Bioenergy-related description of CATALONIA (Spain)

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1. General information on the Region

Location and size of the region, its cities, rural areas, etc.

Catalonia is one of the gateways between the Iberian Peninsula and Europe. This has had an effect on the region's character and history. Situated in the north east of the Iberian Peninsula, Catalonia covers an area of approximately of 32,000 km^2 (see figure 1). With its own governing body—the *Generalitat de Catalunya*—it is one of Spain's autonomous communities [1].

To the east is the Mediterranean, to the north are the borders with France and Andorra, and to the west are the autonomous communities of Aragon and Valencia. This strategic position has helped to foster close relations with the other Mediterranean countries as well as with continental Europe. Catalonia's varied altitude—plains alternating with several very mountainous regions—provides Catalonia with a wide range of bioclimatic habitats.

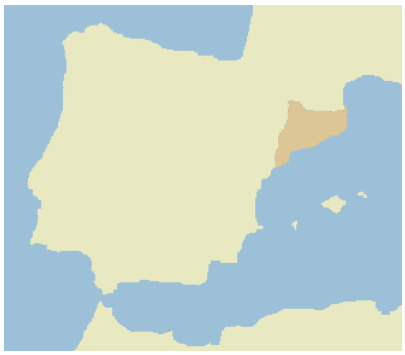

Figure 1. Catalonia and the Iberian Peninsula.

Though the region does not have substantial resources of raw materials, it enjoys a high standard of living both in absolute figures and in comparison with the other autonomous communities in Spain. GDP for 1999 stood at 17.7 billion pesetas, which is 19.02% of Spain's total GDP.

Climate and geography

Generally, the climate in Catalonia is Mediterranean, with plenty of sun. It is mild in winter and hot in summer. The region's morphological diversity determines the variations in its climate. In the Pyrenees and nearby areas, the climate is typical of mountainous regions, with minimum temperatures below 0ºC, annual rainfall above 1,000 mm and heavy snowfall in winter. Coastal areas have mild, temperate weather, with increasing temperatures and decreasing levels of rainfall the further south one travels. Inland, the climate is typical of continental Mediterranean regions, with cold winters and very hot summers.

The main relief features are the Pyrenees, the Central Depression, the Ebre Depression, the Catalan Mediterranean system, the coastal plains and the Cordillera Transversal. The impressive mountain range of the Pyrenees, with its east- and west-facing slopes, stretches from the Atlantic to the Mediterranean and separates the Iberian Peninsula from the rest of Europe. In Catalonia the south-eastern slopes of the range form a long strip that runs 230 km from the Val d'Aran to the sea. The axial Pyrenees are predominantly made up of granite and dark slatey areas and have steep sides and high peaks (the Estats peak is 3,143 m high, Comaloformo is 3,033 m and Puigmal is 2,193 m). There are also lower areas such as "La Cerdanya", with its very beautiful, diverse landscape marked by glacial cirques with tarns and pools, water courses that have cut out deep valleys, meadows and forest pine, fir trees and birch. The steep pre-Pyrenean folds of Montsec and Pedraforca largely consist of limestone. Protected areas include Aigüestortes and the Estany de Sant Maurici National Park, El Cadí-Moixeró Natural Park, the Natural Park of the Volcanic Region of "La Garrotxa", and the Cap de Creus Natural Park.

The Catalan Mediterranean system consists of three areas that run parallel to the coast: the Serralada Litoral, a range of mountains that stretches from the Garraf massif to the Begur massif; the Serralada Prelitoral, which stretches from Les Guilleries to Els Ports, with major massifs such as El Montseny, Montserrat and El Montsant; and between them the depression Prelitoral, which holds the most densely-populated regions of El Gironès, La Selva, El Vallès, El Penedès and El Camp de Tarragona. The natural parks in this area include the Garraf, El Montseny, Montserrat, Sant Llorenç del Munt and El Montnegre-Corredor parks.

The Central Depression, at the eastern end of the Ebre Depression, consists of a series of basins formed by erosion (the Plana de Vic, the Pla de Bages, the Conca de Barberà), high plateaus (La Segarra and El Lluçanés) and the alluvial plains (El Segrià and L'Urgell), which are largely used for growing crops. Other smaller distinctive areas include the coastal plains of l'Empordà and the Delta de l'Ebre, and the Serralada Transversal (Puigsacalm) mountain range. The natural parks of the Aiguamolls of L'Empordà and the Ebre Delta are on the coast and are important havens for migratory birds.

The sheer coastline consists of 580 km of steep cliffs interspersed with hidden or sandy coves, depending on the proximity of the mountains. The stretches of coastline are known to tourists as, from north to south, the Costa Brava, the Costa del Maresme, the Costa del Garraf and the Costa Daurada.

Total population and population density

The population of Catalonia is around six million, giving a density of around 188 habitants per km^2.

Current structure of energy provision in the region (fuels, types of energy, problems, etc.)

Catalonia's lack of energy resources has traditionally been combated by using rivers as a power source. The mountainous nature of the land makes it possible to generate hydroelectric power. Recent decades have seen the construction of oil refineries, extensions of the natural gas supply network to industry and homes, and the construction of thermal and nuclear power stations. Attention is now increasingly turning towards alternative energy resources. Table 1 shows the different types of energy sources used in Catalonia by the various sectors of activity.

Table 1. Consumption of energy by activity sectors in Catalonia in 2003 (ktoe) [2].

	Industry	Domestic	Primary	Services	Transport	TOTAL
Carbon	24.9	0.5	-	1.0	-	26.4
Coke oil	748.1	4.0	0.3	0.7	-	753.0
Fuel-oil	282.2	-	-	9.2	-	291.5
Diesel	109.6	156.2	520.1	98.6	3,506.8	4,391.3
Kerosene	-	0.2	-	-	741.2	741.4
Gasoline	-	-	-	-	1,398.3	1,398.3
GLP	34.3	181.3	15.1	69.5	7.6	307.7
Natural gas	2,287.8	842.2	9.8	358.5	3.4	3,501.7
Non-renewable waste	42..8	-	-	-	-	42..8
Electricity	1,637.8	798.1	35.8	1,120.5	63.6	3,655.7
Biomass	43.0	39.9	1.8	8.8	-	93.5
Bioethanol	-	-	-	-	23.7	23.7
Biodiesel	-	-	-	-	5.4	10.5
Biogas	4.0	-	0.8	0.6	-	5.4
Solar	0.1	2.2	-	0.5	-	2.7
TOTAL	5,214.7	2,024.6	583.6	1,667.8	5,749.9	15,240.6

The demand for energy is heterogeneous throughout the region. Figure 2 shows the consumption of electricity in 2003 by the various municipalities. Consumption is concentrated in highly populated areas and around industrial areas. Table 2 shows the power generation capacity available to satisfy this demand. More combined cycle plants will soon be in service.

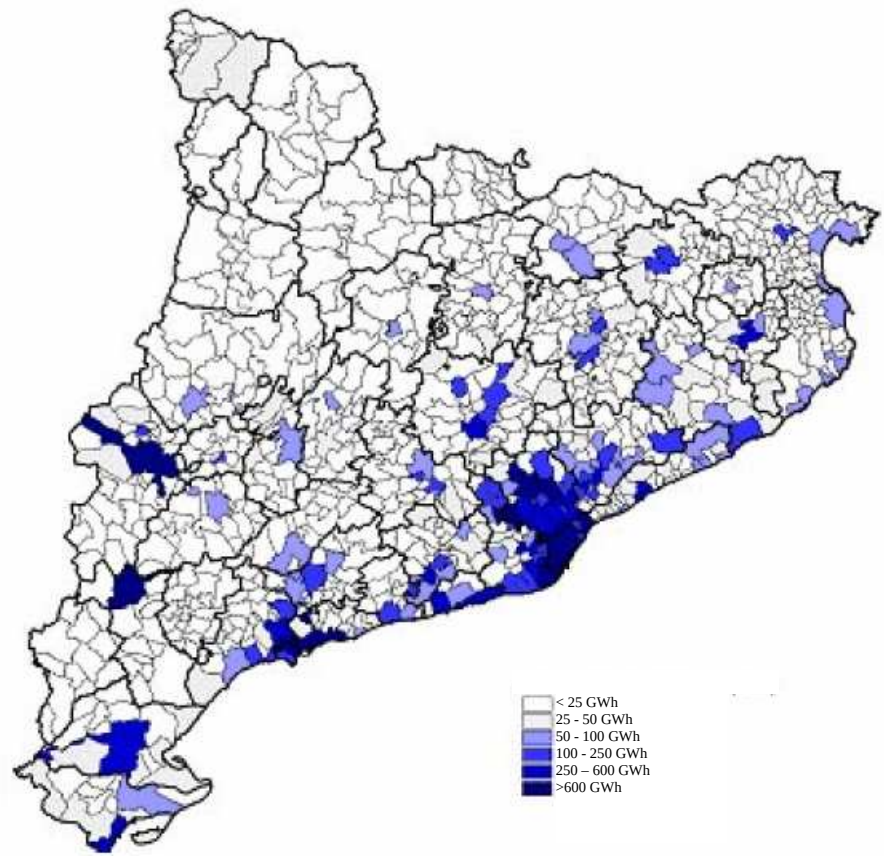

Figure 2. Electricity demand by municipalities in Catalonia (2003) [2]

Table 2. Installed capacity of power generation plants in Catalonia in 2003 [2]

Conventional plants	**Capacity (MWe)**
Nuclear	3,146.8
Hydropower	2,088.3
Carbon	160.0
Fuel-oil	1,235.9
Combined cycles	1,579.4
TOTAL	*8,210.4*
Cogeneration and renewable energy	
Cogeneration	1,139.1
Hydropower (low capacity)	231.9
Industrial and municipal waste incineration	54.4
Biogas and waste reduction	115.8
Biomass	0.5
Waste methanisation	23.2
Wind power generation	86.7
Photovoltaic	2.2
TOTAL	*1,653.8*
TOTAL POWER CAPACITY	**10,082.2**

Industrial structure

Ever since the Industrial revolution—in which Catalonia led the way—industry has formed one of the bases of the Catalan economy. Textiles, especially the manufacture of wool and cotton fabrics and, later, the manufacture of manmade fibres, used to be extremely important but this has given way to high-technology industries in the chemical, pharmaceutical and precision mechanics sectors and, more recently, automobile production and allied industries, the manufacture of railway parts and machinery, and the petrochemical and electronic industries, etc. The publishing industry, graphic arts and fashion are also economically important. The construction sector, often allied to tourism, has always been and remains a driving force of the economy.

Since the Middle Ages, when merchant ships reached every port in the Mediterranean, trade has been a decisive element in the region's economy. Small traders, who traditionally have been very dynamic, co-exist today with the huge hypermarkets that are a feature throughout Europe. Other sectors worth mentioning in the service industries include transport and communications, telecom and advertising, and especially the hotel and restaurant sector, which grew hand in hand with the boom in tourism that began in the 1960s.

Agricultural structure and agricultural and forest areas

In recent decades, Catalan agriculture has moved over to crops and production that have a high added value, such as vineyards. Vineyards stretch across 71,000 ha that include nine wine-producing areas that hold a *denominació d'origen*, or guarantee of origin. Table wine and prestigious sparkling wine known as cava are also produced (especially in El Penedès). These products are much appreciated throughout the world, as is demonstrated by their high export figures. Also worth mentioning is the intensive cultivation of flowers in El Maresme. Another prestigious crop are olives, and a large amount of quality olive oil is produced in Les Garrigues from the arbequina variety. Fruit is grown in the artificially irrigated orchards in the El Segrià plain around Lleida, nuts are harvested in El Camp de Tarragona, rice is grown in the Delta de l'Ebre, vegetables and citrus fruits are grown in the region of Tortosa, and cereals and animal feed are produced in L'Empordà. Cattle and sheep are reared mainly in the Pyrenees. Large numbers of pigs, fowl and other farm animals are also reared. Fishing is a long-established tradition on the coast, but, in order to protect stocks and the environment, catches are now limited to some 60,000 tonnes per year.

According to data from 1993 [3], 34.4% of the area of Catalonia was used for agriculture and 37.1% of the area were forests.

Political framework in the region with regard to bioenergy use (programmes, aims, etc.)

On December 30th, 1999 the Spanish government passed the *Plan de Fomento de las Energías Renovables 2000-2010* (PFER), a plan for the promotion of renewable energy. The general aim of this plan was to increase the contribution of renewable energy to primary energy consumption to 12% from 2000 to 2010. This plan has recently been updated for the period 2005–2010 (see later).

Other laws directly related to energy issues but including measures to promote renewable energy are:

- Ley 51/2002 (*Ley Reguladora de las Haciendas*), by which municipalities can offer tax reductions on economic and other activities to companies using or producing energy from renewable energy or cogeneration.

- Ley 36/2003 (*Ley de Medidas de Reforma Económica*), which established various types of tax cuts for companies that help to improve the environment.

Also, IDAE (*Instituto para la Diversificación y Ahorro de la Energía*—the Spanish Institute for Energy Diversification and Saving) and ICO (*Instituto de Crédito Oficial*—the Official Credit Institute) sign annual collaboration agreements aimed at creating a line of finance for investment projects in renewable energy and energy efficiency.

The legislation to support energy efficiency and renewable energy has generally been effective in view of the great development in wind energy and, to a lesser extent, in hydro energy and cogeneration. However, it has not been sufficient so far for the development of other kinds of renewable energy, such as biomass or solar energy. Figure 3 shows biomass consumption in Catalonia for different biomass sources.

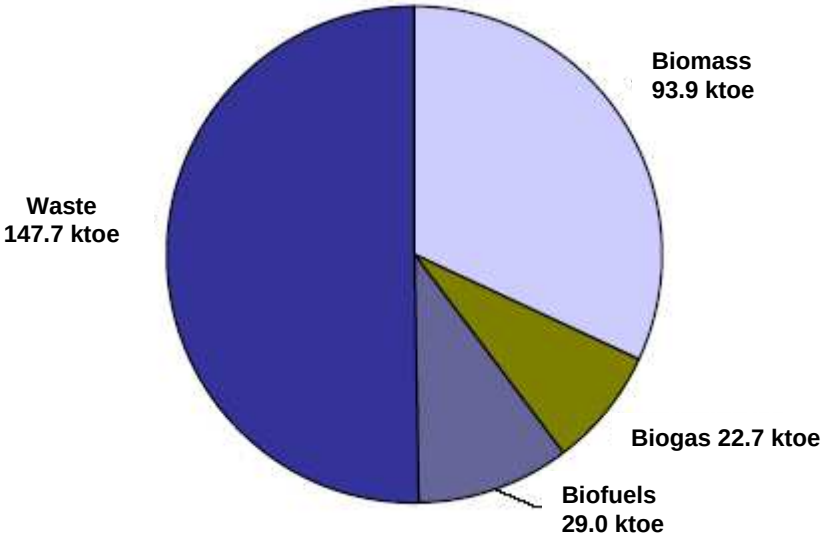

Figure 3. Distribution of biomass consumption in Catalonia in 2003 [2].

In the next section we will describe in detail the current situation in Catalonia and Spain with regard to biomass, biofuels and biogas.

BIOMASS

By the end of 2004, the aim of the national plan for the promotion of renewable energy sources (PFER) for renewable energy to reach a contribution of 12% to primary energy consumption was met by only 28.4% [4]. Until 2003 the annual installed capacity in Spain was 361 MW. In the last few years this increased annually by an average of around 46% (see figure 4). However, this is still far below PFER's initial estimate, which aimed at 1700 MWe of installed capacity by 2010.

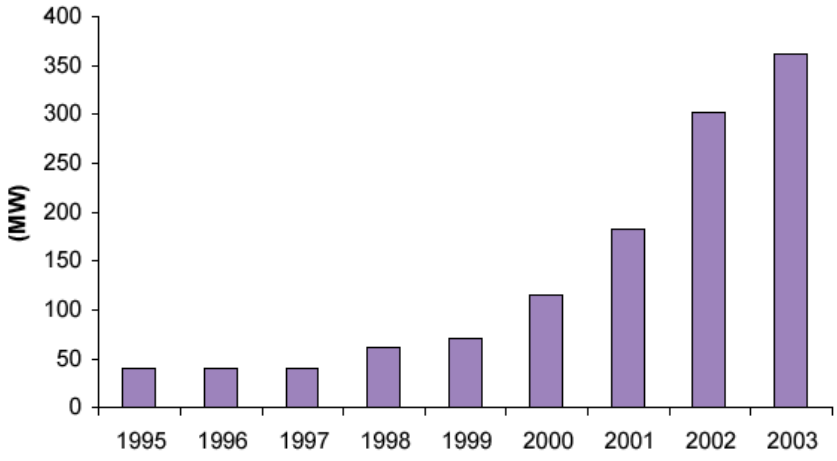

Figure 4. Biomass accumulated installed capacity in Spain (MW). Source: APPA

In the biomass sector, a large amount of biomass is used for heating in domestic or industrial applications without the generation of electric power. For these applications it is difficult to estimate the amount of consumed biomass. An estimation that is more easily to be obtained for plants with biomass power generation plants.

The Spanish region with the highest biomass installed capacity is Andalusia (see Table 3), with Catalonia in 7th position. Andalusia is also the biggest consumer of biomass in Spain, with Catalonia in 4th position (see Table 4).

Table 3. Biomass accumulated installed capacity (MW) in 2003 by region. Source: SOCINTEC

Region	Power capacity	%
Andalusia	105	29
Navarre	41	11
Autonomous Community of Madrid	37	10
Galicia	34	9
Asturias	33	9
Castilla-La Mancha	26	7
Catalonia	25	7
Aragon	21	6
Basque Country	19	5
Valencia	10	3
Castilla-Leon	5	1
Murcia	2	1
Cantabria	2	1
Extremadura	1	1
The Canary Islands	0	0
The Balearic Islands	0	0
La Rioja	0	0
TOTAL	360	100

Table 4. Biomass consumption in 2002 in Spain by region (toe). Source: SOCINTEC.

Region	Consumption	%
Andalusia	891,709	23
Galicia	667,357	17
Castilla y Leon	410,679	11
Catalonia	295,505	8
Castilla – La Mancha	231,151	6
Basque Country	230,053	6
Asturias	227,462	6
Valencia	201,576	5
Aragon	169,999	4
Navarre	168,977	4
Extremadura	117,123	3
Autonomous Community of Madrid	79,937	2
Murcia	65,709	2
The Balearic Islands	49,801	1
Cantabria	48,910	1
La Rioja	34,826	1
The Canary Islands	2,608	0

TOTAL	3,893,382	100

Comparison with the rest of Europe

The highest producer of electricity from biomass in Europe is Finland, followed by Germany and Sweden. Between 1997 and 2002, production in Germany doubled and tripled in Denmark during the same period. Biomass now contributes 1.5% to the total gross consumption of electricity in Europe. Tables 5 and 6 compare total biomass consumption and electricity produced from biomass in Spain and Europe.

Table 5. Gross biomass consumption in 2002 (toe). Source: SOCINTEC

	Biomass	Total renewable	% w/ total renewable
Spain	4,175	6,953	60.0
EU 15	53,912	85,266	63.2
EU 25	62,110	94,936	65.4

Table 6. Gross production of electrical power in Europe in 2002 (GWh). Source: SOCINTEC

	Biomass	Total renewable	% w/ total renewable
Spain	4,454	36,196	12.3
EU 15	47,556	368,876	12.9
EU 25	48,821	386,671	12.6

Figure 5 shows the expected development of the Spanish market according to data obtained from a planning report for the electricity and gas sector (RETELGAS) drawn up by the Spanish Ministry of Economy in September 2002 and the PFER [4].

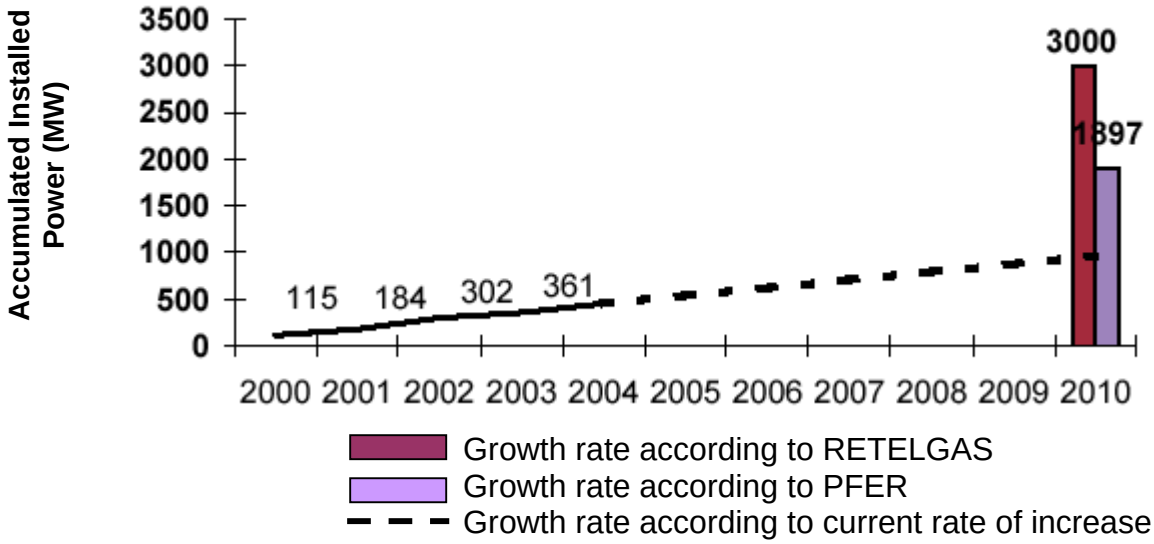

Figure 5. Expected development of the biomass market in Spain. Source: SOCINTEC.

BIOFUELS

General description

In 2003 the production of liquid biofuel in Spain was 186,000 tons. Of this, 6,000 tons was biodiesel and the rest was bioethanol. In this year, Spain was the seventh largest European producer of biodiesel, but a long way behind the leading producer. However, it was the largest producer of bioethanol.

In Europe in 2003 the production of biofuel was 1.75 million tons, which reflects a 26% increase on the preceding year. Table 3 shows the installed capacity of biofuel plants in Spain in 2003.

Table 7. Biofuel in Spain in 2003 (thousands of tons). Source: IDAE.

	2000	***2001***	***2002***	***2003***
Annual installed capacity	-	-	69.9	4.7
Accumulated installed capacity	51.2	51.2	121.1	125.8

Two European Directives directly promote the use of biofuels:

- Directive 2003/30/CE promotes the use of biofuels in the transport sector. This states that each member country must have a minimum percentage consumption. Until November 2005 this is 2% and until December 2010 it will be 5.75%.

- Directive 2003/96/CE modifies the taxation framework for energy products and electricity by reducing or eliminating taxes on the use of biofuels in order to make them more competitive.

The result of applying Directive 2003/30/CE to local legislation is that each Member State must follow European Union objectives, which state that by 31 December, 2005, 2% of fuel marketed for transportation must be biofuels and that this must gradually increase to 6.76% by 31 December, 2010. If any member state fails to implement the measures needed to meet these objectives, the European Commission may request justification based on reasonable criteria. The Directive also requires each MS to enact all the legal and administrative regulations necessary to comply with its objectives by no later than December 31, 2004. A key component of the Directive states that the European Commission will formulate a report at the end of 2006 and every two subsequent years to review the progress of biofuel integration into every member state. This report will help to determine whether further legislation is needed to promote the use of biofuels in the EU.

Because bioethanol production is not as competitive as petrol, the biofuels industry depends on financial support from the member states. A special tax on fossil fuels will enable biofuels to compete with petrol and meet the objectives of the Directive. In October 2003, the EU passed the Directive on Taxation of Energy, which includes a special fiscal regulation of biofuels and allows member states to exempt biofuels from fuel tax.

The European Commission is also developing legal and administrative measures to adapt the technical regulations for the introduction of biofuels in fuel, including new quality standards to guarantee the optimum performance of motors. With the revision of Directive 98/70 on the Quality of Petrol, passed in February 2003, the Commission added a paragraph requiring that, prior to December 31, 2005, the EU should modify the volatility limits in this Directive to allow the direct blending of bioethanol into petrol. Several member states, including Spain, Germany, Sweden, France, the United Kingdom and Poland (which became a member state in May 2004) have already developed the necessary local legislation to comply with the European Directive's mandates. The objective in the Spanish PFER was 500,000 toe of liquid biofuels, which is lower than the 5.75% of the fuel market stated in Directive 2003/30/CE. By the end of 2004, 45,6% of the objective was

already met. As we will see later, the new energy plan for 2005–2010 will set its objectives in accordance with this Directive.

In Spain the *Ley de Acompañamiento de los Presupuestos del Estado* (Accompanying Law on State Budgets), issued on 31 December, 2002, states that all biofuels introduced into fuel will be exempt from hydrocarbon tax. This is an important and pioneering step taken by the Spanish Government to comply with new European Directives. The law includes a clause allowing for a transition period for pilot projects begun under previous legislation to bring those projects into compliance with new legislation after the finalization of their legal status as pilot projects.

In December 2003, the Spanish government approved a bill regulating the specifications of petrol, including specifications for the blending of 5% ethanol into gasoline.

The international market

Biodiesel

The production of biodiesel in Europe on an industrial scale began in 1992. Table 8 shows the Spanish installed capacity compared to that of other countries. There are 40 biodiesel plants in Europe with a production of 1.35 million tons. This production is concentrated in Germany, France and Italy.

Table 8. Biodiesel installed capacity in different countries (thousands of tons).
Source EBB (European Biodiesel Board)

Country	2003	2004	%
Germany	1,025	1,088	48.4
France	500	502	22.4
Italy	420	419	18.7
Austria	50	100	4.5
Spain	6	70	3.1
Europe	2,048	2,246	100
Rest of the world	1,800	n. a.	

Bioethanol

The greatest production of biofuel in the world is that of bioethanol, with 18.3 million tons in 2003. By far the main producers of bioethanol are Brazil (mainly from sugar cane fermentation) and the USA (mainly from maize fermentation), which for 20 years have been fully committed to using ethanol as a substitute for fossil fuels (Table 9). Spain is the main European producer with 180,000 tons/year produced by the company Abengoa [5].

The PFER target for biofuels is 500 ktoe for the period 1999–2010 and this is mainly concentrated in bioethanol (400 ktoe). In the first quarter, 50% of the target has already been reached.

Table 9. Accumulated installed capacity of Bioethanol (thousand tons). Source: EurObserver.

Country	2003
Spain	180
France	103
Sweden	54
Total Europe	337
Brazil	9,900
USA	8,400
Rest of the world	18,300

The potential European demand for bioethanol (either blended into petrol or used in the manufacture of ETBE) based on the objectives of the Directive on the Promotion of Biofuels (2% in 2005 and 5,75% in 2010) is shown in Table 10 (energy equivalent). For the EU15, total potential demand is 4.92 million litres in 2005, and 14,146 million litres in 2010. The potential demand for the EU25, which includes the ten new member states incorporated in May 2004, is 5,393 million litres in 2005 and 15,504 million litres in 2010.

Table 10. Expected demand for bioethanol in Europe [5].

Country	kt. gasoline 2000	2% EtOH kt.	EtOH kt. eq.	2% EtOH MHI eq.	5,75% EtOH kt.	EtOH kt. eq.	5,75% EtOH MHI eq.
Germany	30,036	601	1,001	12.52	1,727	2,878	35.98
UK	22,703	454	757	9.46	1,305	2,176	27.20
Italy	17,527	351	584	7.30	1,008	1,680	21.00
France	14,347	287	478	5.98	825	1,375	17.19
Spain	8,958	179	299	3.73	515	858	10.73
EU15	118,091	2,362	3,936	49.20	6,790	11,317	141.46
Poland	5,213	104	174	2.17	300	500	6.24
Czech Rep.	1,953	39	65	0.81	112	187	2.34
EU25	129,422	2,588	4,314	53.93	7,442	12,403	155.04

BIOGAS

The installed capacity for the production of electricity from biogas in 2003 already reached the expected capacity stated in the PFER—78 MW—for 2010 (see Table 11). The consumption of biogas in 2004 was 275.4 ktoe, which was three times as high as the consumption in 1998. Biogas comes from farm residues, wastewater treatment plants (30%) and landfills (60%). Catalonia has the third highest installed capacity of electrical power from biogas (see Table 12).

The biggest users of biogas for electricity production in percentage (over 50%) are Germany and Denmark. Spain is still well below the level of production of these countries (see Table 13).

Table 11. Installed capacity of electrical power plants using Biogas in Spain (MW). Source: IDAE.

	2000	2001	2002	2003	2004
Annual installed capacity	4.9	5.2	16.6	50.0	16.2
Accumulated installed capacity	50.1	55.3	71.9	121.9	138.1

Table 12. Installed capacity of electrical power plants using Biogas in Spain by region (MW). Source: IDAE.

Region	Capacity	%
Autonomous Community of Madrid	19.09	26.6
Asturias	10.69	14.9
Catalonia	10.53	14.6
Galicia	10.30	14.3
Valencia	5.93	8.2
Navarre	3.12	4.3
Basque Country	3.12	4.3
Andalusia	2.56	3.6
Castilla y León	2,1	2,9
Murcia	2.05	2.9
Cantabria	2.00	2.8
La Rioja	1.32	1.8
Aragon	1.22	1.7
TOTAL	71.90	100.0

Table 13. Gross production of Biogas in Europe (thousand toe). Source: EurObserver.

Country	2002	2003	%
Spain	168	257	8.0
United Kingdom	1,076	1,151	35.8
Germany	659	685	21.3
France	302	322	10.0
Total EU15	2,999	3,219	100.0

Balance of the PFER (Plan for the Promotion of Renewable Energy in Spain)

Now that the first half of the PFER has been completed, we can see that the increase in renewable energy consumption has been large but not as large as expected. Also, as the increase in primary energy consumption in Spain (more than 3.2 % per year) has been higher than expected by the PFER, the contribution of renewable energy to the total primary energy consumption is even lower.

The contribution from renewable energy sources to the consumption of primary energy in Spain at the end of 2004 was 6.5% [6]. It is important to note that, due to the low rain regime using the theoretical production corresponding to an average year calculated considering the existing capacity, the

contribution goes up to a 6.9%. Compared to the renewable energy consumption (6.3%) in 1998, the base year used by the PFER, the improvement is very low, so a new plan has recently been approved for the period 2005–2010.

Plan de Energías Renovables 2005-2010 (PER, Plan for Renewable Energy)

The objective of this new plan is to cover the 12% of primary energy consumption from renewable energy but with a different distribution between renewable energies, as we now explain for each type of bioenergy.

Biomass

The target for biomass electricity production is now 1,427 MW. To reach this target, the following measures will be implemented:

- a new program of co-firing of biomass and carbon in 19 existing power plants,
- a considerable increase in retribution from electricity produced in biomass plants, and
- support from the interministerial commission on biomass, which will increase its activities in order to stimulate the potential biomass market.

For thermal biomass, the target for 2010 is 1,383 ktoe. This will be supported by a new non-refundable investment budget.

Biogas

The aim for the 2005–2010 period is to increase installed power by 94 MW, with an associated generated power of 592 GWh in 2010. This amounts to a further 188 ktoe in terms of primary energy.

Biofuels

European Directive 2003/30/CE already adapted to the national legislation with the objective to cover the 5.75% of the market for transport fuel with biofuels and renewables has modified the target in the new plan. The target for 2010 is now 2.2 million toe.

Stakeholders and existing networks in the region's bioenergy sector

Stakeholders

- Brief descriptions of the various groups of stakeholders and their relevance and role in the region's bioenergy sector

The bioenergy sector includes areas such as biomass, liquid biofuels (biodiesel and bioethanol) and biogas. Many industrial activities are involved—from the collection of raw material, logistics, pre-treatment and energy production to support activities by public energy entities. The highly complex structure of the sector limits its development. Except for bioethanol, the Spanish bioenergy sector has no solid industrial structure but desegregated industries working only on certain aspects.

A large number of stakeholders are involved to some extent in bioenergy. Here we provide a list of the most important ones.

BIOMASS

Public research organisations

- CIEMAT

Companies

- EHN
- Foster Wheeler
- Guascor
- EQTEC
- Cadagua, S.A.

University research groups

- Extremadura
- Pontifica de Comillas

Technological centres

- Cartif
- Cener
- Aicia
- Circe

Energy agencies

- SODEAN (Sociedad para el Desarrollo Energético de Andalucía)
- IDAE (Instituto para la Diversificación y Ahorro de la Energía)
- ICAEN (Institut Català d'Energia)
- EVE (Ente Vasco de la Energía)

BIOFUELS

Public research organisations

- CIEMAT
- INTA

Companies

- EHN

- Abengoa
- Guascor
- Reagra

University research groups

- Extremadura
- Castilla La Mancha

Technological centres

- Cartif
- Cener
- Cidaut
- Gaiker
- Ikerland

Energy agencies

- IDAE
- ICAEN
- EVE

BIOGAS

Public research organisations

- CIEMAT

Companies

- Cadagua
- Besel
- Guascor
- Tragsa

University research groups

- Extremadura
- Cádiz

Technological centres

- Cartif
- Cener
- Aicia
- Cidaut

Energy agencies

- IDAE
- SODEAN
- ICAEN
- EVE

- Missing stakeholders and missing stakeholder contributions

In terms of its potential, biomass is the least developed renewable energy source. The sector is very heterogeneous, with fragmented contributions from many companies whose main activities are carried out in other fields. Spanish companies' today involvement in biomass projects is very low. On the other hand the logistic supply of biomass is not sufficiently developed.

Existing networks (regular and established meeting groups, conversation circles, round tables):

- a short description of the networks including target groups, aims, tasks, outcomes
- Internet-link, if available
- missing networks and activities

Spain has no specific networks for bioenergy activities. Instead, a brief list of bioenergy-related associations is provided:

APERCA – *Associació de Professionals de les Energies Renovables de Catalunya* (Catalan Association of Renewable Energy Producers)

APPA – *Asociación Española de Productores de Energías Renovables* (Spanish Association for Renewable Energy Producers)

ADABE - Association for Promoting the Production of Biomass in Spain

Bioenergy facilities in the region

Aim: To provide an overview of pellet, biogas, biomass/wood-chips and biofuel facilities in your region.

Please note:

- Small facilities of up to around 100 kW from the same kind (e.g. pellet facilities) may be aggregated. In this case, please add the number of facilities considered in the "comment" column.
- Facilities of more than 100 kW should be described in more detail.
- Estimation of data is permitted if no data are available (please indicate!).

BIOMASS PLANTS

This section describes some of the most important biomass plants.

Catalonia

Molins Energia, S. L.

This plant belongs to the Grup CASSA (Companyia d'Aigües de Sabadell, S. A.) and Hidrowatt, S.A. (55%), Municipality of Molins de Rei (15%), Entitat Metropolitana del Medi Ambient (15%) and ICAEN (15%). The plant is run by the company SERVEDAR, S.L., which belongs to the CASSA group.

The distribution network for heating and domestic hot water from biomass began in 2001. The plant supplies heating to the "La Granja" residential area, which has 695 houses and 2,000 residents and is located 1 km from the heating plant. Currently, 575 houses (82.7%) are connected to the heating network. Each house has its own heat exchangers.

Characteristics and performance at full development (100% of deployment) [7]:

- Biomass: pine fruits, fruit shells and wood waste
- Biomass boiler: 2,250 kW (Biomass burned in 2 stages: biomass incineration (750ºC) and biomass total combustion (1200ºC), heat recovery in a horizontal pirotubular boiler with 3 smoke paths) (figure 6).
- Back-up natural gas boiler: 1,634 kW (6 boilers with 2 burners each)
- Thermal production: 6,800 MWh/year at 90ºC
- Biomass consumption: 2,200 tons/year (540 kg/h maximum per boiler)
- Boiler efficiency: 85%
- Boiler pressure: 4 bar
- Network length (supply and return): 4,734 m
- Network volume: 125 m^3
- Maximum flow rate: 275 m^3/h
- Network diameter: between 60 and 273 mm with polyurethane insulation
- Investment cost (Central plant+network): 1,622,733 Euros, of which 456,769 Euros were from subsidies. (from the Thermie Programme and the Spanish and Catalan governments)
- Biomass storage: 180 m^3
- Hot water storage: 200 m^3
- Area of the central plant building: 450 m^2

Results at full development:

- Primary energy saving: 730 toe/year
- CO_2 emission reduction: 1,700 tons/year

Operational results until June 2004:

- Consumption of biomass: 4,009 tons
- Thermal production: 11,671 MWh
- Primary energy saving: 1,330 toe
- Reduction in CO_2 emission: 3,098 tons

Figure 6. Burner and boiler of the Molins Energia plant [7]

Energia Natural de Mora, S. L.

Description

This is an integrated biomass gasification power plant located in Mora la Nova (Catalonia) [8].

ENERGIA NATURAL DE MORA, SL was commissioned by the food and farming company PERE ESCRIBÀ, SA to develop an integrated biomass gasification power plant, called ENAMORA, that ran on almond shells. The plant, which began its industrial operation in October 1997 with 500 kW power alternative engines, has proved to be technologically flexible and reliable and has provided primary energy savings of over 500 toe per year, thus preventing some 1,500 tonnes of CO_2 from being emitted into the atmosphere.

It uses a cylindrical fluidised bed gasification reactor working at atmospheric pressure. The process consumes 500 kg/h of almond shells. The gas obtained by the gasification process is used in 2 ignition spark VOLVO engines with a nominal capacity of 250 kW. The annual electricity production is 2 GWh with a consumption of 2,500 tons of almond shells.

The plant was extended in April 2001 with a new 250 KW generator, which made the total output 750 KW. The plant has now run for more than 15,000 hours and has produced more than 10,000,000 KWh of electricity from various types of biomass, such as almond shells, wood chips, olive pits, etc.

EQTEC IBERIA and ENERGIA NATURAL DE MORA have jointly designed several types of gasification power plants, with output ranging from 250 KW to 2500 KW and with an electrical efficiency of 30 %. Higher outputs can be achieved using two or more gasification lines.

Plant origin

As some of the industries that used almond shells as solid fuel closed down and the consumption of natural gas increased, a surplus of this solid fuel—which, until recently was a real source of income for dry fruit producing companies—was inevitable. Almond producers such as PERE ESCRIBÀ, SA thus found it difficult to make a profit out of selling almond shells, and this problem is expected to get worse. In view of this situation, in 1993 PERE ESCRIBÀ, SA studied various energy solutions aimed

at maximising the use of almond shells. In 1994, their survey concluded with an ambitious research project whose aim was to set up a gasification system to allow companies to operate with a small-sized reactor. This system provided a high-energy performance and was environmentally friendly. Three years later, this project led to the current ENAMORA gasification system built by ENERGIA NATURAL DE MORA, SL with the support of the ICAEN. This plant generates the power required for self-consumption and sells any surplus to the grid.

Process

At the beginning of the gasification process (see figure 7), motor-driven shovels carry almond shells to the main hopper. Once the shells have been ground to about 4x4 mm, they are transported to the hoppers, which directly feed the reactor-gasifier. This consists of two groups in series, to which shells are added via a mechanical system. Hoppers have built-in sensors and pneumatic valves, which guarantee that there is never any shortage of material. These valves, which open sequentially, stop air from entering and gas from leaving.

The reactor-gasifier, where the thermal chemical reaction of solid organic matter into fuel gas takes place, is strongly protected with fireproof and heat-resistant material. This allows for high-energy transfer efficiency, keeps the bed temperature constant throughout programmed stops, guarantees an even distribution of temperature at any one time and keeps fuel accumulation inside to a minimum. The reactor is furnished with a balanced-pressure fluidised system, which integrates tar reduction, and has several built-in dispersing concentric ring injectors to make the inert catalyst more effective. Various sounding devices are distributed along the gasifier to control and regulate the optimal reaction temperatures and provide the monitoring computer with the parameters it needs to act on the frequency converter of the fuel-feeding system. A flow meter constantly measures the amount of air retained inside the reactor, which is regulated by means of a pneumatic valve. The gasifying agent used is non-enriched ambient air, which is preheated to around 250ºC before it is reintroduced to the reactor in the opposite direction to the gas (which is approximately exhausted at 700ºC). This is done to optimise energy efficiency. The resulting lean gas is cleaned and cooled so that it reaches the engine in optimal conditions. Filtering lean gas implies eliminating solid fractions, tar remains and water excess, which largely minimises polluting emissions. Solid fractions, consisting of non-reacted ashes and coal microparticles, are trapped inside a sleeve filter and reduced to mineral ashes via a thermal self-oxidation process. Sleeves cleaning bring along a proprietary system, which guarantees that the process is safe and efficient.

Later, the gas is cooled in a gas/water heat exchanger (as the water comes from a cooling tower, external contributions are not required), which leads to a condensate made up of the water remaining from reactions and short-chain hydrocarbons. The process ends when lean gas is mixed with the combustion air from engines. This mixture is compressed in the turbo-compressor and introduced into the combustion chamber. The two engines running on dual fuel gas – diesel mode keep a certain diesel injection level, which ignites the mix. Diesel accounts for 5–8% of the energy supplied to the engine. The plant uses two land-traction VOLVO diesel engines adapted by the company to generate electricity and operate with a lean gas and liquid fuel (diesel oil) mix. The third engine running with the Otto cycle does not need diesel injection since it operates by induced ignition, so one spark plug per cylinder is responsible for igniting the air-gas mixture.

The priorities of the plant (see figure 8), which was designed to operate at a power (between 250 KW and 750 kW, were safety, ease of operation and minimum maintenance costs.

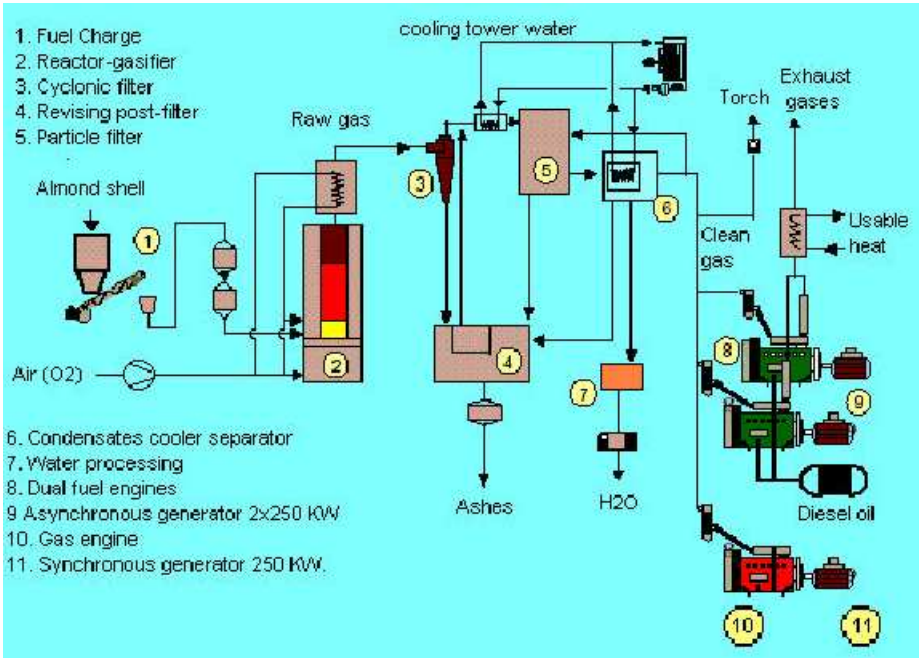

Figure 7. Process diagram of the biomass integrated gasification plant at Enamora, S. L. [8].

Figure 8. Biomass gasification plant in Mora la Nova (Catalonia) [8].

Results

The power generation and gasification plant completed its test period in October 1997. Since then, regular industrial exploitation has continued. The system has proved to be extremely flexible, since it allows for an unattended and uninterrupted 16-hour daily operation 5 days a week i.e. the plant does not need any staff to be exclusively devoted to it. The daily ignition and stop operations, for example, are fully automatic. For 8-hour stops, nominal power is reached 30 minutes after the sequence has started and for stops of up to 48 hours it is reached 90 minutes after. During the four years of its operation, therefore, the plant was in service for over 15,000 hours, during which time it generated over 10 GWh of electricity from such a renewable source as almond shells.

This accounts for savings of almost 1,600 toe and minimises CO_2 emission levels by almost 5,000 tonnes. Following this successful first phase, the company is now attempting to duplicate the plant's power and generate 1 MW of electricity by feeding it with 1 t/h of almond shells.

Once the almond shell system was seen to be flexible and reliable, ENERGIA NATURAL DE MORA and EQTEC IBERIA began plans to adapt the gasifier to other types of biomass from both natural and waste sources, organic waste that cannot be recycled, such as plastics. The basic research programme that made this technology possible cost over 2.5 million Euros. This development effort will lead to future applications under competitive market conditions.

Rest of Spain

Biomass plant at Sangüesa

This plant, which is owned and run by EHN (Empresa Hidroeléctrica de Navarra), is one of the first plants of its kind in the south of Europe to burn cereal straw (see figure 9). The difficulty with this fuel is its high chloride and alkaline contents. It is also difficult to ensure supply and to handle the straw. The plant is the property of EHN (90%) and IDAE (10%), the Spanish energy agency, and was included in both the Thermie European Programme and the Spanish Energy Saving and Efficiency Plan.

Installed capacity is 25 MW and it operates with an approximate consumption of 160,000 tons/year of cereal straw [8]. The plant was connected to the grid in July 2002 after two years construction, is operational 8,000 hours per year and produces 200 GWh, which is around 6% of electricity consumption in the Navarre region. The cost of this project was around 51 million Euros. Iberinco and Powertec was responsible for the plant's engineering project. Bioener (boiler), Alstom and ABB Power Technology supplied the main equipment.

The plant (see figure 10) has a constructed surface area of 10,108 m^2, and consists of a warehouse (5.120 m^2), a boiler house (1.900 m^2), a turbine shed, a control area and offices (2.635 m^2), and other auxiliary installations (453 m^2).

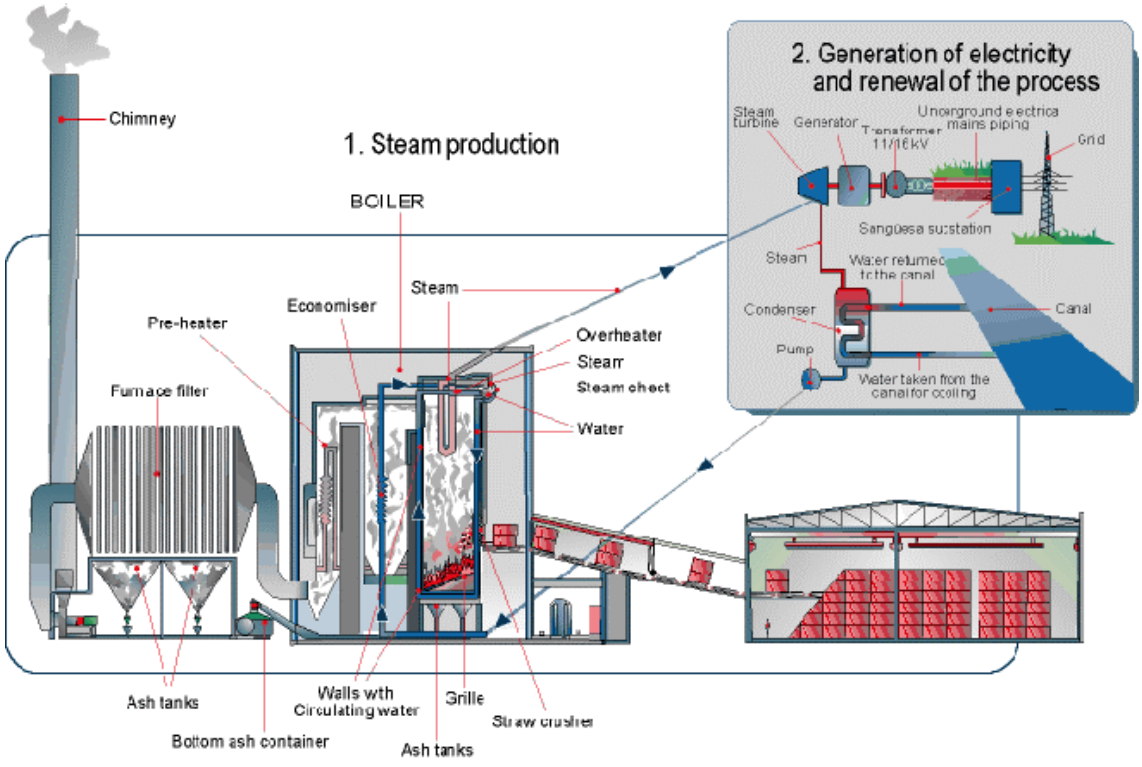

Figure 9. The Sangüesa biomass plant [9].

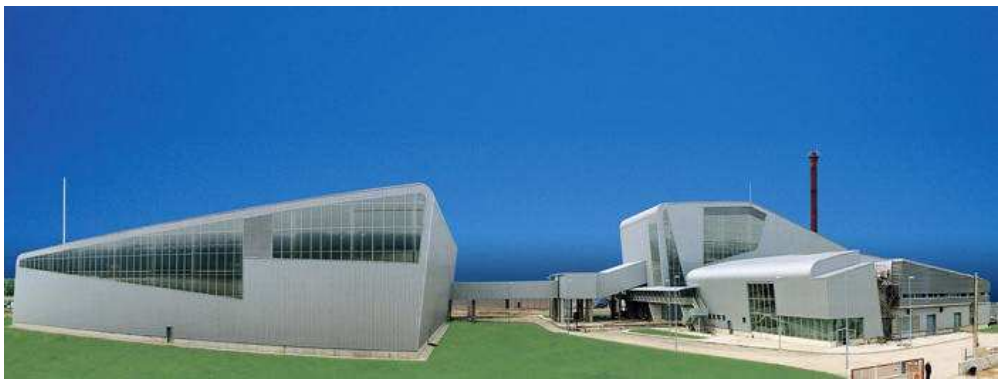

Figure 10. – View of the Sangüesa biomass plant [9].

Biomass plant of ENCE in Huelva

In 2000 Celulosa Energía S.L. (CENER), part of the cellulose group ENCE, started a cogeneration plant of 27 MWe in Huelva that uses forestry biomass and natural gas.

Biomass plants of CECSA and BIOMAP

These twin biomass plants of 12 MWe consume 100,000 tons of biomass from energy crops (thistle straw and cereal). The CECSA plant (Cultivos Energéticos de Castilla) is situated in Burgos and the BIOMAP plant (Biomasas del Pirineo) is situated in Huesca.

Agroenergética de Baena

Location: Baena (Cordova, Andalusia)
Start of operation: 2001
Owner: Vapor y Electricidad El Tejar (VETEJAR)
Biomass: Orujo (20-40% moisture)
- Capacity: 25 MWe.
- Biomass consumption: 225,000 tons/year
- Power produced: 168,750 MWh/year
- Self-consumption of electricity: 16,875 MWh/year

Boiler: Standkessel
- Type: moving grate
- Steam produced: 110 tons/h
- Pressure: 65 bar
- Temperature: 450ºC

Steam turbine: Ansaldo
- Capacity: 25 MW
- Steam: 65 bar/450ºC
- Condensation pressure: 0.16 bar
- Consumption: 3.1 kg/kWh
- Extraction of Steam: no

Figure 11. The Agroenergética de Baena plant [10].

Agroenergética de Algodonales, S. L.

Location: Algodonales (Cádiz)
Start of operation: 2002
Owner: Vapor y Electricidad El Tejar (VETEJAR)
Biomass: Orujo (40% moisture)
- Capacity: 5.0–5.7 MWe.
- Biomass consumption: 53,000 tons/year
- Power produced: 37,500 MWh/year
- Self-consumption of electricity: 3,750 MWh/year

Boiler: Standarkessel
- Type: moving grate
- Steam produced: 25 tons/h
- Pressure: 72 bar
- Temperature: 450ºC

Steam turbine: Nadrowski (Prematécnia)
- Capacity: 5.0 MWe
- Condensation pressure: 0.17 bar
- Steam extraction: no

Figure 12. The Agroenergética de Algodonales plant [10].

Bioeléctrica Jinense S.A.

16.2 MWe. Owned by Abener (90%).

Enemansa Biomass Plant

16 MWe. Owned by ECYR (52%), Aceites Pina (24%), AGECAM (24%). Engineering by Ghesa Ingeniería y Tecnología, S.A. Main equipment supplied by Foster Wheeler, Balcke Durr and Siemens.

La Loma

Location: Villanueva del Arzobispo (jaén, Andalusia)
Start of operation: 2002
Owner: ECYR (40%), Grupo Cobra (20%), Caja Rural de Jaén (10%), Iverjaén (5%) and olive oil producers (25%)
Biomass: orujillo
- Capacity: 16 MWe.
- Biomass consumption: 103,236 tons/year
- Power produced: 112,150 MWh
- Self-consumption of electricity: 11,215 MWh/year

Boiler: Foster Wheeler (Engineering by Ghesa Ingeniería y Tecnología, S.A.)
- Type: burner/grate
- Steam generated: 65.8 tons/year
- Pressure: 62 bar
- Temperature: 450ºC

Steam turbine: Thermodyn
- Condensation pressure: 0,1 bar
- Steam extraction: no

VETEJAR - Vapor y Electricidad El Tejar, S.L.

Location: Palenciana (Cordova)
Start of operation: 1995
Owner: Vapor y Electricidad El Tejar, S.L. (VETEJAR)
Biomass: Orujo (60% moisture)
- Capacity: 12.5 Mwe.
- Biomass consumption: 150,000 tons/year
- Power produced: 90,000 MWh/year
- Self-consumption of electricity: 10,800 MWh/year

Boiler: Foster Wheeler (Engineering by Abener).
- Type: fluidised bed
- Steam generated: 50 tons/year
- Pressure: 85 bar
- Temperature: 450ºC

Steam turbine: Siemens
- Condensation pressure: 0.15 bar

Secaderos de Biomasa en Puente Genil (Sedebisa)

10 MWe. Owned by Alvaro Espuny S.L. and SACYR. Engineering by Iberese.

Extragol, S. L.

9,5 MWe. Plant located in Villanueva de Algaidas (Málaga). The biomass is orujillo (dry). Owned by Oleoliva (50%) Iberese and Sacyr (50%). Engineering by Iberese. Main Equipment by Kem (boiler) and Iberese (turbine).

Biomasas de Puente Genil, S.L.

9.5 MWe. Biomass: orujillo. Owned by Biomasas de Puente Genil, S.L. Iberese (turbine).

Oleícola El Tejar

Location: Palenciana (Cordova)
Start of operation: 1999
Owner: Oleícola El Tejar
Capacity: 5.7 Mwe
Biomass consumption: 45,000 tons/year
Power produced: 42,750 MWh/year
Self-consumption of electricity: 4,275 MWh/year
Boiler: San Carlos
- Type: grate
- Steam generated: 30 tons/year
- Pressure: 45 bar
- Temperature: 450ºC

Steam turbine: Nadrowski
- Capacity: 5.7 MWe
- Condensation pressure: 0,2 bar
- Steam extraction: no

Uniener

3.5 MWe. Owned by Uniener S.A., Ocaña (Toledo), manufactured by Uniarte and Sinae Energía y Medio Ambiente). Boiler supplied by Kem.

C. T. Hermanos Santamaria

Location: Lucena
Start of operation: 2000
Owner: Hermanos Santamaria Muñoz S.L. (30%), and Siif Energies (70%)
Biomass: Orujillo
- Capacity: 1,7 MWe
- Biomass Consumption: 15,000 tons/year
- Power produced: 12,750 MWh/year
- Self-consumption of electricity: 1,275 MWh/year

Boiler: Standarkessel
- Type: Grate
- Steam generated: 12 tons/h
- Pressure: 17 bar
- Temperature: 320ºC

Steam turbine: Nadrowski/Prematécnia
- Capacity: 1,778 kWe
- Condensing pressure: 0.11 bar
- Consumption: 6.19 kg/kWh
- Steam extraction: no

District heating network in Cuellar

Location: Cuellar (Castilla y Leon)

Type of plant: District heating network supplying heat and domestic hot water to three municipal buildings (a school, a sport centre and a cultural centre), three house communities and thirteen individual houses.
Start of operation: April 1999.
Biomass: Forestry industry waste
Biomass consumption: 789 toe/year
Investment cost: 1.17 million Euros

BIOFUEL PLANTS

Abengoa Bioenergía is the leading producer of fuel bioethanol in Europe [5]. Current operations include two cereal-based bioethanol plants in Spain (Ecocarburantes Españoles and Bioetanol Galicia), with an annual installed capacity of 150 and 170 million litres, respectively. In partnership with Ebro Puleva, Biocarburantes de Castilla y Leon S.A., Abengoa Bioenergia is developing a third plant in Salamanca with an annual capacity of 200 million litres, of which 5 million litres are derived from the conversion of biomass from cereal crops using a new technology developed by Abengoa Bioenergy R&D.

Abengoa Energia's business plan also involves the construction of two new cereal-based bioethanol plants in Europe. Following the recent guidelines approved in the European Directives for the Promotion and Taxation of Biofuels, these plants will be built in countries where the demand and legal framework make it possible to quickly and effectively initiate bioethanol production. Feasibility studies and collaboration agreements with local partners are now being developed for both facilities.

In the next section we will briefly describe the most important biofuel plants.

Catalonia

Repsol Petróleo, S.A.

The oil refinery of Repsol Petróleo, S.A. in Tarragona (Catalonia) produces 44.8 ktoe of ETBE from ethanol produced from vegetal oil. Of this amount, 23.6 ktoe are consumed in Catalonia. The ETBE is mixed with gasoline (5-15%) to increase the octane index and avoid using lead-based additives.

Stocks del Vallès, S. A.

The biodiesel plant of Stocks del Vallès, S. A. in Montmeló (Catalonia), which began its operations in 2002, uses recycled vegetal oil. It has a production of 6,000 tons/year, which in the future may increase to 18,000 tons/year. In the process, subproducts such as glycerine (500 tons/year) and potassium-based fertilisers (100 tons/year) are obtained. The investment cost was 3,606,000 Euros. The biodiesel is commercialised under the name of BDP 30 because its biodiesel content is 30%.

Bionet Europa, S. A.

The biodiesel plant of Bionet Europa, S. A. in Reus (Catalonia), which began its operations in 2004, has a capacity of 50,500 tons/year of biodiesel using recycled vegetal oil. Also, 3.200 tons/year of Glycerine are obtained as a useful subproduct. The investment cost was 12.5 million Euros.

The rest of Spain

Ecocarburantes Españoles - Cartagena (Murcia)

The bioethanol plant of Abengoa Bioenergy is located in the port of Escombreras in Cartagena, in the region Murcia in the southeast of Spain. It was constructed in 1999 and produces 100 million litres (26

million gallons) of ethanol, plus 130,000 tons of dried distillers grain and 78,000 tons of food-grade CO_2 every year. In the year 2000, a wine alcohol distillation plant was added with an annual capacity of 50 million litres to upgrade waste from winery processing. The Ecocarburantes plant employs 81 people in areas such as maintenance, operations, material handling, engineering, logistics and marketing, and also includes part of the administration section of the Abengoa Bioenergy Business Group.

Figure 13. The bioethanol plant in Cartagena [5].

Murcia

The biodiesel plant in Murcia, produces 250,000 tons/year and is since 2005 is perhaps the biggest in Europe. Seventy jobs were created from a total investment of 50 million Euros.

Bioetanol Galicia - A Coruña (Galicia)

Constructed in 2001 and located in Teixeiro-Curtis near A Coruña in Galicia in the northwest of Spain, this plant produces 100,800 tons of bioethanol every year (around 65 ktoe) from cereals (wheat and barley). Part of Abengoa Bioenergy, it has been in operation since 2002 and employs 65.

The plant also produces 96,000 tons of dried distillers grain and 98,000 tons of food-grade CO_2. In 2003, a wine alcohol distillation plant was added with an annual capacity of 50 million litres to upgrade waste from winery processing.

Figure 14. The bioethanol plant in Galicia.

Alava (Basque Country)

This biodiesel plant has an installed capacity of 20,000 tons/year

Biocarburantes Castilla y León, Salamanca (Castile- Leon)

This bioethanol plant belongs to Abengoa Bioenergy. In the last month of October 2003, Abengoa Bioenergy began construction of its third European plant. This new plant will be located at Babilafuente in Salamanca and is designed to produce 200 million litres (52.8 million gallons) of fuel-grade ethanol (FGE) per year. It will use barley as feedstock for 87.5% of its production and European wine alcohol as feedstock for the remaining 12.5%. As subproducts, 656 t/day of distillers dried grains and 416 t/day of CO_2 will be produced.

Figure 15. The bioethanol plant in Salamanca [5].

Benavente (Castilla y Leon)

This bioethanol plant has a production of 100,000 tons/year and is in service since 2005 using cereals. The investment is 100 million Euros with a creation of 300 jobs.

Alcalá de Henares (Madrid)

This biodiesel plant has a capacity of 100,800 tons/year.

BIOGAS PLANTS

Catalonia

Tractaments de Juneda, S.A. (TRACJUSA)

Since 2001, it is operating in Juneda (Les Garrigues, Catalonia) pig slurry waste-to-energy plant to treat this animal waste produced on the farms in the area producing biogas consumed in a cogeneration plant. The treatment capacity is 110.000 tons/year of pig slurry and uses a reciprocating engine cogeneration plant with an installed capacity of 16.3 MWe, of which 1.3 MWe is from biogas. The production of biogas is 10,900 MWh and the production of electricity is 119,900 MWh considering 8,000 h/year of operation. The production of biogas is theoretically 27.5 m^3 per ton of treated pig slurry (3,025,000 m^3/year), of which with a 65% ofis methane. The plant, which was built with an investment of 18 million Euros, uses a proprietary process design called Valpuren. The two digesters have a total volume of 3,000 m^3 each.

The CHP plant is designed to meet the heat and electricity requirements of all the slurry-treatment processes. The excess electricity generated is exported to the grid, thus helping to make the project financially feasible.

Six Jenbacher model JMS 620 GS-N. L gas engines, each with an output of 2740-kWe, are installed. The fuel used is natural gas combined with the biogas produced in the slurry digestion process. The engines are rated for natural gas but with one difference: to accommodate the addition of a maximum of 10% of biogas to the natural gas, a main gas ramp of 80-200 mbar was installed for each engine, rather than the 3 bar ramp generally used for 100% natural gas.

The exhaust gas from the six engines is sent to a single-pass fire-tube boiler capable of raising 10,000 kg/h of 6-bar steam. In normal operation the processing steam demand is 4670 kg/h. The water from the engine high-pressure cooling circuit is used to supply heat to the evaporator and maintain the required temperature in the digesters. The waste heat in the low-pressure water circuit is dissipated in the cooling towers. These towers, as well as the water-treatment plant, the biogas tank and the natural gas regulating and metering station, are situated in an independent area connected to the rest of the plant through a pipeline rack.

Can Mata Landfill

The Can Mata landfill, located in Hostalets de Pierola (Anoia, Catalonia), began operating in January 2001. The maximum capacity of the landfill is 3,000 tons/day including municipal and industrial residues. Electrical power is 1,050 kW. The expected annual electricity production is 8,000 MWh/year, with an associated primary energy saving of 2,500 toe/year. The installed capacity is expected to increase to 2 MWe.

Other landfills with recovery of biogas are given in table 16.

Table 16. Landfills with biogas recovery in Catalonia.

Plant	Location	Owner	Capacity (kWe)
Vertedero del Garraf	Gava	ECYR and Envirogas	12,444
Vertedero de Vacarisses	Vacarisses	Coll Cardus Gas, S. L.	5,712
Planta de biometanización Form	Terrasa	Cespa y Adasa Sistemas, S. A.	1,250
Cespa - Santa Maria de Palau Tordera	Santa Maria de Palau Tordera	Cespa	1,064
Can Mata	Els Hostalets de Pierola	Ecoenergia de can Mata A.I.E.	1,050

ECOPARC

The Ecoparc plant is mainly used to treat organic waste of municipal origin. The organic waste undergoes a methanisation process to generate biogas used in engines to produce electricity and heat. There are three Ecoparc plants:

Ecoparc I – Ecoparc de Barcelona, S.A. in Barcelona
Ecoparc II – Ecoparc del Besos, S. A. in Montcada i Reixach (Barcelona)
Ecoparc III – Ecoparc del Mediterrani, S. A. in Sant Adrià del Besos (Barcelona)

The Ecoparc I plant began operating in August 2001. The main characteristics of the plant are:

- Organic waste treatment capacity: 325,000 tons/year
- Digesters capacity: 90,000 tons/year
- Power capacity: 5.24 MWe
- Biogas production : 14 million m^3/year
- Power production: 22 million kWh/year
- Investment cost: 48.25 million Euros

Waste-water treatment plants

In Catalonia some waste-water treatment plants use biogas from the anaerobic digestion process to produce electricity and heating for their own processes. Table 17 provides a list of these plants.

Table 17. Waste-water treatment plants in Catalonia with recovery of biogas.

Plant	Location	Owner	Capacity (kWe)
EDAR San Feliu	Sant Feliu de Llobregat	Empresa Metropolitana de Sanejament, S. A.	642
Edar Sabadell – Riu Ripoll	Sabadell	Servicios y Procesos Ambientales, S. A.	640
Emssa-Gava	Gavà-Viladecans	Empresa Metropolitana de Sanejament, S. A.	450
Aigües de Lleida	Lleida	Municipality of Lleida	240
EDAR Manresa	Manresa	Aigües de Manresa	240

The rest of Spain

The most important biogas plants in the rest of Spain are:

Galicia

There are several plants in Galicia:

- Aldaba has a capacity of 8 MWe and treats 135,000 tons/year of RSU

- Nostián has a capacity of 6 MWe.

- Biocerceda has a capacity of 2,27 MWe.

- Conservas Calvo has a capacity of 50 kWe

- Vertedero de Bens—a landfill of 2.5 MWe

Andalusia

Biogas y energía
Location: Puente Génave (Andalusia)
Start of operation: 2002
Owner: Sinae
Biomass: Orujo (65% moisture)
Capacity: 5 MWe
Biomass consumption: 100,000 tons/year

Power produced: 37,500 MWh/year

Digester: Felguera – I.H.I. S.A.

Capacity: 3,000 m3

Digester temperature: 55ºC

Number of digesters: 2

Engine: Jenbacher

Power: 1,036 kWe

Number of engines: 5

3.1.4 Raw materials/biomass resources for bioenergy application in Catalonia

Aim: To provide an overview of the biomass resources available for energy use in Catalonia.

Catalonia (32,090 km^2) can be divided into different areas according to land use (see figure 16). Of the total area, 37.1 % is dense forestry. According to data from 1993, this represents an area of around 1,220,000 ha. The density of the forest area is clearly shown in figure 17.

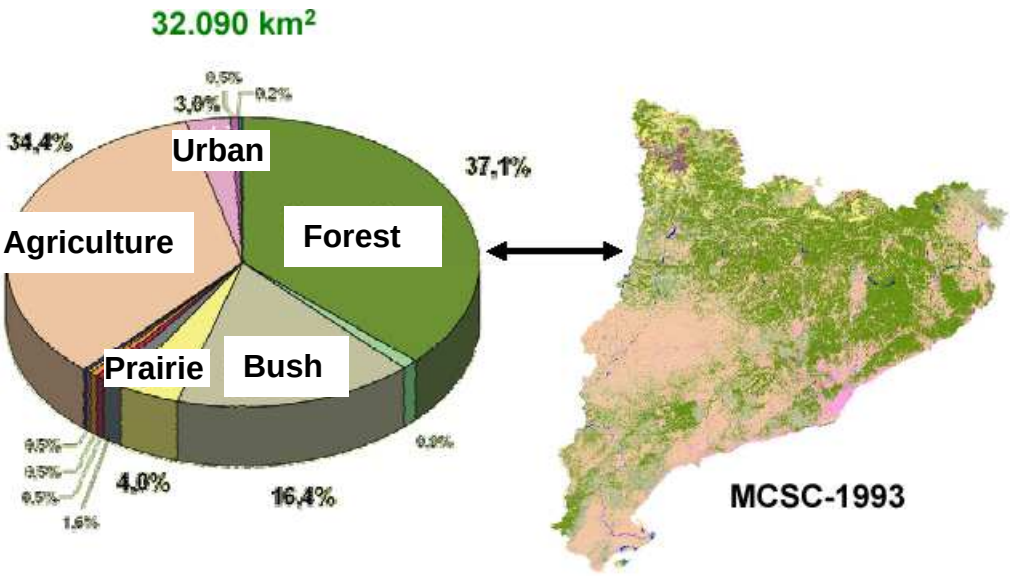

Figure 16. Catalonia divided according to land use [3].

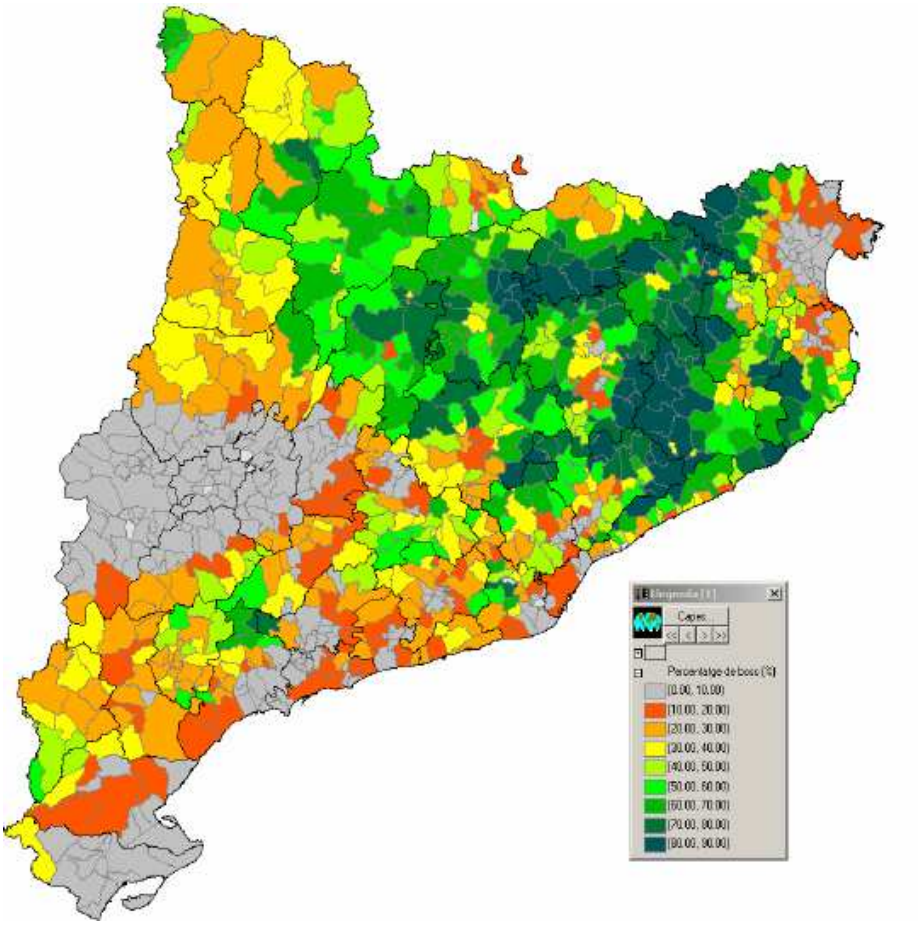

Figure 17. Forest area in percentage by municipality limits [3].

In 2001, 19% of the forests were publicly owned and 81% were privately owned. The division of private forests according to size is shown in table 14.

Table 14. Division of private forests according to size [3].

	Number of owners	Area (ha)	Number owners (%)	Area (%)
< 25 ha	41,115	163,837	83	16
> 25 ha	8,452	838,677	17	84
Total	49,567	1,002,514	100	100

Table 15. Losses due to forest fires [3].

	Forest area affected	Wood volume	Wood volume + skin	Biomass
Year	ha	m^3	m^3	tons + 20%
1993	3,328	156,409	223,530	152,999
1994	62,575	2,940,890	4,202,938	2,876,773
1995	2,202	103,489	147,900	101,233
1996	531	24,956	35,665	24,412
1997	625	29,374	41,979	28,733
1998	13,714	644,528	921,120	630,477
1999	486	22,841	32,643	22,343
2000	2,584	121,442	173,558	118,795
2001	993	46,669	66,696	45,651
2002	951	44,695	63,875	43,721

The price of wood in 2001 was about 43.6 Euros per ton. The price of triturated wood was 21.6 Euros per ton.

Annual figures for forest biomass in Catalonia are:

Biomass Growth = 3,000,000 tons/year (100%)
Biomass Fired (with profit?) = 600,000 tons/year (21%)
Used Biomass = 500,000 tons/year (16%)

Net balance = 1,900,000 tons/year (62%)

Figures 18 and 19 show that these figures are not uniform throughout the region.

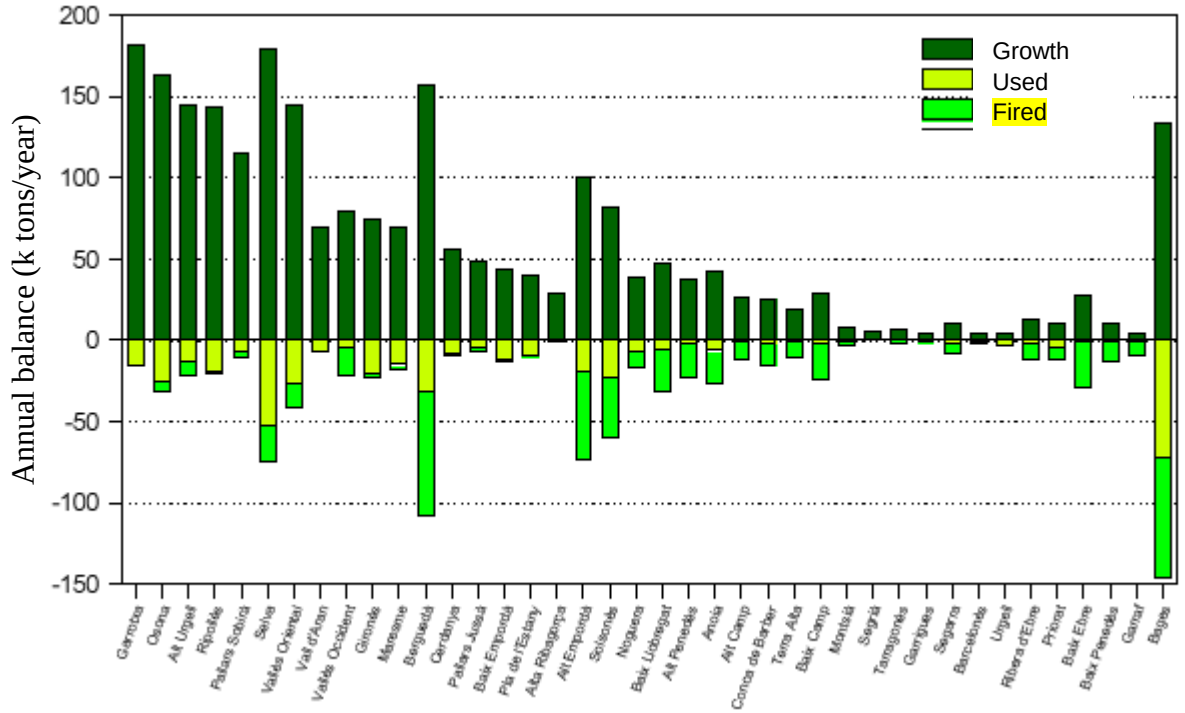

Figure 18. Annual balance of forest biomass in Catalonia by area [3]

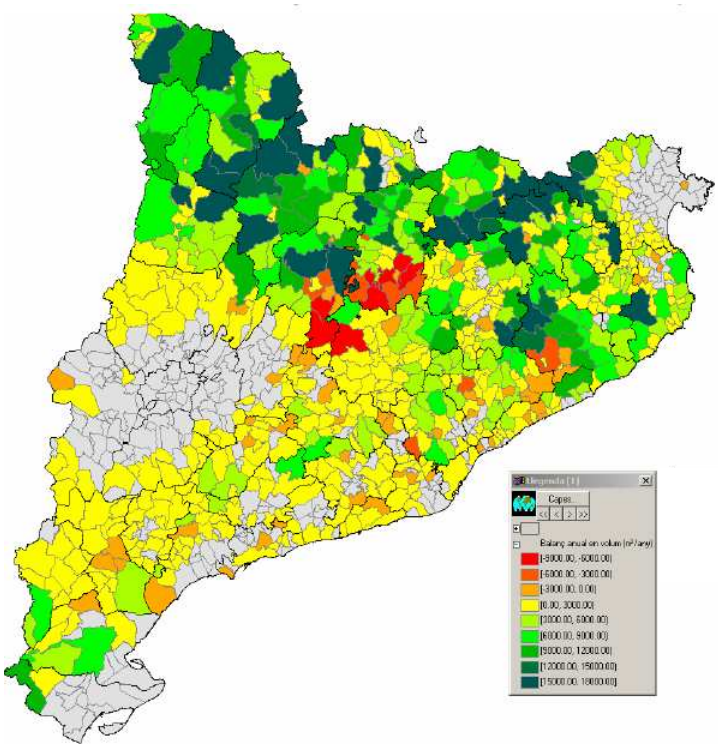

Figure 19. Annual balance in volume (m^3/year) by municipality. Dark green indicates high growth, dark red indicates low growth. Grey indicates an absence of dense forest [3].

Annex 1: Overview of bioenergy facilities in Catalonia (to be completed)

Plant type	Name of facility	Overall concept with special reference to urban situation (e.g. ecological, economic and social aspects)	Plant details				Biomass details			Further comments, problems / positive effects with special reference to urban situation
			Start of operation (year)	Type	Size, heat and power output	Further information	Type	Source	Supplier / logistics	
Pellet/wood-chip heating on a household level)	a)									
	b)									
	….									
Heating plants (communal level)	Molins Energia, S. L.	Heating and domestic hot water distribution network from biomass	2001		2,250 kW of heating		pine fruits, fruit shells and wood waste			Network length (supply and return): 4.734 m
	b)									
	……									
CHP plants	Energia Natural de Mora, S. L.	Integrated biomass gasification power plant	1997, enlarged in 2001		750 kWe		almond shells			Plans to adapt the gasifier to other types of biomass (both natural and waste sources)
Biogas plants and gas processing	TRACJUSA	pig slurry waste-to-energy plant	2001		16.3 MWe		Pig slurry			This plant uses a proprietary process design called Valpuren.
	Can Mata	Landfill	2001		1,050 kWe					
	Vertedero del Garraf	Landfill			12,444 kWe					
	Vertedero de Vacarisses	Landfill			5,712 kWe					
	Planta de biometanización Form	Landfill			1,250 kWe					
	Cespa - Santa Maria de Palau Tordera	Landfill			1,064 kWe					
	San Feliu	Waste-water treatment plant			642 kWe					

	Sabadell-Riu Ripoll	Waste-water treatment plant			640 kWe					
	Emssa-Gava	Waste-water treatment plant			450 kWe					
	Aigües de Lleida	Waste-water treatment plant			240 kWe					
	Manresa	Waste-water treatment plant			240 kWe					
Biofuel facilities (oil press, oil conversion)	Repsol Petróleo, S.A.	Production of ETBE from ethanol produced from vegetal oil			44.8 ktoe of ETBE		Ethanol produced from vegetal oil			The ETBE is mixed with gasoline in a proportion of 5-15% to increase the octane index and replace the use of leaded additive
	Stocks del Vallès, S. A.	Biodiesel plant using recycled oil	2002		6,000 tons/year of biodiesel		Recycled oil			The biodiesel is commercialised under the name of BDP 30 because it contains 30% biodiesel
	Bionet Europa, S. A.	Biodiesel plant using recycled oil	2004		50,500 tons/year		Recycled oil			
Others	….									

Annex 2: Biomass resources available for energy purposes in Catalonia (to be completed)

Type of biomass	More detailed biomass specification	Quantity (Potential/year) *	Current used quantity (per year) *	Price (please indicate year and unit) *	Comments	Reference/ Literature
	Please clearly indicate your unit used!	**toe**	**toe**	**EUR/kg (MWh)**		
Biomass from wood	Forest wood	92,340	301,305			C. A. Fernández, IDAE, 2003 (*)
	Wood pellets					
	Wood from landscape management					
	(By-)products and residues from wood processing industry					
	Used wood / contaminated wood					
	Others (energetic crops)	277,007				C. A. Fernández, IDAE, 2003 (*)
Biomass from agriculture and garden (except wood and manure)	Grass and leaves	605,670				C. A. Fernández, IDAE, 2003 (*)
	Straw					
	Whole crop					
	Grain or seed					
	Others (wood)	129,170				C. A. Fernández, IDAE, 2003 (*)
Biomass (by-) products and residues from industry	(By-)products and residues from food industry	10,725				C. A. Fernández, IDAE, 2003 (*)
	(By-)products and residues from other industries	146,525				C. A. Fernández, IDAE, 2003 (*)
Biogas / Others / Mixtures	Manure and residues from animal husbandry		49,088			C. A. Fernández, IDAE, 2003 (*)
	Biowaste from households					
	Others					

(*) Carlos Alberto Fernández (IDAE), Situación del Sector de la Biomasa, Jornada Hispano-Alemana de Biomasa, Madrid, November, 2004.

- You may estimate if no data is available
- Please indicate clearly which unit you are using

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