Combined cycle	57	68	67	63	82	87			74			52	-		92	57	-	74	62	63				51	87	85	68
Steam : backpressure turbine	76	80	77	58	87	77	68	69	77	82	74	86	-	81	81		83	-	88	68	83	73	37	42	82	82	77
Steam : condensing turbine	57	63	54	51	61		48		75	70		56	-	79	58		61	-	47	62	72	82	75	34	84	84	69
Gas turbine with heat recovery	76	80	79	53	85	86		74	75	78	76	78	-	88			78	-	83	83	60	79	82	61	85	82	73
Internal combustion engine	71	75	75	68	87	80	68		69	75	76	74	-	70		86	75	-	81	75		61	60	78	74	84	69
Others	62	74				83							-					-				67	90			80	
All plants	70	73	74	59	71	79	60	72	74	79	76	61	-	79	61	89	75	-	71	65	74	74	50	36	83	82	69

Table 5: Efficiencies of CHP plants in EU-25 in 2002, %

Performance of CHP plants

The average efficiency of all EU-25 CHP plants was 70% in 2002. The efficiency was highest (76%) in steam backpressure turbines and in gas turbines with heat recovery. The lowest efficiency (57%) was recorded in combined cycle plants and in steam condensing – extraction plants.

The efficiency is calculated by summing up the gross electricity generation and CHP heat production and dividing by the fuel consumption. The fuel consumption includes the fuel which is used for both CHP and non-CHP electricity generation, since the methodology applied does not support division of the fuel between CHP and non-CHP electricity.

➤ ESSENTIAL INFORMATION – METHODOLOGICAL NOTES

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The CHP statistics for 2002 in EU-15 were collected in a separate project funded by the DG TREN SAVE programme. The statistics for the new Member States were collected in the framework of the Phare programme. In Cyprus and Malta there is no CHP generation.

The definition of CHP or “cogeneration” implies that heat and electricity are produced simultaneously in one process. In CHP production intermediate fluids, either hot steam or exhaust gases, are used first in electricity generation after which the remaining heat is recovered and not released to the environment. If any part of the intermediate fluid or the remaining thermal energy is ejected to the environment without heat recovery, the portion of the electricity generation corresponding to this part is by default not CHP electricity.

In separate electricity generation the conversion efficiency is between 35-55%, but in cogeneration plants overall efficiencies as high as 80-90% can be achieved by using the remaining thermal energy to produce heat, either for industrial processes or district heating. The energy savings potential of cogeneration is important with regard to achieving the targets of the Kyoto protocol in reducing CO₂ emissions, improving energy efficiency and reducing dependence on imported energy in the EU.

There are many types of CHP plants in which the share of CHP electrical power can be changed on demand or whose operation can switch completely between CHP mode and electricity generation only. CHP plants are seldom equipped with any device to monitor CHP electricity generation, since it would require detailed measurements and thermodynamic calculations. Accordingly, indirect methods have been developed to calculate the CHP electricity generation.

The method used to calculate CHP electricity in the project for 2002 is based on the same principles as applied in the Directive 2004/8/EC to promote cogeneration in the EU. The overall efficiency of a CHP unit is used as a measure to determine whether the electricity generation is fully CHP or not. If the overall efficiency is above a threshold set at 75% (85% for steam condensing extraction turbines and combined cycle units), all the electricity generated is considered as CHP electricity. On the other hand, if the overall efficiency is below the threshold, the amount of CHP electricity, E_{CHP} is calculated as follows:

$$E_{CHP} = C \cdot H$$

Where

C is power-to-heat ratio characteristic to the plant

H is CHP heat generation of the plant.

Abbreviations :

MWh : Megawatt hour (10³ kWh)

MW : Megawatt

GWh : Gigawatt hour (10⁶ kWh)

GW : Gigawatt

TWh : Terawatt hour (10⁹ kWh)

GW_e : Gigawatt electric

TJ : Terajoule (10⁹ kJ)

GW_{th} : Gigawatt thermal







PJ : Petajoule (10¹² kJ)

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