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ANALYSIS OF THE EVOLUTION IN BIOMASS TO ENERGY STRATEGIES AND REGULATIONS IN SPAIN

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ABSTRACT
Global warming is one of the most serious challenges facing humankind as it has the potential to dramatically modify the living conditions of future generations. In order to reduce the emission of greenhouse gases, most countries are implementing regulations aimed at reducing their dependence on fossil fuels, promoting energy efficiency practices and favoring the deployment of low carbon energy technologies, including renewable energy sources. In line with the international commitments assumed as a member of the European Union (EU) and also as a signatory of the Kyoto Protocol, Spain developed a National Plan for Renewable Energies (*PER 2005-2010*) that forms the basis of the national strategy in this field. Spain has often been cited as an example for the rapid growth in the use of low carbon energy technologies. However, despite significant progress in the last decade, Spain is far from meeting the national objectives set in PER primarily due to slow growth in the demand for biofuels and the limited success of biomass fired power plants. The evolution in other energy technologies has been faster, situating Spain as world a leader in solar and wind energy. However, the contribution of these technologies to the national consumption is very marginal. In the midst of intense regulatory, commercial and R&D activity, this paper analyses the current situation with respect to the production of renewable energies in Spain, focusing primarily on the use of biomass resources. The paper offers a general view of policy and regulatory background, illustrates current progress towards meeting national objectives and provides a brief description of representative projects and market activity in biofuel production and biomass valorization.

KEYWORDS: Renewable energies, biomass, energy policy, Spain.

1. CURRENT ENERGY SITUATION IN SPAIN

1.1 Primary energy consumption

Since becoming a member of the European Union (EU) in 1986, Spain has undergone a rapid economic expansion that has been accompanied by a similarly fast growth in energy consumption. For instance, between 1990 and 2005, Spanish Gross Domestic Product (GDP) grew by 49,1 %, compared to 12,0 % in the EU. In that period, consumption of primary energy and emission of greenhouse gases (GHG) increased by 61,3 % and 61,6 %, respectively (MMA, 2007). Despite the scarcity of petroleum and natural gas in its national territory, the Spanish energy system is highly dependent on fossil fuels. Imports in 2007 accounted for 64,0 % of the coal, 99,5 % of the oil and 99,1 % of the natural gas consumed. Hence, only 20,8 % of the 146,6 Million tons of oil equivalent (Mtoe) of primary energy consumed in Spain in 2007 were met by national resources (MITYC, 2008).

This situation is illustrated in Figure 1, which shows that 48,1 % of the primary energy consumed in Spain comes from petroleum derivates, 21,5 % from natural gas, 13,7 % from coal, 9,8 % from

nuclear power and only 6,9 % from renewable resources. Most of the demand for petroleum derivates (73,7 %) originates from the consumption of transportation fuels. Hence, a reduction in the consumption of petroleum would necessarily require a profound transformation of the transport fleet. Biomass, primarily used for heat applications in small combustion plants, was by far the most widely used renewable energy source (2,7 % contribution to overall primary energy), followed wind and hydraulic (1,6 % each) both directed to the generation of electricity. Despite the notable growth in other alternative energy sources like photovoltaic or solar thermal, their overall contribution is still minimal.

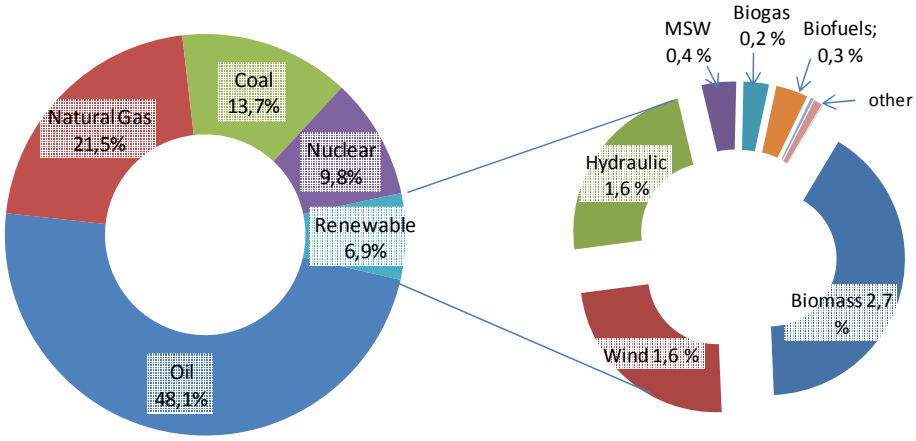

Figure 1. Breakdown of primary energy sources in Spain for an annual consumption of 146.6 Mtoe (extracted from MITYC, 2008)

1.2 Electricity generation in Spain

In 2007, production of electricity in Spain reached 312.138 GWh. As shown in Figure 2, this energy was generated from the following sources: 31,6 % natural gas, 24,1 % coal-fired power plants, 17,6 % nuclear power stations, 6,2 % oil derived fuels and 20,0 % from renewable resources.

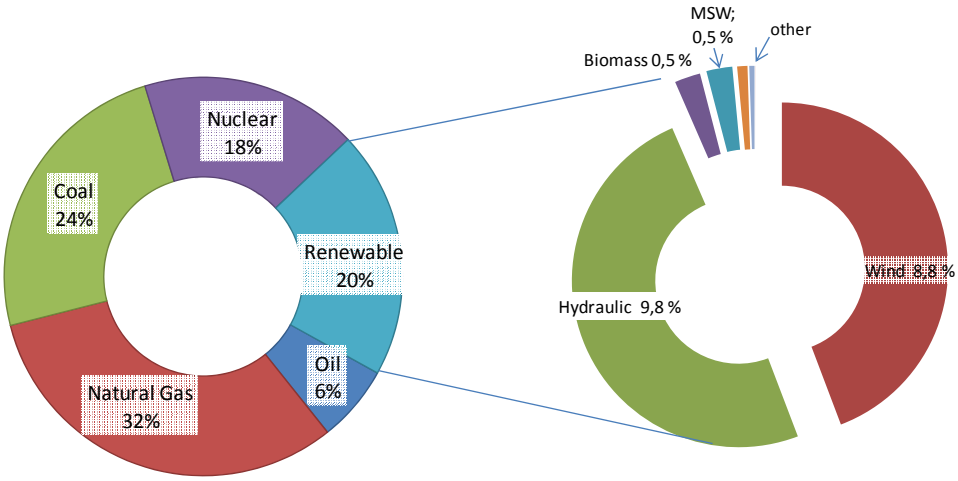

Figure 2. Breakdown of electricity sources in Spain for a total generation of 312.138 GWh (extracted from MITYC, 2008)

In the last decade, the production of electricity from renewable sources has almost doubled, from 36.609 GWh in 1997 to 62.361 GWh in 2007. As shown in Figure 2, the highest input currently corresponds from hydraulic and wind energy, which account for 9,8 % and 8,8 % of the production, respectively. The contribution from other renewable energy sources (photovoltaic, biogas, biomass, municipal solid waste) was marginal, accounting for the remaining 1,4 %.

2. RENEWABLE ENERGIES IN SPAIN

2.1 Current situation

Prior to the application of any incentives, the production of energy from renewable sources in Spain relied essentially on small scale biomass combustion for heat generation. There is also a tradition in medium and small hydraulic plants for electricity generation, although the contribution of this technology to the overall energy supply has been reduced with the growing demand of the last few decades.

In a context of increasing concern for reducing the consumption of fossil fuels, Spain started to develop a public system for the promotion of renewable energies in the late 1990's. This strategy has been followed and extended by subsequent governments of different political signs, creating a sense of continuity and stability that has benefited the market. Spain has often been cited as an example for its success in the rapid deployment of alternative energy technologies. However, this evolution has not been the same for all technologies due to the different levels of economic support.

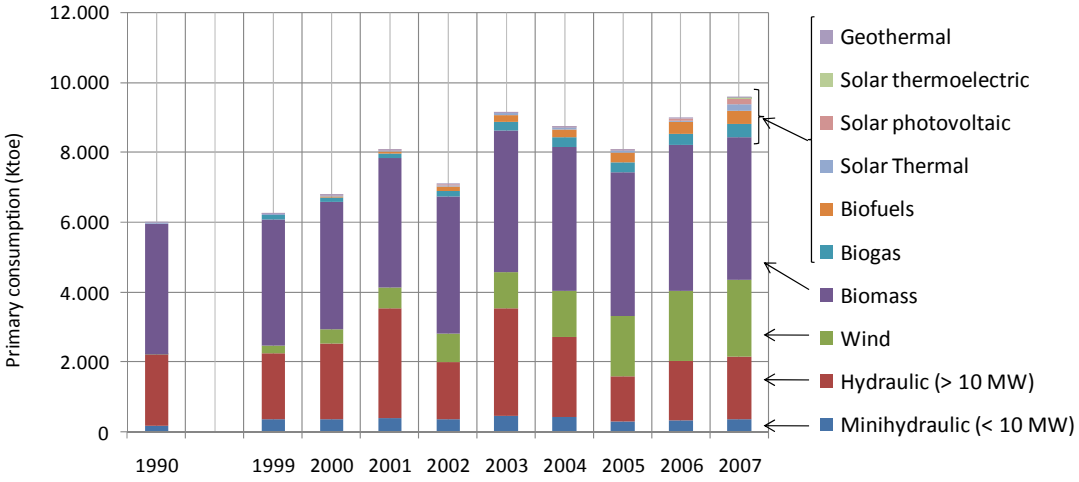

Figure 3. Evolution in the production of renewable energies in Spain (Extracted from MITYC, 2008 and MITYC, 2004)

As illustrated in Figure 3, the consumption of renewable energy increased by 56 % between 1999 and 2007, primarily as a result of a rapid expansion in wind (from 232 to 2.200 ktoe) power. A rapid growth in photovoltaic generation (from 1 to 75 ktoe) has also taken place over this period, although its overall contribution still remains very limited. In contrast, the production of energy from biomass and hydraulic plants has remained stable. This overall growth, however, is insufficient considering the ambitious objectives set in the National Plan for Renewable Energies (PER) for 2010, as described in the following sections.

2.2 Policy and legislation

Spanish policy on the promotion of renewable energies needs to be evaluated within a wider international context. On the one hand, the European Union (EU) sets a common strategy and producing basic legislation in the form of Directives that are subsequently transposed and developed by each Member State. On the other, international commitments on greenhouse gas emissions stated in the Kyoto Protocol became legally binding to EU Member States following ratification in 2002. This section provides a summary of national and international policy and legislation that is currently affecting the use of renewable energies in Spain, particularly focusing on that related to biofuels and biomass.

2.2.1 *International Context*

The Kyoto Protocol, ratified by the EU in 2002, allowed Spain to increase its greenhouse gas emissions by 15% between 1990 and the reference period 2008-2012. This allocation has been largely exceeded due to a larger than expected economic expansion in that period. In 2007, Spain emitted 441,4 million tons of CO_2 equivalent, representing a 52,3 % increase from the baseline value. This value has been reduced to 42,7 % in 2008 (406 million tons of CO2 equivalent) owing to reduced economic activity levels caused by the economic crisis.

The Spanish Government approved a regulation (*Real Decreto 1030/2007*) increasing emission allowances from the original 15 % to a more realistic 37%, considering current situation. This figure derives from the acquisition of carbon credits under the Kyoto Protocol Flexibility Mechanisms (20 %) and the addition of a further 2% from absorption of CO_2 by carbon sinks to the original 15 % allowance.

2.2.2 *European Context*

The *Renewable Energy White Paper* (EU, 1997) is the origin of most of the existing EU policy on the promotion of renewable energies. This document defined the first action plan and set the target of increasing the deployment of renewable energy sources from 6% in 1996 to 12% in 2010.

The Renewable Energy Sources (RES) Directive (*Directive 2001/77/EC on the promotion of the electricity produced from renewable energy source in the internal electricity market*) established the basis to promote the deployment of renewable energy sources for electricity generation. It also set the target of 21 % for electricity generation by 2010. This regulation has been recently revised in Directive 28/2009/EC.

The Biofuels Directive (Directive 2003/30/CE on the promotion of biofuels for transport) set non-legally binding targets on the use of transport biofuels (2,0% in 2005 and 5,75% in 2010). These targets were missed by most EU countries, including Spain.

Directive 2003/96/EC restructuring the Community framework for the taxation of energy products and electricity defines a common strategy for the taxation of energy products and electricity within the EU. The Directive allowed Member States to exempt or reduce taxes on biofuels.

Directive 2003/17/EC relating to the quality of petrol and diesel fuels, states technical specifications for transportation fuels. The Directive modifies the definition of diesel (EN 590) and petrol (EN 228) to allow the incorporation of up to 5 % of biodiesel or bio-ethanol without the need to specify this information in the commercial product. This directive is being revised to allow the incorporation of higher proportions of renewable fuels.

The *Biomass Action Plan* (EU, 2005) set out the EU strategy for the promotion of biomass energy between 2005 and 2010. The overall objective was to increase its demand from the 69 Mtoe estimated in 2004 to around 150 Mtoe in 2010. The Plan announces more than 20 actions including the promotion of biofuels obligations, support for developing countries that want to produce transport biofuels and revision of fuel standards. These tasks have been adopted in subsequent legal documents.

The European Climate Change and Energy Package (2008) (also referred to as 20/20/20 by 2020) is a recent Communication from the European Commission that includes a package of proposals aimed at meeting European commitments in the field of climate change and promotion of renewable energy sources. The document includes three binding targets to be achieved by 2020:

- Reduce energy consumption by 20%.
- Reduce greenhouse gas emissions by 20%.
- Increase the contribution of renewable energy to 20%.

The *new RES Directive* (Directive 28/2009/EC on the promotion of the use of energy from renewable sources) sets the regulatory framework and targets for the following decade. The Directive includes some of the objectives described in previous documents like 20% contribution of renewable energy sources in final energy consumption.

2.2.3 *National context*

The National Plan for Renewable Energies (*Plan de Energias Renovables 2005-2010*), PER hereafter, (MITYC, 2005) was approved in 2005 and describes the basis of the Spanish strategy in this field, including information on general and specific objectives for different technologies and support measures. In the context of the original RES Directive 2001/77/EC, this Plan set a series of national objectives for 2010 including:

- 12.1 % of primary energy from renewable sources.
- 30.3 % of electricity production from renewable sources.
- 5.83 % of transport fuels from renewable sources.

Table 1. Energy production from renewable sources in Spain and objectives for 2010 (Extracted from MITYC, 2004 and 2008)

	2007		**Nation Plan for Renewable Energies 2010**	
	Installed capacity (MW)	Production in terms of primary energy (ktoe)	Installed capacity (MW)	Production in terms of primary energy (ktoe)
ELECTRICITY GENERATION				
Hydraulic (> 50 MW)	13.521	1.623	13.521	1.979
Hydraulic (10-50 MW)	2.999	365	3.257	557
Hydraulic (< 10 MW)	1.852	353	2.199	575
Biomass	396	585	2.039	5.138
M.S.W.	189	649	189	395
Wind	15.090	2.368	20.155	3.914
Solar photovoltaic	638	40	400	52
Biogas	166	202	235	455
Solar thermal	11	2	500	509
Total electricity	34.862	6.187	42.495	13.574
THERMAL APPLICATIONS				
Biomass		3.452		4.070
Solar thermal low temperature	1.198.453 m^2	93	4.900.000 m^2	376
Geothermal		8		8
Total thermal energy		3.553		4.454
TRANSPORTATION BIOFUELS				
Total transportation biofuels		382		2.200
TOTAL RENEWABLE ENERGIES		10.122		20.200
CONSUMPTION PRIMARY ENERGY (Ktoe)		146.646		167.100
Renewable energies /Primary energy (%)		6,9		12,1

The National Plan envisaged the generation of 20.200 ktoe from renewable energy sources in 2010, a 12,2 % of the total energy consumption in Spain. The contribution of different technologies was intended to be as follows: 3.914 ktoe from wind power, 5.138 ktoe from biomass power plants, 4.070 ktoe from biomass to heat installations and 2.200 ktoe from transport biofuels. Table 1 shows a more detailed description of these objectives and the situation in 2007. In addition, Figure 3 illustrates the evolution in the production of energy from different renewable sources over the last decade.

Wind power installed capacity has increased very rapidly in Spain over the last few years. Only in 2007, this value increased by 3.515 MW to reach 15.090 MW. In 2007 there were 678 wind parks in operation in Spain generating 2.368 ktoe of energy. This value set Spain in second position worldwide behind Germany, and ahead of the United States. However, a 65 % increase is still required to meet the target set in PER for 2010.

Biomass energy has not developed as fast as expected, which has been attributed primarily to insufficient financial support for biomass power plants and also as a result of the late implementation of biofuels regulations. The 396 MW installed capacity registered at the end of 2007 for biomass power plants is far from the 2.039 MW considered in PER for 2010. To close this gap, new mechanisms are being introduced to promote joint combustion of biomass in conventional fossil fuel fired power stations and the introduction of additional support schemes.

With respect to biofuels, PER set the objective of replacing 5,83 % (by volume) of transport fuels by 2010. The Plan describes the production of 1.412 ktoe of biodiesel (86 % from pure vegetable oils and 14 % from used oils) and 788 ktoe of bioethanol (73 % from cereals and biomass, and 27 % from wine derivates). Spain is far from these objectives and did not meet the 2% target set for 2005 in the Biofuels Directive.

In summary, an analysis of the results published for the year 2007 (MITYC, 2008) shows a yearly increase of 800 ktoe in the production of renewable energies for a total generation of 10.300 ktoe. Hence, a much faster growth will be required to reach the 20.200 ktoe objective set for 2010. Low compliance is primarily observed in the areas of biomass to electricity, biomass to heat and transport biofuels. Better agreement is found in the generation of wind (56,6 %) and photovoltaic (132 %) energy.

3. INCENTIVES

In order to reach the objectives set in the *Plan de Energías Renovables* (PER), the Spanish government has developed a number of financial and fiscal incentives to promote the generation of heat and electricity from renewable energy sources, and also to increase the demand for transport biofuels. An analysis of the regulations and promotion schemes in the electricity, transport and heat sectors is provided below.

3.1 Electricity

Ley 54/1997 del Sector Eléctrico (Electric Power Act) set up the basis of the existing electricity sector in Spain. In addition of establishing the liberalization of the electricity market, this piece of legislation created a “special regime” for electricity generated from renewable energy resources. For electricity generated under this regime, this piece of legislation ensured: guaranteed grid access; obligation of the distributor to buy from the producer; and also, a price support mechanism based on the so called “feed-in tariff” system.

Real Decreto 2818/1998 developed the support system for electricity producers, who could choose between two alternatives:

- “Fixed feed-in”: the price of each kWh sold to the distribution grid is fixed by law.
- “Fixed premium”: the electricity generated is sold in the conventional energy market and the producer gets a fixed bonus on top of the market price.

These incentives are revised annually taking into consideration several factors including: environmental considerations of each energy generation technology; investment and generation costs; energy efficiency; degree of compliance with the objectives set in the *National Plan for Renewable Energies (PER)*. The costs of implementing this scheme are passed on to the consumers through higher electricity tariffs. Real Decreto 2818/1998 was first amended by Real Decreto 436/2004 and subsequently by Real Decreto 661/2007, which is the one currently in application. To have an idea of the current situation, Table 2 summarizes the range of incentives (fixed feed-in) described in this latter piece of legislation.

Electricity production from biomass is subsidized differently depending on the origin of the biomass and also the size of the power capacity of the plant. The highest financial support goes to electricity generated from energy crops in small size (< 2 MWe) plants (up to 16,0 c€/kWh), and the lowest to large power plants (> 25 MWe) using industrial biomass (up to 12,6 c€/kWh). Far higher economic incentives were allocated for other technologies like photovoltaic (up to 44,0 c€/kWh) or solar thermal (up to 26,9 c€/kWh) owing to the high cost and the limited penetration of this technology at the time of writing the legislation. This has resulted in a very rapid expansion in solar technologies for power generation over the last few years. In contrast, wind power generation is subsidized at a lower rate (between 6,1 – 7,3 kWh) due to the lower costs involved in this increasingly mature technology.

Feed-in tariffs are the most widely used supporting scheme for renewable energies in Europe. The degree of success, both in terms of effectiveness and cost, depends on the selection of the specific monetary values adopted. Countries set their objectives considering economic context, geographical and environmental circumstances, market and industrial situation, technology potential and also the idiosyncrasy of each culture. Other schemes, based on with tradable green certificates (TGC) are also applied in other EU countries like Belgium, United Kingdom, Sweden and Italy. The benefits and limitations of each one of the these schemes are discussed in various articles (del Río, 2008; Lund, 2009).

3.2 Transport biofuels

Ley 53/2002 de Medidas Fiscales, Administrativas y del Orden Social (of fiscal, administrative and social order measures) established a tax exemption for biofuels, anticipating the requirements of Directive 2003/96. The legislation states that this measure is aimed at facilitating the penetration of

renewable energies into the market and warns of the possibility of modifying this decision depending on the production costs of fossil fuels and biofuels. In addition, *Ley 36/2003 de medidas de reforma económica* (economic reform measures) lays down a 10 % special deduction for investments in equipment and installations intended for the conversion of agricultural products into biofuels. In accordance with the objectives set in the National Plan for Renewable Energies (PER), Law 12/2007 established mandatory biofuels blending requirements intended to meet the 5,83 % objective set for 2010.

Table 2. Feed in tariffs for electricity generated from different energy sources (extracted from *Real Decreto 661/2007*)

Energy source	**Period**	**Fixed price (c€/kWh)**
Wind energy	First 20 years	7,3
	After 20 years	6,1
Photovoltaic energy	First 25 years	23,0 – 44,0
	After 25 years	18,4 – 35,2
Solar thermal	First 25 years	26,9
	After 25 years	21,6
Geothermal, tidal, waves	First 20 years	6,9
	After 20 years	6,5
Energy crops	First 15 years	14,7 – 16,0
	After 15 years	11,9 – 12,3
Agriculture and forest biomass	First 15 years	10,8 – 15,9
	After 15 years	8,1 – 12,3
Biogas	First 15 years	5,4 – 13,1
	After 15 years	5,4 – 6,5
Industrial biomass	First 15 years	6,5 – 12,6
	After 15 years	6,5 – 8,5

3.3 Heat from renewable energies

Real Decreto 314/2006 por el que se aprueba el código técnico de la edificación (Technical Buildings Code), approved under Royal Decree 314/2006, made mandatory that up to 70% of domestic hot water demand in new and renovated buildings was produced from solar thermal technology. This legislation also laid down subsidies (up to 45 %) and special loans for investments carried out by individuals, private companies and local authorities for the production of heat from biomass.

4 BIOMASS AND BIOFUEL EFFORTS IN SPAIN

The coming into effect of the regulations described in previous sections has prompted the development of a very active renewable energy sector, particularly in solar and wind technologies. However, other areas like biomass power and biofuels are still behind expectations, and a notable impulse is expected during the next years. This section provides a description of the market situation and some of the most representative projects undertaken in Spain in the field of biomass energy. Information from official channels has been revised with that published by the specialized media or provided directly by relevant organization and companies. Information published as internal reports or in the websites of the following organizations has been of special interest: Associación de Productores de Energías Renovables (APPA); BiodieselSpain; Comisión Nacional de la Energía (CNE); Instituto para la Diversificación y el Ahorro Energético (IDEA); Ministerio de Industria, Turismo y Comercio (MITYC).

4.1 Biomass combustion for electricity

4.1.1 Cereal straw power plant in Sangüesa (Navarra)

Acciona Energía owns and operates a 25 MW power plant in Sangüesa (Navarra). This venture was opened in 2005, consumes 160.000 t of cereal straw and generates 200.00 MWh per year. The plant involved a total investment of 50 million €, employs 26 people full time and has created more than 100 indirect jobs.

The combustion technology is based on a water cooled grate furnace that generates superheated steam (500ºC and 90 bar) that is directed into a steam turbine. According to Acciona Energía, a key technical challenge in this plant related to reducing damage to the boiler by corrosion derived from the high concentration of chlorine and potassium in the cereal straw. The running of this plant also involves a logistic challenge in order to guarantee a continuous supply of straw throughout the year. The process generates an ash residue that is commercialized as a fertilizer (Lopez-Gonzalez *et al.*, 2007).

4.1.2 Electricity from olive oil production residues in El Tejar (Cordoba)

Spain is one of the top producers of olive oil in the world with 900.000 ha dedicated to this activity and a total production that is expected to reach over 1,2 million tons in the 2007/2008 season. *Cooperativa Oleícola El Tejar*, based in El Tejar (Córdoba), is one of the largest cooperative companies in this sector, integrating over 259 smaller companies and associations dedicated to the production of olive oil. This company is currently the largest producer of biomass derived electricity in Spain, with four power plants operating in El Tejar and Palenciana (Cordoba). These four plants have a combined capacity of 48,3 MW and generate 340.000 MWh per year of electricity from the combustion of olive oil production waste (*alperujo*). A fifth plant (5 MW capacity) is being built in Algodonales (Cadiz) that will generate a further 40.000 MWh. The investment for this plant was 6,1 million €, of which 2,2 million € were subsidized by a national program.

4.1.3 Hybrid biomass/solar plants

This novel concept relies on the integration of a solar collector into the water/steam cycle of a conventional biomass power plant. The combination of these two technologies benefits from increased overall energy efficiency, reduced investment for a given power (compared to CSP with molten salts heat storage), and longer operating hours (24 hours a day without the need for heat storage).

From an economic point of view, this approach benefits from the higher feed-in tariff established in *Real Decreto 661/2007* for the production of electricity from thermo-solar power, which is paid at 0,28 €/kWh compared to 0,11-0,15 €/kWh for biomass. A research project lead by Universidad Politecnica de Madrid (UPM) and participated by several private companies and research centers are currently working in the development of a first hybrid biomass/solar plant of 2 MWe capacity expected to run into operation in 2012.

4.2 Biomass combustion for heat generation

4.2.1 Heat and sanitary water from biomass in Cuellar (Segovia)

This project involved the construction of a centralized system designed to supply heating and hot sanitary water to a neighborhood of approximately 1,000 inhabitants including a school, a cultural centre and a municipal sports centre in Cuellar (Segovia). This project was selected by the EU Directorate-General for Energy and Transport in its Penelope Project Good Practice Database (EU, 2004).

The process consists of three main elements: a 5,95 MW thermal plant fed with biomass (2.300 t/year) a system of distribution pipelines (total length 2.500 m) transporting the hot water (200 $m^3 h^{-1}$) from the thermal plant to consumption areas; and feeding systems that allow end users to connect to the distribution network. Most of the biomass comes from local wood processing industries (furniture, boards and wood mills). The project involved a total investment of 1,2 million € that was financed by the national and the regional Energy Agencies (IDEA and EREN).

4.3 Transport biofuels

Spain is currently in the middle of a biofuel turmoil caused by the coming into effect of regulations aimed at meeting the commitments established in the *Plan de Energías Renovables 2005-2010*. Several companies have made large investments to increase their bioethanol and biodiesel

production capacity. However, national demand has remained low, due primarily to the late application of regulations. As a result, only 3 of the 30 plants dedicated to the production of biofuels in Spain were operating at full capacity at the beginning of 2008.
This regulation has finally come in the form of Ley 12/2007 (amending the Hydrocarbon Sector Act) which defines the minimum amount of biofuel that should be incorporated into transport fuels. The target was 1,9 % content by the end of 2008, 3,4 % by 2009 and 5,83% by 2010. However, the 2008 target was not made mandatory.
This section provides a picture of the Spanish biofuels sector with information about the current situation and the changes that are to be expected in the near future. Owing to the fast changing regulatory and market situation, the information offered by official institutions has been updated with that published by key organizations like the Asociación de Productores de Energías Renovables-APPA (Association of Small Producers of Renewable Energies), Biodiesel Spain and specialized media.

4.3.1 Bioethanol

Spain is the top producer of bioethanol in Europe, with four plants operating in its national territory providing a total capacity of 445.000 t/year. However, owing to low national demand, the production in 2007 was estimated at only 284.000 t, most of which was exported to central Europe. This ethanol is produced primarily from wheat and barley, which are extensively grown in Spain. Residues derived from the production and processing of wine are also employed at a smaller scale.
Abengoa Bioenergia is first producer of bioethanol in Europe and fifth in the US. It currently operates three plants in Spain, four in the US and two more in France and the Netherlands. The three plants in Spanish territory include:

- Biocarburantes de Castilla y León is a joint venture between Abengoa Bioenergía and Ebro Puleva. The plant is located in Babilafuente (Salamanca), has been in operation since 2006 and has a production capacity of 160.000 t/year.
- Bioetanol Galicia located in Curtis (La Coruña), the plant opened in 2002 with capacity to produce 140.000 t/year of bioethanol.
- Ecocarburantes Españoles is located in Cartagena (Murcia) and started production in 2000 with capacity to produce 120.000 t/year.

A smaller plant co-owned by Acciona Energía and Uriel Inversiones started operations in 2006 in Alcazar de San Juan (Ciudad Real) with a capacity of 26.000 t/year.
Three more bioethanol plants are under construction in Zamora (145.000 t/year), Cantabria (126.000 t/year) and Badajoz (110.000 t/year), and several joint ventures have announced their intentions to build some in the future. As discussed above, some of these plants have been going through difficulties due to low national demand and had to reduce production or close for a period of time. This has been the case of Biocarburantes de Castilla y León (BCyC) which has remained closed between September 2007 and July 2008.

4.3.2 Biodiesel

In 2007, Spain had 24 biodiesel plants in operation with capacity to generate 815.000 t/year. However, the total production during this year was only 147.000 t, 18 % of its capacity (MITYC, 2008). Two thirds of this production was exported to European markets. During that year, Spain also imported 150.000 t of biodiesel, primarily from US. Imports are favored by the high €/US$ exchange rate and also by the heavy subsidies applied to biodiesel production in the US (up to 200 € / t).
These figures are changing rapidly and the latest information from Biodiesel Spain (http://www.biodieselspain.com/) indicate the existence of 27 biodiesel plants in operation, 26 more plants under construction and 22 in project. The opening of all these new plants will increase the production capacity of the country 5 times.
Raw materials used for production vary depending on plant size and location. Smaller capacity plants tend to use recycled secondhand oil collected from restaurants and catering companies. The larger plants use virgin oils, mostly from soybean, sunflower, rapeseed and palm oil. Most of this soybean oil is imported from the US and the palm oil from Asia.
A typical example of a biodiesel company is Combustibles Ecológicos Biotel SL, which has a production facility in Barajas de Melo (Cuenca). The plant was originally designed and used by the Domecq Group for the production of whiskey. Bought by the Tello Group, it was adapted in 2002 for

the production of biodiesel. A total of eight stirred tanks provide the plant a production capacity of 150.000 t/year.

5 CONCLUSIONS

Production of renewable energies is growing rapidly in Spain owing to the coming into effect of regulations derived from the coming into force of EU regulations and the National Plan for Renewable Energies (PER 2005-2010). This Plan set very ambitious objectives for 2010 which relied primarily on the development of wind and biomass derived energy, including biofuels. Growth in wind energy and photovoltaic generation has been significant in the last few years, situating Spain as a world leader in these technologies. In contrast, progress in the biofuel and biomass sectors has been much slower than expected owing to the late coming into force of biofuels legislation and the limited success of the biomass power plants. Regarding the former, Spain has developed a large capacity for the production of biofuels over the last few years and a larger number of additional plants will be ready for production in the next few years. However, existing biofuel plants are currently working at reduced capacities, owing to the low internal demand and competition from highly subsidized imports. With respect biomass power, incentives in the form of more favorable "feed-in tariff" are expected to benefit this sector, so that installed capacity and energy generation can reach the expectations stated in PER. With national governments increasingly concern about the economic implications of the financial crisis that is hitting the world since 2007, it may be said that the promotion of RES is now a second priority. This does not mean that progress in this sector is coming to a standstill situation, as key countries like US and China have made public ambitious plans in this field. The economic expansion that will follow the end of the financial crisis will be accompanied by necessary increase in the price of conventional energy sources, particularly fossil fuels. Those countries best adapted to this situation will have an advantage over the others. Hence, despite the difficulties, the next decade will be a period of substantial growth in the field of renewable energy, with a great deal of instability provoked by market adjustments and significant opportunities derived from an inexorable increase in demand. In Spain, this development will be coordinated under the new Renewable Energy Plan (2011-2020) (being drafted at the time of writing).

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