Intelligent Energy Europe

EUBIONET II

Current situation and future trends in biomass fuel trade in Europe

IEA Bioenergy

Task40

Efficient trading of biomass fuels and analysis of fuel supply chains and business models for market actors by networking

Country report of Belgium

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CONTENTS

1 INTRODUCTION

This report relates at the same time to work package 1 (WP1) of EUBIONET II and Task40 of IEA.

WP1 of EUBIONET II concentrates on rating the current situation and future trends of biomass fuel trade in Europe. The aim of WP1 is to assess the economically and technically viable volume of solid biomass fuels (woody, agro-biomass, some waste fractions) by means of CEN TC 335 specifications on solid bio-fuels. Both raw material and bio-energy needs are taken into account. The inmost purpose of WP1 is to bring bio-fuel trade experts together to assess the utilisation potential of biomass. Also information on price levels and trends for different fuels, as well as the main fossil fuels for comparative reasons, are being collected during two years period. Import-export of bio-fuels is also analysed. National reports, lists of traders and summary reports are to be published.

To reach the targets mentioned above, a questionnaire form was created to get the information from different countries in comparable form. The questionnaire was launched in June 2005, and the answers are to be returned in October 2006. Based on the answers, country-wise reports will be prepared, and conclusions will be drawn in the Final Report.

IEA Bio-energy is an international collaborative agreement, set up in 1978 by the International Energy Agency (IEA) to improve international cooperation and information exchange between national bio-energy research, development and demonstration (RD&D) programs. IEA Bio-energy aims at realizing the use of environmentally sound and cost competitive bio-energy on a sustainable basis, thereby providing a substantial contribution to meeting future energy demands. IEA Bio-energy currently has 12 Tasks, all of which are supervised by the IEA Bio-energy Executive Committee. Each Task has a defined work program and is led by one of the participating countries (Operating Agent). A Task Leader, appointed by the Operating Agent, directs and manages the work program.

The aim of **Task 40** is to investigate what is needed to create a “commodity market” for bio-energy. The future vision on global bio-energy trade is that it develops over time into a real “commodity market” which will secure long term and sustainable supply and demand of bio-energy. Through the participation of interested parties e.g. industrialists, governmental bodies and NGO’s (producers and consumers), this task contributes to the development of sustainable bio-energy markets on short and on long term, at different scale levels e.g. local, regional, international, to global. Task 40 planned activities take into account several stages of development of the biomass markets in different regions of the world. Furthermore, the aim is that this platform can set the agenda and initiate a host of new activities relevant for developing biomass potentials worldwide.

2 BELGIAN ENERGY SECTOR

2.1 FUEL MIX

Belgium is a Federal State consisting of 3 regions: the Flemish Region, the Walloon Region and the Brussels-Capital Region. The evolution of the Belgian energy policy has been shaped by the country's general political evolution, and has led to the transfer of wide competences from the State to the Regions. ValBiom c/o CRA-W – Agricultural Research Centre, Agricultural Engineering Department has done the data collection. Majority of information used in the report is publicly available. Apart from literary and website references, also interviews with some experts have been executed. Regarding uncertainties related to the report, some figures, especially biomass resources and some price related estimations, include various assumptions, which means they are to be considered not more than directive ones.

Table 1 and 2 presents some basic facts and figures for Belgium.

Table 1. Key indicators for Belgium, 2003 (IEA, 2005, http://library.iea.org)

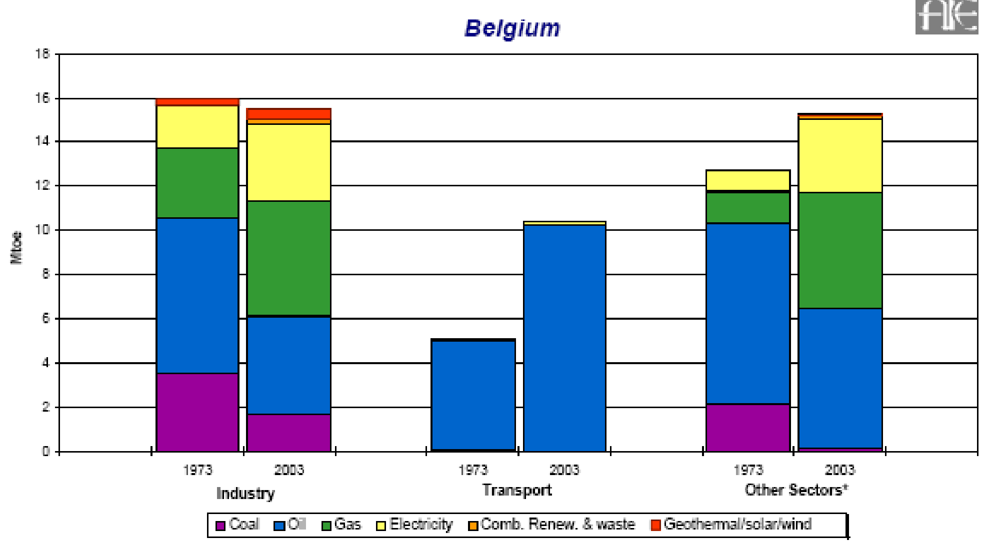
Key Indicators	
Population (million)	10.37
GDP (billion 2000 US$)	235.06
GDP (PPP) (billion 2000 US$)	276.92
Energy Production (Mtoe)	13.45
Net Imports (Mtoe)	52.65
TPES (Mtoe)	59.16
Electricity Consumption* (TWh)	87.28
CO_2 Emissions ** (Mt of CO_2)	120.07

Table 2. Belgium in brief, 2003 (ICEDD, 2005)

Gross inland energy consumption	55.8 Mtoe	2 336 PJ
* of which biomass	1.0 Mtoe	42.8 PJ
Biomass inputs to power generation production	0.63 Mtoe	26.4 PJ
Biomass in final energy consumption	0.45 Mtoe	18.8 PJ

The main energy consumers are the residential sector (32%), the industry (31%) and the transport (23%). The energy consumption of each sector is described in Figure 1.

Figure 1.
Breakdown of Sectorial Final Consumption by Source in 1973 and 2003



* Includes residential, commercial and public services, agriculture and non-specified.

Biomass represents just a few percents of the gross energy consumption in Belgium (1.8% for the year 2003). That's the reason why there is no accurate data related to the different types of biomass used to produce energy in Belgium. There are just partial surveys for Flanders and for Wallonia (Figure 2).

Figure 2.
Evolution of Total Primary Energy Supply* from 1971 to 2003

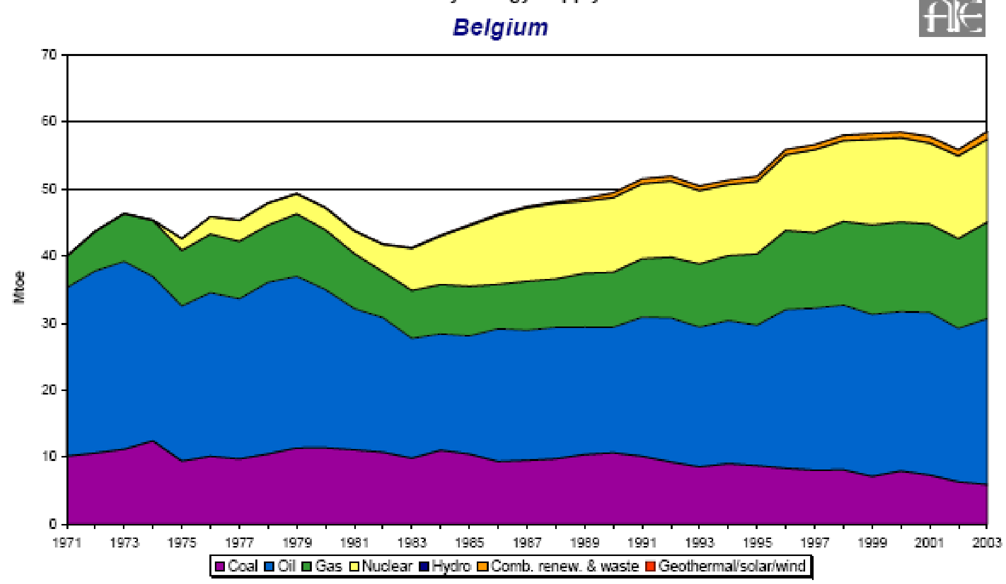
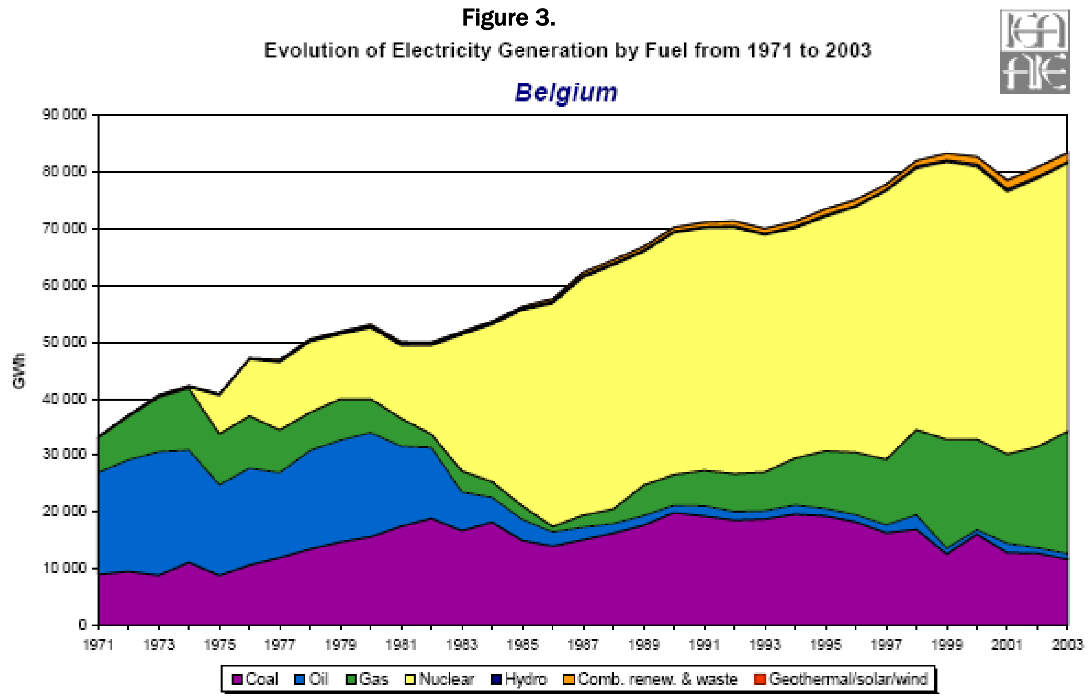


Table 3 gives information concerning the roles and responsibilities of the Federal and Regional regulators in the frame of the Belgian electricity market.

Table 3. Electricity market roles and responsibilities of the Federal and Regional regulators (IEA, 2006)

Federal *CREG*	**Flanders** *VREG*	**Wallonia** *CWaPE*	**Brussels-Capital** *IBGE/BIM*
- Advise federal government - Regulate transmission above 70 kV - Monitor the wholesale electricity market - Monitor the federal green certificate market - Give advice on the appointment of the transmission grid operator - Work with the competition authority - Verify the absence of cross-subsidies between categories of clients - Approve tariffs for using the transmission and distribution network - Arbitrate disputes	- Advise Flemish government - Regulate transmission and distribution up to 70 kV - Issue retail supply licenses - Monitor the regional electricity market - Monitor the Flemish green certificate and CHP market - Appoint distribution system grid operators - Provide dispute mediation	- Advise Walloon government - Regulate transmission and distribution up to 70 kV - Issue retail supply licenses - Monitor the regional electricity market - Monitor the Walloon green certificate market - Appoint distribution system grid operators - Arbitrate grid access disputes	- Regulate transmission and distribution up to 70 kV - Issue retail supply licenses - Monitor the regional electricity market - Monitor the Brussels-Capital green certificate market - Appoint distribution system grid operators - Arbitrate grid access disputes

As far as electricity is concerned, generation is clearly dominated by nuclear power plants making about 56% of the electricity but which has a more or less stable share. Natural gas is increasing since the mid-80's while oil has nearly disappeared. Since 2002 renewables are growing rapidly due to the strong support delivered by the green certificate systems (Figure 3). Since 2005, biomass is taking a growing share while coal is decreasing accordingly.



2.2 FUEL PRICES

Retail prices of biomass in the Belgian industry are quite confidential. That's the reason why there are just a few data related to energy use of biomass in Belgium. Figures 4 and 5 show prices for fuels used in *heat production* in December 2004 and June 2005. Prices are given for following end user categories: retail prices, prices for municipal plants and prices for industrial plants. The prices are consumer prices without value added tax (VAT).

Figure 4. Fuel prices for users of different sizes in December 2004

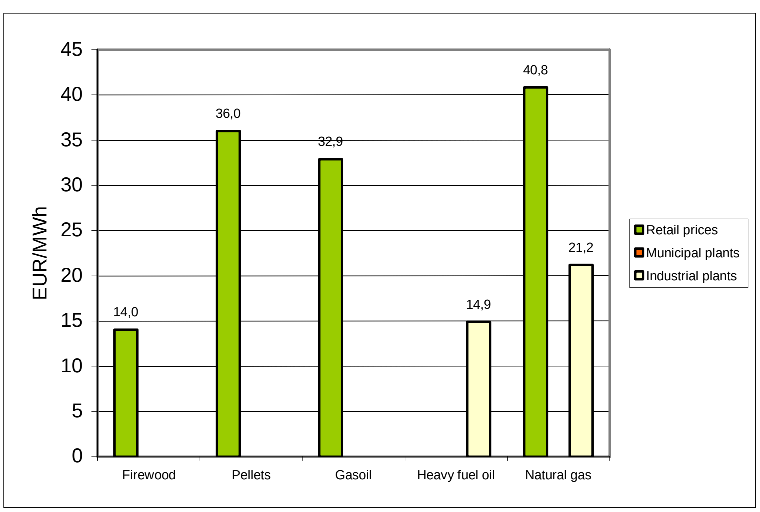
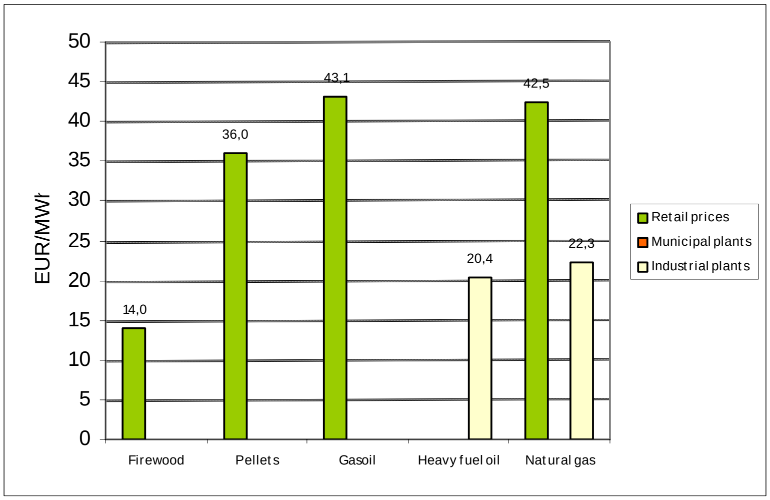
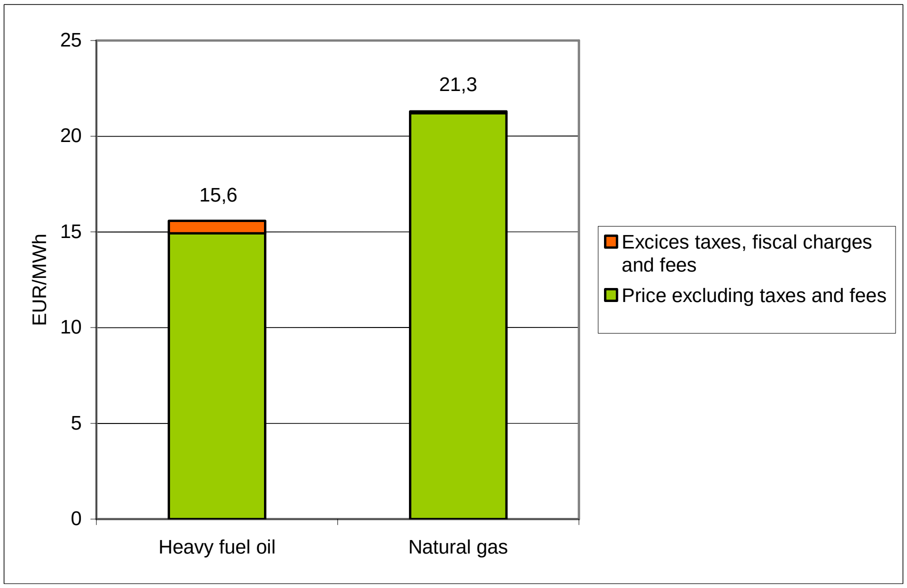


Figure 5. Fuel prices for users of different sizes in June 2005



Figures 6 and 7 illustrate the share of excise taxes[1], fiscal charges and fees from the consumer fuel prices in heat production for fossil fuels. Comparison of the fuel prices in December 2004 and June 2005 is given in figure 8.

Figure 6. Fuel prices in industrial energy plants in December 2004.
VAT not included.



[1] Source : http://www.fisconet.fgov.be

Valorisation de la Biomasse asbl

Figure 7. Fuel prices in industrial energy plants in June 2005. VAT not included.

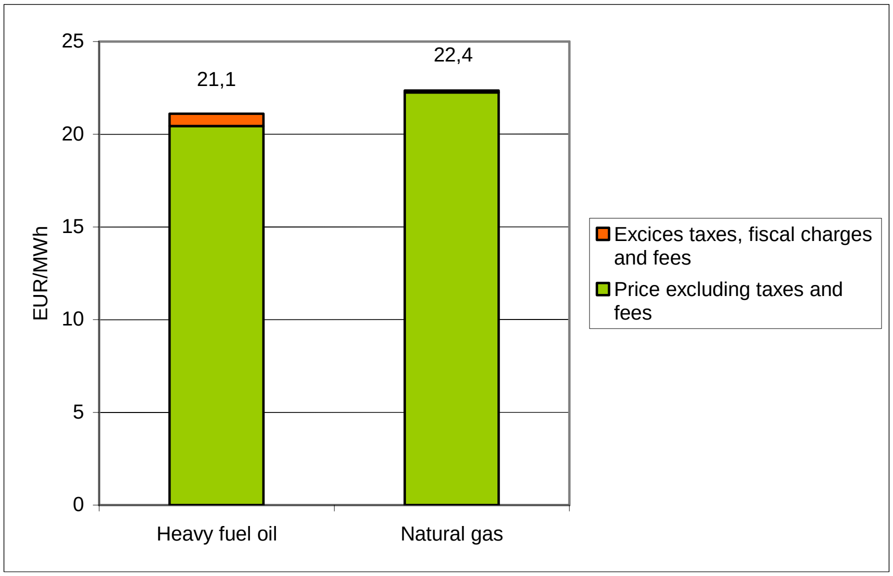
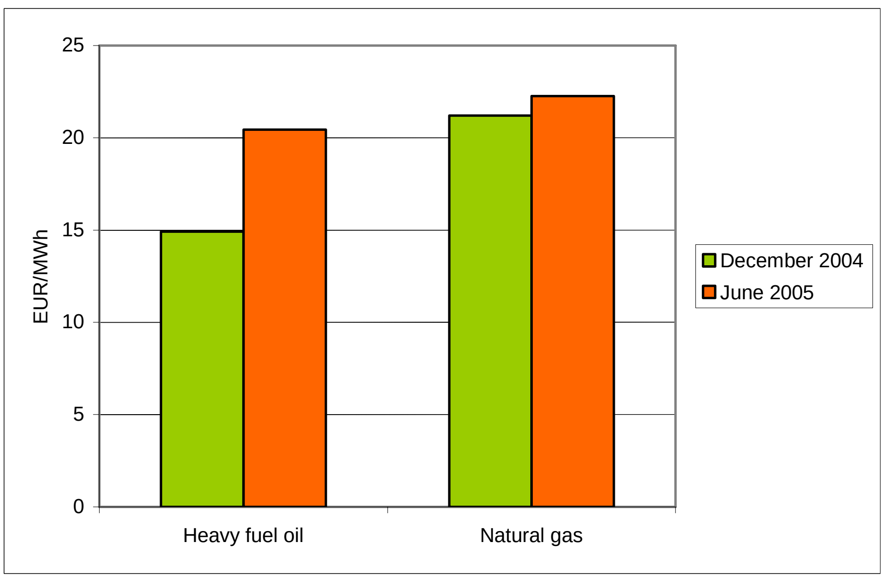


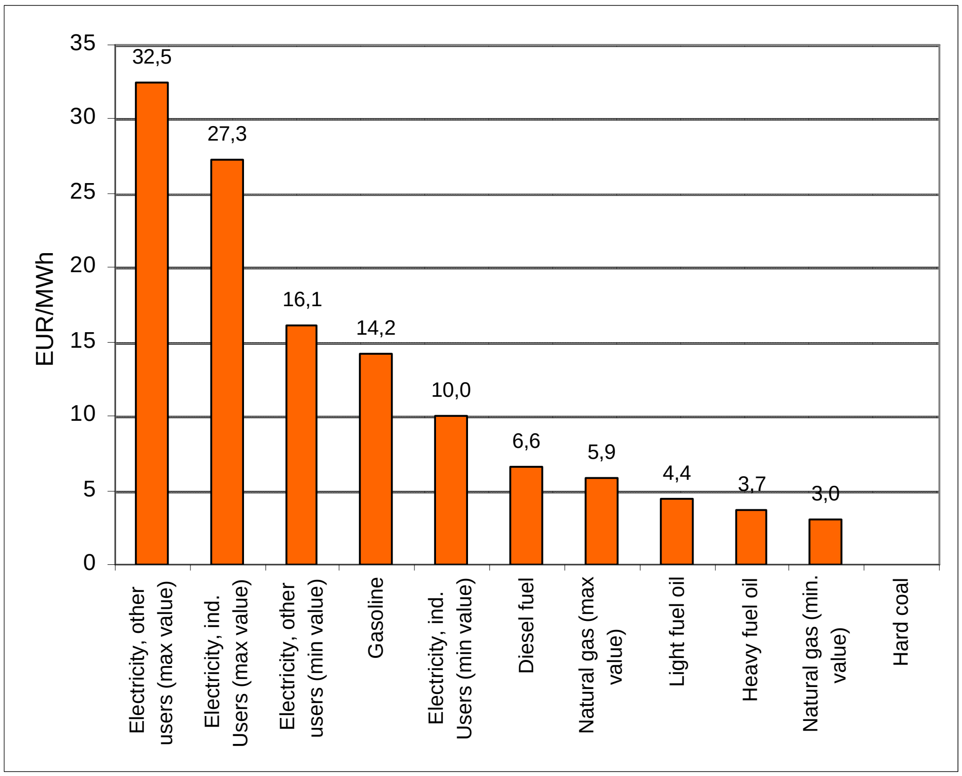
Figure 8. Fuel prices in industrial energy plants in December 2004 and June 2005. VAT not included.



2.3 FUEL AND ENERGY TAXATION

The energy tax changes fuels' price ratios and greatly enhances the competitiveness of wood fuels in heat production (Figure 9 and Table 4).

Figure 9. Fuel and energy taxation in Belgium in 2004 (Federal Public Service Economy, SMEs, Self-employed and Energy)[2]



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[2] http://mineco.fgov.be

Table 4. Fuel and energy taxation in Belgium in 2004 (Federal Public Service Economy, SMEs, Self-employed and Energy)

	Unit	Tax	Tax (EUR/MWh)
Gasoline	EUR/litre	0.1415	14.21
Diesel fuel	EUR/litre	0.0654	6.57
Light fuel oil [fuel oil moyen]	EUR/t	51.4869	4.40
Heavy fuel oil [fuel oil lourd]	EUR/t	41.6031	3.71
Natural gas (min. value)	EUR/GJ	0.8400	3.02
Natural gas (max.value)	EUR/GJ	1.6338	5.88
Hard coal	EUR/t	?	?
Electricity, industrial users (min. value)	EUR/100 kWh	0.9975	9.98
Electricity, industrial users (max. value)	EUR/100 kWh	2.7258	27.26
Electricity, other users (min. value)	EUR/100 kWh	1.6071	16.07
Electricity, other users (max. value)	EUR/100 kWh	3.2507	32.51

3 FINANCIAL SUPPORT TO BIOMASS

3.1 FINANCIAL INCENTIVES

Financial measures should give a chance to biomass investments and can be justified by environmental externalities.

3.1.1 For the production of energy crops

In Belgium, the "set-aside" policy is in place.

3.1.2 For the conversion of energy crops

No specific subsidies or loans are given for the energy conversion of biomass. Only subsidies over the whole investment (comprising, grinding, and drying) are available.

3.1.3 For the utilisation of energy from energy crops

There are green certificate mechanisms granting a fairly attractive price for the generated green power.

Specific limits for wood fired emissions are implemented in the regional legislations and are more stringent for biomass compared to the EU level only for Flanders (Vlarem).

No national wood fuels standard exists at present.

As a market support, a grant is available for companies that are investing in RE projects, calculated upon the marginal supplementary investment required with respect to conventional technologies.

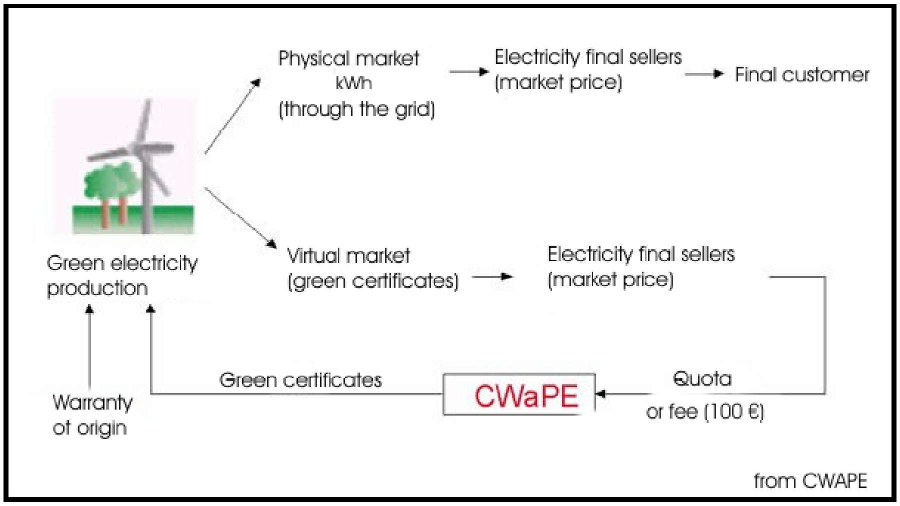
The increasing tax on landfilled residues results in an incentive to the developments of wood boilers in the wood industry.

3.2 GREEN POWER GENERATION

To comply with Kyoto protocol targets and new EC environmental regulations, Belgium has put into place a new regulation system. The level of CO2eq emissions (CO_2, CH_4, N2O) for the country was 142 307 ktons in 1990. It was increased to 150 675 ktons in 1999. With a target of 131 634 ktons for the 2008 – 2012 period, there is need for a reduction of 19,041 ktons. One means of reaching this level will be through the use of renewable energy for electricity generation.

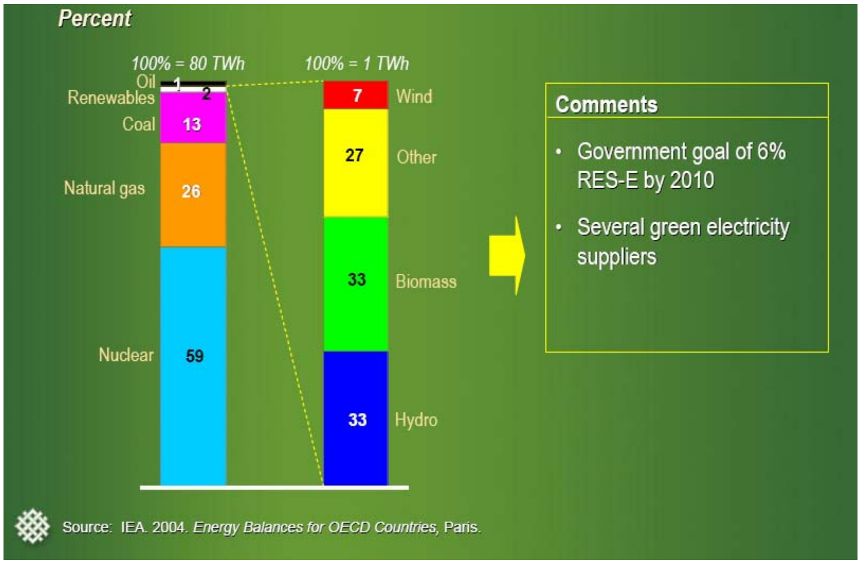
Today, electricity suppliers have to buy a minimum % of “green” electricity (i.e. made from renewable energy sources: wind, hydro, solar, biomass, cogeneration). To ensure this, a new market mechanism has been set up. It consists of a system of green certificates (Figure 10). These are delivered to the green producer on the basis of its reduction of fossil CO_2 emissions. This is done by comparing the emissions due to the fuel supply and energy generation with those of the best classic conversion process (i.e. Natural Gas Turbine Combined Cycle with an efficiency of 55% with 456 kg of CO_2/MWhe).

Figure 10. Green certificate scheme in Wallonia



Today, the market value for a green certificate is above 90 €. Compared to the physical electricity price of 30 €, this is a 300 % bonus for the clean producer !!!. This has already delivered a significant increase of the green power generation (Figure 11, 2004).

Figure 11. Renewable electricity market in Belgium in 2004.



Flanders has implemented a system of green certificates for renewable electricity in January 2002 and Wallonia in October 2002, as decribed in the previous chapter. Table 5 shows clearly that biomass takes the greatest share and that the share is increaing every year. This is related to the limited potential of the country especially in hydraulics (located in Wallonia only) and also in a certain measure in wind energy. This has to make with a relatively flat country, that is at the same time quite populated and with a limited sea-shore (64 km). This explains why only biomass to electricity can grow in a significant way.

Within statistics, Flanders (VREG, Flemish energy regulator) makes a distinction between biogas and solid or liquid biomass, while Wallonia makes a distinction between biomass power plants (including biogas) making pure electricity and biomass cogeneration plant up to 20 MWe. This is because the Walloon system also grants green certificates for cogeneration. In Table 5, green certificates granted in Wallonia to fossile cogeneration plant are not included. Only the cogeneration part of the biomass plants is included (corresponding to additional certificates between 40% and 80% of those granted for the green power).

Table 5. Annual generation of green power in total and with biomass in Flanders and in Wallonia since the start-up of the green certificates systems

	Green power in Flanders in certificates equivalent to 1000 kWh (2002-2005)				
	Total	Biogas	Solid+Liquid biomass	Total Biomass	%
2002	150.042	49.427	54.714	104.141	69,4%
2003	291.568	133.948	96.729	230.677	79,1%
2004	543.891	212.095	234.433	446.528	82,1%
2005	881.195	231.014	493.201	724.215	82,2%
	Green power in Wallonia in certificates equivalent to 1000 kWh (2002-2005)				
	Total	Electricity with biomass	Cogeneration with biomass	Total Biomass	%
2003	546.993	140.910	76.258	217.168	39,7%
2004	625.319	186.842	86.553	273.395	43,7%
2005	805.349	198.023	262.276	460.299	57,2%

4 CERTIFICATION SYSTEMS

4.1 BELGIAN GREEN CERTIFICATE SYSTEMS

Belgium has committed itself to reduce the greenhouse gas emissions with 7,5% by 2012. In addition, electricity sales are submitted to a renewable obligation of 6% renewable electricity by 2010 in the frame of targeted green certificate systems in each of the three Belgian regions. The obligation is coupled with a penalty for the unrealized share of green power (Table 6). Each region has its own target and penalty. Total electricity consumption in Belgium is about 78 TWh, spread out in 50 TWh for Flanders, 23 TWh for Wallonia and 5 TWh for Brussels.

Table 6. The 3 Belgian green certificates systems resp. for Flanders, Brussels and Wallonia (courtesy CogenSud)

The Green Certificates mechanism

Evolution of the green electricity production (expected…)

Years	Quota/Penalty Green Cert. (Flanders)		Quota/Penalty Cogen Cert. (Flanders)		Quota/Penalty (Brussels)		Quota/Penalty (Wallonia)	
2002	0.8%	75 €	-	-	-	-	-	-
2003	1.2%	100 €	-	-	-	-	3%	75 €
2004	2%	125 €	-	-	2%	75 €	4%	100 €
2005	2.5%	125 €	1.19%	40 €	2.25%	75 €	5%	100 €
2006	3%	125 €	2.16%	45 €	2.5%	75 €	6%	100 €
2007	3.75%	125 €	2.96%	45 €	?	100 €	7%	100 €
2008	4.5%	125 €	3.73%	45 €	?	100 €	?	?
2009	5.25%	125 €	4.39%	45 €	?	100 €	?	?
2010	6%	125 €	4.9%	45 €	?	?	?	?
2011	?	125 €	5.2%	45 €	?	?	?	?

The system in Flanders is based upon the energy balance and the use of fossil energy along the supply chain that is then subtracted from the number of granted certificates. An example of calculation is given hereunder for wood pellets originating from Canada (British Columbia). The electricity used for the pellet plant and for the drying is directly subtracted as well as the primary energy used for the local and overseas transportation. The reader shall note that this means that electricity is considered like it was a primary energy source.

Contributions for energy consumption:

1) Electricity consumption pelleting:	106 kW_e/ton
2) Primary energy for drying is biomass:	0 kW_p/ton
3) Train transport : 700 km per train or	108 kWh_p/ton
4) Sea transport: 750 ton diesel/40000 ton=	232 kWh_p/ton
TOTAL	446 kWh/ton

Primary energy in 1 ton wood pellets is	4700 kWh_p
Gross electricity generation per ton (38%)	1786 kWh_e
Subtraction	- 446 kWh_e
Net result	1340 kWh_e

The number of certificates is then reduces with a factor:

- k = 1786/1606 = 0,75 (loss of 25% green certificates).

One sees that energy needed for drying is not considered if it is made from renewable sources, while electricity is always taken into consideration, even if from renewable origin.

The second system in Wallonia is compatible with the one in Brussels region. It is based upon avoided fossil CO_2 emissions with respect to a reference being the combined cycle power plant firing natural gas with an efficiency of η_E=55%. The regulatory body (Commission Wallonne pour l'Energie, CWaPE) has published a list of reference specific fossil CO_2 emissions of the whole supply chain for all fossil fuels as well as the major biomass resources. Some elementary operations have even been quantified for woody products as well (see Table 7).

Table 7. Reference specific CO2 emission factors in Wallonia (kg CO2/MWhp of primary energy)

	kgCO2/MWhp
❖ NON FOSSILE	
• wind/solar/hydraulics	0
• organic biodegradable matters	0
❖ milling	4
❖ transport < 200 km	5
❖ transport > 200 km	25
❖ drying	10
• corn crops	22
• wood	23
• wood pellets with residues from the forestry	30
• cultivated wood (short rotation coppices)	45
• rapeseed oil	65
• bio-diesel	80
❖ FOSSILE	
• natural gas	251
• gas-oil	306
• light fuel oil	310
• heavy fuel oil	320
• coal	385

Let us considered 'C' factors as CO2 emission rates with respect to primary energy. Then for natural gas one has:

$$C_{NG} = 251 \text{ kgCO2/MWhp.}$$

Let us considered 'G' factors as CO2 emission rates with respect to electricity generation. For the reference technology, a STAG power plant firing natural gas, one has:

G_{NG} = 251/55% = 456 kgCO2/MWh_e.

The number of granted certificates is reduced with a 'k' factor corresponding to the relative avoidance of fossil CO_2 emissions with respect to the reference. This means that one green certificate is granted every time 456 kg of fossil CO2 emissions are saved with respect to the reference power plant.

If G_{PP} is the specific CO_2 emission rate of the considered power plant with respect to its fuel mix according to the official published emission factors, then, the 'k' factor is calculated according to the following formula (α_E, net electric efficiency of the power plant) :

$$k = \frac{G_{NG} - G_{PP}}{G_{NG}} = 1 - \frac{G_{PP}}{G_{NG}} = 1 - \frac{C_{PP}/\alpha_e}{C_{NG}/\eta_e}$$

Let us take the example of a thermal power plant firing wood pellets with a net efficiency of α_E=34%. For Belgian wood pellets, one has in Table 7 the contribution for wood pellets (30) and the one for the transportation on less than 200 km (5). With η_E=55%, α_E=34%, on has:

C_{PP}= 30 + 5 =35 kgCO2/MWhp,

k = 0,77 (loss of 23% green certificates).

For Canadian wood pellets, one has a higher contribution for transportation (25) such that:

C_{PP}= 30 + 25 = 55 kgCO2/MWhp,

k = 0,65 (i.e. loss of 35% of green certificates).

Within both systems, one sees that the final result is similar and that the development potential of wood pellets, as a new type of fuel for generating renewable electricity, appears to be attractive for Belgium. This is mainly due to the high penalty level related to the green obligation (12,5 c€/kWh in Flanders and 10 c€/kWh in Wallonia), and it remains true even if the Belgian systems reduce significantly the number of granted green certificates according to a rather detailed LCA analysis.

4.2 CERTIFICATION OF IMPORTED BIOMASS

Walloon authority imposes that each supplier undergoes an audit within 6 months. The audit must examine the sustainability of the wood sourcing as well as detail the energy balance of the whole supply chain. This includes the energy that is used for pelleting the wood and for transporting the final product up to the site of the power plant. If the product would appear in contradiction with the sustainability principle, the CWaPE (Energy Regulator in Wallonia) would then have the right to cancel the granted green certificates.

For each producer, the global supply chain is analyzed by SGS international, accepted as independent body by all Belgian Authorities for the grant of green certificates. SGS happens to be represented in all parts of the world as well since one of their core businesses consists in certified inspections of vessels lading in harbors. This means that local branches of SGS can perform audits and analyses everywhere in the world that are then accepted by Belgian authorities.

SGS checks first of all the sourcing of the wood (hardwood, softwood, saw dust, shavings, coppices) and the transportation between the sources and the pellet plant. If the biomass is not a secondary product but a primary one, then the whole energy consumption needed for planting, fertilizing, harvesting etc. must be taken into consideration and energy used subtracted from the number of granted green certificates. SGS evaluates all energy consumptions for making the pellets (electricity for the densification and auxiliaries, fossil fuels or biomass for drying). Finally, SGS looks to the final transportation to the sea harbor (train, truck) and checks the global traceability.

4.3 WORLD FORESTRY

In addition to the energetic audit of the supply chain including greenhouse gas emissions, Walloon authorities impose that the sustainable character of the forestry resources for imported biomass be proven as well. Evidence of sustainability can be delivered according to:

- a traceable chain management system at the supplier’s end,
- forest certificates pertaining sustainability of sources, of the type “Forest Stewarship Council” or equivalent,
- or in the absence of such forest certification, all public documents originating from independent bodies like FAO, or NGO’s like WWF, GreenPeace, … making a review of the forest management and control in the considered country.

It is the first time in our knowledge that such an extensive check is performed by an independent body for analyzing the sustainability of the wood pellets supply chain in many different regions of the world with a accent put on the fossil energy use, CO_2 equivalent greenhouse gas emissions and the management of the forestry resources.

4.4 THE SUPPLIER DECLARATION OF ELECTRABEL

To protect the environment a certification program with a quality mark is necessary in order to replace in a sustainable fashion fossil fuels by biomass and generating traceable green power.

The quality system for being granted green certificates corresponding to the generated renewable electricity firing wood pellets is focused on a tracing system for biomass from (by) products (and its energy produced) back to the sustainable source.

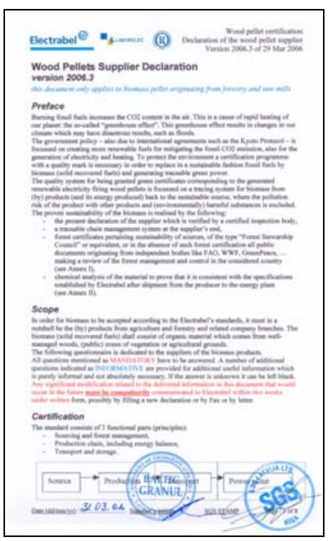
Till now, Flanders authorities have not requested audits or a certification procedure for imported biomass by law. Since Wallonia does and since the products might be used in two power plants not being located in the same region, Electrabel has decided to apply the same certification procedure gathering the requirements of both regions.

It is also necessary to inform a potential supplier of all requirements made by Electrabel concerning:

- the technical specifications of the product for firing it in a thermal power plant (chemical composition, physical properties),
- the sustainability criteria for being accepted within the Belgian green certificate systems.

All this is concentrated in one single document called "Supplier Declaration" (8 pages). This document is signed by a representative of the producer and is verified and stamped by a certified inspection body before being delivered to the Belgian authority (Figure 12). Swiss inspection company SGS is in charge of checking the document and carrying out a full audit of the pellet plant and of the supply chain within the 6 months following the first time the pellets are fired (Figure 13).

Figure 12. Electrabel certificate for imported biomass



Electrabel

Wood pellet certification
Declaration of the wood pellet supplier
Version 2006.3 of 29 Mar 2006

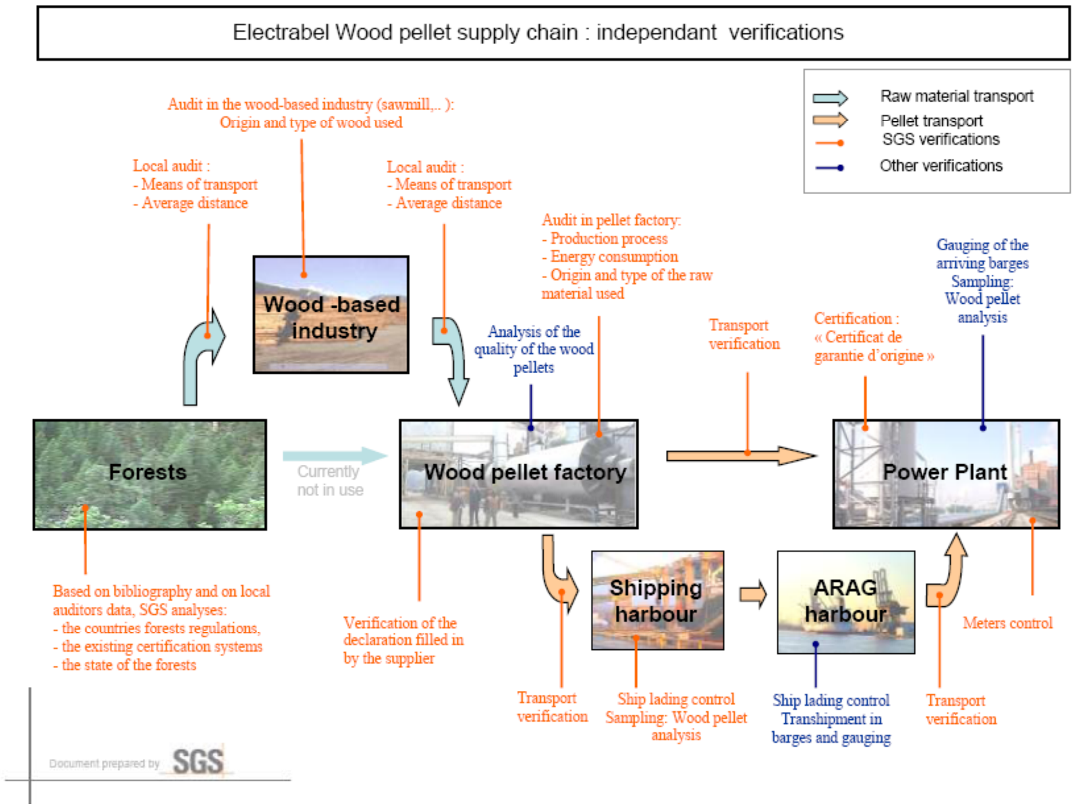
Wood Pellets Supplier Declaration
version 2006.3

Preface

Scope

Certification

Figure 13. Independent inspections of the wood pellets supply chain operated by SGS

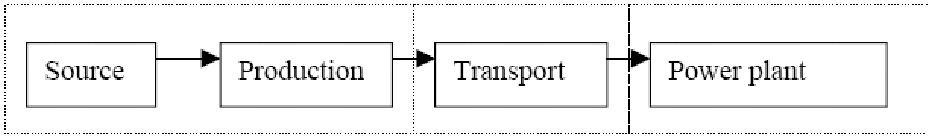


In order for biomass to be accepted according to the Electrabel's standards, it must in a nutshell be a by- product (preferably not a primary one such that additional certificates are not lost) from agriculture and forestry. The biomass (solid recovered fuels) shall consist of organic material that comes from well-managed woods, (public) zones of vegetation or agricultural grounds. Energy consumption must be reasonable with respect to other references and heat for drying must be generated from renewable sources (biomass).

For calculating the number of granted certificates Flemish authorities require the knowledge of a list of parameters related to the pellet plant. Therefore, the supplier must fill in an informative questionnaire that consists of three functional parts (Figure14):

- sourcing and forest management: wood origin;
- production chain, including energy consumptions;
- transport and storage, including rail and sea transport.

Figure 14. Functional parts of supply chain



4.5 CO_2 FOR PELLETS SUPPLY CHAIN

Electrabel is using the “Supplier Declaration” since end of 2005, and about 26 different suppliers have already been screened by SGS for the delivery of feedstock to Awirs and Rodenhuize power plants. The data collection gives already a unique view on fossil CO_2 emissions related to pellet plants located everywhere in the world. The results are presented in Table 8. The total value calculated takes electricity consumption, transportation to the harbor, sea transport and the transport in flat boats to the power plant into consideration.

The final result (last column) shows that the total emissions range between 19 and 55 $kgCO_2/MWh_p$, the average being 32 $kgCO_2/MWh_p$. If the real factor were used (instead of the imposed value for imported pellets of 55 $kgCO_2/MWh_p$ in Wallonia), the k reduction factor for the number of granted green certificates would have range between 0,65 and 0,85. Electrabel still negotiates with the Walloon Region to obtain that each supplier be considered separately for the calculation, as it is in Flanders.

By all 26 producers, heat for drying is generated mainly from local biomass resources such that drying does not contribute to the fossil CO_2 emissions.

Local transport of the wood residues to the pellet plant in not included but has been estimated to be always less than 2 $kgCO_2/MWh_p$.

The global results show that no immediate conclusion can be drawn according to the yearly capacity of the pellet plant or the distance from Belgian harbor. In some sense, a pellet plant located far away from its customers tends to be more efficient than the other ones.

Table 8. Specific fossil CO2 emissions of 26 wood pellet suppliers in the world

Country supplier	ID	Harbor	Capacity	Electricity		Drying (0=biomass)		Train or Truck		Sea transport					Flat boat		Total CO2
			ton/a	kWh /tonne	kgCO2 /MWhp	kWhp /tonne	kgCO2/ MWhp	km	kgCO2/ MWhp	boat size tons	sea milles	fuel oil (ton)	ton_CO2/ ton_pellet	kgCO2 /MWhp pellets	fuel oil (ton)	kgCO2 /MWhp pellets	kgCO2 /MWhp pellets
Canada	1	Vancouver	120.000	50	**4,64**		**0,00**	**700**	**5,70**	40000	8861	750	73,43	**14,94**	1,156	**1,70**	**26,99**
	2	Vancouver	65.000	100	**9,29**		**0,00**	**700**	**5,70**	40000	8861	750	73,43	**14,94**	1,156	**1,70**	**31,63**
South-Africa	3	Durban	80.000	112	**10,40**		**0,00**	**< 2**	[redacted]	25000	7028	525	82,25	**16,74**	1,156	**1,70**	**28,84**
Thailand	4	Si Racha	60.000	54	**5,02**		**0,00**	**95**	**2,32**	55000	?	878	62,52	**12,72**	1,156	**1,70**	**21,76**
Russia	5	St-Petersburg	21.600	150	**13,93**	**100,00**	**0,00**	**83**	**2,03**	3000	1350	36,75	47,98	**9,76**	1,156	**1,70**	**27,42**
	6	St-Petersburg	25.000	120	**11,14**	**100,00**	**0,00**	**325**	**7,94**	3000	1350	36,75	47,98	**9,76**	1,156	**1,70**	**30,54**
	7	St-Petersburg	12.000	240	**22,29**		**0,00**	**950**	**7,73**	3000	1350	36,75	47,98	**9,76**	1,156	**1,70**	**41,49**
	8	St-Petersburg	24.000	130	**12,07**	**100,00**	**0,00**	**35**	**0,85**	3000	1350	36,75	47,98	**9,76**	1,156	**1,70**	**24,39**
	9	St-Petersburg	12.000	280	**26,00**	**300,00**	**0,00**	**260**	**6,35**	3000	1350	36,75	47,98	**9,76**	1,156	**1,70**	**43,82**
	10	St-Petersburg	8.500	120	**11,14**		**0,00**	**55**	**1,34**	3000	1350	36,75	47,98	**9,76**	1,156	**1,70**	**23,95**
Ukraine Sunflower	11	Klaipeda	18.000	100	**9,29**		**0,00**	**1400**	**11,40**	3000	800	50	65,27	**13,28**	1,156	**1,70**	**35,67**
Estonia	12	Tallin	35.000	120	**11,14**	**1000,00**	**0,00**	**120**	**2,93**	3000	1015	87,5	114,23	**23,25**	1,156	**1,70**	**39,02**
	13	Muuga	80.000	100	**9,29**	**1000,00**	**0,00**	**110**	**2,69**	3000	953	87,5	114,23	**23,25**	1,156	**1,70**	**36,92**
Latvia	14	Riga	35.000	135	**12,54**	**1295,00**	**0,00**	**< 2**	[redacted]	3000	930	87,5	114,23	**23,25**	1,156	**1,70**	**37,48**
	15	Riga	80.000	150	**13,93**	**720,00**	**0,00**	**< 2**	[redacted]	3000	930	87,5	114,23	**23,25**	1,156	**1,70**	**38,88**
	16	Riga	40.000	148	**13,75**	**720,00**	**0,00**	**< 2**	[redacted]	1250	930	59,5	186,42	**37,94**	1,156	**1,70**	**53,38**
	17	Riga	70.000	110	**10,22**	**1000,00**	**0,00**	**< 2**	[redacted]	3000	930	87,5	114,23	**23,25**	1,156	**1,70**	**35,16**
	18	Liepaja	65.000	125	**11,61**	**1200,00**	**0,00**	**90**	**2,20**	3000	830	70	140,00	**28,49**	1,156	**1,70**	**44,00**
Lithuania	19	Klaipeda	40.000	148	**13,75**	**615,00**	**0,00**	**120**	**2,93**	3000	800	50	65,27	**13,28**	1,156	**1,70**	**31,66**
	20	Klaipeda	40.000	112	**10,40**	**720,00**	**0,00**	**315**	**7,69**	3000	800	50	65,27	**13,28**	1,156	**1,70**	**33,08**
Poland	21	Stettin	100.000	180	**16,72**		**0,00**	**< 2**	[redacted]	3500	700	28	31,33	**6,38**	1,156	**1,70**	**24,79**
	22	Stettin	40.000	120	**11,14**		**0,00**	**< 2**		3500	700	28	31,33	**6,38**	1,156	**1,70**	**19,22**
Sweden	23	Härnosand	140.000	200	**18,57**	**820,00**	**0,00**	**< 2**		3000	650	21	27,42	**5,58**	1,156	**1,70**	**25,85**
	24	Lulea	95.000	151	**14,02**	**1072,00**	**0,00**	**< 2**		5000	1460	27,5	21,54	**4,38**	1,156	**1,70**	**20,11**
	25	Ulricehamn	90.000	180	**16,72**	**960,00**	**0,00**	**130**	**3,17**	3000	650	21	27,42	**5,58**	1,156	**1,70**	**27,17**
Germany	26	Straubing	140 000	170	**15,79**	**650,00**	**0,00**	**< 2**	[redacted]	3000	694	[redacted]			7,223	**10,62**	**26,41**

5 BELGIAN BIOMASS MARKET

5.1 LOCAL BIOMASS RESOURCES

In Belgium, about 600,000 ha of the land are covered by forest. The total exploitable production should be around 4.8m3 per year, but only 4m3 are effectively exploited (Table 9). This overproduction however is not entirely usable for biomass. The Belgian experience with energy crops is recent and small. There are no commercial or large-scale uses of energy crops neither are there important demonstration units. Energy crops in Belgium are more or less mainly for scientific reasons.

Table 9. Data of total area and areas of interest for biomass production

Unit: 1 000 ha Country	Total area	Agriculture area	Arable land (% of total area)		Forest (% of total area)		Permanent grass (% of total area)		Fallow
Belgium	3 053	1 393	833	27	607	20	536	18	28

http://europa.eu.int/comm/eurostat/

The estimated annual biomass resources in Belgium are presented in Table 10. The most important resources are forest residues (located in Wallonia, for the greatest part) and industrial by-products (solid by-products and black liquor).

Table 10. Estimated annual available biomass resources in Belgium

Source	Flanders[3] (ktoe)	Wallonia [4] (ktoe)	Belgium (ktoe)
Solid agricultural residues	n.d.	9)[5]	9
Manure	100	0 – 58[3]	100 – 158
Forest residues	0	137	137
Wood industry by-products	283	44	327
Industrial organic residues	18	n.d.	18
Green wastes	66	18	84
TOTAL	467	209 – 267	675 – 733

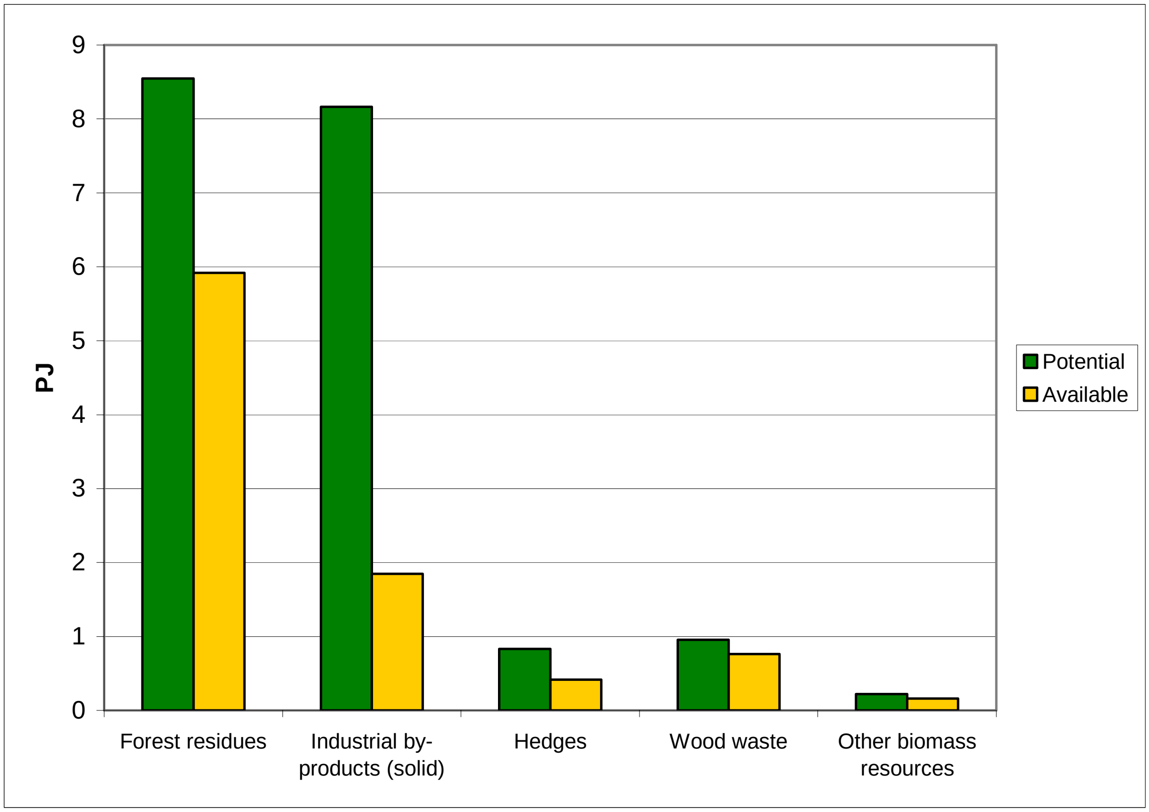
[3] Devriendt *et al*. (2004)

[4] Marchal *et al*. (2003)

[5] ValBiom (2004)

Figure 15 illustrates the estimated annual biomass resources in Wallonia.

Figure 15. Estimated annual biomass resources in Wallonia 2000 (total potential 18.7 PJ, total available 9.1 PJ) [Source : Marchal et al. *2003]*



Belgium is divided into three regions - Brussels, Wallonia, and Flanders - that have considerable political autonomy in the field of environment, energy and agriculture. Among them, the Wallonia region is the most active in the biomass for energy sector.

The achievement of the bio-energy objectives in the two main regions of Belgium needs a significant increase in the biomass supply either through the development of energy crops, through an increased availability of existing biomasses or through biomass importing.

Belgium considers the use of renewables as part of an environmental policy to help the country attain the carbon emission guidelines. The country does not have a RE programme on a National level. Environmental guidelines have been recently drawn up for the Walloon and Flemish regions. Wallonia has defined a contribution target of 5% in the total energy consumption by the year 2010 (Table 11). In Flanders the objective is less stringent, a three percent by the year 2010.

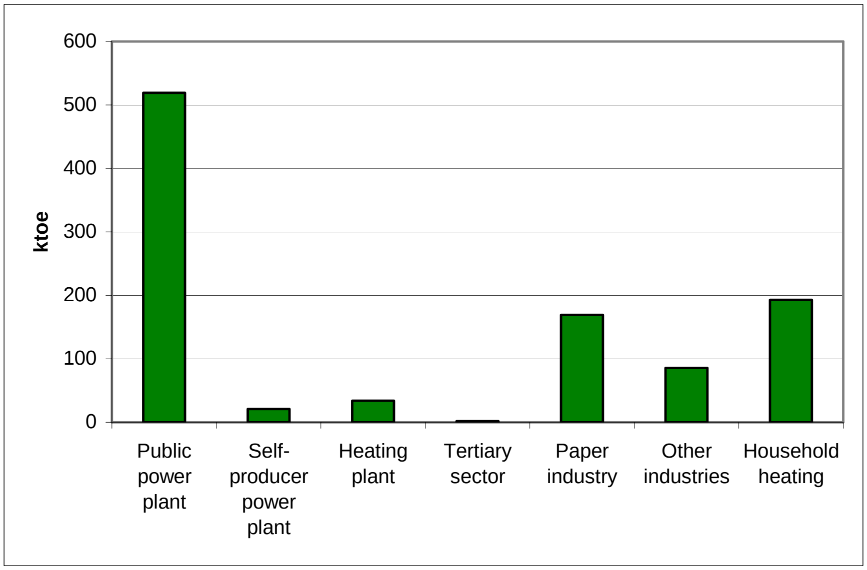
Table 11. Estimated and forecasted annual use of biomass to energy in Wallonia (Plan pour la Maîtrise Durable de l'Energie, 2004)

Wallonia : Plan pour la Maîtrise Durable de l'Energie			
Energie/source	Estimation 2000 (GWh)	Prevision 2005 (GWh)	Prevision 2010 (GWh)
Electricity from forestry	149	200	370
Electricity for cultivated biomass	0	55	225
Total electricity	*149*	*255*	*595*
Heat from forestry	1108	1600	3250
Heat from wood waste and agriculture	1814	2000	2500
Total heat	*2922*	*3600*	*5750*
Total electricity and heat	*3071*	*3855*	*6345*

5.2 BIOMASS USERS

At the present time, there is no distinction in the figures between the different types of biomass used to produce energy in Belgium. Figure 16 gives the different users of biomass in Belgium for the year 2003. The term "biomass" brings together the following types of products: industrial by-products, wood logs, wood chips, black liquor, …. There are about 200 power plants using woody biomass as a fuel in Belgium.

Figure 16. Gross inland energy from biomass consumption in Belgium 2003 (total 1 023 ktoe [Source : ICEDD. 2005]



5.3 CO-FIRING IN COAL POWER PLANTS

Since 2002, in order to cope with the green obligation, the Belgian main utility Electrabel started carrying out co-firing of different biomass resources in its pulverized coal power plant. In 2005, Electrabel has retrofitted two existing pulverized coal power plants of the year 1960's for firing wood pellets instead of coal. Rodenhuize power plant, located near Gent, generates electricity with hardcoal (70%), wood-pellets (25%) and olive cake (5%). Les Awirs power plan, located near Liège, has been converted for firing exclusively wood pellets (100%) with co-firing limited quantity of natural gas. Today the Belgian capacity of Electrabel for generating green electricity with biomass reaches 260 MW (Table 12).

Table 12. Use of biomass in Belgian thermal power plants

Power plant	**Biomass and technique**	**Shared power level**
Ruien	separate injection of wood dust of Belgian origin	10 MW
Ruien	co-gasification of clean wood chips (Belgium, France)	22 MW
Langerlo	co-milling of sewage sludge of Belgian origin	4 MW
Langerlo	separate injection of wood dust of Belgian origin	28 MW
Langerlo, Rodenhuize, Ruien	co-milling of imported olive cake	34 MW
Mol	co-milling of imported coffee ground	2 MW
Rodenhuize	separate milling and injection of wood pellets	80 MW
Les Awirs	firing imported wood pellets	80 MW
Total	**biomass**	**260 MW**

Both retrofitted plants Rodenhuize (Unit 4) and Les Awirs (Unit 4) operate at nominal load since September 2005. The capacity of both plants together is about 2500 tons of wood pellets per day or 700 000 tons a year. The suppliers are spread all over the world. Globally about 15% of the feedstock is expected to originate from Belgium, about 40% from Scandinavia and Eastern EU as well as bordering countries (Russia, Ukraine) and 45% from overseas (Northern and Southern America, Asia, South-Africa).

Flat boats up to the sites of the power plants ship to the harbor of Antwerp and from there the imported feedstock on. For being granted green certificates for the green power that is generated, Electrabel is submitted by the Belgian authorities to an extensive analysis of the supply chain. The present paper delivers the key results of this analysis.

5.4 IMPORTED VEGETAL OIL

5.4.1 Electrawinds

The company Electrawinds NV is building two biomass power plants in Belgium The first plant is located in Oostende (Belgium) with a capacity of 11,6 MW net power. The plant is a technical innovation for Europe, as it will be fed by used frying oil, vegetable oils and animal fats, most of them being imported from the Netherlands (Biox). A second power plant is built in Mouscron in Wallonia. Electrawinds NV has selected Desmet Ballestra as technical partner for elaborating the technologies for converting these various raw materials into a valuable fuel, feeding the motors of the power plant.

- Input: 25 000 ton oil, fry-oil and animal fat.
- Technology: combustion in diesel engines.
- Investment: € 17 million, with € 2,25 million subsidies.
- Net power 11,64 MW.
- Electricity generation: 93 000 MWh/y.

5.4.2 SPE

The second utility in Belgium, SPE, is operating a former peak power plant in Harelbeke equipped with 8 diesel engines, each having a net installed power of 9 MWe (Figure 17).

Since end of 2005 4 engines fire only palm oil making 36 MWe of green power. The heated generated though the flue gases of the engines is recuperated for making steam that feeds a steam turbine of 3,6 MWe. Palm oil is imported from Malaysia.

Figure 17. Harelbeke power plant os SPE.

5.5 HOUSEHOLD MARKET

In 2001, there were about 54 000 households using wood as first energy source for heating in Belgium (National Statistics Institute). Wood stoves constituted the main part. There were only 600 wood central heating systems (1,1%), with wood fire-logs. Since that time, some new heating systems had appeared on the Belgian market: especially wood stoves and automatic wood boilers (pellets, wood chips)

For the moment there is no accurate evaluation of this new market on a Belgian scale. Nevertheless, there is an increase in the use of automatic systems, especially systems using wood pellets. Valbiom performed a first assessment in 2004: there were 321 pellets stoves and 62 automatic pellet boilers in Wallonia. Since the last oil price crisis, there has been a clear increase in the field of pellet use: 1586 new pellet devices were installed in 2005 (Table 13).

Table 13. Evolution of the number of biomass devices in Wallonia in 2005.

	Number before 2005	Number by the end of 2005	Power before 2005 (kW)	Power by the end of 2005 (kW)
Boilers	62	272	1 570	7 717
Stoves	321	1 648	2 722	12 535
St-boilers	30	79	454	1 188
Total	*413*	*1 999*	*4 746*	*21 439*

5.6 BIOMASS IMPORT AND EXPORT

At the present time, there are no accurate dedicated statistics related to biomass import and export in Belgium.

5.6.1 Wood pellets

Nevertheless, significant amounts are imported to produce gren electricity since August 2005 en the start-up of Electrabel Awirs4 and Rodenuize4 power plants firing wood pellets, about **600 000 tons** of wood pellets/year are being imported by Electrabel in 2005.

5.6.2 Vegetal oil

The new projects of Electrawinds in Oostende en Mouscron as weel as the Harelbeke power plant of SPE make together about 167 MWe. From there on, one can estimate that the amount of imported vegetal oil (including palm oil from Malaysia) will be about **100 000 tons** in 2005.

5.6.3 *Other biomass*

In addition, it could be useful to mention some data related to international biomass trade in Belgium. In the Eurostat statistics[6], traded products are grouped based on EU's combined customs nomenclature, which gives 8 digits CN (Combined Nomenclature) codes for different products. The statistics record the amounts and the values of the traded products.

The foreign trade quantities (in tons) and values (in €) of the product groups selected for the study are presented in Tables 14 and 15. The forest industry's wooden raw material streams have been included in the study, but forestry products have been excluded. Straw was included in the study.

Table 14. Imported biomass streams in 2004 (Eurostat, 2006)

	CN code(s)	**Quantities (t)**	**€/ton**
Round wood	[7]	1.752.234	49,3
Chips	44012100, 44012200	96.022	40,8
Sawdust of wood	44013010	173.434	48,0
Wood waste and scrap	44013090	897.118	31,1
Fuel wood	44011000	16.543	77,4
Tall oil	38030010, 38030090, 38070090	1.500	410,9
Peat	27030000	620.745	41,5
Ethanol	29051100, 29094911, 29094919	434.364	353,9
MTBE, ETBE, …	29091900	82.374	442,6
Straw	12130000, 84334010, 84334090	68.995	775,7

Table 15. Exported biomass streams in 2004 (Eurostat, 2006)

	CN code(s)	**Quantities (t)**	**€/t**
Round wood	[7]	754.588	87,9
Chips	44012100, 44012200	305.570	46,8
Sawdust of wood	44013010	130.912	20,5
Wood waste and scrap	44013090	450.200	62,0
Fuel wood	44011000	20.719	44,7
Tall oil	38030010, 38030090, 38070090	2.356	530,1
Peat	27030000	255.563	59,5
Ethanol	29051100, 29094911, 29094919	77.676	957,9
MTBE, ETBE, …	29091900	248.058	412,1
Straw	12130000, 84334010, 84334090	37.210	2.028,0

[6] http://epp.eurostat.cec.eu.int (July 2006)

[7] (1) 44032031, 44032039, 44032011, 44032019, 44032091, 44032099, 44039110, 44039190, 44039200, 44039210, 44039951, 44039959, 44034100, 44039910, 44039995

Customs statistics can give rough figures on international biomass trade. Statistics don't differentiate the end-use purposes of the material into energy use and raw material use, and various products can be included in the CN codes.

For the moment, sea transportation is the dominating form of transportation: ARAG harbour zone (Amsterdam, Rotterdam, Antwerpen, Gent) is the main entry point to Belgium. After, biomass (pellets, for example) is transported by flatboat via the main Belgian rivers (Schelde, Meuse) or channels (Albert channel).

6 BIOMASS TECHNOLOGY DEVELOPMENT

6.1 XYLOWATT DECENTRALISED GASIFICATION

Université Catholique de Louvain-la-Neuve (GEB) has developed a unique technology. It is now marketed by XYLOWATT (www.xylowatt.be) that manufactures CHP plants equipped with down-draft gasifier(s). Continuous solid bio-fuels feeding is converted into producer gas that is in turn used as main fuel in a gas engine. Syngas composition is mainly carbon monoxide and hydrogen. Major technical advance has been obtained through the development of a cost effective gas cleaning system removing tars. Envisaged installed electrical capacity is between 50 kWe and 5 MWe with an electrical efficiency of about 25%. Recuperated heat can be used by a local industrial process or in a district heating system. The facility is fully automated and can be started up to 100% by remote control in less than 15 minutes. This technology is pretty well adapted to limited wood streams (between 500 and 5 000 tons wood per year) originating from saw mills, wood factories, gardens and forests. Specific investment costs lead to power production costs close to on shore wind energy. Two pilot plants have already been built in Belgium between 1996 and 1998, with an installed power of 150 kWe and 300 kWe.

ELECTRABEL has commissioned two industrial gasification plants of this type, each equipped of a twin unit with an installed power of 600 and 700 kWe. Each plant shall deliver 3 million kWh of electrical power and more than 3 million kWh of heat. The first one has been installed with a pallet manufacturer near Liège en there, in addition, the residual heat will be used for drying the available wood fuel under 20% moisture. The second plant has been installed in a saw mill South of Charleroi. Both small-size gasification plants are fully integrated in an operational wood industry what is thought to be a world premiere.

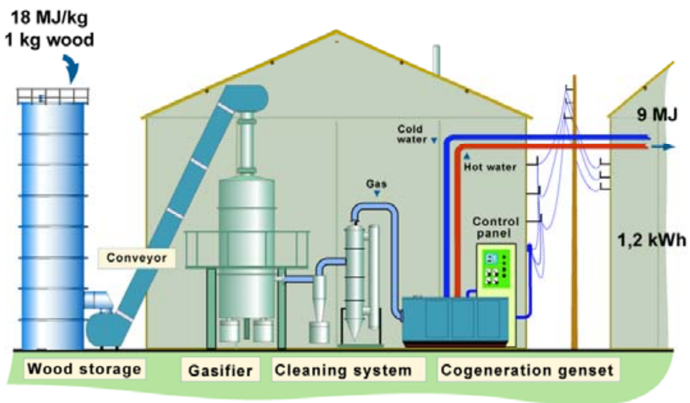
6.1.1 Wood handling

The wood is stored in a silo thereby ensuring the autonomy of the plant. This storage system can integrate a drying process if the wood moisture is higher than 20%. The gasifier is fed with wood and converts it into a fuel gas. This gas is then cooled and processed in a cleaning system, before being burnt in the engine of the

CHP genset. The electricity can be either locally consumed or fed in the grid. The heat can supply a (district-)heating network or an industrial process.

The CHP plant (Figure 18) is fully automated and remote-controlled. It does not need any specific operation from the final user. Start-up occurs with the engine firing 100% natural gas and the plant shifts gradually to 100% syngas in less than 15 minutes.

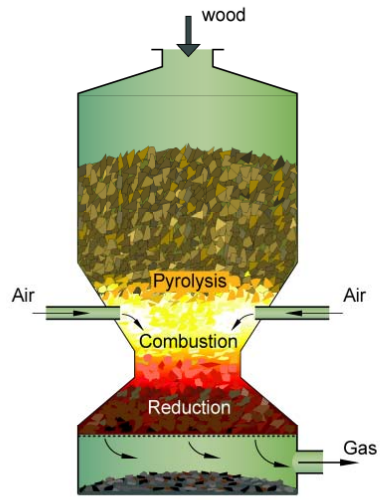
Figure 18. XYLOWATT CHP gasification plant.



6.1.2 Gasification process

The heart of the CHP wood gasification plant is the downdraft fixed bed gasifier (Figure 19). The process by which biomass is converted into gas uses various thermo-chemical reactions : pyrolysis, oxidation, reduction.

Figure 19. Downdraft fixed bed gasifier



The wood is reduced to ashes that represent 1% to 3% of the initial wood mass. Valuable output is a gas mainly composed of hydrogen (H2) and carbon monoxide (CO). This gas presents a low calorific value (LCV) between 4.5 and 5.8 MJ/Nm3, which suits standard engines perfectly well. The conversion efficiency of the downdraft fixed bed gasifier reaches 70% to 80% (see Table 16).

Table 16. Typical gasifier output

Flow:	600 Nm3/h
Syngas LHV:	5,2 MJ/Nm3
Syngas temperature	300 to 600 °C
CO	25 %
H2	14 %
CH4	2 %
CO2	10 %
N2	49 %
Ashes	1-3%

6.1.3 Tar removal

Key equipment of the system is a cost effective gas cleaning system avoiding tar condensation. This major difficulty has recently been solved in the frame of a project carried out at Université Catholique de Louvain-la-Neuve (GEB) and sponsored by ELECTRABEL and the Walloon Region of Belgium (SRC-Gazel project).

Tars removal efficiency is expressed as follows :

- 0.5 to 2 g/Nm^3 outlet gasifier,
- < 10 mg/Nm^3 outlet gas cleaning.

6.1.4 Gas engine

Critical question: is the syngas well suited for combustion in a conventional gas engine ? Properties of the syngas listed in Table 17 show that properties of mix air gas is quite comparable. With a lower temperature of combustion, the wood gas can be burn at lower lambda while respecting NOx standards. No de-rating of the engine is therefore needed.

Table 17. Use of syngas in a gas engine.

	Natural gas	Syngas
Energetic content		
LHV (kJ/Nm3)	36 504	5 000
Air ratio (Nm3air/m3gas)	9.7	1.05
LHV mix air/gas at λ= 1	3400	2440
LHV mix air/gas at λ = 1.6	2040	1460
Knocking		
Methane index	80	60 ..75
Flame propagation velocity	42 cm/s	48 cm/s
Adiabatic Combustion Temperature (λ=1)	2290	1940

6.1.5 On-site power generation performances

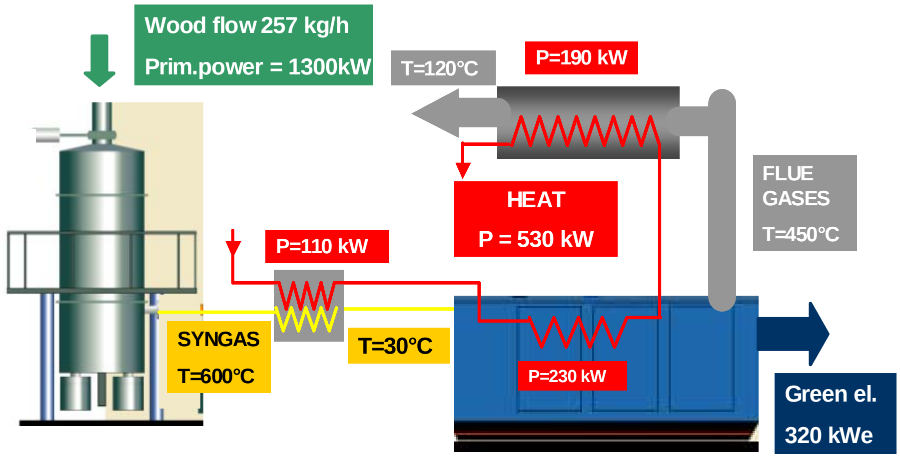
Excellent results have been obtained in the sense that the turbo-engine can operate firing 100% syngas.

CHP gasification power plant allows on-site power production with the highest efficiency ever obtained for wood electricity production on this small power scale. Envisaged installed electrical capacity is between 50 kWe and 5 MWe with an electrical efficiency of about 25%, while the heat generated can be used by a local industrial process or in a district heating system and leads to increased overall efficiencies up to 75% (Table 18).

Table 18. Typical on-site performances of XYLOWATT gasification modules depending on wood quality.

Module serie n°	xW300	xW900
Electric power	300-350 kW	900-1050 kW
Thermal power	500-700 kW	1500-2100 kW
Wood consumption	0.3-0.6	0.9-1.8 tons/h
Net electric efficiency	25%	
Thermal efficiency	50%	
Global efficiency	75%	

Figure 20. Typical energy balance of the plant.



6.1.6 *Environmentally friendly technology*

Wood is a renewable energy source and an alternative to fossil energy sources such as petroleum or natural gas. In substitution to fossil fuel, the wood fuel reduces fossil greenhouse gas emissions which trigger global warming.

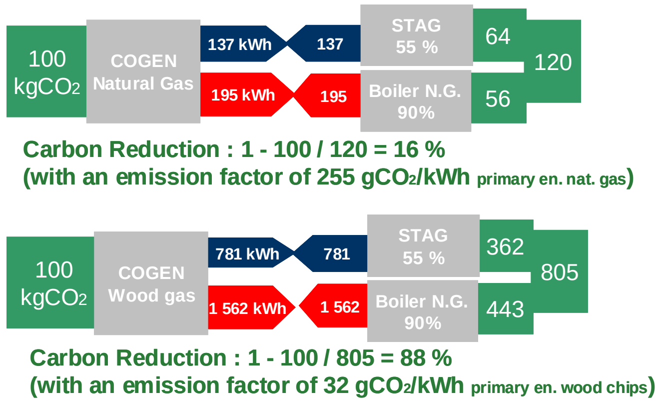
The gasification produces a gas that is easily and homogeneously burned in the engine resulting in lower NOx and CO emissions than when firing natural gas (see Table 19). Contrary to wood boilers downdraft gasification does not produce any dust or chimney ash emissions.

Table 19. Typical emissions of the gasification plant.

	Syngas	**Natural gas**
CO	80 ppm/Nm3 after catalytic oxidation	< 150 ppm/Nm3
NOx	200 ppm/Nm3	600 ppm/Nm3
Dust	<10 mg/Nm3	<10 mg/Nm3

Wood is CO_2-neutral resulting in strong reduction of fossil CO2 emissions : wood gas CHP cuts CO2 emissions by 89% compared to 16% when firing natural gas (Figure 21).

Figure 21. CO2 emissions with natural gas and syngas CHP.



6.2 CO-GASIFICATION OF WOOD IN A CFB

As partner of EU-Thermie BioCoComb Project in Austria between 1996 and 1998, Electrabel and its subsidiary research centre Laborelec have gained much experience concerning biomass gasification in a separate, external Circulating Fluidised Bed (CFB) reactor and co-firing of the gas in the coal boiler. Conversion of biomass into electricity is ensured with the same efficiency as a large coal fired unit with a minimum of requirements for the preparation of the biomass.

Electrabel has upscaled this technology within one of his coal power plant located in Belgium. The gasifier has been delivered by Foster Wheeler and has been commissioned by December 2002. Since then it is operated succesfully. The concept of the process guarantees a complete combustion of the syngas in the coal boiler. A low gas quality is quite sufficient and therefore no pre-drying or milling of the biomass and no hot gas (850°C) cleaning or gas cooling is necessary. This reduces the costs and the risks dramatically compared to other concepts, needing a clean, dust and tar-free high quality gas for the use in gas engines or gas turbines.

Nominal capacity of the gasifier is 50 MWth with average moisture content of 50% in the used biomass mixture. With an efficiency of about 34% the corresponding electrical output is 17 MW. This means that about 9% of the coal is substituted by syngas on a nominal basis. On yearly basis 120 GWh will be produced, and this is, for Belgium and Flanders Region a significant increase of the electricity produced from renewable energy sources. By using biomass instead of coal the CO2 output from fossil fuels will be reduced by 120.000 ton/year. The plant has operated 2650 hours in 2003 with an averaged power level of 22 MW.

Electrabel has now become the operator of one of the few successful biomass gasification projects in Europe.

6.2.1 Background and planning

Biomass gasifier has been commissioned by the end of 2002 and has started commercial operation by January 2003.

Ruien power plant is located in West Flanders along the Scheldt River, near the French border (Figure 22). It is the largest fossil fuel-fired power plant in Belgium, with a total installed capacity of 900 MWe via 4 operating units:

- Unit 3: started in 1967, 130 MWe, coal & fuel oil,
- Unit 4: started in 1966, 125 MWe, coal & fuel oil,
- Unit 5: started in 1973, 190 MWe on coal, 300 MWe on gas or fuel oil,
- Gas turbine (1997): 40 MWe direct and 12 MWe through unit 5 steam cycle,
- Unit 6: started in1979, 300 MWe gas and fuel oil.

Figure 22. Electrabel Ruien power station

Unit 5 originally fired heavy-fuel oil, and was retrofitted for coal firing in 1986. Steam data are: HP: 540°C/180 bar; MP: 540°C/40 bar. Maximum thermal power level with coal is limited to 530 MWth. The boiler operates about 6 500 hours per year. In 1997, the plant was repowered with a gas turbine connected to the pre-heater for the boiler feed water. Maximum electrical output of this gas turbine is 49 MWe, for a reference outside temperature of -25°C.

The boiler fires 500 000 tons coal per year. It makes use of primary measures (over-fire air) for NO_x removal and is expected to be equipped with a flue gas desulphurisation (FGD) system by 2006.

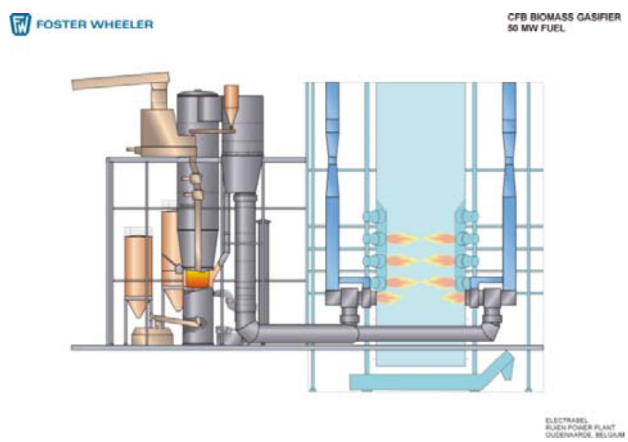
6.2.2 Atmospheric CFB gasification system

Process is based on a Circulating Fluidised Bed (CFB) reactor for the thermal degradation of biomass and mechanical attrition of the created char to a particle size, which guarantees a complete combustion of the syngas in a coal boiler. For this concept a low gas quality is quite sufficient and therefore nor pre-drying or milling nor hot gas (850°C) cleaning and cooling is necessary. This reduces the costs dramatically compared to all other concepts, which need a clean, dust and tar free high quality gas for the use in gas engines or -turbines (like I.C.C.G.). This makes the project competitive compared to other renewables like wind farms. The use of an existing infrastructure is cost effective and avoids visual impact

Gasification and co-firing (i.e. co-gasification) is one of the most appropriate technologies, because of the high energetic efficiency of the steam cycle. Biomass is converted into a low calorific value (LCV) gas by partial gasification in a separate reactor, working on the principle of an atmospheric circulating fluidised bed (CFB). Operating reactor temperature range is 800-1000°C depending on the load and fuel composition. Inert circulating bed material serves as a heat carrier and stabilises the temperatures in the process (Figure 23).

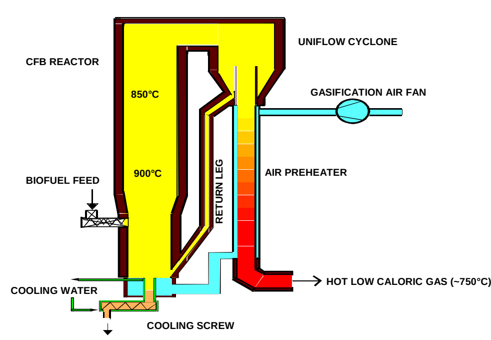
Foster Wheeler Oy has manufactured the gasifier. It works as thermo-mechanical mill for fuel preparation in the sense that thermal conversion and mechanical attrition deliver a char particle size that guarantees complete combustion in a pulverised coal boiler.

Figure 23. Lay-out of the Foster Wheeler co-gasification system in Ruien.



The system consists in a reactor where gasification takes place, a cyclone to separate the bed material from the gas, and a pipe to return the circulating material to the bottom part of the gasifier. All of the above mentioned components are entirely refractory lined (Figure 24).

Figure 24. Lay-out of the Foster Wheeler CFB gasifier.



6.2.3 Fuel Handling

From the variety of solid biomass sources only clean fractions like untreated wood chips, bark and uncontaminated residues of hard- and soft-board are used to avoid other negative environmental impacts. Roxon has delivered wood supply system. Bio-fuel is transported by trucks in arrange of 20 km (walking floors and tipping trucks). From the unloading pit an underground conveyor lifts the fuels to a belt conveyor, which has a magnetic separator above it. The belt conveyor transports the fuel onto a disk screen. The coarse fuel fractions fall from the disk screen into a crusher, while a chain conveyor transport the fine fractions from the screen and the crushed bio-fuel to the fuel storage building.

A silo with a storage capacity of 8000 m³ insures 4 to 5 days autonomy and adequate homogenisation of the fuel mixture before it is fed into the gasifier. The discharger (screw reclaimer) of the silo has variable speed control. Supply chain is a crucial step of the process.

CFB gasification accepts a wide range of moisture content (from 20% up to 60%) and particle dimensions (length + width +height) up to 15 cm. On a yearly basis up to 10 to 15% of the coal consumption i.e. 50 000 tons can be avoided (depending on wood low heating value).

From the process point of view, the major difference compared to the gasifiers in the mid-80’s [6,7] is that fuel will not be dried in this application although its moisture content can be up to 60% (dry basis). For this concept a low gas quality is quite sufficient and therefore no pre-drying or milling of the biomass and no hot gas cleaning or gas cooling is necessary. This reduces the costs dramatically compared to all other concepts, which need a clean, dust and tar-free high quality gas for the use in gas engines or –turbines.

6.2.4 Performances

Overall efficiency is about 34%, resulting from the combined efficiencies of the existing boiler (about 36%) and the gasifier (about 98%).

Generated renewable power depends strongly on the moisture content, ranging from 38 MWth with 60% moisture (dry basis) up to 86 MWth with a moisture content of 20% Energetic content of the syngas takes three different forms: sensible heat (flue gas), latent heat (fuel gas) and fine char particles. When the fuel is wet, low heating value of the gas is very poor. Typically, when the fuel moisture is about 60% the calorific value is only about 2 MJ/Nm³ and latent heat and sensible heat are approximately equal. Ratio between latent heat and sensible heat increases when moisture content decreases, sensible heat being only 20% of latent heat with moisture content of 20%.

Nominal capacity is 50 MWth with moisture content of 50%, resulting in net nominal electrical power of 17 MW and, in expected yearly generation, of about 120 GWh green power. This is for Belgium and Flanders Region, a significant increase of the power produced from renewable energy sources. By using biomass instead of coal, about 9% of the coal is substituted by syngas on a yearly basis and fossil CO_2 output is reduced by 120.000 ton/year.

The gasifier has operated 2650 hours in 2003 with an averaged power level of 22 MW. The plant is the first source of green certificates in Flanders in the year 2003.

Technical problems were mainly encountered when firing recycled wood instead of fresh wood and can be summarised as follows :

- due to faulty design, leakage in concentric primary air pre-heater resulting in fire in the syngas channel;
- degradation of refractories inside the reactor;
- two times congestion of cyclone and return leg that could be caused by faulty design or excessive lime injection for sulphur reduction;
- blockage of ash screw due to slagging related to non ferrous metals within feedstock;
- congestion of steam ejectors at the top of the gasifier (this is a required safety equipment in the case of emergency shutdown of the gasifier);
- fouling of the syngas burners in the coal boiler;
- mechanical breakages in the wood supply system;
- fire in the dust filter of the wood supply system;
- faulty working of some measurements.

7 MAJOR FUEL TRADERS AND TRADE ASSOCIATIONS

Because of the decentralisation of responsibility for agriculture, energy, and environment, not only Federal government but also Governments of each Region are mainly involved.

Among Non-Governmental-Organisations involved the next ones must be mentioned.

- ERBE (http://users.skynet.be/erbe) - the Wallonia Biomass Energy Agency gives information and advice in the field of bio-energy, pre-feasibility studies, assistance to enterprises and municipalities in the implementation of bio-energy projects;
- VITO (www.vito.be) - the Flemish Institute for Technological Research carries out studies on the potential of energy production from landfill gas in Flanders, inventory of Flemish actors on the biomass for energy market, studies on potential and barriers of biomass for energy production and setting up a regional biomass network;
- VALBIOM (www.valbiom.be) - the Belgian Biomass Association is a non-profit association that gathers people involved in the biomass issues. Its aim is to promote the production and use of biomass in Belgium. VALBIOM has 96 members, including, companies universities, research centres and professional organisations, co-ordinates national activities on biomass. VALBIOM is member of AEBIOM , European biomass association (www.ecop.ucl.ac.be/aebiom)
- CRA Gembloux - the Agricultural Engineering Station of the Centre for Agronomic Research is involved in the research and experimentation of biomass use and on thermal and chemical transformations of ligneous matter.

Table 20. Belgian wood pellet mills and their estimated production capacities by the end of year 2005

Company	Location	Production capacity, [t/a]
Granubois[8]	Bièvre	**18 000**
Total		**18 000**

[8] Granubois has started to produce pellets by the end of the year 2005.

Table 21. Main Belgian wood pellet retailers at the end of year 2005

Company	**Location**
A1 BAT sa	Ransart
AlterEnerg	Annevoie
Ets Baes	Floreffe
Cheminées Liégeois	Rocourt
Delta Products	Neuvillers
Exinor sa	Malmedy
Francq & Ghislain sprl	Gerpinnes
Girretz Pierre	Herve
HD Honclaire Maryse	Masnuy-St-Pierre
Henrotte & Cie sa	Baillonville
Ets Kuppi	Nalinnes
Lebois	Couvin
Leseine Construct Belgium	Baileux
Oekotech BeLux	Amel
Omniconfort sa	Tournai
R & B	Bellefontaine

8 CONCLUSIONS

The Belgian energy production system is based on a variety of energy sources: oil, natural gas, nuclear (56% of power generation), coal (about 3,5 mio ton/y for power), wind, hydro and biomass. Natural gas and biomass are the most growing resources.

In Belgium, the proportion of biomass in overall energy usage used to be very low. There were just sawmills and paper pulp industries using industrial by-products to produce heat and/or electricity. However, a considerable amount of wood is still left in the forests, and cannot be exploited at a competitive price with present techniques.

As there is a growing interest to bio-fuels in Belgium, driven by Kyoto and the electrical power certificates, there are ongoing increase in import of biomass like wood (600 000 ton/y) and palm oil (100 000 ton/y).

Systems of green certificates have been developed in Belgium from 2002 on that makes the level of the green support mechanism proportional to the energetic efficiency of the whole supply chain. This is unique in the EU.

Within that frame Electrabel has developed together with SGS a global biomass certification scheme for imported biomass that adds up the wishes of both regional authorities in Belgium, Flanders and Wallonia to technical and sustainability criteria developed by Electrabel. This certificate system is fast, not costly and focuses on energy consumption of the pellet plant and of the needed transportation. Sustainability criteria implemented within the certification process are bio-diversity, energy efficiency for making the bio-fuels and for transporting them, environmental efficiency in terms of physical and chemical specifications aiming at the absence of pollutants in the product. Throughout the set-up criteria Electrabel desires to promote as well the use of renewables for the local energy consumption.

From the first 26 examples of suppliers that have been considered by Electrabel, it appears that all are much more efficient than Belgian authorities thought at the beginning. Even suppliers located overseas compete very well with European ones if they put the accent on efficiency and scale effect. This is also the positive result of the availability of a large sea harbour like Antwerp that is fairly well connected to the rest of the country with rivers and channels, making transportation very efficient.

SOURCES

[1] Bureau federal du Plan (http://www.plan.be)

[2] CWaPE (Commission wallonne pour l'Energie, http://www.cwape.be)

[3] Devriendt N., Briffaerts K., Lemmens B., Theunis J., Vekemans G. (2004). Hernieuwbare warmte uit biomassa in Vlaanderen. Eindrapport, VITO, 149 p.

[4] Federal Public Service Economy, SMEs, Self-employed and Energy (http://mineco.fgov.be)

[5] Federal Public Service of Finance (http://www.fisconet.fgov.be)

[6] ICEDD (2005). Recueil de statistiques énergétiques de la Région wallonne. Namur, Institut de Conseil et d'Etudes en Développement Durable, 197 p.

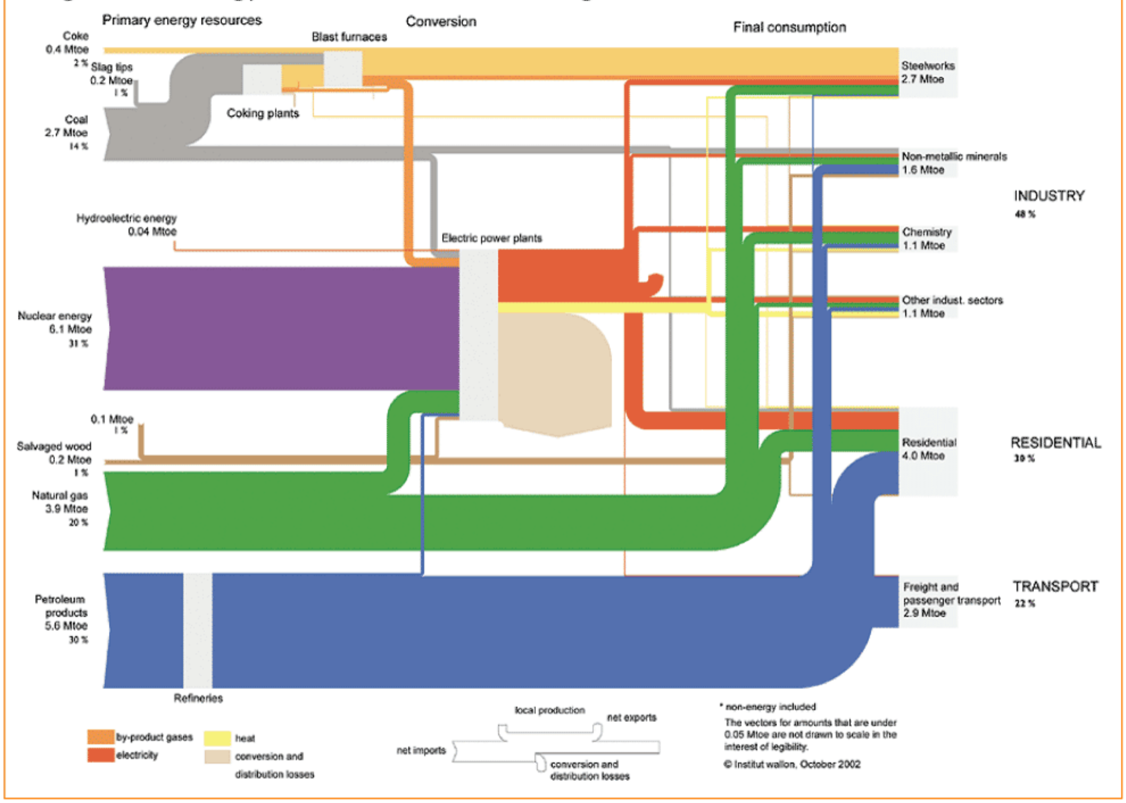
[7] Marchal D., Grulois C., Vankerkove R. (2003). Inventaire des sources de biomasse ligneuse en Région wallonne (pour la production d'énergie). ERBE, 63 p.

[8] ValBiom (Belgian Biomass Association, http://www.valbiom.be)

APP. A. ENERGY BALANCE IN 2002 (THE WALLOON REGION)

FIGURE ENER 0-1

Diagram of energy flows in the Walloon Region (2002)



Source : MRW - DGTRE (Atlas énergétique de la Région wallonne) (Copyright ICEDD)

APP. B. CN CODES USED IN THE STUDY[9]

CN code	Product
12130000	CEREAL STRAW AND HUSKS UNPREPARED WHETHER OR NOT CHOPPED GROUND PRESSED OR IN THE FORM OF PELLETS
27030000	PEAT INCL. PEAT LITTER WHETHER OR NOT AGGLOMERATED
29051100	METHANOL "METHYL ALCOHOL"
29091900	ACYCLIC ETHERS AND THEIR HALOGENATED SULPHONATED NITRATED OR NITROSATED DERIVATIVES (EXCL. DIETHYL ETHER)
29094911	2-"2-CHLOROETHOXY"ETHANOL
29094919	ACYCLIC ETHER-ALCOHOLS AND THEIR HALOGENATED SULPHONATED NITRATED OR NITROSATED DERIVATIVES (EXCL. 22"-OXYDIETHANOL "DIETHYLENE GLYCOL DIGOL" MONOALKYLETHERS OF ETHYLENE GLYCOL OR OF DIETHYLENE GLYCOL AND 2-"2-CHLOROETHOXY"ETHANOL)
38030010	CRUDE TALL OIL
38030090	TALL OIL WHETHER OR NOT REFINED (EXCL. CRUDE TALL OIL)
38070090	BREWER"S PITCH AND SIMILAR PREPARATIONS BASED ON ROSIN RESIN ACIDS OR VEGETABLE PITCH; WOOD TAR OILS WOOD CREOSOTE WOOD NAPHTHA AND VEGETABLE PITCH (EXCL. WOOD TAR BURGUNDY PITCH YELLOW PITCH STEARIN PITCH FATTY ACID PITCH FATTY TAR AND GLYCERIN PITCH)
44011000	FUEL WOOD IN LOGS BILLETS TWIGS FAGGOTS OR SIMILAR FORMS
44012100	CONIFEROUS WOOD IN CHIPS OR PARTICLES (EXCL. THOSE OF A KIND USED PRINCIPALLY FOR DYING OR TANNING PURPOSES)
44012200	WOOD IN CHIPS OR PARTICLES (EXCL. THOSE OF A KIND USED PRINCIPALLY FOR DYING OR TANNING PURPOSES AND CONIFEROUS WOOD)
44013010	SAWDUST OF WOOD WHETHER OR NOT AGGLOMERATED IN LOGS BRIQUETTES PELLETS OR SIMILAR FORMS
44013090	WOOD WASTE AND SCRAP WHETHER OR NOT AGGLOMERATED IN LOGS BRIQUETTES PELLETS OR SIMILAR FORMS (EXCL. SAWDUST)
44032011	SAWLOGS OF SPRUCE OF THE SPECIES "PICEA ABIES KARST." OR SILVER FIR "ABIES ALBA MILL." WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED
44032019	SPRUCE OF THE SPECIES "PICEA ABIES KARST." OR SILVER FIR "ABIES ALBA MILL." IN THE ROUGH WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED (EXCL. SAWLOGS; ROUGH-CUT WOOD FOR WALKING STICKS UMBRELLAS TOOL SHAFTS AND THE LIKE; WOOD IN THE FORM OF RAILWAY SLEEPERS; WOOD CUT INTO BOARDS OR BEAMS ETC.; WOOD TREATED WITH PAINT STAINS CREOSOTE OR OTHER PRESERVATIVES)
44032031	SAWLOGS OF PINE OF THE SPECIES "PINUS SYLVESTRIS L." WHETHER OR NOT

[9] http://epp.eurostat.cec.eu.int (July 2006)

	STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED
44032039	PINE OF THE SPECIES "PINUS SYLVESTRIS L." IN THE ROUGH WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED (EXCL. SAWLOGS; ROUGH-CUT WOOD FOR WALKING STICKS UMBRELLAS TOOL SHAFTS AND THE LIKE; WOOD IN THE FORM OF RAILWAY SLEEPERS; WOOD CUT INTO BOARDS OR BEAMS ETC.; WOOD TREATED WITH PAINT STAINS CREOSOTE OR OTHER PRESERVATIVES)
44032091	SAWLOGS OF CONIFEROUS WOOD WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED (EXCL. SPRUCE OF THE SPECIES "PICEA ABIES KARST." SILVER FIR "ABIES ALBA MILL." AND PINE OF THE SPECIES "PINUS SYLVESTRIS L.")
44032099	CONIFEROUS WOOD IN THE ROUGH WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED (EXCL. SAWLOGS; ROUGH-CUT WOOD FOR WALKING STICKS UMBRELLAS TOOL SHAFTS AND THE LIKE; WOOD IN THE FORM OF RAILWAY SLEEPERS; WOOD CUT INTO BOARDS OR BEAMS ETC.; WOOD TREATED WITH PAINT STAINS CREOSOTE OR OTHER PRESERVATIVES; AND SPRUCE OF THE SPECIES "PICEA ABIES KARST." SILVER FIR "ABIES ALBA MILL." AND PINE OF THE SPECIES "PINUS SYLVESTRIS L.")
44034100	DARK RED MERANTI LIGHT RED MERANTI AND MERANTI BAKAU WOOD IN THE ROUGH WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED (EXCL. ROUGH-CUT WOOD FOR WALKING STICKS UMBRELLAS TOOL SHAFTS AND THE LIKE; WOOD CUT INTO BOARDS OR BEAMS ETC.; WOOD TREATED WITH PAINT STAINS CREOSOTE OR OTHER PRESERVATIVES)
44039110	SAWLOGS OF OAK "QUERCUS SPP." WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED
44039190	OAK "QUERCUS SPP." IN THE ROUGH WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED (EXCL. SAWLOGS; ROUGH-CUT WOOD FOR WALKING STICKS UMBRELLAS TOOL SHAFTS AND THE LIKE; WOOD IN THE FORM OF RAILWAY SLEEPERS; WOOD CUT INTO BOARDS OR BEAMS ETC.; WOOD TREATED WITH PAINT STAINS CREOSOTE OR OTHER PRESERVATIVES)
44039200	BEECH 'FAGUS SPP.' IN THE ROUGH WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED (EXCL. ROUGH-CUT WOOD FOR WALKING STICKS UMBRELLAS TOOL SHAFTS AND THE LIKE; WOOD IN THE FORM OF RAILWAY SLEEPERS; WOOD CUT INTO BOARDS OR BEAMS ETC.; WOOD TREATED WITH PAINT STAINS CREOSOTE OR OTHER PRESERVATIVES)
44039210	SAWLOGS OF BEECH "FAGUS SPP." WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED
44039910	POPLAR IN THE ROUGH WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED (EXCL. ROUGH-CUT WOOD FOR WALKING STICKS UMBRELLAS TOOL SHAFTS AND THE LIKE; WOOD CUT INTO BOARDS OR BEAMS ETC.; WOOD TREATED WITH PAINT STAINS CREOSOTE OR OTHER PRESERVATIVES)
44039951	SAWLOGS OF BIRCH WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED
44039959	BIRCH IN THE ROUGH WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED (EXCL. SAWLOGS; ROUGH-CUT WOOD FOR WALKING STICKS UMBRELLAS TOOL SHAFTS AND THE LIKE; WOOD CUT INTO BOARDS OR BEAMS ETC.; WOOD TREATED WITH PAINT STAINS CREOSOTE OR OTHER PRESERVATIVES)
44039995	WOOD IN THE ROUGH WHETHER OR NOT STRIPPED OF BARK OR SAPWOOD OR ROUGHLY SQUARED (EXCL. ROUGH-CUT WOOD FOR WALKING STICKS UMBRELLAS TOOL SHAFTS AND THE LIKE; WOOD CUT INTO BOARDS OR BEAMS ETC.; WOOD TREATED WITH PAINT STAINS CREOSOTE OR OTHER PRESERVATIVES TROPICAL

	WOOD OF SUBHEADING NOTE 1 TO THIS CHAPTER AND CONIFEROUS WOOD OAK BEECH POPLAR EUCALYPTUS AND BIRCH WOOD)
84334010	PICK-UP BALERS FOR STRAW OR FODDER
84334090	STRAW OR FODDER BALERS (EXCL. PICK-UP BALERS)