AREA OF BIOMASS AND BIOFUELS
RENEWABLE ENERGY PLAN 2005 – 2010*

8 August 2005

* **Document amended to comply with the European Commission's requirement concerning information on national biomass plans**

Biomass Area

CHAPTER 3.6

RENEWABLE ENERGY PLAN FOR SPAIN, 2005-2010

3.6. Biomass Area

The predominant characteristic of the biomass area is its diversity. This diversity applies when describing the materials that can be used as fuels and also with regard to their possible energy uses. This means that this area cannot be approached from a single perspective since there are so many combinations of usable types of biomass and technologies for their energy use.

The analysis of the biomass area in this chapter begins with a review of the European situation in the context of the targets contained in the White Paper on Renewable Energy. It then goes on to focus on the state of the sector in Spain.

Insofar as it concerns Spain, it includes a detailed study of the various types of biomass resources, discussing the specific problems associated with those resources and identifying priority areas and measures for their exploitation for energy purposes. It also includes a review of the main technical, legislative, environmental and financial aspects associated with the use of biomass energy. In the first of these aspects, special emphasis is placed on the need to adapt biomass for energy use and the low transformation efficiency traditionally associated with the equipment used. As far as environmental aspects are concerned, the report emphasises the neutral CO_2 balance of projects to exploit biomass energy and, finally, as far as financial aspects are concerned, the effect of Royal Decree 436/2004 of 12 March is examined as regards its impact on the financial profitability of projects for generating electricity using biomass.

The last sections of this chapter consist of an analysis of the main barriers to the development of applications of this type, a group of measures to overcome those barriers in the short and medium term, energy targets for the 2005-2010 period, a discussion of the structure of the Spanish industrial sector and, finally, a review of the sector's requirements in the area of R&D, which is of vital importance for the consistent development of this area over the next few years.

3.6.1. The situation in the European Union

In 1977, the desire to achieve substantial growth in renewable energy sources in the European Union led the European Commission to draft the White Paper for a Community Strategy and Action Plan for Renewable Energy, within the framework of Community energy policy.

That document was an attempt to achieve an ambitious overall target of **12% of the primary demand for energy in the European Union as a whole being met by renewable energy sources by 2010**.

Regarding the use of biomass for generating energy in thermal or electrical applications, the target established for 2010 was to increase the share of biomass in the Union's energy consumption by 57 million TOE, with 30 million TOE coming from biomass deriving from waste and the remainder from energy crops.

As Figure 1 shows, the consumption of biomass in the European Union at the end of 2003, measured in terms of primary energy, amounted to 43 MTOE in the EU-15, which represented a 6.1% increase compared to the data for 2002. However, the pattern of consumption varies greatly from one country to another and in any case the trends observed would make it impossible for the overall targets announced in the White Paper to be fulfilled.

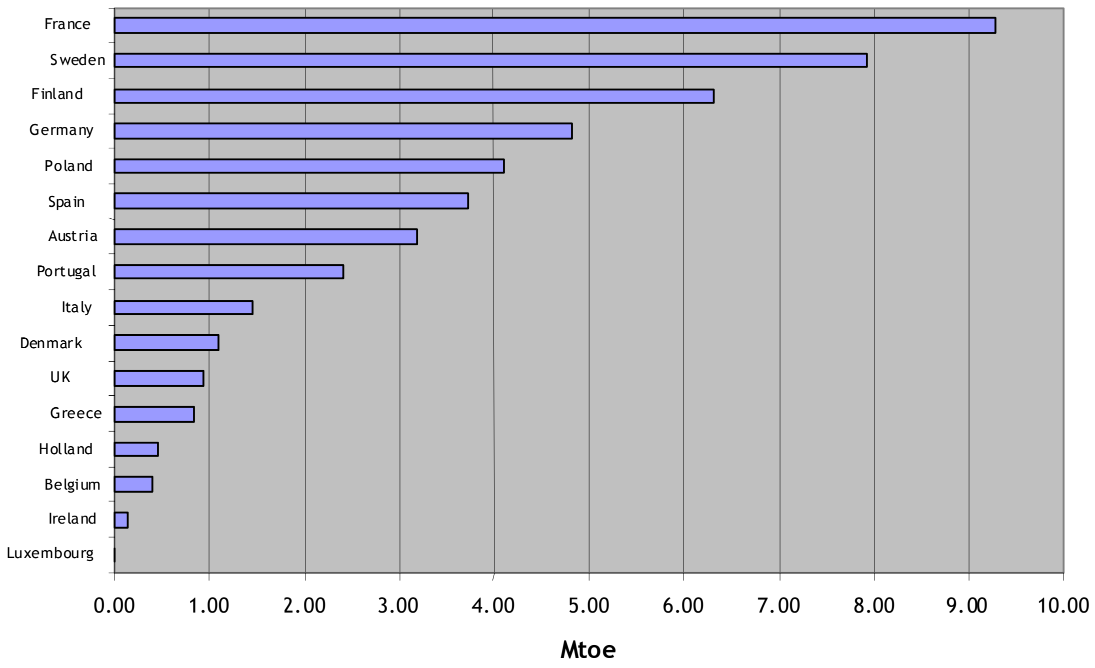


Figure 1. Consumption of biomass in the European Union at 31/12/2003 (EurObserv'ER). The figure corresponds to the EU-15 and includes the figure for consumption in Poland due to its relevance

3.6.2. Analysis of the Biomass Area

A Plan to Promote Renewable Energy was drawn up on the basis of the energy target contained in the European Commission White Paper and the commitment assumed in Act 54/1997 of 27 November on the Electricity Sector. This Plan was approved by the Council of Ministers on 30 December 1999. The Plan laid down targets for the development of each area of renewable energy. It was intended that those areas should between them account for at least 12% of national consumption of primary energy by 2010.

In the area of biomass, the target for development during the 1999-2010 period was established at 6,000,000 TOE, divided between 5,100,000 TOE for electrical applications and 900,000 TOE for thermal applications, in both the domestic and industrial spheres.

3.6.2.1. The Current Situation

Consumption of biomass in Spain amounted to 4,167 kTOE at the end of 2004. The following table shows that highest consumption takes place in the domestic sector, which accounts for almost half the total, followed by the pulp and paper sector, the wood, furniture and cork sector and the food, drink and tobacco sector. These four sectors account for almost 90% of the total.

Consumption of biomass in Spain broken down by sectors (2004)

SECTOR	TOE	%
Domestic	2,056,508	49.4%
Paper and pulp	734,851	17.6%
Wood, furniture and cork	487,539	11.7%
Food, drink and tobacco	337,998	8.1%
Electrical energy stations (not CHP)	254,876	6.1%
Ceramics, cement and plasters	129,013	3.1%
Other industrial activities	57,135	1.4%
Catering	30,408	0.7%
Agriculture and livestock	21,407	0.5%
Services	19,634	0.5%
Chemical products	16,772	0.4%
Water collection, purification and distribution	15,642	0.4%
Textiles and leather	5,252	0.1%
TOTAL	4,167,035	

In terms of Autonomous Communities, Andalucia, Galicia and Castilla y Leon have the highest consumption. This is due to a number of factors such as the existence of companies consuming large quantities of biomass (for example the cellulose sector), the existence of a well-developed forestry sector and a highly dispersed population structure, which is associated with higher domestic consumption. Figure 2 shows consumption per Autonomous Community at the end of 2004.

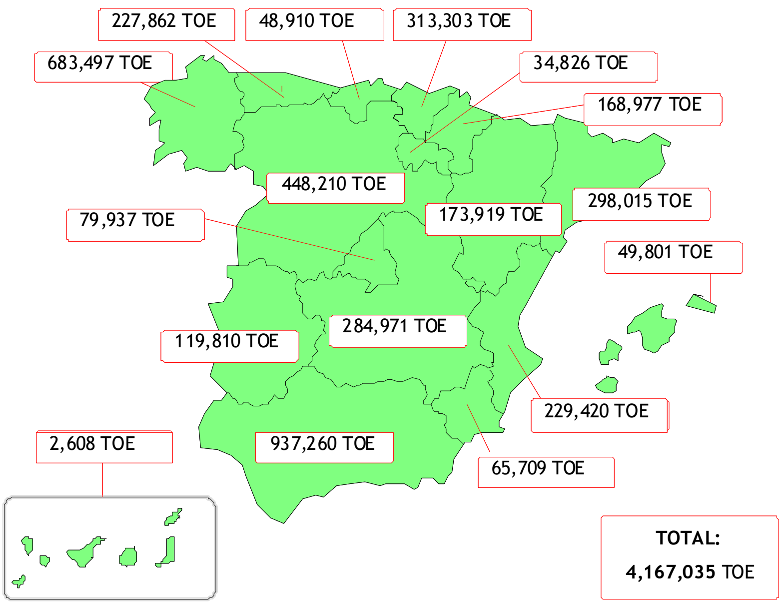


Figure 2. Consumption of biomass in Spain per Autonomous Community at 31/12/2004 (IDAE - Instituto para la Diversificación y Ahorro de la Energía [Spanish Institute for Energy Diversification and Saving]*)*

The progress of consumption of biomass from the base year for the Promotion Plan (1998) onwards shows an increase in quantitative terms of 538 kTOE up to the end of 2004, mainly concentrated in electricity applications. Nevertheless, according to the growth target contemplated in the Plan, which is to reach 9,568 kTOE by 2010, this figure is insufficient. Taking that target as a reference, growth in this area during the 1999-2004 period only represents 9.0% of the target.

	Years						
	1999	2000	2001	2002	2003	2004	2010 Target
Electrical application	227	236	302	516	644	680	5,311
Thermal application	3,435	3,454	3,462	3,466	3,478	3,487	4,318
TOTAL	**3,663**	**3,691**	**3,764**	**3,982**	**4,122**	**4,167**	**9,629**

The trend indicated in the above table is shown more clearly in Figure 3. In any case, it should be borne in mind that this data could be affected by the study on the progress of thermal biomass consumption since it is more than likely that use of biomass has shifted in favour of electrical applications, though those changes would not mean the addition of any primary energy to the total biomass balance.

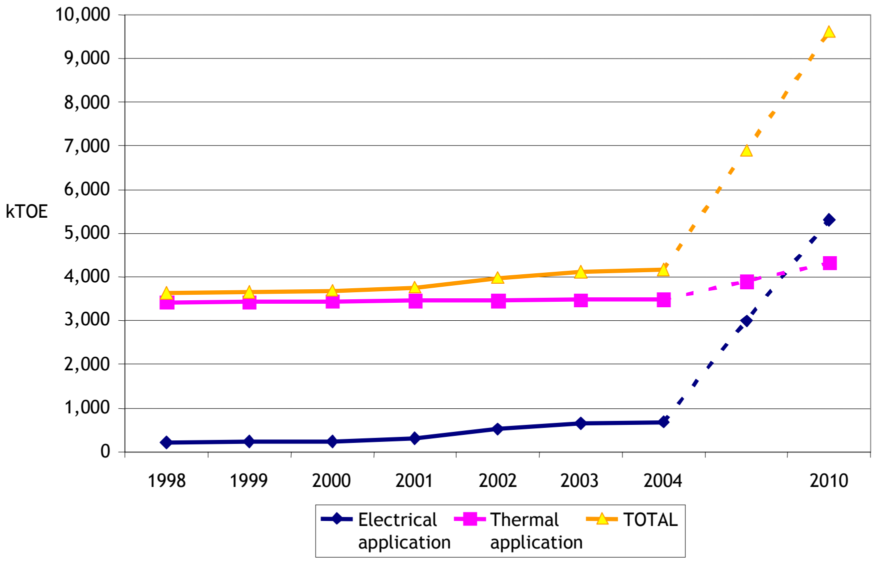


Figure 3. Progress of biomass consumption and forecasts in accordance with the Promotion Plan (IDAE)

A differential analysis according to the type of application reveals that the target established in the Promotion Plan of an increase of 900,000 TOE in the contribution by **thermal uses** during the 1999-2010 period is far from being achieved since that contribution currently amounts to only 69,446 TOE, which represents a rate of growth of 11,574 TOE per year rather than the 75,000 TOE per year which would be necessary. Figure 4 shows the progress of this application since 1999 and indicates the variations in growth.

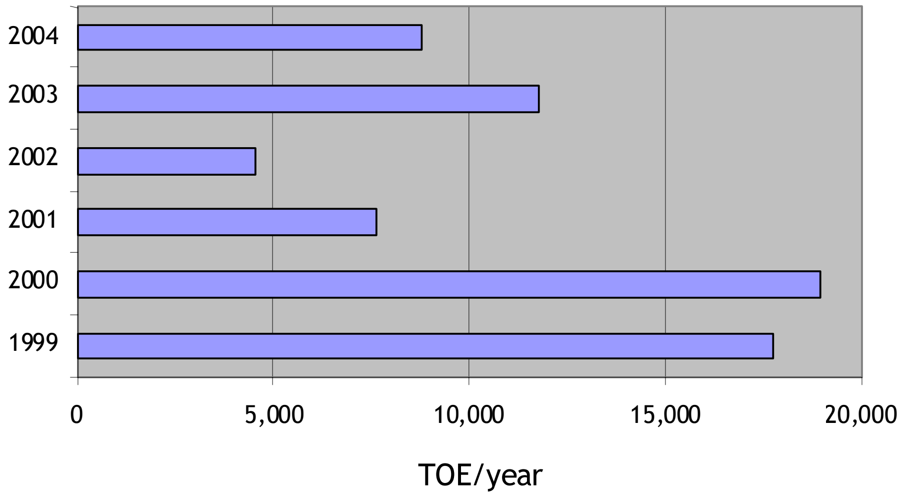


Figure 4. Progress of thermal use of biomass during the period of the Promotion Plan (IDAE)

Finally, with regard to the type of resource used in these projects, it must be emphasised that there are a large number of projects relating to domestic stoves and boilers fuelled by forest waste although, due to their relevance in terms of energy, the most relevant projects are those using industrial waste from both forestry and agricultural industries as a raw material. This information is shown in the following table.

Thermal biomass: projects in operation (1999-2004)

	Number of projects	Primary energy (TOE)
Forest waste	147	3,898
Woody agricultural waste	0	0
Herbaceous agricultural waste	1	3,303
Waste from forestry industries	113	40,368
Waste from agricultural industries	26	21,877
Energy crops	0	0
TOTAL	**287**	**69,446**

With regard to **electrical applications** of biomass, the balance sheet is even more pessimistic. An increase of 5,100,000 TOE by 2010 entails average growth of 425,000 TOE per year, though in actual fact a total increase of only 468,856 TOE was achieved in the 1999-2004 period, which represents an average of 78,143 TOE per year. Figure 5 shows the progress made in these applications since 1999.

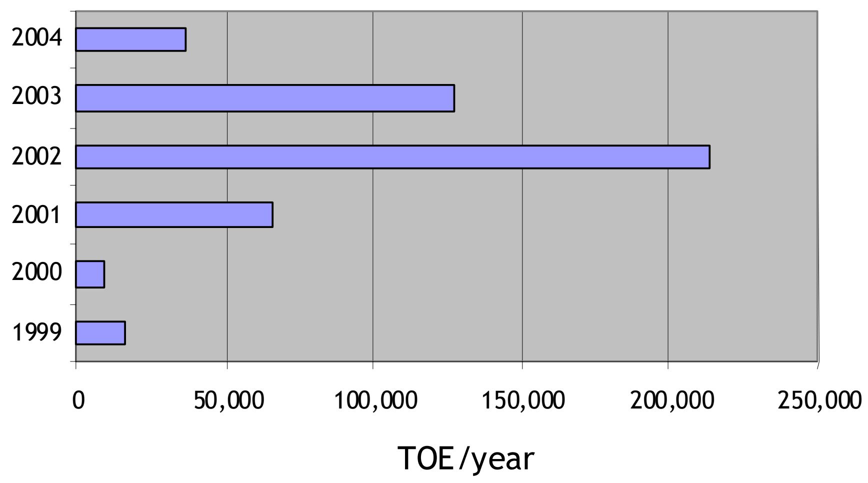


Figure 5. Progress in use of biomass for electricity in terms of primary energy during the period of the Promotion Plan (IDAE)

Figure 6 shows the same progress in terms of installed power.

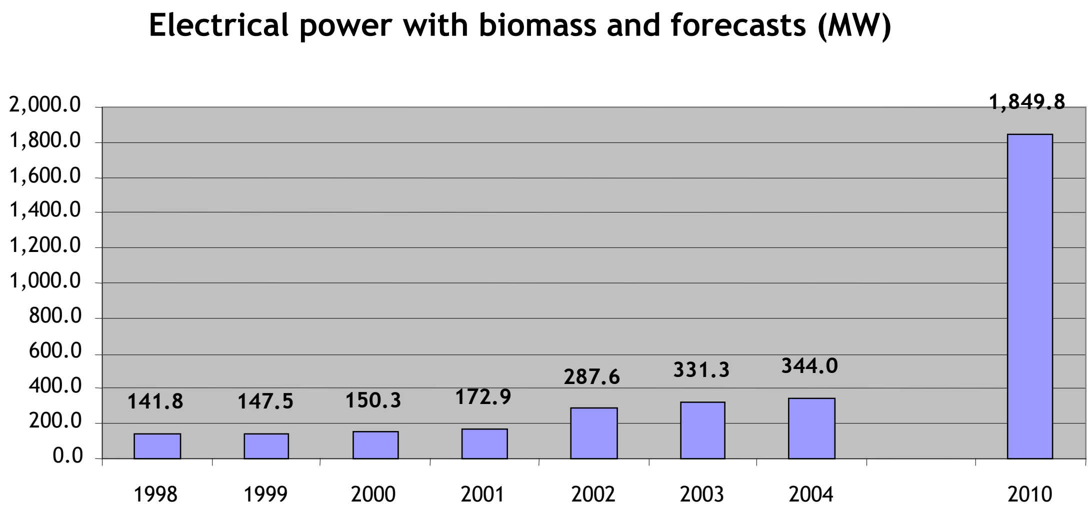


Figure 6. Progress in use of biomass for electricity measured in terms of installed power during the period of the Promotion Plan (IDAE)

Finally, with regard to the type of resource used in these projects and also in thermal applications, waste from forestry and agricultural industries is the most commonly used resource, although isolated projects in other areas also exist. This information is presented in more detail in the following table.

Biomass for electricity: projects in operation (1999-2004)

	Number of projects	Primary energy (TOE)
Forest waste	2	5,773
Woody agricultural waste	0	0
Herbaceous agricultural waste	1	55,500
Waste from forestry industries	8	166,578
Waste from agricultural industries	11	241,005
Energy crops	0	0
TOTAL	**22**	**468,856**

Overall, the fulfilment of the targets contained in the Promotion Plan has been hindered in the biomass area by the lack of results from use of agricultural waste and energy crops. As is stated in previous paragraphs, the little progress that was made was based on the use of industrial waste. Outside of this, there was only room for a few isolated projects relating to extremely low-capacity facilities. This information is presented in more detail in the following table.

Biomass: projects started up during the 1999-2004 period

	Number of projects	Primary energy (TOE)	Objective Plan 2010 (TOE)	Degree of fulfilment of the target (%)
Forest waste	149	9,671	450,000	2.1%
Woody agricultural waste	0	0	350,000	0.0%
Herbaceous agricultural waste	2	58,803	1,350,000	4.4%
Waste from forestry industries	121	206,946	250,000	82.8%
Waste from agricultural industries	37	262,882	250,000	105.2%
Energy crops	0	0	3,350,000	0.0%
TOTAL	**309**	**538,302**	**6,000,000**	**9.0%**

3.6.2.2. Analysis of the Resource

At the end of 2004, the consumption of biomass in Spain amounted to 4,167 kTOE, distributed almost equally between the domestic sector and the industrial sector.

A brief analysis of biomass consumption according to the type of resource used as a fuel shows large-scale use of waste from the forestry and agricultural industries, as opposed to other types of resource such as forest or agricultural waste or energy crops, which are as yet unknown in this country. This diversity is both a basic characteristic of the biomass area and a source of problems for its development, to the point where it is impossible to understand how the sector operates without a detailed examination of the features of each type of resource. There follows a list of the main resources in existence:

a) Forest waste

Description: residue resulting from the processing and exploitation of vegetable mass in order to protect and improve it. It is obtained from operations of felling, removal and transportation to tracks.

It is very difficult to introduce mechanisation into the exploitation of forest waste. Chipping is a possibility in order to make its transportation financially more worthwhile, rendering the product more manageable because of the uniform size of the chips. Machinery exists on the market, though in many cases it is impossible to make its use profitable. Technologies for compaction on site have been developed in recent years using new equipment involving presses to increase the density of the material for transportation.

Obtaining forest waste involves a number of cleaning, chipping and transportation operations whose cost is appreciably higher than what can be paid for energy use. However, these are operations that give rise to this resource and they are justified from the environmental point of view.

Problems:

- Availability of the resource in terms of quantity, quality and price

The characteristics of forestry operations and mountain-cleaning activities make it difficult to guarantee stable production of large quantities of biomass for a particular area. Also, the varied nature of the waste obtained in some forestry activities does not allow a final uniform product to be produced throughout the period during which energy generating plants operate. Furthermore, financial resources must be available for a sustained period to improve the forest and prevent fires, thus maintaining the continuity that energy investments require. This leads to dependence on the various bodies responsible for allocating those financial resources.

- The existence in some cases of an alternative use

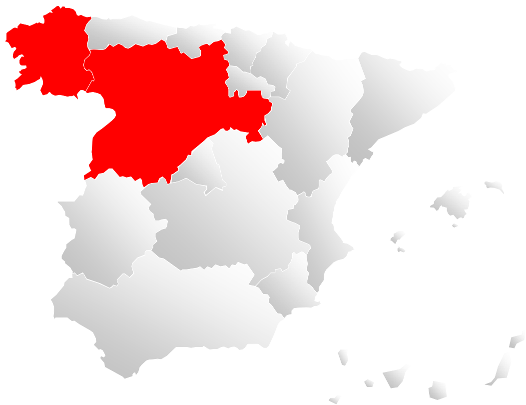
Forest waste has other uses, both traditional and industrial. The use of firewood on some mountains or the sale of chippings to board factories or to the paper industry limits the existing resources on some mountains, particularly the more profitable ones.

- Absence of pre-processing to prepare the resource

Forest waste is deposited on the mountain as it is generated in the forestry sector's activities. This makes for great diversity, both in physical terms and in terms of the composition of the waste. Alternatives are available to produce a more uniform resource or to facilitate its transportation, as appropriate. These alternatives consist of chipping and compaction, though in many cases demonstration activities are necessary to ensure that these practices are profitable.

Priority areas for action:

Studies carried out on potential resources of forest waste for biomass have indicated two Autonomous Communities as priority areas for action. These areas stand out due to the specific characteristics of their forestry sectors. The two Autonomous Communities in question are Castilla y Leon and Galicia. In these Autonomous Communities, the existence of a high percentage of forest area and extensive activities in the wood sector enable projects to exploit the biomass to be more profitable. These two Autonomous Communities together account for over 40% of the Spain's potential biomass from forest waste, providing over 580,000 TOE per year from existing resources.



Community	Forest waste (TOE)	Percentage	Existing resources (TOE)	Existing resources (t)
Andalucia	124,380	9.1%	0	0
Aragon	98,058	7.1%	0	0
Asturias	34,238	2.5%	0	0
Balearics	0	0.0%	0	0
Canaries	0	0.0%	0	0
Cantabria	25,823	1.9%	0	0
Castilla-La Mancha	113,156	8.2%	0	0
Castilla-Leon	367,668	26.8%	367,668	1,050,480
Catalonia	92,340	6.7%	0	0
Com. Valenciana	54,851	4.0%	0	0
Extremadura	134,338	9.8%	0	0
Galicia	220,461	16.1%	220,461	629,889
La Rioja	12,454	0.9%	0	0
Madrid	12,991	0.9%	0	0
Navarra	19,302	1.4%	0	0
Basque C.	34,239	2.5%	0	0
Region of Murcia	29,129	2.1%	0	0
TOTAL	1,373,428		588,129	1,680,369

b) *Woody agricultural waste*

Characterization: waste deriving from pruning of olive trees, fruit trees and vineyards.

This waste is markedly seasonal in nature, depending on the type of crop from which it derives. As with forest waste, the biomass must be subjected to chipping or compacting in order to reduce its volume and thus the costs of transporting it.

Problems:

- Availability of the resource in terms of quantity, quality and price

Depending on how this waste is produced, extensive logistics work is required to supply the plants, since biomass storage centres are required because of its seasonal nature. Also, the diverse nature of the waste obtained from some crops does not allow a final uniform product to be produced throughout the period when energy generating plants operate. In this case there are also increasingly restrictive rules on retaining the waste in the crops or burning it in the field. This makes it necessary to seek alternative solutions, such as exploiting the waste for generating energy.

- Dispersion and small scale of the agricultural holdings generating the resource

The dispersion of this waste and the small scale of most of the holdings are also problems to be taken into consideration since they make supply logistics more difficult and also mean that contact must be established with a large number of producers.

- Absence of pre-processing to prepare the resource

This waste is generated during the activities associated with the crops from which it derives. This means that it is widely dispersed, both physically and in terms of time. Alternatives exist to produce a more uniform resource or, as appropriate, to facilitate its transportation. These alternatives consist of conversion to chippings and compaction, though in many cases demonstration activities are required to ensure that these practices are profitable.

Priority areas for action:

Having analysed studies on potential resources of woody agricultural waste, a number of Autonomous Communities have been indicated as priority areas for action. These areas stand out due to their great potential for producing woody species in the agricultural sector. The priority areas are located in the Autonomous Communities of Catalonia, Valencia, Castilla La Mancha and Andalucia. A particularly high percentage of the area is used for woody crops in these areas compared to the rest of Spain. These Autonomous Communities account for approximately 68% of the Spain's potential biomass deriving from woody agricultural waste, with potential production in excess of 1,950,000 TOE per year.

Community	Woody Ag. Waste (TOE)	Percentage	Existing resources (TOE)	Existing resources (t)
Andalucia	266,740	26.6%	266,740	762,114
Aragon	84,930	8.5%	0	0
Asturias	2,470	0.2%	0	0
Balearic Is.	13,240	1.3%	0	0
Canary Is.	3,020	0.3%	0	0
Cantabria	0	0.0%	0	0
Castilla-La Mancha	145,510	14.5%	145,510	415,743
Castilla-Leon	22,850	2.3%	0	0
Catalonia	129,170	12.9%	129,170	369,057
Com. Valenciana	145,160	14.5%	145,160	414,743
Extremadura	64,790	6.5%	0	0
Galicia	6,240	0.6%	0	0
La Rioja	31,310	3.1%	0	0
Madrid	7,410	0.7%	0	0
Navarra	11,530	1.1%	0	0
Basque C.	3,240	0.3%	0	0
Region of Murcia	66,360	6.6%	0	0
TOTAL	1,003,970		686,580	1,961,657

c) Herbaceous agricultural waste

Characterization: waste consisting mainly of straw from cereals and maize stover

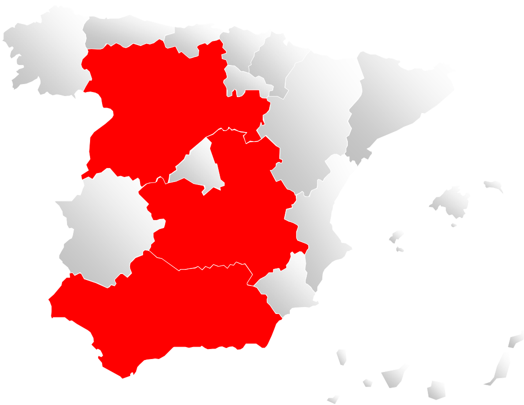
Problems:

- Availability of the resource in terms of quantity, quality and price

This waste is also generated on a seasonal basis, depending on when the various food and agricultural products are harvested. This, combined with annual variations in agricultural production, makes it more difficult to provide stable supplies for energy generation plants. Variations in production also give rise to variations in the prices of this waste, which are also affected by existing alternative markets.

Priority areas for action:

The main areas of herbaceous agricultural production in Spain are located in the Autonomous Communities of Castilla y Leon, Castilla La Mancha and Andalucia. Having analysed studies on potential resources deriving from herbaceous agricultural waste, these Autonomous Communities have been indicated as priority areas for action. These Autonomous Communities account for approximately 65% of Spain's potential biomass deriving from herbaceous agricultural waste, with potential production of around 5,200,000 TOE per year.



Community	Herbaceous A. Waste (TOE)	Percentage	Existing resources (TOE)	Existing resources (t)
Andalucia	1,152,960	14.7%	1,152,960	3,294,171
Aragon	730,930	9.3%	0	0
Asturias	2,180	0.0%	0	0
Balearic Is.	21,880	0.3%	0	0
Canary Is.	2,030	0.0%	0	0
Cantabria	1,830	0,0%	0	0
Castilla-La Mancha	1,188,480	15.1%	1,188,480	3,395,657
Castilla-Leon	2,863,020	36.4%	2,863,020	8,180,057
Catalonia	605,670	7.7%	0	0
Com, Valenciana	97,490	1.2%	0	0
Extremadura	380,510	4.8%	0	0
Galicia	181,380	2.3%	0	0
La Rioja	97,830	1.2%	0	0
Madrid	101,100	1.3%	0	0
Navarra	331,110	4.2%	0	0
Basque C.	92,170	1.2%	0	0
Region of Murcia	15,460	0.2%	0	0
TOTAL	7,866,030		5,204,460	14,869,886

d) Waste from forestry and agricultural industries

Characterization: waste from forestry industries is produced in industries engaged in primary and secondary processing of wood. Waste from agricultural industries derives from activities by industries such as the olive oil, preserves and dried fruits industries, among others.

Waste from forestry industries is varied and includes chips, bark, sawdust, cuttings, stumps and twigs. It is processed and handled where it originates, since there is the equipment for this purpose. It can be exploited to a considerable degree, though variations in its production may prevent its being used in some energy applications. Its availability is also conditional on the industrial activity that generates it.

Waste from agricultural industries is of extremely varied origin, with much deriving from the olive oil production sector. One further group of materials with a high moisture level is normally used for animal feed. Much of this waste is also obtained from dried fruit production.

Problems:

- Limited availability of the resource

In general, this waste is conditional on the industrial activity that generates it. In many cases, activities of this type are seasonal, which requires more complex collection logistics for supplying electricity generation plants. Furthermore, fluctuations in production by industries in the agricultural and forestry sectors mean that it is impossible to make long-term estimates of the annual resources available for a particular plant.

- Absence of pre-processing to prepare the resource

Although some industries in the forestry sector possess suitable equipment for processing waste, in most cases, particularly in the agricultural sector, suitable equipment is lacking. This means that investments in equipment are required, which reduces the profitability of projects.

Priority areas for action:

In view of the importance of the Spanish olive oil industry, which is the largest producer in the world, and taking into consideration the quality of the waste generated in this sector, the area where most olive oil production is concentrated has been established as a priority area. This area is coterminous with the Autonomous Community of Andalucia, and specifically with the province of Jaen. In fact, around 37% of the potential waste from the agricultural and forestry industries is located in that Autonomous Community, amounting to 1,084,160 TOE per year.

Community	Potential industrial waste (TOE)	Industrial waste used (TOE)
Andalucia	1,084,160	517,148
Aragon	103,621	46,449
Asturias	79,230	97,162
Balearic Is.	26,240	6,993
Canary Is.	32,251	0
Cantabria	14,247	10,381
Castilla-La Mancha	156,235	121,757
Castilla-Leon	125,511	117,732
Catalonia	247,198	238,924
Com, Valenciana	199,224	86,832
Extremadura	69,047	20,078
Galicia	366,138	161,044
La Rioja	14,206	15,788
Madrid	59,894	11,749
Navarra	107,090	65,927
Basque C.	226,654	145,957
Region of Murcia	38,053	21,079
TOTAL	**2,949,000**	**1,685,000**

Note: The potential industrial waste has been estimated on the basis of data from the *Plan de Fomento de las Energías Renovables* [Plan to Promote Renewable Energy], which only evaluated industries associated with oil production and forestry industries. This means that the actual figure for potential industrial waste is higher than indicated in this table.

e) Energy crops

Characterization: crops intended specifically for production of fuel materials. In Spain they consist basically of thistle, sorghum and Ethiopian rape.

Crops of this type may be herbaceous or woody and provide an alternative to extensive cereals. The main characteristics of these crops are their high productivity, the fact that they only require normal agricultural machinery and the fact that they do not contribute appreciably to soil degradation. Also, their energy balance is positive and the land may be easily recovered after the energy crop is over.

Besides these crops, other woody crops such as black poplar may also be used, though these are limited to irrigated areas. In unirrigated areas, eucalyptus may also be considered as an energy crop, with the species varying according to the region where the crop is located.

Problems:

- Need for a framework of legislation and subsidies

Due to the absence of experience in this field, it is necessary to establish a legal framework and a system of support to provide security for farmers when they change from traditional activities to production of energy crops.

- High costs, which compromise the profitability of their cultivation

In view of the absence of conventional systems for cultivation and exploitation of these materials for energy purposes, it is necessary to establish sufficient amounts of support to compensate for the costs deriving from developing new equipment and the additional costs deriving from cultivation and harvesting.

- Activities at the demonstration stage

The absence of experience and projects in progress gives rise to uncertainty when it comes to making large-scale investments in projects to exploit energy crops. For that reason, pilot projects must be implemented to serve as a demonstration for future investors.

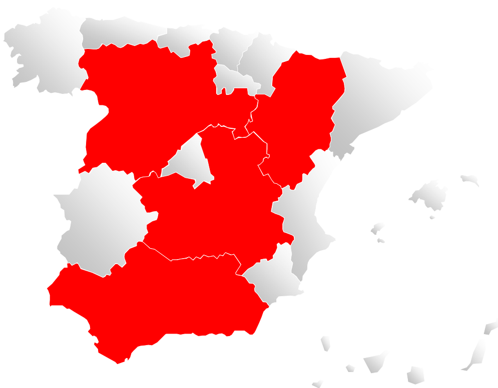
New species must also be sought and genetic selection is required to allow higher production per hectare in order to reduce the unit costs of the crop.

- As regards their application to energy production, their price and the associated volume of investment

The costs associated with cultivating and harvesting these species are still too high to be assumed as raw material costs in electricity generating plants. Also, the investment costs associated with the use of energy crops in thermal power stations are much higher than the cost of conventional equipment. This reduces the profitability of the projects to the point where they are of no interest to investors.

Priority areas for action:

Regions in which the agricultural area devoted to crops accounts for a significant percentage of the total area of the region have been considered as priority areas for action. These areas include the Autonomous Communities of Andalucia, Castilla La Mancha, Castilla y Leon and Aragon. These four Autonomous Communities account for 80% of the potential resources for production of energy crops, in excess of 4,600,000 TOE per year.



Community	Energy crops (TOE)	Percentage	Existing resources (TOE)	Existing resources (t)
Andalucia	1,061,828	18.4%	1,061,828	2,949,522
Aragon	716,299	12.4%	716,299	1,989,719
Asturias	0	0.0%	0	0
Balearic Is.	0	0.0%	0	0
Canary Is.	0	0.0%	0	0
Cantabria	0	0.0%	0	0
Castilla-La Mancha	1,130,223	19.6%	1,130,223	3,139,508
Castilla-Leon	1,700,445	29.5%	1,700,445	4,723,458
Catalonia	277,007	4.8%	0	0
Com, Valenciana	0	0.0%	0	0
Extremadura	383,940	6.7%	0	0
Galicia	0	0.0%	0	0
La Rioja	23,118	0.4%	0	0
Madrid	96,940	1.7%	0	0
Navarra	194,959	3.4%	0	0
Basque C.	55,591	1.0%	0	0
Region of Murcia	128,213	2.2%	0	0
TOTAL	5,768,563		4,608,795	12,802,208

As stated above, the availability of biomass in the necessary quantities and at the necessary quality and price is a problem which affects the implementation of all projects involving the use of biomass for energy since the market for biomass resources is practically non-existent. Constructing such a market would entail promoting the incorporation of **companies to resolve the problems of logistics and adaptation** to energy use and providing contractual systems to allow stable, regulated, long-term relationships to be established between biomass suppliers and biomass transformers.

3.6.2.3. Technological Aspects

Here it is advisable to clearly distinguish the problems associated with **management of the resource** from those associated with its transformation to energy. In the first of these areas, the most relevant aspects relate to harvesting the resource and changing its particle size, density and moisture for use in energy production, along with the logistics of supplying consumption centres.

Although these aspects are common to all types of biomass, their characteristics are specific to the resource in question. These are discussed as follows:

- ✓ **Harvesting the resource**

  Mechanisation, though desirable, is a particularly complex matter in the case of forest waste due to the particular characteristics of Spanish forests. For that reason, the work is labour-intensive and that is the root cause of the high prices associated with the purchase of residues of this type. As far as the development of energy crops is concerned, this often involves designing and building machinery suitable for harvesting the resource, since the machinery currently used in agricultural work is not suitable.

- ✓ **Preparing the resource for application to energy production**

  This is a fundamental factor in ensuring that reliable progress is made in energy assessment projects. However, it is not at present taken into account in most projects for financial reasons. Preparing the resource means that the resource must be available in optimum conditions in terms of its moisture, density and particle size for application to energy production, which requires different procedures depending on the type of biomass in question. Thus, in the case of forest waste, waste from forestry industries, woody agricultural waste and woody energy crops, these procedures mainly consist of chipping and compaction using existing machinery, whereas compaction would be useful in some cases for herbaceous agricultural waste and, in the case of herbaceous energy crops, the material could also be crushed.

- ✓ **Supply logistics**

The creation of biomass marketing channels to allow consumption centres to obtain the appropriate quality of resource regularly and at an acceptable price is one of the greatest challenges for the development of the sector. This affects resources of all types since it is only possible to refer to the existence of a biomass market in one or two isolated cases. Resolving the current situation requires the creation of biomass distribution centres, which is a new concept at present, and the implementation of long-term supply contracts between biomass suppliers and biomass consumers.

This problem of guaranteeing supply logistics is always the first to be faced when developing any project to exploit biomass for energy. At the energy **transformation** stage, the main disadvantages of biomass for thermal uses – which currently faces competition with other fuels and with natural gas in particular – compared to conventional transformation technologies consist of the additional cost of equipment and the lower transformation efficiency, along with the additional requirements relating to storage, handling and maintenance of facilities. The problem of low efficiency is common to traditional methods of electricity production based on a boiler-turbine system with a steam cycle, which are also characterised by the fact that they require high levels of investment for small power ranges. In the main, projects can only be implemented in these ranges due to the problem of availability of biomass.

One possible solution to the problems involved in the application of biomass to conventional electricity production is development of technology for gasification of the biomass linked to the combustion of gas produced in a motor, which leads to higher transformation efficiency than traditional technologies, even though problems currently exist with some aspects of the procedure, such as the stability of the gasifier or the efficiency of the system for cleaning gases prior to entry to the motor.

3.6.2.4. Legislative Aspects

As far as the resource is concerned, there are two main regulations affecting the possible use of biomass in Spain. Firstly, there is the Fourth Additional Provision of Act 43/2003 of 21 November on Mountains which states that, "the Government, cooperating with the Autonomous Communities, will draw up a strategy to develop the use of forest waste and biomass for energy production in accordance with the objectives set out in the *Plan de Fomento de las Energías Renovables en España* [the Plan to Promote Renewable Energies in Spain]". Secondly, there are all the provisions on the organisation of the Common Agricultural Policy, which are of exceptional importance with regard to the possible use for energy production of biomass deriving from agricultural waste or energy crops. With regard to this latter point, the provisions contained in Council Regulation (EC) No 1782/2003 of 29 September 2003, which contains the bulk of the latest CAP reform and also includes for the first time a line of support aimed at the development of energy crops, is of particular importance. That support is developed more fully in two Regulations: Commission Regulation (EC) No 2237/2003 of 23 December 2003 and Commission Regulation (EC) No 1973/2004 of 29 October 2004.

Also, as far as the resource is concerned, support is available from the EAGGF for the introduction of forest energy crops, this support being established in Council Regulation (EC) No 1257/1999 of 17 May 1999, which was transposed to Spanish law by Royal Decree 6/2001 on promotion of forestation of agricultural land.

With regard to the use of biomass resources for energy, the first distinction to be made is to separate thermal use from electrical use. As far as thermal use is concerned, the most recent development in terms of statutes is the current revision of the *Reglamento de Instalaciones Térmicas en los Edificios (RITE)* [Regulations on Thermal Installations in Buildings] to include biomass heating installations. As far as the generation of electricity using biomass is concerned, the most notable milestones as far as statutes are concerned consist of Act 54/1997 on the Electricity Sector and Royal Decree 436/2004 of 12 March, which establishes the methodology for updating the legal and financial system for the production of electricity under a special system and rendering it more systematic. This latter Decree establishes aspects such as the financial system for generating electricity using biomass, which includes incentives for selling the electricity on the electricity market.

3.6.2.5. Environmental Aspects

The use of biomass for energy, within a sustainable system for producing the resource, is highly beneficial for the environment. This is true both at the stage of producing the resource and at the stage of transforming it to energy.

At the fuel production stage, perhaps the most positive impact on the environment is the reduced risk of forest fires and forestry infestations associated with the management of forest waste and the reduction in dumping and environmental risks deriving from management of waste from agricultural and forestry industries. Finally, with regard to the production of energy crops, emphasis should be placed on the minimal risk of contamination due to the small amount of farming work associated with this agricultural activity.

At the application stage, one constant factor is the low danger levels associated with emissions to the atmosphere from facilities exploiting biomass for energy production. This is mainly due to the elemental composition of the biomass, which contains negligible quantities of elements such as sulphur or chlorine. Likewise, as far as CO_2 emissions are concerned, the first premise adopted should be the principle that, in a sustainable system for producing the resource such as that referred to in the first paragraph, the CO_2 balance will be at least neutral since a quantity of carbon equal to (or less than) that fixed by the biomass during its formation is emitted to the atmosphere.

Based on this principle, a general balance sheet for an electricity power station of **5 MW** electrical power fuelled by biomass would be as follows: on the one hand it produces approximately 37,500 MWh per year, equivalent to the domestic consumption of 11,400 Spanish families. On the other hand, that production, which is equivalent to approximately 14,900 TOE in terms of primary energy, **avoids the emission of approximately 14,000 tons of CO_2 per year**, a volume of gas which would be emitted to the atmosphere if that same amount of energy were generated by conventional thermal power stations (in this case the calculation has been carried out by comparison with emissions for a natural gas combined cycle power station).

The saving in CO_2 emissions to the atmosphere as a consequence of the use of biomass for energy production is currently of particular importance due to the commitment assumed by Spain to comply with international agreements to reduce greenhouse gas emissions.

3.6.2.6. Financial Aspects

The various applications of biomass for energy use have given rise to various sectors of production. These are becoming more clearly differentiated and increasingly specialise in specific markets. Thus, the technologies are divided firstly into thermal and electrical applications, with specific markets for domestic thermal use, industrial thermal use, pure generation of electricity using biomass and co-combustion technologies. These technologies are at different stages of maturity in Spain, ranging from mature technologies for thermal uses in the industrial sector to innovative technologies in domestic thermal uses or generation of electricity by co-combustion.

The investment costs associated with each type of technology also vary considerably from one case to another, not only due to their degree of maturity, but also due to the requirements of each application.

The operating expenses of the various facilities should also be divided between the applications referred to above for the same reasons. The main component of these expenses is the purchase of biomass for fuel. The cost of the biomass is extremely sensitive according to the quantity required, transportation and any processing to improve its quality, such as drying or pelletisation, which may be necessary to allow it to be used.

Financial aspects of biomass processing plants

In view of the diverse nature of the materials making up what we refer to as biomass, not all biofuels require the same processing to allow them to be used. Also, the quality of the biofuel and therefore the processing it requires, varies according to the biomass application.

The most common standard processing is crushing or chipping of the material, with a process of drying or subsequent grinding of the chipped product, with pelletisation occasionally being necessary when a higher quality product is required.

The main parameters defining a typical biomass processing facility are shown in the following table.

Processing of biomass for thermal use in the domestic sector	
Production	1,580 t/year
Investment in plant	564,000 €
Useful life	20 years
Hours of operation per year	1,167 h/year
Quantity of biomass consumed	1,751 t/year
Cost of purchase of biomass	3.0 cent/kg
Personnel costs	18,030 €/year
Repair costs	600 €/year
Replacement costs	3,200€/year
Selling price	6.0 cent/kg

Financial aspects of thermal biomass applications

As stated above, the investment costs depend on the type of application due to the differing needs of the final user of the energy. This difference in the user’s needs means that investment costs for industrial thermal uses are around 73 €/kW installed whereas for domestic thermal uses they rise to around 282 €/kW.

With regard to operating expenses, domestic thermal facilities require fuels which are cleaner and easier to transport, distribute and handle inside the facility. The main fuels used in these applications are pellets, which are high price/high quality products. In general, costs for biomass in domestic applications vary between 60 €/t for less highly processed biomass used in large heating networks and 160 €/t for packaged pellets for small biomass boilers installed in houses.

These costs are significantly lower in industrial thermal applications, where the biomass is normally owned by the user, with processing of some kind occasionally being necessary to allow the biomass to be used in the boiler. In these cases, the cost is between 0 and 35 €/t, although the cost may be affected by parallel markets for waste for non-energy applications.

With regard to operating expenses other than fuel costs, these are more important in thermal applications where they account for between 40% and 60% of total expenses. These costs are particularly significant in centralised heating networks where there are long distances between the centre and the final consumers.

The main parameters defining a typical thermal biomass facility are shown in the following tables. These tables consider two characteristic types of project: an industrial thermal application and a centralised heating network.

Industrial boiler		
Gross power		1,000 kW
Overall efficiency		80.0%
Useful life		20 years
Hours of operation per year		5,000 h/year
Quantity of biomass consumed	PCI_h = 3,000 kcal/kg	1,792 t/year
Cost of biomass	84.8 €/TOE	36,000€/year
Operating and maintenance costs	114 €/TOE	49,000€/year
Investment	73 €/kW	72,740 €
Energy production		430 TOE/year

Centralised heating network		
Gross power		6,000 kW
Transformation efficiency		85.0%
Transport efficiency		90.0%
Useful life		20 years
Hours of operation per year		820 h/year
Quantity of biomass consumed	PCIh = 3,500 kcal/kg	1,580 t/year
Cost of biomass	224 €/TOE	94,800 €/year
Operating expenses	384 €/TOE	162,450 €/year
Investment	282 €/kW	1.69 M€
Energy production		423 TOE/year

Financial aspects of electrical biomass applications

Investment costs in generation of electricity are clearly differentiated according to whether the facilities in question are specific biomass electricity generation facilities or biomass and coal co-combustion facilities in conventional thermal power stations.

The main component of operating expenses in electricity generation facilities is always the cost of the biomass used, even when that biomass consists of industrial waste. In view of the high demand for biomass for facilities of this type, biomass is supplied over an extremely large area, which means that transport costs have a significant effect on its final cost. The fact that it is purchased in large quantities may also mean a reduction in the price at source.

✓ **Specific biomass facilities**

Specific biomass facilities require more complex systems allowing combustion of all components of the biomass, including the volatile components. Because of this, boilers must be designed with larger fireboxes, which in turn reduces their efficiency. The larger size of the firebox, combined with the other components for processing and moving the biomass in the plant, give rise to investment costs of around 1,800 €/kW installed.

In applications of this type for generating electricity with biomass, the higher demand for resources and the fewer limitations on the quality of the fuel mean that the cost of the biomass is significantly lower. In these cases, the main components defining the cost are the distance transported and the type of biomass, which may vary between 43 €/t in the case of energy crops and 31 €/t when waste from agricultural crops or forest waste is used.

Industrial electrical applications are a separate case. Their conditions are similar to those of industrial thermal uses. As stated above, in these cases, the cost is between 0 and 35 €/t, although the cost may be affected by parallel markets for waste for non-energy applications. Installation of electricity production plants using waste from agricultural and forestry industries which are not owned by the company generating the waste is a further possibility.

In such circumstances the cost of the biomass may rise, but the concentration of an adequate quantity and quality of biomass in a single producer may facilitate supply contracts, making the investment more attractive for the promoter.

The following tables show the main parameters defining a typical specific biomass electricity facility. They consider four characteristic types of project, depending on the biomass used: electricity generation using energy crops, agricultural or forest waste, waste from agricultural industries and waste from forestry industries.

Electricity generation using energy crops		
Electrical power		5 MW
Overall efficiency		21.6%
Useful life		20 years
Quantity of biomass consumed		53,500 t/year
Fuel costs	0.061753 €/kWh	2,315,737 €/year
Operating and maintenance costs	0.009306 €/kWh	348,975 €/year
Investment	1,803 €/kW	9,015,200 €
Electricity produced		37,500 MWh/year

Electricity generation using forest and agricultural waste		
Electrical power		5 MW
Overall efficiency		21.6%
Useful life		20 years
Quantity of biomass consumed		53,500 t/year
Fuel costs	0.044942 €/kWh	1,685,325 €/year
Operating and maintenance costs	0.009306 €/kWh	348,975 €/year
Investment	1,803 €/kW	9,015,200 €
Electricity produced		37,500 MWh/year

Electricity generation using waste from agricultural industries		
Electrical power		5 MW
Overall efficiency		21.6%
Useful life		20 years
Quantity of biomass consumed		53,500 t/year
Fuel costs	0.044942 €/kWh	1,685,325 €/year
Operating and maintenance costs	0.009306 €/kWh	348,975 €/year
Investment	1,803 €/kW	9,015,200 €
Electricity produced		37,500 MWh/year

Electricity generation using waste from forestry industries		
Electrical power		5 MW
Overall efficiency		21.6%
Useful life		20 years
Quantity of biomass consumed		45,900 t/year
Fuel costs	0.018820 €/kWh	705,750 €/year
Operating and maintenance costs	0.009306 €/kWh	348,975 €/year
Investment	1,803 €/kW	9,015,200 €
Electricity produced		37,500 MWh/year

✓ **Co-combustion facilities**

In co-combustion facilities, most of the equipment used forms part of the pre-existing conventional facility, which means that the investment is confined to equipment to prepare the biomass for injection into the coal-fired boiler. This means that the costs of investing in biomass and coal co-combustion facilities in conventional power stations fall to around 856 €/kW.

Co-combustion facilities are characterised by their higher generation efficiency and higher installed power, which means that the demand for biomass is greater than in specific biomass facilities. Thus, although the fewer restrictions on the quality of the fuel mean lower costs for the biomass at source, the costs deriving from the longer average distance transported and the need for a greater quantity of resource, which must sometimes be covered by more expensive biomass, means an average cost of around 47 €/t for the biomass.

The following table shows the main parameters defining a typical biomass and coal co-combustion facility in a conventional thermal power station.

	Generation of electricity (Co-combustion in a coal-fired thermal power station)	
Electrical power		56 MW
Overall efficiency		30%
Useful life		20 years
Quantity of biomass consumed		340.300 t/year
Fuel costs	0.038000 €/kW	15,960,000 €/year
Operating and maintenance costs	0.007600 €/kWh	3,192,000 €/year
Investment	856 €/kW	47,936,000 €
Electricity produced		420,000 MWh/year

3.6.2.7. Barriers

This section identifies the main problems impeding the development of the use of biomass to produce energy. Problems relating to production of the resource are differentiated from problems relating to its transformation to energy.

Barriers at the production stage

✓ **General**

Absence of a developed market for biomass logistics

There are currently very few companies engaged in the logistics of biomass supply. Many of the companies engaged in this area are logistics companies for conventional fuels such as coal which have devoted part of their business to biomass logistics. Nevertheless, lack of demand for biomass from the sector means that even existing biomass logistics companies are exporting much of their biomass to other countries.

This situation means that there is no biomass market to guarantee supply of the necessary quantity and quality for any generating plant that may be established.

✓ **Forest waste**

Availability of the resource in terms of quantity, quality and price.

The use of biomass from waste from forestry exploitations depends on forestry activities carried out in the mountains of Spain rather than energy activities. These activities are scheduled according to non-energy criteria, which means that availability of biomass to suit the needs of energy production facilities cannot be guaranteed. Also, the material obtained in the mountains has a high level of moisture and may be contaminated by earth from dragging the wood in the mountains. Furthermore, the wide variation in the cost of removing the wood, which depends on the gradient of the land, the species and the type of exploitation, leads to wide variation in the cost of the biomass which in most cases exceeds the limits established for its use for energy purposes.

The existence of an alternative use in some cases

In some cases forest waste can be used by companies in the forestry sector such as board manufacturing industries, which means competing with a sector which is able to pay higher prices for forest waste than are admissible in the energy sector.

Absence of pre-processing to prepare the resource

At present, waste from forestry exploitations is left in the mountains in the form of firewood or waste and is not subject to chipping or any other type of processing. In order for it to be used for energy purposes, this waste must receive the relevant processing to allow it to be transported economically.

This pre-processing may consist of preliminary chipping, compaction or other processes to reduce the transport costs. Pre-processing of this type is not carried on in optimum conditions either in technical or financial terms and projects must be promoted to stimulate its development.

✓ **Woody agricultural waste**

Availability of the resource in terms of quantity, quality and price.

The use of biomass from waste generated by woody agricultural crops depends on agricultural activities, mainly consisting of pruning, rather than energy activities. These activities are scheduled according to non-energy criteria, so the availability of biomass to suit the needs of energy production facilities cannot be guaranteed. Likewise, the material obtained from pruning activities has a high moisture level. Furthermore, the wide variation in pruning costs according to the type of crop, the species and the region where the crops are located gives rise to a wide variation in the cost of the biomass which in most cases exceeds the limits established for its energy use.

Dispersion and small scale of the agricultural holdings generating the resource.

Agricultural holdings are characterised by their high degree of fragmentation, high number of owners and small size. In general, those owners leave waste in the field since the small amounts generated do not reach the minimum necessary for establishing a project.

Nevertheless, enough biomass for a project to be considered may be accumulated by combining the waste from several closely-grouped holdings. The main difficulty with projects of this type lies in the complications deriving from the large number of biomass supply contracts – one with each proprietor – that must be established, each involving a particular price and method, in order to obtain large quantities of biomass.

Absence of pre-processing to prepare the resource.

At present, waste generated by pruning woody agricultural crops is left in the fields in the form of firewood or waste and is not subject to chipping or any other type of processing. In order for it to be used for energy purposes, this waste must receive the relevant processing to allow it to be transported economically.

Pre-processing may consist of preliminary chipping, compaction or other processes to reduce the transport costs. Pre-processing of this type is not carried on in optimum conditions either in technical or financial terms and projects must be promoted to stimulate its development.

✓ **Herbaceous agricultural waste**

Availability of the resource in terms of quantity, quality and price.

The use of biomass from waste generated by herbaceous agricultural crops depends on agricultural activities, such as harvesting cereals, rather than energy activities. These activities are scheduled according to non-energy criteria so the availability of biomass to suit the needs of energy production facilities cannot be guaranteed. Likewise, the material obtained from pruning activities has a high moisture level and contains elements, such as sodium and potassium, deriving from fertilisers which may cause problems in combustion systems. Furthermore, the wide variation in the cost of waste, which depends on the type of crop, the species and the region where the crops are located, leads to wide variations in the cost of the biomass which in some cases exceeds the limits established for its energy use.

✓ **Waste from forestry and agricultural industries**

Limited availability of the resource.

The generation of waste from forestry and agricultural industries is determined by raw material production campaigns, not energy campaigns. The planning of these activities is very different from planning in the energy sector. Likewise, the generation of this waste varies according to production in the agricultural sector and does not allow security of supply in the energy sector.

Absence of pre-processing to prepare the resource.

Although some of the waste generated in agricultural and forestry industries can be used directly for generating energy, there is a great deal of waste that must be duly processed for transportation and use in an energy production plant. This type of pre-processing is not carried on in optimum conditions in technical or financial terms.

✓ **Energy crops**

Need for a legislative framework and a system of subsidies.

The lack of a clear, suitable legislative framework for the production of energy crops leads to a situation whereby the farmers and future users of this type of biomass are not defined, which means that the long-term contracts which would provide stability for the development of this market cannot be signed. Furthermore, the costs deriving from the cultivation of species for energy purposes requires support leading to final prices for biomass which are in keeping with the energy market. This support is somewhat insufficient at present, with subsidies being established for fallow land devoted to energy uses.

High costs, which compromise the profitability of cultivating energy crops.

As stated in the previous section, the high costs involved in the production of energy crops do not allow the establishment of suitable prices for marketing the biomass obtained. Consequently, there is a need to develop cultivation methods to lower these costs.

Activities at the demonstration stage.

The energy crops currently being developed in Spain have not reached the demonstration stage and there is a need for projects to be implemented to confirm the real possibilities associated with these resources and to allow promoters to gain the necessary experience to develop new projects.

From the point of view of application to energy production, their price and the associated volume of investment.

In view of the current prices of raw material generated by energy crops, the high costs of necessary pre-processing such as drying, compaction or chipping and the high investment costs at generation plants, use of these resources is not financially viable compared to prices for conventional forms of energy.

Barriers at the stage of transforming the resource to energy

✓ **Domestic thermal application**

Competition with other fuels.

Not only must the use of biomass in the domestic sector be offered to users in the same price and service conditions, but the same quality of service as for the conventional fuels normally used in the sector must also be provided. This means a need for clean generation systems as far as handling the fuel is concerned, with systems for automatic lighting and automatic removal of ash, remote management and low noise levels. A period of technological development and the relevant transfer of technology from other countries with more experience of using this fuel is required to adapt thermal biomass applications to these requirements.

Need for personnel to handle, maintain and store biomass.

Since biomass is a solid, low-density fuel, qualified personnel are required for logistical processes and home delivery. Also, the lower density of the fuel means that more storage space is required in buildings which are often not equipped for that purpose or that building land with a high market value is used for storage.

Lack of specific provisions and regulations on the use of domestic thermal biomass

The lack of specific provisions on thermal biomass installations in buildings leads to problems when it comes to planning, building and legalising installations in the domestic sector since neither the technicians commissioned to design projects nor those responsible for legalising them have any documents on which to base their decisions. At present, the only provisions in existence are obsolete provisions on solid fuels, such as on coal inside buildings.

✓ **Industrial thermal application**

Competition with other fuels.

The use of biomass in the industrial sector must be offered to users in the same price and service conditions as the conventional fuels normally used in the sector. Prices for conventional fuels are lower in the industrial sector than in the domestic sector, which makes it even more difficult for thermal biomass applications to compete. The service must also be provided with the same quality levels as for conventional fuels. This means a need for secure fuel supply systems using automatic operating methods and particle cleaning systems with levels at least equal to those of conventional fuels.

Additional cost compared to similar installations fuelled by fossil fuels.

Biomass thermal generation equipment is less technologically developed than equipment for conventional fuels. In many cases it is made to measure, which means that no cost savings can be made from manufacture in series. The equipment also has more moving parts such as screw conveyors, movable grills, etc. These facilities also require more storage space than conventional facilities, which leads to a number of additional investment costs for biomass facilities and makes them less financially viable.

Need for space and auxiliary facilities.

As stated above, facilities of this type require larger storage areas due to the lower density of the biomass. Generation equipment for solid fuels also normally occupies more space, which is often exacerbated by the need for auxiliary biomass transformation systems.

✓ **Electrical application**

Low energy efficiency.

As is stated above, specific biomass facilities require complex systems which allow combustion of all components of the biomass, including the volatile components. This requires the design of boilers with larger fireboxes which, combined with the energy consumption from processing the biomass and its transportation within the plant, gives rise to lower electricity generation efficiency than that obtained in conventional energy facilities.

This fact, along with the higher investment costs associated with projects of this type, means lower returns on investments, which do not reach the minimum required by promoters in the sector.

Need for a minimum size to reach the profitability threshold.

Also, the lower the generation power installed, the lower the efficiency of biomass electricity generation facilities. For that reason, low-power electricity generating plants only achieve sufficient profitability levels when the biomass is practically free of charge or when the remuneration for the electricity generated is much higher than the levels established at present. Because of this, it is necessary to plan facilities whose power exceeds certain limits, at which point the investment costs make projects unviable.

However, designing higher power facilities means meeting a higher demand for biomass, which is often not available either because of shortages of the resource or because of higher prices than applications of this type can pay. Also, since greater quantities of biomass are required, part of that biomass must be supplied from places which are further from the point of consumption, which means higher transport costs that therefore make the project less profitable.

Absence of bonuses for co-combustion.

As is stated above, the efficiency of electricity generation using biomass is low, which gives rise to problems relating to the profitability of facilities. Nevertheless, biomass and coal co-combustion systems in conventional facilities allows that efficiency to rise to the levels of the conventional power stations in which they are installed. This allows efficiency to rise from around 22% to around 30%. Nevertheless, in accordance with the provisions established in Act 54/1997 on the electricity sector, facilities of this type cannot receive bonuses at present because they are owned by large electricity companies which operate under the *Régimen Ordinario* [Ordinary System]. This prevents the potential of biomass being developed. Development of that potential would significantly increase the contribution from this area and provide greater energy efficiency.

Scope of applicability	Barriers
Production Stage. General.	- Lack of a developed market for biomass logistics
Production Stage. Forest waste.	- Availability of the resource in terms of quantity, quality and price.

	- The existence of an alternative use in some cases.
	- Absence of pre-processing to prepare the resource.
Production Stage. Woody agricultural waste.	- Availability of the resource in terms of quantity, quality and price.
	- Dispersion and small scale of the agricultural holdings generating the resource.
	- Absence of pre-processing to prepare the resource.
Production Stage. Herbaceous agricultural waste.	- Availability of the resource in terms of quantity, quality and price.
Production Stage. Waste from forestry and agricultural industries.	- Limited availability of the resource.
	- Absence of pre-processing to prepare the resource.
- Energy crops.	- Need for a legislative framework and a system of subsidies.
	- High costs, which compromise the profitability of cultivating them.
	- Activities at the demonstration stage.
	- From the point of view of application to energy production, their price and the associated volume of investment.
Stage of Transformation to Energy. Domestic thermal application.	- Competition with other fuels.
	- Need for personnel to handle, maintain and store biomass.
	- Lack of specific provisions and regulations on the use of domestic thermal biomass.
Stage of Transformation to Energy. Industrial thermal application.	- Competition with other fuels.
	- Additional cost compared to similar facilities fuelled by fossil fuels.
	- Need for space and auxiliary facilities.
Stage of Transformation to Energy. Electrical application.	- Low energy efficiency.
	- Need for a minimum size to reach the profitability threshold.
	- Absence of bonuses for co-combustion.

3.6.3. Measures

A number of measures have been devised in order to overcome the barriers described in the previous section. These are divided into the following sections:

General measures to develop the Biomass Area

Inter-departmental committee for the exploitation of biomass for energy purposes

This committee was created in Order PRE/472/2004 of 24 February. Its purpose is to study and put forward proposals for measures aimed at regulating the Government's strategic initiative on the exploitation of biomass for energy production, as contemplated in the *Plan de Fomento* [Promotion Plan].

The structure of the inter-departmental committee, as established in the aforesaid Order, is headed by the *Director General de Política Energética y Minas* [Director General for Energy Policy and Mines] and consists of the following members, whose membership must be subject to review as a result of the changes made to the General State Administration after the elections of 14 March:

- 3 from the *Secretaría de Estado de Energía, Desarrollo Industrial y de la Pequeña y Mediana Empresa* [State Secretariat for Energy, Industrial Development and Small and Medium-Sized Enterprises] (2 from the IDAE)

- 2 from the *Secretaría General de Agricultura y Alimentación* [General Secretariat for Agriculture and Food]
- 2 from the *Secretaría General de Medio Ambiente* [General Secretariat for the Environment]
- 1 from the *Secretaría de Estado de Política Científica y Tecnológica* [State Secretariat for Scientific and Technological Policy]
- 1 from the *Secretaría de Estado de Hacienda* [State Secretariat for the Public Treasury]
- 1 from the *Secretaría de Estado de Organización Territorial del Estado* [State Secretariat for the Organisation of State Territory]
- 1 from the *Secretaría de Estado de Asuntos Europeos* [State Secretariat for Foreign Affairs]

Order PRE/472/2004 also lays down the functions of the inter-departmental committee, which are as follows:

a) To be informed of draft provisions applicable throughout Spain and of agricultural, industrial or territorial organisation plans insofar as they affect the planning of biomass exploitations.

b) To compile a catalogue of activities carried out by public bodies

c) To promote the adaptation of rules to rationalise exploitation of resources, promoting financial incentives

d) To approve the launch programme, applying for a minimum period of three years

e) To draw up a proposal for research, scientific/technical and demonstration activities in the areas of energy crops and manures

f) Dissemination of the Government's strategic initiative and support for the implementation of its measures

g) Other promotion functions

The committee will submit an annual report to the *Comisión Delegada del Gobierno para Asuntos Económicos* [Government Delegate Committee for Financial Affairs] on the results from the performance of its functions. The proposal put forward by the IDAE for a table of contents for this report is shown below:

1.- Introduction
2.- Situation in the European Union
3.- Situation in Spain
4.- Environmental aspects
5.- Agricultural aspects
6.- Economic and fiscal aspects
7.- Legislative aspects
8.- Technological innovation
9.- Conclusions:

  - ✓ Prior considerations
  - ✓ Measures proposed

Measures to develop the resource

✓ **General**

Development of logistics for use of the resource to produce energy

In view of the absence of a developed market for biomass supply logistics, measures must be developed to favour the creation of biomass logistics companies.

- ✓ **Forest waste**

Development of the Fourth Additional Provision of Act 43/2003 on Mountains

As far as the use of forest waste to produce energy is concerned, the possibilities provided by the Fourth Additional Provision of Act 43/2003, of 21 November, on Mountains must be developed. This will allow mobilisation of specific quantities of biomass, which has been located and evaluated, from forestry exploitations and will also provide suitable exploitation and logistics systems for use of that biomass to produce energy.

The proposal focuses on the urgent need to set up a Working Group with the Autonomous Communities to begin work on preparing the strategy to develop the use of Spanish forest biomass to produce energy.

Programme of support for the acquisition of removal, transportation and processing equipment

In view of the high costs of removal, transportation and processing of forest biomass and the current lack of pre-processing to prepare the resource, a programme for support for mechanisation of these processes is proposed in order to guarantee production of biomass of a suitable quality and at a suitable cost for energy use.

- ✓ **Woody agricultural waste and energy crops**

Improvements in the mechanised collection of biomass

In order to reduce the costs of collection and delivery to the plant of biomass produced in woody crops and energy crops, measures must be developed which lead to improvements in the mechanised collection of biomass from woody agricultural waste and energy crops.

Programme of support for the acquisition of removal, transportation and processing equipment

In view of the high costs of removal, transportation and processing of biomass from woody crops and energy crops and the current lack of pre-processing to prepare the resource, a programme for support for mechanisation of these processes is proposed in order to guarantee production of biomass of a suitable quality and at a suitable cost for energy use.

Establishment of standard contracts for the acquisition of biomass

It is proposed that standard contracts be drawn up to avoid the uncertainty caused by having to make purchase agreements with a large number of producers of residues due to the high degree of fragmentation of agricultural holdings.

Measures for technological development

- ✓ **Domestic thermal application**

30% subsidy for investment in equipment for domestic biomass use

Because of the high cost of investing in thermal biomass applications for domestic use, it is necessary to lower these costs for users through lines of subsidies to make investments in this technology attractive.

Development of provisions and regulations on thermal biomass installations in buildings

In order to avoid problems relating to the legalisation of thermal biomass installations in the domestic sector, work is currently being carried on to include specific sections dealing with thermal biomass installations in the *Reglamento de Instalaciones Térmicas en los Edificios (RITE)* [Regulations on Thermal Installations in Buildings]. Likewise, specific UNE [*Una Norma Española* – Spanish Standard] standards are being developed for biomass in the AENOR [*Asociación Española de Normalización y Certificación* – Spanish Association for Standardisation and Certification] Committee CTN [*Comité Técnico de Normalización* – Technical Standardisation Committee] 164 for “Solid Biofuels”, which allow biomass to be legally established as a fuel.

✓ **Electricity application**

Amendment of Act 54/1997

Amendments to Articles 27 and 30 of Act 54/1997 of 27 November on the Electricity Sector are proposed in accordance with the contents of Articles 3 and 4 of the *Proyecto de Ley de Reformas para el Impulso a la Productividad* [Bill of Reforms to Stimulate Productivity]. These Articles contain the following amendments:

Article 3 of the Bill of Reforms to Stimulate Productivity. Promotion of co-combustion.

A new paragraph is inserted in section 5 of Article 27 of Act 54/1997, of 27 November, on the Electricity Sector, worded as follows:

> “Likewise, the Government may establish the right for thermal electricity production facilities from the Ordinary System to receive a bonus to supplement the system for remuneration when, in addition to using the fuel for which they were authorised, they also use biomass as a secondary fuel. The energy consumption produced and the additional costs deriving from that use will be taken into account for that purpose. The resolution establishing the amount of the bonus will also contain conditions for use of the biomass.”

Article 4 of the Bill of Reforms to Stimulate Productivity. Promotion of biomass.

The final paragraph of part b) of section four of Article 30 of Act 54/1997 of 27 November on the Electricity Sector is amended, being worded as follows:

> “In exceptional circumstances, the Government may authorise higher bonuses than those contemplated in the preceding paragraph for facilities using solar energy or biomass as primary energy.”

These two Articles develop measure number 43. “Adoption of support measures for biomass (Act) and (M)” included in the group of reforms to stimulate productivity. This group consists of over 100 measures. The purpose of the measure is to stimulate this source of renewable energy in line with the objectives of the Plan to Promote Renewable Energy. Specifically, it is a question of allowing this raw material to be used in facilities operating under the Ordinary System.

Support for coal and biomass co-combustion technology

The proposals on this matter focus on including coal and biomass co-combustion facilities in the *Régimen Especial* [Special System] for electricity production, pursuant to previous proposals to amend Article 27 of Act 54/1997 on the Electricity Sector, and including these projects in the activities to promote new economic activities in coal-mining conversion areas to allow them access to specific support (including biomass collection activities).

The following table provides an overall view of the potential for developing co-combustion in Spain. It may be observed from the table that this could involve the use of 2,119,889 TOE of biomass if that potential were achieved.

Name	Owning company	Municipality	Province	Type of station	Power (MW)	Biomass power (MW)	Biomass power (TOE)
Puente Nuevo	Viesgo Generación	Espiel	Cordoba	Coal + anthracite	324	32.4	60,794
Litoral	Endesa Generación	Carboneras	Almeria	Imported coal	1,159	115.0	182,876
Los Barrios	Endesa Generación	Los Barrios	Cádiz	Imported coal	568	56.0	91,046
				Subtotal Andalucia	2,051	203.4	334,717
Escatrón	Viesgo Generación	Escatrón	Zaragoza	Black lignite	80	8.0	15,011
Escucha	Viesgo Generación	Escucha	Teruel	Black lignite	160	16.0	30,022
Teruel	Endesa Generación	Andorra	Teruel	Black lignite	1,102	110.2	206,775
				Subtotal Aragon	1,342	134.2	251,808
Aboño	Hidrocantábrico	Gijón	Asturias	Coal + anthracite	916	91.6	171,875
Lada	Iberdrola Generación	La Felguera	Asturias	Coal + anthracite	513	51.3	96,257
Narcea	Unión Fenosa Generación	Tineo	Asturias	Coal + anthracite	595	59.5	111,644
Soto de Ribera	Hidrocantábrico	Ribera de Arriba	Asturias	Coal + anthracite	671	67.1	125,904
				Subtotal Asturias	2,695	269.5	505,680
Puertollano	Viesgo Generación	Puertollano	Ciudad Real	Coal + anthracite	221	22.1	41,468
				Subtotal Castilla-La Mancha	221	22.1	41,468
Anllares	Unión Fenosa (66%)/Endesa (33%)	Páramo del Sil	Leon	Coal + anthracite	365	36.5	68,487
Compostilla	Endesa Generación	Cubillos del Sil	Leon	Coal + anthracite	1,312	131.2	246,179
Guardo	Iberdrola Generación	Velilla del Río Carrión	Palencia	Coal + anthracite	516	51.6	96,820
La Robla	Unión Fenosa Generación	La Robla	Leon	Coal + anthracite	655	65.5	122,902
				Subtotal Castilla y Leon	2,848	284.8	534,388
Serchs	Viesgo Generación	Cercs	Barcelona	Black lignite	160	16.0	30,022
				Subtotal Catalonia	160	16.0	30,022
Meirama	Unión Fenosa Generación	Ordes	La Coruña	Brown lignite	563	56.3	105,639
Puentes	Endesa Generación	As Pontes	La Coruña	Brown lignite	1,468	146.8	275,450
				Subtotal Galicia	2,031	203.1	381,089
Pasajes	Iberdrola Generación	Pasajes de San Juan	Guipuzcoa	Imported coal	217	21.7	40,717
				Subtotal Basque C.	217	21.7	40,717
				Total Spain	11,565	1,154.is 8	2,119,889

The following schedule for action to stimulate co-combustion in coal-fired power stations is proposed:

1. Establishment of contact with electricity companies owning coal-fired power stations to stimulate the relevant feasibility studies.

2. Amendments to regulations. As is indicated above, it is necessary to amend Act 54/1997 of 27 November on the Electricity Sector and Royal Decree 436/2004 of 12 March. The purpose of these amendments is to include co-combustion in the Special System, establishing suitable remuneration for the energy generated which allows projects of this type to be developed.

3. When contact has been made with the various electricity companies, a suitable term must be established in the 2005 – 2006 period to allow the following activities to be carried out:

    a. Performance of individual studies on the potential of biomass in the areas in which conventional coal-fired thermal power stations are located.
    b. Performance of an analysis of the various co-combustion technologies and their suitability for each existing conventional thermal power station.

    A term of one year is established for these two measures to allow projects to be implemented in the 2005-2010 period for those power stations which have not evaluated these two fundamental questions. A term of 18 months is contemplated in which to make the required investments.

Finally, it is necessary to take into consideration the fact that amendments to the regulations which will provide companies with a framework in which to make the investments must enter in force in 2006.

To sum up, the following table shows the measures to be adopted in the area of biomass:

Barrier	Measure	Body responsible	Budget	Planning
General lack of development of the area of biomass.	Inter-departmental committee for the exploitation of biomass for energy purposes.	Ministry of Industry, Commerce and Tourism. Directorate General for Energy Policy and Mines	No cost	2005-2010
Absence of a developed market for biomass logistics	Development of logistics for use of the resource to produce energy.	Ministry of Agriculture, Fisheries and Food. Ministry of Education and Science. Ministry of Industry, Tourism and Commerce.	Pending evaluation	2005-2010
Availability of biomass from forest waste in the appropriate quantity and at the appropriate quality and price.	Development of the Fourth Additional Provision of Act 43/2003 on Mountains.	Ministry of the Environment Directorate General for Biodiversity.	Pending evaluation	2005-2010
Absence of pre-processing to prepare the resource and the high costs of forestry and woody agricultural waste and energy crops.	Programme of support for the acquisition of machinery for collection, transport and processing.	Ministry of Agriculture, Fisheries and Food. Ministry of the Environment	71.01 M€ (Total at the end of the period attributed as support for thermal biomass)	2005-2010
Availability of biomass from woody agricultural waste and energy crops in the appropriate quantity and at the appropriate quality and price.	Improvements in the mechanised collection of biomass from woody agricultural waste and energy crops.	Ministry of Agriculture, Fisheries and Food. Ministry of Education and Science.	Pending evaluation	2005-2010
Dispersion and small scale of the agricultural holdings.	Establishment of standard contracts for the acquisition of biomass.	Ministry of Agriculture, Fisheries and Food. Ministry of Industry, Tourism and Commerce.	No cost	2005-2008
Competition between domestic thermal biomass applications and other fuels.	30% subsidy for investment in equipment for domestic biomass use.	Ministry of Industry, Tourism and Commerce. Autonomous Communities.	213.03 M€ (Total at the end of the period)	2005-2010
Lack of specific provisions and regulations on the use of domestic thermal biomass.	Development of provisions and regulations on thermal biomass installations in	Ministry of Industry, Tourism and Commerce. AENOR.	No cost	2005-2010

	buildings.			

Lack of efficiency and financial viability of plants using biomass to generate electricity.	Amendment of Article 30 of Act 54/1997 to authorise higher bonuses for biomass. Currently being processed	Ministry of Industry, Tourism and Commerce. Ministry of Economy and Finance. National Energy Commission].	Included in the amendment of Royal Decree 436/2004	2005-2010
Lack of efficiency and financial viability of plants using biomass to generate electricity.	Amendment of Royal Decree 436/2004.	Ministry of Industry, Tourism and Commerce. Ministry of Economy and Finance. National Energy Commission.	776.8 M€ (total for the period excluding co-combustion) 359.8 M€/year (annual total at the end of the period, excluding co-combustion)	2005-2010
Lack of co-combustion facilities	Contact with electricity companies.	Ministry of Industry, Tourism and Commerce. Ministry of Economy and Finance.	No cost	2005
Absence of bonuses for co-combustion.	Support for coal and biomass co-combustion technology. (Amendment of Article 27 of Act 54/1997 and Royal Decree 436/2004). Currently being processed	Ministry of Industry, Tourism and Commerce. Ministry of Economy and Finance. National Energy Commission. Electricity companies.	283.15 M€ (total for the period) 118.72 M€/year (annual total at the end of the period)	2005-2010
Lack of studies on the potential of co-combustion	Performance of individual studies on the potential of biomass for each conventional thermal power station.	Ministry of Industry, Tourism and Commerce. Ministry of Economy and Finance. Electricity companies.	Pending evaluation	2005 - 2007
Lack of technological studies on co-combustion in Spain	Performance of analyses on suitable co-combustion technologies for each conventional thermal power station.	Ministry of Industry, Tourism and Commerce. Ministry of Economy and Finance. Electricity companies.	Pending evaluation	2005 -2007

3.6.4. Objectives for 2010

In the area of biomass for electricity, the Promotion Plan established the target for development of the sector of 1,849 MW by the end of 2010, thus increasing the contribution of the sector by 1,705 MW during the period of the Plan. This target was subsequently increased in the document entitled "*Planificación de los sectores de Electricidad y Gas, desarrollo de las redes de transporte 2002-2011*" [Planning of the electricity and gas sectors, development of transport networks 2002-2011] of the Ministry of the Economy to 3,098 MW by the end of 2011. Nevertheless, the target established in this latter document cannot be considered realistic and for that reason the target should be revised downwards.

3.6.4.1. Power and Energy Data

The following table shows a comparison between the situation in 2004 and the new targets for growth for electricity applications currently being proposed in this Renewable Energies Plan 2005-2010. Although the distribution of resources per Autonomous Communities is known, the distribution of power among them is not specified due to the difficulty of locating possible projects.

Autonomous Community	Situation in 2004 (MW)	Renewable Energy Plan growth target 2005- 2010 (MW)
ANDALUCIA	95	
ARAGON	26	
ASTURIAS	39	
BALEARIC ISLANDS	0	
CANARY ISLANDS	0	
CANTABRIA	3	
CASTILLA Y LEON	11	
CASTILLA LA MANCHA	39	
CATALONIA	2	
EXTREMADURA	1	
GALICIA	32	
MADRID	0	
MURCIA	0	
NAVARRA	38	
LA RIOJA	0	
C. VALENCIANA	7	
BASQUE COUNTRY	51	
TOTAL	**344**	**1,695**

Source: IDAE

The proposed energy objectives for each type of resource and application are shown below. They correspond to an increase in primary energy during the 2005-2010 period.

	TARGETS (TOE)
Resources	
Forest waste	462,000
Woody agricultural waste	670,000
Herbaceous agricultural waste	660,000
Waste from forestry industries	670,000
Waste from agricultural industries	670,000
Energy crops	1,908,300
Applications	
Thermal applications	582,514
Electrical applications	4,457,786
TOTALS	
Primary energy	5,040,300

The following table shows the energy targets in terms of installed electrical power in the 2005-2010 period.

PER 2005-10: targets (MW)	
Distributed generation	
Breakdown by type of resource	
Forest waste	60
Woody agricultural waste	100
Herbaceous agricultural waste	100
Waste from forestry industries	100
Waste from agricultural industries	100
Energy crops	513
Total distributed generation (MW)	**973**
Co-combustion (MW)	
Total co-combustion (MW)	**722**
Total electricity generation with biomass	
TOTAL (MW)	**1,695**

The following table shows the distribution by Autonomous Communities of the energy objectives for the 2005-2010 period, in terms of primary energy.

A.C.	Energy crops	Forest waste	Woody Ag. waste	Herb. Ag. waste	Waste from for. ind.	Waste from ag. ind.	TOTAL
Andalucia	264,158	41,840	178,015	96,740	189,618	104,616	874,987
Aragon	304,391	32,985	56,676	61,329	20,672	82,294	558,347
Asturias	0	11,517	1,648	183	13,046	2,478	28,872
Balearic I.	0	0	8,834	1,836	7,926	1,595	20,191
Canary I.	0	0	2,014	170	9,710	965	12,858
Cantabria	0	8,687	0	154	4,291	1,337	14,468
C-Leon	538,624	123,676	15,245	240,223	37,844	177,950	1,133,563
C-La Mancha	447,496	38,064	97,106	99,720	48,903	124,379	855,668
Catalonia	50,985	31,062	86,204	50,820	75,346	36,288	330,704
Extremadura	151,557	45,190	43,236	31,926	22,152	46,285	340,345
Galicia	0	74,160	4,164	15,219	88,614	19,170	201,326
Madrid	39,856	4,371	4,945	8,483	18,146	12,026	87,826
Murcia	57,391	9,799	44,285	1,298	11,568	16,160	140,501
Navarra	53,843	6,493	7,695	27,782	10,664	18,944	125,420
La Rioja	0	4,189	20,894	8,207	4,292	3,907	41,489
C,Valenciana	0	18,450	96,874	8,179	60,583	14,575	198,661
Basque C.	0	11,517	2,161	7,733	46,625	7,031	75,067
TOTAL	**1,908,300**	**462,000**	**670,000**	**660,000**	**670,000**	**670,000**	**5,040,300**

The projected annual increase in the new installed power for generation of electricity using biomass in the 2005-2010 period is as follows:

BIOMASS AREA

		2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
ANNUAL ELECTRICAL POWER FROM BIOMASS	MW	10	40	95	210	285	333	**973**
ANNUAL CO-COMBUSTION POWER	MW	0	50	125	125	200	222	**722**

This increase in power in the area of biomass depends on revision of the bonuses and incentives established for the production of electricity using biomass and the inclusion of co-combustion facilities in the Special System, as is proposed in this Plan.

The following table shows the projected energy results for generation of electricity using biomass:

BIOMASS AREA

		2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
ANNUAL ELECTRICAL PRODUCTION USING BIOMASS	GWh	69.8	348.8	1,011.4	2,476.1	4,464.0	6,786.7	**15,156.7**
ANNUAL CO-COMBUSTION PRODUCTION	GWh	0	348.8	1,220.6	2,092.5	3,487.5	5,036.0	**12,185.3**

Consequently, the electricity production using biomass corresponding to the incremental power of 1,695 MW planned for 2010 is 11,822.6 GWh.

The planned annual increments in thermal capacity in the 2005-2010 period are as follows:

BIOMASS AREA

		2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
DOMESTIC THERMAL BIOMASS: THERMAL CAPACITY	TOE/year	20,000	30,000	35,000	35,000	40,000	44,722	**204,722**
INDUSTRIAL THERMAL BIOMASS: THERMAL CAPACITY	TOE/year	30,000	50,000	50,000	60,000	80,000	107,792	**377,792**

This growth in the area of biomass depends on the development of a mature market for the supply of biomass and the development of provisions governing the introduction of biomass installations in the domestic sector through their inclusion in the Regulations on Thermal Installations in Buildings and through more extensive development of the AENOR standards relating to fuels, installations, etc.

3.6.4.2. Emissions avoided and creation of employment

The following table shows the CO_2 emissions avoided in 2010 alone due to the planned 1,695 MW increase in power plus the generation of 582,514 TOE per year in thermal biomass. For the electricity component, a combined cycle power station using natural gas with an efficiency of 54% (372 tCO_2 per GWh produced) was used as a benchmark, except in the case of biomass and coal co-combustion, in which the benchmark was a coal-fired power station with an efficiency of 36.1% (961 tCO_2 per GWh produced). As far as thermal uses of biomass are concerned, the benchmark was the use of gas-oil C for heating:

		BIOMASS AREA
CO_2 EMISSIONS AVOIDED, BIOMASS FOR ELECTRICITY	(t CO_2)	7,364,191
CO2 EMISSIONS AVOIDED, THERMAL BIOMASS	(t CO2)	1,788,326
CREATION OF EMPLOYMENT, BIOMASS FOR ELECTRICITY	(men/year)	39,816
CREATION OF EMPLOYMENT, THERMAL BIOMASS	(men/year)	17,277

The same table shows the estimated creation of employment at the end of 2010. This employment data relates to the total for all jobs with a duration of one year created during the six years of the period and includes the total number of jobs created due to investment in the establishment of the project and the jobs deriving from the implementation of the project.

3.6.4.3. Associated investment

An average investment ratio of 1,803 € per kW installed in 2005 has been considered for electricity generating facilities using only biomass, with an annual reduction of 5% throughout the period. That rate also applies in the case of coal and biomass co-combustion, where the investment ratio is considered to be 856.4 €/kW installed. In the case of thermal biomass, the average investment ratios in 2005 were considered to be 72.74 €/kW for industrial uses and 282.47 €/kW for domestic uses, with the same annual reduction throughout the period in the case of generation of electricity.

As a result, the following figures have been obtained for the amounts of annual investment associated with the biomass sector:

BIOMASS AREA

		2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
ANNUAL INVESTMENT, BIOMASS FOR ELECTRICITY	(mill. €)	18.0	68.5	154.6	324.6	418.6	464.6	**1,448.9**
ANNUAL INVESTMENT, CO-COMBUSTION	(mill. €)	0	40.7	96.6	91.8	139.5	147.1	**515.7**
ANNUAL INVESTMENT, INDUSTRIAL THERMAL BIOMASS:	(mill. €)	5.1	8.0	7.6	8.7	11.0	14.1	**54.6**
ANNUAL INVESTMENT, DOMESTIC THERMAL BIOMASS:	(mill. €)	80.1	114.2	126.5	120.2	130.5	138.6	**710.1**

TOTAL ANNUAL INVESTMENT, BIOMASS AREA	(mill. €)	103.2	231.4	385.3	545.3	699.6	764.4	**2,729.3**

3.6.4.4. Public subsidies

Subsidies must be available to stimulate the current state of the biomass market at the level of both production and demand to allow the biomass area to develop. Furthermore, it is necessary to maintain and improve the public subsidies granted by means of the bonuses established within the framework laid down for the Special System by Royal Decree 436/2004.

In view of this, the following table shows the amount of public operating subsidies, i.e., the subsidies deriving from the inclusion of biomass electricity generating facilities in the Special System:

ELECTRICITY BIOMASS AREA

		2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
PUBLIC SUBSIDIES FOR ELECTRICITY BIOMASS	(mill. €)	2.3	15.6	46.0	122.9	230.3	359.8	**776.8**
PUBLIC SUBSIDIES FOR CO-COMBUSTION	(mill. €)	0	7.8	27.6	48.0	81.1	118.7	**283.2**
TOTAL PUBLIC SUBSIDIES FOR ELECTRICITY BIOMASS	(mill. €)	2.3	23.3	73.6	170.9	311.3	478.5	**1,059.9**

Furthermore, the need to establish a subsidy for investment in order to stimulate the market for thermal biomass applications in the domestic area and a line of support for acquiring machinery was also taken into consideration when drawing up this Plan. The following table shows the total amounts deriving from this during the 2005-2010 period:

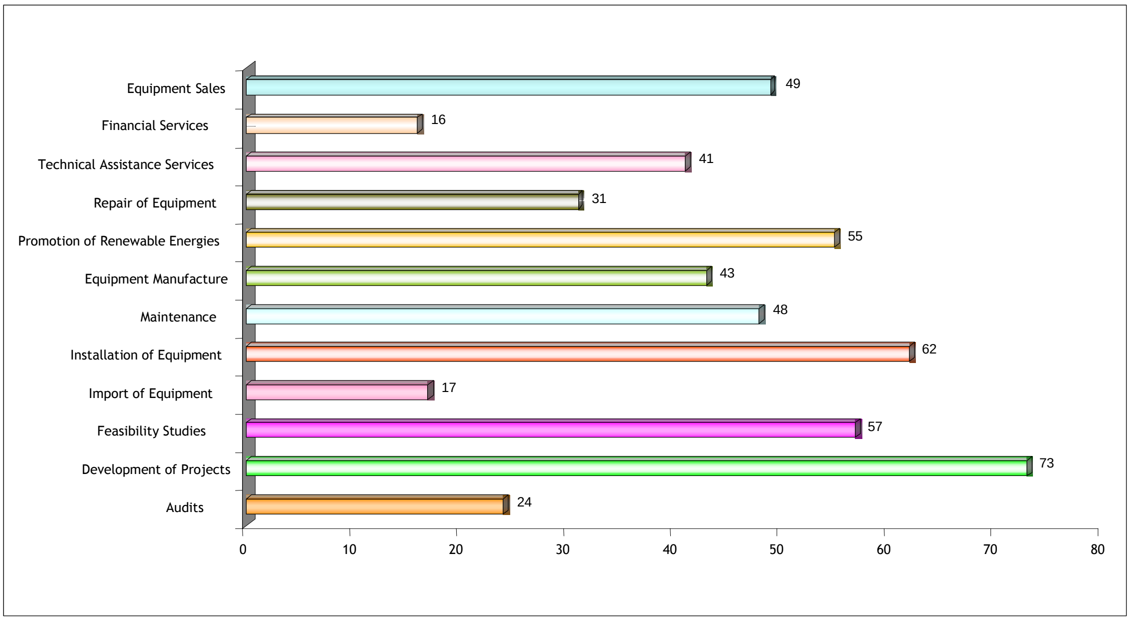
THERMAL BIOMASS AREA

		2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
PUBLIC SUBSIDIES FOR INDUSTRIAL THERMAL BIOMASS	(mill. €)	0	0	0	0	0	0	**0**
PUBLIC SUBSIDIES FOR DOMESTIC THERMAL BIOMASS	(mill. €)	32.0	45.7	50.6	48.1	52.2	55.4	**284.0**
TOTAL PUBLIC SUBSIDIES FOR THERMAL BIOMASS	(mill. €)	32.0	45.7	50.6	48.1	52.2	55.4	**284.0**

3.6.5. Industrial sector

The industrial biomass sector in Spain is characterised by the presence of a large number of companies covering all aspects relating to the development of a project. Nevertheless, very few of these companies are engaged in the use of biomass to produce energy as their sole or main branch of activity.

These companies may be distinguished according to the type of activities they carry out, as the following chart shows:



NOTE: The companies simultaneously carry on different activities from those shown. It is common for a company which manufactures equipment to also be engaged in the sale, installation and maintenance of that equipment. Likewise, companies which implement projects normally offer technical assistance services and carry out feasibility studies.

3.6.6. Lines of Technological Innovation

The biomass area requires great efforts in this regard which affect both the production of the resource and its energy application. Taking into consideration the different problems associated with these stages, the priority actions to be carried out as far as innovations are concerned are as follows:

PRODUCTION STAGE

- ✓ Analytical methods to establish quality standards
- ✓ Establishment of the characteristics of the biomass both physically and in terms of energy
- ✓ Development of a Programme to Promote Energy Crops, which includes:
    - Selection and improvement of species
    - Sustainable methods for their development
    - Analysis of productivity and real costs
- ✓ Development of systems and machinery to collect biomass
- ✓ Logistical systems for the supply of biomass
- ✓ Methods and equipment to prepare the biomass for use in producing energy

APPLICATION STAGE

- ✓ Improvements in biomass handling and feeding systems
- ✓ Development of efficient equipment for the use of biomass in the domestic area
- ✓ Development of national technology to manufacture biomass boilers which can be used in thermal and electrical applications
- ✓ Development of fluidized bed technologies
- ✓ Development of efficient **gasification** systems for the production of:
    - Electricity. Through the combustion of the gas produced in motors in pure or co-generation facilities and, in the latter case, facilities linked to an industrial process or a centralised heating system.
    - Thermal energy. In the industrial area, through the production of hot gases for drying and firing processes
- ✓ Development of techniques for cleaning gases in gasification and combustion
- ✓ Adaptation of gas turbines and motors for combustion of the gas deriving from the gasification of biomass
- ✓ Development of air conditioning systems using biomass for heating and cooling, based on boilers and absorption machines

Biogas Area

CHAPTER 3.7

RENEWABLE ENERGY PLAN FOR SPAIN, 2005-2010

3.7. Biogas Area

Production of biogas through treatment of biodegradable waste is carried out mainly for environmental reasons at present. Biogas is therefore considered as a by-product of that treatment process.

The possible exploitation of biogas for energy (both thermal and electric) is based on four types of biodegradable waste: livestock, from sludge from *estaciones depuradoras de aguas residuales (EDAR)* [sewage treatment plants], from industrial effluent and from organic fraction of *residuos sólidos urbanos (RSU)* [solid urban waste].

The application of anaerobic digestion processes to livestock waste is only technologically possible on the basis of a high concentration of head of livestock in intensive holdings. The current level of exploitation of this waste for energy production may be considered as low.

There are a growing number of applications for the biogas produced from organic fraction of solid urban waste in controlled landfill, though it is necessary to boost anaerobic digestion in bioreactors which include co-digestion with treatment plant sludge.

There are already a considerable number of applications for the biogas produced from waste from industrial facilities and sludge from urban sewage treatment plants.

3.7.1. Situation in the European Union

In 1977, the importance for the European Union of achieving substantial growth in renewable energy sources led the European Commission to draft the White Paper for a Community Strategy and an Action Plan for Renewable Energy, within the framework of Community energy policy.

This document was an attempt to achieve an ambitious general target of **12% of the primary demand for energy in the European Union as a whole** being met by renewable energy sources by 2010.

As far as the use of biogas for energy was concerned, the target established for 2010 was to increase its share of energy consumption in the European Union by 15 million TOE.

As Figure 1 shows, at the end of 2003, the consumption of biogas in the European Union, measured in terms of primary energy, amounted to 3.219 kTOE, which represented an increase of 7.3% compared to the data for 2002. However, this consumption varies greatly from one country to another and in any case the trends observed would make fulfilment of the overall objectives announced in the White Paper impossible.

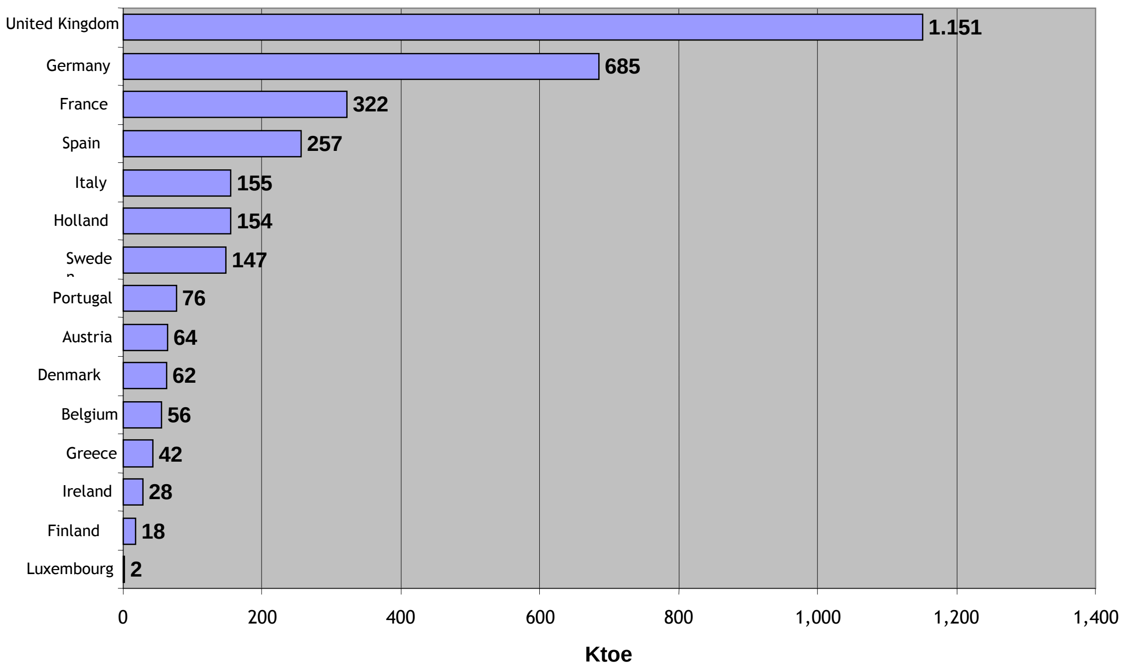


Figure 1. Consumption of biogas in the European Union at 31/12/2003 (EurObserv'ER).

3.7.2. Analysis of the Biogas Area

A Plan to Promote Renewable Energy was drawn up on the basis of the energy objective established in the European Commission White Paper and the commitment assumed in Act 54/1997 of 27 November on the Electricity Sector. This Plan was approved by the Council of Ministers on 30 December 1999. The Plan defined the development target for each area of renewable energy. It was intended that these areas should account, between them, for at a least 12% of national consumption of primary energy by 2010.

3.7.2.1. The Current Situation

Consumption of biogas in Spain amounted to 266.7 kTOE at the end of 2004. This figure is the culmination of a phase of development which has led the sector to triple its contribution to the national energy balance since 1998 and which allowed it to reach the targets established for 2010 by the Plan to Promote Renewable Energies by as early as the end of 2003.

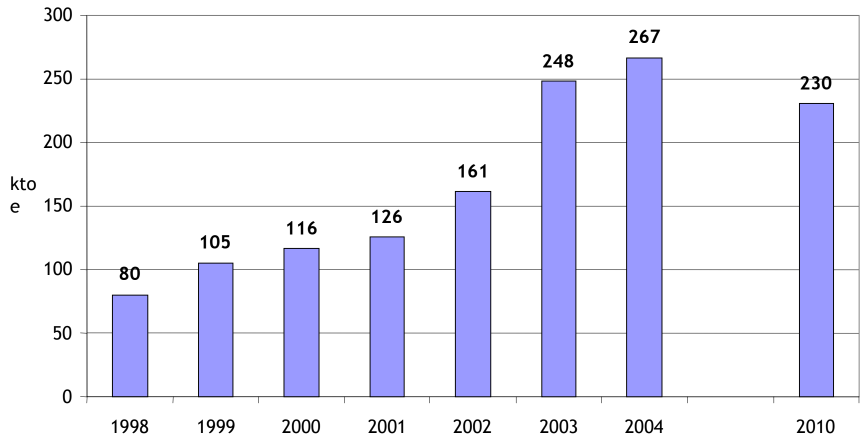


Figure 2. Progress of consumption of biogas and forecasts within the framework of the Promotion Plan, in terms of primary energy (IDAE)

Figure 3 shows the same progress in terms of installed power.

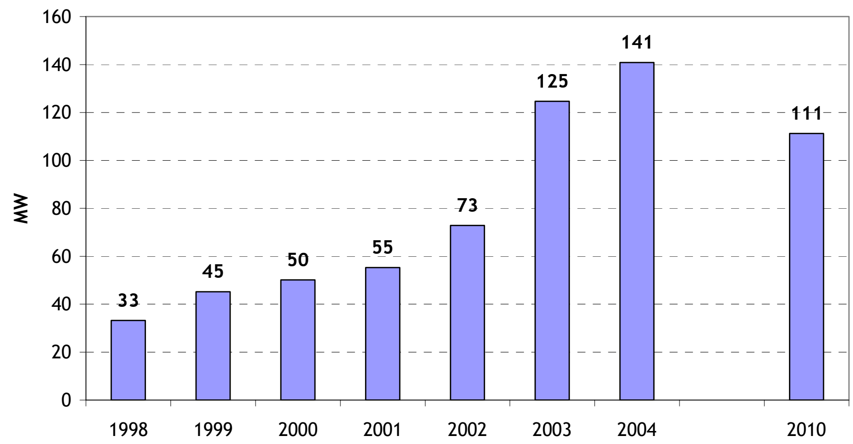


Figure 3. Progress of consumption of biogas and forecasts within the framework of the Promotion Plan, in terms of installed power (IDAE)

Figure 4, which shows the start-up rate of projects since 1999, indicates the growth in the sector during the period of the Promotion Plan.

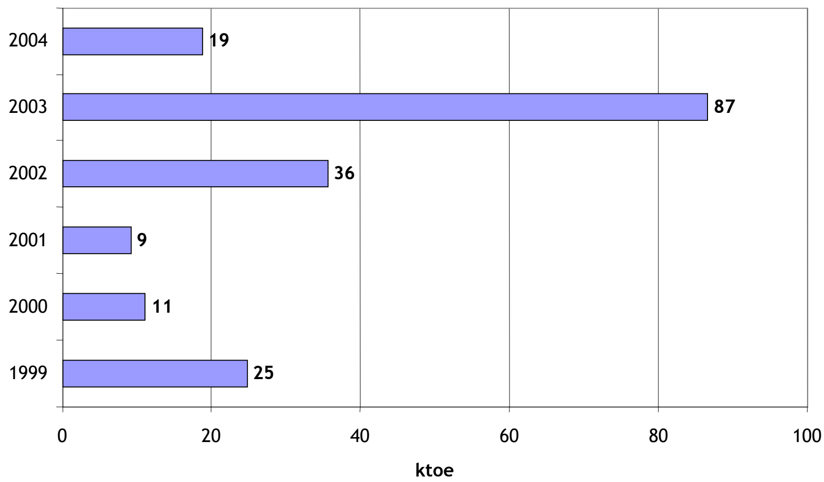


Figure 4. Start-up of biogas projects, in terms of primary energy, during the period of the Promotion Plan (IDAE)

Finally, the main type of project implemented in Spain concerns the energy use of biogas produced in the degasification of landfill, which accounts for 80% of the primary energy produced by projects started up in the 1999-2004 period. There are also projects relating to treatment of sludge from treatment plants, treatment of livestock waste and, to a lesser extent, exploitation of biodegradable industrial waste. This information is shown in detail in the following table.

Biogas: projects in operation (1999-2004)

	Numer of projects	Primary energy (TOE)	Target from Plan 2010 (TOE)	Achievement of the target (%)
Treatment of sewage	3	3,222	59,832	5.4%
Livestock waste	2	3,875	7,643	50.7%
Industrial waste	1	1,798	26,539	6.8%
Gas from landfill	24	177,438	55,986	316.9%
TOTAL	**30**	**186,333**	**150,000**	**379.8%**

The distribution by Autonomous Communities shows that Madrid and Catalonia are the largest consumers of biogas, with over 50% of the total. This is a direct consequence of the development in these Autonomous Communities of projects for energy exploitation of the biogas generated by treatment of urban waste.

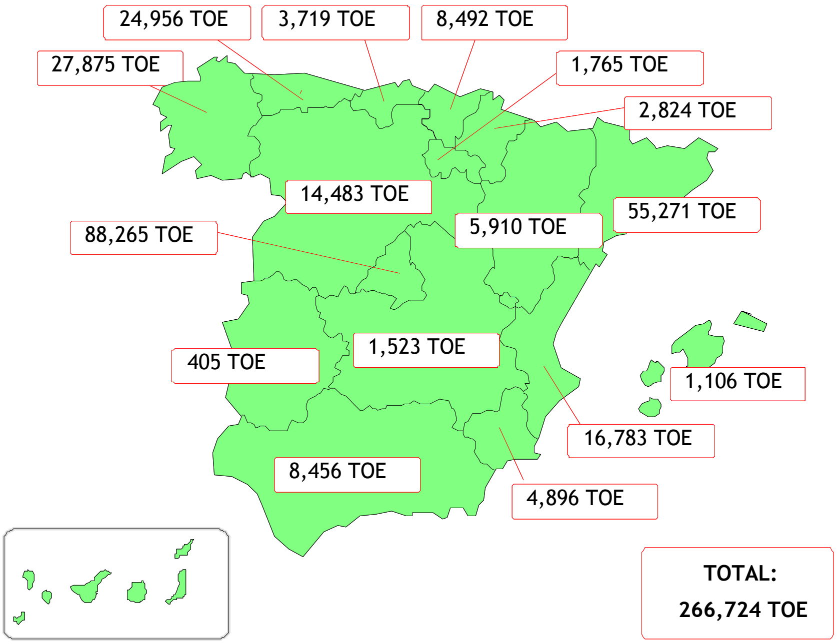


Figure 5. Consumption of biogas in Spain at the end of 2004 (IDAE)

3.7.2.2. Analysis of the resource

Biogas is a gas formed mainly by CH_4, CO_2 and N_2, which results from the action of a type of bacteria on biodegradable waste as part of a process of anaerobic digestion. As such, it must therefore be considered as a by-product of the treatment of that waste.

The following types of waste are used as raw materials for obtaining biogas:

a) Livestock waste

Anaerobic digestion is a technology suitable for treating waste produced in intensive livestock holdings with a high concentration of livestock. Nevertheless, this application is used very little in Spain at present due to competition from other technologies such as thermal drying of purines using natural gas as a fuel.

b) Organic fraction of solid urban waste

This type of waste may be used to produce biogas by two main methods: through degasification of landfill or through anaerobic digestion in bioreactors. The first of these methods is a technology which becomes profitable from a volume of 200-250 t/day upwards. This technology has become extensively used in Spain in recent years. Technology involving anaerobic digestion of waste in bioreactors is at present less suitable for treating waste of this type than other simpler procedures such as aerobic composting.

c) Biodegradable industrial waste

The use of anaerobic digestion technologies to treat biodegradable waste generated by such industries such as the beer, sugar, alcohol, milk and oil industries, among others, is fairly common in Spain and the prospects for its development are consistent since technologies of this type fit perfectly within the industrial process itself.

d) Sludge from treatment of urban sewage

The sludge from primary and secondary treatments carried out in sewage treatment plants can be subjected to anaerobic digestion technologies to produce biogas which, when it is a question of considering an energy application of the biogas produced, is particularly suitable from the equivalent of 100,000 inhabitants upwards. There has been considerable development of the energy use of the biogas generated from waste of this type due to progress in this waste treatment sector in Spain.

3.7.2.3. Technological Aspects

Energy applications from the use of biogas may be electrical or thermal, though both types are occasionally produced together in co-generation plants.

Electricity is generated with biogas as a fuel using internal combustion motors which are specially adapted to burn a gas with the particular characteristics of biogas – which has lower calorific power and a chemical composition which differs from the normal composition of similar fuels such as natural gas. Applications of this type are characterised by their high levels of investment, though they are developed mainly for environmental reasons rather than any prospect of profitability.

Biogas combustion for thermal use is currently less common than in electricity applications and takes place particularly in facilities for producing biogas from biodegradable industrial waste. This type of heat is normally used to heat the digestor, which must be kept within a specific range of temperatures, and any surplus would either be used for other purposes in the industrial plant or exported to other industries. This is something which occurs very rarely in Spain.

A common type of installation in Spain includes an area for preparing the biodegradable waste, another area for biomethanisation and a final area for use of biogas for energy purposes, where the biogas is prepared prior to entry to a motor. The electricity generated using this process is sold to the grid within the framework provided by the Special System for electricity production, whereas the heat from the motor’s high voltage refrigeration circuit is used to heat the digestors. Finally, the heat contained in the motor’s exhaust gases is emitted to the atmosphere.

The prospects for developing the technology for using biogas for energy purposes include perfecting the anaerobic digestion of small volumes of waste, the possibility of using sludge from sewage and sludge from organic fraction of solid urban waste together in digestion processes and the enrichment of biogas through digestion along with non-waste materials. These processes are constantly aiming to increase the efficiency of anaerobic digestion technologies for the production of biogas and raise the quality of the biogas, particularly with regard to its calorific power.

3.7.2.4. Legislative Aspects

As far as the generation of electricity using biogas is concerned, the most notable milestones in the area of legislation consist of Act 54/1997 on the Electricity Sector and Royal Decree 436/2004 of 12 March, which establishes the methodology for updating the legal and financial system for the production of electricity under a special system and rendering it more systematic. This latter Decree establishes aspects such as the financial system for generating electricity using biogas, which includes incentives for selling the electricity in the electricity market.

3.7.2.5. Environmental Aspects

The use of biogas for energy is always the final part of a waste treatment process in which environmental aspects are therefore always given priority.

Firstly, biodegradable waste management systems involve the implementation of measures to avoid percolation and any possible impact of this waste on the aquatic environment.

Furthermore, application for energy purposes entails exploiting a resource whose composition includes a significant amount of methane. This greenhouse gas, which has a much greater impact on the environment than CO_2, is burned in motors or boilers which form part of facilities which are equipped with gas cleaning and purification systems to ensure that emissions to the atmosphere are always below the limits permitted in the legislation.

Improvement of energy efficiency is another aspect closely linked to the protection of the environment. From that point of view, treatment of waste by means of anaerobic digestion is a particularly suitable alternative for surplus purines from intensive holdings, particularly compared to the alternative of thermal drying using natural gas as a fuel.

Nevertheless, there are inherent impacts on the environment associated with the establishment and operation of a facility of this type. These include the impact on the landscape and the possible existence of unpleasant odours associated with the management of the waste. Nevertheless, it is now possible to develop measures to correct these aspects which could limit or even eliminate their impact on the environment.

3.7.2.6. Financial Aspects

As far as the electrical applications of the use of biogas for energy is concerned, the passing of Royal Decree 436/2004 of 12 March, which establishes the methodology for updating the legal and financial system for the production of electricity under a special system and rendering it more systematic, is extremely important for the sector since it establishes the financial system applying to the electricity produced by facilities of this type, which is of key importance for ensuring that they are profitable. The financial remuneration for the kWh exported to the grid within this framework, with facilities of this type being included in group b.7 of Article 2.1, may be considered adequate and that remuneration is applied in the following sample project, which shows the main aspects to be taken into consideration in financial analysis of a plant of this type.

Generation of electricity using biogas		
Electrical power		2 MW
Overall efficiency		27.09%
Useful life		20 years
Operating and maintenance costs	0.025122 €/kWh	351,708 €/year
Investment	1,502.53 €/kW	3,005,060 €
Electricity produced, gross		35,000 MWh/year

3.7.2.7. Barriers

This section identifies the main problems impeding the development of the use of biogas to produce energy. Problems relating to the production of the resource are differentiated from the problems relating to its transformation to energy.

Barriers at the production stage:

Economically viable alternatives, particularly drying of purines using natural gas as a fuel

The inclusion of drying of purines with natural gas in the special system for electricity production has deterred possible investors from using anaerobic digestion technologies for the treatment of waste of this type for purely financial reasons relating to the profitability of projects.

Technological complexity compared to the traditional activities of the producer of the waste

In the area of use of livestock waste, it must be said that the development of anaerobic digestion technology is far from common in the rural environment and is perceived by farmers as falling outside the scope of their activities. Dissemination of information on the potential of this technology in the areas where the waste is produced will be of fundamental importance for the future of these applications.

Furthermore, the situation is similar with regard to exploitation of biodegradable industrial waste or sludge from urban sewage treatment for producing biogas for energy purposes, since in both cases the energy application falls outside the traditional activities of the producer of the waste.

Compliance with the provisions contained in Directive 1999/31 on the deposit of organic material in landfill

The objectives of the Landfill Directive include a progressive reduction of the quantity of organic material deposited in landfill. This has undeniable repercussions on the future possibilities of developing applications to exploit biogas from the degasification of landfill sites since that process takes place precisely due to the fermentation of the organic material.

Barriers at the application stage:

High investment

There is an interest in developing projects for the use of biogas for energy basically for environmental rather than energy reasons. This is due to the nature of the projects themselves, which are linked to the treatment of a waste material, but also due to the high investment per unit of power installed. This also means that projects are viable only from a certain scale of waste treatment onwards.

3.7.3. Measures

The progress made in this area in recent years, though considerable, has weak points which must be taken into consideration. As has been shown in previous chapters, this progress has occurred almost solely through the development of projects linked to degasification of landfill, while there has been little progress made in the use of biogas produced by waste of other types for energy purposes. This is particularly true in the case of treatment of livestock waste by anaerobic digestion, an application which has been supplanted in Spain by thermal drying with natural gas, which is an extremely questionable alternative from the point of view of energy efficiency.

In view of the reasoning put forward in the previous paragraph, the promotion measures proposed for the sector are as follows:

- **Dissemination of information on existing technologies among the bodies concerned, such as local authorities, councils and others.**

  It is clear that, despite the relative progress made in applications for the use of biogas for energy purposes in Spain in recent years, technologies of this type are still largely unknown to many of the agents that could be involved in developing them. This is particularly significant in the case of public bodies. This is a problem because it is precisely these bodies that must act as the promoters of projects in most cases.

- **Promotion of technologies of proven technical feasibility and benefit to the environment for treatment of waste from agricultural/livestock activities by anaerobic digestion of that waste to generate biogas and its subsequent increase in value in energy terms.**

The use of anaerobic digestion technologies to treat waste from agricultural/livestock activities must be one of the areas experiencing the greatest expansion in Spain in the near future as far as treatment of waste is concerned. The use of drying based on combustion of natural gas for waste of this type, and particular for purines, is highly inefficient both in energy terms and from the financial point of view and a change in the short term towards more extensive use of anaerobic digestion in these applications should be made a priority.

- **Maintaining unchanged the financial system applicable to facilities for generation of electricity using biogas that was provided in Royal Decree 436/2004 of 12 March.**

  In the area of generation of electricity using biogas, the publication of Royal Decree 436/2004 of 12 March meant the consolidation of a financial system which favoured the development of applications of this type. In view of this and the positive progress made in the sector in recent years, it does not appear appropriate to promote alterations in the financial system affecting the electricity sold to the grid by facilities of this type.

- **Development of co-digestion processes.**

  As far as the future is concerned, technological development is of fundamental importance to achieve greater efficiency from facilities and thus allow greater profitability. The development of co-digestion processes, in which waste from a range of sources is subjected to a process of anaerobic digestion, plays a fundamental part in this and there is still considerable work to be done in the sphere of R&D to achieve it.

The following table shows a summary of the measures proposed, associating them with the barriers described above:

Barriers	Measures	Body responsible	Cost (€)	*Timetable*
Economically viable alternatives, particularly drying of purines using natural gas as a fuel	Promotion of technologies, whose technical feasibility and environmental advantages have been demonstrated, for treatment of waste from agricultural/livestock activities by anaerobic digestion of that waste to generate biogas and its subsequent increase in value in energy terms.	Ministry of Agriculture, Fisheries and Food Ministry of the Environment Ministry of Industry, Commerce and Tourism	To calculate the cost during the period	*2005-2010*
Technological complexity compared to the traditional activities of the producer of the waste	Dissemination of information on existing technologies among the bodies concerned	Ministry of Agriculture, Fisheries and Food Ministry of the Environment Ministry of Industry, Commerce and Tourism	To calculate the cost during the period	*2005-2010*
Compliance with the provisions contained in Directive 1999/31 on the deposit of organic material in landfill	Development of co-digestion processes	Ministry of Industry, Commerce and Tourism	Pending evaluation	*2007-2010*
High investment	*1.- Maintaining unchanged the financial system applicable to facilities for generation of electricity using biogas that was provided in Royal Decree 436/2004 of 12 March.* *2.- Development of co-digestion processes.*	*Ministry of Industry, Commerce and Tourism*	*Pending evaluation*	*2005-2010*

3.7.4. Objectives 2010

Within the area of biogas, the Promotion Plan established the target of 111.20 MW and 239,103 TOE by the end of 2010, which meant an increase of 78 MW and 150,000 TOE in the 1999-2010 period. As stated above, the proposed target was reached at the end of 2003 and it is therefore necessary to establish a new target which is more suited to the progress in the sector in recent years and its prospects for growth.

3.7.4.1. Energy Data

The table below shows the progress towards reaching the target made by each Autonomous Community in the 2005-2010 period. As far as the table is concerned, it is necessary to take into consideration that although the final national target has been established, the distribution according to Autonomous Communities is included strictly for the purposes of illustration. Nevertheless, in this regard, it should be noted that this distribution has been made considering the criteria of location of the resource, both with regard to the location of the livestock and the population distribution or the existence of industry generating biodegradable industrial waste.

Autonomous Community	Growth objective 2005-2010 (TOE)
Andalucia	26,480
Aragón	6,487
Asturias	5,323
Balearic Is.	8,100
Canary Is.	5,650
Cantabria	3,708
C-Leon	14,358
C-La Mancha	5,834
Catalonia	40,920
Extremadura	3,890
Galicia	6,817
Madrid	18,842
Murcia	13,472
Navarra	6,472
La Rioja	4,705
C.Valenciana	11,449
Basque Ctry.	5,492
TOTAL	**188,000**

Source: IDAE

The proposed energy targets for each type of waste used for production of biogas are shown below. They show the increase in primary energy during the 2005-2010 period.

Renewable Energies Plan 2005-2010	
Resources (TOE)	
Livestock waste	8,000
Organic fraction of SUW	110,000
Biodegradable industrial waste	40,000
Sludge from treatment of urban sewage	30,000
Applications (TOE)	
Electrical applications	188,000

3.7.4.2. Emissions avoided and creation of employment

The following table shows the CO_2 emissions avoided in 2010 alone due to the planned 94 MW increase in power. A combined cycle electricity power station using natural gas, with an efficiency of 54% (372 tCO_2 per GWh produced) was used as a reference:

		BIOGAS AREA
CO_2 EMISSIONS AVOIDED	(t CO_2)	220,298
EMPLOYMENT	(men/year)	1,880

The same table shows the estimated creation of employment at the end of 2010. This employment data relates to the total of all jobs with a duration of one year created over the six years of the period and includes the total number of jobs due to investment in the establishment of the project and the jobs deriving from the implementation of the project.

3.7.4.3. Associated investment

An investment ratio of 1,502.53 euro per TOE in 2005 has been considered for projects to produce biogas, which would gradually descend to an annual rate of 5% until 2010.

As a result, the following figures have been obtained for the amounts of annual investment associated with the biogas sector:

BIOGAS AREA

		2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
ANNUAL INVESTMENT	(mill. €)	7.51	14.27	16.27	21.9	30.6	29.1	119.6

3.7.4.4. Public subsidies

Subsidies relate solely to the financial system for including facilities of this type in the Special System for electricity production. Taking this into account, the amounts of public subsidies over the six years to which this Plan refers are shown as follows:

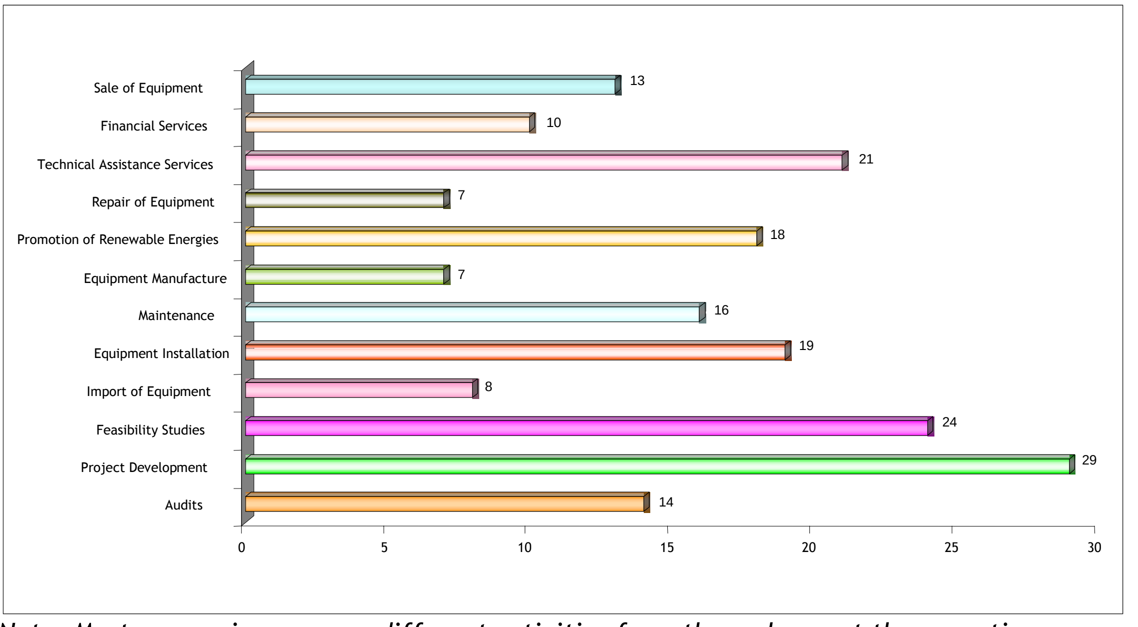
BIOGAS AREA

		2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
PUBLIC SUBSIDIES	(mill. €)	0.9	2.81	5.1	8.5	13.5	18.6	49.4

3.7.5. The Industrial Sector in Spain

The industrial biogas sector in Spain is characterised by the presence of several companies which are involved in all aspects relating to the development of a project. There are nine companies in which these activities form a significant part of the company's operations, although the number of companies taking part in the final development of the project may be much higher if we take into account engineering companies with the capacity to participate and companies able to supply equipment which is non-specific to the processes of anaerobic digestion and use of biogas for energy purposes.

These companies may be distinguished according to the type of activities they carry out, as the following chart shows:



Note: Most companies carry on different activities from those shown at the same time.

3.7.6. Lines of Technological Innovation

Spain has a great deal of experience of developing facilities for the energy use of biogas produced both in installations for degasification of landfill and treatment of biodegradable waste of industrial origin or sludge from treatment plants. Treatment of livestock waste, where the thermal drying of purines has emerged as an alternative to the treatment of this waste by anaerobic digestion, is a special case in this area.

At the current stage of development of applications of this type, the objectives to be achieved as far as technological innovation is concerned should be as follows:

- ✓ Improvements in the efficiency of biogas production processes
- ✓ Development of co-digestion systems for biodegradable waste
- ✓ Optimisation and improvement of processes for treating and cleaning biogas
- ✓ Development of systems to introduce biogas into the natural gas network
- ✓ Technological progress linked to the use of small quantities of waste (livestock, industrial or sludge from treatment plants) for the use for energy purposes of the biogas produced in their anaerobic digestion.
- ✓ Technical improvements with regard to the efficiency of motors

BIOFUELS AREA

CHAPTER 3.8

RENEWABLE ENERGY PLAN FOR SPAIN, 2005-2010

3.8. Biofuels Area

In 1977, the aim of achieving substantial growth in renewable energy sources led the European Commission to draft the White Paper for a Community Strategy and Action Plan for Renewable Energy, within the framework of Community energy policy.

This document was an attempt to achieve an ambitious general target consisting of **12% of the primary demand for energy in the European Union as a whole** being met by renewable energy sources by 2010.

As far as the consumption of biofuels was concerned, the target established for 2010 was to increase their share of energy consumption in the European Union by 18 million TOE.

3.8.1. Situation in the European Union

By the end of 2003, the production of biofuels in the European Union, measured in terms of primary energy, amounted to 1,489 kTOE, which represented an increase of 26.1% compared to the data for 2002. Nevertheless, despite these high rates of growth, the current trend is insufficient to fulfil the energy objectives established in the White Paper. Added to this, only a small number of Member States are involved in developing this sector.

Figures 1 and 2 show the situation of the production of bioethanol and biodiesel, respectively, in the European Union. Most notable is Spain's leadership in bioethanol production and Germany's leadership in the biodiesel sector. This is part of a process of rapid expansion which had already raised production capacity to over one million tonnes by the end of 2003.

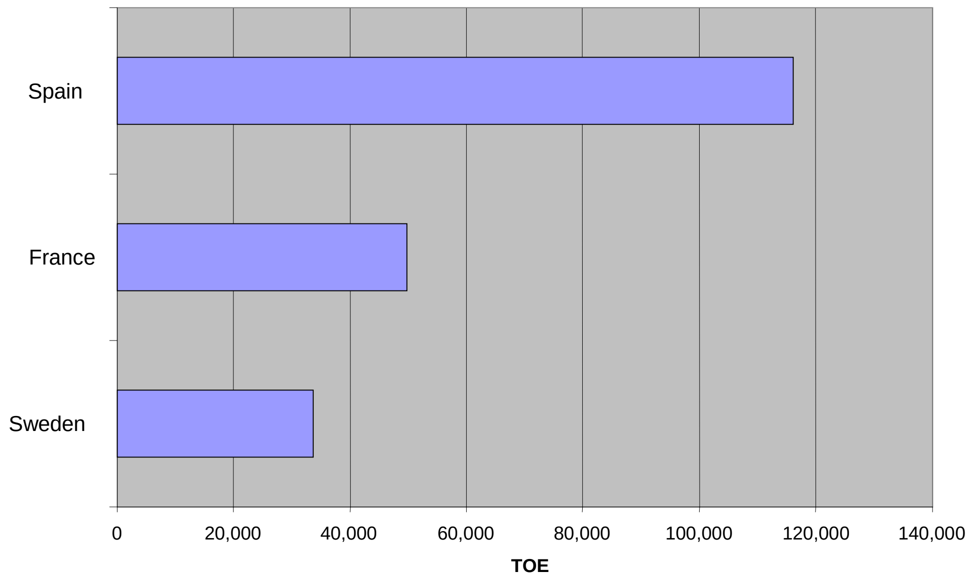


Figure 1. Consumption of bioethanol in the European Union at 31/12/2003 (EurObserv'ER).

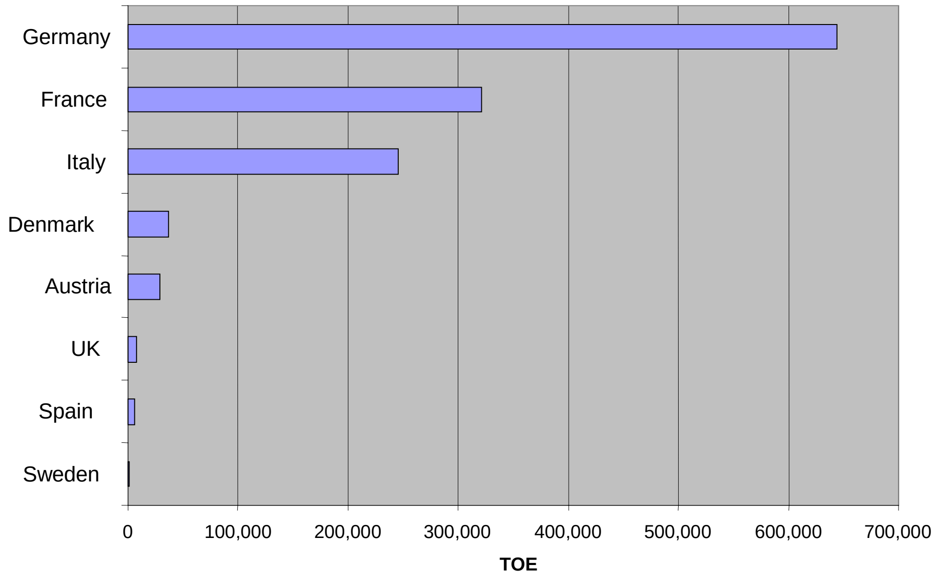


Figure 2. Consumption of biodiesel in the European Union at 31/12/2003 (EurObserv'ER).

Directives promoting the use of biofuels and amending the taxation of energy products and which thus open the door for a reduction in the fiscal pressure on these products, within a framework for developing a sector to which specific targets to be reached by 2010 already apply – albeit in the nature of guidelines –, will play an important part in stimulating the growth of the sector throughout Europe over the next few years.

- **Directive 2003/30/EC**, of 8 May 2003, on the promotion of the use of biofuels or other renewable fuels for transport
  - ✓ This Directive establishes the target of a 2% market share in the transport sector in 2005 and a 5.75% share in 2010
- **Directive 2003/96/EC**, of 27 October 2003, restructuring the Community framework for the taxation of energy products and electricity
  - ✓ This Directive contemplates the possibility of applying a tax reduction or exemption for biofuels produced in industrial projects

3.8.2. Analysis of the Biofuels Area

3.8.2.1. The Current Situation

Consumption of biofuels in Spain amounted to 228.2 kTOE at the end of 2004. This figure is relevant because until 2000 there were no biofuel production plants operating whereas, by the end of 2004, Spain was the leading European country in production of bioethanol and had also made rapid progress in the biodiesel sector.

However, the current growth trends in this sector – which indicate extremely good prospects for expansion – are even more important than the absolute values, which show that 45.6% of the energy target for 2010 established in the Promotion Plan for this area had already been reached by the end of 2004. This is shown in figure 3, which indicates the progress made in the sector in recent years.

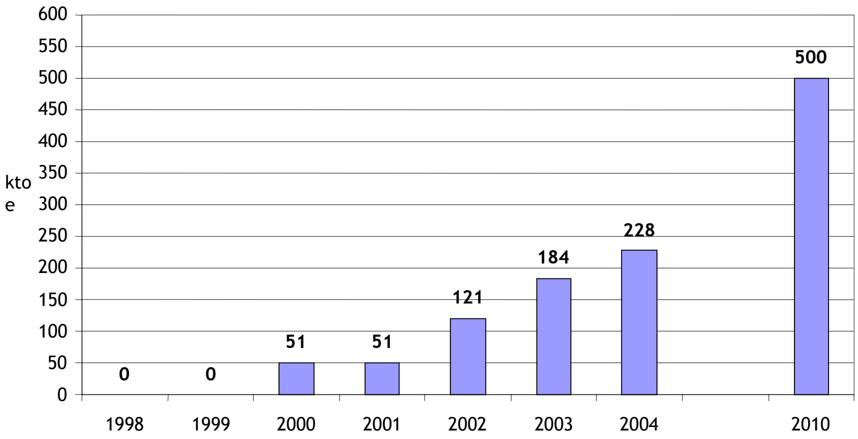


Figure 3. Progress in the production of biofuels and prospects for that production within the framework of the Promotion Plan, in terms of primary energy (IDAE)

Finally, with regard to the type of projects implemented in Spain, it may be said that production projects currently exist for both bioethanol and biodiesel. Bioethanol projects are characterised by the use of cereals as a raw material for the process, whereas all the biodiesel production plants which have started up to date employ used vegetable oil as a raw material. This is due merely to the price of the product. This information is shown in more detail in the following table.

Biofuels: projects in operation (1999-2004)

	Number of projects	Primary energy (TOE)	Target from Plan 2010 (TOE)	Achievement of target (%)
Bioethanol	2	115,700	400,000	28.9%
Biodiesel	6	112,500	100,000	112.5%
TOTAL	**8**	**228,200**	**500,000**	

As this table shows, at the end of 2004 there were eight biofuel production plants operating in Spain: two producing bioethanol and six producing biodiesel. The following table shows the details of these plants:

Plant	Autonomous Community	Biofuel	Production capacity (t/year)	*Start-up*
Ecocarburantes Españoles	Murcia (Cartagena)	Bioethanol	80,000	*2000*
Stocks del Vallés	Catalonia (Montmeló)	Biodiesel	6,000	*2002*
Bioethanol Galicia	Galicia (Curtis)	Bioethanol	100,000	*2002*
Bionet Europa	Catalonia (Reus)	Biodiesel	6,000	*2003*
Bionor Transformación	The Basque Country (Berantevilla)	Biodiesel	20,000	*2003*
Biodiesel de Castilla-La Mancha	Castilla-La Mancha (Santa Olalla)	Biodiesel	40,000	*2004*
Bionorte	Asturias (S. Martín del Rey Aurelio)	Biodiesel	4,000	*2004*
Biodiesel-IDAE	*Madrid (Alcalá de Henares)*	*Biodiesel*	*5,000*	*2004*

The situation described in the above paragraphs, stated in terms of primary energy, is as shown in figure 4, which indicates that the national total for this sector amounted to 228,200 TOE at the end of 2004.

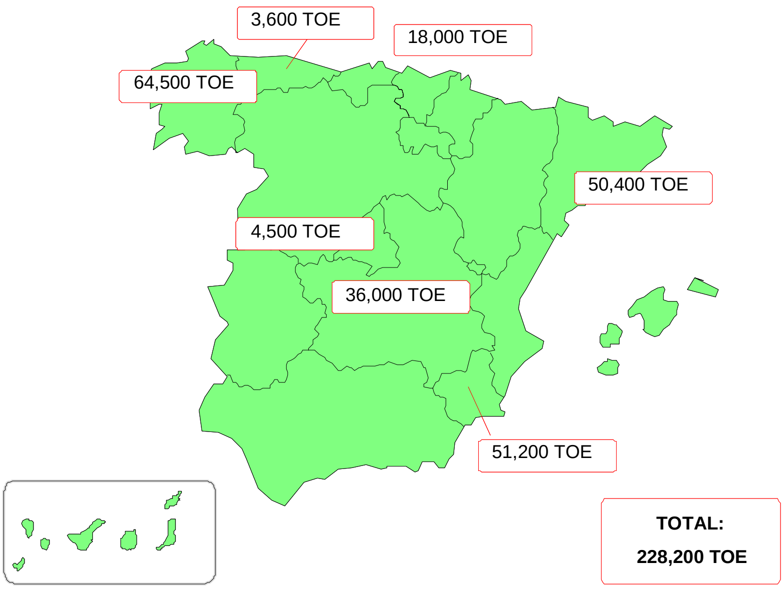


Figure 4. Production of biofuels in Spain at the end of 2004 (IDAE)

3.8.2.2. Technological Aspects

The term “biofuels” refers to liquid fuels deriving from various kinds of transformation of vegetable or animal materials which can be used in vehicle engines to replace materials deriving from conventional fossil fuels. Nevertheless, the term “biofuels” includes two totally different product lines: bioethanol and biodiesel.

Bioethanol is obtained from traditional crops such as cereal, maize or beet using processes to prepare the raw material which are then followed by fermentation and distillation. its applications include blending with gasoline or the manufacture of ETBE, an oxygenate additive for lead-free gasoline.

Biodiesel, on the other hand, is produced through a process of transesterification and refining of clean vegetable oil (sunflower or rapeseed, for example) or used vegetable oils. The product thus obtained is used in diesel engines as a substitute for gas-oil, either blended with gas-oil or as the only fuel.

3.8.2.3. Legislative Aspects

The most important milestones reached recently in Europe are as follows:

- ✓ **Directive 2003/30/EC**, of 8 May: This Directive establishes the target of a 2% market share in the transport sector in 2005 and a 5.75% share in 2010

- ✓ **Directive 2003/96/CE**, of 27 October: This Directive contemplates the possibility of applying a tax reduction or exemption for biofuels produced in industrial projects

As far as Spanish legislation is concerned, the most noteworthy events in recent times, always in relation to European legislation, are as follows:

- ✓ **Act 53/2002**, of 30 December and Royal Decree 1739/2003 of 19 December: These establish a 5-year tax exemption for pilot plants and a flexible tax exemption for industrial plants up to 2012 at least.

- ✓ **Royal Decree 1700/2003**, of 15 December: This Royal Decree transposes Directive 2003/30 and adapts the technical specifications relating to the 5% blend of bioethanol and gasoline and establishes that these blends, along with blends of biodiesel and gas-oil in the same percentages, do not require a special label.

- ✓ **Royal Decree 1739/2003**, of 19 December: This Royal Decree amends the Regulations for Special Taxes as drafted in Royal Decree 1165/1995, specifying the definition and procedure applicable to pilot projects for developing biofuel production technologies.

3.8.2.4. Environmental Aspects

Obtaining the resources necessary for the production of biofuels has either a negligible or clearly positive impact on the environment. The development of energy crops for the production of this resource falls into the first of these categories, whereas one example of a positive environmental impact is the use of used vegetable oils as a raw material for obtaining biofuels, an activity which consists of managing a waste material and increasing its value in energy terms.

As far as the handling and management of biofuel is concerned, its biodegradability is an extremely important factor from the environmental point of view since that serves to limit the effects from possible escapes or accidents during transportation.

Nevertheless, the most-studied aspect of the environmental impact of the use of biofuels is emissions to the atmosphere as a result of their combustion in engines. There are reasons for considering that impact as positive, particularly compared to the use of conventional fossil fuels, including the fact that there is practically no sulphur in the elemental composition of biofuels and therefore there is practically none in the emissions resulting from their combustion. Studies have also shown, based on the same comparison with fossil fuels, that exhaust gases contain fewer substances such as carbon monoxide, aromatic hydrocarbons or particles.

3.8.2.5. Financial Aspects

The breakdown of factors affecting the cost of producing a biofuel is shown in figures 5 and 6. It may be observed from these figures, firstly, that the production costs for these fuels are higher than the production costs for the fossil fuels with which they are being compared and also that the price of the raw material used is always the most influential factor when it comes to calculating production costs.

			For E5
Size of plant		[1]	200
Investments			**Meuro**
Investments in tangible assets			
Total investments in tangible assets			136.1
Investments in intangible assets			
Total investments in intangible assets			22.0
Land			
Initial stock of cereals			
VAT investment			
Total investment		[2]	179.3
Depreciation of tangible assets		[3]	27.2
Depreciation of intangible			4.4
Cost structure			**Euro/l**
Fixed costs			
	Personnel O&M and distribution		
	Maintenance of plant		
	Other fixed costs		
	Depreciation of tangible assets		
	Depreciation of intangible assets		
Total fixed costs			**0.2615**
Variable costs			
	Enzymes and chemicals		
	Water and electricity		
	Natural gas		
	Other variable costs		
Total variable costs			**0.1233**
Additional income			
	DDGS		
	Electricity and others		
Total additional income			**0.1828**
Subtotal for net costs (not including raw material)			0.2021
Raw material	Cereal [4]		0.3823
Total net costs			0.5843
Transport and distribution costs			0.0467
Sales costs			0.6310
Sales margin			0.0000
Sale of product without tax			**0.6310**

[1] In million litres. Figures based on actual cases
[2] They are all included in the total for investment, but only tangible and intangible assets have been included in the calculation of depreciation
[3] They are considered as depreciations at five years
[4] Only cereal is included as a raw material, since vinic alcohol is not considered sustainable in the medium term

Figure 5. Costs for production of bioethanol from cereals

Plant producing 50,000 t/year of biodiesel

		Capacity	50,000.0	t
		Investment in equipment	12,621,254.2	Euro
		Investment in civil works	300,506.1	Euro
		Depreciation	5	years

Cost structure	**Item**	**Euro/year**	**cent/kg**	**cent/l**
COSTES FIJOS	Operating personnel	841,416.9	1.7	1.5
	Plant maintenance	120,202.4	0.2	0.2
	Insurance and charges	138,232.8	0.3	0.2
	Other expenses	649,093.1	1.3	1.1
	Depreciation of equipment (5 years)	2,524,250.8	5.0	4.4
	Depreciation of buildings (5 years)	60,101.2	0.1	0.1
TOTAL FIXED COSTS		**4,333,297.3**	**8.7**	**7.6**
VARIABLE COSTS	Methanol	1,156,948.3	2.3	2.0
	Additives	450,759.1	0.9	0.8
	Water vapour and electricity	900,108.8	1.8	1.6
	Other consumables	90,452.3	0.2	0.2
Raw material	Sunflower oil	33,500,000.0	67.0	59.0
	Yield (kg/l)	0.88		
	Cost (cent/kg)	67.0		
TOTAL Variable Costs		**36,098,268.5**	**72.2**	**63.5**
ADDITIONAL INCOME				
Glycerin	Income	1,532,700.0	3.1	2.7
	Production (kg/l)	0.053		
	Price (cent/kg)	51.1		
TOTAL ADDITIONAL INCOME		**1,532,700.0**	**3,1**	**2,7**
NET COSTS				
TOTAL NET COSTS		**38,898,865.7**	**77.8**	**68.5**
SALES COSTS	Distribution costs	3,425,769.0	6.9	6.0
TOTAL SALES COSTS		**42,324,634.7**	**84.6**	**74.5**

Figure 6. Costs for production of biodiesel from sunflower oil

3.8.2.6. Analysis of barriers in the sector

Here we identify the main problems affecting the development of the biofuels sector, distinguishing between general problems affecting the sector as a whole and problems which are specific to the production of either bioethanol or biodiesel.

General barriers:

Necessary general tax exemption for a period of at least 10 years

The current system of support for biofuels through tax incentives is based, for industrial plants, not on tax exemption but on a zero rate system which is flexible in terms of time. This gives rise to uncertainty in the sector. This uncertainty is aggravated by the fact that current legislation establishes a term for reviewing this support system. Not knowing what will occur from that moment onwards (December 2012) serves to discourage possible investment in the sector.

Need to separate production of the raw material from the variable percentages for compulsory set-aside in the CAP

This barrier will stay as it is until the measures planned in the reform of the CAP are actually applied and production in the European Union of raw material for the manufacture of biofuels will be severely affected by the fluctuation in the percentage for compulsory set-aside established.

When the CAP has actually been reformed, new prospects will open up for the production of raw material intended for the manufacture of biofuels since it will be possible to benefit from a specific subsidy intended for production of energy crops. Also, the uncoupling of subsidies, which will cease to be connected to the level of production in the area, will mean a release from the connection with percentages for compulsory set-aside.

Worse agricultural conditions for cereals and oleaginous crops in Spain than in northern Europe

This is a barrier caused by objective conditions which is extremely difficult to overcome other than through research and development to achieve better varieties which are better adapted than those used at present to achieving high production in the conditions existing in Spain.

Necessary fitting out of the general fuel distribution network

Widespread consumption of biofuels requires a distribution infrastructure that is suited to the requirements for their use, either pure or blended with fossil fuels.

Thus, for example, the use of existing underground deposits for storage of blends of bioethanol and gasoline may give rise to problems in the event of water filtration because it will separate the components of the blend, which could give rise to problems for the final consumer.

Overcoming this barrier will require considerable financial investment and a programme of action which would be almost sure to extend beyond the limits of this Plan.

Necessary guarantees from vehicle manufacturers

It is not enough for biofuels to be adapted to meet quality standards if there is no support from vehicle manufacturers. Significant progress in this regard has been made at international level and that progress must be reflected in the Spanish internal market.

Support by vehicle manufacturers for the use of quality biofuels in vehicles generates so much confidence in all the market operators involved in this sector that it could be said that without that support the sector cannot really be said to have taken off.

Furthermore, it is necessary to develop legislation aimed at adapting all vehicles to biofuels and making it obligatory for all new vehicle models to be equipped to use a certain percentage of biofuel in a blend with fossil fuel without any modification whatsoever.

Specific barriers for each type of biofuel:

Bioethanol

Limited availability of the isobutylenes needed to produce ETBE

Besides ethanol, production of ETBE requires another component which is a by-product of processes in refineries: isobutylene. The quantities produced in Spain restrict the market for ETBE and therefore the use of bioethanol means the use of the production from the two bioethanol production plants currently operating (Ecocarburantes Españoles and Bioetanol Galicia).

Leaving aside the notion of importing isobutylene, which would be inefficient, the logical consequence of this barrier is that the market for bioethanol in Spain will be developed through applications blending bioethanol and automotive petrol.

Biodiesel

High market price for oil for food use, which is higher than the energy application can pay

This is a specially important barrier, particularly in the medium and long term. The legislative framework relating to the possibility of blending fossil fuels and biofuels, combined with trends in consumption habits, allows the conclusion to be drawn that, within the medium and long term, most of the development in the biofuels sector will inevitably take place in the area of biodiesel production. This area is currently sustained by the use of used vegetable oils as raw material. However, since the potential of these oils is extremely limited, only development based on the transformation of pure vegetable oils can be considered with a view to the future. It is here that this barrier becomes completely relevant since if there is no change in the current situation, developments in this direction could dry up completely for purely financial reasons.

The barriers identified in the various spheres of application are briefly listed as follows:

Scope of application	Barriers
General	Necessary general tax exemption for a period of at least 10 years
	Need to separate production of the raw material from the variable percentages for compulsory set-aside in the CAP
	Worse agricultural conditions for cereals and oleaginous crops in Spain than in northern Europe
	Necessary fitting out of the general fuel distribution network
	Necessary guarantees from vehicle manufacturers
Bioethanol	Limited availability of the isobutylenes needed to produce ETBE
Biodiesel	High market price for oil for food use, which is higher than the energy application can pay

3.8.3. Measures

The implementation of measures which have been demanded by the sector for a long time, such as the tax incentive of a zero rate for biofuel produced, has been a key factor in the takeoff of this sector in Spain in recent years. Nevertheless, the consistent development of this new industrial sector requires further action and for that reason the following series of measures is proposed:

- **Tax incentives**

  The current system of tax incentives for industrial biofuel production plants, which is contained in Act 53/2002, involves the application of a zero rate of the special tax on hydrocarbons for the biofuel produced, the time-limit for application of this measure being established at 2012, with no certainty whatsoever as to how the situation will develop from that point onwards. This latter aspect serves to discourage possible investors, since all operators involved in this sector are aware of the importance of the tax incentive for making projects profitable.

  In order to ensure that investments are profitable and thus encourage investment, we propose that the current system of tax incentives should be extended for a least the first ten years of the life of a project. That would remove the uncertainty deriving from the process of reviewing the tax incentive in 2012 and would ensure a stable framework for a certain number of years (ten at least) for these projects.

- **Raw material and the CAP**

  In Europe, the production of biofuels from indigenous materials is subject to the requirements established by the Common Agricultural Policy with regard to agricultural production not intended for food and, specifically, intended for energy use. Recently, the CAP has undergone a process of reform which has led to the emergence of a new concept – the possibility of a Community subsidy for establishing energy crops (45 €/ha) – while systems which were already present in the previous system, which are of interest but which are not developed to any great extent, such as the possibility of applying a national subsidy for energy crops of up to 50% of their establishment cost, have been retained.

  We propose that all the possibilities offered by the CAP should be developed, particularly with regard to European and national subsidies for producing energy crops, in order to stimulate the market for raw materials for applications of this type.

- **Technological innovation**

  The current development of the sector is founded on bases which mean that large amounts are required in the form of public subsidies to ensure profitability. R&D activities, both with regard to the raw material and the transformation processes, will be a key factor in enabling this sector to develop in the future without the aid of public subsidies. As far as the raw material is concerned, innovation activities must allow varieties and species to be obtained which are better adapted to Spanish agricultural conditions, which provide higher yields and which are more suitable for energy use. Furthermore, with the development of the sector, transformation processes must allow higher quality production to be obtained at lower prices and must also allow the introduction of new possibilities (such as production of bioethanol from hydrolysis of lignocellulosic material) which will allow the sector to develop using a new approach in the near future.

  We propose research and development regarding the characteristics of the products used as raw material and the transformation process. This is indispensable to guarantee progress in the sector in the medium and long term.

- **Development of distribution logistics**

  Making a new fuel available to the consumer is no easy matter, particularly if the fuel in question is produced outside the circuit of the large companies in the sector. It is necessary to cover all the links in the chain from the producer of the raw material to the service station and reach the largest possible number of sales outlets.

  For that reason, in order to facilitate consumer access to the product, all the necessary steps should be taken to make biofuel a product which is easily accessible by all fuel consumers in the transport sector.

- **Blends of biofuel and conventional fuel**

  The use of blends of biofuel and conventional fuel, even within the limits allowed by legislation, has given rise to suspicion among operators in the sector and vehicle manufacturers, who distrust the quality of the biofuel reaching the consumer.

  For that reason, the necessary technical developments must be carried out to guarantee the quality of the biofuel produced for consumers. Furthermore, legislation must be developed aimed at adapting all vehicles to biofuels and preventing any new model of car being placed in circulation without having been equipped for the use of a certain percentage of biofuel blend.

- **Certification and monitoring of biofuel quality standards**

  Further to what is stated in the previous section with regard to the aspect of inspiring and maintaining confidence among all operators involved in the development of the biofuel sector, there must be insistence on the work of certification and monitoring of quality standards being carried out rigorously.

- **Development of logistics for collection of used vegetable oils**

  Used vegetable oils are a raw material for obtaining biodiesel. Their main advantage consists of their price and the existence of a fairly organised network of possible suppliers. It is of vital importance that this network be extended, organised and structured in order to take maximum advantage of the benefits of using a raw material of this type, which involves exploitation of a material which otherwise should be treated as waste.

  Furthermore, we should bear in mind that the sector of production of biodiesel from used vegetable oils has limited potential and therefore the need to implement the measures proposed here will become more and more pressing as the sector develops.

The following table shows a summary of the measures proposed, associating them with the barriers described above:

Barriers	Measures	Body responsible	Cost (€)	*Timetable*
Necessary general tax exemption for a period of at least 10 years	To extend the current system of tax incentives for at least the first ten years of the life of a project	Ministry of Finance	To calculate the cost during the period	*2006*
Need to separate production of the raw material from the variable percentages for compulsory set-aside in the CAP	Development of all the possibilities offered by the CAP, particularly those relating to European and national subsidies for producing energy crops	Ministry of Agriculture, Fisheries and Food Ministry of Finance	No cost in addition to the current cost	*2005-2010*
Worse agricultural conditions for cereals and oleaginous crops in Spain than in northern Europe	Development and selection of new species of oleaginous crops, adapted to the agricultural characteristics of Spain	Ministry of Agriculture, Fisheries and Food Ministry of Industry, Commerce and Tourism	Pending evaluation	*2007-2010*
Necessary fitting out of the general fuel distribution network	1.- Development of distribution logistics 2.- Technical developments relating to blends of biofuels and conventional fuels	Ministry of Industry, Commerce and Tourism	Pending evaluation	*2005-2010*
Necessary guarantees from vehicle manufacturers	Certification and monitoring of biofuel quality standards To develop legislation aimed at adapting all vehicles to enable them to use biofuels	Ministry of Industry, Commerce and Tourism Autonomous Communities	No cost	*2007*
High market price for oil for food use, which is higher than the energy application can pay	*1.- Development of logistics for collection of used vegetable oils* *2. Development and selection of new species of oleaginous crops, adapted to the agricultural characteristics of Spain*	*Ministry of Agriculture, Fisheries and Food* *Ministry of the Environment* *Autonomous Communities*	*1.- No cost* *2.- Pending evaluation*	*2005-2010*

3.8.4. Objectives 2010

The Promotion Plan established the target in the area of biofuels of achieving 500,000 TOE by the end of 2010 on the basis of a base situation of a total absence of biofuel production plants.

In the current situation, with 45.6% of the target contained in the Plan having been reached and a rapidly expanding industrial sector in existence, and after the passing of Directive 2003/30, which contains the target that biofuels and other renewable fuels should account for 5.75% of the market for fuel for the transport sector, it is necessary to extend the development scenario for the sector over the next ten years, assuming the targets contained in Directive 2003/30, which would raise the energy target for the sector to 2.2 million TOE by 2010.

3.8.4.1. Energy Data

The following table shows a comparison between the situation in 2004 and the targets for 2010 contained in both the previous Promotion Plan and this Renewable Energies Plan 2005-2010. The targets relating to the Renewable Energies Plan 2005-2010 are distributed according to a list of projects which are currently being implemented or studied and is, therefore, the result of accumulated experience relating to the sector.

Autonomous Community	Situation 2004 (TOE)	Total accumulated targets	
		PFER Target 2010 (TOE)	PER Target 2010 (TOE)
Andalucia	0	100,000	88,000
Aragon	0	50,000	88,000
Asturias	3,600	0	44,000
Balearic Is.	0	0	44,000
Canary Is.	0	0	0
Cantabria	0	0	220,000
C-Leon	0	100,000	330,000
C-La Mancha	36,000	50,000	176,000
Catalonia	50,400	50,000	330,000
Extremadura	0	50,000	176,000
Galicia	64,500	50,000	220,000
Madrid	4,500	0	22,000
Murcia	51,200	50,000	220,000
Navarra	0	0	154,000
La Rioja	0	0	0
C.Valenciana	0	0	0
Basque Ctry.	18,000	0	88,000
TOTAL	**228,200**	**500,000**	**2,200,000**

Source: IDAE

PFER = *Plan de Fomento de las Energías Renovables* [Plan to Promote Renewable Energy]
PER = *Plan de Energías Renovables* [Renewable Energy Plan]

The proposed energy targets for each type of resource and biofuel are shown below. They show the increase in primary energy during the 2005-2010 period.

ENERGY TARGETS 2005-10 (TOE)	
Resources	
Cereals and biomass	550,000
Vinic alcohol	200,000
Pure vegetable oils	1,021,800
Used vegetable oils	200,000
Applications	
Bioethanol	750,000
Biodiesel	1,221,800
TOTALS	
Primary energy (TOE)	1,971,800

3.8.4.2. Emissions avoided and creation of employment

The following table shows the CO_2 emissions avoided in 2010 alone. It also shows the creation of employment deriving from both investment in projects and the implementation of projects.

		BIOFUELS AREA
CO_2 EMISSIONS AVOIDED	(t CO_2)	5,905,270
EMPLOYMENT CREATED	Men/year	46,227

3.8.4.3. Associated investment

For projects relating to production of bioethanol, an investment ratio has been considered of 1,409 euros/TOE in 2005, which would gradually fall at a rate of 5% per year until 2010. For production of biodiesel, the ratio falls to 258 euros/TOE, falling over time by the same proportion as in the first case.

As a result, the following figures have been obtained for the amounts of annual investment associated with the biofuels sector:

BIOFUELS AREA

		2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
ANNUAL INVESTMENT	(mill. €)	12.90	170.6	205.6	200.8	231.0	335.8	**1,156.8**

3.8.4.4. Public subsidies

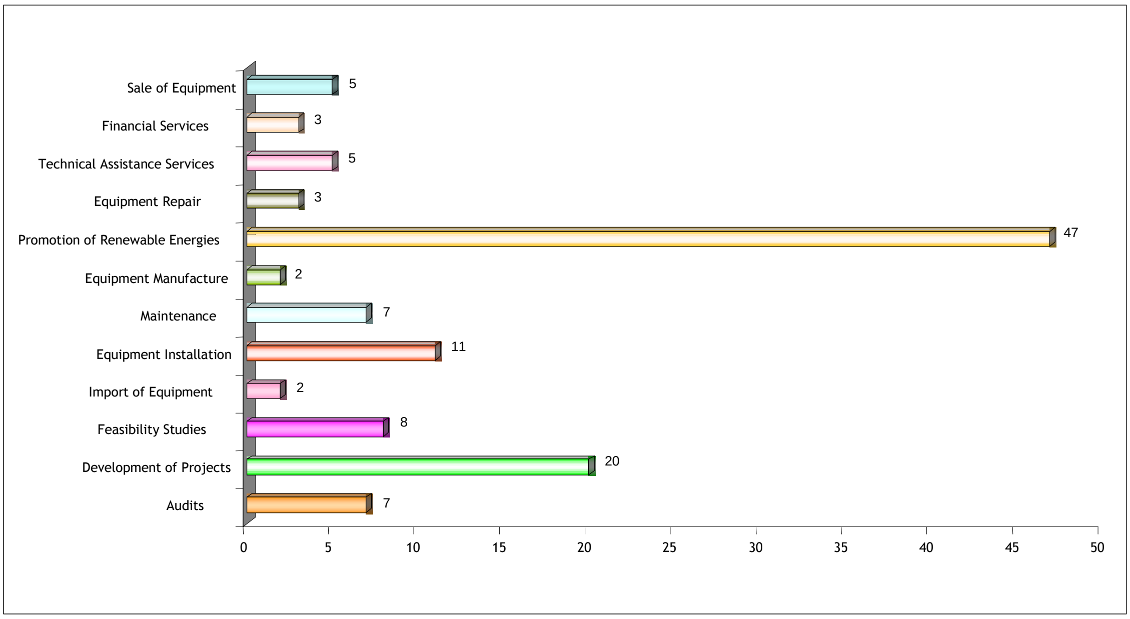
The subsidies consist of the tax incentives received by the biofuel produced, considered as a zero rate of the special tax on hydrocarbons. Taking this into account, the amounts of public subsidies in the six years to which this Plan refers are as follows:

BIOFUELS AREA

		2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
PUBLIC SUBSIDIES	(mill. €)	18.6	153.0	328.8	517.6	751.5	1,085.6	**2,855.1**

3.8.5. The Industrial Sector in Spain

There are currently five biofuel production plants in operation. They are the most visible aspect of an industrial sector which is expanding rapidly in Spain. Although only two companies are involved in biofuel production technologies, there are many other companies in the sector connected with the possible development and implementation of a project of this type. The following chart shows a breakdown of these companies.



Note: Most of the companies carry on different activities from those shown at the same time.

3.8.6. Lines of Technological Innovation

The medium and long-term development of the sector is directly linked to progress made under this heading, with regard both to the production of raw material and transformation processes. In the first case, development is aimed at obtaining high productivity crops intended for energy applications and, as far as transformation processes are concerned, development will take place by improving the yields from existing crops and also through the commercialisation of other technologies which are at present in R&D.

Specifying the aims described in the previous paragraph, the objectives in the sphere of technical innovation for this area are as follows:

PRODUCTION STAGE

- ✓ Development of technologies for collecting, preparing, transporting and storing raw material.

- ✓ **Bioethanol:**

    - Selection of vegetable varieties which optimise the starch/protein ratio and search for and selection of sugar- or lignocellulosics-producing species which are suitable for the production of this biofuel.

- ✓ **Biodiesel:**

    - Development and selection of oleaginous species which are better adapted to the agricultural characteristics of Spain and which allow quality production at low cost.

APPLICATION STAGE

- ✓ Development of technologies for producing biofuels from lignocellulosic products and/or seeds and animal fats.

- ✓ Performance of long-term demonstrations of the use of biofuels in captive fleets.

Biomass Area

SAMPLE PROJECTS

TECHNOLOGICAL AREA: BIOMASS
APPLICATION: Generation of electricity using energy crops

A non-developed application experiencing problems due to lack of knowledge on both production of the raw material and its transformation to energy. For that reason it requires a high level of support, at least during the early years of its development

ENERGY TARGETS (Biomass Area, Generation of electricity using energy crops):

- INCREASE IN POWER: 245 MW
- GENERATION OF ELECTRICITY (2010): 1,709 GWh/year
- EQUIVALENT PRIMARY ENERGY (2010): 731,597 TOE/year

SAMPLE PROJECT AND HYPOTHETICAL PROGRESS:

- Start-up year: 2005
- Power: 5 MW
- Investment ratio: 1,803.04 €/kW
- Implementation period: 1 year
- Hours of operation: 7,500 hours/year
- Useful life: 15 years
- Cost of biomass: 4.3273 cents/kg
- Effect of the cost of the biomass: 6.1753 cents/kWh net
- O&M costs: 0.9306 cents/kWh net
- **Total operating expenses: 7.1059 cents/kWh (2004)**
- Selling price of electricity: Invoicing with regulated tariffs
  Years 1-20: 135% TMR
  Remainder: 80% TMR
  Tarifa media o de referencia, TMR [average or benchmark tariff] (2005):7.3304 cents/kWh
  Annual progress of TMR: 1.4%
- Supplement for Reactive Energy: 4% TMR

SPECIFIC DISTRIBUTION OF THE INVESTMENT:

- Promoter: 20% of the investment
- External Finance: 80% of the investment
- Subsidy: Not specified

SUPPORT FOR OPERATION:

- Premium on the market price: 80% TMR
- Subsidy at interest rate: Not specified

TAX INCENTIVES:

- Tax allowance equivalent to 10% of the investment

APPLICABLE FORMS OF FINANCE:

- None contemplated

TECHNOLOGICAL AREA: BIOMASS
APPLICATION: Electricity generation using forestry and agricultural waste

There is currently only one project that can be included in this category: the Sangüesa electricity generating plant. It requires support to achieve takeoff.

ENERGY TARGETS (Biomass Area, Generation of electricity using forestry and agricultural waste):

- INCREASE IN POWER: 260 MW
- GENERATION OF ELECTRICITY (2010): 1,815 GWh/year
- EQUIVALENT PRIMARY ENERGY (2010): 776,389 TOE/year

SAMPLE PROJECT AND HYPOTHETICAL PROGRESS:

- Start-up year: 2005
- Power: 5 MW
- Investment ratio: 1,803.04 €/kW
- Implementation period: 1 year
- Hours of operation: 7,500 hours/year
- Useful life: 15 years
- Cost of biomass: 3.1493 cents/kg
- Effect of the cost of the biomass: 4.4942 cents/kWh net
- O&M costs: 0.9306 cents/kWh net
- **Total operating expenses: 5.4248 cents/kWh (2004)**
- Selling price of electricity: Invoicing with regulated tariffs
  Years 1-20: 110% TMR
  Remainder: 80% TMR
  Average or benchmark tariff, TMR (2005): 7,3304 cents/kWh
  Annual progress of TMR: 1.4%
- Supplement for Reactive Energy: 4% TMR

SPECIFIC DISTRIBUTION OF THE INVESTMENT:

- Promoter: 20% of the investment
- External Finance: 80% of the investment
- Subsidy: Not specified

SUPPORT FOR OPERATION:

- Premium on the market price: 60% TMR
- Subsidy at interest rate: Not specified

TAX INCENTIVES:

- Tax allowance equivalent to 10% of the investment

APPLICABLE FORMS OF FINANCE:

- None contemplated

TECHNOLOGICAL AREA: BIOMASS
APPLICATION: Generation of electricity using waste from agricultural industries

Projects of this type exist throughout Spain and are normally associated with projects using *orujillo* olive oil as a raw material, though not always. They require a certain level of support to guarantee their profitability

ENERGY TARGETS (Biomass Area, Generation of electricity using agricultural waste):

- INCREASE IN POWER: 100 MW
- GENERATION OF ELECTRICITY (2010): 698 GWh/year
- EQUIVALENT PRIMARY ENERGY (2010): 298,611 TOE/year

SAMPLE PROJECT AND HYPOTHETICAL PROGRESS:

- Start-up year: 2005
- Power: 5 MW
- Investment ratio: 1,803.04 €/kW
- Implementation period: 1 year
- Hours of operation: 7,500 hours/year
- Useful life: 15 years
- Cost of biomass: 3.1493 cents/kg
- Effect of the cost of the biomass: 4.4942 cents/kWh net
- O&M costs: 0.9306 cents/kWh net
- **Total operating expenses: 5.4248 cents/kWh (2004)**
- Selling price of electricity: Invoicing with regulated tariffs
  Years 1-20: 110% TMR
  Remainder: 80% TMR
  Average or benchmark tariff, TMR (2005): 7.3304 cents/kWh
  Annual progress of TMR: 1.4%
- Supplement for Reactive Energy: 4% TMR

SPECIFIC DISTRIBUTION OF THE INVESTMENT:

- Promoter: 20% of the investment
- External Finance: 80% of the investment
- Subsidy: Not specified

SUPPORT FOR OPERATION:

- Premium on the market price: 60% TMR
- Subsidy at interest rate: Not specified

TAX INCENTIVES:

- Tax allowance equivalent to 10% of the investment

APPLICABLE FORMS OF FINANCE:

- None contemplated

TECHNOLOGICAL AREA: BIOMASS
APPLICATION: Generation of electricity using waste from forestry industries

Traditional application. The level of support granted in Royal Decree 436/2004 of 12 March is sufficient to ensure profitability.

ENERGY TARGETS (Biomass Area, Generation of electricity using waste from forestry industries):

- INCREASE IN POWER: 100 MW
- GENERATION OF ELECTRICITY (2010): 698 GWh/year
- EQUIVALENT PRIMARY ENERGY (2010): 298,611 TOE/year

SAMPLE PROJECT AND HYPOTHETICAL PROGRESS:

- Start-up year: 2005
- Power: 5 MW
- Investment ratio: 1,803.04 €/kW
- Implementation period: 1 year
- Hours of operation: 7,500 hours/year
- Useful life: 15 years
- Cost of biomass: 1.5386 cents/kg
- Effect of the cost of the biomass: 1.8820 cents/kWh net
- O&M costs: 0.9306 cents/kWh net
- **Total operating expenses: 2.8126 cents/kWh (2004)**
- Selling price of electricity: Invoicing with regulated tariffs 80% TMR
  Average or benchmark tariff, TMR (2005): 7.3304 cents/kWh
  Annual progress of TMR: 1.4%
- Supplement for Reactive Energy: 4% TMR

SPECIFIC DISTRIBUTION OF THE INVESTMENT:

- Promoter: 20% of the investment
- External Finance: 80% of the investment
- Subsidy: Not specified

SUPPORT FOR OPERATION:

- Premium on the market price: 30% TMR
- Subsidy at interest rate: Not specified

TAX INCENTIVES:

- Tax allowance equivalent to 10% of the investment

APPLICABLE FORMS OF FINANCE:

- None contemplated

TECHNOLOGICAL AREA: BIOMASS
APPLICATION: Co-combustion in conventional power stations

This is a completely new application. Due to interest in this application it requires a framework which allows it to takeoff and become consolidated as one of the main alternatives for the generation of electricity using biomass in the medium term.

ENERGY TARGETS (Biomass Area, Co-combustion in conventional power stations):

- INCREASE IN POWER: 722 MW
- GENERATION OF ELECTRICITY (2010): 5,036 GWh/year
- EQUIVALENT PRIMARY ENERGY (2010): 1,552,300 TOE/year

SAMPLE PROJECT AND HYPOTHETICAL PROGRESS:

- Start-up year: 2005
- Power: 56 MW
- Investment ratio: 856.397 €/kW
- Implementation period: 1 year
- Hours of operation: 7,500 hours/year
- Useful life: 20 years
- Cost of biomass: 4.69 cents/kg
- Effect of the cost of the biomass: 3.80 cents/kWh net
- O&M costs: 0.76 cents/kWh net
- **Total operating expenses: 4.56 cents/kWh (2004)**
- Selling price of electricity: Sale to the market
  Premium: 30% TMR
  Power guarantee: 0.48 cents/kWh

Average or benchmark tariff, TMR (2005): 7.3304 cents/kWh
Annual progress of TMR: 1.4%

SPECIFIC DISTRIBUTION OF THE INVESTMENT:
- Promoter: 20% of the investment
- External Finance: 80% of the investment
- Subsidy: Not specified

TAX INCENTIVES:
- None contemplated

APPLICABLE FORMS OF FINANCE:
- None contemplated

TECHNOLOGICAL AREA: BIOMASS
APPLICATION: Centralised heating and hot water network.

This is a widely established technology in some European countries such as Denmark or Austria. Its financial profitability is ensured only through investment subsidies due to the high prices of fuels deriving from petroleum for domestic uses.

ENERGY TARGETS (Domestic Thermal Biomass Area):

- EQUIVALENT PRIMARY ENERGY (2010): 204,722 TOE/year

SAMPLE PROJECT AND HYPOTHETICAL PROGRESS:

- Start-up year: 2005
- Power: 6,000 kW
- Investment ratio: 282 €/kW
- Implementation period: 1 year
- Equivalent hours of operation: 820 hours/year
- Efficiency of the facility: 77 %
  - Boiler efficiency: 85 %
  - Efficiency of distribution network: 90 %
- Useful life: 20 years
- Operating/Maintenance Costs (2006): 3.40 cents €/kWh (rises or falls with the Retail Price Index)
- Fuel Cost (2006): 1.98 cents €/kWh (rises or falls with the Retail Price Index-0.5%)
  - Cost in weight: 61.5 €/t*
  - Lower calorific power: 4.07 kWh/kg
- Selling price of thermal energy: 0.065 €/kWh (Gas-oil C price: 0.08 €/te)
  - Discount Ratio 10%
  - Final Selling Price 0.059 €/kWh

SPECIFIC DISTRIBUTION OF THE INVESTMENT:

- Promoter: 20% of the investment
- External Finance: 50% of the investment
- Investment subsidy: 30% of the investment

* The calculation of the fuel cost includes a subsidy on investment in production machinery equivalent to 10% of the heating network investment.

TAX INCENTIVES:

- None contemplated

TECHNOLOGICAL AREA: BIOMASS
APPLICATION: Industrial boiler.

This technology is mainly used in industries in the forestry and agricultural and food sectors which exploit their own waste to generate the necessary energy for their production processes. The profitability of these facilities depends on alternative uses for the biomass and the prices of conventional fuels for industrial uses.

ENERGY TARGETS (Industrial Thermal Biomass Area):

- EQUIVALENT PRIMARY ENERGY (2010): 377,792 TOE/year

SAMPLE PROJECT AND HYPOTHETICAL PROGRESS:

- Start-up year: 2005
- Power: 1,000 kW
- Investment ratio: 72.74 €/kW
- Implementation period: 0.5 years
- Equivalent hours of operation: 5,000 hours/year
- Efficiency of the facility: 80 %
- Useful life: 20 years
- Operating/Maintenance Costs (2006): 0.98 cents €/kWh (rises or falls with the Retail Price Index)
- Fuel Cost (2006): 0.73 cents €/kWh (rises or falls with the Retail Price Index-0.5%)
  - Cost in weight: 20 €/t
  - Lower calorific power: 3.49 kWh/kg
- Saving of substituted thermal energy: 0.0183 €/kWh (Price of PCS Natural Gas: 0.0163 €/kWh)

SPECIFIC DISTRIBUTION OF THE INVESTMENT:

- Promoter: 20% of the investment
- External Finance: 80% of the investment
- Subsidy: None contemplated

TAX INCENTIVES:

- Tax allowance equivalent to 10% of the investment

Biogas Area

POSSIBLE SCENARIOS

TECHNOLOGICAL AREA: BIOGAS:
APPLICATION: Generation of electricity

This is an application undergoing expansion. The level of support granted in Royal Decree 436/2004 of 12 March is sufficient to ensure profitability.

ENERGY TARGETS (Biogas Area):

- INCREASE IN POWER: 94 MW
- GENERATION OF ELECTRICITY (2010): 592.2 GWh/year
- EQUIVALENT PRIMARY ENERGY (2010): 188,000 TOE/year

SAMPLE PROJECT AND HYPOTHETICAL PROGRESS:

- Start-up year: 2005
- Power: 2 MW
- Investment ratio: 1,502.53 €/kW
- Implementation period: 1.5 years
- Hours of operation: 7,000 hours/year
- Useful life: 20 years
- **Total operating expenses: 2.5122 cents/kWh (2004)**
- Selling price of electricity: Invoicing with regulated tariffs
  Years 1-20: 90% TMR
  Remainder: 80% TMR
  Average or benchmark tariff, TMR (2005): 7.3304 cents €/kWh
  Annual progress of TMR: 1.4%
- Supplement for Reactive Energy: 4% TMR

SPECIFIC DISTRIBUTION OF THE INVESTMENT:

- Promoter: 20% of the investment
- External Finance: 80% of the investment
- Subsidy: Not specified

SUPPORT FOR OPERATION:

- Premium on market price: 40% TMR
- Subsidy at interest rate: Not specified

TAX INCENTIVES:

- None contemplated

APPLICABLE FORMS OF FINANCE:

- Tax allowance equivalent to 10% of the investment

Biofuels Area

SAMPLE PROJECTS

TECHNOLOGICAL AREA: BIOFUELS
APPLICATION: Production of bioethanol for E-5

This is an application which represents the immediate future of the bioethanol production sector.

ENERGY TARGETS (Biofuels Area):

- EQUIVALENT PRIMARY ENERGY (2010): 1,971,800 TOE/year

SAMPLE PROJECT AND HYPOTHETICAL PROGRESS:

- Start-up year: 2005
- Plant capacity: 200,000 m^3/year
- Total investment in tangible assets: 136.1 million euro
- Total investment in intangible assets: 22.0 million euro
- Useful life: 20 years

- **Additional income:**
- DDGS and other by-products: 0.1828 euro/l

- **Cost structure**
- Fixed costs (personnel, maintenance and others): 0.2615 euro/l
- Variable costs (raw materials and energy): 0.1233 euro/l
- Cost of main raw material (cereal): 0.3823 euro/l
- Transport and distribution costs: 0.0467 euro/l
- Total costs (without industrial benefit): 0.6310 euro/l

TAX INCENTIVES:
- Zero rate of the special tax on hydrocarbons
- Tax allowance equivalent to 10% of the investment

TECHNOLOGICAL AREA: BIOFUELS
APPLICATION: Production of biodiesel

This application is in its early stages in Spain.

ENERGY TARGETS (Biofuels Area):

- EQUIVALENT PRIMARY ENERGY (2010): 1,971,800 TOE/year

SAMPLE PROJECT AND HYPOTHETICAL PROGRESS:

- Start-up year: 2005
- Plant capacity: 50.000 t/year
- Total investment in equipment: 12.6 million euro
- Total investment in civil works: 0.3 million euro
- Useful life: 20 years

- **Additional income:**
- Glycerine: 0.027 euro/l of biodiesel

- **Cost structure**
- Fixed costs (personnel, maintenance and others): 0.076 euro/l
- Variable costs (raw materials and energy): 0.046 euro/l
- Cost of main raw material (sunflower oil): 0.59 euro/l
- Transport and distribution costs: 0.06 euro/l
- Total costs (without industrial benefit): 0.745 euro/l

TAX INCENTIVES:
- Zero rate of the special tax on hydrocarbons
- Tax allowance equivalent to 10% of the investment