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"Green Refinery"

The economic viability of biomass treatment to produce Diesel fuel

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Abstract

The rapid growth of industrial production and economic development in general, was based mainly on the treatment of crude oil and the use of diesel. The direct output of this process was an unlimited pollution. Secondly, the scenario of depleting oil reserves over the years seems to be more certain than ever and hence the search for alternative sources of production fuel is imperative.

In recent years, even the most sceptical understand the immediate switch to alternative energy sources in order to reduce environmental pollution while maintaining the low cost of purchasing and processing of raw materials.

This research is based on the belief that the use of biomass as feedstock is an inevitable trend in refining and will try to explore the possibilities that exist today in Greece to extend this project.

Then this paper will attempt to examine the supply chain governing the processing of biomass, the analysis of external and internal factors affecting the operation of all agencies involved in the process and the examination of three undesirable scenarios which according to the responses of respondents are their main fears.

For data collection conducted in-depth interviews with executives involved in all stages of processing of biomass for biodiesel production such as an owner of energy crops, the vice president of a biodiesel production unit, a scientist from the EKETA and an executive of Planning Department of the Hellenic Petroleum Group. Further information was sought between the relevant Greek and foreign literature, as well from statistical surveys.

The main conclusion of this research is that the biomass processing is an opportunity for rural and industry development in the country but largely dependent on EU subsidies and state tax exemption because of its high production costs.

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Chapter 1: Introduction

1 – 1: The importance

During the last decade, the global community deeply engaged by the rapid changes in climatic conditions. If during the last few decades the development and production at any cost has been the sole priority, the present unprecedented large-scale natural disasters have raised the issue as the first problem to solve.

The heavy cost of human lives lost, major damages to infrastructure and the depletion of natural resources that planet offers require immediate and universal action. Apart from these, should take into account the harmful effects of emissions from fossil fuel usage in human as lung cancer, asthma, allergies and other respiratory problems.

Organizations worldwide, coalitions of states, national governments, individuals and enterprises should implement policies towards environmental protection as a matter of longer survival of the planet and its inhabitants.

In this context, we had to determine the economic exploitation of alternative energy sources of little value raw materials and also match the level of energy's production quantity and quality to those of already known sources.

The processing of biomass for the production of diesel fuel contributes to this effort. Political leaders and the scientific personnel have decided that this process will gradually meet energy needs (Vesudevan et al., 2005).

The importance of the subject and the tight time forced the international community to adopt measures with the Kyoto Protocol, which was signed in December 1997, adopted by Greece in April 1998 and ratified by all European Union's members in February 2002. Under the Protocol, the E.U. and its members have an obligation to reduce emissions of CO_2 by 8% during 2008-2012 compared to base year emissions which was the 1990.

Indeed, Greece in alignment with the European Union's directives is bound and determined to proceed, firstly in partial, production of diesel from biomass. Moreover, the dependence of Greece on oil and solid fuels is much higher than the average for the Euro zone countries. Nearly 85% of the whole energy consumption produced in our country from the use of oil and lignite.

Table 1 - Greece – Share of Total Energy Consumption (%), 2009

Greece – Share of Total Energy Consumption (%), 2009				
Nuclear	Solid	Natural Gas	Crude oil	Renewable
0	85.4	0.2	0.7	13.8

Source: Eurostat

The significance of the process is specified by the legislation that supports it. The European Union in the 2003/30/EC Directive ("Biodiesel Directive") aims to promote bio fuels and other renewable fuels in order to gradually replace diesel or petrol for transportations within member countries. The directive is part of meeting the European Union's commitments towards the Kyoto's Protocol to effectively tackle climate change. In this context, each member country should ensure a minimum proportion of bio fuel use in transportation sector and set national targets. Specifically, the Directive sets a reference value of 2% use of biodiesel up to 12/31/2005 and 5, 75% of biodiesel use by 31/12/2010.

Table 2 - Quantities of biodiesel required so that Greece achieves EU goals (thousand tons)

Year	**Estimated consumption diesel**	**% Biodiesel**	**Quantity**
2005	2.084.000	2	46.976
2006	2.125.000	3	71.851
2007	2.167.000	4	97.695
2008	2.208.000	4.5	111.986
2009	2.249.000	5	126.739
2010	2.290.000	5.75	148.407

Source: Ministry of Development (2006).

Of course, apart from the obvious environmental reasons, there are also other economic and political incentives. It is an issue at the level of energy diversification of sources and technologies for the European Union, as far as has no gas sources such as Russia and other oil fields as the United States and the Arab countries.

1 – 2: The process, the product, the company

It is necessary to define what exactly qualifies as biomass. In its broadest sense includes any material derived from living organisms. In particular, biomass for energy purposes includes any type that can be used to produce solid, liquid and / or gaseous fuels.

In practice there are two types of biomass: the forms and residual biomass produced from energy crops. Greece uses mainly residual forms and recently made a serious effort to engage and energy crops.

As a residual form of biomass are defined:

1. Agricultural residues (straw, pruning)
2. Forestry residues (logging, cleaning)
3. Residues of agricultural and forestry industries (chips, cheese-waste)
4. Wastes from livestock farms (manure, slaughterhouse waste)
5. Municipal wastes
6. Organic fraction of waste

As energy crops are defined:

1. Traditional crops that can be used to produce bio fuels / energy (beets, wheat, sunflower, eucalyptus).

It is easily seen that all these materials can be found in the Greek territory in abundance. It is the result of primary and secondary processing of raw materials. They cover a wide range of different shape and composition materials, allowing their use in many ways. The ways of using biomass and the results are very widespread. They constantly encountered in our everyday life, just might not know that these procedures are part of this process.

From the burning of biomass we can produce energy for heating; most known is the wood burning. With the necessary processing, in some small European countries like Sweden (17%), Finland (20%) and Austria (11%), but also in large extent countries like Germany, France and Spain, the heat energy from biomass is used equally for domestic use but also to heat large buildings such as schools, hospitals and other public and governmental buildings.

Another process that most of us have heard and takes place in Greece as well as the use of bio fuels for energy production. The use of high moisture waste such as municipal waste, waste holdings and the organic part of waste through anaerobic digestion takes place in Greece through the landfill waste (X.Y.T.A.). The result produces heat and electricity and with additional procedures can be produced transport fuel and gas. Currently in our country there are three such units (Ano Liosia - Athens, Psyttalia and Thessaloniki), with total energy capacity of 24 MW.

Finally, the use of biomass for bio fuels for transport is the most important application of this technology. The most common are bio diesel and bio ethanol while there is an interest in pure vegetable oil.

This part of the use of biomass will employ this thesis. The benefits are numerous and highly significant due to protection of the environment by reducing emissions, effective response to global warming, reduction of soil erosion, low inputs in fertilizers and exploitation of land with low fertility.

The financial sector contributes to reduce fuel imports, increase agricultural and livestock income, reduce dependence on oil and increase energy independence of the country.

The matter should be also combined with the existence of agricultural surpluses in the European Union and the economic problems being involved which lead to reduced agricultural land and production. In the case of Greece, it is estimated that about 10 million acres of farmland will be abandoned over the forthcoming years. If this land attribute to energy crops is being expected to cover 50-60% of the existing national needs for oil. Hence, it is a matter of great strategic importance for Greece.

Not least, there should be the implications of social issue of reducing regional inequalities, regenerating of rural areas of the countryside and promoting sustainable development.

An integrated approach to the use of biomass should also entitle a reference to the disadvantages in comparison to fossil fuels. Specifically, there is a difficulty in collecting, processing, transporting and storing them. More costs for the necessary facilities and the processing of biomasses should be counted. The production is widely dispersed and vulnerable to seasonality. Finally, high volume and moisture content per unit of energy is measured.

But, if there is anyone today to contest the amount of renewable fossil fuels, it is enough to read the sentence of Professor Jeff Dukes of Utah University, Salt

Lake: *"…each litre of gasoline currently consumed, came from 26 tons of Prehistoric plants"*.

According to Article 4 of the EU "Biodiesel" Directive, any country has to prepare the annual report on its progress in implementation of appropriate targets relating to the replacement of fossil fuels with bio fuels and the national resources allocated to bio fuel production and submit it to the European Commission.

The Greek Parliament ratified the European directive on the law 3423/2005 (ΦΕΚ Α' 304) which came into force on 13th of December 2005. The technical specifications for bio diesel production from biomass are set according to the standard ELOT EN 14214 adopted by the Supreme Chemical Council of Greece with the decision 334/2004 (ΦΕΚ Β΄ 713/2005 and ΦΕΚ Β' 1149/2005).

Leading role in this effort plays the key energy carrier of the country, Hellenic Petroleum Group (HELPE), which is the largest industrial and commercial group in Greece. It is an integrated oil company with a wide range of activities, such as refining of crude oil and fuel supply, marketing of oil products, including sales abroad, power generation Production and Trading, oil & Gas Exploration and Production and participation in transportation of crude and oil products

In 2006, the Hellenic Petroleum Renewable Energy Sources S.A. has been founded aiming at the production, distribution and retailing of energy produced from one or more renewable energy sources. Through this subsidiary HELPE participates with 25% interest in Biodiesel S.A. The latter is going to implement a bio diesel production facility. In this scheme participate Viochalco S.A., Hellenic Fabricks S.A. and Prima Holdings with 25% interest each.

The HELPE's Refinery in Thessaloniki – there are two more, in Aspropyrgos and Elefsina - is of a simple hydro skimming type. It has a vacuum distillation unit, desulphurization units, isomeric units and naphtha conversion units while petrochemical production units operate on the facilities. The Thessaloniki Refinery is the only refinery in North Greece with the capability to access the neighbouring Balkan countries. It is connected via pipeline to the storage facilities of the oil products retail partners.

More details about HELPE's key financial indicator and key operating indices which confirm company's strength as well as global economy's and industry's data of the last five years are given below:

Key Financial Indicators

Table 3 – Total Revenues

Total Revenues (in million €)				
2005	2006	2007	2008	2009
6.653,0	8.121,5	8.538,0	10.131,0	6.757,0

Table 4 – Income before Tax

Income before Tax (in million €)				
2005	2006	2007	2008	2009
494,8	358,5	489,0	17,0	242,4

Table 5 – Investments in Fixed Assets and Acquisitions

Investments in Fixed Assets and Acquisitions (in million €)				
2005	2006	2007	2008	2009
185,0	144,8	195,0	337,6	613,9

Table 6 – Total Assets

Total Assets (in million €)				
2005	2006	2007	2008	2009
4.189,8	4.363,5	5.059,0	5.146,0	5.763,2

2. Key Operating Indices

Table 7 – Number of Employees

Number of Employees				
2005	2006	2007	2008	2009
3.578	5.425	5.194	5.184	5.148

Table 8 – Refinery Output

Refinery Output (in thousand tones)				
2005	2006	2007	2008	2009
14.402	14.233	14.463	14.897	13.833

Table 9 – Refinery Sales

Refinery Sales (in thousand tones)				
2005	2006	2007	2008	2009
16.481	16.977	17.130	16.977	15.855

3. Global Economy and Industry Data

Table 10 – Average Price of Brent crude oil

Average Price of Brent crude oil (Platt's dated)				
2005	2006	2007	2008	2009
$ 54,38 / Bbl	$ 65,12 / Bbl	$ 75,52 / Bbl	$ 96,99 / Bbl	$ 61,67 / Bbl

Table 11 – Refining Margin of a Complex Refinery

Refining Margin of a Complex Refinery (in Mediterranean region)				
2005	2006	2007	2008	2009
$ 6,78 / Bbl	$ 5,73 / Bbl	$ 5,83 / Bbl	$ 6,76 / Bbl	$ 3,90 / Bbl

Table 12 – Refining Margin of a Simple Refinery

Refining Margin of a Simple Refinery (in Mediterranean region)				
2005	2006	2007	2008	2009
$ 0,08 / Bbl	$ -0,96 / Bbl	$ -1,10 / Bbl	$ -3,50 / Bbl	$ -2,26 / Bbl

Table 13 – Global Vs Greek growth Rate

Global Vs Greek Growth Rate (%)									
2005		2006		2007		2008		2009	
4,9	3,5	5,4	4,2	4,9	3,6	3,7	3,1	-0,6	-2,6

In addition to the Thessaloniki's refinery there is the National Centre for Research and Technological Development (EKETA) to make maximum use of biomass for bio fuel production within bio refinery.

Bio diesel is produced through esterification of raw materials from vegetable oils and animal fats and methanol. The production does not present particular technical difficulties so it can be obtained with the existing infrastructure of the domestic market for diesel fuel. Bio diesel is mixed with diesel at the Greek refineries in the volume fraction of 5%. After having overcome some technical difficulties it should be available in the market as blended products with more than 5% by volume and as unchanged bio diesel. The physical and chemical properties of bio diesel are very similar to the mineral oil and conventional engines do not need conversions to use mixtures up to 5%. In fact, they can use blends with 30% bio diesel, but needs care because such a use may cancel several guarantees of the manufacturers.

The use of bio diesel in 5%, the rest 95% of diesel, reduces carbon dioxide emissions (CO_2) at 2-2.5%.

The first domestic bio diesel production plant was launched in Kilkis in December 2005, followed by other two in Thessaloniki and Patras in July 2006. Up to now operate at least ten more such units throughout Greece as in Fthiotida and Volos. It is worth mentioning that for the construction of these units were used both European and national financial resources.

As regards the supply chain of these units consist of materials from oil imports (rapeseed oil, soybean oil) at 70-80% and domestic oils (cottonseed oil, sunflower oil and cooked in oil) at 20%.

Note that hard efforts are made to foster domestic sunflower and rapeseed in order for domestically produced raw materials to overcome the imported ones.

A prerequisite for successful and sustained use of bio fuels production is the adequate availability of raw materials. For this reason it has drafted the National Capital of Raw Materials in which are referred all biomass sources in the country as well as estimates the future quantities after the planned exploitation.

In Greece during a year, available agricultural and forestry residues are equivalent of energy with 3-4 million tons of oil, while, with the current data, the potential of energy crops can overcome them comfortably.

As far energy is concerned, this amount corresponds to the 30-40% of the quantity of oil consumed annually in this country. Note that a ton of biomass and of no humidity is equivalent to 0, 4 ton of oil.

In Greece there is already extensive cotton cultivation to ensure adequate quantities of cotton oil, while it plans to expand the cultivation of sunflower and rapeseed. At the same time, there is considerable availability of animal fats and cooked oils, the use of which entails, apart from other, significant environmental concessions.

The total biomass readily available in Greece is estimated at around 7,5 million tons remains of agricultural crops (cotton, tobacco, cereals, sunflower, etc) and approximately 2,7 million tons of forestry remains of logging (twigs, barks).

In the field of bio ethanol production, which is currently based on sugar beet, maize and cereals, the cultivation is widespread in the country while there is an effort to promote the cultivation of sweet sorghum which produces a higher volume of bio fuels as well as it thrives particularly in Greece.

1 – 3: Objectives of the study

Objectives of this research are the deep understanding of the processes that constitute the treatment of biomass to produce biodiesel in terms of economic interest, the identification of existing domestic market of biomass and the development of scenarios that Thessaloniki's refinery can use these processes in order to produce economic benefit.

Answers are expected to the following research issues:

1. Investigate domestic market for existence and adequacy of biomasses, especially in North Greece.
2. Create a Strengths-Weaknesses-Opportunities-Threats (SWOT) Analysis according to strategic management to better prepare the expansion of activities in this section.
3. Determine the ideal supply chain performance.
4. Investigate the performance of biomass markets.
5. Use of different scenarios in order to react to possible situations of changes on prices of ingredients.

The research aims to investigate the existence, the types, the efficiency and especially the economic viability of the process for Thessaloniki's refinery in order to meet the demand for cleaner environment in the context of Corporate Social Responsibilities and to meet requirements derived from Greek State laws and the European standards.

Chapter 2: Literature review

As already mentioned, the processing of biomass for diesel in Greek area is relatively a new procedure and an unexplored but of extremely strategic scope process.

Currently, only the two or three percent of the total refinery product is coming from biomass. Therefore, the relevant experience and literature is extremely limited. The lack of data makes this research novel and beyond the academic interest has the ambition to serve the real needs of the domestic market research in terms of Thessaloniki's refinery.

Nevertheless, there are enough available articles in scientific journals, reports of agencies and organizations, particularly in recent years. In this part we are going to mention articles on the subject of biomass processing for bio fuels to be used for transport.

Biomass can be converted into solid, liquid or gaseous fuels through thermo-chemical and biological routes. Liquid fuels, which are biofuels in the liquid form, are of special interest as petrol and diesel substitutes, in running internal combustion engines, especially for transportation. The rising cost of petroleum-based liquid fuels due to the depletion of oil sources, has brought biofuels into focus. This survey will make it clear that it would consider the liquid form of biofuels from biomass processing and according to Padma Vasudevan et al. (2005) such output are biodiesel and bio methanol which are already in the world markets but will have to integrate this practice with the available local resources in each country and in Greece is valid only for biodiesel as there is no bio methanol production at all.

The juxtaposition of the availability of biomass in any form in the country is essential to any research for this subject. Sources of information are the statistics of the country, available from the ministry or the National and European Statistical Institutes and other investigations. Boukis I. et al. (2009), depending on availability, classify biomass in two large categories and based on this, this Thesis will investigate the potential sources of raw materials in Greece. The first one includes directly available biomass such as the solid or liquid wastes coming mainly from large agricultural activities, forest industry, as well as solid municipal wastes. The second one includes indirectly available biomass such as the residues from agricultural cultivations (straw, corn and cotton) and forest activities (non-collected residues from forestry).

Biodiesel is an ester that is produced from the transesterification of vegetable oils. This process involves reacting a vegetable oil with an alcohol (ethanol or methanol), in the presence of a catalyst to produce an ester (biodiesel) and glycerin. It is important to explain the method of biodiesel production because the chemical ingredients needed and their costs are involved in the formation of the final price according to Diakoulaki D. et al. (2002) and the same scheme for explaining the sensitivity of the final price to its ingredients will be adopt by this Thesis.

Biodiesel can be produced by various oilseeds by first extracting the oil from the seeds, purifying it, adding methanol for the transesterification and finally separating and purifying the resulting methyl-ester.

Additional cases for the consuming of biodiesel in the transport sector are hosted by Al-Zuhair S. (2007). Biodiesel, compared to petroleum-based diesel, has a more favorable combustion emission profile, such as low emissions of carbon monoxide, particulate matter and unburned hydrocarbons. It has also a relatively high flash point (150^o C) compared to 55-60^o C for diesel, which makes it less volatile and safer to transport or handle than diesel as it has low oral and dermal toxicity. It provides better lubricating properties which reduce engine wear and extend engine life In accordance with EU governments should promote the use of biodiesel in public transports and this will be a proposal to the Greek authorities in the last section of this work.

Ruth (2008) in her article refers to the three generations of biomass treatment. Fuels based on food crops are called first-generation biofuels. Scientists and engineers are already forging ahead with second and third-generation biofuels. Second-generation biofuels are derived from cellulose by enzymatic conversion and fermentation. Third-generation biofuels are broadly defined as new and hybrid-processing technologies that convert organic materials. As most methods of producing second and third-generation fuels are still unavailable, countries that use biofuels generally rely on various first-generation fuels depending on domestic climate and agricultural resources. Greece's technological equipment allows only the first generation process at this moment but it is a matter of discussion to provide at least the second generation treatment in the following years.

Processing of biofuels and raw materials pace away for multifunctional farming, this would lead to a new source of income and jobs. For example, if EU had a sustained demand of 2 million tons of biofuel, an estimated 2.000 jobs could be created in plant cultivation itself and 7.000 jobs would be generated in processing (DGS, 2005).

Another promising alternative for producing biodiesel is waste cooking oil. Waste cooking oil is also the main material of biodiesel which is treated by the Hellenic Petroleum. It is a cheaper raw material that also avoids the cost of waste product disposal and treatment. It reduces the need to use land for biodiesel producing crops and can be collected from large scale food processing and service facilities. Its treatment is a matter of public health as these waste oils were used as an additive to animal food, so the EU banned the use of waste cooking oils in the composition of animal feeds in 2002 (Bautista L.F. et al. 2009).

The biorefinery concept according to Octave S. et al. (2009) is based on the use of the whole plant can evolve to a generalization. The reduction of the wastes or byproducts could be linked not only to one whole plant transformation but also to the use of several plants based on complementarities of different processes, different factories belonging sometimes to different companies. The wastes and byproducts of the first one could be the starting material for the second one and a source of energy for the third one. This philosophy governs the imprinting of the supply chain of this industry in Greece, as would occur in the next chapter of this work, since the limited domestic and accurate production supplemented by imports from abroad. Optimization of the flow of raw materials, of byproducts, of energy between different industrial production units on a given site is a generalization of the concept of biorefinery through an actual “Industrial Metabolism”.

Biodiesel market development is highly dependent on promoting policies because of competitiveness, in terms of cost, of biofuel technology compared with fossil fuel technology. For these reasons, Common Agricultural Policy (CAP) introduces a favorable context for biofuel development through the introduction of compulsory “set-aside” land. In this area, only crops for non food consumption can be cultivated. Farmers have been able to take advantage of a special aid for energy crops. Bernard F. et al. (2007) represents the excellent example of France which as a member country also introduced tax exemption on biofuels so that industrialists are sure to sell their biofuel productions to refiners who can benefit fossil fuel tax exemption in proportion to the quantity of biofuel used in substitution of taxed fossil fuel. This policy is adopted also by the Greek authorities as a motivation to enter in the specific industry. It will be seen later, however, that other measures and applications make the entrance to biodiesel industry more difficult in Greece.

According with European Union's Directive, 2005 was appointed as the first year of efforts to harmonize the member countries with the objective of 2% of biofuels for transportation. The EU biofuel production was quite considerable, approximately 1,5% mainly because large transport fuel consumers like Germany, France and Spain reached the 2% target. Deurwaarder E.P. (2005) indicates the countries that have set a lower national target than 2% gave various reasons for this deviation, which the main ones were that biofuels for transport were considered not cost-effective for reducing greenhouse gas emissions, fuel and its use was problematic and limited amount of feedstock was available in certain countries. In comparison with these circumstances an attempt to measure Greece's achievements will be done.

The current economic situation demonstrates with the most convincing way that the sectors of industry and agriculture diminished in contrast to other sectors which are involved to a greater extent in the production of national wealth. The service industry makes up the largest, most vital and fastest growing sector of the Greek economy (74,4%), followed by industry (20,6%) and agriculture (5,1%). Therefore it is a historical and critical opportunity for the restructuring and expansion of the national economy the adoption at a larger scale of biomass processing to produce biodiesel (Lazarou S. et al. 2007),

In 2007, ten more countries became members of the EU. These countries have a special interest as far as biofuels is concerned, mainly because of their land availability and agricultural and production experience as Kondili E.M. et al. (2007) is commented. The accomplishment of EU's targets does not require that feedstock or biofuel production should be domestic. For many countries in the EU the target values will be reached only by biofuel imports. These facts will be considered as the Supply Chain will be examined. Also these factors are important in order to present company's SWOT Analysis later. So, there is a question in which part of this process a member country should enter. The value chain of biofuels includes, in general terms, feedstock, biofuel production, blending, distribution and finally consumption. It is critical to identify the role of each member in the biofuel supply chain. Some countries will serve only as raw material producers, others as biofuel producers and others will combine a more complex role.

Special reference to the existence of large areas and therefore the existence of large production is done. It is concluded that plants with capacities less than 15kt/year should be avoided as the plant operation cannot be profitable while only the plants with capacities greater than 50kt/year can be feasible from the economic point of view as Apostolakou A.A. et al (2009) derives after a techno-economic analysis provided cost calculations and process specifications. Statistical data that present large and available plants in Greece should be considered in this text in order to allocate biodiesel facilities due to efficient and effective purposes.

In Greece, especially in Thessaly, there is a renewable source of energy from cotton-stalks. The cultivation of cotton suggested by the EU as ideal due to the topography of Greece and the experience that exists in rural communities of the country as Tatsiopoulos I.P. et al. (2002) states. The treatment of cotton stalks can be a combined solution to problems like the lack of energy and gradual expansion of energy needs, the emissions of dangerous greenhouse gases like CO_2, the development of parasite sources in cotton fields and the seasonal unemployment of people after the seed cotton harvesting and collection. This thesis will examine a representative place of Thessaly in comparison with two other places in order to rate them based on their local factors.

Apart from cotton field, Panoutsou C et al. (2007) lists other large areas of sunflower cultivation which is mainly grown in northern regions of Greece (Macedonia and Thrace) and soybean cultivation which is grown in western and southern regions (Epirus and Peloponnesus). Many chances of biomass treatment are allocated to the cultivation of tobacco and tomato, which remained stable in the last decade but due to new opportunities are going to recover soon. Corn cultivation is thrived in many places of Greek territory. The wide variety of seeds in Greek territory does not affect the price depending on the type of seeds as we shall see in later chapter.

Several investigations were carried out to find what the ideal plant for biodiesel production is. Most agree that after comparing energy corps and counting basic factors such as biodiesel productivity, cultivated area and environmental impacts, it seems the sunflower crop to be the optimum solution for biodiesel production because it combines the relation between the volume of production and the corresponding implications as Tsoutsos T. et al. (2010) concludes after taking into account local factors that affects the biodiesel productivity. Sunflower in our search was found as the prevalent cultivation in North Greece and in any case the most preferable among biodiesel industries.

On the other hand, a significant production of biomass raw material comes from animal waste sources. Mainly, these sources are manures form pigs, chickens, cattle, sheep, goat and also some horses and fur animals and residues from meat industry processing. Most farm owners used to sell animal manures as a fertilizer for agricultural land or just throw them causing immediate danger to public health and burdening the environment. Although the farms could be an excellent source of mass biomass production, it is found out that the scarce installation of farms in Greece makes it difficult an organized harvest and exploitation of them (Skoulou V. et al., 2007). This was approved also after the in depth interviews with biodiesel owner which is presented in later chapter.

Another great Greek region that can provide a large volume of biomass raw materials, mainly from wood, is of Eastern Macedonia and Thrace, where according to a survey a large percentage is (three quarters) aware of the population of the practice of using biodiesel. Also it is impressive that most of the residents (almost half of them) are ready to adopt biodiesel for home or business use (Papadopoulos A.N. et al., 2009).

The development of biofuels plants in Greece is significant and in any case in line with EU and national policies. The first domestic biodiesel production plant started its operation in December of 2005 by ELVI S.A. at Kilkis. By next year, three more units started their operation: Vert Oil S.A. in Thessaloniki, P.Petas S.A. in Patra and Agroinvest in Lamia. Nowadays more than ten additional units operate in this sector. The decision to convert two plants of Hellenic Sugar Industry S.A. to bioethanol production plants is a tangible evidence of the willingness of the government to accelerate development (Karagiannidis A. et al., 2007). The current and fully updated catalogue of all Greek industries that operate in the sector will be presented.

A desirable characteristic of biofuels plants is the capability to use simultaneously various biomass types. These plants should have a multi-feeding capability in order to be fed with biomass which is available during each time period, avoiding dependency on specific feedstock and material. It is expected that this capability should increase operating cost (Boukis I. et al., 2009). This perspective was also one of the questions raised in the biodiesel unit owner.

The Greek Legislation Framework of biodiesel production was a subject of criticisms from all directions because of the disparity between the volumes allocated to companies and their much higher productive capacities and on the other side, the low capacity producers who have been unprofitable because they were not allowed to sell biodiesel outside the quota scheme. It must be counted the traditional bureaucratic system and the expected doubts from some NGOs and political parties (Iliopoulos C. et al., 2010). Despite the problems, the objections and the obstructionism the national project continues. The inevitable complaints from all sides will be evaluated in the forthcoming SWOT Analysis.

It is obvious that the efficient treatment of biomass is a challenge for the country, the communities and the individuals that must be answered. For this reason synergies have to be developed towards the land use strategies compatible to the climatic, environmental and socio-economic profiles in each region, the improved efficiency in agricultural production and management systems to cope with the high demand of raw materials to satisfy diverse market requirements and the harmonization of support mechanisms and funding schemes to improve the overall effectiveness of biomass supply chain (Panoutsou C., 2008).

Different economic criteria of the feasibility of the process are used by many researchers. Total capital cost, total biodiesel cost, capital equipment cost and a compilation of fixed capital cost and total manufacturing cost are some of these criteria. A latest economic criterion of Net Present Value of this process is used in order to define the most feasible process of biodiesel production (Marchetti J.M. et al., 2008).

In order to identify the viability of biodiesel production, the most important impact factors on biofuels costs must be measured. These factors are the feedstock cost, investment costs, fixed and variable Operation & Maintenance costs distribution and retail costs as well as policies which vary by region and country (Ajanovic A. et al., 2010). This path will be followed by this Thesis to evaluate the current costs of all processes stage by stage.

Chapter 3: Methodology

The process of biomass treatment for biodiesel production which can be used in the transport sector is quite complex and involves a number of links in the entire process either directly or indirectly. The institutional framework is a set by both the EU and by national legislation framework in order to determine more specifically the EU directives and adapt them to the particular Greek environment. The methodology that is going to be applied, will gradually answer the questions raised in previous chapter as is going to analyze the latest regulations that determine the exact annual allotment of biodiesel production.

The information, figures, arithmetical and statistical data derived from in-depth interviews with senior executives that their businesses are involved throughout the development and production of biodiesel. More specifically the owner of an energy crop, located in Serres, North Greece, the vice president of a biodiesel production unit located also in Serres, a researcher of EKETA in Thessaloniki who is responsible for biomass treatment methods and an executive of Planning Department of Hellenic Petroleum Group in the refinery of Thessaloniki were interviewed during September of 2010. Additional information was taken from available surveys of the Statistical Service of Greece and the EU but also from several institutes.

First, we try to define the types of raw materials that they come from plant or animal residues or waste oils, the sources of supply of raw material from Greece or other EU countries and their locations and specifications of the storage of verbatim biodiesel. In this way, identify and analyze the existing supply chain and the exact details which govern it.

As far as the supply chain process is concerned, this thesis is going to record the sequence of processes and flows that takes place within and between different stages, from the farmer of a plant or an energy crop to the final customer of a biodiesel mixture. Data about the range of quantity required, the lead time, the variety of raw materials, the number of channels through which raw materials may be acquired and the service level are going to be collected. Also, it is going to be investigated the existence or not of risk in supply and demand of biodiesel products and if it is possible to predict them through the existing model or should be organised a new one.

Through the process of interviews with executives involved in exploitation of biodiesel, an attempt to explore the processes in depth will be done, based on their experience with the operations of biodiesel. According to their answers it is going to be characterised the existing supply chain as efficient or responsible and to what extend. Factors such as inventories, transportation, facilities and handling and information will be considered according to their decisions making. The performance characteristics of the existing network will be assessed according to time, the quality, the profitability and the satisfaction of standards prescribed by the law.

In addition to recording reality, will be asked from the respondents to be fastened critical to the system, identify the weaknesses, if there are, of the chain and to propose solutions that will have as objective to increase profit margins without having to devalue the quality of product provided.

Finally, an attempt will be done by this thesis to present an optimized network model through the ideal allocation of demand to existing production facilities.

The investigation of the circumstances of a company which operates in the field of biomass processing and production of biodiesel should be held after consideration of the external environment. The external factors that affect the operation of a unit, most of the times create opportunities and sometimes conceal threats to survival and development of the company. The external environment includes the macroeconomic factors affecting the economic activity of organizations, social, cultural, demographic and environmental factors, the political, legal and governmental factors, the technological factors and the competitive forces. In order to, these factors, be determined an External Factors Evaluation (EFE) Matrix should be done for the study of a representative unit of the industry.

On the other side should take into account the internal image of the same representative unit that operates in this industry in order to identify the strengths and weaknesses, which certainly has. Timely and realistic portrayal of these critical characteristics is the necessary information on the design and implementation of the strategic plan of a company. For this, an Internal Factors Evaluation (IFE) Matrix should be done.

Finally, a Strengths-Weaknesses-Opportunities-Threats (SWOT) Analysis should be presented in order to give an overview of the company's operation in this industry and the national economy and society generally.

The last part of this thesis will be devoted to analyzing the economic conditions for the functioning of a representative company in the industry. The data will be collected on a survey to the companies, as well as from the available statistical studies. Direct contact with the operators of this market would provide an opportunity to obtain a fully updated study of the costs included to this process.

In particular, it is going to be presented a comprehensive and schematic presentation of the supply chain of this industry from the first to the last stage. It will also follow the Cost Analysis of a sunflower cultivation in Greece. The choice of the sunflower is made because of the massive shift of Greek farmers in specific energy crops which is encouraged particularly by the domestic climate. The Cost Analysis of biodiesel Greek production company is needed in order to complete the presentation of the path followed of price configuration until the final product, full text biodiesel, be bought by the refinery.

Table 14 - Sunflower in Greece: total acreage, annual oilseed and percentage of non-food use (2003-2007)

	2003	**2004**	**2005**	**2006**	**2007**
Farm land cultivated (ha)	8200	3700	4600	8600	14.000
Oilseed production (tons)	10.300	4600	5700	15.743	19.273
Non-food uses (%)	0	0	0	46.51	64.29

Source: National Statistical Service of Greece (2009).

Additionally, an attempt to investigate the future economic prospects of biofuels in Greece will be done. The prices of raw materials as well as the prices of all stages involved with biodiesel production will be measured. The data will be derived form various sources of Statistical Organisations but due to their deviation from market prices will be aggregated with the values that respondents participating in the interviews will provide.

Since the quantity of produced biodiesel in Greece is defined by the authorities, we will try a sensitivity analysis to shape the final price if ingredients or raw materials needed to produce biodiesel suffer from price changes. The scenarios will be analyzed basically on historical data variation of prices which is a safe way to predict future price fluctuations.

Chapter 4: The External and Internal Assessment

In this chapter we will make an investigation of the external environment and the major factors outside the control of the company as well as the internal characteristics of the company which is involved on a supply chain of biomass treatment and biodiesel production.

The verification and presentation of the information listed below has emerged after taking interviews with business executives whose companies are the key factors in production processes and the study of statistic data and relevant literature.

The purpose of an external audit is to develop a finite list of opportunities that could benefit a firm and threats that should be avoided.

External Forces can be divided into five broad categories: 1) Economic forces, 2) Social, cultural, demographic and environmental forces, 3) Political, legal and governmental forces, 4) Technological forces and 5) Competitive forces.

As far as the economic environment is concerned, it is considered as the most crucial among all the others. In May of 2010, Greece was entered under the Emergency Financing Mechanism (EFM) and a three year Stand-By Arrangement (SBA) is approved by the International Monetary Found, European Central Bank and European Commission. The macroeconomic indicators of Greece do not allowed short term optimism and in any case the country has entered in a period of recession in the midst of imposed structural changes. High inflation due to indirect tax hikes, liquidity in banking system is tight, unemployment rate increases (11,8%), private consumption remains stable due to households' saving cushions, real GDP is expected to decline at 4% rate this year (2010), public debt is expected to peak at 144% in 2013 as a share of GDP and the primary balance of last year (2009) was 8,6% of GDP.

Key challenges for Greece remain restoring fiscal sustainability, safeguarding financial sector stability and boosting competitiveness hence growth and employment.

As far as social, cultural, demographic and environmental forces are concerned, Greek people are asked to cope with rapid changes required by the fiscal consolidation. The country is plagued by frequent general strikes and demonstrations that various teams of professionals, when they feel that they lose existing benefits, do not hesitate to paralyze the country and the economic life by closing essential infrastructure such as ports, airports, national roads, customs, courts, tax offices and energy production units.

The estimated population in 2008 was about 11.230.000 of whom the 66% lives in urban areas and the 33,4% in the Attica periphery. Country’s peculiar geography marked by the existence vast number of islands and mountainous and craggy mainland while the three quarters of the country covered by mountains.

As far as political, legal and governmental forces are concerned, Greece is a full EU member since 1980 and participates in the euro area since 2002. The last election in the October of 2009 held through policies scandals and acute economic problems. The wide victory of the Socialist Party with over 10 per cent allowed the government to take legislative action to exit the country from crisis. The inclusion of the country in EFM, entitles representatives of international economic foundations to intervene to exercise of fiscal policy of the country. Political stability is not threatened but the opposition parties aggregates react to the structural changes. The legislation fracture of the country is affected by the EC directives, even with a delay, adopted by the Parliament.

As far as the technological and competitive forces are concerned, the country has a rich breadth of scientific personnel who could adopt the latest technological developments and adapt them to domestic peculiarities. Greek universities and scientific institutes, several times, produce innovative techniques in all disciplines. Government should provide a basis to strengthen the research project and the integration of these results in the production process. The harmonization of the country with the European directives ensures a healthy economic competition. The proximity to countries with abundant cheap labour supply is the main responsible for the competitive disadvantage of Greek production although must not ignore the existence of bureaucracy, government corruption and state interference in business through heavy direct and indirect taxation.

In this overall framework for Greece, we can formulate a representative SWOT analysis of Greek companies which are active in the processing of biomass for biodiesel used in the transport sector.

First, we try to identify the sixteen most important external factors which determine Opportunities and Threats and then we try to rank them and assign a weight to each of them according to their importance. Second, we try to identify the sixteen most important internal factors which determine Strengths and Weaknesses and respectively we try to rank them and assign a weight to each of them according to their importance.

The apposition of the data will be completed with the calculation of i) the External Factor Evaluation – EFE, ii) the Internal Factor Evaluation – IFE and iii) the Strengths-Weaknesses-Opportunities-Threats (SWOT) Analysis.

We can define as opportunities the steady increase in demand for liquid biofuels, tax incentives, availability of agricultural land and production, proximity to countries which can provide biomass, favourable legislation framework, adequacy of existing technology, existence of EU subsidies and adequacy of necessary infrastructure such as ports and national roads.

As threats we can define the problem of liquidity and financing companies, bureaucracy, market crisis and decrease in private consumption, possible reactions of environmental organizations and small political parties, abandonment of agriculture and rural in general, aging of population and concomitant exodus of youth abroad, reduction in public investments and social unrest because of the crisis and ongoing strikes.

As strengths we can define the available large production capacity, large storage capacity of raw materials, possibility to export, guaranteed sales, spatial adequacy, and wide variety of suppliers, offer of a competitive price and tradition and experience in the cultivation of suitable species.

As weaknesses we can define the high interest rates, the lack of competition, the reduced exploitation of production capacity, ignorance of the general public about the project, expensive raw material compared with fossil, illiquidity, no option to sell directly to individuals and deficiencies in security of the personnel.

Figure 1: The External Factor Evaluation Matrix

Key External Factors		Weight	Rating	Weighted Score
Opportunities				
1.	Steady increase in demand for liquid biofuels	0,14	3	0,42
2.	Tax incentives	0,13	4	0,52
3.	Availability of agricultural land and production	0,03	2	0,06
4.	Proximity to countries / providers of biomass	0,04	2	0,08
5.	Favourable legislation framework	0,02	2	0,04
6.	Adequacy of existing technology	0,05	3	0,15
7.	Existence of EU subsidies	0,11	4	0,44
8.	Adequacy of necessary infrastructure	0,06	3	0,18
Threats				
1.	Problem of liquidity and financing companies	0,10	3	0,30
2.	Bureaucracy	0,06	3	0,18
3.	Market crisis / lower private consumption	0,11	4	0,44
4.	Reactions of environmental organizations	0,02	1	0,02
5.	Abandonment of agriculture and rural in general	0,05	2	0,10
6.	Aging of population / exodus of youth abroad	0,04	1	0,04
7.	Reduction in public investments	0,03	3	0,09
8.	Social unrest	0,02	1	0,02
Total		**1,00**		**3,08**

Regardless of the number of key opportunities and threats included in an EFE Matrix, the highest possible total weighted score for an organisation is 4,0 and the lowest possible total weighted score is 1,0. The method of approach is according to David, 2009.

Weights and ratings are recorded due to the responses of the interviewed executives. The average total weighted score is 2, 5. The total weighted score of 3, 08 indicate that the representative company is responding in a quite satisfying way to existing opportunities and threats in its industry.

Figure 2: The Internal Factor Evaluation Matrix

Key Internal Factors		Weight	Rating	Weighted Score
Strengths				
1.	Large production capacity	0,10	4	0,40
2.	Large storage capacity of raw materials	0,06	2	0,12
3.	Possibility to export	0,07	2	0,14
4.	Guaranteed sales	0,12	4	0,48
5.	Spatial adequacy	0,04	3	0,12
6.	Wide variety of suppliers	0,07	2	0,14
7.	Offer of a competitive price	0,08	3	0,24
8.	Tradition / experience in the cultivation	0,03	4	0,12
Weaknesses				
1.	High interest rates	0,04	4	0,16
2.	Lack of competition	0,03	3	0,09
3.	Reduced exploitation of production capacity	0,06	2	0,12
4.	Ignorance of the general public	0,02	3	0,06
5.	Expensive raw material compared with fossil	0,07	4	0,28
6.	Illiquidity	0,04	4	0,16
7.	No option to sell directly to individuals	0,09	4	0,36
8.	Deficiencies in security of the personnel	0,08	2	0,16
Total		**1,00**		**3,15**

Regardless of the number of key strengths and weaknesses included in an IFE Matrix, the highest possible total weighted score for an organisation is 4,0 and the lowest possible total weighted score is 1,0. The average total weighted score is 2, 5. The total weighted score of 3, 15 indicates that the representative company is responding in a more than satisfying way to existing strengths and weaknesses in its industry.

Chapter 5: Supply Chain Management

Key role in the process of biomass treatment for biodiesel production plays the organization's supply chain. This research will attempt to capture all stages involved in that process.

First of all it is appropriate to cite a definition of what is meant by supply chain. Supply Chain Management encompasses the planning and the management of all activities involved in sourcing and procurement, conversion an all Logistics Management activities. Importantly it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies (Council of Supply Chain Management Professionals).

The stages that leading up to the finished product which reaches the consumer are in the following series:

The first stage consists of the domestic producer or farmer who signs a contract with the biodiesel industry for one year and grows rapeseed, sunflower and soybean. The produced seeds are the product that it is sent with producer’s expense in the mill where treatment is conducted according to the process of pressing or extraction.

The mill is the second stage of the whole procedure. The chosen procedure is an extremely important case because with the pressing it is produced about 33% oil while the extraction assigned 40% oil. At this point there is the possibility of importing ready oil from abroad and which is exploited by the Greek biodiesel companies. Thus, import soybean oil from Argentina, which is transported through ships in the port of Kavala or Thessaloniki and rapeseed oil imported from Hungary, Romania and Bulgaria and transported in tankers.

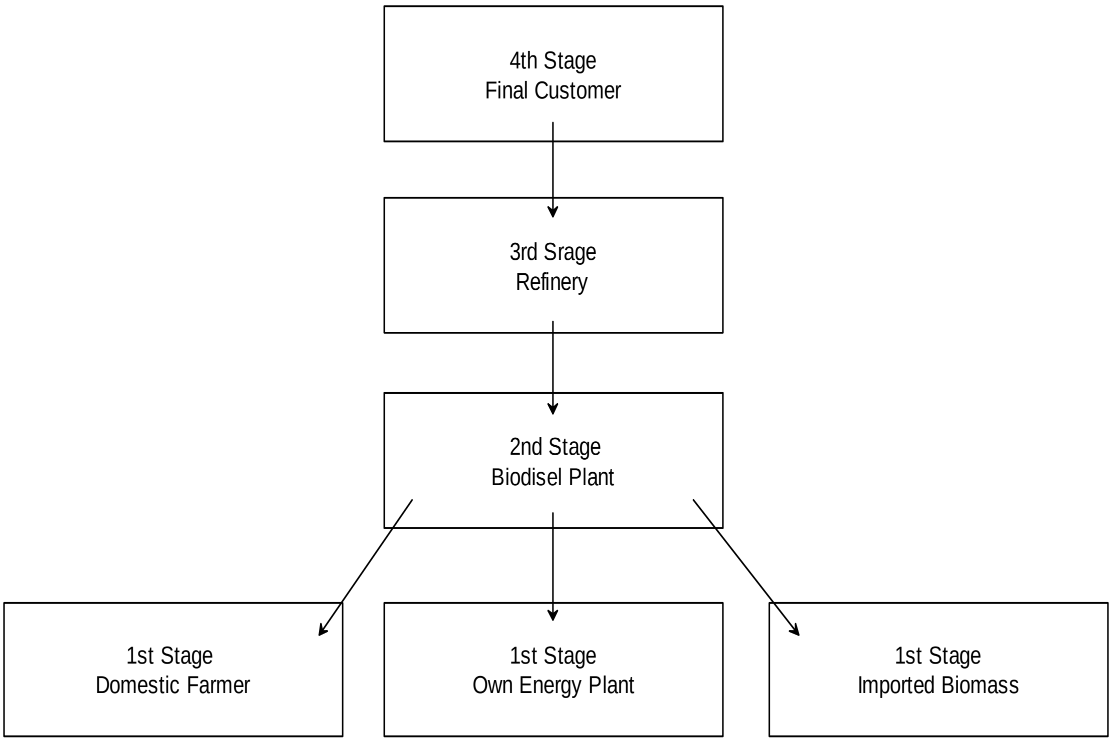
The third stage consists of the processing plant oils into biodiesel. The process involves the chemical treatment with methanol and also the plenty use of water which is necessary first to go through the process of osmosis and desalination in order not to wear the equipment of the Company from the salt and rust. The smooth operation of conversion machinery of oils into biodiesel eliminates the loss rates on quantities of biodiesel. These rates range from 0.5% at best to about 10%

worse. However, this loss in some cases covered by the sale of generated soap oil which currently reaches the price of 250 € per ton.

Further, glycerine is defined as a by-product but unfortunately there is no demand for it so there is no more a source of revenue for the company. Nearly two years ago there were companies that buy the glycerine for 150 € per ton but now the biodiesel companies give it for free.

Biodiesel is produced there and then the product is transferred via tanks at the refinery which is the fourth stage.

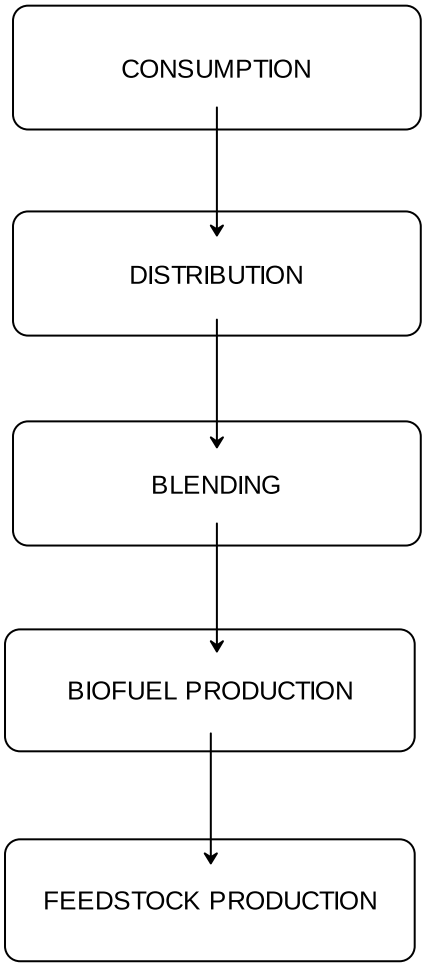
Figure 3: Stages of Biodiesel Supply Chain



Transportation to the refineries is done with tanks whose costs assume the refinery. Apart from refineries belonging to the Hellenic Petroleum and Motor Oil, biodiesel may be sold to the oil companies such as Jet Oil. In the fourth stage, carried out quality control of each tank separately and after certifying the quality of biodiesel then it is mixed with diesel. The rate of mixing diesel with biodiesel currently amounts to 6.6% for the Greek production.

In relation to the percentage of blending in Greece, which is at 6.6%, it is worth noting that in Germany it is available a blend of 20% biodiesel, named B20 and there is also available with diesel blending rate of 100%, named B100.

Figure 4: Operational Stages of Supply Chain



Furthermore, regarding the use of biodiesel is necessary to extend it not only to diesel, but to heating diesel and to diesel for maritime transport for environmental reasons especially since it significantly reduces the burden on the domestic use but also on the seas respectively.

In designing the supply chain the distance between the involved parties plays an important role. In this case study the biodiesel processing plant operates in Northern Greece in a prefecture (Serres) bordering Bulgaria, which is an EU member and also a producer of raw material, while domestic producers are located in a distance between twenty and thirty kilometres from the industry. This design minimizes the transportation charges initially incurred by the biodiesel plant. In the second phase and after biodiesel is produced, transportation charges incurred by the refining companies.

Chapter 6: Economic Data

This chapter will provide useful economic data that constitutes the processing of biomass for biodiesel production. An attempt is made to record data from the first to the last stage of the supply chain, in other words from the field up to the refinery.

Prices and quantities are real and emerged through in depth interviews with stakeholders. So, this is an updated analysis of prices for the year 2010.

The Greek legal framework enforced the percentage use of biomass raw materials by domestic production. As expected, the prices to be charged from Greek farmers in comparison to those of their colleagues from neighbouring countries are particularly higher. This fact serves as a deterrent for many Greek companies who wish to enter the biodiesel industry. The figures are indicative of the situation. The rapeseed, sunflower and soy used in the industry as raw material costs in Greek market from 0, 35 € to 0, 45 € per kilo or 350 € to 450 € per ton. On the other hand, the prices offered abroad ranges from 0, 17 € up το maximum 0, 30 € per kilo or 300 € to 170 € per ton. Worth noting, that one acre of crop attaches annually 300 to 500 kg of grain crops. The efficiency of the field depends on the fertility as well as the quality of seed planted. Germ mutant seeds and their plants are cheaper but often result to reduced quality and defections of derivative grain.

At this point an analysis of production costs for Greek farmers would be presented. Data is based on national Statistics and General Directorate for Agriculture in northern Greece. Sunflower’s cultivation is examined as a representative energy crop and as trend cultivation among Greek farmers. Also, it must be mentioned that according to Common Agricultural Policy (CAP) farmers receive an average subsidy for their cultivation until 2013 and an additional subsidy for energy crop cultivation which is of 45 € per hectare. We will estimate first the Total Production Cost (TPC), which is divided into land rent, labor and equipment, second the Gross Income (GI) by multiplying the produced quantity with the current market price. Then after abstracting the TPC from the GI the average subsidy will be added. More specifically:

Table 15 – Sunflower's Cultivation Cost Analysis

Sunflower	
Yield (t/ha)[1]	3
Selling price (€/t)	350
Gross income (GI)	**1.050**
Land rent[1]	350
Labor / Equipment	740
Total Production Cost (TPC)	**1.090**
Production Costs (€/kg)	0,35
Net Profit before Subsidies (GI-TPC)	**-40**
Subsidy (CAP)[2]	294
Subsidy (energy crop)	45
Profit after Subsidies	**299**

1 - Yield and land rent are referred to irrigated land that is the yield and the rent as high. For non irrigated land the yields and the rents are significantly lower.

2 – Council Regulation No. 1782/2003. The estimated subsidy is the average of the three year period 2000-2002 subsidy.

In conclusion, it is understood that the cultivation of the specific plant is uneconomic for the Greek farmers. Only the existence of subsidies converts this cultivation to profitable. The existence of subsidies and the legislative framework which imposes a percentage supply of oil-seeds from domestic producers ensure the continuation of economic viability of energy crops.

The available data is collected after a phone contact with the owner of this sunflower crop which is located in Serres, North Greece in September 2010.

Bearing in mind the fact that domestic production is insufficient to meet the needs of the Greek biodiesel companies, it is explained why imports of raw materials are up to 60% with a tendency to increase. The Greek side responds to the current reality with 1.000.000 yield stress for energy crops.

One factor that in any case affects the final price of the product is the cost of transportation. As it is mentioned above the charge is covered by either biodiesel or the refining company. In this case, the short distance between energy crops and plant designed to benefit the final consumer. The value of transport at current rates not exceeding 6 € per ton for distances nor exceeding 70km and for larger distances can reach 20 € per ton, always within the Greek territory.

The energy crop produces seeds that are used as raw material for biomass. However, for their treatment it is necessary to convert them to liquid form before the production of biodiesel. The treatment costs varies between 150 € to 200 € a ton. The price variation is due to the handling since there is a difference in quantity of produced oil.

The treatment in the biodiesel plant costs about 300 € per ton. The most important part in shaping that price plays methanol, its use currently costs about 350 € per ton, while two years ago had reached 500 € per ton. After the treatment, the refining companies receive the full text of biodiesel.

The level of market prices paid for biodiesel from refining companies varies from year to year. Sales have begun in substance since 2006 when it cost 800 € per ton, while in 2007 the average price was 950 € per ton. In 2008, the price rocketed to 1350 € per ton, until last year dropped to 1000 euros, while the current price offered by the refineries this year is 1280 € per ton.

Each year the ministry sets the maximum price premium offered for each company, depending on the distribution of production quantities of biodiesel that are assigned to each Greek company. It is easily understood that for all the companies producing biodiesel, the assigned amount is significantly to dramatically less than their real production capacity.

For calculating the price in EURO per m^3 of full text biodiesel the Department states the following way:

(BP) * 0, 88 (specific weight) + premium

Where:

BP: the Base Price calculated as the average of MO (Platt’s) * rate ($ / €) and of MO (Reuters).

MO (Platt’s): average $ / MT of low price "Biodiesel" for the winter or «FAME0» for the summer season (in the column Barges FOB Rotterdam) of Platt's European Marketscan.

MO (Reuters): average in € / MV price «Reuters Biodiesel ex Works» (in the column FAME2 GERMANY)

Premium: 430 € per m^3

Rate: European Central Bank rate for the same calendar half when Base Price calculated

This Base Price together with the premium calculated in € / m3 in any case should not exceed 1.280 € / m^3.

Considering that the selling price to refineries is 1.280 € per ton and after extracted the fixed and variable costs we can calculate the gross profit (premium) of a biodiesel industry per ton. Specifically, the Unitary Cost (€ per ton) for the current year 2010 is:

Table 16 – Bio diesel’s production Cost Analysis

Raw Material Cost	550 €	700 €
Mill’s expenses	150 €	200 €
Processing costs	300 €	300 €
Transportation costs	50 €	50 €
TOTAL COSTS	1.050 €	1.250 €
Selling price	**1.280 €**	**1.280 €**
Premium (limit 430 / m^3)	280 €	30 €

Previously, it is sawn that the price of that the Selling Price of a ton of sunflower seed is 350 € and here we see that Raw Material Cost is estimated from 550 to 700 €. This difference is explained by the average oil content from the sunflower seed that is of 42%. The production of one ton of full text biodiesel needs a ton of sunflower oil plus further 10%, totally around 1.110 kg.

Processing Costs consists of: electrical energy of 60kWh / per ton, 110 kg of methanol per ton, natural gas of 440kWh per ton, 1,28 tons of water per ton, labor costs

Table 17 - Total distribution verbatim biodiesel to recipients for 2010

	Biodiesel Company	Total annual broken down quantity verbatim Biodiesel (In millilitres)	Premium
1.	ΕΚΚΟΚΙΣΤΗΡΙΑ–ΚΛΩΣΤΗΡΙΑ Β. ΕΛΛΑΔΟΣ Α.Ε.	4.447,79	850
2.	ΠΕΤΣΑΣ Α.Ε.	1.457,59	480
3.	ΒΙΟΝΤΗΖΕΛ Ε.Π.Ε.	7.071,21	600
4.	ΚΑΤΟΪΛ Α.Ε.Β.Ε.	2.836,63	685
5.	STAFF COLOUR – ENERGY A.B.E.E.	2.796,20	825
6.	AGROINVEST SA	15.323,11	410
7.	ΜΟΤΟΡ ΟΪΛ ΔΙΫΛΙΣΤΗΡΙΑ ΚΟΡΙΝΘΟΥ Α.Ε.	1.897,79	595
8.	ΠΑΥΛΟΣ Ν. ΠΕΤΤΑΣ Α.Β.Ε.Ε.	27.891,61	980
9.	ΦΥΤΟΕΝΕΡΓΕΙΑ Α.Ε.	12.586,50	833
10.	ΕΛΙΝ ΒΙΟΚΑΥΣΙΜΑ Α.Ε.	10.707,12	1000
11.	BIODIESEL A.E	7.551,73	450
12.	GF ENERGY A.B.E.E.	17.893,65	795
13.	Mil Oil Hellas A.E.	3.419,56	815
14.	ΜΑΝΟΣ Α.Ε.	11.483,45	850
15.	ΕΛ.ΒΙ. - ΕΛΛΗΝΙΚΑ ΒΙΟΠΕΤΡΕΛΑΙΑ Α.Β.Ε.Ε.	32.148,15	990
16.	OIL.B S.R.L.	4.487,91	450
	TOTAL	**164.000,00**	

Source: Ministry of Environment, Energy and Climate Change (2010)

Chapter 7: Scenarios and Proposals to the Company

In this chapter an attempt will be done to detect the areas of intervention in the supply chain of biodiesel and to suggest ways of optimizing, given the limits set by the State. Then, as regards the analysis of the cost of biodiesel will attempt to set two different scenarios based on the experience of the price fluctuations in previous years.

7.1 Location Factor Rating

As regards the supply chain is obvious that the distribution of quantity but also the definition of maximum profit margin from the ministry, determine several important factors that as fact and not as an issue to solve.

Factors such as the uncertainty of demand which employs every link in the supply chain, does not exist in this industry. A clearly defined space of time deliveries per month also ensures the timely delivery of biodiesel through a year. As regards the customer channels are limited as only reaching out to companies with refining licenses and companies of petroleum product trading of first class.

Moreover, the range of manufactured products is non-existent as only full text biodiesel is produced, which is sold and some by-products, such as glycerine which is currently difficult to sell because of lack of demand and soap oils due to possible wastage during the treatment. Also it is not possible to maintain inventories because of the determination of production quantities and the existence limitation of only 10% excess. Therefore, due to these conditions is easily observed that there is no competition among biodiesel companies and the refineries in part on biofuels.

Therefore, it is necessary to consider at what point the refining company and biodiesel production industry can affect factors of the supply chain and which of them to maximize responsiveness and efficiency.

The first functional driver to be thoroughly examined is that of location of facilities. The sites producing raw materials, of treatment and of final acceptance must be in as shortest distance and in all cases related to modern road transport network. Northern Greece is ideal since the location of energy crops in prefectures like Serres and Kilkis, the existence of processing plants in the industrial area of

Serres and the final mission in Thessaloniki refinery does not contain distances bigger than 70 km.

In order to detect the right locations, the Location Factor Rating method will be used. We examined three representative regions in Greece in the northern, central and the bigger Greek island. This rating is done to present an ideal site of a plant of biodiesel, which is a coherent link between the fields and the refinery. Thus, indicates the correct choice of a biodiesel supplier by refineries whom facilities are huge and located in specific sites in Thessaloniki and Attica since decades.

Figure 5: Location Factor Rating

		Scores (0 to 100)					
Location Factor	Weight	Serres	Weighted Score	Karditsa	Weighted Score	Crete	Weighted Score
Labour pool	0.10	80	8	80	8	80	8
Proximity to Suppliers	0.20	100	2	100	2	100	2
Proximity to Customers	0.20	90	18	80	16	40	8
Infrastructure	0.20	70	14	70	14	60	12
Community	0.10	80	8	80	8	80	8
Climate	0.05	60	3	80	4	100	5
Proximity to borders	0.15	100	15	50	7.5	20	3
	1.00		**68**		**59.5**		**46**

With this method it is subjectively, shown that the best area in Greece for the establishment of a biodiesel production unit, and simultaneously the best option for a refinery located in Thessaloniki to cooperate with it, is the Serres-North Greece due to its proximity to the borders, which is not valid with Karditsa-Thessaly and Crete, and also the proximity to the Thessaloniki refinery via vertical link road. According to climate conditions, Thessaly and Crete enjoy milder climates but this factor is not essential. Proximity to the producers and communities' conditions are similar to three sites and infrastructure Serres is either not lagging Karditsa, either is superior compared with Crete.

7.2 Proposed Contractual Relationship

A second area that the refinery can employ is the contractual relationship that is signed with the biodiesel plant. The use of a Firm Fixed Price contract (FFP) seems to be the most appropriate as the specifications are well defined, the cost, schedule and technical risk is low, and the Ministry haw established the maximum price. Production's disclosure facilitate the refining company to commit large amounts of biodiesel, so large that for a biodiesel plant could be more than the two thirds of its production, making the refinery the most-favoured-customer and indicate warranty terms about the lowest offered price.

In such cases, the coverage of output from one client can obtain a quantity discount contract. But as there is a fixed maximum selling price for biodiesel generators, all adopt this value which in the current year amounts to 1280 € per ton. The refining company, however, may require guaranteed lowest price and if it emerged that another producer offers the full text of biodiesel at a lower price (by compressing its premium) to demand the same.

Ministry also sets monthly production limits to biodiesel producers. So, the companies adopt the policy of seasonal inventory to cover predictable demand from refineries. The result of this policy is not to produce unavailable products and reduce inventory costs only by being responsible to the orders. Of course the downside is that it lacks of flexibility in hypothetic additional orders which are however unlikely to be taken in this operation framework. A real example of this framework for a biodiesel producer for 2010 is given below:

Table 18 - Monthly quantity of full text biodiesel production according to national quota

Biodiesel Company	Monthly quantity of full text biodiesel (in millilitres)
July 2010	0.00
August 2010	325.13
September 2010	374.26
October 2010	374.26
November 2010	298.60
December 2010	276.47
January 2011	261.02
February 2011	309.71
March 2011	327.35
April 2011	265.43
May 2011	329.58
June 2011	331.77
TOTAL	**3419.56**

Source: Ministry of Environment, Energy and Climate Change (2010)

7.3 Scenarios of Price Variations

At this point we consider various scenarios of price variation in materials that make up the final price of biodiesel as it reaches the final consumer. As references are construed the available statistics and the answers given during the interviews by the executives whose enterprises involved in the production of biodiesel. The experience of four years spent in biodiesel production in Greece gives them also the right to make additional estimates for the future.

It should be noted that the scenarios considered are generated after the answers of the respondents based on their concerns on the development of biomass and biodiesel industry in Greece and their experience to date.

It is prerequisite to separate the costs to variable and fixed. As variable costs are considered the cost of labour, material or overhead that changes according to the change in the volume of production units. Combined with fixed costs, variable costs make up the total cost of production. While the total variable cost changes with increased production, the total fixed costs stay the same.

It should also be defined these items that are sensitive to fluctuations of the supply and demand for their price formation. The availability of these products depends on several factors such as raw materials depend on weather conditions or by-product of biodiesel production, glycerine, which as noted above, its price plummeted because of the enormous supply of the product.

By analysing the costs, it will be assumed that Land, Labour and Equipment Costs for energy crops cultivation are remained stable. Market prices of produced seeds will rise only if the subsidies will cease to exist and national quotas demand from biodiesel producers to buy from domestic farmers. Inevitably the cost of the lack of subsidies will be borne by biodiesel industry. This will be the first scenario for consideration.

A possible variation of a cost, based on the experience of previous years, as formulated by the owner of a biodiesel production unit is to increase the purchasing price of methanol, the basic ingredient for biodiesel production. Therefore, in the second scenario will be estimated the final cost of full text biodiesel with a possible price increase of 30% in methanol and given that other costs remain the same.

In the third scenario, a potential enforcement by the state will be considered if duty is beard in full text biodiesel. Currently biodiesel is free from any state tax as an incentive for wider production and use of it. If they bear the tax, or even the value added tax (VAT) which is currently 23% in Greece, the total cost will change.

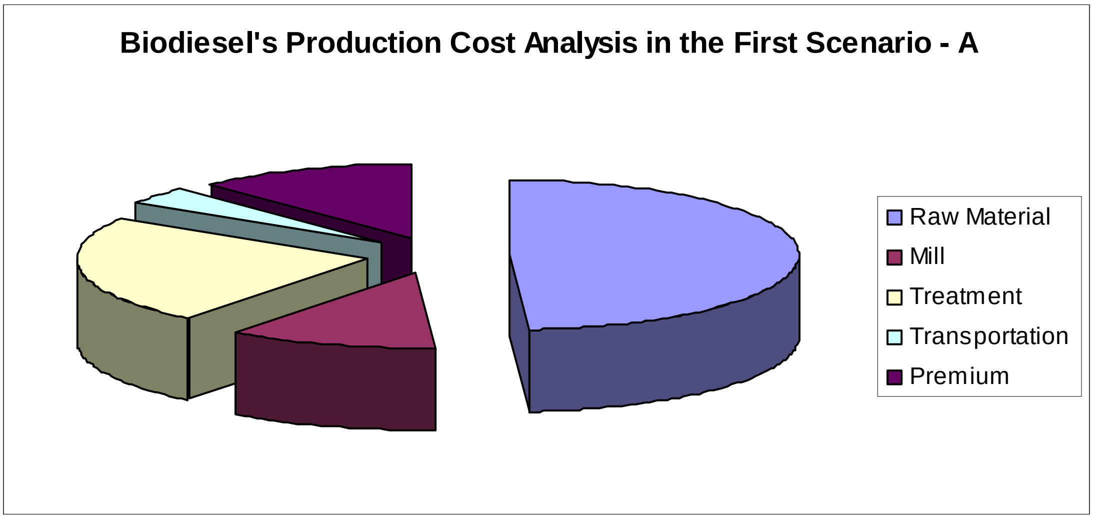
7.3.1 First Scenario

As previously referred the sunflower cultivation is not an economically viable crop for the Greek farmers. The existence of subsidies is what it makes it automatically very profitable. Subsidies from EU are guaranteed under the CAP until 2013 and after then there is no motion for extension, at least for the moment. If the Greek authorities continue to impose the quota market biomass from Greek farmers, the last would be forced to increase the selling price of raw materials to avoid a loss and to add a reasonable profit, which in this case would be around 10%. Therefore, we will have the following Cost Analysis:

Table 19 – Bio diesel's Production Cost Analysis in the First Scenario

	A	B
Raw Material Cost	(550) **625 €**	(700) **790 €**
Mill's expenses	150 €	200 €
Processing costs	300 €	300 €
Transportation costs	50 €	50 €
TOTAL COSTS	1.125 €	1.340 €
Selling price	**1.280 €**	**1.280 €**
Premium (limit 430 / m^3)	(280) **155 €**	(30) **-60 €**

Figure 6: Bio diesel's Production Cost Analysis in the First Scenario, Case A



It is obvious that due to the increase in Raw Material Cost the profitability of biodiesel production is squeezed as in the first case there is a fall in profits of 45% and in the second there is a loss as the roof of the premium exists. Therefore, in this case, the second bid must be abandoned as a loss.

7.3.2 Second Scenario

Among the main ingredients in the processing of oils from biomass for biodiesel production is methanol. Fluctuation in methanol's price in accordance with the answers of the respondent manager of Biodiesel Company this season ranges down. Two years ago the price had increased to 500 € and now stands at 350 € per ton. The costs associated with the use of electricity, gas, water and the catalyst as well as the depreciation expense for the investment is considered as almost remain stable since the quantity of biodiesel production remain stable due to the existence of state quotas.

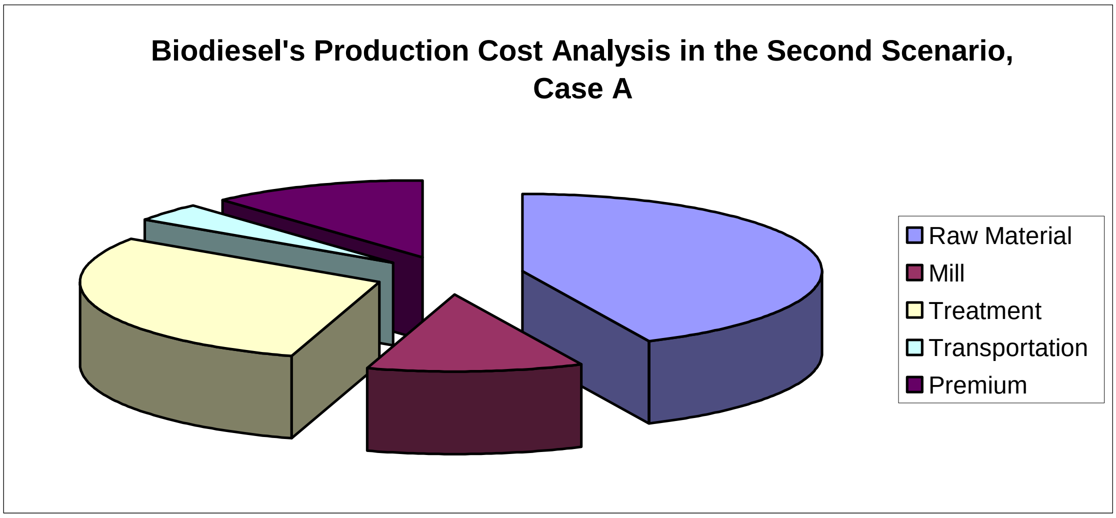
According to this scenario we assume that the market price of methanol per ton reaches again the levels of 2008. The cost of methanol to the production of a ton of full text biodiesel is about the 60% of its total treatment cost. That means that from 300 € of total treatment cost in the biodiesel industry about 188 € is the cost of used methanol. With the assuming raise of 43% (350 € to 500 €) the cost of methanol will be about 267 € per ton of produced biodiesel.

So, according to the following table:

Table 20 – Bio diesel’s Production Cost Analysis in the Second Scenario

	A	B
Raw Material Cost	550 €	700 €
Mill’s expenses	150 €	200 €
Processing costs	**(300) 379 €**	**(300) 379 €**
Transportation costs	50 €	50 €
TOTAL COSTS	1.129 €	1.329 €
Selling price	**1.280 €**	**1.280 €**
Premium (limit 430 / m^3)	(280) **151 €**	(30) **-49 €**

Figure 7: Bio diesel's Production Cost Analysis in the Second Scenario, Case A



It is obvious that due to the increase in Processing Costs the profitability of biodiesel production is squeezed as in the first case there is a fall in profits of 46% and in the second there is a loss as the roof of the premium exists. Therefore, in this case, the second bid must be again abandoned (as in the first scenario) as a loss.

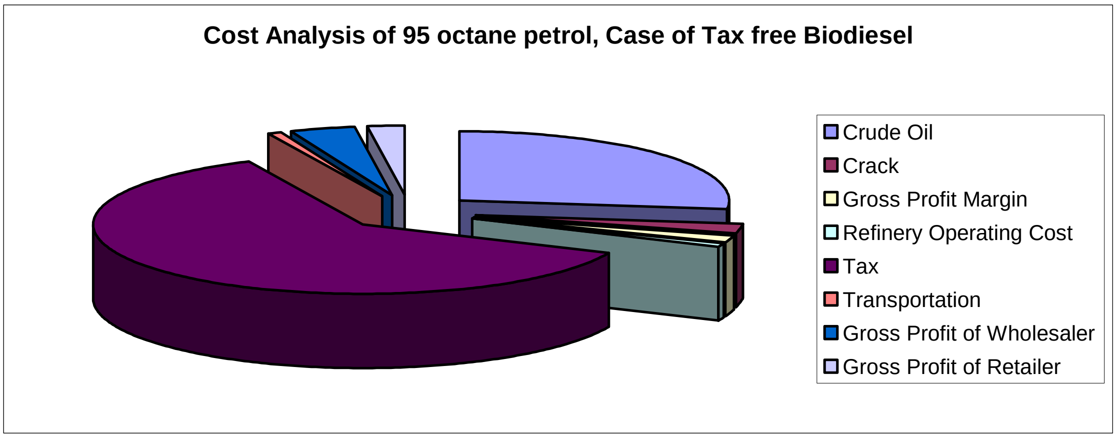
7.3.3 Third Scenario

The third and final scenario will be considered to apply the excise duty levied on fossil fuels to biodiesel as well. Although this scenario seems like extreme because of the EU Directive on establishing tax incentives for biodiesel, the dire economic position of the country and the unstoppable seeking for new sources of revenue can lead to biofuels tax. Today, HELPE mix the diesel with biodiesel at 6%. This rate is not subject to tax. It follows the analysis of the cost configuration of 95 octane petrol up to the final consumer as it is now and then by imposing a tax on biodiesel blend at rate 6%.

Table 21 – Cost Analysis of 95 octane petrol

	Tax free Biodiesel		**Tax Biodiesel**	
	Cost	Total	Cost	Total
Crude Oil	0.41	0.41	0.41	0.41
Crack	0.036	0.447	0.036	0.447
Gross Profit Margin	0.025	0.472	0.025	0.472
Refinery Operating Cost	-0.012	0.46	-0.012	0.46
Tax	**0.94**	**1.40**	**1.00**	**1.46**
Transportation	0.01	1.41	0.01	1.47
Gross Profit of Wholesaler	0.06	1.47	0.06	1.53
Gross Profit of Retailer	0.035	**1.505 €/lt**	0.035	**1.565 €/lt**

Figure 8: Cost Analysis of 95 octane petrol, Case of Tax free Biodiesel



As it is shown in this table, the extra charge reaches to six cents per litre. According to the existing trend, which demands to increase the mixture of diesel with biodiesel, the final price to consumer will remain the same, despite decreases in proportion to the percentage of biodiesel. The absence of a tax exemption would eliminate the incentive to use biodiesel.

Chapter 8: Conclusions

The study investigated the operation of an entire sector of the Greek economy concerning the processing of biomass for biodiesel production used in the transportations. On the occasion of environmentally friendly fuels that will reduce the emission of pollutants, Greece is in front of the challenge to restructure a large part of its production possibility to renewable energy sources. The examination of the facts as these is resulted from the interviews taken by stakeholders and also the other relevant literature and available statistical data show an extremely promising prospect for economic growth. This perspective is particularly important at this point of time if we count the extremely difficult economic situation in Greece which is under surveillance and lending by the IMF and the ECB.

This final chapter will summarize the findings that the questions raised in the first chapter. Regarding the first research issue, the availability of exploitable biomass, which is an essential raw material for biodiesel production, all available evidences from the government but also the results of scientific research agree that Greece has a satisfying coverage of energy needs as far as the treatment of biomass is concerned.

The conduct of the evaluation methods of external and internal factors that affect the industry and more detailed measurement of EFE and IFE as well as the SWOT Analysis of the factors depicted at the suggestion of the respondents due to the answer of the second research issue. Respondents also moved further in assessing the gravity of each of the factors separately and in comparison. The conclusion that came out is that a representative company in this industry responds positively to opportunities and responds efficiently to threats of the external environment.

As far as the third research issue, the existing Supply Chain of biomass treatment is evaluated as satisfactory. The important role of the location of the facility is noted as the small distance between the cooperating units and the proximity to countries which supply the raw materials ensure higher profit margins and responsible response to demand. Also it is presented a comparative analysis of the ideal place to install a unit in this industry due to Location Factor Rating depending on various important factors. Also it is examined the ideal contractual relationship between them.

About the fourth question, it is presented Cost Analysis of feedstock production, biomass processing until the final price from the refinery. It is noteworthy that the appeared data come directly from the answers of respondents and the market like an updated portrayal of the market.

Finally on the fifth posed question, three different scenarios were analyzed although characterized as undesirable by the stakeholders. The scenarios were modelled on fears of possible distortions. The lack of subsidies for farmers, increase in the purchasing price of methanol and taxation on biodiesel are likely to hinder bio diesel's industry development.

8.1 Limitations of Study

The research conducted faced a number of limitations. The fore most impediment faced was the timeframe that influenced the collection of the data. Being more specific, collection of updated data for such a complex process, which is affected by EU Directives and national policies within the time restrictions, especially during Greek summer and vacation period for the involved companies was quite difficult.

8.2 Future Work

It is more than likely that research will continue over the processing of biomass for biodiesel production. Further research can be done on the creation of integrated implementation plans of existing technologies and rearrangement of resources to maximize the productivity. It should also be explored the development of further incentives in order to enter new players to market and to reflect the higher production levels regarding the exports. Finally, an interesting issue is determining the balance between crops for food products and energy crops so that the domestic food production not to be reduced.

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