VITO

Cogeneration report for Flanders
The situation in 2005 (2)

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Management summary

The cogeneration capacity installed in Flanders has been surveyed by Vito [The Flemish Institute for Technological Research] since 1990. In an earlier report "Cogeneration report for Flanders: the situation in 2005" this survey was updated for the VEA [The Flemish Energy Agency] for 2005. In 2006 important changes were made to the quality definition and the Flemish and European efficiency reference values for calculating the energy performance of cogeneration units. In this report "Cogeneration for Flanders: the situation in 2005 (2)" the figures from the report "Cogeneration report for Flanders: the situation in 2005" have been recalculated taking into account the previous changes. The figures which appear in it can therefore no longer be compared with those from the previous surveys because of the changed method of calculation used.

The table below gives a summary of the capacity and energy figures of the installed cogeneration units in Flanders in 2005:

- In addition to the data for the total installed electrical capacity and the total electricity production, the corresponding figures were calculated according to Annex II of Directive 2004/8/EC of the European Parliament and of the Council [1] or according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2]. With this, heat or electricity from the same unit which is not derived from cogeneration is excluded. Moreover the figures are also given for the cogeneration units eligible for a certificate. These are the units as from 01/01/2002 which are high-efficiency according to Annex III of the Decree of the Flemish Government of 7 July 2006 [2], in which account was taken of the European efficiency reference values [3].
- For classification into high-efficiency and non-high-efficiency cogeneration units, account was taken of points a and c of Annex III of Directive 2004/8/EC of the European Parliament and of the Council [1] or of Annex III of the Decree of the Flemish Government of 7 July 2006 [2].In this, small-scale cogeneration units are considered to be high-efficiency if the RPES > 0 and the large cogeneration units are considered to be high-efficiency if the RPES > 10%. Moreover, for the efficiency reference values account was taken of the Ministerial Decree of the Flemish Government which appeared in the Official Gazette on 1/12/2006 [3], and in which the European efficiency reference values were transposed. No account was taken of Annex IV of this latter decree (correction factors for network losses) because insufficient data was available to be able to apply this. For units larger than 25 MWe account was taken of Article 12(2) of Directive 2004/8/EC of the European

Parliament and of the Council [1] for determining whether a unit is high-efficiency or not.

- The primary energy savings were calculated three times: once on the basis of the European efficiency reference values (according to the Ministerial Decree of the Flemish Government which appeared in the Official Gazette on 1/12/2006 [3])and twice on the basis of the Flemish efficiency reference values as described in Article 10 of the Decree of the Flemish Government of 7 July 2006 [2] whereby once, for those units which work with steam recovery, account was taken of the nominal steam generation efficiency as described in the Annex to Decision 2004-62 of the VREG [4].

	Engines	Gas turbines	STEG	Steam turbines, grid-connected	Steam turbines, direct drive	**Total**
Total installed electrical cogeneration capacity [MW]						
Total installed thermal cogeneration capacity [MW]						
Installed electrical cogeneration capacity according to Annex II						
Installed electrical high-efficiency cogeneration capacity according to the definition in Directive 2004/8/EC [MW]						
Installed electrical cogeneration capacity eligible for a certificate [MW]						
Electricity and heat production of cogeneration units						
Total net electricity production [GWh/year]						
Total heat production [GWh/year]						
Net electricity production according to Annex II						
Net electricity production of high-efficiency cogeneration according to the definition in Directive 2004/8/EC [GWh/year]						
Net electricity production eligible for a certificate [GWh/year]						
Average time operating at full power [h/year]						
Primary energy savings of cogeneration units						
Primary energy savings based on Flemish efficiency reference values [GWh/year]						
Primary energy savings based on Flemish efficiency reference values with nominal steam generation efficiency [GWh/year]						
Primary energy savings of high-efficiency cogeneration based on Flemish efficiency reference values						
Primary energy savings of high-efficiency cogeneration based on Flemish efficiency reference values with nominal steam generation efficiency [GWh/year]						
Primary energy savings based on European efficiency reference values [GWh/year]						
Primary energy savings of high-efficiency cogeneration based on European efficiency reference values						
Relative primary energy savings of cogeneration units						
RPES based on Flemish efficiency reference values						
RPES based on Flemish efficiency reference values with nominal steam generation efficiency [%]						
RPES of high-efficiency cogeneration based on Flemish efficiency reference values [%]						
RPES of high-efficiency cogeneration based on Flemish efficiency reference values with nominal steam generation efficiency [%]						

RPES based on European efficiency reference values						
RPES of high-efficiency cogeneration based on European efficiency reference values [%]						

The total electrical capacity of cogeneration units recorded in 2005 in Flanders was 1,457 MWe, which means there was an additional 378 MWe from cogeneration units in 2005. These units have a total net electricity production of 7,918 GWh/year. The cogeneration production according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2] is 76% of this. 53% of the installed capacity relates to high-efficiency cogeneration units according to Article 12(2) of the European Directive 2004/8/EC [1]. 30% of the installed capacity and 17% of the electricity production is eligible for a certificate.

The total installed thermal capacity is 2,762 MW with a total heat production of 16,261 GWh per year.

Industry is the most important sector with a total installed electrical capacity of 925 MWe or 63.5% of the total installed capacity.

As far as fuels are concerned, natural gas is by far the most important fuel with a total installed electrical capacity of 1,176 MWe or almost 81% of the total installed capacity.

The total primary energy savings calculated with the Flemish efficiency reference values is 3,526 GWh per year or 12.7 PJ. If only the high-efficiency units are taken into consideration, this is 4,175 GWh per year or 15 PJ. The total primary energy savings calculated with the European efficiency reference values is 6,414 GWh per year or 23.1 PJ, which is almost double as much as that calculated with the Flemish efficiency reference values.

There is 1 STEG unit for which, in spite of a RPES of more than 10%, the cogeneration efficiency is, however, less than 70%, on account of which this may not be considered to be high-efficiency for Europe. This unit is however eligible for a certificate, because the accompanying requirement pursuant to Article 12(2) for units with a capacity of more than 25 MWe was not included in the Flemish quality definition.

The total primary energy savings which come into consideration for cogeneration certificates in 2005 is 281 GWh or 1 PJ.

1 Introduction

The cogeneration capacity installed in Flanders has been surveyed by Vito since 1990.

In an earlier report "Cogeneration report for Flanders: the situation in 2005" this survey was updated for the VEA for 2005. From 2004 the way in which data has been collected for the cogeneration surveys has been different than before. With the Ministerial Decree of 23.02.2005 CHP producers are obliged to inform the VEA annually before 1 May of the energy figures and installed capacity of their units. The first surveys mainly used the data of the CHP designers (capacity installed and capacity taken out of service). No production figures were included in the surveys before 2002. For the surveys for 2002 and 2003 energy production and use by CHP producers was estimated by extrapolation of the energy figures of a few units. With the new data collection method from 2005, from 2004 energy figures from many more units could be used for the cogeneration surveys. The accuracy of the figures in the surveys from 2004 is also greater than in the previous surveys. Moreover figures were also included for CHP electricity production, the CHP electrical capacity and the CHP percentage according to the calculations of Annex II of the European cogeneration directive 2004/8/EC [1].

In 2006 a number of important changes were made to the quality definition and the Flemish and European efficiency reference values for calculating the energy performance of cogeneration units, namely:

- The Decree of the Flemish Government of 7 July 2006 [2] in which an adjusted definition was included of whether a cogeneration unit is high-efficiency or not and in which amended efficiency reference values were also included for biofuels for calculating heat and power savings;
- The approval of the European efficiency reference values in the Ministerial Decree of the Flemish Government [3].

In this report "Cogeneration report for Flanders: the situation in 2005 (2)" the figures from the report "Cogeneration report for Flanders: the situation in 2005" have been recalculated taking account of the previous changes. The figures which appear in it can therefore no longer be compared with those from the previous surveys because of the changed method of calculation used.

2 Report on cogeneration units with engines

Since 1990 a survey has been conducted by Vito of the cogeneration units operating at the time. In 1990 the installed electrical capacity was almost 8 MW. In 2004 this had increased to a total capacity of 157.4 MW. In 2005 the total capacity had increased to 160.6 MW.

2.1 Installed capacity of cogeneration engines

2.1.1 Change in the installed capacity of cogeneration engines

Figure 1 shows the development of the installed electrical capacity of cogeneration engines in Flanders between 1990 and 2005.
The figure shows that installed capacity in Flanders has increased sharply from 1995. Between 1995 and 1996 the installed capacity almost doubled from 27 MWe to 52 MWe. From 1996 to the present the installed electrical capacity has more than tripled to a total installed electrical capacity in 2005 of 160.6 MWe.

Figure 1: Development of installed electrical capacity of cogeneration engines in Flanders between 1990 and 2005

Key to figure:
Opgesteld elektrisch vermogen = installed electrical capacity

Figure 2 shows the annual additional installed capacity of cogeneration engines. Here we can see that growth reaches a maximum in the second half of the 90's and that the additional capacity has been falling since 2000.

Figure 2: Additional electrical capacity of cogeneration engines in Flanders between 1983 and 2005

Key to figure:
Jaarlijkse groei opgesteld elektrisch vermogen = annual growth of installed electrical capacity
Aangroei = growth
Aflvlakking = levelling-off

Figure 3 shows the change in the installed thermal capacity of cogeneration engines. In 2005 a total thermal capacity of 199.9 had been installed.

Figure 3: Development of installed thermal capacity of cogeneration engines in Flanders between 1990 and 2005

Key to figure:
Opgesteld thermisch vermogen = installed thermal capacity

2.1.2 Distribution of installed electrical capacity of cogeneration engines by sector

Figure 4 gives the installed electrical capacity for the years 1990, 1995, 2000, 2004 and 2005, divided into the 6 most important sectors in which cogeneration units based on engines are to be found in Flanders. Horticulture remains the most important sector with a total installed capacity of 74.4 MW (46%); the installed capacity in industry is 60.9 MW (38%). The shares taken by waste-processing, hospitals and rest homes, sport/recreation/culture and offices/residential are 7%, 6%, 2% and 1% respectively. Compared with the survey for 2004 this distribution has remained almost the same.

Figure 4: Distribution of electrical capacity of cogeneration engines over the different sectors in 1990, 1995, 2004 and 2005

Key to figure:
Opgesteld elektrisch vermogen = installed electrical capacity
Afvalverwerking = waste-processing; Industrie = industry; Kantoren/residentieel = offices/residential; sport-recreatie/cultuur = sport/recreation/culture; Tuinbouw = horticulture; Zieken-en rusthuizen = hospitals and rest homes

2.1.3 Change in unit size of cogeneration units with engines

The total installed cogeneration capacity based on engines increased sharply between 1990 and 2005 but the size of the various projects has also been increasing. Table 1 gives an overview.
In recent years the number of projects and the number of engines have been decreasing but the unit size of the units has been increasing.

Table 1: Unit size of cogeneration engines in 1990, 1995, 2000, 2003, 2004 and 2005

	1990	1995	2000	2002	2003	2004	2005
Total electrical capacity							
Total thermal capacity							
Number of cogeneration projects							
Average electrical capacity per project							
Average thermal capacity per project							
Number of engines							
Average electrical capacity per engine							
Average thermal capacity per engine							

2.1.4 Distribution of installed electrical capacity of cogeneration engines by fuel

Figure 5 shows the total installed electrical capacity of cogeneration engines in 1990, 1995, 2000, 2003, 2004 and 2005. Up to 1994 diesel was still the most important fuel, from 1995 it was natural gas. Up to and including 2004 the installed capacity has increased uniformly for the various fuels. This trend is also continuing for biogas in 2005. In 2005, on the contrary, for the first time there has been a decrease for natural gas and diesel.

Figure 5: Number of different fuels in 1990, 1995, 2000, 2003, 2004 and 2005

Key to figure:
Opgesteld elektrisch vermogen = installed electrical capacity; Aardgas = natural gas; Gasolie = diesel; Biogas = biogas.

Moreover a further 2.4 MWe have also been installed on engines which run on several fuels. These are 1 unit of 1.1 MWe which works both on diesel and on biofuel and 1 unit on natural gas and/or biogas of 1.3 MWe.

Figure 6 gives an overview of the fuels used by sector. Only in the horticulture, industry and sport/recreation/culture sectors does diesel still have a share although here too natural gas is by far the most important fuel. In the waste-processing sector biogas is the most important fuel. The dual fuel engines only occur in the horticulture and waste-processing sectors.

Figure 6:Installed capacity of cogeneration engines by fuel and by sector in 2005

Key to figure:
Opgesteld elektrisch vermogen = installed electrical capacity; Aardgas = natural gas; Gasolie = diesel; Biogas = biogas; Dual Fuel = dual fuel
Afvalverwerking = waste-processing; Industrie = industry; Kantoren/residentieel = offices/residential; sport-recreatie/cultuur = sport/recreation/culture; Tuinbouw = horticulture; Zieken-en rusthuizen = hospitals and rest homes

2.1.5 Distribution of installed electrical capacity of cogeneration engines by type of management

Figure 7 and Figure 8 give an overview of the type of management used: own management or working together with the electricity company. Apart from a number of projects, own management is still the most common form of management; for installed capacity, working

together with an electricity company is, however, the most frequent form of management which indicates larger installed capacity per project.

Figure 7: Number of cogeneration projects under own management - collaboration

Key to figure:
Aantal installaties = number of units; Eigen beheer = under own management; Samenwerking = collaboration

Figure 8:Total installed capacity under own management - collaboration

Key to figure:
Opgesteld elektrisch vermogen = installed electrical capacity; Eigen beheer = under own management; Samenwerking = collaboration

2.2 Energy production of cogeneration units based on engines in 2005

No production figures were included in the surveys conducted before 2002. For the 2002 and 2003 surveys energy production and use by cogeneration units was estimated by extrapolation of the energy figures of a few units. With the Ministerial Decree of 23.02.2005 it became possible for this survey to have energy figures of far more units available. The accuracy of the figures in the surveys from 2004 is also greater than in the previous surveys. It should be borne in mind, however, that by no means all data are from measurements. In these cases the operator of the cogeneration unit or VITO made an estimate on the basis of, among other things, operating times.

The result is given in table 2: Energy figures for the installed cogeneration units based on engines in Flanders in 2005.

In addition to the data for the total installed electrical capacity and the total electricity production, the corresponding figures were calculated according to Annex II of Directive 2004/8/EC of the European Parliament and of the Council [1] or according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2]. These figures are found in Table 2 “cogeneration share”. With this, heat or electricity from the same unit which is not derived from cogeneration is excluded. These figures must be reported to Europe and must also be included on the registration of the cogeneration certificates by the VREG (Flemish regulatory body for the electricity and gas markets).

For classification into high-efficiency and non-high-efficiency cogeneration engines, account was taken of points a and c of Annex III of Directive 2004/8/EC of the European Parliament and of the Council [1] or of Annex III of the Decree of the Flemish Government of 7 July 2006 [2].In this, small-scale cogeneration units are considered to be high-efficiency if the RPES > 0 and the large cogeneration units are considered to be high-efficiency if the RPES > 10%. Moreover for the efficiency reference values, account was taken of the Ministerial Decree of the Flemish Government which appeared in the Official Gazette on 1/12/2006 [3], and in which the European efficiency reference values were transposed. No account was taken of Annex IV of this later decree (correction factors for network losses) because insufficient data was available to be able to apply this.

The primary energy savings were calculated twice: once on the basis of the European efficiency reference values (according to the Ministerial Decree of the Flemish Government

which appeared in the Official Gazette on 1/12/2006 [3]) and once on the basis of the Flemish efficiency reference values as described in Article 10 of the Decree of the Flemish Government of 7 July 2006 [2].

Finally, Table 2 also gives the figures for the units eligible for the certificate These are units from 01/01/2002 which are high-efficiency according to Annex III of the Decree of the Flemish Government of 7 July 2006 [2], in which account was taken of the European efficiency reference values [3].

Table 2: Energy figures for the installed cogeneration units on the basis of engines in Flanders in 2005.

	Total	**Cogeneration share**
Installed electrical capacity		
Installed thermal capacity		
Annual operating time		
Electricity production		
Heat production		
Overall cogeneration percentage		
Relative primary energy savings		
High-efficiency cogeneration engines*		
Installed electrical capacity		
Installed thermal capacity		
Electricity production		
Primary energy savings*		
Primary energy savings**		
Relative primary energy savings*		
Cogeneration percentage		
Cogeneration engines eligible for a certificate*		
Installed electrical capacity		
Installed thermal capacity		
Electricity production		
Primary energy savings*		
Primary energy savings**		
Relative primary energy savings*		
Cogeneration percentage		

* Based on the European efficiency reference values
** Based on Flemish efficiency reference values

The table above shows that there are approx. 40 MWe installed engines which in principle can be considered for cogeneration certificates in 2005.

2.3 Distribution of energy production of cogeneration engines by fuel and by sector in 2005

The following figures give a distribution for cogeneration engines in 2005 by fuel and by sector of:

- The net electricity production (Figure 9);
- The electricity production calculated according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2] (Figure 10);
- The high-efficiency electricity production (Figure 11);
- The electricity production of the units eligible for a certificate (Figure 12).

Figure 9: Net electricity production of cogeneration engines by fuel and by sector in 2005

Key to figure:
Netto electriciteitsproductie = net electricity production; Aardgas = natural gas; Gasolie = diesel; Biogas = biogas; Dual Fuel = Dual Fuel;
Afvalverwerking = waste-processing; Industrie = industry; Kantoren/residentieel = offices/residential; sport-recreatie/cultuur = sport/recreation/culture; Tuinbouw = horticulture; Zieken-en rusthuizen = hospitals and rest homes

Figure 10: Electricity production of cogeneration engines by fuel and by sector in 2005 calculated according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2]

Key to figure:
Elektriciteitsproductie volgens bijlage II = electricity production according to Annex II; Aardgas = natural gas; Gasolie = diesel; Biogas = biogas; Dual Fuel = Dual Fuel;
Afvalverwerking = waste-processing; Industrie = industry; Kantoren/residentieel = offices/residential; sport-recreatie/cultuur = sport/recreation/culture; Tuinbouw = horticulture; Zieken-en rusthuizen = hospitals and rest homes

Figure 11: High-efficiency electricity production of cogeneration engines by fuel and by sector in 2005

Key to figure:
Kwalitatieve elektriciteitsproductie = high-efficiency elektriciteitsproductie; Aardgas = natural gas; Gasolie = diesel; Biogas = biogas;
Afvalverwerking = waste-processing; Industrie = industry; Kantoren/residentieel = offices/residential; sport-recreatie/cultuur = sport/recreation/culture; Tuinbouw = horticulture; Zieken-en rusthuizen = hospitals and rest homes

Figure 12:Net electricity production of cogeneration engines eligible for a certificate by fuel and by sector in 2005

Key to figure:
Energieproductie voor certificaten = energy production for certificates; Aardgas = natural gas; Gasolie = diesel; Biogas = biogas;
Afvalverwerking = waste-processing; Industrie = industry; Kantoren/residentieel = offices/residential; sport-recreatie/cultuur = sport/recreation/culture; Tuinbouw = horticulture; Zieken-en rusthuizen = hospitals and rest homes

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Up to Figure 12 in all these figures the same ratios are seen as in the graph with the installed electrical capacity by fuel and by sector (Figure 6): natural gas proves to be by far the most important fuel, while diesel is only still used in the sectors industry, horticulture and sport/recreation/culture. Both biogas and diesel take a relatively larger proportion for the units eligible for a certificate. Moreover, the dual fuel engines which are high-efficiency according to the definition in Annex III of the Decree of the Flemish Government of 7 July 2006 [2], are not eligible for a certificate because this relates to units dating back to before 2002.

2.4 Distribution of primary energy savings of cogeneration engines by fuel and by sector in 2005

The following figures give a distribution for cogeneration engines in 2005 by fuel and by sector of:

- The primary energy savings calculated on the basis of the European efficiency reference values [3] (Figure 13);
- The primary energy savings calculated on the basis of the European efficiency reference values [3] for the units which are high-efficiency according to the definition of Annex III of the Decree of the Flemish Government of 7 July 2006 [2] (Figure 14};
- The primary energy savings calculated on the basis of the Flemish efficiency reference values are described in Article 10 of the Decree of the Flemish Government of 7 July 2006 [2] for the units from 01/01/2002 which are high-efficiency according to the definition of Annex III of the Decree of the Flemish Government of 7 July 2006 [2]. These are the cogeneration engines eligible for a certificate (Figure 15)

Figure 13: Primary energy savings of cogeneration engines by fuel and by sector in 2005

Key to figure:
Primaire energiebesparing = primary energy savings; Aardgas = natural gas; Gasolie = diesel; Biogas = biogas; Dual Fuel = Dual Fuel;
Afvalverwerking = waste-processing; Industrie = industry; Kantoren/residentieel = offices/residential; sport-recreatie/cultuur = sport/recreation/culture; Tuinbouw = horticulture; Zieken-en rusthuizen = hospitals and rest homes

Figure 14: High-efficiency primary energy savings of cogeneration engines by fuel and by sector in 2005

Key to figure:
Kwalitatieve primaire energiebesparing = high-efficiency primary energy savings; Aardgas = natural gas; Gasolie = diesel; Biogas = biogas; Dual Fuel = Dual Fuel;
Afvalverwerking = waste-processing; Industrie = industry; Kantoren/residentieel = offices/residential; sport-recreatie/cultuur = sport/recreation/culture; Tuinbouw = horticulture; Zieken-en rusthuizen = hospitals and rest homes

Figure 15:Primary energy savings of cogeneration engines eligible for a certificate by fuel and by sector in 2005

Key to figure:
Primaire energiebesparing voor WKK-certificaten = primary energy savings for cogeneration certificates; Aardgas = natural gas; Gasolie = diesel; Biogas = biogas;
Afvalverwerking = waste-processing; Industrie = industry; Kantoren/residentieel = offices/residential; sport-recreatie/cultuur = sport/recreation/culture; Tuinbouw = horticulture; Zieken-en rusthuizen = hospitals and rest homes

The same remarks apply for primary energy savings as those which were made for electricity production.

2.5 Conclusions regarding cogeneration units based on engines in 2005

In the last 15 years the installed cogeneration capacity with engines has risen from 7.7 to 160.6 MWe and from 9.9 to 199.9 MW_{th}.

The most important trends in this are:

- The total installed electrical capacity is 161 MWe, with a total net electricity production of 418 GWh/year. The cogeneration production calculated according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2]still accounts for 95% of this. 89% of the installed capacity relates to high-efficiency cogeneration engines according to Annex III of this decree. Only 25% of the installed capacity is eligible for cogeneration certificates. This equates to 14% of the electricity production.
- In 2005 the additional installed capacity dropped compared with 2004 and was even less than in 2003. There continues to be a general downward trend.

- Most units are to be found in horticulture and industry where in 2005 135.4 MW_e of cogeneration capacity was installed.
- The most important fuel continues to be natural gas, although the installed electrical capacity of cogeneration engines running on natural gas in 2006 was less than in 2004. The latter also applies for diesel engines. The installed electrical capacity of cogeneration engines running on biogas, on the other hand, in 2005 was 154% of that in 2004.
- In the waste processing and horticulture sectors cogeneration engines have also been installed which run on more than 1 fuel. This accounts for a total installed electrical capacity of 2.4 MWe.
- The majority of the projects are still run under own management; based on capacity, the energy sector is, however, the most important owner of the cogeneration units, which indicates a greater installed capacity per project.

3 Report on cogeneration with gas turbines and STEGs

3.1 Installed capacity of gas turbines and STEGs

3.1.1 Change in the installed capacity of gas turbines and STEGs

In 2005 1 additional STEG unit came into operation in Flanders, namely Zandvliet Power in Antwerp. Furthermore there was a considerable shift for the Petrofina plant compared with the survey for 2004. In 2002 a back pressure steam turbine was placed downstream of the waste gas boiler of the gas turbine. According to the owner, these two units work as one STEG combination and are recorded here as such. In the 2004 survey the units were still recorded separately (1 for the gas turbines and 1 for the gird-connected steam turbines). Furthermore for a few units the installed capacity is different from the values in the survey for 2004. This can be explained by the fact that data from the producers in 2005 sometimes differ from those for 2004. The total installed electrical capacity of gas turbines in 2005 is 326 MWe and that of STEGs is 731 MWe. Of the 15 units, 6 have a downstream steam turbine (STEG-CHPs). The installed thermal capacity is 422 MW for gas turbines and 437 MW for STEGs.

Table 3 gives an overview of the installed gas turbine and STEG cogeneration units.

Table 3: Installed capacity of cogeneration gas turbines and STEGs in 2005

NAME	PLACE	SECTOR	IN OPERATION	Electrical	Thermal	TURBINE	MAKE
Esso	Antwerp	chemicals				gas turbine	
Stora	Langerbrugge	paper				STEG	
Phenolchemie	Beveren	chemicals				gas turbine	
Gent Ham	Ghent	construction				STEG	
Cargill	Izegem	food				STEG	
Distrigas	Zeebrugge	chemicals				gas turbine	
SAPPI	Lanaken	paper				gas turbine	
Amoco	Geel	chemicals				gas turbine	
VPK	Oudegem	paper				gas turbine	
Amylum	Aalst	chemicals				STEG	
Petrofina	Antwerp	chemicals				STEG	
Lanxess	Lillo	chemicals				gas turbine	
Degussa	Antwerp	chemicals				gas turbine	
Monsanto	Antwerp	chemicals				gas turbine	
BASF	Antwerp	chemicals				STEG	

Key to table: stoom = steam

3.1.2 Distribution of the installed electrical capacity of gas turbines and STEGs by sector

Figure 16 gives the installed electrical capacity for gas turbines and STEGs in 2005 broken down into the 4 sectors in which these cogeneration units operate in Flanders. Industry is the most important sector with a total installed electrical capacity of 864 MWe, which constitutes almost 82% of the total installed capacity of gas turbines and STEGs. In the offices/residential and food sectors there are only STEG installations. The STEGs make up a total of 69% of the total installed electrical capacity.

Figure 16: Distribution of electrical capacity of gas turbines and STEGs across the various sectors in 2005

Key to figure:
Opgesteld elektrisch vermogen = installed electrical capacity; Papier en drukken = paper and printing; Industrie = industry; kantoren/residentieel = offices/residential; Voeding = food; STEG's = STEGs; Gasturbines = gas turbines

3.1.3 Distribution of the installed electrical capacity of gas turbines and STEGs by fuel

Figure 17 shows the distribution of the installed electrical capacity of STEGs and gas turbines for the various fuels. Natural gas clearly occupies the largest proportion of this: natural gas is the fuel used by 96% of the installed capacity. In industry 1 unit has been installed which consists of a gas turbine which can run on more than 1 fuel: it runs either on natural gas or on refinery gas.

Figure 17: Distribution of electrical capacity of gas turbines and STEGs across the various sectors in 2005

Key to figure:
Opgesteld elektrisch vermogen = installed electrical capacity; Aardgas = natural gas; Dual Fuel = Dual Fuel; STEG's = STEGs; Gasturbines = gas turbines

3.2 Energy production of the cogeneration units based on gas turbines and STEGs in 2005

No production figures were included in the surveys conducted before 2002. For the 2002 and 2003 surveys energy production and use by cogeneration units was estimated by extrapolation of the energy figures of a few units. With the Ministerial Decree of 23.02.2005 it became possible for this survey to have energy figures of far more units available. The accuracy of the figures in the surveys from 2004 is also greater than in the previous surveys. It should be borne in mind, however, that by no means all data are from measurements. In these cases the operator of the cogeneration unit or VITO made an estimate on the basis of, among other things, operating times.

The result is given in Table 4: Summary of energy production data and performance of cogeneration units based on gas turbines and STEGs in Flanders in 2005.

In addition to the data for the total installed electrical capacity and the total electricity production, the corresponding figures were calculated according to Annex II of Directive 2004/8/EC of the European Parliament and of the Council [1] or according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2]. These figures are found in Table 2 "cogeneration share". With this, heat or electricity from the same unit which is not derived from cogeneration is excluded. These figures must be reported to Europe and must also be included on the registration of the cogeneration certificates by the VREG (Flemish regulatory body for the electricity and gas markets).

For classification into high-efficiency and non-high-efficiency cogeneration gas turbines and STEGs, account was taken of points a and c of Annex III of Directive 2004/8/EC of the European Parliament and of the Council [1] or of Annex III of the Decree of the Flemish

Government of 7 July 2006 [2]. In this, small-scale cogeneration units are considered to be high-efficiency if the RPES > 0 and large cogeneration units are considered to be high-efficiency if the RPES > 10%. Moreover for the efficiency reference values account was taken of the Ministerial Decree of the Flemish Government which appeared in the Official Gazette on 1/12/2006 [3], and in which the European efficiency reference values were transposed. No account was taken of Annex IV of this latter decree (correction factors for network losses) because insufficient data was available to be able to apply this. For units larger than 25 MWe account was taken of Article 12(2) of Directive 2004/8/EC of the European Parliament and of the Council [1] for determining whether a unit was high-efficiency or not. This only affected 1 unit, namely the BASF unit: in spite of a RPES of more than 10%, the cogeneration efficiency of this unit is, however, less than 70%, on account of which this may not be considered to be high-efficiency for Europe. This unit is however eligible for a certificate because the additional requirement from Article 12(2) for units with a capacity of more than 25 MWe was not included in the Flemish quality definition.

The primary energy savings were calculated twice: once on the basis of the European efficiency reference values (according to the Ministerial Decree of the Flemish Government which appeared in the Official Gazette on 1/12/2006 [3]) and once on the basis of the Flemish efficiency reference values as described in Article 10 of the Decree of the Flemish Government of 7 July 2006 [2].

Finally, Table 4 also gives the figures for the units eligible for the certificate These are units from 01/01/2002 which are high-efficiency according to Annex III of the Decree of the Flemish Government of 7 July 2006 [2], in which account was taken of the European efficiency reference values [3].

When interpreting the table it is important to take account of the fact that none of the high-efficiency units are eligible for a certificate. There is only 1 unit eligible for a certificate that, for Europe, cannot be regarded as being high-efficiency.

Table 4: Summary of the energy production data and performance of cogeneration units based on gas turbines and STEGs in Flanders in 2005

	Total	**Cogeneration share**
Installed electrical capacity		
Installed thermal capacity		
Annual operating time		
Electricity production		
Heat production		
Overall cogeneration percentage		

Relative primary energy savings		
High-efficiency cogeneration gas turbines and STEGs*		
Installed electrical capacity		
Installed thermal capacity		
Electricity production		
Primary energy savings*		
Primary energy savings**		
Relative primary energy savings*		
Cogeneration percentage		
Cogeneration gas turbines and STEGs eligible for a certificate*		
Installed electrical capacity		
Installed thermal capacity		
Electricity production		
Primary energy savings*		
Primary energy savings**		
Relative primary energy savings*		
Cogeneration percentage		

* Based on the European efficiency reference values
** Based on Flemish efficiency reference values

3.3 Distribution of energy production from gas turbines and STEGs by fuel and by sector in 2005

The following figures give a distribution for cogeneration gas turbines and STEGs in 2005 by fuel and by sector of:

- The net electricity production (Figure 18);
- The electricity production calculated according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2] (Figure 19);
- The high-efficiency electricity production (Figure 20);

Figure 18: Net electricity production of gas turbines and STEGs by fuel and by sector in 2005

Key to figure:
Netto electriciteitsproductie = net electricity production; Papier en drukken = paper and printing; Industrie = industry; kantoren/residentieel = offices/residential; Voeding = food; Dual Fuel = Dual Fuel; Aardgas STEG = STEG natural gas; Aardgas GT = GT natural gas

Figure 19: Electricity production of gas turbines and STEGs by fuel and by sector in 2005 calculated according to Annex II of the decree of the Flemish Government of 7 July 2006 [2]

Key to figure:
Elektriciteitsproductie volgens bijlage II = electricity production according to Annex II; ; Papier en drukken = paper and printing; Industrie = industry; kantoren/residentieel = offices/residential; Voeding = food; Dual Fuel = Dual Fuel; Aardgas STEG = STEG natural gas; Aardgas GT = GT natural gas

Figure 20: High-efficiency electricity production of gas turbines and STEGs by fuel and by sector in 2005

Kwalitatieve elektriciteitsproductie = high-efficiency electricity production; Papier en drukken = paper and printing; Industrie = industry; kantoren/residentieel = offices/residential; Voeding = food; Aardgas STEG = STEG natural gas; Aardgas GT = GT natural gas

From this it is clear that industry is the most important sector. Moreover, of the STEGs which have been installed in the offices/residential sector, there is not a single installation which is high-efficiency but all STEGs in the food and paper and printing sectors are high-efficiency.

The only unit eligible for a certificate is to be found in industry.

3.4 Distribution of primary energy savings of gas turbines and STEGs by fuel and by sector in 2005

Figure 21 shows the primary energy savings of the cogeneration units based on gas turbines and STEGs for 2005 distributed over the different fuels and sectors.

Figure 21: Primary energy savings of gas turbines and STEGs by fuel and by sector in 2005

Key to figure:
Primaire energiebesparing = primary energy savings; ; Papier en drukken = paper and printing; Industrie = industry; kantoren/residentieel = offices/residential; Voeding = food; Dual Fuel GT= GT Dual Fuel; Aardgas STEG = STEG natural gas; Aardgas GT = GT natural gas

The largest primary energy savings are achieved in chemicals due to the fact that in this sector most cogeneration units are installed on the basis of gas turbines and STEGs. Figure 22 is similar to Figure 21 but only takes into account the high-efficiency cogeneration units. Comparison of Figure 21 and Figure 22 reveals that only in the sectors food and paper and

printing are high-efficiency cogeneration units installed on the basis of STEGs and that in the offices/residential sector there are only non-high-efficiency units.

Figure 22: High-efficiency primary energy savings of gas turbines and STEGs by fuel and by sector in 2005

Key to figure:
Kwalitatieve primaire energiebesparing = high-efficiency primary energy savings; Papier en drukken = paper and printing; Industrie = industry; kantoren/residentieel = offices/residential; Voeding = food; Aardgas STEG = STEG natural gas; Aardgas GT = GT natural gas

The only unit eligible for a certificate is to be found in industry.

3.5 Conclusions regarding cogeneration units based on gas turbines and STEGs in 2005

- As far as gas turbines and STEGs are concerned, 1 STEG unit was added in 2005. Nevertheless for a number of units different capacities have been recorded from those in the previous survey which is due to the fact that the producer has given slightly amended data for 2005. Furthermore, there was a shift from one unit as a gas turbine unit to STEGs (together with a back pressure steam turbine which was included in the earlier survey in the gird-connected steam turbines).
- The total installed electrical capacity of cogeneration units with gas turbines and STEGs in Flanders in 2005 is 1057 MWe, with a total net electricity production of 5,980 GWh/year. The cogeneration production calculated according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2] accounts for 70.6% of this. 46% of the installed capacity relates to high-efficiency cogeneration gas turbines and STEGs according to Article 12(2) of the European Directive 2004/8/EC [1]. Not a single one of the high-efficiency units is eligible for a certificate according to Europe. Only 1 of the units installed can be considered for cogeneration certificates. This means that 37% of the installed capacity and 20.6% of the electricity production is eligible for a certificate.
- The installed thermal capacity is 858 MW.
- Most units are in industry, where in 2005 there was a total installed electrical capacity of 864 MWe (82%).
- The most important fuel is natural gas, with a share of 96% of the installed electrical capacity. In industry there is a further installed electrical capacity of 42.6 MWe which consists of a dual fuel unit in which either natural gas or refinery gas are used as fuel.

- The cogeneration units based on gas turbines and STEGs are succeeding in achieving very good primary energy savings. On an annual basis they are saving almost 3400 GWh of primary energy. If only the high-efficiency cogeneration units are examined, the primary energy savings achieved come to 2,958 GWh/year.

4 Report on cogeneration with steam turbines

Previous reports on cogeneration for steam turbines were based on data from the Belgian federation of electricity producers, the BFE, and a survey that had been carried out together with Fedichem. As from 2005, under the ministerial decree of 23.02.2005, operators of steam turbine CHPs have been obliged to report the energy figures of their units, as a result of which the reports produced since 2004 have been based on more accurate figures than was the case before.

A distinction is made between grid-connected and non-grid-connected steam turbines. Most steam turbines are not connected to the grid. Some units, particularly in large chemical companies, are not connected to the grid: in these cases the steam turbines drive directly 1 or more large machines (compressors, pumps, etc.).

4.1 Installed capacity of steam turbines

4.1.1 Change in the installed capacity of steam turbines

As regards the grid-connected steam turbines, no additional units were reported for 2005. Compared with the report in 2004 there have however been some changes for various reasons:

- 1 unit is now operating with reduced capacity compared with the previous survey;
- For another unit a lower thermal capacity has been reported;
- 1 unit has switched from the grid-connected to the non-grid-connected steam turbines;
- 1 unit has moved from the grid-connected steam turbines to the STEGs.

The non-grid-connected steam turbines are found mainly in the major process industry. In these cases the steam turbines are powered predominantly by waste heat or by high-pressure residual gases from the process. Compared with the cogeneration report for 2004, 2 additional units have been reported. There have also been a number of changes compared with the previous survey:

- For 1 unit a lower thermal capacity has been reported;

- 1 unit has been added to the non-grid-connected units which in the previous year was still a grid-connected unit;
- Some companies that reported their steam turbines in previous years have no longer done so since 2005. For these companies it has been assumed that the steam turbines are continuing to operate as they did in 2003.

The total installed electrical capacity in 2005 was 239.5 MWe, namely 126 MWe of grid-connected and 113 MWe of non-grid-connected steam turbines. The corresponding thermal capacity was 742 MW and 962 MW respectively. There were a total of 23 grid-connected and 55 non-grid-connected steam turbines.

4.1.2 Distribution of installed electrical capacity of steam turbines by sector

Figure 23 shows the installed electrical capacity for steam turbines broken down by the 4 sectors in which these units were to be found in Flanders in 2005. The chemicals industry is clearly the main sector with a total installed capacity of 128 MWe, which accounts for almost 54% of the total installed electricity capacity of steam turbines. More than 99% of the installed capacity of non-grid-connected steam turbines is installed in the chemicals sector. For the grid-connected steam turbines the greatest proportion is installed in the food sector, namely 59.6 MWe, or 47%. In the non-ferrous and the paper sectors there are only grid-connected units.

Figure 23: Distribution of electrical/mechanical capacity of steam turbines over the various sectors in 2005

Key to figure:
Opgesteld elektrisch vermogen = installed electrical capacity; Voeding = food; Chemie = chemicals; Non-ferro = non-ferrous products; Papier = paper; Mechanisch = mechanical; Netgekoppeld = grid-connected.

4.1.3 Distribution of installed electrical capacity of steam turbines by fuel

Figure 24 gives an overview of the installed electrical capacity of steam turbines by fuel in 2005. Almost 43% of the installed capacity, or in total 102 MWe, consists of steam turbines that operate on recovered steam. These are mainly (82%) non-grid-connected drives. Also the number of units that are powered by more than 1 type of fuel accounts for a large proportion

of the total installed capacity, namely 23.4%. These are all grid-connected steam turbines. For coal and diesel too, there are only grid-connected units.

Figure 24: Installed electrical/mechanical capacity of steam turbines by fuel in 2005

Key to figure:
Opgesteld elektrisch vermogen = installed electrical capacity; Aardgas = natural gas; Kolen = coal; Gasolie = diesel; Recuperatiestoom = steam recovery; Dual Fuel = Dual Fuel; Mechanisch = mechanical; Netgekoppeld = grid-connected.

Figure 25 shows the distribution of the different fuels by sector. Recovered steam is only used in the chemicals and the non-ferrous sectors. Natural gas is only used in the food and the chemicals sectors. Coal and diesel are still only used in the food sector. In the paper sector, only oil is used as a fuel

Figure 25: Installed electrical/mechanical capacity of steam turbines by fuel and by sector in 2005

Key to figure:
Opgesteld elektrisch vermogen = installed electrical capacity; Voeding = food; Chemie = chemicals; Non-ferro = non-ferrous sector; Papier = paper; Mechanisch = mechanical; Dual fuel elek = dual fuel electricity; Recuperatiestoom mech = steam recovery mechanical; Recuperatiestoom elek = steam recovery electrical; Gasolie elek = diesel electrical; Kolen elek = coal electrical; Aardgas mech = natural gas mechanical; Aardgas elek = natural gas electrical

Except for 2 grid-connected steam turbines, all cogeneration units with steam turbines are operated only for the operator concerned.

4.2 Energy production from cogeneration units based on steam turbines in 2005

No production figures were included in the surveys conducted before 2002. For the 2002 and 2003 surveys energy production and use by cogeneration units was estimated by extrapolation of the energy figures of a few units. With the Ministerial Decree of 23.02.2005 it became possible for this survey to have energy figures of far more units available. The accuracy of the figures in the surveys from 2004 is also greater than in the previous surveys. It should be borne in mind, however, that by no means all data are from measurements. In these cases the operator of the cogeneration unit or VITO made an estimate on the basis of, among other things, operating times.

The result is given in Table 5: Energy figures for the installed cogeneration units based on steam turbines in Flanders in 2005

In addition to the data for the total installed electrical capacity and the total electricity production, the corresponding figures were calculated according to Annex II of Directive 2004/8/EC of the European Parliament and of the Council [1] or according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2]. These figures are found in Table 2 "cogeneration share". With this, heat or electricity from the same unit which is not derived from cogeneration is excluded. These figures must be reported to Europe and must also be included on the registration of the cogeneration certificates by the VREG (Flemish regulatory body for the electricity and gas markets).

For classification into high-efficiency and non-high-efficiency cogeneration steam turbines, account was taken of points a and c of Annex III of Directive 2004/8/EC of the European Parliament and of the Council [1] or of Annex III of the Decree of the Flemish Government of 7 July 2006 [2]. In this, small-scale cogeneration units are considered to be high-efficiency if the RPES > 0 and large cogeneration units are considered to be high-efficiency if the RPES > 10%. Moreover for the efficiency reference values account was taken of the Ministerial Decree of the Flemish Government which appeared in the Official Gazette on 1/12/2006 [3], and in which the European efficiency reference values were transposed. No account was taken of Annex IV of this latter decree (correction factors for network losses) because insufficient data was available to be able to apply this. For units larger than 25 MWe account was taken of Article 12(2) of Directive 2004/8/EC of the European Parliament and of the Council [1] for determining whether a unit was high-efficiency or not. This did not affect any units. For the steam turbines that operate with recovered steam , the fuel chosen from the gaseous fuels in the Ministerial decree of the Flemish Government that appeared in the Official Gazette on 01/12/2006 [3], was "recovered heat".

The primary energy savings were calculated three times: once on the basis of the European efficiency reference values (according to the Ministerial Decree of the Flemish Government which appeared in the Official Gazette on 1/12/2006 [3])and twice on the basis of the Flemish efficiency reference values as described in Article 10 of the Decree of the Flemish Government of 7 July 2006 [2] whereby once, for those units which work with steam recovery, account was taken of the nominal steam generation efficiency as described in the Annex to Decision 2004-62 of the VREG [4].

Finally, Table 5 also gives the figures for the units eligible for the certificate. These are units from 01/01/2002 which are high-efficiency according to Annex III of the Decree of the Flemish Government of 7 July 2006 [2], in which account was taken of the European efficiency reference values [3].

Table 5:Energy figures for the installed cogeneration units based on steam turbines in Flanders in 2005

	Total	**Cogeneration share**
Installed electrical/mechanical capacity		
Installed thermal capacity		
Annual operating time		
Production of electricity or power		
Heat production		
Overall cogeneration percentage		
Relative primary energy savings*		
High-efficiency cogeneration steam turbines*		
Installed electrical/mechanical capacity		
Installed thermal capacity		
Production of electricity or power		
Primary energy savings*		
Primary energy savings**		
Primary energy savings** with VREG reduction		
Relative primary energy savings*		
Cogeneration percentage		
Cogeneration steam turbines eligible for a certificate*		
Installed electrical/mechanical capacity		
Installed thermal capacity		
Production of electricity or power		
Primary energy savings*		
Primary energy savings**		
Primary energy savings** with VREG reduction		
Relative primary energy savings*		
Cogeneration percentage		

* Based on the European efficiency reference values
** Based on Flemish efficiency reference values

The table above shows that there are steam turbines with a capacity of about 5 MWe that in theory were eligible for cogeneration certificates in 2005. These are all grid-connected units. Moreover, 1 of these units is entitled to a certificate, but however is not eligible for cogeneration certificates because of a negative PES calculated with the Flemish efficiency reference values and taking into account the nominal steam generation efficiency in accordance with [4].

4.3 Distribution of the electrical and mechanical production of cogeneration steam turbines by fuel and by sector in 2005

The figures below show the distribution for steam turbines in 2005 by fuel and by sector of:

- The net electricity/power production (Figure 26);
- The electricity/power production calculated in accordance with Annex II of the Decree of the Flemish Government of 7 July 2006 [2] (Figure 27);
- The high-efficiency electricity/power production (Figure 28);

Figure 26: Net electrical and mechanical production of steam turbines in 2005 by fuel and by sector

Key to figure:
Netto elektriciteit/kracht productie = net electricity/power production; Voeding = food; Chemie = chemicals; Non-ferro = non-ferrous sector; Papier = paper; Dual fuel elek = dual fuel electricity; Recuperatiestoom mech = steam recovery mechanical; Recuperatiestoom elek = steam recovery electrical; Gasolie elek = diesel electrical; Kolen elek = coal electrical; Aardgas mech = natural gas mechanical; Aardgas elek = natural gas electrical

Figure 27: Electrical and mechanical production of steam turbines in 2005 by fuel and by sector calculated in accordance with Annex II of the Decree of the Flemish Government of 7 July 2006 [2]

Key to figure:
Netto elektriciteit/kracht productie volgens bijlage II = net electricity/power production according to Annex II; Voeding = food; Chemie = chemicals; Non-ferro = non-ferrous sector; Papier = paper; Dual fuel elek = dual fuel electricity; Recuperatiestoom mech = steam recovery mechanical; Recuperatiestoom elek = steam recovery electrical; Gasolie elek = diesel electrical; Kolen elek = coal electrical; Aardgas mech = natural gas mechanical; Aardgas elek = natural gas electrical

Figure 28: High-efficiency electrical and mechanical production of steam turbines in 2005 by fuel and by sector

Key to figure:
Kwalitatieve elektriciteit/kracht productie = High-efficiency electrical/power production; Voeding = food; Chemie = chemicals; Non-ferro = non-ferrous sector; Papier = paper; Dual fuel elek = dual fuel electricity; Recuperatiestoom mech = steam recovery mechanical; Recuperatiestoom elek = steam recovery electrical; Gasolie elek = diesel electrical; Kolen elek = coal electrical; Aardgas mech = natural gas mechanical; Aardgas elek = natural gas electrical

These graphs show the same ratios as in the graphs for installed capacity by fuel and by sector (Figure 25). Recovered steam is used only in the chemicals and the non-ferrous sectors. Natural gas is only used in the food and the chemicals sectors. Coal and diesel is still only used in the food sector. In the paper sector, only diesel is used as fuel.

In the food sector and in the non-ferrous sector, all energy production can be regarded as being cogeneration energy production in accordance with Annex II of the Decree of the Flemish Government of 7 July 2006 [2]. Of the grid-connected steam turbines powered by natural gas, none of the units in the chemicals sector is high-efficiency. Also, none of the grid-connected "dual fuel" steam turbines in the non-ferrous sector are high-efficiency.

Energy production by the steam turbines eligible for a certificate is 40 GWh per year and all of this is generated in the chemicals sector by 2 grid-connected steam turbines that run on recovered steam.

4.4 Distribution of primary energy savings of cogeneration steam turbines by fuel and by sector in 2005

The figures below show a distribution for cogeneration steam turbines in 2005 by fuel and by sector of:

- The primary energy savings calculated on the basis of the European efficiency reference values [3] (Figure 29);
- The primary energy savings calculated on the basis of the European efficiency reference values [3] for the units that are high-efficiency according to the definition in Annex III of the Decree of the Flemish Government of 7 July 2006 [2] (Figure 30);

Figure 29: Primary energy savings of cogeneration steam turbines by fuel and by sector in 2005

Key to figure:
Primaire energiebesparing = Primary energy savings; Voeding = food; Chemie = chemicals; Non-ferro = non-ferrous sector; Papier = paper; Dual fuel elek = dual fuel electricity; Recuperatiestoom mech = steam recovery mechanical; Recuperatiestoom elek = steam recovery electrical; Gasolie elek = diesel electrical; Kolen elek = coal electrical; Aardgas mech = natural gas mechanical; Aardgas elek = natural gas electrical

Figure 29 shows that the grid-connected steam turbines in the chemicals sector together have negative energy savings. The same also applies for the grid-connected steam turbines in the non-ferrous and the paper sectors.

Figure 30: High-efficiency primary energy savings of cogeneration steam turbines by fuel and by sector in 2005

Key to figure:
Primaire energiebesparing = Primary energy savings; Voeding = food; Chemie = chemicals; Non-ferro = non-ferrous sector; Papier = paper; Dual fuel elek = dual fuel electricity; Recuperatiestoom mech = steam recovery mechanical; Recuperatiestoom elek = steam recovery electrical; Gasolie elek = diesel electrical; Kolen elek = coal electrical; Aardgas mech = natural gas mechanical; Aardgas elek = natural gas electrical

Also, the same comments made regarding energy production also apply for the primary energy savings.

Primary energy savings calculated on the basis of the Flemish efficiency reference values as described in Art. 10 of the Decree of the Flemish Government of 7 July 2006 [2] for units that are eligible for a certificate are 76 GWh per year and all of this is generated in the chemicals sector by 2 grid-connected steam turbines that run on recovered steam. If the nominal steam generation efficiency is taken into account, the primary energy savings for 1 of the two units are 23.4 GWh/year. The other unit then has a negative primary energy saving of -87.7 GWh/year, as a result of which for the VREG this is not eligible for cogeneration certificates.

4.5 Conclusions regarding cogeneration units based on steam turbines in 2005

- In 2005 no steam turbine cogeneration units were added. There were however changes in the results compared with those in the survey of 2004. This is due to the fact that for 2005, on the one hand different numbers were reported and on the other hand more units were reported. Also, there was a shift from the grid-connected steam turbines to the STEGs and from the grid-connected to the non-grid-connected steam turbines.
- The total installed electrical capacity of cogeneration units with steam turbines in 2005 in Flanders was 239 MWe, with a total net electricity production of 1,519 GWh/year. Cogeneration production according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2] accounted for 93.4% of this. 59.8% of the installed capacity was from high-efficiency cogeneration steam turbines in accordance with Article 12(2) of European

Directive 2004/8/EC [1]. Only 2% of the installed capacity was eligible for a certificate. This is equivalent to 2.6% of electricity production.

- The installed thermal capacity was 1,704 MW.
- Most units are in the chemicals sector, where in 2005 there was a total installed capacity of 128 MW (53.6%).
- The main fuel was recovered steam, accounting for 42.7% of installed capacity.
- Energy production by steam turbines eligible for a certificate is 40 GWh per year and is all generated in the chemicals sector with grid-connected steam turbines powered by recovered steam. There is however 1 unit that is not eligible for cogeneration certificates because of a negative PES calculated with the Flemish efficiency reference values and taking into account the nominal steam generation efficiency in accordance with [4].

5 General conclusion

Table 6 gives a summary of the capacities and energy figures of the cogeneration units in Flanders in 2005.

In addition to the data for the total installed electrical capacity and the total electricity production, the corresponding figures were calculated according to Annex II of Directive 2004/8/EC of the European Parliament and of the Council [1] or according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2]. With this, heat or electricity from the same unit which is not derived from cogeneration is excluded. Moreover the figures are also given for the cogeneration units eligible for a certificate. These are the units as from 01/01/2002 which are high-efficiency according to Annex III of the Decree of the Flemish Government of 7 July 2006 [2], in which account was taken of the European efficiency reference values [3].

For classification into high-efficiency and non-high-efficiency cogeneration units, account was taken of points a and c of Annex III of Directive 2004/8/EC of the European Parliament and of the Council [1] or of Annex III of the Decree of the Flemish Government of 7 July 2006 [2].In this, small-scale cogeneration units are considered to be high-efficiency if the RPES > 0 and the large cogeneration units are considered to be high-efficiency if the RPES > 10%. Moreover, for the efficiency reference values account was taken of the Ministerial Decree of the Flemish Government which appeared in the Official Gazette on 1/12/2006 [3], and in which the European efficiency reference values were transposed. No account was taken of Annex IV of this latter decree (correction factors for network losses) because

insufficient data was available to be able to apply this. For units larger than 25 MWe account was taken of Article 12(2) of Directive 2004/8/EC of the European Parliament and of the Council [1] for determining whether a unit is high-efficiency or not.

The primary energy saving was calculated 3 times: once on the basis of the European efficiency reference values (in accordance with the Ministerial Decree of the Flemish Government that appeared in the Official Gazette on 1/12/2006 [3]), twice on the basis of the Flemish efficiency reference values as described in Article 10 of the Decree of the Flemish Government of 7 July 2006 [2], whereby on one occasion, for the facilities working with recovered steam, the nominal steam generation efficiency as described in the Annex to Decision 2004-62 of the VREG [4] was taken into account.

The primary energy savings were calculated three times: once on the basis of the European efficiency reference values (according to the Ministerial Decree of the Flemish Government which appeared in the Official Gazette on 1/12/2006 [3]) and twice on the basis of the Flemish efficiency reference values as described in Article 10 of the Decree of the Flemish Government of 7 July 2006 [2] whereby once, for those units which work with steam recovery, account was taken of the nominal steam generation efficiency as described in the Annex to Decision 2004-62 of the VREG [4].

Table 6: Summary of installed capacities and energy performance of the cogeneration units in Flanders in 2005

	Engines	Gas turbines	STEG	Steam turbines, grid-connected	Steam turbines, direct drive	**Total**
Total installed electrical cogeneration capacity [MW]						
Total installed thermal cogeneration capacity [MW]						
Installed electrical cogeneration capacity according to Annex II						
Installed electrical high-efficiency cogeneration capacity according to the definition in Directive 2004/8/EC [MW]						
Installed electrical cogeneration capacity eligible for a certificate [MW]						
Electricity and heat production of cogeneration units						
Total net electricity production [GWh/year]						
Total heat production [GWh/year]						
Net electricity production according to Annex II						
Net electricity production of high-efficiency cogeneration according to the definition in Directive 2004/8/EC						

[GWh/year]						
Net electricity production eligible for a certificate [GWh/year]						
Average time operating at full power [h/year]						
Primary energy savings of cogeneration units						
Primary energy savings based on Flemish efficiency reference values [GWh/year]						
Primary energy savings based on Flemish efficiency reference values with nominal steam generation efficiency [GWh/year]						
Primary energy savings of high-efficiency cogeneration based on Flemish efficiency reference values						
Primary energy savings of high-efficiency cogeneration based on Flemish efficiency reference values with nominal steam generation efficiency [GWh/year]						
Primary energy savings based on European efficiency reference values [GWh/year]						
Primary energy savings of high-efficiency cogeneration based on European efficiency reference values						
Relative primary energy savings of cogeneration units						
RPES based on Flemish efficiency reference values						
RPES based on Flemish efficiency reference values with nominal steam generation efficiency [%]						
RPES of high-efficiency cogeneration based on Flemish efficiency reference values [%]						
RPES of high-efficiency cogeneration based on Flemish efficiency reference values with nominal steam generation efficiency [%]						
RPES based on European efficiency reference values						
RPES of high-efficiency cogeneration based on European efficiency reference values [%]						

The total surveyed electrical capacity of cogeneration units in 2005 in Flanders was 1,457 MWe, which means that 378 MWe of cogeneration was added in 2005. These units have a total net electricity production of 7,918 GWh/year. Cogeneration production according to Annex II of the Decree of the Flemish Government of 7 July 2006 [2] accounts for 76% of this. 53% of the installed capacity is from high-efficiency cogeneration units in accordance with Article 12(2) of Directive 2004/8/EC [1]. 30% of the installed capacity and 17% of the electricity production is eligible for a certificate.

The total installed thermal capacity was 2,762 MW, with a total production of heat of 16,261 GWh per year.

Figure 31 shows the total surveyed electrical and mechanical capacity of cogeneration units by type and by sector. It is clear from the figure that industry is the main sector with a total installed electrical capacity of 925 MWe, or 63.5%, of the total installed capacity.

Figure 31: Installed electrical and mechanical capacity of cogeneration units by type and by sector

Key to figure:
Opgesteld elektrisch/mechanisch vermogen = Installed electrical/mechanical capacity; Afvalverwerking = waste-processing; Industrie = industry; Kantoren/residentieel = offices/residential; sport-recreatie/cultuur = sport/recreation/culture; Tuinbouw = horticulture; Zieken-en rusthuizen = hospitals and rest homes; Voeding = food; Chemie = chemicals; Non-ferro = non-ferrous sector; Papier en drukken = paper and printing; Niet-netgekoppelde stoomturbines = non-grid-connected steam turbines; Netgekoppelde stoomturbines = grid-connected steam turbines; STEG's = STEGs; Gasturbines = gas turbines; Motoren = engines

Figure 32 shows the distribution of the surveyed electrical/mechanical capacity of cogeneration units by type and by fuel. Natural gas is by far the main fuel with a total installed electrical capacity of 1,176 MWe, or almost 81% of the total installed capacity.

Figure 32: Installed electrical/mechanical capacity of cogeneration units by type and by fuel

Key to figure:
Opgesteld elektrisch/mechanisch vermogen = Installed electrical/mechanical capacity; Aardgas = natural gas; Gasolie = diesel; Biogas = biogas; Dual Fuel = dual fuel; Kolen = coal; Recuperatiestoom = steam recovery; Niet-netgekoppelde stoomturbines = non-grid-connected steam turbines; Netgekoppelde stoomturbines = grid-connected steam turbines; STEG's = STEGs; Gasturbines = gas turbines; Motoren = engines

The total primary energy savings calculated with the Flemish efficiency reference values are 3,526 GWh per year, or 12.7 PJ. If only the high-efficiency units are considered, the savings are 4,175 GWh per year, or 15 PJ. The total primary energy savings calculated with the European efficiency reference values are 6,414 GWh per year, or 23.1 PJ, which is almost double that calculated with the Flemish efficiency reference values.

There is 1 STEG unit for which, despite the RPES of more than 10%, the cogeneration efficiency is however less than 70%, as a result of which for Europe this cannot be considered as being high-efficiency. This unit is however eligible for a certificate, because the additional

requirement from Article 12(2) for units with a capacity greater than 25 MWe was not included in the Flemish definition of quality.

In 2005 the total primary energy savings that are eligible for cogeneration certificates was 281 GWh, or 1 PJ

References

[1] 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.

[2] Decree of the Flemish Government of 7 July 2006 on the promotion of electricity generation in high-efficiency cogeneration facilities.

[3] Ministerial decree establishing efficiency reference values for applying the conditions for high-efficiency cogeneration units.

[4] Annex to BESL-2004-62 of the VREG: More detailed rules regarding the procedure for assessing the recognition of quality of cogeneration units: how to consider a cogeneration unit in the calculation of the heat and power saving and the relative primary energy savings.