Strategic Analysis of Biofuels Production and Consumption in Portugal and Spain and the Prospects for Biorefineries Future Competitiveness

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Abstract

Concerns regarding Global Warming, the excessive reliance on petroleum and non-renewable energy sources in countries such as Portugal and Spain, which do not hold commercially significant reserves of hydrocarbons, and also with the high price per barrel of petroleum, has led European institutions to implement an optimization of the current energy framework.

Biofuels appear as renewable and inexhaustible energy sources, with the potential to replace fossil fuels. In a political/economical context, their great advantage is in turning countries more independent of suppliers of petroleum and natural gas. From an environmental standpoint, their use leads to the reduction in GHG emissions. Moreover, they provide the added benefit of engendering rural development, thus benefitting less developed regions.

In this scope, the search for a technological strategy for the use and economically sustainable production of biofuels, and, if possible, promote traditional agriculture and other activities in the rural areas of the Iberian Peninsula that favor the production of biodiesel as well as bioethanol, is the main objective of this Dissertation.

1. Introduction

The production and use of biofuels derived from renewable sources emerged in the 1970s, following the first two oil shocks and due to the awareness of the need to diversify energy sources and reduce dependence on oil. In Europe, the Agricultural Policy associated with motivations to improve the environment, led to the introduction of a line of production and use of biofuels in several EU countries.

Biofuels production in Europe has grown significantly since early 2000 as a result of rising oil prices and the existence of a favorable legislation adopted by the EU institutions.

The energy sector assumes in the world today, one of the R&D priorities n order to face the challenge of sustainable development. The importance of this sector is also the result of the need to reduce energy dependency of fossil fuels, since the global reserves are scarce and also by international commitments to reduce global GHG emissions.

To counter these developments, the European Member States are bound by international commitments and European Directives that commit themselves to jointly reduce their GHG by at least 5% compared to 1990 levels during the period 2008 to 2012, and Directive 2009/28/EC of 23 April, calling for the replacement of fossil fuels with alternative fuels.

The production and marketing of biofuels in the Iberian Peninsula is a well-established practice in recent years. In Portugal, the production focuses on biodiesel, in Spain there is also the industrial production of bioethanol, which makes the Iberian Peninsula an interesting market to study, compare and evaluate.
On the other hand, given that in Portugal there is a major cellulosic industry, there is also a strong interest in studying alternative procedural diagrams leading to the use of new products obtained from the manufacture of pulp, including compounds capable of being used as biofuels, especially bioethanol, creating a new concept of biorefineries.
This work aims to firstly get an overview of the current process diagrams of industrial production of biodiesel and bioethanol in the Iberian Peninsula in terms of economic and technological competitiveness in the face of tax laws and environmental regulations. In addition, the theme also aims to clarify some issues in terms of competitiveness of process diagrams currently used in industry, including:

- Technological and economic potential of obtaining biofuels from biorefineries, particularly in the pulp industry, with production at the same time of biofuels and bio-products;
- Technological and economic potential of industrial production of biodiesel from the isomerization and hydrogenation, of a series of vegetable fats, and also animal, made in the context of oil refineries.

2. Framework

The fuels of biological origin, based on photosynthesis, have the potential to reduce emissions of GHG and ensuring better energy use. In a political-economic perspective, a great advantage is to make importing countries more independent from suppliers of oil and natural gas. They have the added benefit of generating rural development, particularly through the use of underutilized land, securing jobs and supporting in this way, socially disadvantaged regions.
Biofuels have a wide variety of sources, and are differentiated according to two generations of the raw materials that are coming from. 1st Generation Biofuels (1G) are obtained from consumer goods that may also have food use. More specifically, it is 1G biodiesel produced from the transesterification reactions (FAME) of vegetable oils, such as soybean, rapeseed, and sunflower, and 1G bioethanol is produced from the fermentation of sugars contained in wheat, corn and sugarcane. 2nd Generation biofuels (2G) are made from materials considered non-food items, such as jatropha and other animal fats to produce biodiesel, and biomass crop residue (straw) or wood used in bioethanol production.

Biorefineries

Biorefineries allow us to produce 2G biofuels, since the raw material used is not for food use.
There are 1st Generation biorefineries, and in this group we can consider any factory that produces bio-value-added products from lignocecullosic material using their resources in an integrated way and that reuses the existing currents in the process to achieve is energy optimization, as is the case of modern pulp mills. The 2nd Generation biorefineries, have big differences with the 1st Generation ones concerning the technology that in this case can produce biofuels.
There is another type of biorefineries that can be considered as a 2nd Generation. These biorefineries will use the HVO process for producing biodiesel from vegetable oils of non-food crops.
Two processes allow the conversion of biomass into value-added products, not unique to 1G or 2G biorefinery. These processes are called Biochemical Platform and Thermochemical Platform.
The biochemical process is defined as the fractionation of biomass in its main components (cellulose, hemicellulose and lignin) for the fermentation of sugars that produces bioethanol and recovery of remaining waste (lignin).
Thermochemical Platform consists of a set of processes for thermal pretreatment of biomass that allows the production of synthesis gas as an intermediate for production of bioenergy, biofuels and biochemicals.
Depending on the technology used, it is possible to produce bioethanol and in some cases some bio-products. These may have

different classifications, which are presented in Table 1.

Table 1 – Classification of 2G biofuels from lignocellulosic raw materials.

Biofuel Group	Biofuel	Production Process
Bioethanol	Cellulosic Ethanol	Advanced Enzymatic Hydrolysis and Fermentation (Biochemical)
Syntetic Biofuels	Biomass-to-Liquids (BtL) Synthetic diesel, plug-Tropsch (FT) Heavy alcohols (methanol and mixtures) Dimethyl ether (DME)	Gasification and Synthesis (Thermochemical)
Methane	Biosynthetic Natural Gas (SNG)	Gasification and Synthesis (Thermochemical)
Bio--Hydrogen	Hydrogen	Gasification and Synthesis (Thermochemical) or Biological Processes (Biochemical)

There were identified 58 biorefineries working all around the world. Some of them, which we studied in more detail, are presented in Table 2.

Table 2 – 2^{nd} Generation biorefineries references in the production of bioethanol.

Name	Place	Technology	Type	Raw Materials	Production Capacity (t/y)
Borregaard	Norway	Biochemical	Commercial	Sulfite liquor	15.800
M-Real Hallein AG	Austria	Biochemical	Demo	Sulfite liquor	12.000
Coskata	EUA	Hybrid	Pilot	Several waste	?
Abengoa Bioenergy	Spain	Biochemical	Demo	Wheat straw and corn	4.000

3. Biofuels and sustainability

Socioeconomic perspective

In recent years, the importance of non-food crops has increased significantly. The need for the existence of these cultures, benefiting in the EU, from the availability of land from a previous system of compulsory set-a-side policy for food crops, creates an opportunity to increase the production of biodiesel in particular.

Some of the most common criticisms raised in relation to the development of 1^{st} Generation biofuels are the direct additional cost of biofuels, the impact it will have on food prices, increased demand for biofuels, and the threat to biodiversity because it could represent the large areas of intensive monocultures that this demand will result.

The high availability of arable land unproductive, especially in the tropical zone, where 70% of the land is arable, income and productivity are higher, leads to the logical conclusion that the prices of agricultural raw materials stabilize the expansion of investment in agricultural production.

The close link between oil prices and agricultural prices, mediated by the demand for biofuels, establishing a reference level for the prices of agricultural products - and which is determined by crude oil prices. When fossil fuel prices reach or exceed the cost of production of biofuels, the energy market will generate demand for agricultural products. If energy demand is high it will drag a greater consumption of agricultural raw materials for biofuels, as they become more competitive in the energy market, which will create a minimum price for certain agricultural products, imposed by the fossil fuel prices. However, agricultural prices cannot increase faster than energy prices or they are out of the energy market. Thus, as the size of the energy market is very large compared to the agricultural market, agricultural prices tend to be driven by energy prices.

The results of the study by FAO (Food and Agriculture Organization) and OECD (Organization for Economic Cooperation and Development) show a wide variation in the ability of different systems to provide economically competitive biofuels. The sugar cane is the lower cost raw material specially in Brazil. This is due to the availability of plantations of sugar cane land in Brazil that has existed for many years and is very extensive, and also due to the fact that the existing process for bioethanol production is already well developed and stabilized in terms of technology..

Note that the sugar beet used to produce bioethanol in the EU in 2007 apparently reached the market price of fossil fuels, making it extremely competitive.

In Portugal the share of 70,000 tons of sugar beet previously awarded to DAI (Society of Agro-Industrial Development) was reduced in 2007 and to 34,500 in 2008 to 15,000, and the company decided, after authorization by the European Commission, devotes himself exclusively to the refining of imported sugar

cane, thus enabling to produce beet in Portugal.

While the agricultural raw materials compete with fossil fuels in the energy market, agricultural crops also compete among themselves for productive resources. For example, a given plot of land can be used to grow corn for ethanol or wheat bread. When the demand equals the supply of biofuel crops used as feedstock, it tends to raise prices of all crops that have the same resource base.

For this reason, the production of biofuels from non-food crops will not necessarily eliminate the competition between food and fuel, in fact if the same land and other resources are needed for both food crops and raw materials for biofuels, their prices will move together, even if the cultivation of raw materials cannot be used for food.

Environmental Perspective

The life cycle analysis is the analytical tool used to calculate the amount of GHG emissions throughout the manufacturing process and the direct use of these products. Thus, the result obtained in this study is the result of a comparison of all emissions of GHG during the stages of production and use of biofuels. Although conceptually well established, the method is complex because it analyzes each component of the value chain to estimate GHG emissions.

Given the wide range of biofuels, raw materials and production technologies that exist, it would be expected a wide range of results in terms of emission reductions – which is actually the case. Most studies found that the production of 1st Generation biofuels resulted in emission reductions between 20% to 60% compared to fossil fuels, provided they are used the most efficient systems and emissions CO_2 resulting from changes in land use are excluded.

Table 3 presents the emissions reductions by the utilization of bioethanol and biodiesel produced from different raw materials.

Table 3 – Reduction of gas emissions of biofuels depending on the raw material.

	Raw Material	Total Emissions (g $CO_{2,eq}/MJ_{Biofuel}$)	Emissions Reduction
Bioethanol	Wheat	54,61	34,8%
	Sugar Beet	40,05	52,2%
Biodiesel	Rapeseed - FAME	51,75	38,2%
	Rapesees - HVO	44,24	47,2%

Brazil, which has long experience of producing bioethanol from sugar cane, shows even greater reductions in 2G biofuels, although insignificant in terms of trade, normally offer potential emission reductions of 70% to 90% compared to fossil diesel and gasoline, without release of CO_2 related to the change of land use.

Environmental impacts vary greatly between raw materials, production practices and locations, and depend critically on the form of land use. Replacing annual crops with perennial raw materials (such as palm oil, jatropha or perennial grasses) can improve the amount of carbon in the soil, but the conversion of tropical forests for the production of crops of any kind may release quantities of GHG which can greatly exceed the potential annual savings of biofuels. This will be the most important change to monitor land use.

Taking Advantage of Used Vegetable Oil

The cost of raw materials is an important factor in the economic viability of biodiesel production. The price of Used Cooking Oils (UCO) is from 2.5 to 3.5 times cheaper than virgin vegetable oils, therefore, can significantly reduce the total cost of manufacturing
biodiesel

A Recovery Plan of UCO was developed in Portugal for the production of biodiesel for self-consumption of municipal transport. It is an important aspect of energy recovery of waste which may, if well managed, have significant economic and environmental benefits.

After collection, the UCO are sent to a processing unit licensed for this purpose, where biodiesel is produced. In general terms, the technical solution adopted is based on the conversion of UCO into biodiesel, through the chemical process of transesterification.

Taking into account the evolution that has taken place in the waste treatment sector, and especially with regard to the implementation of policies to stimulate the pursuit of alternative energies, including biodiesel, a technical study of the economic life cycle of edible oils was promoted and its main

objective was to support the feasibility of a global management system.

The UCO have contributed to policy management and recovery of waste, with the benefit of improving the air quality in urban centers and reducing the energy bill of the municipality. This management is also covered by specific legislation that sets limits and obligations of municipalities involved.

4. Strategic Analysis of the Production and Consumption of Biofuels

As an overview, America is arguably the largest bioethanol producer in the world, with 54% market share, followed by Brazil with 34%. Far away from these countries is Europe, which presents an overall quota of 4% of the world production of bioethanol. Germany is the largest producer of biodiesel in the world with 16% market share, followed by France with 12% and USA with 11. Globally, for the production of biodiesel Europe has a much more significant share of 49% of the global market.

The Directive 2009/28/EC aims to establish a common goal to promote energy from renewable sources, including biofuels.

Each Member State has a target for the share of energy from renewable sources by the end of 2020. Moreover, the share of energy from renewable sources in transport must be at least 10% of the final energy consumption in this sector by 2020.

Portugal

Portugal began producing biodiesel in 2006, but to date does not yet produce bioethanol.

According to APPB (Portuguese Association of Biofuel Producers) biodiesel production in 2010 amounted to 441 million liters of biodiesel. The numbers are presented in Table 4.

Table 4 – Market statistics on the production of biodiesel in Portugal.

	2008	2009	2010	Total
Diesel Consumption (m^3)	5.431.293	5.761.775	5.841.763	28.430.100
Recommended Incorporation (m^3)	312.300	369.000	401.900	1.368.710
Held Incorporation (m^3)	169.300	294.100	441.000	1.168.900
Installed Capacity (m^3)	617.900	617.900	617.900	
Used Capacity	27%	48%	65%	

FAME is the process used by the five major players in the Portuguese market: the Iberrol, Prio Energy, Sovena, Torrejana and Biovegetal, and also by the small biodiesel producers who often use UCO for their production but have no relevant output for this analysis.

The main raw materials used in Portugal for the production of FAME biodiesel are: soybeans, rapeseed and palm. However, those who currently have a higher rate of use are rapeseed and soybeans, because palm oil is becoming unsustainable due to customs fees.

It appears that the endogenous resources are scarce, representing the current year only 1% of the total raw materials consumed.

In terms of exports of biodiesel, Portugal had in 2009, virtually nil.

Production quotas are presently allocated for biodiesel producers through TdB-D's (biodiesel titles). The early quota available to producers is the value of half of the production made in the previous year, and the surplus is up for the market. This will certainly motivate producers to compete more to ensure a greater share of titles.

The distribution chain in this industry operates inefficiently, without a strong vertical integration upstream or downstream. The biofuels industry has low control of the upstream supply chain. In the case of Sovena and Prio Energy, which have favorable locations can be considered to have a pro-business logistics integration.

Several factors hinder the entry of new competitors, including the initial investment and difficulties in access to distribution channels. The initial investment is usually very high due to the costs of building a manufacturing plant and distribution channels. To minimize the fixed costs is necessary to increase the amount of goods transported. When comparing the prices practiced in Portugal and Spain for the sale of diesel with biodiesel already incorporated, it appears that diesel by itself is slightly cheaper in Portugal. However, taxes in Portugal represent 44.6% of the total, while in Spain represent only 42.1%.

Spain

Spain began producing biodiesel in 2005, one year before Portugal. Bioethanol production also started in that year.

In 2009, in Spain there were about 45 producers of biofuels, of which four producers are of bioethanol.

Spain increased significantly its installed capacity for biodiesel production in 2009 to 4,213,057 m^3 (about 3,656,933 tons) and production reached 907,222 m3 (over 800,000 tons), representing 5% of the global market. Figure 1 presents the production and the production capacity of biodiesel in Spain in 2005, 2006 and 2007.

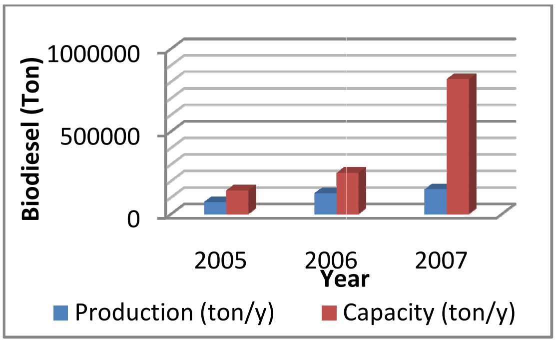

Figure 1 – Evolution of biodiesel production in Spain in relation to production capacity in 2005, 2006 and 2007.

The consumption of biodiesel this year was 1,169,626 m3 (about 1,016,665 tons).

Bioethanol is produced in Spain from traditional 1st Generation process, using the fermentation of sugars, or in some cases one more advanced technology from biomass, using the 2nd Generation processes mentioned.

In 2009 the installed capacity for bioethanol production was 569,000 m^3 (just over 500,000 tons) and production was 462,924 m3 (approximately 412.00 tons). Figure 2 shows the evolution of bioethanol production in 2005, 2006 and 2007.

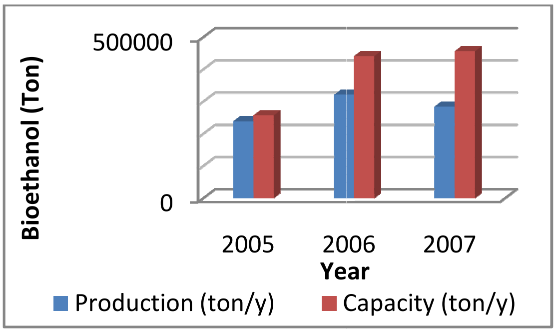

Figure 2 – Evolution of bioethanol production in Spain in relation to production capacity in 2005, 2006 and 2007.

The consumption of bioethanol in 2009 amounted to 299,158 m3 (approximately 236,035 tons) were exported about half of bioethanol.

For the production of biodiesel Spain imports more than 80% of the raw materials needed. The most commonly used raw materials for biodiesel production are soybean, palm oil, UCO, sunflower oil, rapeseed, animal fats and olive oil. The countries that export these raw materials to Spain are Indonesia, Argentina and Brazil.

For bioethanol production, about 45% of the raw materials are endogenous, the main ones being: corn, wheat, barley and wine alcohol.

The country that exports raw materials for bioethanol production in Spain is the United Kingdom, the remaining fraction coming mainly from European countries.

Despite the high production capacity, Spain relies on imports of biodiesel and bioethanol, which in 2009 accounted for approximately 31% and 36% respectively of the total consumption.

The reason for the situation is unclear, but may be explained by the fact that Spain is able in some periods to import biodiesel and bioethanol cheaper than those produced internally.

The study, assess that in Spain unlike Portugal, there are no quotas allocated to producers of biofuels, and consequently there are no limitations in terms of quantity of production, the Spanish producers not being protected by laws in force against imports.

In Spain the distribution chain in this industry works efficiently and there is a robust downstream vertical integration. The biofuels industry has no control of the upstream supply chain in case of biodiesel. Downstream there is some control on the clients because they have a favorable location next to the main Spanish refineries.

As many producers of FAME biodiesel have a consortium with the refineries, there is the possibility to add FAME directly into pipelines to terminals and logistic centers, allowing the ability to do the blending and also to import biofuels to coastal terminals.

The factors that hinder the entry of new competitors in the market are virtually the same as those identified in Portugal. The initial investment and difficulties in access to

distribution channels are the major problems. And given the fact that Spain has a production capacity for biodiesel almost four times its consumption, it will not be a good option to invest in a factory for the production of biodiesel.

Economies of scale are not considered a barrier to entry because the producers of biofuels produce below capacity.

Product differentiation is also not a relevant factor to promote biodiesel sales, it has only to ensure their quality according to EN 14214, in the case of biodiesel, and EN 15376 for bioethanol.

Minute Conclusions

From the strategic analysis carried out, we can verify that Portugal and Spain have built some competitive factors that allow them to maintain a position as producers of biofuels in their respective markets.

However, the big problem in Portugal is arguably the production cost of biodiesel that is considerably higher than fossil fuel production cost. However, this problem may be minimized by changing the raw materials used in production, including UCO for e.g.

Sugar beet may be competitive, as a raw material for the production of bioethanol but it requires a more detailed analysis, which does not fit the purpose of this work, but can be an interesting theme.

In Spain the production cost is not an obvious problem, because the addition of biodiesel to diesel fuel reduces its traditional final average price.

Spain has certainly interest to export biofuels, both biodiesel and bioethanol, because Spain has the capacity to produce more than twice what is currently producing.

The goals of biofuels incorporation required by the EU, the political forces to reduce GHG emissions and reducing the dependence on fossil fuels are clearly a strong driver for this market.

With regard to biorefineries that produce ethanol, Spain currently has one operating in Salamanca. In Portugal there is still no 2nd Generation biorefineries, but there is the potential of their existence in the future.

5. Biorefineries and the Future of Biofuels in the Iberian Peninsula

There are already some examples of 2nd Generation biorefineries laboring in the World (Borregaard, Coskata, M-Real and Abengoa), which could serve as examples of technologies to be adopted in Portugal and Spain.

Portugal

Pulp Industry

Portugal is a country with a strong pulp and paper industry, existing a possibility to incorporate 2nd Generation biorefineries in industrial premises, taking into account the technological and commercial context that may allow companies to produce 2nd Generation biofuels.

Analyzing this industry, we can see that Portugal is the 13th largest producer of pulp globally, and 5th at the European level, which gives it a relatively prominent position internationally.

Of the five existing stages in the production process of paper/pulp, there is one that is what matters for this analysis – the cooking and processing into wood pulp.

The major producers of national paper/pulp Caima – Altri Group, and Portucel/Soporcel, use chemical processes for the production of pulp/paper, including sulfite and kraft, respectively.

Caima uses the sulfite process to produce pulp.

It is known how to produce lignosulfonates, vanillin, ethanol and other value-added products in pulp mills. The best known case is the group Borregaard in Norway, already mentioned, where the main business is the production of specialty chemicals and pulp production is a secondary business.

It is common and has been known for decades that the fermentation of sugars from sulfite liquor in processes that use softwood forest species and where the main sugars are hexoses. However, the main source of raw material in Portugal is the species Eucalyptus globulus, due to its excellent skills for the production of paper, its rapid growth and high performance, supporting a low consumption of reagents.

Eucalyptus is a hardwood in which the main sugars are pentoses. The fermentation of pentoses into bioethanol production is a new technology, still in development, and there are yet no industrial facilities that make sulfite liquor fermentation for the production of bioethanol.

Still, Caima has been investing in the development of know-how in this area (2nd Generation biorefinery) in particular with the University of Aveiro, which has been developing the knowledge of wood chemistry and especially the eucalyptus, and published some scientific works.

Knowing the potential of black liquor including its use for the manufacture of bioethanol, xylose/xylitol, proteins, vanillin, lignosulfonates, and for the production of energy by evaporation of the remaining liquor in a recovery boiler, the next step would be to find a way to ferment the.

For the development of new technologies is also necessary to take some financial risk which is only accessible to big business,

In Portucel/Soporcel all plants (Setúbal, Cacia and Figueira da Foz) use the kraft process (also called sulfate process). At Portucel this liquor is used only for burning to produce energy, both electrical and thermal, which holds that these process can be considered 1st Generation biorefineries.

The Institute Raíz dedicated to R&D in the area of process optimization its currently underway two projects in forestry and process technology, indicating some strategic areas that Portucel is pursuing for the future.

The projects in question are:

• Pt-Lyptus Project, which aims at sustainable development of energy crops;

• BIIPP Project, which will run until 2013 in partnership with three Portuguese Universities (Porto, Aveiro and Coimbra), whose objectives are:

- Get the value-added products before the kraft process digestion – pre--extraction of sugar before baking, for bioethanol production;
- Increase use of waste streams in the kraft process-oriented production of bioethanol from conversion of primary sludge;
- Obtaining the components of the bark of Eucalyptus globulus, oriented to the extraction of triterpenes and phenolic compounds present in the bark.

Knowing that many projects have already been announced but unfortunately did not prove to be competitive, a source of Portucel states that they consider that investing in R&D is fundamental, but within 10 to 15 years will be difficult evolve from a 1st Generation biorefinery to a 2nd Generation biorefinery.

Other Projects

The Correio da Beira Serra published November 30, 2010 the news that BLC3 - Platform for Development of the Interior and Beiras Area (PDRIC) aims to transform Oliveira do Hospital municipality in an energetically self-sustaining area through renewable energy by of the "BioRefina-Ter."

Having already achieved the participation of 17 entities linked to the scientific world, a partnership that brings together some of the most prestigious universities in Portugal (Aveiro and Coimbra) and also two universities in Spain (Madrid and Bilbao), the "BioRefina-Ter" has also the participation of three major enterprise partners: Sonae Indústria, Galp Energia and the Spanish group Aurantia.

However, it is known that this project is about to apply for the QREN (National Strategic Reference Framework), and is expected to start in 2012 the construction of a pilot scale biorefinery. The technologies to use, it seems, are not yet defined, as well as what to produce as biofuels, the sub-products produced by the process or raw materials io be used, which are believed to be mostly forest residues, given the dual character of this project : to produce clean energy and to clean the forests.

Galp Energia has ongoing an analysis of a project that involves the production of biodiesel by the process HVO, incorporating it in Galp Energia's refinery in Sines, using in particular the hydrogen produced in the refining process of crude oil. This integration, if it were to materialize, will produce a new process type centered in the existing oil refinery complex that will produce 2nd Generation biodiesel.

There are currently two possible scenarios for this project:

1. From 2015, the HVO begins to be incorporated into the mineral diesel to supplement the FAME;
2. From 2015, Galp Energia will incorporate only HVO in diesel sold for the domestic market, ceasing to buy FAME biodiesel from domestic producers.

Therefore, this project of Galp Energia is an alternative solution to complement the incorporation of FAME in Portugal, and thus, be able to achieve the goal of 10% (by energy content) of the incorporation of renewable energy in transport in 2020.

Galp Energia has a fuel distribution network covering both Portugal and Spain, and so the two scenarios proposed for the implementation and marketing of HVO, allowthe opportunity to present itself as a reference operator in the area of biofuels, not only at national level but also at the level of the Iberian Peninsula.

Spain

As to the development of biorefineries in Spain was not possible to collect any relevant information.

It was already mentioned, the existence of a lignocellulosic based biorefinery laboring in demonstration scale in Salamanca, which belongs to Abengoa.

It is known that Spain already has the capacity to produce 1G bioethanol enough to meet the needs of the country, and even export some. Therefore, when compared with Portugal, Spain hasn't a greater need to find processes that enable the production of 2nd Generation bioethanol. It is believed, however, that there are R&D projects in development, most likely with Spanish universities, but it was not possible to obtain concrete data.

6. Main Conclusions and Future Work

The Iberian market of biofuels was analyzed, mainly on biodiesel production and current production methods, existing and alternative methods for producing bioethanol, especially from lignocellulosic material, thus having evaluated the concept of biorefinery, and the applicability of these methods to the market under study.

This study shows that Portugal and Spain have some potential as producers of biofuels, and that there are some areas for improvement to develop in the future.

Biodiesel producers both in Portugal and in Spain have higher production capacities than necessary to meet domestic consumption, and use the traditional method - FAME - to produce biodiesel. Spain has, however, a vertically integrated chain, which translates into greater control over the entire process involving biodiesel, something that is not the case in Portugal.

Portugal could become more competitive due to the technology of producing biodiesel from HVO proposed by Galp Energia. For the production of bioethanol there will probably be more difficult to achieve competitiveness in the market in the short to medium term since, as it turned out, there are not yet industrial facilities that enable the production of bioethanol.

There are however some points that were not covered or fully developed and can be considered as future work to develop this theme. Some of the outstanding issues are listed below:

- The theme of the UCO has a wide scope, where there are survey data that was impossible to obtain, and it would be important to get an overview with quantitative data collected about the OAU over the years, how much of it is turned into biodiesel and which percentage in market terms;
- Continue to follow the technological advances, its implementations and the points that make them more competitive;
- Understand how it is intended to introduce 2.5% (v/v) of bioethanol in gasoline in Portugal in 2015, to meet the targets set in Decree - Law No. 117 / 2010 of 25 October;
- Analyze more deeply the Spanish market in terms of technological development and investment in renewables, including biofuels.

Nomenclature

1G – First Generation
2G – Second Generation
EU – European Union
FAME – Fatty Acid Methyl Esther
GHG – Greenhouse Gases

HVO – Hydrogenated Vegetable Oils
R&D – Research and Development
UCO – Used Cooking Oils

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Strategic Analysis of Biofuels Production and Consumption in Portugal and Spain and the Prospects for Biorefineries Future Competitiveness

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Abstract

Concerns regarding Global Warming, the excessive reliance on petroleum and non-renewable energy sources in countries such as Portugal and Spain, which do not hold commercially significant reserves of hydrocarbons, and also with the high price per barrel of petroleum, has led European institutions to implement an optimization of the current energy framework.

Biofuels appear as renewable and inexhaustible energy sources, with the potential to replace fossil fuels. In a political/economical context, their great advantage is in turning countries more independent of suppliers of petroleum and natural gas. From an environmental standpoint, their use leads to the reduction in GHG emissions. Moreover, they provide the added benefit of engendering rural development, thus benefitting less developed regions.

In this scope, the search for a technological strategy for the use and economically sustainable production of biofuels, and, if possible, promote traditional agriculture and other activities in the rural areas of the Iberian Peninsula that favor the production of biodiesel as well as bioethanol, is the main objective of this Dissertation.

1. Introduction

The production and use of biofuels derived from renewable sources emerged in the 1970s, following the first two oil shocks and due to the awareness of the need to diversify energy sources and reduce dependence on oil. In Europe, the Agricultural Policy associated with motivations to improve the environment, led to the introduction of a line of production and use of biofuels in several EU countries.

Biofuels production in Europe has grown significantly since early 2000 as a result of rising oil prices and the existence of a favorable legislation adopted by the EU institutions.

The energy sector assumes in the world today, one of the R&D priorities n order to face the challenge of sustainable development. The importance of this sector is also the result of the need to reduce energy dependency of fossil fuels, since the global reserves are scarce and also by international commitments to reduce global GHG emissions.

To counter these developments, the European Member States are bound by international commitments and European Directives that commit themselves to jointly reduce their GHG by at least 5% compared to 1990 levels during the period 2008 to 2012, and Directive 2009/28/EC of 23 April, calling for the replacement of fossil fuels with alternative fuels.

The production and marketing of biofuels in the Iberian Peninsula is a well-established practice in recent years. In Portugal, the production focuses on biodiesel, in Spain there is also the industrial production of bioethanol, which makes the Iberian Peninsula an interesting market to study, compare and evaluate.
On the other hand, given that in Portugal there is a major cellulosic industry, there is also a strong interest in studying alternative procedural diagrams leading to the use of new products obtained from the manufacture of pulp, including compounds capable of being used as biofuels, especially bioethanol, creating a new concept of biorefineries.
This work aims to firstly get an overview of the current process diagrams of industrial production of biodiesel and bioethanol in the Iberian Peninsula in terms of economic and technological competitiveness in the face of tax laws and environmental regulations. In addition, the theme also aims to clarify some issues in terms of competitiveness of process diagrams currently used in industry, including:

- Technological and economic potential of obtaining biofuels from biorefineries, particularly in the pulp industry, with production at the same time of biofuels and bio-products;
- Technological and economic potential of industrial production of biodiesel from the isomerization and hydrogenation, of a series of vegetable fats, and also animal, made in the context of oil refineries.

2. Framework

The fuels of biological origin, based on photosynthesis, have the potential to reduce emissions of GHG and ensuring better energy use. In a political-economic perspective, a great advantage is to make importing countries more independent from suppliers of oil and natural gas. They have the added benefit of generating rural development, particularly through the use of underutilized land, securing jobs and supporting in this way, socially disadvantaged regions.
Biofuels have a wide variety of sources, and are differentiated according to two generations of the raw materials that are coming from. 1st Generation Biofuels (1G) are obtained from consumer goods that may also have food use. More specifically, it is 1G biodiesel produced from the transesterification reactions (FAME) of vegetable oils, such as soybean, rapeseed, and sunflower, and 1G bioethanol is produced from the fermentation of sugars contained in wheat, corn and sugarcane. 2nd Generation biofuels (2G) are made from materials considered non-food items, such as jatropha and other animal fats to produce biodiesel, and biomass crop residue (straw) or wood used in bioethanol production.

Biorefineries

Biorefineries allow us to produce 2G biofuels, since the raw material used is not for food use.
There are 1st Generation biorefineries, and in this group we can consider any factory that produces bio-value-added products from lignocecullosic material using their resources in an integrated way and that reuses the existing currents in the process to achieve is energy optimization, as is the case of modern pulp mills. The 2nd Generation biorefineries, have big differences with the 1st Generation ones concerning the technology that in this case can produce biofuels.
There is another type of biorefineries that can be considered as a 2nd Generation. These biorefineries will use the HVO process for producing biodiesel from vegetable oils of non-food crops.
Two processes allow the conversion of biomass into value-added products, not unique to 1G or 2G biorefinery. These processes are called Biochemical Platform and Thermochemical Platform.
The biochemical process is defined as the fractionation of biomass in its main components (cellulose, hemicellulose and lignin) for the fermentation of sugars that produces bioethanol and recovery of remaining waste (lignin).
Thermochemical Platform consists of a set of processes for thermal pretreatment of biomass that allows the production of synthesis gas as an intermediate for production of bioenergy, biofuels and biochemicals.
Depending on the technology used, it is possible to produce bioethanol and in some cases some bio-products. These may have

different classifications, which are presented in Table 1.

Table 1 – Classification of 2G biofuels from lignocellulosic raw materials.

Biofuel Group	Biofuel	Production Process
Bioethanol	Cellulosic Ethanol	Advanced Enzymatic Hydrolysis and Fermentation (Biochemical)
Syntetic Biofuels	Biomass-to-Liquids (BtL) Synthetic diesel, plug-Tropsch (FT) Heavy alcohols (methanol and mixtures) Dimethyl ether (DME)	Gasification and Synthesis (Thermochemical)
Methane	Biosynthetic Natural Gas (SNG)	Gasification and Synthesis (Thermochemical)
Bio--Hydrogen	Hydrogen	Gasification and Synthesis (Thermochemical) or Biological Processes (Biochemical)

There were identified 58 biorefineries working all around the world. Some of them, which we studied in more detail, are presented in Table 2.

Table 2 – 2nd Generation biorefineries references in the production of bioethanol.

Name	Place	Technology	Type	Raw Materials	Production Capacity (t/y)
Borregaard	Norway	Biochemical	Commercial	Sulfite liquor	15.800
M-Real Hallein AG	Austria	Biochemical	Demo	Sulfite liquor	12.000
Coskata	EUA	Hybrid	Pilot	Several waste	?
Abengoa Bioenergy	Spain	Biochemical	Demo	Wheat straw and corn	4.000

3. Biofuels and sustainability

Socioeconomic perspective

In recent years, the importance of non-food crops has increased significantly. The need for the existence of these cultures, benefiting in the EU, from the availability of land from a previous system of compulsory set-a-side policy for food crops, creates an opportunity to increase the production of biodiesel in particular.
Some of the most common criticisms raised in relation to the development of 1st Generation biofuels are the direct additional cost of biofuels, the impact it will have on food prices, increased demand for biofuels, and the threat to biodiversity because it could represent the large areas of intensive monocultures that this demand will result.
The high availability of arable land unproductive, especially in the tropical zone, where 70% of the land is arable, income and productivity are higher, leads to the logical conclusion that the prices of agricultural raw materials stabilize the expansion of investment in agricultural production.
The close link between oil prices and agricultural prices, mediated by the demand for biofuels, establishing a reference level for the prices of agricultural products - and which is determined by crude oil prices. When fossil fuel prices reach or exceed the cost of production of biofuels, the energy market will generate demand for agricultural products. If energy demand is high it will drag a greater consumption of agricultural raw materials for biofuels, as they become more competitive in the energy market, which will create a minimum price for certain agricultural products, imposed by the fossil fuel prices. However, agricultural prices cannot increase faster than energy prices or they are out of the energy market. Thus, as the size of the energy market is very large compared to the agricultural market, agricultural prices tend to be driven by energy prices.
The results of the study by FAO (Food and Agriculture Organization) and OECD (Organization for Economic Cooperation and Development) show a wide variation in the ability of different systems to provide economically competitive biofuels. The sugar cane is the lower cost raw material specially in Brazil. This is due to the availability of plantations of sugar cane land in Brazil that has existed for many years and is very extensive, and also due to the fact that the existing process for bioethanol production is already well developed and stabilized in terms of technology..
Note that the sugar beet used to produce bioethanol in the EU in 2007 apparently reached the market price of fossil fuels, making it extremely competitive.
In Portugal the share of 70,000 tons of sugar beet previously awarded to DAI (Society of Agro-Industrial Development) was reduced in 2007 and to 34,500 in 2008 to 15,000, and the company decided, after authorization by the European Commission, devotes himself exclusively to the refining of imported sugar

cane, thus enabling to produce beet in Portugal.

While the agricultural raw materials compete with fossil fuels in the energy market, agricultural crops also compete among themselves for productive resources. For example, a given plot of land can be used to grow corn for ethanol or wheat bread. When the demand equals the supply of biofuel crops used as feedstock, it tends to raise prices of all crops that have the same resource base.

For this reason, the production of biofuels from non-food crops will not necessarily eliminate the competition between food and fuel, in fact if the same land and other resources are needed for both food crops and raw materials for biofuels, their prices will move together, even if the cultivation of raw materials cannot be used for food.

Environmental Perspective

The life cycle analysis is the analytical tool used to calculate the amount of GHG emissions throughout the manufacturing process and the direct use of these products. Thus, the result obtained in this study is the result of a comparison of all emissions of GHG during the stages of production and use of biofuels. Although conceptually well established, the method is complex because it analyzes each component of the value chain to estimate GHG emissions.

Given the wide range of biofuels, raw materials and production technologies that exist, it would be expected a wide range of results in terms of emission reductions – which is actually the case. Most studies found that the production of 1st Generation biofuels resulted in emission reductions between 20% to 60% compared to fossil fuels, provided they are used the most efficient systems and emissions CO_2 resulting from changes in land use are excluded.

Table 3 presents the emissions reductions by the utilization of bioethanol and biodiesel produced from different raw materials.

Table 3 – Reduction of gas emissions of biofuels depending on the raw material.

	Raw Material	Total Emissions (g $CO_{2,eq}/MJ_{Biofuel}$)	Emissions Reduction
Bioethanol	Wheat	54,61	34,8%
	Sugar Beet	40,05	52,2%
Biodiesel	Rapeseed - FAME	51,75	38,2%
	Rapesees - HVO	44,24	47,2%

Brazil, which has long experience of producing bioethanol from sugar cane, shows even greater reductions in 2G biofuels, although insignificant in terms of trade, normally offer potential emission reductions of 70% to 90% compared to fossil diesel and gasoline, without release of CO_2 related to the change of land use.

Environmental impacts vary greatly between raw materials, production practices and locations, and depend critically on the form of land use. Replacing annual crops with perennial raw materials (such as palm oil, jatropha or perennial grasses) can improve the amount of carbon in the soil, but the conversion of tropical forests for the production of crops of any kind may release quantities of GHG which can greatly exceed the potential annual savings of biofuels. This will be the most important change to monitor land use.

Taking Advantage of Used Vegetable Oil

The cost of raw materials is an important factor in the economic viability of biodiesel production. The price of Used Cooking Oils (UCO) is from 2.5 to 3.5 times cheaper than virgin vegetable oils, therefore, can significantly reduce the total cost of manufacturing
biodiesel

A Recovery Plan of UCO was developed in Portugal for the production of biodiesel for self-consumption of municipal transport. It is an important aspect of energy recovery of waste which may, if well managed, have significant economic and environmental benefits.

After collection, the UCO are sent to a processing unit licensed for this purpose, where biodiesel is produced. In general terms, the technical solution adopted is based on the conversion of UCO into biodiesel, through the chemical process of transesterification.

Taking into account the evolution that has taken place in the waste treatment sector, and especially with regard to the implementation of policies to stimulate the pursuit of alternative energies, including biodiesel, a technical study of the economic life cycle of edible oils was promoted and its main

objective was to support the feasibility of a global management system.

The UCO have contributed to policy management and recovery of waste, with the benefit of improving the air quality in urban centers and reducing the energy bill of the municipality. This management is also covered by specific legislation that sets limits and obligations of municipalities involved.

4. Strategic Analysis of the Production and Consumption of Biofuels

As an overview, America is arguably the largest bioethanol producer in the world, with 54% market share, followed by Brazil with 34%. Far away from these countries is Europe, which presents an overall quota of 4% of the world production of bioethanol. Germany is the largest producer of biodiesel in the world with 16% market share, followed by France with 12% and USA with 11. Globally, for the production of biodiesel Europe has a much more significant share of 49% of the global market.

The Directive 2009/28/EC aims to establish a common goal to promote energy from renewable sources, including biofuels.

Each Member State has a target for the share of energy from renewable sources by the end of 2020. Moreover, the share of energy from renewable sources in transport must be at least 10% of the final energy consumption in this sector by 2020.

Portugal

Portugal began producing biodiesel in 2006, but to date does not yet produce bioethanol.

According to APPB (Portuguese Association of Biofuel Producers) biodiesel production in 2010 amounted to 441 million liters of biodiesel. The numbers are presented in Table 4.

Table 4 – Market statistics on the production of biodiesel in Portugal.

	2008	2009	2010	Total
Diesel Consumption (m^3)	5.431.293	5.761.775	5.841.763	28.430.100
Recommended Incorporation (m^3)	312.300	369.000	401.900	1.368.710
Held Incorporation (m^3)	169.300	294.100	441.000	1.168.900
Installed Capacity (m^3)	617.900	617.900	617.900	
Used Capacity	27%	48%	65%	

FAME is the process used by the five major players in the Portuguese market: the Iberrol, Prio Energy, Sovena, Torrejana and Biovegetal, and also by the small biodiesel producers who often use UCO for their production but have no relevant output for this analysis.

The main raw materials used in Portugal for the production of FAME biodiesel are: soybeans, rapeseed and palm. However, those who currently have a higher rate of use are rapeseed and soybeans, because palm oil is becoming unsustainable due to customs fees.

It appears that the endogenous resources are scarce, representing the current year only 1% of the total raw materials consumed.

In terms of exports of biodiesel, Portugal had in 2009, virtually nil.

Production quotas are presently allocated for biodiesel producers through TdB-D's (biodiesel titles). The early quota available to producers is the value of half of the production made in the previous year, and the surplus is up for the market. This will certainly motivate producers to compete more to ensure a greater share of titles.

The distribution chain in this industry operates inefficiently, without a strong vertical integration upstream or downstream. The biofuels industry has low control of the upstream supply chain. In the case of Sovena and Prio Energy, which have favorable locations can be considered to have a pro-business logistics integration.

Several factors hinder the entry of new competitors, including the initial investment and difficulties in access to distribution channels. The initial investment is usually very high due to the costs of building a manufacturing plant and distribution channels. To minimize the fixed costs is necessary to increase the amount of goods transported. When comparing the prices practiced in Portugal and Spain for the sale of diesel with biodiesel already incorporated, it appears that diesel by itself is slightly cheaper in Portugal. However, taxes in Portugal represent 44.6% of the total, while in Spain represent only 42.1%.

Spain

Spain began producing biodiesel in 2005, one year before Portugal. Bioethanol production also started in that year.

In 2009, in Spain there were about 45 producers of biofuels, of which four producers are of bioethanol.

Spain increased significantly its installed capacity for biodiesel production in 2009 to 4,213,057 m^3 (about 3,656,933 tons) and production reached 907,222 m3 (over 800,000 tons), representing 5% of the global market. Figure 1 presents the production and the production capacity of biodiesel in Spain in 2005, 2006 and 2007.

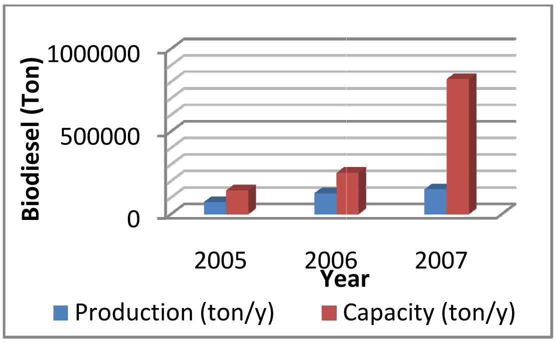

Figure 1 – Evolution of biodiesel production in Spain in relation to production capacity in 2005, 2006 and 2007.

The consumption of biodiesel this year was 1,169,626 m3 (about 1,016,665 tons).

Bioethanol is produced in Spain from traditional 1st Generation process, using the fermentation of sugars, or in some cases one more advanced technology from biomass, using the 2nd Generation processes mentioned.

In 2009 the installed capacity for bioethanol production was 569,000 m^3 (just over 500,000 tons) and production was 462,924 m3 (approximately 412.00 tons). Figure 2 shows the evolution of bioethanol production in 2005, 2006 and 2007.

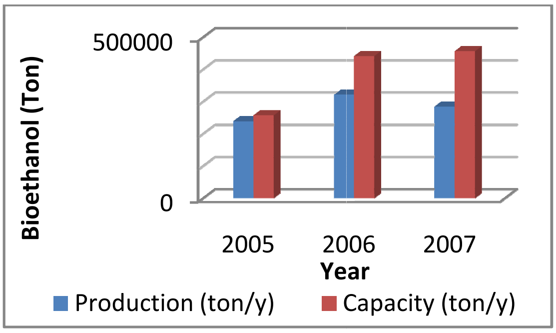

Figure 2 – Evolution of bioethanol production in Spain in relation to production capacity in 2005, 2006 and 2007.

The consumption of bioethanol in 2009 amounted to 299,158 m3 (approximately 236,035 tons) were exported about half of bioethanol.

For the production of biodiesel Spain imports more than 80% of the raw materials needed. The most commonly used raw materials for biodiesel production are soybean, palm oil, UCO, sunflower oil, rapeseed, animal fats and olive oil. The countries that export these raw materials to Spain are Indonesia, Argentina and Brazil.

For bioethanol production, about 45% of the raw materials are endogenous, the main ones being: corn, wheat, barley and wine alcohol.

The country that exports raw materials for bioethanol production in Spain is the United Kingdom, the remaining fraction coming mainly from European countries.

Despite the high production capacity, Spain relies on imports of biodiesel and bioethanol, which in 2009 accounted for approximately 31% and 36% respectively of the total consumption.

The reason for the situation is unclear, but may be explained by the fact that Spain is able in some periods to import biodiesel and bioethanol cheaper than those produced internally.

The study, assess that in Spain unlike Portugal, there are no quotas allocated to producers of biofuels, and consequently there are no limitations in terms of quantity of production, the Spanish producers not being protected by laws in force against imports.

In Spain the distribution chain in this industry works efficiently and there is a robust downstream vertical integration. The biofuels industry has no control of the upstream supply chain in case of biodiesel. Downstream there is some control on the clients because they have a favorable location next to the main Spanish refineries.

As many producers of FAME biodiesel have a consortium with the refineries, there is the possibility to add FAME directly into pipelines to terminals and logistic centers, allowing the ability to do the blending and also to import biofuels to coastal terminals.

The factors that hinder the entry of new competitors in the market are virtually the same as those identified in Portugal. The initial investment and difficulties in access to

distribution channels are the major problems. And given the fact that Spain has a production capacity for biodiesel almost four times its consumption, it will not be a good option to invest in a factory for the production of biodiesel.

Economies of scale are not considered a barrier to entry because the producers of biofuels produce below capacity.

Product differentiation is also not a relevant factor to promote biodiesel sales, it has only to ensure their quality according to EN 14214, in the case of biodiesel, and EN 15376 for bioethanol.

Minute Conclusions

From the strategic analysis carried out, we can verify that Portugal and Spain have built some competitive factors that allow them to maintain a position as producers of biofuels in their respective markets.

However, the big problem in Portugal is arguably the production cost of biodiesel that is considerably higher than fossil fuel production cost. However, this problem may be minimized by changing the raw materials used in production, including UCO for e.g.

Sugar beet may be competitive, as a raw material for the production of bioethanol but it requires a more detailed analysis, which does not fit the purpose of this work, but can be an interesting theme.

In Spain the production cost is not an obvious problem, because the addition of biodiesel to diesel fuel reduces its traditional final average price.

Spain has certainly interest to export biofuels, both biodiesel and bioethanol, because Spain has the capacity to produce more than twice what is currently producing.

The goals of biofuels incorporation required by the EU, the political forces to reduce GHG emissions and reducing the dependence on fossil fuels are clearly a strong driver for this market.

With regard to biorefineries that produce ethanol, Spain currently has one operating in Salamanca. In Portugal there is still no 2nd Generation biorefineries, but there is the potential of their existence in the future.

5. Biorefineries and the Future of Biofuels in the Iberian Peninsula

There are already some examples of 2nd Generation biorefineries laboring in the World (Borregaard, Coskata, M-Real and Abengoa), which could serve as examples of technologies to be adopted in Portugal and Spain.

Portugal

Pulp Industry

Portugal is a country with a strong pulp and paper industry, existing a possibility to incorporate 2nd Generation biorefineries in industrial premises, taking into account the technological and commercial context that may allow companies to produce 2nd Generation biofuels.

Analyzing this industry, we can see that Portugal is the 13th largest producer of pulp globally, and 5th at the European level, which gives it a relatively prominent position internationally.

Of the five existing stages in the production process of paper/pulp, there is one that is what matters for this analysis – the cooking and processing into wood pulp.

The major producers of national paper/pulp Caima – Altri Group, and Portucel/Soporcel, use chemical processes for the production of pulp/paper, including sulfite and kraft, respectively.

Caima uses the sulfite process to produce pulp.

It is known how to produce lignosulfonates, vanillin, ethanol and other value-added products in pulp mills. The best known case is the group Borregaard in Norway, already mentioned, where the main business is the production of specialty chemicals and pulp production is a secondary business.

It is common and has been known for decades that the fermentation of sugars from sulfite liquor in processes that use softwood forest species and where the main sugars are hexoses. However, the main source of raw material in Portugal is the species Eucalyptus globulus, due to its excellent skills for the production of paper, its rapid growth and high performance, supporting a low consumption of reagents.

Eucalyptus is a hardwood in which the main sugars are pentoses. The fermentation of pentoses into bioethanol production is a new technology, still in development, and there are yet no industrial facilities that make sulfite liquor fermentation for the production of bioethanol.

Still, Caima has been investing in the development of know-how in this area (2nd Generation biorefinery) in particular with the University of Aveiro, which has been developing the knowledge of wood chemistry and especially the eucalyptus, and published some scientific works.

Knowing the potential of black liquor including its use for the manufacture of bioethanol, xylose/xylitol, proteins, vanillin, lignosulfonates, and for the production of energy by evaporation of the remaining liquor in a recovery boiler, the next step would be to find a way to ferment the.

For the development of new technologies is also necessary to take some financial risk which is only accessible to big business,

In Portucel/Soporcel all plants (Setúbal, Cacia and Figueira da Foz) use the kraft process (also called sulfate process). At Portucel this liquor is used only for burning to produce energy, both electrical and thermal, which holds that these process can be considered 1st Generation biorefineries.

The Institute Raíz dedicated to R&D in the area of process optimization its currently underway two projects in forestry and process technology, indicating some strategic areas that Portucel is pursuing for the future.

The projects in question are:

• Pt-Lyptus Project, which aims at sustainable development of energy crops;

• BIIPP Project, which will run until 2013 in partnership with three Portuguese Universities (Porto, Aveiro and Coimbra), whose objectives are:

- Get the value-added products before the kraft process digestion – pre--extraction of sugar before baking, for bioethanol production;
- Increase use of waste streams in the kraft process-oriented production of bioethanol from conversion of primary sludge;
- Obtaining the components of the bark of Eucalyptus globulus, oriented to the extraction of triterpenes and phenolic compounds present in the bark.

Knowing that many projects have already been announced but unfortunately did not prove to be competitive, a source of Portucel states that they consider that investing in R&D is fundamental, but within 10 to 15 years will be difficult evolve from a 1st Generation biorefinery to a 2nd Generation biorefinery.

Other Projects

The Correio da Beira Serra published November 30, 2010 the news that BLC3 - Platform for Development of the Interior and Beiras Area (PDRIC) aims to transform Oliveira do Hospital municipality in an energetically self-sustaining area through renewable energy by of the "BioRefina-Ter."

Having already achieved the participation of 17 entities linked to the scientific world, a partnership that brings together some of the most prestigious universities in Portugal (Aveiro and Coimbra) and also two universities in Spain (Madrid and Bilbao), the "BioRefina-Ter" has also the participation of three major enterprise partners: Sonae Indústria, Galp Energia and the Spanish group Aurantia.

However, it is known that this project is about to apply for the QREN (National Strategic Reference Framework), and is expected to start in 2012 the construction of a pilot scale biorefinery. The technologies to use, it seems, are not yet defined, as well as what to produce as biofuels, the sub-products produced by the process or raw materials io be used, which are believed to be mostly forest residues, given the dual character of this project : to produce clean energy and to clean the forests.

Galp Energia has ongoing an analysis of a project that involves the production of biodiesel by the process HVO, incorporating it in Galp Energia's refinery in Sines, using in particular the hydrogen produced in the refining process of crude oil. This integration, if it were to materialize, will produce a new process type centered in the existing oil refinery complex that will produce 2nd Generation biodiesel.

There are currently two possible scenarios for this project:

1. From 2015, the HVO begins to be incorporated into the mineral diesel to supplement the FAME;
2. From 2015, Galp Energia will incorporate only HVO in diesel sold for the domestic market, ceasing to buy FAME biodiesel from domestic producers.

Therefore, this project of Galp Energia is an alternative solution to complement the incorporation of FAME in Portugal, and thus, be able to achieve the goal of 10% (by energy content) of the incorporation of renewable energy in transport in 2020.

Galp Energia has a fuel distribution network covering both Portugal and Spain, and so the two scenarios proposed for the implementation and marketing of HVO, allowthe opportunity to present itself as a reference operator in the area of biofuels, not only at national level but also at the level of the Iberian Peninsula.

Spain

As to the development of biorefineries in Spain was not possible to collect any relevant information.

It was already mentioned, the existence of a lignocellulosic based biorefinery laboring in demonstration scale in Salamanca, which belongs to Abengoa.

It is known that Spain already has the capacity to produce 1G bioethanol enough to meet the needs of the country, and even export some. Therefore, when compared with Portugal, Spain hasn't a greater need to find processes that enable the production of 2nd Generation bioethanol. It is believed, however, that there are R&D projects in development, most likely with Spanish universities, but it was not possible to obtain concrete data.

6. Main Conclusions and Future Work

The Iberian market of biofuels was analyzed, mainly on biodiesel production and current production methods, existing and alternative methods for producing bioethanol, especially from lignocellulosic material, thus having evaluated the concept of biorefinery, and the applicability of these methods to the market under study.

This study shows that Portugal and Spain have some potential as producers of biofuels, and that there are some areas for improvement to develop in the future.

Biodiesel producers both in Portugal and in Spain have higher production capacities than necessary to meet domestic consumption, and use the traditional method - FAME - to produce biodiesel. Spain has, however, a vertically integrated chain, which translates into greater control over the entire process involving biodiesel, something that is not the case in Portugal.

Portugal could become more competitive due to the technology of producing biodiesel from HVO proposed by Galp Energia. For the production of bioethanol there will probably be more difficult to achieve competitiveness in the market in the short to medium term since, as it turned out, there are not yet industrial facilities that enable the production of bioethanol.

There are however some points that were not covered or fully developed and can be considered as future work to develop this theme. Some of the outstanding issues are listed below:

- The theme of the UCO has a wide scope, where there are survey data that was impossible to obtain, and it would be important to get an overview with quantitative data collected about the OAU over the years, how much of it is turned into biodiesel and which percentage in market terms;
- Continue to follow the technological advances, its implementations and the points that make them more competitive;
- Understand how it is intended to introduce 2.5% (v/v) of bioethanol in gasoline in Portugal in 2015, to meet the targets set in Decree - Law No. 117 / 2010 of 25 October;
- Analyze more deeply the Spanish market in terms of technological development and investment in renewables, including biofuels.

Nomenclature

1G – First Generation
2G – Second Generation
EU – European Union
FAME – Fatty Acid Methyl Esther
GHG – Greenhouse Gases

HVO – Hydrogenated Vegetable Oils
R&D – Research and Development
UCO – Used Cooking Oils

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Strategic Analysis of Biofuels Production and Consumption in Portugal and Spain and the Prospects for Biorefineries Future Competitiveness

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Abstract

Concerns regarding Global Warming, the excessive reliance on petroleum and non-renewable energy sources in countries such as Portugal and Spain, which do not hold commercially significant reserves of hydrocarbons, and also with the high price per barrel of petroleum, has led European institutions to implement an optimization of the current energy framework.

Biofuels appear as renewable and inexhaustible energy sources, with the potential to replace fossil fuels. In a political/economical context, their great advantage is in turning countries more independent of suppliers of petroleum and natural gas. From an environmental standpoint, their use leads to the reduction in GHG emissions. Moreover, they provide the added benefit of engendering rural development, thus benefitting less developed regions.

In this scope, the search for a technological strategy for the use and economically sustainable production of biofuels, and, if possible, promote traditional agriculture and other activities in the rural areas of the Iberian Peninsula that favor the production of biodiesel as well as bioethanol, is the main objective of this Dissertation.

1. Introduction

The production and use of biofuels derived from renewable sources emerged in the 1970s, following the first two oil shocks and due to the awareness of the need to diversify energy sources and reduce dependence on oil. In Europe, the Agricultural Policy associated with motivations to improve the environment, led to the introduction of a line of production and use of biofuels in several EU countries.

Biofuels production in Europe has grown significantly since early 2000 as a result of rising oil prices and the existence of a favorable legislation adopted by the EU institutions.

The energy sector assumes in the world today, one of the R&D priorities n order to face the challenge of sustainable development. The importance of this sector is also the result of the need to reduce energy dependency of fossil fuels, since the global reserves are scarce and also by international commitments to reduce global GHG emissions.

To counter these developments, the European Member States are bound by international commitments and European Directives that commit themselves to jointly reduce their GHG by at least 5% compared to 1990 levels during the period 2008 to 2012, and Directive 2009/28/EC of 23 April, calling for the replacement of fossil fuels with alternative fuels.

The production and marketing of biofuels in the Iberian Peninsula is a well-established practice in recent years. In Portugal, the production focuses on biodiesel, in Spain there is also the industrial production of bioethanol, which makes the Iberian Peninsula an interesting market to study, compare and evaluate.

On the other hand, given that in Portugal there is a major cellulosic industry, there is also a strong interest in studying alternative procedural diagrams leading to the use of new products obtained from the manufacture of pulp, including compounds capable of being used as biofuels, especially bioethanol, creating a new concept of biorefineries.

This work aims to firstly get an overview of the current process diagrams of industrial production of biodiesel and bioethanol in the Iberian Peninsula in terms of economic and technological competitiveness in the face of tax laws and environmental regulations. In addition, the theme also aims to clarify some issues in terms of competitiveness of process diagrams currently used in industry, including:

- Technological and economic potential of obtaining biofuels from biorefineries, particularly in the pulp industry, with production at the same time of biofuels and bio-products;
- Technological and economic potential of industrial production of biodiesel from the isomerization and hydrogenation, of a series of vegetable fats, and also animal, made in the context of oil refineries.

2. Framework

The fuels of biological origin, based on photosynthesis, have the potential to reduce emissions of GHG and ensuring better energy use. In a political-economic perspective, a great advantage is to make importing countries more independent from suppliers of oil and natural gas. They have the added benefit of generating rural development, particularly through the use of underutilized land, securing jobs and supporting in this way, socially disadvantaged regions.

Biofuels have a wide variety of sources, and are differentiated according to two generations of the raw materials that are coming from. 1st Generation Biofuels (1G) are obtained from consumer goods that may also have food use. More specifically, it is 1G biodiesel produced from the transesterification reactions (FAME) of vegetable oils, such as soybean, rapeseed, and sunflower, and 1G bioethanol is produced from the fermentation of sugars contained in wheat, corn and sugarcane. 2nd Generation biofuels (2G) are made from materials considered non-food items, such as jatropha and other animal fats to produce biodiesel, and biomass crop residue (straw) or wood used in bioethanol production.

Biorefineries

Biorefineries allow us to produce 2G biofuels, since the raw material used is not for food use.

There are 1st Generation biorefineries, and in this group we can consider any factory that produces bio-value-added products from lignocecullosic material using their resources in an integrated way and that reuses the existing currents in the process to achieve is energy optimization, as is the case of modern pulp mills. The 2nd Generation biorefineries, have big differences with the 1st Generation ones concerning the technology that in this case can produce biofuels.

There is another type of biorefineries that can be considered as a 2nd Generation. These biorefineries will use the HVO process for producing biodiesel from vegetable oils of non-food crops.

Two processes allow the conversion of biomass into value-added products, not unique to 1G or 2G biorefinery. These processes are called Biochemical Platform and Thermochemical Platform.

The biochemical process is defined as the fractionation of biomass in its main components (cellulose, hemicellulose and lignin) for the fermentation of sugars that produces bioethanol and recovery of remaining waste (lignin).

Thermochemical Platform consists of a set of processes for thermal pretreatment of biomass that allows the production of synthesis gas as an intermediate for production of bioenergy, biofuels and biochemicals.

Depending on the technology used, it is possible to produce bioethanol and in some cases some bio-products. These may have

different classifications, which are presented in Table 1.

Table 1 – Classification of 2G biofuels from lignocellulosic raw materials.

Biofuel Group	Biofuel	Production Process
Bioethanol	Cellulosic Ethanol	Advanced Enzymatic Hydrolysis and Fermentation (Biochemical)
Syntetic Biofuels	Biomass-to-Liquids (BtL) Synthetic diesel, plug-Tropsch (FT) Heavy alcohols (methanol and mixtures) Dimethyl ether (DME)	Gasification and Synthesis (Thermochemical)
Methane	Biosynthetic Natural Gas (SNG)	Gasification and Synthesis (Thermochemical)
Bio--Hydrogen	Hydrogen	Gasification and Synthesis (Thermochemical) or Biological Processes (Biochemical)

There were identified 58 biorefineries working all around the world. Some of them, which we studied in more detail, are presented in Table 2.

Table 2 – 2nd Generation biorefineries references in the production of bioethanol.

Name	Place	Technology	Type	Raw Materials	Production Capacity (t/y)
Borregaard	Norway	Biochemical	Commercial	Sulfite liquor	15.800
M-Real Hallein AG	Austria	Biochemical	Demo	Sulfite liquor	12.000
Coskata	EUA	Hybrid	Pilot	Several waste	?
Abengoa Bioenergy	Spain	Biochemical	Demo	Wheat straw and corn	4.000

3. Biofuels and sustainability

Socioeconomic perspective

In recent years, the importance of non-food crops has increased significantly. The need for the existence of these cultures, benefiting in the EU, from the availability of land from a previous system of compulsory set-a-side policy for food crops, creates an opportunity to increase the production of biodiesel in particular.

Some of the most common criticisms raised in relation to the development of 1st Generation biofuels are the direct additional cost of biofuels, the impact it will have on food prices, increased demand for biofuels, and the threat to biodiversity because it could represent the large areas of intensive monocultures that this demand will result.

The high availability of arable land unproductive, especially in the tropical zone, where 70% of the land is arable, income and productivity are higher, leads to the logical conclusion that the prices of agricultural raw materials stabilize the expansion of investment in agricultural production.

The close link between oil prices and agricultural prices, mediated by the demand for biofuels, establishing a reference level for the prices of agricultural products - and which is determined by crude oil prices. When fossil fuel prices reach or exceed the cost of production of biofuels, the energy market will generate demand for agricultural products. If energy demand is high it will drag a greater consumption of agricultural raw materials for biofuels, as they become more competitive in the energy market, which will create a minimum price for certain agricultural products, imposed by the fossil fuel prices. However, agricultural prices cannot increase faster than energy prices or they are out of the energy market. Thus, as the size of the energy market is very large compared to the agricultural market, agricultural prices tend to be driven by energy prices.

The results of the study by FAO (Food and Agriculture Organization) and OECD (Organization for Economic Cooperation and Development) show a wide variation in the ability of different systems to provide economically competitive biofuels. The sugar cane is the lower cost raw material specially in Brazil. This is due to the availability of plantations of sugar cane land in Brazil that has existed for many years and is very extensive, and also due to the fact that the existing process for bioethanol production is already well developed and stabilized in terms of technology..

Note that the sugar beet used to produce bioethanol in the EU in 2007 apparently reached the market price of fossil fuels, making it extremely competitive.

In Portugal the share of 70,000 tons of sugar beet previously awarded to DAI (Society of Agro-Industrial Development) was reduced in 2007 and to 34,500 in 2008 to 15,000, and the company decided, after authorization by the European Commission, devotes himself exclusively to the refining of imported sugar

cane, thus enabling to produce beet in Portugal.

While the agricultural raw materials compete with fossil fuels in the energy market, agricultural crops also compete among themselves for productive resources. For example, a given plot of land can be used to grow corn for ethanol or wheat bread. When the demand equals the supply of biofuel crops used as feedstock, it tends to raise prices of all crops that have the same resource base.

For this reason, the production of biofuels from non-food crops will not necessarily eliminate the competition between food and fuel, in fact if the same land and other resources are needed for both food crops and raw materials for biofuels, their prices will move together, even if the cultivation of raw materials cannot be used for food.

Environmental Perspective

The life cycle analysis is the analytical tool used to calculate the amount of GHG emissions throughout the manufacturing process and the direct use of these products. Thus, the result obtained in this study is the result of a comparison of all emissions of GHG during the stages of production and use of biofuels. Although conceptually well established, the method is complex because it analyzes each component of the value chain to estimate GHG emissions.

Given the wide range of biofuels, raw materials and production technologies that exist, it would be expected a wide range of results in terms of emission reductions – which is actually the case. Most studies found that the production of 1^{st} Generation biofuels resulted in emission reductions between 20% to 60% compared to fossil fuels, provided they are used the most efficient systems and emissions CO_2 resulting from changes in land use are excluded.

Table 3 presents the emissions reductions by the utilization of bioethanol and biodiesel produced from different raw materials.

Table 3 – Reduction of gas emissions of biofuels depending on the raw material.

	Raw Material	Total Emissions (g $CO_{2,eq}/MJ_{Biofuel}$)	Emissions Reduction
Bioethanol	Wheat	54,61	34,8%
	Sugar Beet	40,05	52,2%
Biodiesel	Rapeseed - FAME	51,75	38,2%
	Rapesees - HVO	44,24	47,2%

Brazil, which has long experience of producing bioethanol from sugar cane, shows even greater reductions in 2G biofuels, although insignificant in terms of trade, normally offer potential emission reductions of 70% to 90% compared to fossil diesel and gasoline, without release of CO_2 related to the change of land use.

Environmental impacts vary greatly between raw materials, production practices and locations, and depend critically on the form of land use. Replacing annual crops with perennial raw materials (such as palm oil, jatropha or perennial grasses) can improve the amount of carbon in the soil, but the conversion of tropical forests for the production of crops of any kind may release quantities of GHG which can greatly exceed the potential annual savings of biofuels. This will be the most important change to monitor land use.

Taking Advantage of Used Vegetable Oil

The cost of raw materials is an important factor in the economic viability of biodiesel production. The price of Used Cooking Oils (UCO) is from 2.5 to 3.5 times cheaper than virgin vegetable oils, therefore, can significantly reduce the total cost of manufacturing
biodiesel

A Recovery Plan of UCO was developed in Portugal for the production of biodiesel for self-consumption of municipal transport. It is an important aspect of energy recovery of waste which may, if well managed, have significant economic and environmental benefits.

After collection, the UCO are sent to a processing unit licensed for this purpose, where biodiesel is produced. In general terms, the technical solution adopted is based on the conversion of UCO into biodiesel, through the chemical process of transesterification.

Taking into account the evolution that has taken place in the waste treatment sector, and especially with regard to the implementation of policies to stimulate the pursuit of alternative energies, including biodiesel, a technical study of the economic life cycle of edible oils was promoted and its main

objective was to support the feasibility of a global management system.

The UCO have contributed to policy management and recovery of waste, with the benefit of improving the air quality in urban centers and reducing the energy bill of the municipality. This management is also covered by specific legislation that sets limits and obligations of municipalities involved.

4. Strategic Analysis of the Production and Consumption of Biofuels

As an overview, America is arguably the largest bioethanol producer in the world, with 54% market share, followed by Brazil with 34%. Far away from these countries is Europe, which presents an overall quota of 4% of the world production of bioethanol. Germany is the largest producer of biodiesel in the world with 16% market share, followed by France with 12% and USA with 11. Globally, for the production of biodiesel Europe has a much more significant share of 49% of the global market.

The Directive 2009/28/EC aims to establish a common goal to promote energy from renewable sources, including biofuels.

Each Member State has a target for the share of energy from renewable sources by the end of 2020. Moreover, the share of energy from renewable sources in transport must be at least 10% of the final energy consumption in this sector by 2020.

Portugal

Portugal began producing biodiesel in 2006, but to date does not yet produce bioethanol.

According to APPB (Portuguese Association of Biofuel Producers) biodiesel production in 2010 amounted to 441 million liters of biodiesel. The numbers are presented in Table 4.

Table 4 – Market statistics on the production of biodiesel in Portugal.

	2008	2009	2010	Total
Diesel Consumption (m^3)	5.431.293	5.761.775	5.841.763	28.430.100
Recommended Incorporation (m^3)	312.300	369.000	401.900	1.368.710
Held Incorporation (m^3)	169.300	294.100	441.000	1.168.900
Installed Capacity (m^3)	617.900	617.900	617.900	
Used Capacity	27%	48%	65%	

FAME is the process used by the five major players in the Portuguese market: the Iberrol, Prio Energy, Sovena, Torrejana and Biovegetal, and also by the small biodiesel producers who often use UCO for their production but have no relevant output for this analysis.

The main raw materials used in Portugal for the production of FAME biodiesel are: soybeans, rapeseed and palm. However, those who currently have a higher rate of use are rapeseed and soybeans, because palm oil is becoming unsustainable due to customs fees.

It appears that the endogenous resources are scarce, representing the current year only 1% of the total raw materials consumed.

In terms of exports of biodiesel, Portugal had in 2009, virtually nil.

Production quotas are presently allocated for biodiesel producers through TdB-D's (biodiesel titles). The early quota available to producers is the value of half of the production made in the previous year, and the surplus is up for the market. This will certainly motivate producers to compete more to ensure a greater share of titles.

The distribution chain in this industry operates inefficiently, without a strong vertical integration upstream or downstream. The biofuels industry has low control of the upstream supply chain. In the case of Sovena and Prio Energy, which have favorable locations can be considered to have a pro-business logistics integration.

Several factors hinder the entry of new competitors, including the initial investment and difficulties in access to distribution channels. The initial investment is usually very high due to the costs of building a manufacturing plant and distribution channels. To minimize the fixed costs is necessary to increase the amount of goods transported. When comparing the prices practiced in Portugal and Spain for the sale of diesel with biodiesel already incorporated, it appears that diesel by itself is slightly cheaper in Portugal. However, taxes in Portugal represent 44.6% of the total, while in Spain represent only 42.1%.

Spain

Spain began producing biodiesel in 2005, one year before Portugal. Bioethanol production also started in that year.

In 2009, in Spain there were about 45 producers of biofuels, of which four producers are of bioethanol.

Spain increased significantly its installed capacity for biodiesel production in 2009 to 4,213,057 m^3 (about 3,656,933 tons) and production reached 907,222 m3 (over 800,000 tons), representing 5% of the global market. Figure 1 presents the production and the production capacity of biodiesel in Spain in 2005, 2006 and 2007.

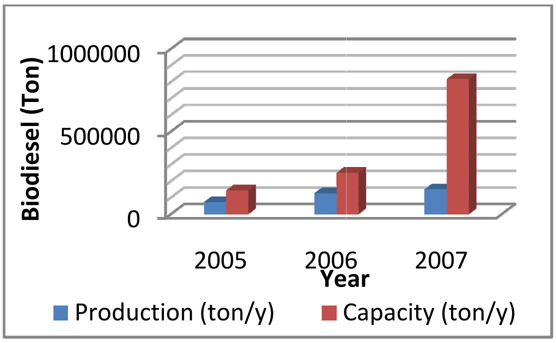

Figure 1 – Evolution of biodiesel production in Spain in relation to production capacity in 2005, 2006 and 2007.

The consumption of biodiesel this year was 1,169,626 m3 (about 1,016,665 tons).

Bioethanol is produced in Spain from traditional 1st Generation process, using the fermentation of sugars, or in some cases one more advanced technology from biomass, using the 2nd Generation processes mentioned.

In 2009 the installed capacity for bioethanol production was 569,000 m^3 (just over 500,000 tons) and production was 462,924 m3 (approximately 412.00 tons). Figure 2 shows the evolution of bioethanol production in 2005, 2006 and 2007.

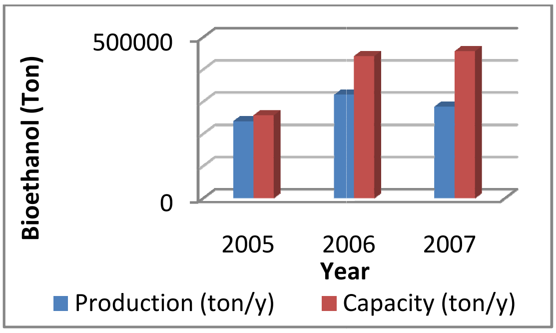

Figure 2 – Evolution of bioethanol production in Spain in relation to production capacity in 2005, 2006 and 2007.

The consumption of bioethanol in 2009 amounted to 299,158 m3 (approximately 236,035 tons) were exported about half of bioethanol.

For the production of biodiesel Spain imports more than 80% of the raw materials needed. The most commonly used raw materials for biodiesel production are soybean, palm oil, UCO, sunflower oil, rapeseed, animal fats and olive oil. The countries that export these raw materials to Spain are Indonesia, Argentina and Brazil.

For bioethanol production, about 45% of the raw materials are endogenous, the main ones being: corn, wheat, barley and wine alcohol.

The country that exports raw materials for bioethanol production in Spain is the United Kingdom, the remaining fraction coming mainly from European countries.

Despite the high production capacity, Spain relies on imports of biodiesel and bioethanol, which in 2009 accounted for approximately 31% and 36% respectively of the total consumption.

The reason for the situation is unclear, but may be explained by the fact that Spain is able in some periods to import biodiesel and bioethanol cheaper than those produced internally.

The study, assess that in Spain unlike Portugal, there are no quotas allocated to producers of biofuels, and consequently there are no limitations in terms of quantity of production, the Spanish producers not being protected by laws in force against imports.

In Spain the distribution chain in this industry works efficiently and there is a robust downstream vertical integration. The biofuels industry has no control of the upstream supply chain in case of biodiesel. Downstream there is some control on the clients because they have a favorable location next to the main Spanish refineries.

As many producers of FAME biodiesel have a consortium with the refineries, there is the possibility to add FAME directly into pipelines to terminals and logistic centers, allowing the ability to do the blending and also to import biofuels to coastal terminals.

The factors that hinder the entry of new competitors in the market are virtually the same as those identified in Portugal. The initial investment and difficulties in access to

distribution channels are the major problems. And given the fact that Spain has a production capacity for biodiesel almost four times its consumption, it will not be a good option to invest in a factory for the production of biodiesel.

Economies of scale are not considered a barrier to entry because the producers of biofuels produce below capacity.

Product differentiation is also not a relevant factor to promote biodiesel sales, it has only to ensure their quality according to EN 14214, in the case of biodiesel, and EN 15376 for bioethanol.

Minute Conclusions

From the strategic analysis carried out, we can verify that Portugal and Spain have built some competitive factors that allow them to maintain a position as producers of biofuels in their respective markets.

However, the big problem in Portugal is arguably the production cost of biodiesel that is considerably higher than fossil fuel production cost. However, this problem may be minimized by changing the raw materials used in production, including UCO for e.g.

Sugar beet may be competitive, as a raw material for the production of bioethanol but it requires a more detailed analysis, which does not fit the purpose of this work, but can be an interesting theme.

In Spain the production cost is not an obvious problem, because the addition of biodiesel to diesel fuel reduces its traditional final average price.

Spain has certainly interest to export biofuels, both biodiesel and bioethanol, because Spain has the capacity to produce more than twice what is currently producing.

The goals of biofuels incorporation required by the EU, the political forces to reduce GHG emissions and reducing the dependence on fossil fuels are clearly a strong driver for this market.

With regard to biorefineries that produce ethanol, Spain currently has one operating in Salamanca. In Portugal there is still no 2nd Generation biorefineries, but there is the potential of their existence in the future.

5. Biorefineries and the Future of Biofuels in the Iberian Peninsula

There are already some examples of 2nd Generation biorefineries laboring in the World (Borregaard, Coskata, M-Real and Abengoa), which could serve as examples of technologies to be adopted in Portugal and Spain.

Portugal

Pulp Industry

Portugal is a country with a strong pulp and paper industry, existing a possibility to incorporate 2nd Generation biorefineries in industrial premises, taking into account the technological and commercial context that may allow companies to produce 2nd Generation biofuels.

Analyzing this industry, we can see that Portugal is the 13th largest producer of pulp globally, and 5th at the European level, which gives it a relatively prominent position internationally.

Of the five existing stages in the production process of paper/pulp, there is one that is what matters for this analysis – the cooking and processing into wood pulp.

The major producers of national paper/pulp Caima – Altri Group, and Portucel/Soporcel, use chemical processes for the production of pulp/paper, including sulfite and kraft, respectively.

Caima uses the sulfite process to produce pulp.

It is known how to produce lignosulfonates, vanillin, ethanol and other value-added products in pulp mills. The best known case is the group Borregaard in Norway, already mentioned, where the main business is the production of specialty chemicals and pulp production is a secondary business.

It is common and has been known for decades that the fermentation of sugars from sulfite liquor in processes that use softwood forest species and where the main sugars are hexoses. However, the main source of raw material in Portugal is the species Eucalyptus globulus, due to its excellent skills for the production of paper, its rapid growth and high performance, supporting a low consumption of reagents.

Eucalyptus is a hardwood in which the main sugars are pentoses. The fermentation of pentoses into bioethanol production is a new technology, still in development, and there are yet no industrial facilities that make sulfite liquor fermentation for the production of bioethanol.

Still, Caima has been investing in the development of know-how in this area (2nd Generation biorefinery) in particular with the University of Aveiro, which has been developing the knowledge of wood chemistry and especially the eucalyptus, and published some scientific works.

Knowing the potential of black liquor including its use for the manufacture of bioethanol, xylose/xylitol, proteins, vanillin, lignosulfonates, and for the production of energy by evaporation of the remaining liquor in a recovery boiler, the next step would be to find a way to ferment the.

For the development of new technologies is also necessary to take some financial risk which is only accessible to big business,

In Portucel/Soporcel all plants (Setúbal, Cacia and Figueira da Foz) use the kraft process (also called sulfate process). At Portucel this liquor is used only for burning to produce energy, both electrical and thermal, which holds that these process can be considered 1st Generation biorefineries.

The Institute Raíz dedicated to R&D in the area of process optimization its currently underway two projects in forestry and process technology, indicating some strategic areas that Portucel is pursuing for the future.

The projects in question are:

• Pt-Lyptus Project, which aims at sustainable development of energy crops;

• BIIPP Project, which will run until 2013 in partnership with three Portuguese Universities (Porto, Aveiro and Coimbra), whose objectives are:

- Get the value-added products before the kraft process digestion – pre--extraction of sugar before baking, for bioethanol production;
- Increase use of waste streams in the kraft process-oriented production of bioethanol from conversion of primary sludge;
- Obtaining the components of the bark of Eucalyptus globulus, oriented to the extraction of triterpenes and phenolic compounds present in the bark.

Knowing that many projects have already been announced but unfortunately did not prove to be competitive, a source of Portucel states that they consider that investing in R&D is fundamental, but within 10 to 15 years will be difficult evolve from a 1st Generation biorefinery to a 2nd Generation biorefinery.

Other Projects

The Correio da Beira Serra published November 30, 2010 the news that BLC3 - Platform for Development of the Interior and Beiras Area (PDRIC) aims to transform Oliveira do Hospital municipality in an energetically self-sustaining area through renewable energy by of the "BioRefina-Ter."

Having already achieved the participation of 17 entities linked to the scientific world, a partnership that brings together some of the most prestigious universities in Portugal (Aveiro and Coimbra) and also two universities in Spain (Madrid and Bilbao), the "BioRefina-Ter" has also the participation of three major enterprise partners: Sonae Indústria, Galp Energia and the Spanish group Aurantia.

However, it is known that this project is about to apply for the QREN (National Strategic Reference Framework), and is expected to start in 2012 the construction of a pilot scale biorefinery. The technologies to use, it seems, are not yet defined, as well as what to produce as biofuels, the sub-products produced by the process or raw materials io be used, which are believed to be mostly forest residues, given the dual character of this project : to produce clean energy and to clean the forests.

Galp Energia has ongoing an analysis of a project that involves the production of biodiesel by the process HVO, incorporating it in Galp Energia's refinery in Sines, using in particular the hydrogen produced in the refining process of crude oil. This integration, if it were to materialize, will produce a new process type centered in the existing oil refinery complex that will produce 2nd Generation biodiesel.

There are currently two possible scenarios for this project:

1. From 2015, the HVO begins to be incorporated into the mineral diesel to supplement the FAME;

2. From 2015, Galp Energia will incorporate only HVO in diesel sold for the domestic market, ceasing to buy FAME biodiesel from domestic producers.

Therefore, this project of Galp Energia is an alternative solution to complement the incorporation of FAME in Portugal, and thus, be able to achieve the goal of 10% (by energy content) of the incorporation of renewable energy in transport in 2020.

Galp Energia has a fuel distribution network covering both Portugal and Spain, and so the two scenarios proposed for the implementation and marketing of HVO, allowthe opportunity to present itself as a reference operator in the area of biofuels, not only at national level but also at the level of the Iberian Peninsula.

Spain

As to the development of biorefineries in Spain was not possible to collect any relevant information.

It was already mentioned, the existence of a lignocellulosic based biorefinery laboring in demonstration scale in Salamanca, which belongs to Abengoa.

It is known that Spain already has the capacity to produce 1G bioethanol enough to meet the needs of the country, and even export some. Therefore, when compared with Portugal, Spain hasn't a greater need to find processes that enable the production of 2nd Generation bioethanol. It is believed, however, that there are R&D projects in development, most likely with Spanish universities, but it was not possible to obtain concrete data.

6. Main Conclusions and Future Work

The Iberian market of biofuels was analyzed, mainly on biodiesel production and current production methods, existing and alternative methods for producing bioethanol, especially from lignocellulosic material, thus having evaluated the concept of biorefinery, and the applicability of these methods to the market under study.

This study shows that Portugal and Spain have some potential as producers of biofuels, and that there are some areas for improvement to develop in the future.

Biodiesel producers both in Portugal and in Spain have higher production capacities than necessary to meet domestic consumption, and use the traditional method - FAME - to produce biodiesel. Spain has, however, a vertically integrated chain, which translates into greater control over the entire process involving biodiesel, something that is not the case in Portugal.

Portugal could become more competitive due to the technology of producing biodiesel from HVO proposed by Galp Energia. For the production of bioethanol there will probably be more difficult to achieve competitiveness in the market in the short to medium term since, as it turned out, there are not yet industrial facilities that enable the production of bioethanol.

There are however some points that were not covered or fully developed and can be considered as future work to develop this theme. Some of the outstanding issues are listed below:

- The theme of the UCO has a wide scope, where there are survey data that was impossible to obtain, and it would be important to get an overview with quantitative data collected about the OAU over the years, how much of it is turned into biodiesel and which percentage in market terms;
- Continue to follow the technological advances, its implementations and the points that make them more competitive;
- Understand how it is intended to introduce 2.5% (v/v) of bioethanol in gasoline in Portugal in 2015, to meet the targets set in Decree - Law No. 117 / 2010 of 25 October;
- Analyze more deeply the Spanish market in terms of technological development and investment in renewables, including biofuels.

Nomenclature

1G – First Generation
2G – Second Generation
EU – European Union
FAME – Fatty Acid Methyl Esther
GHG – Greenhouse Gases

HVO – Hydrogenated Vegetable Oils
R&D – Research and Development
UCO – Used Cooking Oils

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Strategic Analysis of Biofuels Production and Consumption in Portugal and Spain and the Prospects for Biorefineries Future Competitiveness

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Abstract

Concerns regarding Global Warming, the excessive reliance on petroleum and non-renewable energy sources in countries such as Portugal and Spain, which do not hold commercially significant reserves of hydrocarbons, and also with the high price per barrel of petroleum, has led European institutions to implement an optimization of the current energy framework.

Biofuels appear as renewable and inexhaustible energy sources, with the potential to replace fossil fuels. In a political/economical context, their great advantage is in turning countries more independent of suppliers of petroleum and natural gas. From an environmental standpoint, their use leads to the reduction in GHG emissions. Moreover, they provide the added benefit of engendering rural development, thus benefitting less developed regions.

In this scope, the search for a technological strategy for the use and economically sustainable production of biofuels, and, if possible, promote traditional agriculture and other activities in the rural areas of the Iberian Peninsula that favor the production of biodiesel as well as bioethanol, is the main objective of this Dissertation.

1. Introduction

The production and use of biofuels derived from renewable sources emerged in the 1970s, following the first two oil shocks and due to the awareness of the need to diversify energy sources and reduce dependence on oil. In Europe, the Agricultural Policy associated with motivations to improve the environment, led to the introduction of a line of production and use of biofuels in several EU countries.

Biofuels production in Europe has grown significantly since early 2000 as a result of rising oil prices and the existence of a favorable legislation adopted by the EU institutions.

The energy sector assumes in the world today, one of the R&D priorities n order to face the challenge of sustainable development. The importance of this sector is also the result of the need to reduce energy dependency of fossil fuels, since the global reserves are scarce and also by international commitments to reduce global GHG emissions.

To counter these developments, the European Member States are bound by international commitments and European Directives that commit themselves to jointly reduce their GHG by at least 5% compared to 1990 levels during the period 2008 to 2012, and Directive 2009/28/EC of 23 April, calling for the replacement of fossil fuels with alternative fuels.

The production and marketing of biofuels in the Iberian Peninsula is a well-established practice in recent years. In Portugal, the production focuses on biodiesel, in Spain there is also the industrial production of bioethanol, which makes the Iberian Peninsula an interesting market to study, compare and evaluate.

On the other hand, given that in Portugal there is a major cellulosic industry, there is also a strong interest in studying alternative procedural diagrams leading to the use of new products obtained from the manufacture of pulp, including compounds capable of being used as biofuels, especially bioethanol, creating a new concept of biorefineries.

This work aims to firstly get an overview of the current process diagrams of industrial production of biodiesel and bioethanol in the Iberian Peninsula in terms of economic and technological competitiveness in the face of tax laws and environmental regulations. In addition, the theme also aims to clarify some issues in terms of competitiveness of process diagrams currently used in industry, including:

- Technological and economic potential of obtaining biofuels from biorefineries, particularly in the pulp industry, with production at the same time of biofuels and bio-products;
- Technological and economic potential of industrial production of biodiesel from the isomerization and hydrogenation, of a series of vegetable fats, and also animal, made in the context of oil refineries.

2. Framework

The fuels of biological origin, based on photosynthesis, have the potential to reduce emissions of GHG and ensuring better energy use. In a political-economic perspective, a great advantage is to make importing countries more independent from suppliers of oil and natural gas. They have the added benefit of generating rural development, particularly through the use of underutilized land, securing jobs and supporting in this way, socially disadvantaged regions.

Biofuels have a wide variety of sources, and are differentiated according to two generations of the raw materials that are coming from. 1st Generation Biofuels (1G) are obtained from consumer goods that may also have food use. More specifically, it is 1G biodiesel produced from the transesterification reactions (FAME) of vegetable oils, such as soybean, rapeseed, and sunflower, and 1G bioethanol is produced from the fermentation of sugars contained in wheat, corn and sugarcane. 2nd Generation biofuels (2G) are made from materials considered non-food items, such as jatropha and other animal fats to produce biodiesel, and biomass crop residue (straw) or wood used in bioethanol production.

Biorefineries

Biorefineries allow us to produce 2G biofuels, since the raw material used is not for food use.

There are 1st Generation biorefineries, and in this group we can consider any factory that produces bio-value-added products from lignocecullosic material using their resources in an integrated way and that reuses the existing currents in the process to achieve is energy optimization, as is the case of modern pulp mills. The 2nd Generation biorefineries, have big differences with the 1st Generation ones concerning the technology that in this case can produce biofuels.

There is another type of biorefineries that can be considered as a 2nd Generation. These biorefineries will use the HVO process for producing biodiesel from vegetable oils of non-food crops.

Two processes allow the conversion of biomass into value-added products, not unique to 1G or 2G biorefinery. These processes are called Biochemical Platform and Thermochemical Platform.

The biochemical process is defined as the fractionation of biomass in its main components (cellulose, hemicellulose and lignin) for the fermentation of sugars that produces bioethanol and recovery of remaining waste (lignin).

Thermochemical Platform consists of a set of processes for thermal pretreatment of biomass that allows the production of synthesis gas as an intermediate for production of bioenergy, biofuels and biochemicals.

Depending on the technology used, it is possible to produce bioethanol and in some cases some bio-products. These may have

different classifications, which are presented in Table 1.

Table 1 – Classification of 2G biofuels from lignocellulosic raw materials.

Biofuel Group	Biofuel	Production Process
Bioethanol	Cellulosic Ethanol	Advanced Enzymatic Hydrolysis and Fermentation (Biochemical)
Syntetic Biofuels	Biomass-to-Liquids (BtL) Synthetic diesel, plug-Tropsch (FT) Heavy alcohols (methanol and mixtures) Dimethyl ether (DME)	Gasification and Synthesis (Thermochemical)
Methane	Biosynthetic Natural Gas (SNG)	Gasification and Synthesis (Thermochemical)
Bio--Hydrogen	Hydrogen	Gasification and Synthesis (Thermochemical) or Biological Processes (Biochemical)

There were identified 58 biorefineries working all around the world. Some of them, which we studied in more detail, are presented in Table 2.

Table 2 – 2nd Generation biorefineries references in the production of bioethanol.

Name	Place	Technology	Type	Raw Materials	Production Capacity (t/y)
Borregaard	Norway	Biochemical	Commercial	Sulfite liquor	15.800
M-Real Hallein AG	Austria	Biochemical	Demo	Sulfite liquor	12.000
Coskata	EUA	Hybrid	Pilot	Several waste	?
Abengoa Bioenergy	Spain	Biochemical	Demo	Wheat straw and corn	4.000

3. Biofuels and sustainability

Socioeconomic perspective

In recent years, the importance of non-food crops has increased significantly. The need for the existence of these cultures, benefiting in the EU, from the availability of land from a previous system of compulsory set-a-side policy for food crops, creates an opportunity to increase the production of biodiesel in particular.
Some of the most common criticisms raised in relation to the development of 1st Generation biofuels are the direct additional cost of biofuels, the impact it will have on food prices, increased demand for biofuels, and the threat to biodiversity because it could represent the large areas of intensive monocultures that this demand will result.

The high availability of arable land unproductive, especially in the tropical zone, where 70% of the land is arable, income and productivity are higher, leads to the logical conclusion that the prices of agricultural raw materials stabilize the expansion of investment in agricultural production.
The close link between oil prices and agricultural prices, mediated by the demand for biofuels, establishing a reference level for the prices of agricultural products - and which is determined by crude oil prices. When fossil fuel prices reach or exceed the cost of production of biofuels, the energy market will generate demand for agricultural products. If energy demand is high it will drag a greater consumption of agricultural raw materials for biofuels, as they become more competitive in the energy market, which will create a minimum price for certain agricultural products, imposed by the fossil fuel prices. However, agricultural prices cannot increase faster than energy prices or they are out of the energy market. Thus, as the size of the energy market is very large compared to the agricultural market, agricultural prices tend to be driven by energy prices.
The results of the study by FAO (Food and Agriculture Organization) and OECD (Organization for Economic Cooperation and Development) show a wide variation in the ability of different systems to provide economically competitive biofuels. The sugar cane is the lower cost raw material specially in Brazil. This is due to the availability of plantations of sugar cane land in Brazil that has existed for many years and is very extensive, and also due to the fact that the existing process for bioethanol production is already well developed and stabilized in terms of technology..
Note that the sugar beet used to produce bioethanol in the EU in 2007 apparently reached the market price of fossil fuels, making it extremely competitive.
In Portugal the share of 70,000 tons of sugar beet previously awarded to DAI (Society of Agro-Industrial Development) was reduced in 2007 and to 34,500 in 2008 to 15,000, and the company decided, after authorization by the European Commission, devotes himself exclusively to the refining of imported sugar

cane, thus enabling to produce beet in Portugal.

While the agricultural raw materials compete with fossil fuels in the energy market, agricultural crops also compete among themselves for productive resources. For example, a given plot of land can be used to grow corn for ethanol or wheat bread. When the demand equals the supply of biofuel crops used as feedstock, it tends to raise prices of all crops that have the same resource base.

For this reason, the production of biofuels from non-food crops will not necessarily eliminate the competition between food and fuel, in fact if the same land and other resources are needed for both food crops and raw materials for biofuels, their prices will move together, even if the cultivation of raw materials cannot be used for food.

Environmental Perspective

The life cycle analysis is the analytical tool used to calculate the amount of GHG emissions throughout the manufacturing process and the direct use of these products. Thus, the result obtained in this study is the result of a comparison of all emissions of GHG during the stages of production and use of biofuels. Although conceptually well established, the method is complex because it analyzes each component of the value chain to estimate GHG emissions.

Given the wide range of biofuels, raw materials and production technologies that exist, it would be expected a wide range of results in terms of emission reductions – which is actually the case. Most studies found that the production of 1st Generation biofuels resulted in emission reductions between 20% to 60% compared to fossil fuels, provided they are used the most efficient systems and emissions CO_2 resulting from changes in land use are excluded.

Table 3 presents the emissions reductions by the utilization of bioethanol and biodiesel produced from different raw materials.

Table 3 – Reduction of gas emissions of biofuels depending on the raw material.

	Raw Material	Total Emissions (g $CO_{2,eq}/MJ_{Biofuel}$)	Emissions Reduction
Bioethanol	Wheat	54,61	34,8%
	Sugar Beet	40,05	52,2%
Biodiesel	Rapeseed - FAME	51,75	38,2%
	Rapesees - HVO	44,24	47,2%

Brazil, which has long experience of producing bioethanol from sugar cane, shows even greater reductions in 2G biofuels, although insignificant in terms of trade, normally offer potential emission reductions of 70% to 90% compared to fossil diesel and gasoline, without release of CO_2 related to the change of land use.

Environmental impacts vary greatly between raw materials, production practices and locations, and depend critically on the form of land use. Replacing annual crops with perennial raw materials (such as palm oil, jatropha or perennial grasses) can improve the amount of carbon in the soil, but the conversion of tropical forests for the production of crops of any kind may release quantities of GHG which can greatly exceed the potential annual savings of biofuels. This will be the most important change to monitor land use.

Taking Advantage of Used Vegetable Oil

The cost of raw materials is an important factor in the economic viability of biodiesel production. The price of Used Cooking Oils (UCO) is from 2.5 to 3.5 times cheaper than virgin vegetable oils, therefore, can significantly reduce the total cost of manufacturing
biodiesel

A Recovery Plan of UCO was developed in Portugal for the production of biodiesel for self-consumption of municipal transport. It is an important aspect of energy recovery of waste which may, if well managed, have significant economic and environmental benefits.

After collection, the UCO are sent to a processing unit licensed for this purpose, where biodiesel is produced. In general terms, the technical solution adopted is based on the conversion of UCO into biodiesel, through the chemical process of transesterification.

Taking into account the evolution that has taken place in the waste treatment sector, and especially with regard to the implementation of policies to stimulate the pursuit of alternative energies, including biodiesel, a technical study of the economic life cycle of edible oils was promoted and its main

objective was to support the feasibility of a global management system.

The UCO have contributed to policy management and recovery of waste, with the benefit of improving the air quality in urban centers and reducing the energy bill of the municipality. This management is also covered by specific legislation that sets limits and obligations of municipalities involved.

4. Strategic Analysis of the Production and Consumption of Biofuels

As an overview, America is arguably the largest bioethanol producer in the world, with 54% market share, followed by Brazil with 34%. Far away from these countries is Europe, which presents an overall quota of 4% of the world production of bioethanol. Germany is the largest producer of biodiesel in the world with 16% market share, followed by France with 12% and USA with 11. Globally, for the production of biodiesel Europe has a much more significant share of 49% of the global market.

The Directive 2009/28/EC aims to establish a common goal to promote energy from renewable sources, including biofuels.

Each Member State has a target for the share of energy from renewable sources by the end of 2020. Moreover, the share of energy from renewable sources in transport must be at least 10% of the final energy consumption in this sector by 2020.

Portugal

Portugal began producing biodiesel in 2006, but to date does not yet produce bioethanol.

According to APPB (Portuguese Association of Biofuel Producers) biodiesel production in 2010 amounted to 441 million liters of biodiesel. The numbers are presented in Table 4.

Table 4 – Market statistics on the production of biodiesel in Portugal.

	2008	2009	2010	Total
Diesel Consumption (m^3)	5.431.293	5.761.775	5.841.763	28.430.100
Recommended Incorporation (m^3)	312.300	369.000	401.900	1.368.710
Held Incorporation (m^3)	169.300	294.100	441.000	1.168.900
Installed Capacity (m^3)	617.900	617.900	617.900	
Used Capacity	27%	48%	65%	

FAME is the process used by the five major players in the Portuguese market: the Iberrol, Prio Energy, Sovena, Torrejana and Biovegetal, and also by the small biodiesel producers who often use UCO for their production but have no relevant output for this analysis.

The main raw materials used in Portugal for the production of FAME biodiesel are: soybeans, rapeseed and palm. However, those who currently have a higher rate of use are rapeseed and soybeans, because palm oil is becoming unsustainable due to customs fees.

It appears that the endogenous resources are scarce, representing the current year only 1% of the total raw materials consumed.

In terms of exports of biodiesel, Portugal had in 2009, virtually nil.

Production quotas are presently allocated for biodiesel producers through TdB-D's (biodiesel titles). The early quota available to producers is the value of half of the production made in the previous year, and the surplus is up for the market. This will certainly motivate producers to compete more to ensure a greater share of titles.

The distribution chain in this industry operates inefficiently, without a strong vertical integration upstream or downstream. The biofuels industry has low control of the upstream supply chain. In the case of Sovena and Prio Energy, which have favorable locations can be considered to have a pro-business logistics integration.

Several factors hinder the entry of new competitors, including the initial investment and difficulties in access to distribution channels. The initial investment is usually very high due to the costs of building a manufacturing plant and distribution channels. To minimize the fixed costs is necessary to increase the amount of goods transported. When comparing the prices practiced in Portugal and Spain for the sale of diesel with biodiesel already incorporated, it appears that diesel by itself is slightly cheaper in Portugal. However, taxes in Portugal represent 44.6% of the total, while in Spain represent only 42.1%.

Spain

Spain began producing biodiesel in 2005, one year before Portugal. Bioethanol production also started in that year.

In 2009, in Spain there were about 45 producers of biofuels, of which four producers are of bioethanol.

Spain increased significantly its installed capacity for biodiesel production in 2009 to 4,213,057 m^3 (about 3,656,933 tons) and production reached 907,222 m3 (over 800,000 tons), representing 5% of the global market. Figure 1 presents the production and the production capacity of biodiesel in Spain in 2005, 2006 and 2007.

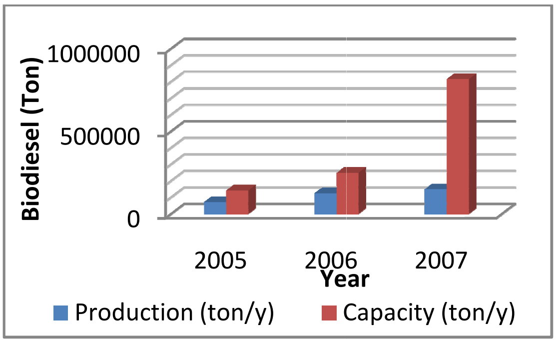

Figure 1 – Evolution of biodiesel production in Spain in relation to production capacity in 2005, 2006 and 2007.

The consumption of biodiesel this year was 1,169,626 m3 (about 1,016,665 tons).

Bioethanol is produced in Spain from traditional 1st Generation process, using the fermentation of sugars, or in some cases one more advanced technology from biomass, using the 2nd Generation processes mentioned.

In 2009 the installed capacity for bioethanol production was 569,000 m^3 (just over 500,000 tons) and production was 462,924 m3 (approximately 412.00 tons). Figure 2 shows the evolution of bioethanol production in 2005, 2006 and 2007.

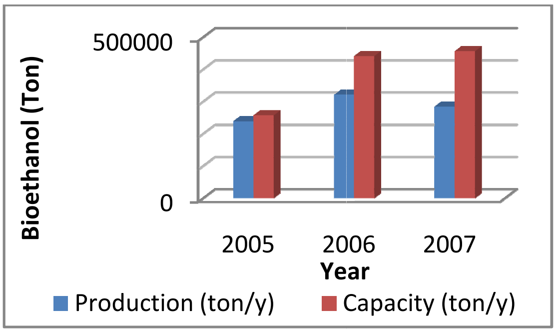

Figure 2 – Evolution of bioethanol production in Spain in relation to production capacity in 2005, 2006 and 2007.

The consumption of bioethanol in 2009 amounted to 299,158 m3 (approximately 236,035 tons) were exported about half of bioethanol.

For the production of biodiesel Spain imports more than 80% of the raw materials needed. The most commonly used raw materials for biodiesel production are soybean, palm oil, UCO, sunflower oil, rapeseed, animal fats and olive oil. The countries that export these raw materials to Spain are Indonesia, Argentina and Brazil.

For bioethanol production, about 45% of the raw materials are endogenous, the main ones being: corn, wheat, barley and wine alcohol.

The country that exports raw materials for bioethanol production in Spain is the United Kingdom, the remaining fraction coming mainly from European countries.

Despite the high production capacity, Spain relies on imports of biodiesel and bioethanol, which in 2009 accounted for approximately 31% and 36% respectively of the total consumption.

The reason for the situation is unclear, but may be explained by the fact that Spain is able in some periods to import biodiesel and bioethanol cheaper than those produced internally.

The study, assess that in Spain unlike Portugal, there are no quotas allocated to producers of biofuels, and consequently there are no limitations in terms of quantity of production, the Spanish producers not being protected by laws in force against imports.

In Spain the distribution chain in this industry works efficiently and there is a robust downstream vertical integration. The biofuels industry has no control of the upstream supply chain in case of biodiesel. Downstream there is some control on the clients because they have a favorable location next to the main Spanish refineries.

As many producers of FAME biodiesel have a consortium with the refineries, there is the possibility to add FAME directly into pipelines to terminals and logistic centers, allowing the ability to do the blending and also to import biofuels to coastal terminals.

The factors that hinder the entry of new competitors in the market are virtually the same as those identified in Portugal. The initial investment and difficulties in access to

distribution channels are the major problems. And given the fact that Spain has a production capacity for biodiesel almost four times its consumption, it will not be a good option to invest in a factory for the production of biodiesel.
Economies of scale are not considered a barrier to entry because the producers of biofuels produce below capacity.
Product differentiation is also not a relevant factor to promote biodiesel sales, it has only to ensure their quality according to EN 14214, in the case of biodiesel, and EN 15376 for bioethanol.

Minute Conclusions

From the strategic analysis carried out, we can verify that Portugal and Spain have built some competitive factors that allow them to maintain a position as producers of biofuels in their respective markets.
However, the big problem in Portugal is arguably the production cost of biodiesel that is considerably higher than fossil fuel production cost. However, this problem may be minimized by changing the raw materials used in production, including UCO for e.g.
Sugar beet may be competitive, as a raw material for the production of bioethanol but it requires a more detailed analysis, which does not fit the purpose of this work, but can be an interesting theme.
In Spain the production cost is not an obvious problem, because the addition of biodiesel to diesel fuel reduces its traditional final average price.
Spain has certainly interest to export biofuels, both biodiesel and bioethanol, because Spain has the capacity to produce more than twice what is currently producing.
The goals of biofuels incorporation required by the EU, the political forces to reduce GHG emissions and reducing the dependence on fossil fuels are clearly a strong driver for this market.
With regard to biorefineries that produce ethanol, Spain currently has one operating in Salamanca. In Portugal there is still no 2nd Generation biorefineries, but there is the potential of their existence in the future.

5. Biorefineries and the Future of Biofuels in the Iberian Peninsula

There are already some examples of 2nd Generation biorefineries laboring in the World (Borregaard, Coskata, M-Real and Abengoa), which could serve as examples of technologies to be adopted in Portugal and Spain.

Portugal

Pulp Industry

Portugal is a country with a strong pulp and paper industry, existing a possibility to incorporate 2nd Generation biorefineries in industrial premises, taking into account the technological and commercial context that may allow companies to produce 2nd Generation biofuels.
Analyzing this industry, we can see that Portugal is the 13th largest producer of pulp globally, and 5th at the European level, which gives it a relatively prominent position internationally.
Of the five existing stages in the production process of paper/pulp, there is one that is what matters for this analysis – the cooking and processing into wood pulp.
The major producers of national paper/pulp Caima – Altri Group, and Portucel/Soporcel, use chemical processes for the production of pulp/paper, including sulfite and kraft, respectively.
Caima uses the sulfite process to produce pulp.
It is known how to produce lignosulfonates, vanillin, ethanol and other value-added products in pulp mills. The best known case is the group Borregaard in Norway, already mentioned, where the main business is the production of specialty chemicals and pulp production is a secondary business.
It is common and has been known for decades that the fermentation of sugars from sulfite liquor in processes that use softwood forest species and where the main sugars are hexoses. However, the main source of raw material in Portugal is the species Eucalyptus globulus, due to its excellent skills for the production of paper, its rapid growth and high performance, supporting a low consumption of reagents.

Eucalyptus is a hardwood in which the main sugars are pentoses. The fermentation of pentoses into bioethanol production is a new technology, still in development, and there are yet no industrial facilities that make sulfite liquor fermentation for the production of bioethanol.

Still, Caima has been investing in the development of know-how in this area (2nd Generation biorefinery) in particular with the University of Aveiro, which has been developing the knowledge of wood chemistry and especially the eucalyptus, and published some scientific works.

Knowing the potential of black liquor including its use for the manufacture of bioethanol, xylose/xylitol, proteins, vanillin, lignosulfonates, and for the production of energy by evaporation of the remaining liquor in a recovery boiler, the next step would be to find a way to ferment the.

For the development of new technologies is also necessary to take some financial risk which is only accessible to big business,

In Portucel/Soporcel all plants (Setúbal, Cacia and Figueira da Foz) use the kraft process (also called sulfate process). At Portucel this liquor is used only for burning to produce energy, both electrical and thermal, which holds that these process can be considered 1st Generation biorefineries.

The Institute Raíz dedicated to R&D in the area of process optimization its currently underway two projects in forestry and process technology, indicating some strategic areas that Portucel is pursuing for the future.

The projects in question are:

• Pt-Lyptus Project, which aims at sustainable development of energy crops;

• BIIPP Project, which will run until 2013 in partnership with three Portuguese Universities (Porto, Aveiro and Coimbra), whose objectives are:

- Get the value-added products before the kraft process digestion – pre--extraction of sugar before baking, for bioethanol production;
- Increase use of waste streams in the kraft process-oriented production of bioethanol from conversion of primary sludge;
- Obtaining the components of the bark of Eucalyptus globulus, oriented to the extraction of triterpenes and phenolic compounds present in the bark.

Knowing that many projects have already been announced but unfortunately did not prove to be competitive, a source of Portucel states that they consider that investing in R&D is fundamental, but within 10 to 15 years will be difficult evolve from a 1st Generation biorefinery to a 2nd Generation biorefinery.

Other Projects

The Correio da Beira Serra published November 30, 2010 the news that BLC3 - Platform for Development of the Interior and Beiras Area (PDRIC) aims to transform Oliveira do Hospital municipality in an energetically self-sustaining area through renewable energy by of the "BioRefina-Ter."

Having already achieved the participation of 17 entities linked to the scientific world, a partnership that brings together some of the most prestigious universities in Portugal (Aveiro and Coimbra) and also two universities in Spain (Madrid and Bilbao), the "BioRefina-Ter" has also the participation of three major enterprise partners: Sonae Indústria, Galp Energia and the Spanish group Aurantia.

However, it is known that this project is about to apply for the QREN (National Strategic Reference Framework), and is expected to start in 2012 the construction of a pilot scale biorefinery. The technologies to use, it seems, are not yet defined, as well as what to produce as biofuels, the sub-products produced by the process or raw materials io be used, which are believed to be mostly forest residues, given the dual character of this project : to produce clean energy and to clean the forests.

Galp Energia has ongoing an analysis of a project that involves the production of biodiesel by the process HVO, incorporating it in Galp Energia's refinery in Sines, using in particular the hydrogen produced in the refining process of crude oil. This integration, if it were to materialize, will produce a new process type centered in the existing oil refinery complex that will produce 2nd Generation biodiesel.

There are currently two possible scenarios for this project:

1. From 2015, the HVO begins to be incorporated into the mineral diesel to supplement the FAME;
2. From 2015, Galp Energia will incorporate only HVO in diesel sold for the domestic market, ceasing to buy FAME biodiesel from domestic producers.

Therefore, this project of Galp Energia is an alternative solution to complement the incorporation of FAME in Portugal, and thus, be able to achieve the goal of 10% (by energy content) of the incorporation of renewable energy in transport in 2020.

Galp Energia has a fuel distribution network covering both Portugal and Spain, and so the two scenarios proposed for the implementation and marketing of HVO, allowthe opportunity to present itself as a reference operator in the area of biofuels, not only at national level but also at the level of the Iberian Peninsula.

Spain

As to the development of biorefineries in Spain was not possible to collect any relevant information.

It was already mentioned, the existence of a lignocellulosic based biorefinery laboring in demonstration scale in Salamanca, which belongs to Abengoa.

It is known that Spain already has the capacity to produce 1G bioethanol enough to meet the needs of the country, and even export some. Therefore, when compared with Portugal, Spain hasn't a greater need to find processes that enable the production of 2nd Generation bioethanol. It is believed, however, that there are R&D projects in development, most likely with Spanish universities, but it was not possible to obtain concrete data.

6. Main Conclusions and Future Work

The Iberian market of biofuels was analyzed, mainly on biodiesel production and current production methods, existing and alternative methods for producing bioethanol, especially from lignocellulosic material, thus having evaluated the concept of biorefinery, and the applicability of these methods to the market under study.

This study shows that Portugal and Spain have some potential as producers of biofuels, and that there are some areas for improvement to develop in the future.

Biodiesel producers both in Portugal and in Spain have higher production capacities than necessary to meet domestic consumption, and use the traditional method - FAME - to produce biodiesel. Spain has, however, a vertically integrated chain, which translates into greater control over the entire process involving biodiesel, something that is not the case in Portugal.

Portugal could become more competitive due to the technology of producing biodiesel from HVO proposed by Galp Energia. For the production of bioethanol there will probably be more difficult to achieve competitiveness in the market in the short to medium term since, as it turned out, there are not yet industrial facilities that enable the production of bioethanol.

There are however some points that were not covered or fully developed and can be considered as future work to develop this theme. Some of the outstanding issues are listed below:

- The theme of the UCO has a wide scope, where there are survey data that was impossible to obtain, and it would be important to get an overview with quantitative data collected about the OAU over the years, how much of it is turned into biodiesel and which percentage in market terms;
- Continue to follow the technological advances, its implementations and the points that make them more competitive;
- Understand how it is intended to introduce 2.5% (v/v) of bioethanol in gasoline in Portugal in 2015, to meet the targets set in Decree - Law No. 117 / 2010 of 25 October;
- Analyze more deeply the Spanish market in terms of technological development and investment in renewables, including biofuels.

Nomenclature

1G – First Generation
2G – Second Generation
EU – European Union
FAME – Fatty Acid Methyl Esther
GHG – Greenhouse Gases

HVO – Hydrogenated Vegetable Oils
R&D – Research and Development
UCO – Used Cooking Oils

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Strategic Analysis of Biofuels Production and Consumption in Portugal and Spain and the Prospects for Biorefineries Future Competitiveness

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Abstract

Concerns regarding Global Warming, the excessive reliance on petroleum and non-renewable energy sources in countries such as Portugal and Spain, which do not hold commercially significant reserves of hydrocarbons, and also with the high price per barrel of petroleum, has led European institutions to implement an optimization of the current energy framework.

Biofuels appear as renewable and inexhaustible energy sources, with the potential to replace fossil fuels. In a political/economical context, their great advantage is in turning countries more independent of suppliers of petroleum and natural gas. From an environmental standpoint, their use leads to the reduction in GHG emissions. Moreover, they provide the added benefit of engendering rural development, thus benefitting less developed regions.

In this scope, the search for a technological strategy for the use and economically sustainable production of biofuels, and, if possible, promote traditional agriculture and other activities in the rural areas of the Iberian Peninsula that favor the production of biodiesel as well as bioethanol, is the main objective of this Dissertation.

1. Introduction

The production and use of biofuels derived from renewable sources emerged in the 1970s, following the first two oil shocks and due to the awareness of the need to diversify energy sources and reduce dependence on oil. In Europe, the Agricultural Policy associated with motivations to improve the environment, led to the introduction of a line of production and use of biofuels in several EU countries.

Biofuels production in Europe has grown significantly since early 2000 as a result of rising oil prices and the existence of a favorable legislation adopted by the EU institutions.

The energy sector assumes in the world today, one of the R&D priorities n order to face the challenge of sustainable development. The importance of this sector is also the result of the need to reduce energy dependency of fossil fuels, since the global reserves are scarce and also by international commitments to reduce global GHG emissions.

To counter these developments, the European Member States are bound by international commitments and European Directives that commit themselves to jointly reduce their GHG by at least 5% compared to 1990 levels during the period 2008 to 2012, and Directive 2009/28/EC of 23 April, calling for the replacement of fossil fuels with alternative fuels.

The production and marketing of biofuels in the Iberian Peninsula is a well-established practice in recent years. In Portugal, the production focuses on biodiesel, in Spain there is also the industrial production of bioethanol, which makes the Iberian Peninsula an interesting market to study, compare and evaluate.

On the other hand, given that in Portugal there is a major cellulosic industry, there is also a strong interest in studying alternative procedural diagrams leading to the use of new products obtained from the manufacture of pulp, including compounds capable of being used as biofuels, especially bioethanol, creating a new concept of biorefineries.

This work aims to firstly get an overview of the current process diagrams of industrial production of biodiesel and bioethanol in the Iberian Peninsula in terms of economic and technological competitiveness in the face of tax laws and environmental regulations. In addition, the theme also aims to clarify some issues in terms of competitiveness of process diagrams currently used in industry, including:

- Technological and economic potential of obtaining biofuels from biorefineries, particularly in the pulp industry, with production at the same time of biofuels and bio-products;
- Technological and economic potential of industrial production of biodiesel from the isomerization and hydrogenation, of a series of vegetable fats, and also animal, made in the context of oil refineries.

2. Framework

The fuels of biological origin, based on photosynthesis, have the potential to reduce emissions of GHG and ensuring better energy use. In a political-economic perspective, a great advantage is to make importing countries more independent from suppliers of oil and natural gas. They have the added benefit of generating rural development, particularly through the use of underutilized land, securing jobs and supporting in this way, socially disadvantaged regions.

Biofuels have a wide variety of sources, and are differentiated according to two generations of the raw materials that are coming from. 1st Generation Biofuels (1G) are obtained from consumer goods that may also have food use. More specifically, it is 1G biodiesel produced from the transesterification reactions (FAME) of vegetable oils, such as soybean, rapeseed, and sunflower, and 1G bioethanol is produced from the fermentation of sugars contained in wheat, corn and sugarcane. 2nd Generation biofuels (2G) are made from materials considered non-food items, such as jatropha and other animal fats to produce biodiesel, and biomass crop residue (straw) or wood used in bioethanol production.

Biorefineries

Biorefineries allow us to produce 2G biofuels, since the raw material used is not for food use.

There are 1st Generation biorefineries, and in this group we can consider any factory that produces bio-value-added products from lignocecullosic material using their resources in an integrated way and that reuses the existing currents in the process to achieve is energy optimization, as is the case of modern pulp mills. The 2nd Generation biorefineries, have big differences with the 1st Generation ones concerning the technology that in this case can produce biofuels.

There is another type of biorefineries that can be considered as a 2nd Generation. These biorefineries will use the HVO process for producing biodiesel from vegetable oils of non-food crops.

Two processes allow the conversion of biomass into value-added products, not unique to 1G or 2G biorefinery. These processes are called Biochemical Platform and Thermochemical Platform.

The biochemical process is defined as the fractionation of biomass in its main components (cellulose, hemicellulose and lignin) for the fermentation of sugars that produces bioethanol and recovery of remaining waste (lignin).

Thermochemical Platform consists of a set of processes for thermal pretreatment of biomass that allows the production of synthesis gas as an intermediate for production of bioenergy, biofuels and biochemicals.

Depending on the technology used, it is possible to produce bioethanol and in some cases some bio-products. These may have

different classifications, which are presented in Table 1.

Table 1 – Classification of 2G biofuels from lignocellulosic raw materials.

Biofuel Group	Biofuel	Production Process
Bioethanol	Cellulosic Ethanol	Advanced Enzymatic Hydrolysis and Fermentation (Biochemical)
Syntetic Biofuels	Biomass-to-Liquids (BtL) Synthetic diesel, plug-Tropsch (FT) Heavy alcohols (methanol and mixtures) Dimethyl ether (DME)	Gasification and Synthesis (Thermochemical)
Methane	Biosynthetic Natural Gas (SNG)	Gasification and Synthesis (Thermochemical)
Bio--Hydrogen	Hydrogen	Gasification and Synthesis (Thermochemical) or Biological Processes (Biochemical)

There were identified 58 biorefineries working all around the world. Some of them, which we studied in more detail, are presented in Table 2.

Table 2 – 2nd Generation biorefineries references in the production of bioethanol.

Name	Place	Technology	Type	Raw Materials	Production Capacity (t/y)
Borregaard	Norway	Biochemical	Commercial	Sulfite liquor	15.800
M-Real Hallein AG	Austria	Biochemical	Demo	Sulfite liquor	12.000
Coskata	EUA	Hybrid	Pilot	Several waste	?
Abengoa Bioenergy	Spain	Biochemical	Demo	Wheat straw and corn	4.000

3. Biofuels and sustainability

Socioeconomic perspective

In recent years, the importance of non-food crops has increased significantly. The need for the existence of these cultures, benefiting in the EU, from the availability of land from a previous system of compulsory set-a-side policy for food crops, creates an opportunity to increase the production of biodiesel in particular.

Some of the most common criticisms raised in relation to the development of 1st Generation biofuels are the direct additional cost of biofuels, the impact it will have on food prices, increased demand for biofuels, and the threat to biodiversity because it could represent the large areas of intensive monocultures that this demand will result.

The high availability of arable land unproductive, especially in the tropical zone, where 70% of the land is arable, income and productivity are higher, leads to the logical conclusion that the prices of agricultural raw materials stabilize the expansion of investment in agricultural production.

The close link between oil prices and agricultural prices, mediated by the demand for biofuels, establishing a reference level for the prices of agricultural products - and which is determined by crude oil prices. When fossil fuel prices reach or exceed the cost of production of biofuels, the energy market will generate demand for agricultural products. If energy demand is high it will drag a greater consumption of agricultural raw materials for biofuels, as they become more competitive in the energy market, which will create a minimum price for certain agricultural products, imposed by the fossil fuel prices. However, agricultural prices cannot increase faster than energy prices or they are out of the energy market. Thus, as the size of the energy market is very large compared to the agricultural market, agricultural prices tend to be driven by energy prices.

The results of the study by FAO (Food and Agriculture Organization) and OECD (Organization for Economic Cooperation and Development) show a wide variation in the ability of different systems to provide economically competitive biofuels. The sugar cane is the lower cost raw material specially in Brazil. This is due to the availability of plantations of sugar cane land in Brazil that has existed for many years and is very extensive, and also due to the fact that the existing process for bioethanol production is already well developed and stabilized in terms of technology..

Note that the sugar beet used to produce bioethanol in the EU in 2007 apparently reached the market price of fossil fuels, making it extremely competitive.

In Portugal the share of 70,000 tons of sugar beet previously awarded to DAI (Society of Agro-Industrial Development) was reduced in 2007 and to 34,500 in 2008 to 15,000, and the company decided, after authorization by the European Commission, devotes himself exclusively to the refining of imported sugar

cane, thus enabling to produce beet in Portugal.

While the agricultural raw materials compete with fossil fuels in the energy market, agricultural crops also compete among themselves for productive resources. For example, a given plot of land can be used to grow corn for ethanol or wheat bread. When the demand equals the supply of biofuel crops used as feedstock, it tends to raise prices of all crops that have the same resource base.

For this reason, the production of biofuels from non-food crops will not necessarily eliminate the competition between food and fuel, in fact if the same land and other resources are needed for both food crops and raw materials for biofuels, their prices will move together, even if the cultivation of raw materials cannot be used for food.

Environmental Perspective

The life cycle analysis is the analytical tool used to calculate the amount of GHG emissions throughout the manufacturing process and the direct use of these products. Thus, the result obtained in this study is the result of a comparison of all emissions of GHG during the stages of production and use of biofuels. Although conceptually well established, the method is complex because it analyzes each component of the value chain to estimate GHG emissions.

Given the wide range of biofuels, raw materials and production technologies that exist, it would be expected a wide range of results in terms of emission reductions – which is actually the case. Most studies found that the production of 1st Generation biofuels resulted in emission reductions between 20% to 60% compared to fossil fuels, provided they are used the most efficient systems and emissions CO_2 resulting from changes in land use are excluded.

Table 3 presents the emissions reductions by the utilization of bioethanol and biodiesel produced from different raw materials.

Table 3 – Reduction of gas emissions of biofuels depending on the raw material.

	Raw Material	Total Emissions (g $CO_{2,eq}/MJ_{Biofuel}$)	Emissions Reduction
Bioethanol	Wheat	54,61	34,8%
	Sugar Beet	40,05	52,2%
Biodiesel	Rapeseed - FAME	51,75	38,2%
	Rapesees - HVO	44,24	47,2%

Brazil, which has long experience of producing bioethanol from sugar cane, shows even greater reductions in 2G biofuels, although insignificant in terms of trade, normally offer potential emission reductions of 70% to 90% compared to fossil diesel and gasoline, without release of CO_2 related to the change of land use.

Environmental impacts vary greatly between raw materials, production practices and locations, and depend critically on the form of land use. Replacing annual crops with perennial raw materials (such as palm oil, jatropha or perennial grasses) can improve the amount of carbon in the soil, but the conversion of tropical forests for the production of crops of any kind may release quantities of GHG which can greatly exceed the potential annual savings of biofuels. This will be the most important change to monitor land use.

Taking Advantage of Used Vegetable Oil

The cost of raw materials is an important factor in the economic viability of biodiesel production. The price of Used Cooking Oils (UCO) is from 2.5 to 3.5 times cheaper than virgin vegetable oils, therefore, can significantly reduce the total cost of manufacturing
biodiesel

A Recovery Plan of UCO was developed in Portugal for the production of biodiesel for self-consumption of municipal transport. It is an important aspect of energy recovery of waste which may, if well managed, have significant economic and environmental benefits.

After collection, the UCO are sent to a processing unit licensed for this purpose, where biodiesel is produced. In general terms, the technical solution adopted is based on the conversion of UCO into biodiesel, through the chemical process of transesterification.

Taking into account the evolution that has taken place in the waste treatment sector, and especially with regard to the implementation of policies to stimulate the pursuit of alternative energies, including biodiesel, a technical study of the economic life cycle of edible oils was promoted and its main

objective was to support the feasibility of a global management system.

The UCO have contributed to policy management and recovery of waste, with the benefit of improving the air quality in urban centers and reducing the energy bill of the municipality. This management is also covered by specific legislation that sets limits and obligations of municipalities involved.

4. Strategic Analysis of the Production and Consumption of Biofuels

As an overview, America is arguably the largest bioethanol producer in the world, with 54% market share, followed by Brazil with 34%. Far away from these countries is Europe, which presents an overall quota of 4% of the world production of bioethanol. Germany is the largest producer of biodiesel in the world with 16% market share, followed by France with 12% and USA with 11. Globally, for the production of biodiesel Europe has a much more significant share of 49% of the global market.

The Directive 2009/28/EC aims to establish a common goal to promote energy from renewable sources, including biofuels.

Each Member State has a target for the share of energy from renewable sources by the end of 2020. Moreover, the share of energy from renewable sources in transport must be at least 10% of the final energy consumption in this sector by 2020.

Portugal

Portugal began producing biodiesel in 2006, but to date does not yet produce bioethanol.

According to APPB (Portuguese Association of Biofuel Producers) biodiesel production in 2010 amounted to 441 million liters of biodiesel. The numbers are presented in Table 4.

Table 4 – Market statistics on the production of biodiesel in Portugal.

	2008	2009	2010	Total
Diesel Consumption (m^3)	5.431.293	5.761.775	5.841.763	28.430.100
Recommended Incorporation (m^3)	312.300	369.000	401.900	1.368.710
Held Incorporation (m^3)	169.300	294.100	441.000	1.168.900
Installed Capacity (m^3)	617.900	617.900	617.900	
Used Capacity	27%	48%	65%	

FAME is the process used by the five major players in the Portuguese market: the Iberrol, Prio Energy, Sovena, Torrejana and Biovegetal, and also by the small biodiesel producers who often use UCO for their production but have no relevant output for this analysis.

The main raw materials used in Portugal for the production of FAME biodiesel are: soybeans, rapeseed and palm. However, those who currently have a higher rate of use are rapeseed and soybeans, because palm oil is becoming unsustainable due to customs fees.

It appears that the endogenous resources are scarce, representing the current year only 1% of the total raw materials consumed.

In terms of exports of biodiesel, Portugal had in 2009, virtually nil.

Production quotas are presently allocated for biodiesel producers through TdB-D's (biodiesel titles). The early quota available to producers is the value of half of the production made in the previous year, and the surplus is up for the market. This will certainly motivate producers to compete more to ensure a greater share of titles.

The distribution chain in this industry operates inefficiently, without a strong vertical integration upstream or downstream. The biofuels industry has low control of the upstream supply chain. In the case of Sovena and Prio Energy, which have favorable locations can be considered to have a pro-business logistics integration.

Several factors hinder the entry of new competitors, including the initial investment and difficulties in access to distribution channels. The initial investment is usually very high due to the costs of building a manufacturing plant and distribution channels. To minimize the fixed costs is necessary to increase the amount of goods transported. When comparing the prices practiced in Portugal and Spain for the sale of diesel with biodiesel already incorporated, it appears that diesel by itself is slightly cheaper in Portugal. However, taxes in Portugal represent 44.6% of the total, while in Spain represent only 42.1%.

Spain

Spain began producing biodiesel in 2005, one year before Portugal. Bioethanol production also started in that year.

In 2009, in Spain there were about 45 producers of biofuels, of which four producers are of bioethanol.

Spain increased significantly its installed capacity for biodiesel production in 2009 to 4,213,057 m^3 (about 3,656,933 tons) and production reached 907,222 m3 (over 800,000 tons), representing 5% of the global market. Figure 1 presents the production and the production capacity of biodiesel in Spain in 2005, 2006 and 2007.

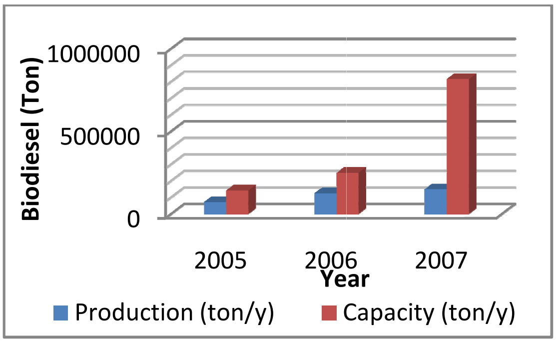

Figure 1 – Evolution of biodiesel production in Spain in relation to production capacity in 2005, 2006 and 2007.

The consumption of biodiesel this year was 1,169,626 m3 (about 1,016,665 tons).

Bioethanol is produced in Spain from traditional 1st Generation process, using the fermentation of sugars, or in some cases one more advanced technology from biomass, using the 2nd Generation processes mentioned.

In 2009 the installed capacity for bioethanol production was 569,000 m^3 (just over 500,000 tons) and production was 462,924 m3 (approximately 412.00 tons). Figure 2 shows the evolution of bioethanol production in 2005, 2006 and 2007.

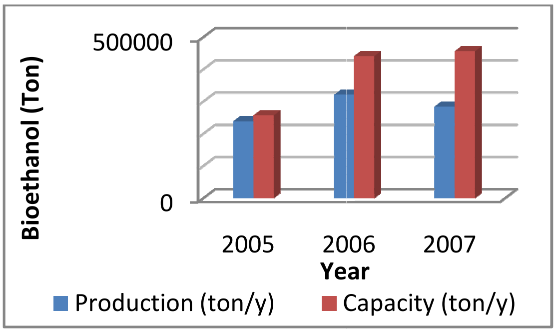

Figure 2 – Evolution of bioethanol production in Spain in relation to production capacity in 2005, 2006 and 2007.

The consumption of bioethanol in 2009 amounted to 299,158 m3 (approximately 236,035 tons) were exported about half of bioethanol.

For the production of biodiesel Spain imports more than 80% of the raw materials needed. The most commonly used raw materials for biodiesel production are soybean, palm oil, UCO, sunflower oil, rapeseed, animal fats and olive oil. The countries that export these raw materials to Spain are Indonesia, Argentina and Brazil.

For bioethanol production, about 45% of the raw materials are endogenous, the main ones being: corn, wheat, barley and wine alcohol.

The country that exports raw materials for bioethanol production in Spain is the United Kingdom, the remaining fraction coming mainly from European countries.

Despite the high production capacity, Spain relies on imports of biodiesel and bioethanol, which in 2009 accounted for approximately 31% and 36% respectively of the total consumption.

The reason for the situation is unclear, but may be explained by the fact that Spain is able in some periods to import biodiesel and bioethanol cheaper than those produced internally.

The study, assess that in Spain unlike Portugal, there are no quotas allocated to producers of biofuels, and consequently there are no limitations in terms of quantity of production, the Spanish producers not being protected by laws in force against imports.

In Spain the distribution chain in this industry works efficiently and there is a robust downstream vertical integration. The biofuels industry has no control of the upstream supply chain in case of biodiesel. Downstream there is some control on the clients because they have a favorable location next to the main Spanish refineries.

As many producers of FAME biodiesel have a consortium with the refineries, there is the possibility to add FAME directly into pipelines to terminals and logistic centers, allowing the ability to do the blending and also to import biofuels to coastal terminals.

The factors that hinder the entry of new competitors in the market are virtually the same as those identified in Portugal. The initial investment and difficulties in access to

distribution channels are the major problems. And given the fact that Spain has a production capacity for biodiesel almost four times its consumption, it will not be a good option to invest in a factory for the production of biodiesel.

Economies of scale are not considered a barrier to entry because the producers of biofuels produce below capacity.

Product differentiation is also not a relevant factor to promote biodiesel sales, it has only to ensure their quality according to EN 14214, in the case of biodiesel, and EN 15376 for bioethanol.

Minute Conclusions

From the strategic analysis carried out, we can verify that Portugal and Spain have built some competitive factors that allow them to maintain a position as producers of biofuels in their respective markets.

However, the big problem in Portugal is arguably the production cost of biodiesel that is considerably higher than fossil fuel production cost. However, this problem may be minimized by changing the raw materials used in production, including UCO for e.g.

Sugar beet may be competitive, as a raw material for the production of bioethanol but it requires a more detailed analysis, which does not fit the purpose of this work, but can be an interesting theme.

In Spain the production cost is not an obvious problem, because the addition of biodiesel to diesel fuel reduces its traditional final average price.

Spain has certainly interest to export biofuels, both biodiesel and bioethanol, because Spain has the capacity to produce more than twice what is currently producing.

The goals of biofuels incorporation required by the EU, the political forces to reduce GHG emissions and reducing the dependence on fossil fuels are clearly a strong driver for this market.

With regard to biorefineries that produce ethanol, Spain currently has one operating in Salamanca. In Portugal there is still no 2nd Generation biorefineries, but there is the potential of their existence in the future.

5. Biorefineries and the Future of Biofuels in the Iberian Peninsula

There are already some examples of 2nd Generation biorefineries laboring in the World (Borregaard, Coskata, M-Real and Abengoa), which could serve as examples of technologies to be adopted in Portugal and Spain.

Portugal

Pulp Industry

Portugal is a country with a strong pulp and paper industry, existing a possibility to incorporate 2nd Generation biorefineries in industrial premises, taking into account the technological and commercial context that may allow companies to produce 2nd Generation biofuels.

Analyzing this industry, we can see that Portugal is the 13th largest producer of pulp globally, and 5th at the European level, which gives it a relatively prominent position internationally.

Of the five existing stages in the production process of paper/pulp, there is one that is what matters for this analysis – the cooking and processing into wood pulp.

The major producers of national paper/pulp Caima – Altri Group, and Portucel/Soporcel, use chemical processes for the production of pulp/paper, including sulfite and kraft, respectively.

Caima uses the sulfite process to produce pulp.

It is known how to produce lignosulfonates, vanillin, ethanol and other value-added products in pulp mills. The best known case is the group Borregaard in Norway, already mentioned, where the main business is the production of specialty chemicals and pulp production is a secondary business.

It is common and has been known for decades that the fermentation of sugars from sulfite liquor in processes that use softwood forest species and where the main sugars are hexoses. However, the main source of raw material in Portugal is the species Eucalyptus globulus, due to its excellent skills for the production of paper, its rapid growth and high performance, supporting a low consumption of reagents.

Eucalyptus is a hardwood in which the main sugars are pentoses. The fermentation of pentoses into bioethanol production is a new technology, still in development, and there are yet no industrial facilities that make sulfite liquor fermentation for the production of bioethanol.

Still, Caima has been investing in the development of know-how in this area (2nd Generation biorefinery) in particular with the University of Aveiro, which has been developing the knowledge of wood chemistry and especially the eucalyptus, and published some scientific works.

Knowing the potential of black liquor including its use for the manufacture of bioethanol, xylose/xylitol, proteins, vanillin, lignosulfonates, and for the production of energy by evaporation of the remaining liquor in a recovery boiler, the next step would be to find a way to ferment the.

For the development of new technologies is also necessary to take some financial risk which is only accessible to big business,

In Portucel/Soporcel all plants (Setúbal, Cacia and Figueira da Foz) use the kraft process (also called sulfate process). At Portucel this liquor is used only for burning to produce energy, both electrical and thermal, which holds that these process can be considered 1st Generation biorefineries.

The Institute Raíz dedicated to R&D in the area of process optimization its currently underway two projects in forestry and process technology, indicating some strategic areas that Portucel is pursuing for the future.

The projects in question are:

• Pt-Lyptus Project, which aims at sustainable development of energy crops;

• BIIPP Project, which will run until 2013 in partnership with three Portuguese Universities (Porto, Aveiro and Coimbra), whose objectives are:

- Get the value-added products before the kraft process digestion – pre--extraction of sugar before baking, for bioethanol production;
- Increase use of waste streams in the kraft process-oriented production of bioethanol from conversion of primary sludge;
- Obtaining the components of the bark of Eucalyptus globulus, oriented to the extraction of triterpenes and phenolic compounds present in the bark.

Knowing that many projects have already been announced but unfortunately did not prove to be competitive, a source of Portucel states that they consider that investing in R&D is fundamental, but within 10 to 15 years will be difficult evolve from a 1st Generation biorefinery to a 2nd Generation biorefinery.

Other Projects

The Correio da Beira Serra published November 30, 2010 the news that BLC3 - Platform for Development of the Interior and Beiras Area (PDRIC) aims to transform Oliveira do Hospital municipality in an energetically self-sustaining area through renewable energy by of the "BioRefina-Ter."

Having already achieved the participation of 17 entities linked to the scientific world, a partnership that brings together some of the most prestigious universities in Portugal (Aveiro and Coimbra) and also two universities in Spain (Madrid and Bilbao), the "BioRefina-Ter" has also the participation of three major enterprise partners: Sonae Indústria, Galp Energia and the Spanish group Aurantia.

However, it is known that this project is about to apply for the QREN (National Strategic Reference Framework), and is expected to start in 2012 the construction of a pilot scale biorefinery. The technologies to use, it seems, are not yet defined, as well as what to produce as biofuels, the sub-products produced by the process or raw materials io be used, which are believed to be mostly forest residues, given the dual character of this project : to produce clean energy and to clean the forests.

Galp Energia has ongoing an analysis of a project that involves the production of biodiesel by the process HVO, incorporating it in Galp Energia's refinery in Sines, using in particular the hydrogen produced in the refining process of crude oil. This integration, if it were to materialize, will produce a new process type centered in the existing oil refinery complex that will produce 2nd Generation biodiesel.

There are currently two possible scenarios for this project:

1. From 2015, the HVO begins to be incorporated into the mineral diesel to supplement the FAME;
2. From 2015, Galp Energia will incorporate only HVO in diesel sold for the domestic market, ceasing to buy FAME biodiesel from domestic producers.

Therefore, this project of Galp Energia is an alternative solution to complement the incorporation of FAME in Portugal, and thus, be able to achieve the goal of 10% (by energy content) of the incorporation of renewable energy in transport in 2020.

Galp Energia has a fuel distribution network covering both Portugal and Spain, and so the two scenarios proposed for the implementation and marketing of HVO, allowthe opportunity to present itself as a reference operator in the area of biofuels, not only at national level but also at the level of the Iberian Peninsula.

Spain

As to the development of biorefineries in Spain was not possible to collect any relevant information.

It was already mentioned, the existence of a lignocellulosic based biorefinery laboring in demonstration scale in Salamanca, which belongs to Abengoa.

It is known that Spain already has the capacity to produce 1G bioethanol enough to meet the needs of the country, and even export some. Therefore, when compared with Portugal, Spain hasn't a greater need to find processes that enable the production of 2nd Generation bioethanol. It is believed, however, that there are R&D projects in development, most likely with Spanish universities, but it was not possible to obtain concrete data.

6. Main Conclusions and Future Work

The Iberian market of biofuels was analyzed, mainly on biodiesel production and current production methods, existing and alternative methods for producing bioethanol, especially from lignocellulosic material, thus having evaluated the concept of biorefinery, and the applicability of these methods to the market under study.

This study shows that Portugal and Spain have some potential as producers of biofuels, and that there are some areas for improvement to develop in the future.

Biodiesel producers both in Portugal and in Spain have higher production capacities than necessary to meet domestic consumption, and use the traditional method - FAME - to produce biodiesel. Spain has, however, a vertically integrated chain, which translates into greater control over the entire process involving biodiesel, something that is not the case in Portugal.

Portugal could become more competitive due to the technology of producing biodiesel from HVO proposed by Galp Energia. For the production of bioethanol there will probably be more difficult to achieve competitiveness in the market in the short to medium term since, as it turned out, there are not yet industrial facilities that enable the production of bioethanol.

There are however some points that were not covered or fully developed and can be considered as future work to develop this theme. Some of the outstanding issues are listed below:

- The theme of the UCO has a wide scope, where there are survey data that was impossible to obtain, and it would be important to get an overview with quantitative data collected about the OAU over the years, how much of it is turned into biodiesel and which percentage in market terms;
- Continue to follow the technological advances, its implementations and the points that make them more competitive;
- Understand how it is intended to introduce 2.5% (v/v) of bioethanol in gasoline in Portugal in 2015, to meet the targets set in Decree - Law No. 117 / 2010 of 25 October;
- Analyze more deeply the Spanish market in terms of technological development and investment in renewables, including biofuels.

Nomenclature

1G – First Generation
2G – Second Generation
EU – European Union
FAME – Fatty Acid Methyl Esther
GHG – Greenhouse Gases

HVO – Hydrogenated Vegetable Oils
R&D – Research and Development
UCO – Used Cooking Oils

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