INTERNATIONAL HELLENIC UNIVERSITY

CYNERGY PELLETS

MSc in Banking & Finance

Business Plan for an Industrial Pellet Plant

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EXECUTIVE SUMMARY

Biomass is characterized as "the sleeping giant" of energy production and, until 2020, energy agriculture is due to contribute to the renewable energy sources by 31.31%. Millions tonnes of biomass remain unexploited due to low energy density, high moisture, heterogeneity and other supply chain issues. The problems of conventional biofuels gain economic efficiency by the production of pellets with consistent quality, low moisture content, high energy density and homogeneous size and shape.

Global consumption on pellets in 2009 was estimated at 10.6 million tonnes of which, 65% was attributed to the residential sector and 35% to energy production. According to several studies, the energy sector alone by 2020 will be in demand of 10million to 25million tonnes depending on policy makers and the decisions implemented on the reduction of greenhouse emissions and coal co-firing or coal substitution.

Nowadays, the global production of pellets is utilizing sawdust or wood chips as raw material. However, the rapid growth in industry capacity of wood pellet production and the effect of the global financial crisis on the output of sawmills, have made these raw materials scarce and more expensive. Profitability margins have shrunk and production became in some cases even inefficient. This situation has led in a search of new types of raw material origin.

CYNERGY PELLETS is aiming at the production of industrial quality pellets using as raw material the perennial crop cardoon *(Cynara cardunculus* L.). The plant is well adapted to the xerothermic conditions of southern Europe, typical conditions of arid and semi-arid areas of the Mediterranean basin and has the potential to produce the cheapest biofuel comparing to all other bio-energy crops known. Raw material supply will be secured by contractual agriculture.

The location of the pellet plant is within the prefecture of Evros in Greece and near the village of Tihero. CYNERGY will be a "first mover" in this region. In a radius of 50km are available thousands of arable ha of which 1.66%-2.5% are necessary for full operation of the site. A railway station with adequate infrastructure is available. Additionally, the port of Alexandroupolis is located in the south-west, 50km from the selected location and is connected to the railway. The capacity of the plant is estimated to be at 3t/h and 21,000t/y (estimated with 7,000 full operating hours) and production will be 24/7. Production procedures and equipment are exact the same as in wood pellet production and only minor adjustments are needed.

Revenues will occur either by sales in local biomass power plants or sales to a Greek wholesaler for further export. Four biomass power plants are authorized for operation in the prefecture of Evros and will be operational within 2013, utilizing agricultural residues. Two of the power plants will be situated within a radius of 10-20km and the other two in a distance of 70km. Estimates on biomass consumption for these plants are between 120,000-140,000 tonnes of biomass per year.

The total cost of installation for the pellet plant is estimated at €3,363,400. Total equity will be provided by the investor. The approximately €1.6million funding provided by the Greek Incentives Law, will cover working capital needs and offer liquidity for the first years of operations, as bank financing, given the current conditions, will be very difficult and expensive for the start up.

Construction period is scheduled in an 18month period and initial operation of the plant must coincide with raw material harvesting. Operational profitability is reached by the second year of operation, while full operational capacity will be achieved by year 5. Cash flow analysis indicated an IRR of 19.8% for the investor while sensitivity analysis on several factors affecting costs and selling price, yielded an IRR ranging from 13.44% to 25.99%.

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1. INTRODUCTION

1.1. Background

Biomass comprises the most important energy source, which due to the increasing energy needs, must replace the mineral energy sources for environmental sustainability, according to European and international protocols. Thus, until 2020 energy agriculture is due to contribute to the renewable energy sources by 31.1%, whereas transport energy in the EU-25 countries should be covered by renewable sources by at least 5,75% in 2010.

Biomass energy is energy produced from organic material grown, collected or harvested for energy use. At present, biomass is the main renewable energy source used for electricity production, heat production and transport. The range of technologies exploiting biomass resources is very wide and the choice of technology depends not only on final use, but also on the nature of the biomass feedstock. The biomass resource can be estimated, based on the land available for dedicated crops and the available forestry and agricultural residues and waste.

The drawbacks of biomass as a fuel alternative to coal, oil or gas are attributed mainly to its low energy density, high moisture content and heterogeneity. The problems of conventional biofuels can be lessened or even prevented altogether by the production of pellets with consistent quality, low moisture content, high energy density and homogeneous size and shape. Consistent fuel quality makes pellets a suitable fuel type for all areas of application, from stoves and central heating systems up to large-scale plants, and with practically complete automation in all these capacity ranges.

The production of the pellets is labor intensive and commercially challenging. Still, recent years have seen advancement in machinery and processes used for the transformation of low grade biomass to high grade solid biofuels. Pellets can be packaged and transported in a variety of forms such as consumer bags, jumbo or big bags, inside containers, railcars, flat bed trucks, tanker or silo trucks and ocean bulk carriers. They can also be stored in readily available flat storages as well as vertical silos. Year-round pellet supply can therefore be realized by reasonable and efficient fuel logistics.

1.2. Purpose

The purpose of the venture is the production of industrial quality biomass pellets. Pellets are a solid biofuel with consistent quality, low moisture content, high energy density and homogenous size and shape.

The raw material utilized is the perennial crop cardoon (*Cynara cardunculus* L.), also know as Spanish thistle artichoke, of Mediterranean origin, well adapted to the xerothermic conditions of southern Europe, typical conditions of arid and semi-arid areas of the Mediterranean environment. Cardoon has the potential to produce the cheapest biofuel comparing to all other bio-energy crops known (Grammelis et al., 2008). The raw material availability will be secured through contractual agriculture.

1.3. Opportunity

For pellet production the important factors influencing company performance are raw material, storage of raw material, equipment, pelletising process and proficiency of the staff. The main cost factor of pellet production is the raw material. Therefore, raw material prices play a decisive role in the economy of pellet production. All kinds of raw materials are subject to strong seasonal and local price fluctuations.

The international pellet industry is today using as raw materials sawdust and wood savings, which are byproducts of the wood industry. The rapid growth of the wood pellet industry internationally combined with the competition on raw material with the particle board industry on the one hand, and the variability of the wood industry production (affected by the economic cycles and weather conditions) on the other hand, have led to the scarcity of the raw material and the increase of its price over the years. The minimum and maximum price of sawdust for instance was 4 €/lcm and 10 €/lcm (loco sawmill) between November 2007 and October 2008 (pelle@tlas project, 2009). Thus the difference between highest and lowest price was 150%. These numbers illustrate how important securing long-term and economic raw material availability is for pellet production. Another example of this situation is the fact that in autumn 2005 more pellet boilers were sold than ever before and this led to an unexpected rise in fuel demand the following winter. In addition, consumption and hence demand were boosted by the long and harsh winter of that year. At the same time, the snowy winter inhibited the wood harvest, which is the reason why sawmills produced less sawdust – the main raw material for pellets. As a consequence, the sawdust price rose and pellet production costs increased substantially while capacity utilization rates had fallen. Increased demand and lower production led to shortages in pellet supply.

Prices for fossil fuels have risen dramatically, which rendered the pelletisation of energy crops more economical. Market growth in the pellets sector led to a shortage of easily available raw materials such as sawdust and wood shavings, which made market players look for alternative raw materials for pellet production. A lot of research has been carried out in this respect, including some trial areas where energy crops are grown for pelletisation (Gominho et al., 2010).

Through the use of the perennial crop cardoon and the contractual agriculture, CYNERGY will secure the availability and price of raw material and stabilize capacity utilization rates. Also, low moisture content of the raw material, makes the drying process unnecessary and reduces the cost of pellet production further more. Thus cardoon is able to produce cheaper (€/ton) product for industrial use.

1.4. Definitions

Below are given the definitions of several terms used in the context of the business plan:

- A *biofuel* is a fuel produced directly or indirectly from biomass.
- *Biofuel pellet* is a densified biofuel made of pulverized biomass with or without additives usually with a cylindrical form, random length of typically 5 to 40 mm and broken ends. The raw material for biofuel pellets can be woody biomass, herbaceous biomass, fruit biomass, or biomass blends and mixtures. Biofuel pellets are usually produced in a die. The total moisture of biofuel pellets is usually less than 10 wt.% (w.b.).
- The *bulk density* is the mass of a portion of a solid fuel divided by the volume of the container that is filled by that portion under specified conditions.
- The *calorific value* or heating value is the energy amount per unit of mass or volume released from complete combustion.
- The *energy density* is the ratio of net energy content to bulk volume. The energy density is calculated using the net calorific value and the bulk density.
- *Herbaceous biomass* is biomass from plants that have a non-woody stem and that die back at the end of the growing season.

- The *mechanical durability* is the ability of densified fuel units to remain intact, e.g. resist abrasion and shocks during handling and transport.
- *Moisture* is the water in a fuel.
- *Sawdust* are fine particles created when sawing wood. Most of the material has a typical particle length of 1 to 5 mm.
- The *total ash or ash content* is the mass of inorganic residue remaining after combustion of a fuel under specified conditions, typically expressed as a percentage of the mass of dry matter in fuel.

2. INDUSTRY AND MARKET ANALYSIS

2.1. Solid biofuels standards

Prior to the description of the pellet industry and the market for pellets, a description of the product standards across Europe is considered essential.

There are national standards and quality regulations that try to control the quality of pellets in ways that, in part, differ greatly from one another. Apart from the national standards, work on European standards for solid biomass fuels has been done in recent years, which lead to the publication of a series of European standards from 2010 onwards and consequently to a harmonization and better comparability of pellets on an international basis. As soon as the European standards are issued, the national standards have to be withdrawn or adapted to these EN standards within six months. Above all, work on ISO standards for solid biomass fuels has been in progress since 2007 and will lead to international standards in a few years. The ISO standards will finally replace all EN standards.

The European Committee for Standardization (CEN) under committee TC335 has published a number of standards and pre-standards for solid biofuels, which have been partly upgraded to full European standards, showing in table 1. Fuel specification and classes standard (EN 14961) consists of the following parts, under the general title “Solid biofuel – Fuel specification and classes”:

• Part 1: General requirements (published in January 2010)
• Part 2: Wood pellets for non-industrial use (published in June 2011)
• Part 3: Wood briquettes for non-industrial use (under development)
• Part 4: Wood chips for non-industrial use (under development)
• Part 5: Firewood for non-industrial use (under development)
• Part 6: Non-woody pellets for non-industrial use (under development) .

The solid biofuels are divided into four sub-categories for classification in EN 14961, i.e. woody biomass, herbaceous biomass, fruit biomass and blends and mixtures. In EN 14961-1 the classification of fuels is flexible, and hence the producer or the consumer may select the classification that corresponds to the produced or desired fuel quality from each property class (so-called “free classification”).

Table 1: EN standards published and under development

Number	Title
prEN 14588	Solid biofuels- Terminology, definitios and descriptions
EN 14774-1	Solid biofuels- Determination of moisture content-Oven dry method- Part 1: Total moisture-Reference method
EN 14774-2	Solid biofuels- Determination of moisture content-Oven dry method- Part 2: Total moisture-Simlified method
EN 14774-3	Solid biofuels- Determination of moisture content-Oven dry method- Part 3: Moisture in general ananysis sample
EN 14775	Solid biofuels- Determination of ash content
prEN 14778	Solid biofuels- Sampling
prEN 14780	Solid biofuels- Sample preparation
EN 14918	Solid biofuels- Determination of calorific value
prEN14961	Solid biofuels- Fuel specifications and classes, multipart standard Part 1- General requirements Part 2- Wood pellets for non-industrial use Part 3- Wood briquettes for non-industrial use Part 4- Wood chips for non-indystrial use Part 5- Firewood for non-industrial use Part 6- Non-woody pellets for non-industrial use
EN 15103	Solid biofuels- Determination of bilk density
prEN 15104	Solid biofuels- Determination of carbon, hydrogen and nitrogen-Instrumental method
prEN 15105	Solid biofuels- Determination of the water soluble content of chloride, sodium and potassium
EN 15148	Solid biofuels- Determination of the content of volatilt matter
EN 15149-1	Solid biofuels- Detennination of particle size distribution- Part 1: Oscillating screen method using sieve of 1 mm and above
prEN 15149-2	Solid biofuels- Detenmination of particle size distribution -Part 2: Horizontal screen method using sieve apertures of 3.15 mm and below
prEN 15150	Solid biofuels- Determination of particle density
EN 15210-1	Solid biofuels- Determonation of mechanical durability of pellets and briquettes- Part 1: Pellets
prEN 15210-2	Solid biofuels- Determination of mechanical duarability of pellets and briquettes- Part 2: Briquettes
prEN 15234	Solid biofuels- Fuel quality assurance, multipart standard Part 1- General requirements Part 2- Wood pellets for non-industrial use Part 3- Wood briquettes for non-industrial use Part 4- Wood chips for non-indystrial use Part 5- Firewood for non-industrial use Part 6- Non-woody pellets for non-industrial use
prEN 15289	Solid biofuels- Determination of total content of sulphur and chlorine
prEN 15290	Solid biofuels- Determination of major elements
prEN 15296	Solid biofuels- Conversion of analytical results from one basis to another
prEN 15297	Solid biofuels- Determination of minor elements
prEN 15370	Solid biofuels- Determination of ash melting behaviour

Source: Obernberger & Thek (2010)

An advantage of this classification is that the producer and the consumer may agree upon characteristics case-by-case. In table 2 are shown the specification of wood pellets for non-industrial according to EN 14961-2 and are compared to the existing standards in some European countries.

Table 2: EN standards published and under development

Parameter	Unit	Final draft prEN 14961-2			ONORM	SS 187120	DIN 51731	DIN $_{plus}$	CTI
		Class A1	Class A2	Class B	Austria	Sweden	Switzerland	Germany	Italy
Diameter D	mm	6 or 8	6 or 8	6 or 8	4-10		4-10	4-10	6
Length	mm	3.15 -40	3.15 -40	3.15 -40	≤ 5 x D	≤ 4 x D	≤ 50	≤ 5 x D	D - 4 x D
Bulk density	kg/m^3	≥ 600	≥600	≥ 600		≥ 600			620 - 720
Particle density	kg/dm^3				≥ 1.12		1 - 1.4	≥ 1.12	
Moisture content	wt.% (w.b.)	≤ 10	≤ 10	≤ 10	≤ 10	≤ 10	≤ 12	≤ 10	≤ 10
Ash content	wt.% (d.b.)	≤ 0.7	≤ 1.5	≤ 3.5	≤ 0.5	≤ 0.7	≤ 1.5	≤ 0.5	≤ 0.7
NCV	MJ/kg (w.b.)	16.5 - 19.0	16.3 - 19.0	16.0 - 19.0	≥ 18.0	≥ 16.9	17.5 - 19.5	≥ 18.0	≥ 16.9
Sulfur content	wt.% (d.b.)	≤ 0.03	≤ 0.03	≤ 0.04	≤ 0.04	≤ 0.08	≤ 0.08	≤ 0.04	≤ 0.05
Nitrogen content	wt.% (d.b.)	≤ 0.30	≤ 0.50	≤ 1.0	≤ 0.30		≤ 0.30	≤ 0.30	≤ 0.30
Chlorine content	wt.% (d.b.)	≤ 0.02	≤ 0.02	≤ 0.03	≤ 0.02	≤ 0.03	≤ 0.03	≤ 0.02	≤ 0.03
Mechanical durability	wt.% (w.b.)	≥ 97.5	≥ 97.5	≥ 96.5	≥ 97.7	≥ 99.2		≥ 97.7	≥ 97.5
Fines	wt.% (w.b.)	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1				≤ 1.0
Additives	%	≤ 2.0	≤ 2.0	≤ 2.0	≤ 2			≤ 2.0	
Ash melting behaviour	°C					IT			
Arsenic	mg/kg (d.b.)	≤ 1	≤ 1	≤ 1			≤ 0.8		
Cadmium	mg/kg (d.b.)	≤ 0.5	≤ 0.5	≤ 0.5			≤ 0.5		
Chromium	mg/kg (d.b.)	≤ 10	≤ 10	≤ 10			≤ 8		
Copper	mg/kg (d.b.)	≤ 10	≤ 10	≤ 10			≤ 5		
Mercury	mg/kg (d.b.)	≤ 0.1	≤ 0.1	≤ 0.1			≤ 0.05		
Nickel	mg/kg (d.b.)	≤ 10	≤ 10	≤ 10					
Lead	mg/kg (d.b.)	≤ 10	≤ 10	≤ 10			≤ 10		
Zinc	mg/kg (d.b.)	≤ 100	≤ 100	≤ 100			≤ 100		
EOX	mg/kg (d.b.)						≤ 3		

Source: Obernberger & Thek (2010)

Non-wood pellets for industrial use have not yet been standardized. The above standards is an effort to ensure trouble free operation of small scale furnaces in the residential heating sector, as these furnaces present shortcomings and failures when pellets of A1 class are not used (due to higher ash contents >0.7% w.t.). Medium and large scale users (district heating, CHP and power plants) do not present such problems due to the robustness and superior combustion technologies, thus are able to use pellets of herbaceous origin.

2.2. Europe

The first steps to introduce pellets as a biological fuel were undertaken at the beginning of the 1980s. Since the second half of the 1990s, the pellet markets in a number of European countries as well as North America and even worldwide have exhibited rapid growth and there is no end to this development in sight. Several factors were crucial for this development. The cornerstone was the automation of furnaces, which created similar user comfort to that previously only possible with gas or oil heating systems. In addition, national funding schemes, price rises in the oil and gas sector and marketing and public information campaigns by both national and international pellet and biomass associations contributed to the success of pellets.

The different development of different markets is very interesting. Whereas pellet use is limited to small-scale applications in some countries (e.g. Austria, Germany and Italy), it is large-scale plants for the most part that are fired with pellets in other countries (e.g. Belgium and the Netherlands). Moreover, in countries such as Sweden or Denmark, pellet utilization takes place in small, medium and large-scale applications whereas other countries solely produce large quantities of pellets but have no or negligible domestic markets (e.g. Canada and some Eastern European countries). Worldwide, around 11 to 12 million tones of pellets are used (basis 2008/2009), of which around 65% are applied in small-scale systems and 35% in power plants and other medium and large-scale applications. Pellet requirements vary in different countries. With regard to large-scale applications, pellets are produced for the sole purpose of reducing transport and storage costs. In part, the pellets are in most cases even ground again before firing. Quality plays a subordinate role in these applications. Large plants for instance can manage a higher fuel ash content, which renders the use of other raw materials in pelletisation, such as bark or straw possible. So raw material potential is broadened. Pellets that are used in small-scale applications must be of superior quality (especially concerning durability and purity) in order to safeguard high user comfort and operational reliability of systems. In table 3 is presented the global wood pellet production, consumption importing and exporting activity in 2009 according to the data collected from the pelle@tlas project and other sources.

The mixed biomass pellet (here after MBP) market is still in a very early stage and available data collected over the web are analyzed below in every country report (where available). Every country report is referring to general production and consumption levels (of wood and mixed biomass pellets) and special focus is given on the consumption of large scale users (e.g. biomass power plants, coal co-firing power plants), capable of utilizing MBPs, since CYNERGY PELLETS is oriented in the production of industrial quality MBPs.

Table 3: Global Wood Pellet Production and Consumption 2009

Countries	Number of Producers	Production (ton.)	Consumption (ton)	Export (Import)	Nature of Markets
Austria	25	626,000	509,000	117,000	Heating
Belgium	10	325,000	920,000	(595,000)	Power/heating
Bulgaria	17	27,200	3,000	24,200	Heating
Cyprus	0	0	0	0	
Czech Rep	12	27,000	3,000	24,000	Heating
Denmark	12	134,000	1,060,000	(926,000)	Power/heating
Estonia	6	338,000	0	338,000	
Finland	19	373,000	149,200	223,800	Heating
France	0	240,000	200,000	40,000	Heating
Germany	50	1,460,000	900,000	560,000	Power/heating
Greece	5	27,800	11,100	16,700	Heating
Hungary	7	5,000	10,000	(5,000)	Heating
Ireland	2	17,000	30,000	(13,000)	Heating
Italy	75	650,000	850,000	(200,000)	Heating
Latvia	15	379,000	39,000	340,000	Heating
Lithuania	6	120,000	20,000	100,000	Heating
Luxemburg	0	0	5,000	(5,000)	Heating
Malta	0	0	0	0	
Netherlands	2	120,000	913,500	(793,500)	Power/heating
Norway	8	35,100	39,800	(4,700)	Heating
Poland	21	340,200	120,000	220,200	Heating
Portugal	6	100,000	10,000	90,000	Heating
Romania	21	114,000	25,000	89,000	Heating
Slovakia	14	117,000	17,550	99,450	Heating
Slovenia	4	154,000	112,000	42,000	Heating
Spain	17	100,000	10,000	90,000	Heating
Switzerland	14	70,000	90,000	(20,000)	Heating
Sweden	94	1,405,000	1,850,000	(445,000)	Power/heating
UK	15	125,000	176,000	(51,000)	Power/heating
Subtotal	477	7,429,300	8,073,150	(643,850)	
Region: North America					
Canada	31	1,200,000	200,000	1,000,000	Heating
USA	97	1,800,000	2,096,150	(296,150)	Heating
Subtotal	128	3,000,000	2,296,150	703,850	
Region: Latin America And Asia					
Brazil	1	25,000	25,000	0	Heating
Argentina	1	7,000	7,000	0	Heating
Chile	1	20,000	20,000	0	Heating
China	1	50,000	50,000	0	Power/heating
India	0	0	0	0	
Japan	55	60,000	109,000	(49,000)	Power/heating
Korea	1	10,000	10,000	0	
New Zealand	5	20,000	20,000	0	Heating
Subtotal	65	192,000	241,000	(49,000)	
Total	670	10,621,300	10,610,300	11,000	

Sources: pellet@tlas, IEA Bioenergy, FA/UNECE, USDA

In summary, the European demand for high quality pellets is currently covered by the domestic production while the use of industrial pellets partly depends on imports from countries such as Canada and partly Russia.

2.2.1. Austria

In Austria, 25 wood pellet producers are active at 29 production sites (as per March 2010). Half of all production sites have production capacities of 10,000 to 50,000 t (w.b.)p/a. Up to 2000, strong annual growth rates of production capacities of up to 115% could be noted and 12 pellet producers had a capacity of 200,000 t (w.b.)p/a. In 2009, pellet production capacity reached about 1.1 million t (w.b.)p/a owing to the erection of new production sites. In 1995, pellet production began with the production of 2,500 t (w.b.)p/a and grew to 695,000 t (w.b.)p/a by 2009, with annual growth rates of 10 to 500%. In comparison, Austrian pellet production capacity grew from 2,500 t(w.b.)p/a to 1.1 million t (w.b.)p/a within the same period.

Consumption has been below production. In the first years of the industry, consumption was 95% of production, so that the two were almost balanced. In 2008 and 2009, it stabilized again to almost 85%. From 1995 to 2000 a part of production was exported, mainly to northern Italy and southern Germany. Minor quantities were exported to Switzerland too. At the same time, imports were observed from 1998, which mainly came from Eastern European countries. From 2001 onwards, export quantities grew strongly due to expanding markets in Italy, Germany and partly in Switzerland, reaching their maximum at 313,000 t (w.b.)p/a in 2007. A part of surplus production was probably stored for security of supply reasons as such storages were first established in 2000.

However, despite the strong wood pellet market, at the moment a MBP market hardly exists. There is only one company selling straw pellets as heating fuel (production started in the end of 2008). There is no recorded consumption of MBP pellets from large scale users.

2.2.2. Belgium

By far the largest share of pellets is used in two power plants for electricity generation. The power plant of Les Awirs (80 MWel) was retrofitted from coal to pellet use and needs around 350,000 t of pellets per year as the only fuel. The pellets are either produced in Belgium or imported. In addition, pellets are co-combusted in the power plant of Rodenhuize (75 MWel) to a degree of 25%, thus 300,000 t (w.b.)p/a are used. On the whole, about 800,000 t (w.b.)p/a of pellets are used in these two large Belgian power plants and some smaller industrial systems.

In 2009, production dedicated to small-scale uses remained steady, while industrial pellet production continued to grow strongly. In the Walloon region, six pellet producers can be counted, with an installed capacity of 421,000 t/a. Actual production reaches 325,000 t/a. This production is mainly dedicated to industrial use, for electricity production. Nevertheless, producers indicate that 62,000 t were sold for domestic use in 2008. The Flemish pellet market is still very young and information about production capacity is scarce. About 20,000 t/a are produced by four producers. The main raw material is wood sawdust. Additional production plants are being planned. The rest of the national demand is satisfied by imports.

There is little information about the Belgian MBP market. According to the Belgian biomass association (VALBIOM), no MBP market exists in the Wallonia Region. At the moment it seems that MBP development is hampered by the use of traditional wood fuel (logs, chips, pellets). At this time, no real development is foreseen until specific issues as combustion quality and durability of devices will be solved.

2.2.3. Denmark

Denmark had long been the second largest pellet consumer in Europe (after Sweden). Large-scale power plants such as those in the Netherlands now consume more pellets (either in co-firing or in power plants that were retrofitted for the sole use of pellets). Due to higher taxes on fossil fuels (CO_2 and energy tax) there is still a strong incentive to change over to pellets. Owing to the long tradition of using pellets, there are numerous pellet furnace manufacturers and manufacturers of pellet production plants in Denmark

The vast majority of large-scale consumption presently takes place in one power plant, the Avedøreværket Unit no. 2 near Copenhagen, which since 2003 has used 100,000 to 355,000 tons of pellets per year. In 2009, Herningværket and Amagerværket Unit no. 1 also commence wood pellet firing at a relatively large scale, and for the coming years more power plants, including Avedøreværket Unit no. 1, are expected to convert from coal to wood pellets.

Concerning the development of pellet consumption in Denmark an increase from 88,000 t (w.b.)p/a in 1990 to 1.06 million t (w.b.)p/a in 2009 can be noted with annual growth rates of between 5 and 63%. In 2009, around 44.4% of pellets were used in small-scale systems for residential heating, 45.5% in CHP and district heating plants, 5.1% in industry and 5.0% in public services. At full load, the power plant of Avedøre uses around 300,000 t of wood pellets a year and the power plant of Amager (Unit no. 2) around 150,000 t of straw pellets.

The high demand for pellets cannot be covered by Danish production plants, therefore, imported quantities increased, reaching more than 926,000 t (w.b.)p/a in 2009 in order to cover the national demand. Imports come mainly from the other Scandinavian countries, the Baltic States and North America.

Concerning estimations of future consumption potential, the Danish wood pellet market will grow significantly in the years to come. The demand in the residential sector can be expected to increase due to high fossil fuel prices and high energy taxes. Some of the development will take place in the commercial and industrial sector that has only recently shown any significant interest in renewable energy fuels. In 2008 large-scale consumption level was of approximately 350,000 tons and is expected to increase steeply in the coming years. This assumption is based on the increased biomass obligation (700,000 tons more) on power companies to meet Denmark's need to significantly reduce CO_2 emissions.

The Danish MBP market is not very developed. It consists of two types of supply chains. The first consists of approximately 8 manufacturers that sell small amounts of MBP in order to satisfy the needs of small to medium scale customers, who demand a cheap fuel and wish to experiment with their plant installation. Most of the manufacturers market feed pellets or rape seed oil, and sell a few tonnes of mainly rape seed cake pellets for fuel purposes. Two manufacturers market sunflower seed shell pellets. Character of these small manufacturers makes it irrelevant to talk about MBP production capacity and actual production. The second type is made out by one large manufacturer, the utility company Vattenfall that produces annually 80-100,000 tonnes of straw pellets at the factory in Køge for its own use at the plant Amagerværket in Copenhagen. In 2008 80,000 tonnes have been used in an old block at the plant, while in 2009 a newly refurbished block was put in operation and is using 100,000 tonnes annually along with a significant amount of wood pellets. Straw for the straw pellets is bought locally/regionally from farmers on Sealand.

2.2.4. Eastern Europe

Recently a new pellet market has become established in Eastern Europe. There are market players in Estonia, Latvia, Lithuania, Poland, Slovakia, the Czech Republic, Slovenia, Bulgaria, Hungary and Romania. Together these countries already produce more than 1.6million tonnes of pellets per year (2009). Utilization in these countries is low and amounts in total to about 250,000 t of pellets per year (2009). The main share of the pellets produced is exported. Only Poland and Lithuania have noteworthy domestic consumption.

Most of these countries have no MBP markets or very limited production with the exception of Poland (60.000t/y) and Czech Republic. The vast amount of agricultural residues is some of these countries (e.g. Hungary) will soon meet the demands of the high growth pellet industry and market growth is expected. All of the MBP production is exported.

2.2.5. Finland

Finnish pellet production began in 1997. With an annual production of 373,000 t (w.b.)p/a (2009), Finland has become one of the largest pellet producers in Europe. In total, 19 pellet producers are operating at 24 locations. Around 149,200 t (w.b.)p/a are consumed domestically, whereby the domestic market is dominated by small-scale applications. The rest is exported to Italy, Belgium, the Netherlands, Germany, the UK, Denmark, Sweden and Baltic countries. Pellets produced in Finland are mainly made of dry raw materials. The use of pellets is indirectly supported by CO_2 and energy taxes on fossil fuels.

In 2009 the MBP market represented approximately 30% of the whole pellet market (approx. 120,000 tons). This mainly concerns peat pellets, for which the market barriers are of non-technical nature. Instead, legislation hampers further use. In the EU peat is not considered as a renewable resource. Due to the technological aspects of wood pellets producing – easier and cheaper - and the fact that Finland has huge wood reserves, it is presumed that the share of MBP in pellet market will not grow further.

2.2.6. France

France is one of the pioneers of pellet production. In 2009, around 60 small- and medium-scale pellet producers were operating again, producing around 240,000 t (w.b.)p/a. The French pellet market is confined to the residential heating sector and in total, around 87,000 pellet stoves and about 20,000 pellet boilers are in place in France, with a consumption of about 200,000 t (w.b.)p/a (2009).

All existing MBP production plants were formerly active in the feed industry, especially in dehydration of alfalfa (cattle feed). For environmental (regulation on coal combustion, CO_2 emissions) and economic reasons (new markets), agro pellets were tested to supply local consumers (mainly households or farmers) in rural areas. Only small quantities have been produced because of lacking regulations on agro pellets, and since the start of market development in 2005, the French MBP market remained at small local level.

2.2.7. Germany

In 2009, around 1.46 million t (w.b.)p/a were produced from about 50 companies at 75 sites in Germany. Production capacity is around 2.5 million t (w.b.)p/a. An estimated amount of about 560,000 tones of pellets were exported in 2009, mainly industrial pellets.

Industrial pellets were exported to Scandinavia, Belgium and the Netherlands. DIN_{plus} pellets were exported to France, Austria, Italy and Switzerland. The total amount of DIN_{plus} pellets exported is less than 2% of the total volume. Some small amounts of imported pellets are known from Austria, Eastern European countries and Sweden.

The MBP market in Germany is still at the initial stage. MBPs, mainly straw pellets, are produced by several small producers (at least 10), and the annual production capacity is probably still below 20,000 tonnes. The produced straw pellets are mostly used for purposes such as littering or animal feeding, and their use for heat and energy production is insignificant. One type of organizations involved are drying cooperatives (Trocknungsgenossenschaften), who specialize in drying all kinds of biomass (also wood for wood pellet production). Some of them also produce straw pellets for several forms of usage.

Production capacities installed can be significant, but they are usually only partly used for MBP production. Typical production volumes would be 1,000 tonnes per year, of which only a fraction is marketed for energy purposes. Some of the companies only market their product for littering.

Pusch AG is a company following a special business strategy. The company plans to set up decentralized MBP production capacities. Basis will be a licensing system, in which special pellet production equipment is given to farmers, who produce MBP from local agricultural and waste materials. Two types of pellets will be produced: one type made of dry manure, remains of biogas production and other available materials will be produced for the combustion in large scale plants. The other type will be made of other available plant materials, without the use of waste materials, for the combustion in household heating. Currently, the company is engaged in Romania, where the concept (including boiler contracting schemes) is promoted in schools and other public buildings. MBPs are rarely used for heating purposes in households, because most boilers are optimized for the use of wood pellets and the use of e.g. straw pellets can cause technical problems, although some boiler producers are working on the adaptation of boilers to the use of MBPs.

2.2.8. Ireland

In 2009 the Irish pellet market was dominated by domestic and small commercial users with an estimated number of 4,000 pellet stoves and boilers installed. Ireland produces about 17,000 t (w.b.)p/a (2 producers) and consumes around 30,000 t (w.b.)p/a. As domestic production cannot cover demand, pellets are imported from Latvia, Finland, Canada, Germany, Sweden and France. Currently, there is no known production or use of MBP in Ireland.

2.2.9. Italy

The Italian pellet market began to develop in the early 1990s, but was weak for many years. It was not until recently that there was a significant increase in pellet production and use. Pellet consumption increased from 150,000 t (w.b.)p in 2001 to 0.85 million t (w.b.)p in 2009. Around 650,000 t of pellets are produced by around 75 producers. The rest is imported. Italy has always been a pellet importing country because production has always been lower than consumption. Imports mainly come from Austria, Germany and Eastern European countries, but imports from China and Brazil have also been reported.

The large majority of production sites, about 80%, have production capacities below 5,000 t (w.b.)p/a. The raw material used for pellet production is mainly sawdust with a share of 65%, followed by wood shavings with 19%. The rest are other raw materials such as wood chips and other residues. Currently there are no additional raw material sources available for a further increase in pellet production. Therefore, pellet producers are increasingly importing raw materials from other countries. Around 90% of the pellets used in Italy are packaged in bags, typically 15 kg bags. This large share of bagged pellets is due to the high number of pellet stoves mainly in northern Italy. Only a few pellet central heating systems are installed in Italy. Their number is estimated to be around 1,000. Part of consumption is in district heating plants. In addition, the wood working and processing industry partly use pellets for in-house heat production.

Mixed biomass pellet market is in its early stages in Italy. Even if MBP production and usage is very present in the media and in the public discussion, MBP production is still very limited. The small amounts of MBP actually produced in Italy are mainly used in medium and large scale power and CHP plants.

Three MBP producers operate in Italy, all of them with very limited production. Installed production capacities on the other hand are considerable, but cannot be fully used due to a lack of demand, especially in the residential heat sector. In order to develop this sector for MBP, market actors are working on improving chemical characteristics of MBP, as well as the adaptation of burning equipment to MBP usage. For now, the use of MBP in large scale applications (e.g. co-firing) remains the most realistic usage type. MBP might become a serious alternative in this sector, even if a reliable supply with MBP cannot be guaranteed at the moment and production capacities still need to be developed.

2.2.10. Netherlands

The main use of wood pellets in the Netherlands is co-firing in coal fired power plants. Currently, approximately 1 million tons of biomass pellets are co-fired, and this is expected to increase to approximately 5 million tons in 2020. The biomass required for this purpose will mainly be imported from overseas (Canada, Brazil, South Africa, Baltic states, etc.). The AMER power plant of Essent in Geertruidenberg alone currently consumes approximately 600,000 tons of wood pellets. In the EON Maasvlakte power plant, pellets are produced from a mixture of several biomass waste products, before they are dumped on the coal conveyor.

In the medium-scale power range, an estimated number of 30 to 50 industrial companies have switched to the use of pellets in the last 10 years for heat supply of industrial users such as poultry farms and cattle breeding farms. In the utility sector, only a few examples exist to date. Small-scale pellet furnaces are not at all common in the Netherlands. This is due to the fact that almost all consumers have been connected to the natural gas network since the 1970s.

With estimated 150,000 to 200,000 t, the current production capacity for wood pellets in the Netherlands is relatively small compared to other countries. Actual production is lower at the moment – in 2009 it was about 120,000 t (w.b.)p/a. Raw materials currently originate mainly from wood processing industries. There are approximately 600,000 t available per year, where 150,000 t are currently used in the wood processing industries for heat production and the remainder is used externally for the production of fiberboard, energy production or for the production of pellets. A large fraction of the biomass pellets produced is exported to Germany, where prices are higher. One producer (production of 80,000 t/a) uses waste wood as raw material and exports to Sweden. A new factory with a capacity of 100,000 t of product based on fresh wood from landscape maintenance is planned to start operation in 2011.

The Dutch biomass pellet market will grow significantly in the years to come, if the coal power sector agrees with the government on a new support mechanism or an obligation to co-fire or reduce CO_2. For 2020, different authors estimate potential consumption to be between 5 and 10 million tons.

In 2006 and 2007 about 15,000 tons of soy husks in pelletized form were bought by Dutch utilities from the Dutch agro industry. The exact origin of these pellets is unknown. Also about 10.000 tons of other mixed biomass pellets were imported in 2007. All MBPs were used for co-firing. In 2008, one utility used 10.000 tonnes of MBPs (produced from agricultural residues) for co-firing with coal to produce renewable electricity. The origin of these MBPs was Western Europe, but more detailed information was not available. Furthermore, the utility Essent started a pilot project with the use of MBP (coffee husks), imported from Brazil. These coffee husk pellets were co-fired in the Amer coal power plant. The initial intention was to increase imports annually to reach 250.000 tonnes per year in 2013. However, due to lacking policy support, Essent decided to stop the import of coffee husk pellets for the time being, as it is economically not possible to use them at this point in time. As soon as a subsidy scheme is put in place that sufficiently rewards the use of MBPs, Essent intends to resume the use of MBPs.

2.2.11. Norway

In Norway, the pellet market is still in the early stages of development. In 1998, 10,000 t of pellets were produced. Production capacity was 164,000 t (w.b.)p/a in 2009. Owing to the small sales volumes in Norway, a great share of production is exported, mainly to Sweden. Exports made up 57% of domestic production in 2006. After 2006, exports decreased and in 2008, Norway became a net pellet importer due to increased pellet sales and reduced domestic production. Domestic consumption rose by over 50% in 2006 as compared to the year before due to increased sales volumes of pellet stoves (around 10,000 pellet stoves were installed by the end of 2006.

Only 12% of houses are equipped with a central heating system in Norway. 75% of the houses are heated electrically. So, the market potential for pellets of this area is low.

Consumption of biomass for energy purposes in Norway is very limited. Norway has large hydropower capacity and is self-sufficient with oil. New power capacity is mainly based on natural gas. Norwegian biomass consumption is mainly in the shape of wood logs for residential heating and wood pellets for an emerging pellet market. According to the Norwegian Biomass Association (NOBIO) and some wood pellet market actors, there is no production and no market for MBPs in Norway.

2.2.12. Portugal

The Portuguese pellet market had an annual pellet production of about 100,000 t and a consumption of about 10,000 t in 2009. The difference, namely approximately 90,000 tonnes per year, is exported, mainly to Northern European countries. Total pellet production capacity amounts to about 400,000 t per year by six plants currently in operation. New plants are planned, however, which will further increase production capacity. Domestic consumption is confined to pellet stoves and boilers in the residential heating sector.

There is no MBP market in Portugal. As there is no domestic demand for pellets (wood or MBP), the major part of wood pellets produced in Portugal is exported. Export opportunities for MBPs hardly exist and MBP production therefore is not considered by potential investors in Portugal. The second factor limiting MBP supply is the shortage of raw material. Portugal doesn't have large volumes of agricultural residues, especially in areas where pellet producers are currently located (around the city of Lisboa and Porto).

2.2.13. Spain

Pellet production in Spain is around 100,000 t of pellets per year (2009). Only a small part of this, around 10,000 t of pellets, is used in pellet stoves in Spain itself. The rest is exported to Italy, German speaking countries, Portugal, France, Ireland and the UK.

All identified companies, state to produce pellets with pure wood as raw material, with the partial exception of Biotermal Agroforestal and Reciclados (their pellet is made up by 95% of wood).Therefore, we can assume that Spanish MBP market is negligible. Some new pellets producers are appearing in the market and some of them are trying to process different kinds of residues. For example, company called Biomasa del Condado declares that “they focus their work on the treatment and recycling of waste residues from agro industries, forestry, and other energetic companies to transform it in to biofuels”.

2.2.14. Switzerland

Similar to Germany and Austria, pellets are mostly used in small–scale applications in the residential heating sector. Pellet consumption and production are balanced in Switzerland, both being around 90,000 t (w.b.)p/a in 2009. Pellet production is dominated by small-scale producers with production capacities typically of between 1,000 and 12,000 t (w.b.)p/a. Only 2 pellet producers (out of 14 in total) have higher production capacities. The dominant raw material for pellet production is sawdust. However, pellet production from log wood has already been started by 2 smaller pellet producers. To date, more pellets were consumed than produced, except in 2004. Thus pellets were imported, mainly from Austria and Germany, in the past. However, pellets were also exported to Italy to some degree. In total, around 800,000 oil heating systems are installed in Switzerland of which every sixth could be replaced by a pellet heating system between 2016 and 2021. The total potential for the Swiss pellet consumption is indicated to be around 3.5 million tons per year.

Information on a MBP market or MBP traders and producers in Switzerland cannot be found; therefore it is assumed that there is no significant market for MBP in Switzerland. Information campaigns on the use of wood pellets are organized by the “Holzenergie Schweiz”, who do not promote the use of alternative raw materials. This results in a lack of information and hampers the MBP market development. Furthermore, the local availability of agricultural residues, such as wheat straw, is very limited. There is no kind of alternative raw material available in larger amounts, while wood is produced in large quantities. Governmental bodies do not seem to promote the use of MBPs and no private organization promoting MBPs could be identified.

Since the wood pellets market in Switzerland is still in an initial stage, the availability of regular pellet raw materials, such as saw dusts, is not limited yet, there seem to be no need for considering alternative raw materials.

2.2.15. Sweden

Imports have always been higher than exports, so Sweden is a net pellet importing country. Moreover, imports are expected to increase further as consumption cannot be covered by domestic production. Imports come mainly from Finland and Canada as well as the Baltic states. Pellets are also imported from Russia and Poland. Pellet production was around 1.4 million t (w.b.)p/a in 2009 in Sweden. There were 94 pellet producers in operation at the beginning of 2009.

The share of pellets used in the residential heating sector played a subordinate role in Sweden for a long time. However, it did rise continuously for some years reaching its maximum at 37% of total consumption in 2007. Since then this share has been decreasing and is expected to decrease further in the coming year due to strong increases in overall consumption.

In Sweden, pellets are chiefly used in large-scale furnaces. The CHP plant Hässelby, which supplies Stockholm with district heat, alone requires around 300,000 t of pellets per year. Large-scale furnaces are normally equipped with pulverized fuel burners, which is why the pellets need to be ground before use. In this case, pelletisation has the sole purpose of reducing transport and storage costs.

Pellet consumption was above 1.8 million t (w.b.)p/a in 2009. Sweden is thus the largest pellet consumer worldwide. Starting from 1995, annual increases have been between 2.1% and 68%, except for a slight decrease in 2002.

Sweden has almost no production of MBPs for fuel purposes. Sweden is a wood industry country and has abundant wood residues that can be used for fuel purposes without the technical obstacles that MBPs may have. However, some development is visible. At the Swedish University of Agricultural Science in Umeå a pilot-plant for pelletising reed canary grass has been tested.

In the ongoing EU-LIFE project "BIOAGRO" Swedish companies are aiming to promote the use of MBPs. The BIOAGRO project will "demonstrate an innovative method to reduce the discharges of greenhouse gases by using energy from grain, waste from grain, seed and grass to produce heat". MBP pelletising line is installed at the seed and grain producer, Skånefrö AB, along with a combustion line producing heat.

2.2.16. United Kingdom

For the UK pellet market of small-scale systems only rough estimations exist. Pellet consumption in this sector is stated to be about 6,200 t (w.b.)p/a. It is common practice in the UK to use pellets for co-firing in coal fired power plants for electricity generation. Pellet imports mainly come from Russia, the Baltic States, Finland and Canada. Minor import quantities come from France, Germany, USA and Argentina. Pellet exports to Ireland and Italy are also reported. Domestic production was around 125,000 t (w.b.)p/a in 2009, with a production capacity of 218,000 t (w.b.)p/a, while consumption was around 176,000t (w.b.)p/a. There are 15 active pellet producers in the UK.

The MBP market in the UK is small. There are two straw pellet manufacturers in operation: Charles Jackson- with a relatively small production capacity, and Agripellets Ltd, capacity unknown. The main market in the UK for MBP is in co-firing in coal fired power stations. The pellets are crushed prior to co-firing. Currently there are no biomass boilers on the market that are suitable for the burning of MBPs on a domestic or community scale.

Agripellets Ltd state on their website that they primarily produce Agri-Straw Pellets, which are sold in bulk to the electricity power generation market to be co-fired alongside coal. They state that they have supplied Scottish and Southern Energy plc and that their main customer is EON UK plc, with whom they have an ongoing contract. Agripellets are developing a new range of high quality straw based hybrid fuel pellets, which combine wheat straw with other agricultural crop by-products and natural additives. Agripellets also produces 10mm miscanthus pellets, which are primarily produced for the co-firing market. The target price for their straw pellets is to be 30% lower than imported wood pellets.

2.3. North America

North American wood pellet production in 2009 was estimated at 3 million tonnes, split between Canada at 1.2 million and US at 1.8 million. Canadian plants reported operating at about 75% of capacity while US plants reported operating at 66%. This means that total North

American capacity is in the range of 4.3 million tonnes and in 2009 there was 1.3 million tonnes of unused capacity.

In Canada, various investors in British Columbia, Quebec, New Brunswick, Newfoundland and Labrador have announced plans for new capacity totaling 600,000tonnes. In the south US, investors have announced several new plants totaling 1.8million tonnes capacity. If all announced projects are completed by the end of 2011, resultant North American capacity will be in the range of 6.7 million tonnes.

Total North American consumption in 2009 was estimated at 2.3 million tonnes, split between Canada at 200,000 and US at 2.1 million. Approximately 700,000 tonnes were exported from North America, with about 640,000 tonnes sent to Europe and 60,000 tonnes to Japan.

The North American domestic wood pellet market is presently limited to residential heating, primarily in Eastern Canada and Northeast US where there is no natural gas distribution system and the next best alternative is heating oil. Wood pellets are cheaper than heating oil. The use of wood pellets for power generation is still virtually non-existent in North America. The reason for Canada exporting such large quantities is that has not implemented policies to reduce greenhouse gas generation from coal burning power plants. Canada's 21 coal plants consume some 61 million tonnes of coal annually. If just 10% of this coal could be replaced with wood pellets (at a 1.5:1 ratio), they would consume nearly 10 million tonnes of wood pellets each year equal to the entire global consumption in 2009. Huge transformations in the pellet production and trade will occur if such policies are to be implemented.

2.4. Greece

The pellet market in Greece is at an initial state. Pellets are produced in considerable amounts, but domestic consumption is hardly developed. Pellets are only used in some industrial applications. Pellet trading within the country does hardly occur, but trade with other European markets is growing significantly. Nowadays, the major raw material for pellet production is wood residues from wood industries (furniture producers, building materials, etc.). The current biomass availability covers the demand of the pellet industry, but if the Greek pellet market starts growing more rapidly, biomass availability will become a limiting factor rather soon. At the moment, large quantities of biomass are unused. With growing demand these raw materials will be considered as potential raw material for pellet production.

There is no legislative framework for pellet production and consumption in Greece. The law on the Development of Renewable Energy Sources that the Greek Government applied (2005), does not promote biomass use for energy purposes (photovoltaic and wind energy are subsidized three times more than biomass), even though 80 % of the Renewable Energy Sources in the European Union comes from biomass. In general, the Greek energy policy is based on fossil fuels, which is proven by the fact that more than 90 % of the total energy consumption is derived from oil, natural gas and coal.

The Greek pellet market just started to develop. The total production during 2008 was 27,800 tons, while the installed production capacity was reported at 87,000 tons. The majority of the production companies are only involved in this market, only one operates also in other business fields (specialized in livestock feed). Small scale producers dominate the Greek market. There is no quality standard for pellet properties in Greece, which poses problems to the producers. They do not provide official quality certifications which lowers the competitiveness of their products on the international markets.

Table 4: Development of the market over the past years

Year	Total production capacity [tons/year]	Total production [tons/year]	Consumption [tons/year]
2008	87,000	27,800	11,100
2007	77,200	26,000	5,400

Source: pellet@tlas project

All of the pellet producers are reported to provide sufficient pellet storage capacities at their plants. However, most of them do not store their final product, because the demand covers the production. At the moment, there is no household use of pellets and only minor use in industry. The producers focus on exports, mainly to Italy and always in big or small bags. The trade is always between the producer and retailer and the transportation is constantly being conducted by trucks on ferries (Igoumenitsa port to Ancona port). Most of the produced quantities are exported. 52.5 % of the national production is sold to a Greek trader, who is exporting the whole quantity to Italy.

Pellet consumption in the country is negligible and only small quantities have been used in industries, mainly in pilot projects. There are companies that use biomass for energy purposes and they were willing to test this new product. Especially the greenhouse industry has shown interest in pellets as they can be utilized in normal biomass boilers.

In Greece the MBP market remains at initial stage. Only one company produces MBPs officially (Aggelousis S.A.). There are two more companies producing MBPs but at experimental stage. There is no formal quality standard for MBP in Greece. Most people who use biomass for heating purposes burn their own byproducts unprocessed like a rice processing company where rice shells are burned directly in big biomass burners. In table 5 below are presented the main companies active in the Greek pellet market. Unfortunately there are no available data on individual capacity or production.

Table 5: Producers of pellets in Greece

Company	Location
Aggelousis S.A.	Velestino
Alfa Wood	Drama
Bioenergy Hellas	Sikourio
BIO-HOL	Drama
Eco Hephaestus	Thessaloniki
Maki S.A	Larissa
Mega Pellets Ltd	Imathia
Sakkas S.A.	Karditsa
Southstar Ltd	Thessaloniki
Thestra Cynara	Velestino

Source: own research

In 2009 the Greek National Energy Utility (DEH) co-fired 50tons of the energy plant cardoon with great results and in collaboration with local farmers in the Kozani prefecture in 2010 has co-fired 6,000tons of cardoon from a 400ha cultivated area. This activity is estimated to be further expanded in the future.

Greek legislation does not cover MBP production, which is a significant drawback for this market to expand. There is a major need for legal coverage of this market, in order to promote this market. Greek legislation could follow other European countries' experience, which were successful. The main obstacle for further market development is the lack of political will. Governmental subsidies should be offered in order to develop and implement business plans. Also another factor that hampers pellet market development is the low public environmental conscience, the increase of which seems to be crucial.

2.5. Potential European Customers – Pellet prices

When selling industrial pellets to European customers, producers may choose to sell through wholesalers or directly to the end customers – the power plants. The advantages of selling to wholesalers are:

- Wholesaler is physically located near the customers. This can save on producer marketing expenses.
- Wholesaler can link the producer to an expanded market base.
- Wholesalers know the markets, customers, and prices.
- Wholesaler can consolidate product from several producers to fill large contracts.
- Wholesaler can help expedite transportation.
- Wholesaler can help in the event of product claims.
- Wholesaler can provide vendor financing.
- Wholesaler can carry inventory.

The disadvantage of selling through a wholesaler is that the wholesaler needs a share of the product value in order to stay in business. Nevertheless, producers that have limited in-house marketing expertise are advised to use the services of a wholesaler. Table 6 shows European wholesalers and consumers of bulk industrial wood pellets.

Pellet prices varied in 2007-2008 between 112 €/tonne and 129 €/tone for wood pellets. Since December 2008, prices have been reported by the Endex energy exchange (www.endex.nl). Since then, bulk prices increased from about 134 €/tonne to about 141 €/tonne in March 2009, but have declined to 125 €/tonne in April 2010. In September 2011 bulk prices are trading at 135€/tonne.

For MBPS there is no transparent market and various reports mention prices from 100€/tonne (Poland) to 210€/tonne (Greece). However, consumption in Europe is estimated to reach 25million tonnes by year 2020 and prices are expected to rise significantly in the future. Shipping costs are a key factor on the supply side of bulk pellets for power production. The Baltic Dry Index (BDI) is a key independent barometer for shipping costs of dry bulk commodities including iron ore, coal and grain by sea, and is derived from professional ship broker assessments. Since summer 2008, the BDI has dropped significantly dropped due to the global financial crisis and world shipping overcapacity. However, the strong decline of the BDI does not necessarily affect the current cost of pellet shipping, at least not immediately. The price that an individual buyer might actually pay for pellets is closely linked to the size and the length of a contract. In addition to long-term contracts, power companies buy pellets on spot markets. The difference between long term contracts of one year and longer (relative high prices) and short term contracts of spot markets (generally lower prices) could be about 10 €/tonne or more.

Table 6: European Wholesalers and Consumers of Bulk Industrial Wood Pellets

Country	Type	Company	Website
Belgium	Consumer	Electrabel	www.electrabel.de
Denmark	Wholesaler	GEE Energy	www.gee-energy.com
Denmark	Consumer	Dong Energy	www.dongenergy.dk
Denmark	Consumer	Vattenfall.dk	www.vattenfall.dk
Netherlands	Wholesaler	GF Energy	www.gfenergy.eu
Netherlands	Wholesaler	Nidera	www.nidera.nl
Netherlands	Wholesaler	The Clean Energy Company	www.thecleanenergycompany.com
Netherlands	Wholesaler	Van Leer Energy BV	www.eduardvanleer.nl
Netherlands	Consumer	Delta Energie	www.delta.nl
Netherlands	Consumer	Electrabel	www.electrabel.nl
Netherlands	Consumer	EoN	www.eon-benelux.com
Netherlands	Consumer	Essent	www.essentrading.com
Netherlands	Consumer	NUON	www.nuon.com
Sweden	Consumer	FORTUM	www.fortum.com
Sweden	Consumer	Oresundskraft	www.oresundskraft.se
UK	Wholesaler	Biomass UK Ltd.	www.biomassuk.com
UK	Wholesaler	International Forest Products	www.ifpcorp.com
UK	Wholesaler	EDF Trading	www.edftrading.com
UK	Consumer	EDF Energy	www.edfenergy.com
UK	Consumer	RWE nPower	www.rwe.com
UK	Consumer	Scottish Power	www.scottishpower.com
UK	Consumer	EoN	www.eon-uk.com
UK	Consumer	International Power	www.ipplc.com
UK	Consumer	Drax Power	www.draxpower.com
UK	Consumer	British Energy	www.british-energy.com
UK	Consumer	Scottish and Southern Energy	www.scottish-southern.co.uk

Source: pellet@tlas project, own research

3. RAW MATERIAL

3.1. The crop

Cardoon (*Cynara cardunculus* L.), also known as Spanish thistle artichoke, is a perennial very deep rooted crop of Mediterranean origin, well adapted to the xerothermic conditions of southern Europe, typical conditions of arid and semi-arid areas of the Mediterranean climatic type areas (Grammelis et al.,2008). It is a multipurpose crop that can be utilized as a raw material in paper pulp industry, as forage in winter time but most importantly solid and/or liquid biofuel in bio-energy sector.

Cardoon is planted in Greece usually in September and has a useful life of ten years. The plant can live for many more years but it has been observed that its productivity is decreasing after the tenth year. Cardoon's growth starts after the first rains in autumn and continues during winter and spring until the beginning of summer when soil moisture drops at very low levels and the aerial part of the plant dies out, and the crop is harvested almost dry in the period July-August, avoiding drying costs and soil compaction risks. Fast re-growth starts again after the first rains in the following autumn, and crop canopy is very soon fully closed, and so forth. Field experiments demonstrated that cardoon, as a very competitive weed itself, would not allow the mutual growth of other weeds, whereas its growth was not affected by pest and diseases, so that its cultivation can be realized without the use of agro-chemicals. Moreover, its deep and effective rooting system takes perfect advantage of the soil's inherent fertility so that the crop does not need but modest nitrogen dressings only in very poor soils. Growing during the rainy period, cardoon takes also good advantage of the winter and spring rains and performs dry biomass yields of 12-16 t/ha without any irrigation. However, if the crop receives 2-3 irrigation applications from mid-April to late May (when irrigation water is normally still available in many regions), dry biomass yields in excess of 25 t/ha may be easily attainable. This is in agreement with other data obtained in the Mediterranean basin (Gominho et al., 2010).

Despite the improved technology in the agricultural sector, the economic feasibility of biomass crops is still uncertain in many European countries under the current market conditions. In general, a substantially greater profit is required for the farmers to change their traditional cultivation with a new one for energy production. This could be successful by introducing crops that require particularly lower inputs. A perennial crop well adapted to the prevailing environmental conditions, well competitive to weeds and with minimal needs to nitrogen and other nutrients would be a very good choice in that respect. This is the reason for the cultivation of cardoon, one among the toughest weeds, for biofuel production.

Cardoon needs less nitrogen than many other crops. High biomass yields are attainable under fertilization dressings from 0 up to 50 kg N/ha in shallow and poor soils. Thus, the modest fertilization dressings of cardoon help controlling the nitrate pollution of surface and ground waters in extensive areas where annual crops (cotton, maize, wheat, etc.) are intensively cultivated. Due to its great adaptation, cardoons' fast (re)growth controls the mutual growth of other weeds in many environments. On the other hand, in all field experiments, no evidence of cardoon suffering by any pest or disease was present. Therefore, cardoon can be cultivated without the use of any agrochemicals, so further reducing the production cost and the environmental risk from the use of these substances. As mentioned, cardoon can take advantage of the winter and spring rains and produces quite high biomass yields without any irrigation. Cardoon starts growing at particularly high rates just after the first rains in October. Soon its canopy is closed and protects the soil from erosion, which is the most important environmental hazard on the sloping lands around the Mediterranean semi-arid zone. After cardoon's establishment, the only field work is harvesting. Thus, cardoon fields do not suffer from soil compaction.

Considering the modest inputs (practically soil preparation and sowing once in 10 years plus annual harvest and transportation to the plant that is estimated at 70-200 €/ha) cardoon may produce the cheapest biofuel comparing to all other bio-energy crops known. Actually the energy production cost is determined at <0.5-1 €/GJ on the farm, 3 €/GJ including the farmers profit (dry biomass sold against 60-70 €/t in 2010), and about 3.5-4.0 €/GJ including the cost of pellet production (current oil price in Greece 950 €/m3 or 22 €/GJ). Unlike other biofuels such as bio-ethanol from maize and biodiesel from oilseed rape (energy balances 1/1.3 and 1/2.5), heat energy produced from cardoon reaches 1:27. Additionally, with on farm output/input ratios of 3.5-4.5 €/€ cardoon appears to be by far the more interesting than many other crops in Greece and elsewhere and may secure a very good income for the farmers.

Based on the above, cardoon is considered as the most important and promising crop for biomass and energy production in Greece in the near future. Cardoon cultivation may partially replace traditional cultivations ensuring a good profit to the farmer (double compared to wheat and to cotton cultivation with present prices, e.g. 70 €/t (dry biomass in the entrance of the factory) and producing biofuel of high energy content.

3.2. Chemical characteristics of raw material

3.2.1. Content of carbon, hydrogen, oxygen and volatiles

The chemical characteristics of the raw material cardoon will be presented in comparison to existing raw materials utilized in the pellet sector today. Table 7 shows average concentrations of carbon, hydrogen and oxygen as well as volatiles in different biomass materials.

The applicability of the materials for pelletisation is not influenced by these elements. However, the concentrations of these elements have an effect on the gross calorific value, hence on the net calorific value. The volatiles influence the combustion behavior. Carbon, hydrogen and oxygen are the main components of biomass fuels (since cellulose, hemi-cellulose and lignin consist of these elements), whereby carbon and hydrogen are the main elements responsible for the energy content. The concentrations of carbon and hydrogen of woody biomass are higher than those of herbaceous biomass, which gives account for the higher gross calorific value of woody biomass.

Table 7: Concentrations of C, H, O and volatiles in biomass materials

Fuel type	C wt.% (d.b.)			H wt.% (d.b.)			O wt.% (d.b.)			Volatiles wt.% (d.b.)		
Wood chips (spruce, beech, poplar, willow)	47.1	-	51.6	6.1	-	6.3	38.0	-	45.2	76.0	-	86.0
Bark (coniferous trees)	48.8	-	52.5	4.6	-	6.1	38.7	-	42.4	69.6	-	77.2
Straw (rye, wheat, triticale)	43.2	-	48.1	5.0	-	6.0	36.0	-	48.2	70.0	-	81.0
Miscanthus	46.7	-	50.7	4.4	-	6.2	41.7	-	43.5	77.6	-	84.0
Cardoon *(Grammelis et al)*	40.6	-	43.7	5.5	-	6.0	40.9	-	45.0	70.0	-	71.8
Cardoon *(Encinar et al)*	44.0	-	46.7	4.6	-	4.8	40.1	-	45.0	71.2	-	77.3

Sources: Obernberger &Thek, Grammelis et al, Encinar et al

3.2.2. Content of nitrogen, sulphur and chlorine

These elements do not have any influence on the pelletising process itself but there are limitations concerning these elements due to technical as well as environmental issues. The concentrations of nitrogen, sulphur and chlorine have different impacts on combustion. High levels of nitrogen, sulphur and chlorine, boost the emissions of NO_x, SO_x and HCl. Chlorine also augments the formation of polychlorinated dibenzodioxins and furans. The combustion products of chlorine and sulphur have corrosive effects and are of great relevance concerning deposit formation. Guiding values for these elements are shown in table 8.

Table 8: Guiding values for N, S and Cl for various biomass fuels

Fuel type	N mg/kg (d.b.)			S mg/kg (d.b.)			Cl mg/kg (d.b.)		
Wood (spruce)	900	-	1,700	70	-	1,000	50	-	60
Bark (spruce)	1,000	-	5,000	100	-	2,000	100	-	370
Straw (winter wheat)	3,000	-	5,000	500	-	1,100	1,000	-	7,000
Whole Crops (triticale)	6,000	-	14,000	1,000	-	1,200	1,000	-	3,000
Cardoon *(Grammelis et al)*	9,000	-	18,000	500	-	1,000	n.a	-	n.a
Cardoon *(Encinar et al)*	7,000	-	15,000	500	-	1,000	n.a	-	n.a

Sources: Obernberger &Thek, Grammelis et al, Encinar et al

3.2.3. Gross calorific value, net calorific value and energy density

The data presented in this section refer to the final product after the pelletising process. The gross calorific value (GCV) of a raw material should be as high as possible with regard to the energy density of the pellets. It is purely dependent on the material used, i.e. the chemical composition of the raw material and can therefore not be influenced. In general, the gross calorific value of woody biomass (including bark) lies around 20.0 MJ/kg (d.b.), the value for herbaceous biomass is around 18.8 MJ/kg (d.b.).

Net calorific value (NCV) depends mainly on the gross calorific value, the moisture content and the content of hydrogen in the fuel. The energy density is the product of net calorific value and bulk density. The required transport and storage capacity is reduced with rising energy density, which is why a high energy density is of great relevance, especially for economic reasons.

The GCV of the analysed biomass fuels made of wood was between 19.8 and 20.7 MJ/kg (d.b.) and the GCV of fuels made of straw was between 18.6 and 19.0 MJ/kg (d.b). The energy density of the pellets was calculated from NCV and bulk density. The energy density of pellets is five to six times higher than that of the raw material. Storage and fuel transport for pellets are thus five to six times more efficient and more economic than of raw material.

Table 9: Gross and net calorific values of densified biomass fuels

Fuel type	**GCV MJ/kg (d.b.)**			**NCV MJ/kg (d.b.)**		
Wood	19.8	-	20.7	17.1	-	18.2
Bark	19.7	-	19.8	17.4	-	17.5
Straw	18.6	-	19.0	16.1	-	16.6
Tropical Wood	20.0	-	20.6	17.2	-	17.9
Eucalyptus	19.6	-	19.7	16.8		16.9
Cardoon *(Grammelis et al)*	13.7	-	16.3	11.2	-	13.6
Cardoon *(Encinar et al)*	15.0	-	18.5	12.5	-	13.6

Sources: Obernberger &Thek, Grammelis et al, Encinar et al

In table 10 are shown the energy densities of the examined raw material. A comparison between the energy densities of pellets and heating oil (around 10 kWh/lt or 36 GJ/m^3) shows that on average 3.5m^3 pellets as a bulk correspond to 1,000lt heating oil. The range of fluctuation exhibited by wood and herbaceous pellets also shows that the difference between the highest and the lowest measured value is nearly 30%, which has a strong impact on transport and storage capacities and thus also on transport and storage economy. This strikingly illustrates the importance bulk density of pellets has for producers, transporters, intermediaries and end users.

Table 10: Energy densities densified biomass fuels

Fuel type	**Energy density GJ/m^3**		
Wood pellet	8.9	-	11.4
Straw pellet	8.9	-	10.6
Cardoon pellet *(Grammelis et al)*	7.3	-	8.8
Cardoon pellet *(Encinar et al)*	9.2	-	10.1

Sources: Obernberger &Thek, Grammelis et al, Encinar et al

3.2.4. Moisture content

A guiding range of moisture content for a raw material just before entering the pellet mill, lies typically between 8 and 12 wt.% (w.b.). When the moisture content is below that range the frictional forces in the compression channel are so great that they render pelletisation impossible; above this value the pellets produced are not dimensionally stable.

A potential conditioning of the raw material with steam or water (to achieve a more homogeneous moisture content and to improve the binding behavior in the mill) must be considered hereby since this can raise the moisture content by up to 2 wt.% (w.b.). The exact regulation of the moisture content is of great significance.

Moisture content of cardoon after harvest has been measured between 7.9 and 8.2 wt% (w.b.) Regarding the combustion technology, the moisture content of pellets is relevant for the net calorific value, the efficiency of the furnace and the combustion temperature.

Net calorific value, efficiency and combustion temperature decrease with rising moisture content. The moisture content of existing wood pellets is set down to be no more than 10 wt.% (w.b.).

3.2.5. Ash content

Table 11 presents typical ash contents of different types of biomass. The ash content of raw materials does not influence the pelletisation itself, although high ash content could possibly increase the wear and consequently reduce the lifetime of roller and die of the pelletising mill. A1 pellets according to the standards require 0.7% wt% (d.b.) which cannot be achieved by cardoon. Pellets from cardoon are indented to be used in medium- or large-scale furnaces, where such low ash contents are not absolutely necessary because bigger installations are built in a more robust way and are typically equipped with more sophisticated combustion and control systems.

Table 11: Energy densities densified biomass fuels

Fuel type	**Typical ash content wt% (d.b.)**		
Softwood	0.4	-	0.8
Hardwood	1.0	-	1.3
Bark	2.0	-	5.0
Straw	4.9	-	6.0
Cardoon	6.4	-	8.2

Sources: Obernberger &Thek, Grammelis et al

Interestingly, herbaceous biomass generally shows much lower heavy metal concentrations than woody biomass, which can be explained by the shorter period of growth as well as the elevated pH-. Heavy metals have a great impact on ash quality and particulate emissions from combustion. Thus, the ash of herbaceous biomass is more appropriate for fertilizing activities as there are limiting values for heavy metals concerning soil utilization of ash.

3.3. Physical characteristics of raw material

3.3.1. Bulk density

The higher the bulk density the higher becomes the energy density and the lesser are transport and storage costs. Therefore, a high bulk density is crucial from the economic point of view as well as for pellet producers, retailers, intermediary distributors and after all for customers. The European standard sets down 600 kg (w.b.)p/m³ as a minimum value. Literature values for bulk densities of pellets from cardoon are reported between 650 and 700 kg (w.b.)p/m³, where the bulk density of the raw material it self is reported between 100-120 kg (w.b.)p/m³ (Raccuia et al., 2004).

3.3.2. Mechanical durability

The mechanical durability is one of the most important parameters in pellet production. The minimum value for the mechanical durability is 97.5 wt.% (w.b.) for the classes A1 and A2. The majority of raw material (woody and herbaceous) gives pellets that are above this value (Wopienka et al.,2009). After all, pellets that are below the limit are used as industrial pellets in medium- and large-scale applications.

3.4. Advancements in raw material treatment

Today torrefaction processes are developed in many places with numerous technologies, for different purposes and for different type of raw material. Torrefaction is a thermo-chemical process for the upgrading of biomass that is run at temperatures ranging from 200°C to more than 300°C under the exclusion of oxygen and at ambient pressure. At these temperatures the biomass becomes almost totally dry. What is more, degradation processes take place that make the biomass lose its strength (through breaking up of the hemi-celluloses) and fibrous structure (through partial depolymerisation of the celluloses). Lignin, however, largely stays as it is and its share thus grows in the torrefied biomass. Grinding of the biomass becomes much easier, the net calorific value is increased and its hygroscopic nature swaps to hydrophobic. Moreover, its biological activity is strongly reduced. These effects are of tremendous importance, as raw material can be stored for more time without any degradation and does not require any storage facilities as it becomes hydrophobic and could be stored outside with no risk. Torrefaction attributes biomass the properties of coal and could be utilized by coal plants with no further investment as it could be stored together with coal for co-firing. Torrefaction opens up new markets for biomass utilization and the replacement of coal in power plants. Already there are torrefied materials on the market but one can not say that it is a general market with no available product today. An outlook for this technology is estimated by market participants as follows:

- 2009-2012 Pilot and full scale demo phase
- 2012-2013 commercialisation phase
- 2013- Expansion of the technology

Torrefaction technologies upon commercialisation are considered a necessary investment for the venture.

3.5. Logistics restrictions and storage of raw material

Loose biomass, for its high moisture content and low volumetric density, poses a serious problem for its transportation and economic use. Another obstacle for biomass is its variety in physical and chemical properties. These properties make it difficult and expensive to transport. Actually, the final density per cubic meter is still far less than e.g. oil given the nature of biomass, also for pellets. Pyrolysis or torrefaction may be a possible pre-treatment option, but still needs to be proven on a commercial scale. Transformation to pellets gives some very good logistical advantages in comparison with other biomasses, facilitating the storage and transport due to the high energy content, therefore the smaller volume to be handled, and also facilitating the storage because of the low moisture content and therefore a better conservation of the product in time.

Transportation is a fairly important factor regarding the economy of pellet industries, thus the pellet plant should be located close to raw material sources. The long transport distances of raw material reduce cost-effectiveness. Economically, the maximum profitable driving distance for truck transportation of forest fuels is evaluated at approximately 50-100 km, depending on the material transported and the logistics system (EUBIA-pellet@tlas). The amount of energy that can be transported by truck is rather small because of the low energy and bulk density of energy crops.

After harvesting, baling equipment will be used to make the harvested plants more easily handled and efficiently transferred to the plant. Bale size accepted by the district heating, CHP and power plants abroad are of dimension approx. 120 x 130 cm, and the bale length suitable for road transportation is approx. 240 cm (the width of a semi-truck). This makes transportation, stacking and handling convenient for a material handling loader. Bales are bound either with twine or wire and are big enough to require mechanical/hydraulic loaders. They weigh 320-550 kg. Most are 0.9 x 0.9 x 2.4 or 1.2 x 1.2 x 2.4 m. Although round bales may be cheaper to produce per ton, with biomass fuel it is typically more efficient and safer (do not roll) to produce large square bales for transportation and storage logistics. Typical balers are capable of baling 10 to 20 t/h (Porter et al., 2008). Bales covered in plastic could be stored in a fly roof type storage facility with no risk of moisture infiltration (reducing capital expenditure in storage).

The surface to dedicate to the storage must be planned with attention, because it can be very extensive. The size depends from the mass of a volume unit and from the way of piling up the bales. Due to seasonality of the raw material large storage facilities are necessary. Another factor under consideration is the chemical behavior of the raw material. During long storage carbon monoxide is produced. Silo or storage has to be well ventilated before a person goes inside it. Temperature increase in organic material during storage is also a well-known phenomenon. Microbial activity is one of the most important reasons for increasing temperatures. Respiration of living parenchyma cells is another process where heat is released and is considered by many researchers to be the initial cause of heating. The temperature development implies biological, chemical and physical changes in the raw materials and has to be considered during storage.

The type of raw material storage suggested is a fully retractable PVC building, custom made for the large area needed (details http://www.kopron.it/en/products/coperture_function.aspx). The plant could be working with the raw material building retracted and only when weather conditions do not allow (rain, high moisture, snow) the building would be fully deployed to protect the raw material from moisture. With this kind of building natural drying is maximized and the best ventilation possible is achieved making the working conditions safer for personnel also, as gases and dust created are free to escape. Moreover, capital expenditure is reduced as a conventional warehouse is much more expensive.

4. AVAILABILITY OF RAW MATERIAL – PLANT LOCATION

The agricultural sector in Greece accounts for more than 5% of GDP, more than three times the EU average of 1.8%. Companies involved in biomass and biofuels will therefore find abundant sources of raw materials.

In Greece 40.2% of total land is agricultural land where as 51,7% is arable land, 20,7% is permanent pasture and 27,3% is permanent crops. The total cultivated land in plant production is 3,425,800 ha and it continues to be stable the last years. 82.7% (3,281,345 ha) of the total agricultural land is classified as less-favored areas (LFAs).Moreover, most of the farmers use small pieces of land that are not in the same area. This has as a result in not using their production efficiently. Most of the farms are less than 5 ha (76,3%) or 5-50 ha (75%). The basic cultivations are arable (2.176.200 Ha), durum wheat (72.130 Ha), maize (corn) (24.100 Ha), tobacco (56.000), cotton (370.000 Ha), sugar beets (36.000 Ha), trees (1.002.000 Ha) - olive trees (780.000 Ha), vines (131.300 Ha) and horticulture (116.300 Ha). Taking into account the existing data for the past 30 years from the National Statistics Agency, one can see stability in the cultivated land with the most of the above plants. Arable and vine cultivations are experiencing a steady small reduction where as the land cultivated, by trees, is slowly increasing. The balance between the sectors of plant production is expected to undergo changes due to the CAP reform. The cultivations that are mostly affected are tobacco, cotton and sugar beets.

The aim of the venture is to cooperate with farmers that own lands that are less favorable (LFA). This is because farmers nowadays are planting these fields with cereal and most of the times do not harvest them because of the high costs occurring from contracting machinery[1] as the majority of farmers own 5ha or less and cannot afford to acquire machinery for themselves. Thus the farmers are receiving only the EU subsidy for their crops and their profit per hectare is rather minimal (after excluding costs for preparation of the land, planting, fertilizing and harvesting). Moreover, demographic data for the agricultural population in Greece shows that this group is aging as youth is not willing to actively involve in the agricultural business, making cardoon an ideal crop for them as the only requirements are planting once every ten years and harvesting once a year. After 2013 when CAP is reformed in terms of subsidies, these lands are probably

[1] Depends every year on the price asked for the cereals

going to be neglected or rented to farmers that own equipment and are able to cultivate achieving economies of scale.

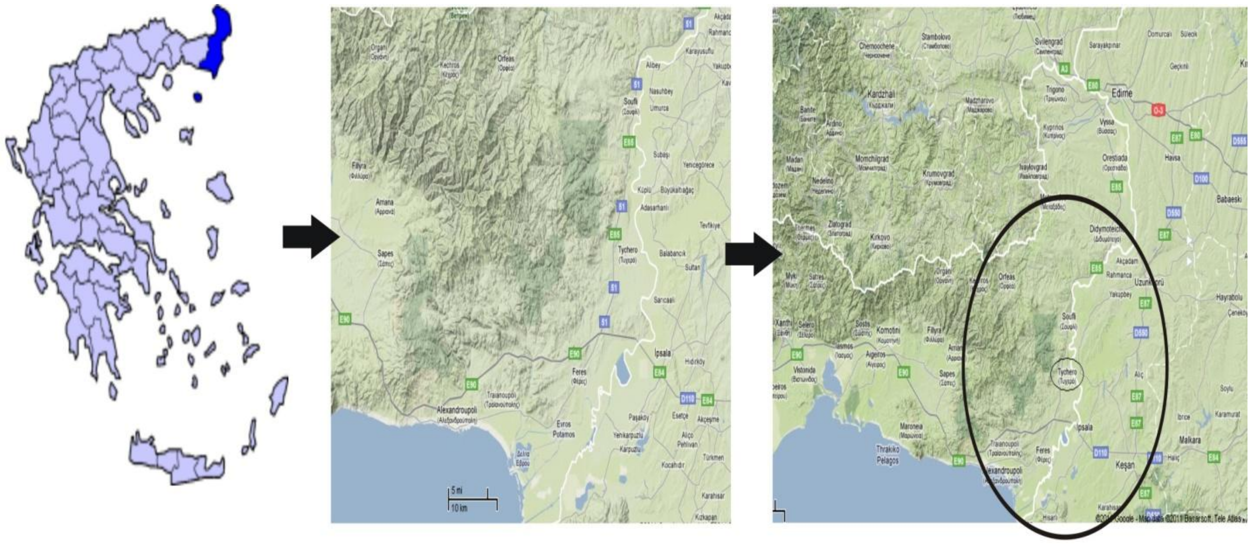
The selected location for the plant lies within the prefecture of Evros. The prefecture o Evros is the third largest in Greece in terms of arable land with 17,900ha, following the prefectures of Larissa (223,400ha) and Serres (189,020ha). The arable land represents 41% of total land of the prefecture of which 32.7% is irrigated (58,173ha).

Transport costs are highest for raw materials, so production should be situated as close to the raw materials as possible. Location and size of a pellet production plant should be assessed with regard to local conditions in each case. A premise is that there are adequate sources of raw materials in reasonable vicinity.

The specific plant location selected is near the village Tihero. The village has a strategic position in the arable lands of central and south Evros, as it is in the center of the greater plains. In a radius of less than 50km there are available lands of approximately 20,000ha of irrigated land and 40,000ha of non irrigated fields (LFA). The lands available are more than enough for the full operation of the plant, even in the case of new entries in the same area. The necessary cultivated lands are calculated at 1,000-1,500ha, which represents 1.66-2.5% of the available arable land in the area of 50km radius. On the north of the plants' location are situated the plains of Soufli and on the south the plains of Feres and Alexandroupolis. In Tihero village there is a railway station which was used heavily from the former Sugar Industry and has adequate infrastructure. The port of Alexandroupolis is located in the south-west, 50km from the selected location and is connected to the railway.

According to public data from Regulatory Authority for Energy (RAE), four applications for biomass power plants have been submitted and approved till June 2011 for the prefecture of Evros alone. The total capacity of the power plants is 12.78MW. Two of the plants are going to be located at Orestiada (70km to the North) and the other two at Tihero, with a combined capacity of 6.86MW. One of the plants (situated in Tihero) is an investment by the Hellenic Petroleum Renewables S.A and has a capacity of 4.68MW. Publications available to investors state that the power plant will utilize 40,000-50,000t/year of biomass originating from agricultural residues and energy crops and will be operational at 2013.

Figure 1: Plant location and 50km radius



Source: Google maps

These plants are considered to potentially become major clients of the venture since yearly full operation of these plants is logistically challenging, as biomass is very bulky and characterized by seasonality and enormous storage facilities would be necessary. Pellet use will provide the power plants with the following advantages:

- The amount of dust produced is minimized
- The fuel is free flowing, which facilitates material handling and rate of flow control
- The energy density is increased, easing storage and transportation
- The capital cost for storage is reduced
- Higher uniformity and stability permits more efficient combustion control
- There are less particulates produced during the combustion process
- There are considerable reductions in labor for feedstock handling
- Risk of fire is reduced considerably (Porter et al., 2008)

Pellets give the power plants the opportunity to minimize their storage needs and it is believed that logistics from these plants will be outsourced. Further on the operation of the venture will be a kick start for future investments in the energy sector at the prefecture, as it will be a critical part of the security of supply for biomass needed for the operation of the power plants.

The storage of raw material is obviously linked to the capacity of pellet production and also the seasonality of crop and pellet production. In general we can consider there is only storage volume for some weeks at the energy plants and for some months at the pellet factories even if it could be better to have a 2-3 month storage capacity to front the market and seasonal evolution. The capacity of the plant is estimated to be at 3t/h and 21,000t/y (estimated with 7,000 full operating hours). The production will be 24/7 as the energy consumed by the equipment if stopped and restarted is very high and inefficient economically.

The municipality of Soufli (where Tihero is pertained) has agreed to grant for free the necessary land to the venture, upon which the construction of the plant will take place. This is common policy on behalf of the municipality, in an attempt to enhance the development of the area by attracting investments. The only demand in return is that the personnel (non scientific) must come from the village of Tihero. This is also the case for the Hellenic Petroleum power plant investment where the municipality has granted 3.5ha for plant development.

5. PELLET PRODUCTION AND LOGISTICS

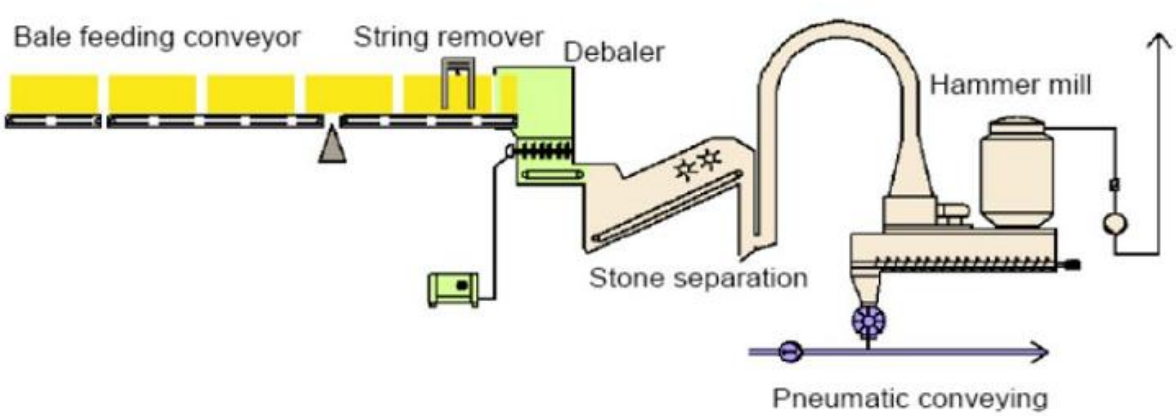
Raw material plays a subordinate role in the pelletisation process. Sawdust, wood dust, wood savings or herbaceous biomass, the steps in the process are only slightly affected by the selected raw material. Minor modifications on equipment setup are necessary to optimize performance in regard to every raw material. The general process line of pelletisation for herbaceous biomass is initiated by the delivery of the raw material at the factory, followed by size reduction, drying (if necessary), conditioning, pelletisation, cooling, screening and final product storage. The quantity of cardoon needed to produce 1t of pellets equals approximately to $7m^3$.

5.1. Pre-treatment of raw material

5.1.1. Reception of raw material

At the plant, cardoon is received as bales weighing up to 500 kg (depending on the balling equipment) and there might be some difficulties in feeding a bale into the system if it is not well planned. When energy crops are to be pelletized, chips have to be produced first using chippers. Figure 2 is showing a schematic of a how some problems related to bales and raw materials handling can be solved prior to hammer milling.

Figure 2: Raw material pre-treatment (Van Loo & Koppejan 2008)



Raw material is fed to the debaler, consisting of a horizontally rotating drum onto which knives are arranged in various ways. Shredded good is transported by fan or conveyor belt. Before the material is expelled it runs into standardized screens that are interchangeable and ensure a consistent output.

From a personnel point of view, one operator per shift is enough for feeding the line with raw material. Additional personnel will be needed during the harvesting period (June-July), as raw material will be arriving at great volumes and an additional operator for unloading the trucks will be necessary. After this point in production, fully automated procedures in production do not require any more personnel until storage of the final product (pellet).

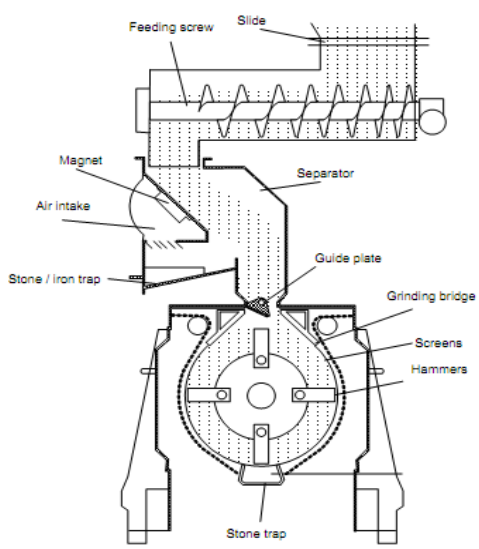
5.1.2. Screening

Magnets and screens for contaminants are normally used at different stages before grinding. Contaminants (metals, stones and other foreign material) are removed from raw material before the pelleting process. Ferrous metals are separated with a magnet from the conveying belt. A stone trap is installed to separate the raw material from the foreign objects (bigger stones and other material). An increased wear of machinery is created by contaminants which damage the machines of the process.

5.1.3. Size Reduction

The material has to be coarse ground in a hammer mill before it can follow the process line. After grinding the particle size is adjusted to a uniform maximum dimension, which is approximately 50-85% or less of the minimum thickness of the pellet to be produced. The typical target value for the particle size of the raw materials is 4mm when pellets of 6mm in diameter are to be produced (6mm is the common diameter for pellets).

Figure 3: Working principle of hammer mill (Van Loo & Koppejan 2008)



A number of studies have examined the impact of the length of chop on the pellet process. Overall it has been realized that fine grinding produces denser pellets and increases the throughput capacity of machines as the material passes through the machine more easily (Daniel et a., 2009). Fine chopped material provides a greater surface area for moisture addition during steam treatment.

5.1.4. Drying

The process of densification in the pellet mill depends on the friction between compression channel and raw material and is amongst other things determined by the moisture content of the raw material. This is why optimal moisture content has to be achieved according to the pelletising technology and the applied raw material.

In the case of cardoon the raw material at hand has already the right moisture content after harvesting, thus drying is not required. Further reduction in moisture could be achieved by natural drying as harvest is on June-July when nominal temperatures are very high and evaporation of water could be induced by exposure to the sun alone of the raw material. Of course this method is preceding the size reduction of raw material and is performed in the storage area of the raw material.

5.1.5. Conditioning

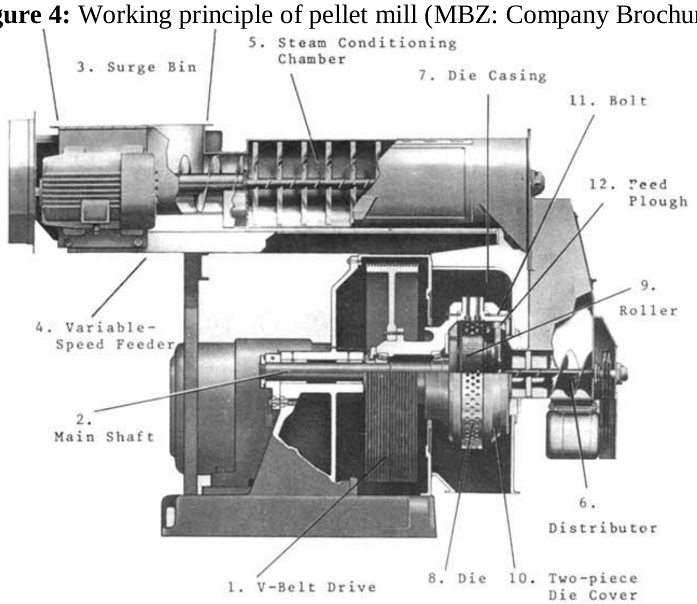
Conditioning denotes the addition of steam or water to the prepared materials just before pelletising. Through the addition of steam or water, a liquid layer is formed on the surface of the particles. As a result, unevenness is balanced out and binding mechanisms take place during the following densification process. If conditioning is to be carried out, one has to consider that during drying, a moisture content slightly underneath the optimum should be achieved as conditioning will raise it again (according to pellet producers by about 2 wt.% (w.b.)). Exact conditioning based on a control system is therefore very important for the good quality of the product.

At present the most common technique used is steam conditioning. Steam is sprayed at 90-150°C to conditioning chamber. Pressure is usually 5-10 bars, sometimes even higher. Proportion of the steam is about 5% from the weight of raw material and process time is 1–4 seconds. There exist also feed expanders, which can be used to expand conditioning. Inside the conditioning chamber a cascade mixer mixes steam, additives (if applicable) and raw material for pelleting. Steam added in the pelleting operation improves pellet durability. Added steam provides heat and moisture and it also helps to reduce energy consumption during pelleting. Steam also activates natural binders and lubricants in the biomass.

5.2. Pelletisation

The next step after grinding and conditioning is the actual pelletising process in the pellet mill. Large-scale producers normally use ring or flat die pellet mills that are especially designed for pelletising; ring die mills are most common. Ring die pellet mills consist of a die ring that runs around fixed rollers. The material is fed to the rollers sideways and pressed through the bore holes of the die from the inside to the outside. The rollers of flat die pellet mills rotate on top of a horizontal die. The material conveyed from above falls onto the platform and is pressed downwards through the die holes.

Figure 4: Working principle of pellet mill (MBZ: Company Brochure)



The raw material is fed into the pellet mill and distributed evenly. It then forms a layer of material on top of the running surface of the die. This layer gets overrun and thus densified by the rollers. By overrunning the dense material, the pressure increases persistently until the material that is in the channels already gets pushed through the channel. An infinite string comes out of the die that either breaks up into pieces randomly or gets cut into the desired length by knives.

Important parameters of pelletising are the press ratio, the quantity of bore holes and the resulting open area of holes (without considering the inlet cones). The press ratio is the ratio of diameter of holes to length of channels. Together with the type of raw material the press ratio determines the amount of friction that is generated inside the channels, which is why it has to be adapted exactly to the raw material in order to achieve high pellet quality and throughput rate. Variation of the press ratio is only possible by varying the length of the channels because the diameter is given by the desired diameter of the pellets. So, materials that do not have a lot of binding strength of their own call for longer compression channels. The temperature in the channels rises with increasing length so that stiffness of pellets also rises with channel length.

Parameters that should be adapted to the raw material to be pelletized are:

- thickness of the die
- channel length (without the counter drill)
- quantity, shape and diameter of bore holes
- quantity, diameter and width of rollers
- shape of rollers (cylindrical or conical) of flat die mills

The quantity of holes and the resultant open hole surface have a direct effect on the throughput together with the available driving power. Constant feeding and homogenously ground material with constant moisture content lying between 8 and 13 wt.% (w.b.) are prerequisites for a pelletising process without failures.

5.3. Post Treatment

5.3.1. Cooling

The last process step in pelletisation is cooling. The material gets heated up by steam or hot water conditioning before pelletising and by frictional forces in the compression channels.

According to the type of pellet mill and operational parameters, the temperature of the pellets directly after the process can vary between 80 and 130°C. This is why cooling before storage is necessary.

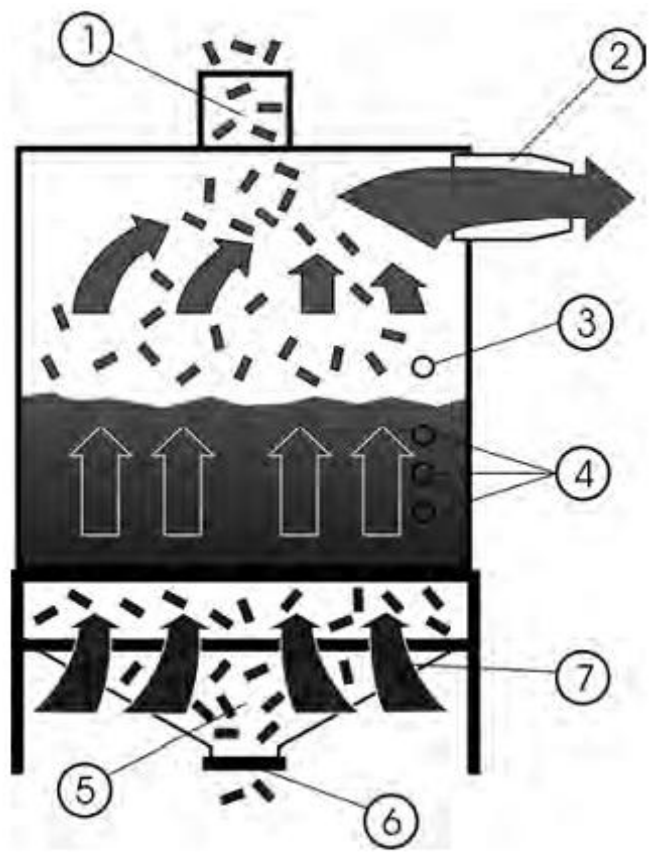
Cooling also enhances mechanical durability and it reduces the moisture content by up to 2 wt.% (w.b.). Frequently, counter flow coolers are deployed for the process whereby dry cold air enters the cooler at the rear end and moisture laden warmer air flows through the pellets entering the cooler at the front (hence the name counter flow cooler).The working principle of a counter flow cooler is shown in figure 5.

The pellets are usually conveyed directly from the cooler to the storage facility via special conveyor systems (e.g. bucket conveyor, chain trough conveyor).

5.3.2. Screening

The residual fines are screened to separate pellets. Fines are harmful in use. Fines are generally re-used in the process and re-pelletized. Some process lines are operated with under pressure in order to minimize dust escape from the process and improve the working environment.

Figure 5: Working principle of counter flow cooler (BLISS: Company Brochure)



Explanations: 1-pellet input via rotary valve; 2-exhaust air; 3-overfilling protection sensor; 4-filling level sensors; 5-pellet outlet; 6-discharge hopper; 7-cooling air;

At all zones of the process where dust might arise, the air is drawn off and filtered (cyclone or baghouse filter). As a rule these zones are:

- grinding
- drying
- after cooling
- before packaging or loading

Drawn off dust is returned to the production process. Screening before transport and packaging, guarantees a small amount of fines in the final product.

5.4. Pellet Storage

Pellets are stored in closed systems along the whole pellet supply chain in order to keep water or moisture from coming in, which would lead to diminished quality. Depending on the framework conditions and the utilization of pellets, they can be stored in closed warehouses, silos, storage spaces or integrated pellet reservoirs. According to Haas et al. (1998) storage capacity should be about 30% of the annual capacity.

A-frame flat storages purposely built for storing pellets in bulk are economical to erect and are used for large volume storage (in our case 11,000m^3). The pellets are loaded into the storage from a telescoping conveyor system in the ceiling and drop down to designated areas on the flat floor.

Figure 6: Example of an A-frame flat storage (Obernberger & Thek 2010)

Handling of pellets with front loaders is common but causes a fair amount of damage to the product and generates high amounts of dust. A fully automated moving scraper/re-claimer with parallel conveyors on each side of the pile may is preferable for retrieving the material for further transportation.

For storage and transportation needs, one operator per shift is necessary for arranging storage and handling/loading of the trucks.

5.5. Distribution

Large pellet storage facilities are required for the venture in the case of export of the product or sales in the rest of the Greek region (power plants or intermediaries), as a large amount of product is required for the transport to be economically efficient. In this case transportation via rail or sea vessels is optimum. Three to four shipments per annum are estimated in this scenario. The railway station is located on the east side of the village of Tihero and will have a distance of approximately 5-10km from the pellet plant. Pellets will be transported to the railway system with contracted trucks. From there, if the sale is inside Greece, pellets are going to be transported to their destination by train to the customers' nearest railway station and from there by trucks to final user. In the case of exports, the train will be unloaded to the port of Alexandroupolis (50km from the railway station of Tihero) and from there loaded to the ship hired for the transport.

In the case of local power plants, the pellets will be supplied to the power plants when a full truck load is complete. The power plants are estimated to be positioned is a radius of no more than 10-20km from the pellet plant. A typical truck will hold up to 24t in bulk (depending on the destination and truck type), so every 7-8 hours of production output transport to the power plant will take place. This is feasible by the owned truck of the venture, making truck contracting unnecessary and reducing distribution costs.

In the case of large volume transportation, no additional personnel is required, as trucks with drivers will be contracted. In the case of regional distribution, a driver is required for transport of pellets to the power plants.

6. FINANCIAL

This chapter briefly presents the main financial projections and other relevant to the investment data. Full cost calculations, framework conditions and detailed financial analysis are provided in the Appendix. The projections were estimated for an investment horizon of ten years. Two case scenarios were estimated, with A being the base case scenario:

- Case A – Sales on local biomass power plants
- Case B – Sales to the Greek wholesaler for further export in the European market

Case A results are summarized here, while case B, for reasons of economy of space, is available upon request. For further analysis, the following statistics were assumed:

- 3t/h production output
- 3 shifts per day
- 7 working days per week
- 7,000 operational hours per year
- 85% equipment simultaneity factor
- 130€/t selling price – Base Case
- 140€/t selling price - Case B
- 700ha contracted the first year increasing by 30% every year until 1,400ha are reached for full operation in 5th year.

6.1. Capital Budget

For the purposes of this business plan, budgetary capital costs were estimated with available quotes of equipment suppliers, local civil engineers and consultants as well as several other available reports from industry experts and existing wood pellet start-ups around the world. Detailed engineering and quotes for the venture will be developed and finalized upon confirmation of financing.

The total cost of installation of the pellet plant is estimated at €3,363,400. The following table presents the allocation of required capital for the investment.

Table12: Total investment costs (€)

Budget Allocation		Cost (€)
Site infrastructure		**108,000**
- Land (1.5ha)	-	
- Land development	*108,000*	
Facilities		**1,605,000**
- Pellet Line Building (900m^2)	*270,000*	
- Pellet Storage (1,200m^2)	*360,000*	
- Raw Material Storage (6,000m^2)	*900,000*	
- Weigh scale	*75,000*	
Planning		**300,000**
Equipment		**1,082,400**
Debaling-Screening	*144,000*	
Hammer Mill	*164,800*	
Pellet Mill	*400,000*	
Counterflow cooler	*25,600*	
Peripheral Equipment	*348,000*	
Vehicles		**268,000**
- Truck	*120,000*	
- Loader	*108,000*	
- Forklift	*40,000*	
Total Initial Investment		**3,363,400**

Land development refers to the necessary utility installations and surroundings for the plant. As mentioned before the land for the plant will be provided by the local municipality. Pellet line building and pellet storage building are budgeted as standard industrial type buildings, while the raw material storage building is a special type retractable pvc building.

All equipment and vehicles are new and unused. Cost for planning is estimated at about 10% of the total investment cost and involves the necessary environmental permitting, fire protection, civil engineer costs and other professionals needed in the start up period.

6.2. Financing Structure

Total equity will be provided by the investor. Bank financing is considered to be extremely difficult (and expensive) for a start up like CYNERGY.

The venture is eligible for integration in the Greek Incentives Law (N.3908/2011). The incentive for the prefecture of Evros totals at 50% of the investment costs and specifically 40% is granted as direct funding and 10% as income tax relief. With a total cost of €3,363,400 the incentive funding will be provided in the form of:

- direct funding at an amount of €1,345,360
- indirect funding in the form of tax relief at a cumulative amount of €336,340

The incentive funding is not going to decrease the equity provided by the investor. On the contrary, the cash will be utilized for the short term working capital needs (see Appendix) of the operations, as in the first three months of operation, yearly supply of raw material will occur after the harvesting period and the farmers need to be paid within 30 days according to contractual agreements.

6.3. Construction period schedule and cashflows

The cultivated energy crop (cardoon) poses a major scheduling barrier in the investment. Initial plantation of the crop is essential to take place at September till mid-October of each year, as the growing period begins in September and lasts until June and July.

In the business plan, an 18 month construction period is estimated, beginning at January and finishing with an operational plant in June of the next year. During this period, the plantation of the energy crop must take place in season (during construction) in order the harvest to coincide with the initial operation of the facility.

The construction period is divided in two sub-periods, 1^{st}-6^{th} month and 7^{th}-18^{th} month. The respective cashflows are presented in table 13. All the necessary permitting, planning and studies will be conducted in the first six months of the construction period. Land development and buildings will also be initiated.

In addition, application for the Greek Incentives Law should be submitted in the first or second month in order for the approval to be ready within the end of the first sub-period. Upon approval, 50% of the direct incentive is available to the company in advance and the rest 50% of the incentive is granted upon total completion of the investment, at the end of the 18months (providing the necessary working capital for the operation of the plant).

All other construction and provisions of equipment and vehicles will be completed in the second sub-period.

Table13: Initial cashflows

	Month 1-6	Month 7-18
Planning	(300,000)	
Land Development	(108,000)	
Facilities	(535,000)	(1,070,000)
Equipment		(1,082,400)
Transport Vehicles		(268,000)
Incentives Law Funding		1,345,360
Fund Outflows	**(943,000)**	**(1,075,040)**

6.4. Operational Costs

The respective costs for complete operation of the plant have been identified and divided in seven major categories. Full cost calculations and framework conditions for every category are given in the Appendix. Comments on each category follow table 14:

Table 14: Estimated operational costs (€)

Cost category	Year 1	Year 2	Year 3	Year 4	Year 5
1 - Raw material	417,480	821,044	1,067,357	1,305,321	1,391,600
2 - Personnel	328,459	328,459	328,459	328,459	328,459
3 - Electricity	102,979	202,526	263,284	321,982	343,264
4 - Maintenance	38,672	76,056	98,872	120,916	128,908
5 - Distribution	2,100	4,130	5,369	6,566	7,000
6 - Consultants	39,000	39,000	39,000	39,000	39,000
7 - Other Costs	77,695	72,643	69,766	63,787	62,285
Total Costs	**1,006,385**	**1,543,857**	**1,872,107**	**2,186,030**	**2,300,516**
Cost category	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year10**
1 - Raw material	1,391,600	1,391,600	1,391,600	1,391,600	1,391,600
2 - Personnel	328,459	328,459	328,459	328,459	328,459
3 - Electricity	343,264	343,264	343,264	343,264	343,264
4 - Maintenance	128,908	131,486	134,064	136,642	139,221
5 - Distribution	7,000	7,000	7,000	7,000	7,000
6 - Consultants	39,000	39,000	39,000	39,000	39,000
7 - Other Costs	61,589	60,894	57,510	57,232	57,093
Total Costs	**2,299,820**	**2,301,702**	**2,300,897**	**2,303,197**	**2,305,636**

Raw material

Raw material costs include purchase of the raw material either at the gate of the factory at 70€/t or at the field at 50€/t (market prices at September 2011), leaving harvesting & transportation costs to the pellet company. 30% of the contacted farmers are estimated to deliver the raw material at the gate with their own equipment in order to take advantage of the higher price, while for the rest 70% harvesting and transportation is carried out by CYNERGY with contracted equipment and trucks (for the harvesting period) at a cost of 8€/t and 6.67€/t respectively (cost calculation in the Appendix).

Human Resources

Four salaried employees are required including a general manager (at €60,200 per annum), plant manager (at €39,900 per annum), logistics manager (at €28,000 per annum) and a book keeper/office clerk (at €19,600 per annum). Salary costs are estimated including benefits and pension schemes for 14 months per year according to Greek legislation.

Positions for workers include one for feedstock handling per shift, a driver (only one shift per day necessary) and an operator per shift. During the harvesting period a weigh master per shift is also budgeted. Total cost of workers is estimated at €180,759 per year.

It should be possible to recruit high-quality and skilled people for the above positions following the recent layoffs from the local industries.

Electricity

Cost of electricity is budgeted at a price of 0.1118€/kWh (http://www.energy.eu/#Industrial-Elec) including all taxes without VAT. Framework conditions of energy consumption are given in the Appendix for each equipment.

Maintenance

Maintenance costs for the equipment where budgeted as a percentage of the initial investment and a function of operational hours per year.

Distribution

In the base case scenario, distribution costs refer to the sales and transportation to near by biomass power plants. The cost of such delivery is based on fuel consumption (estimated at 0.33€/t), as driver and truck are already budgeted. In the second case scenario, transport by train to the Greek wholesaler is assumed. Distribution cost per tonne in this case yielded at 16.70€, raising significantly the total cost per ton.

Consultant Fees

Several special services needed for the operation of the plant and the supply chain will be outsourced. The following table shows the cost per consultant per year.

Table 15: Consultants Fees (€)

Consultant	Annual Cost
Safety Engineer	12,000
Accountant	12,000
Legal	3,000
Agronomist	12,000
Total	**39,000**

Other costs

In the other costs category all other expenses were included, such as insurance (assets-products), travelling, advertising, office supplies and various administrative expenses.

Depreciation & Amortization

Depreciation and Amortization are shown in the income statement as where not budgeted as operational costs. The method used is the linear method according to Greek Legislation (ΠΔ229/2003).

6.5. Annual Income

A summary of projected annual income is shown in table16. The first three years show net losses because operational efficiency is starting to build up until the 5th year (full operation). Operational profitability is reached in year 2.

Allocation of costs for the estimation of C.O.G.S. is provided in the Appendix. Gross margin is calculated at 7.62% for the first year of operation and reaches 25.86% in year 5 in full operation, respectively. Operational margin is -22.88% for the first year of operation, while in the fifth year and further on, is ranging from 15.54%-15.73%.

Estimating the Free CashFlow to Firm (FCFF) and discounting with a hurdle rate of 15% we arrive at positive Net Present Value (NPV) on the investment. Internal Rate of Return (IRR) was calculated at 19.8% and depicts a rational return for the investor bearing in mind the risk of such an investment. Case B yields also positive NPV and an IRR of 12.90%.

Table 16: Annual Income Statement (€)

Income Statement	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Revenue	819,000	1,610,700	2,093,910	2,560,740	2,730,000
-Cost of Sales	**756,616**	**1,282,946**	**1,604,292**	**1,911,802**	**2,024,116**
Gross Profit	**62,384**	**327,754**	**489,618**	**648,938**	**705,884**
- Distribution Costs	190,046	201,379	208,400	214,926	217,138
-Gen. Admin. Expenses	59,722	59,531	59,415	59,302	59,261
EBITDA	**(187,385)**	**66,843**	**221,803**	**374,710**	**429,484**
- Depreciation	286,050	286,050	286,050	286,050	286,050
- Amortization	60,000	60,000	60,000	60,000	59,999
EBIT	**(533,435)**	**(279,207)**	**(124,247)**	**28,660**	**83,435**
- Finance Costs	-	-	-	-	-
EARNINGS BEFORE TAX	**(533,435)**	**(279,207)**	**(124,247)**	**28,660**	**83,435**
- Tax	-	-	-	5,732	16,687
+ Tax relief	-	-	-	5,732	16,687
NET INCOME	**(533,435)**	**(279,207)**	**(124,247)**	**28,660**	**83,435**

Income Statement	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Revenue	2,730,000	2,730,000	2,730,000	2,730,000	2,730,000
-Cost of Sales	**2,023,768**	**2,025,344**	**2,024,232**	**2,026,016**	**2,027,870**
Gross Profit	**706,232**	**704,656**	**705,768**	**703,984**	**702,130**
- Distribution Costs	216,790	217,086	217,382	217,887	218,462
-Gen. Admin. Expenses	59,261	59,272	59,283	59,294	59,305
EBITDA	**430,180**	**428,298**	**429,103**	**426,803**	**424,364**
- Depreciation	286,050	218,524	83,490	83,490	83,490
- Amortization	-	-	-	-	-
EBIT	**144,130**	**209,774**	**345,613**	**343,313**	**340,874**
- Finance Costs	-	-	-	-	-
EARNINGS BEFORE TAX	**144,130**	**209,774**	**345,613**	**343,313**	**340,874**
- Tax	28,826	41,955	69,123	68,663	68,175
+ Tax relief	28,826	41,955	69,123	68,663	68,175
NET INCOME	**144,130**	**209,774**	**345,613**	**343,313**	**340,874**

6.6. Sensitivity Analysis

In table 17 are presented the estimated cost per tonne of pellets. It is obvious that the main cost driver is the raw material price. After summing up harvest and transportation costs, raw material represent 60.36% of total cost (base case). Another significant cost factor is the power demand and personnel costs. In case B distribution costs are of great importance.

Table17: Pellet cost per tonne

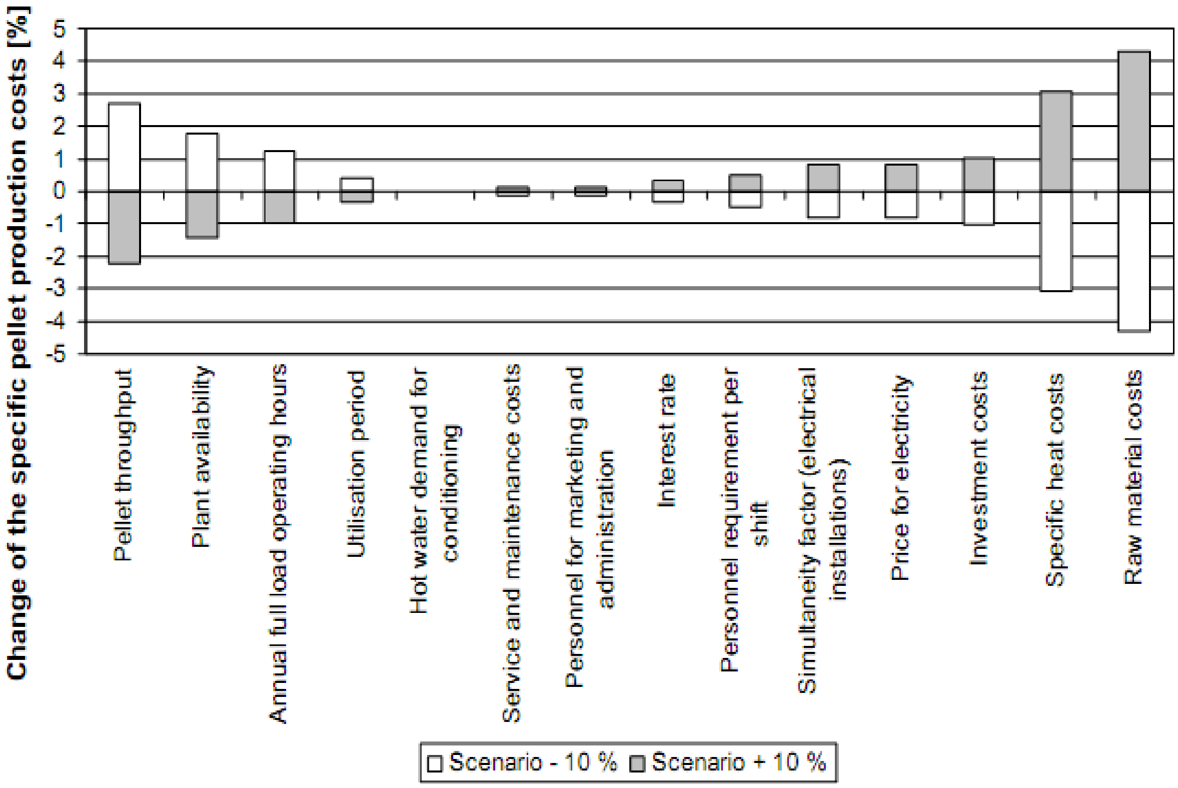
Parameter	Case A		Case B	
	€ per ton.	% of cost	€ per ton.	% of cost
Raw material	56.00	51.01%	56.00	44.35%
Harvesting	5.60	5.10%	5.60	4.44%
Transportation	4.67	4.25%	4.67	3.70%
Personnel	15.64	14.25%	15.64	12.39%
Electricity	16.35	14.89%	16.35	12.95%
Maintenance	6.63	6.04%	6.63	5.25%
Distribution	0.33	0.30%	16.70	13.23%
Consultants	1.86	1.69%	1.86	1.47%
Insurance	2.32	2.12%	2.42	1.92%
Traveling	0.05	0.04%	0.05	0.04%
Advertising	0.19	0.17%	0.19	0.15%
Office supplies	0.01	0.01%	0.01	0.01%
Administration expenses	0.14	0.13%	0.14	0.11%
Total	**109.79**	**100.00%**	**126.26**	**100.00%**

Obernberger and Thek (2010) conducted a sensitivity analysis in a 5t/h wood pellet plant and their results are summarized in figure 7. The scenarios simulated where a ±10% change on each parameter.

In table 18, an overview of the effect of a ±10% change in parameters such as raw material prices, oil prices (affecting distribution costs), electricity prices and selling prices is given is total cost per tonne of pellets as well as IRR of the investment. Additionally, a simultaneous change in all these factors (excluding selling prices) is provided, for an estimation of best-worst case scenario situation.

As expected cost per tonne and IRR are more sensitive to raw material prices. Case B is showing greater variability in effects because of the higher cost per tonne and the greater exposure on distribution costs.

Figure 7: Overview of the effects of parameter changes on the specific pellet production costs



Source: Obernberger & Thek (2010)

Table 18: Sensitivity Analysis

	+10% change		-10% change	
	Cost (€/t)	**IRR**	**Cost (€/t)**	**IRR**
Base Case	*109.79*	*19.85%*	*109.79*	*19.85%*
Raw material	115.40	17.30%	104.19	22.34%
Oil	109.83	19.83%	109.76	19.86%
Electricity	111.42	19.12%	108.16	20.58%
Price	109.92	25.99%	109.66	13.44%
Simultaneously (excl. price)	117.06	16.53%	102.53	23.06%
Case B	*126.26*	*12.90%*	*126.26*	*12.90%*
Raw material	131.86	10.01%	120.65	15.71%
Oil	127.93	12.05%	124.59	13.75%
Electricity	127.89	12.07%	124.63	13.73%
Price	126.40	20.24%	126.12	5.10%
Simultaneously (excl. price)	135.16	8.27%	117.36	17.31%

7. CRITICAL RISKS

One major issue at the moment is that the market is still in its very early stage. Thus, the bigger concern is the insufficient number of customers and suppliers for the raw material.

Regarding the customers, market data point out that industrial use of pellet for energy and heating will have an upward trend if there is enforcement of a law concerning the CO_2 emissions and oil prices continue to rise. Hence, the issues of government support in terms of policy and subsidies are very high in the agenda.

Concerning the suppliers of raw material there is critical thought for the farmers' contracts. Farmers in Greece are very difficult to manage and although the cultivation of cardoon has a great deal of profit for them in Less Favored Areas, disbelief in their part will pose problems in the supply chain.

Another issue is that the promotion of pellets as a reliable fuel in the market is still in the beginning so there might be a lot of reactions concerning the standards and the chemical characteristics of the product, since there is not an official organization for informing Greek consumers for these matters.

Major threats also arrive from the other side of the Atlantic. A rise in the EUR/CAD exchange rate, will make Canadian wood pellets cheaper. On the contrary though, a fall is the exchange rate, will make the Canadian pellets more expensive and will boost intra-European transactions.

Last but not least, a very important factor is the fluctuating price of oil and natural gas. In 2008 oil prices spiked and there was a flurry of interest in pellets. Then oil prices plunged—equivalent to pellet heat and even lower—and interest retracted. Heating oil is a rather fluctuating market and in this case subsidies for pellet installations may be very helpful for market development. If oil and gas prices are very low, it will be difficult to attract new customers.

8. SCHEDULING AND MILESTONES

The conceptual schedule allows 6 months for start up and 12months for construction and commission. CYNERGY will be created legally upon agreement of financing by the investor. The plant should be fully operational by the end of the 18th month which coincides with the harvesting period. Sale should be available within the first two months of operation. The plant will reach full operational efficiency by year 5 when the number of cultivated ha allows so.

Figure 8: Conceptual Schedule

9. CONCLUSIONS

Current situation in the fossil fuel industry, surging oil prices and facts from the status in raw material availability in the wood pellet industry internationally, have led to the emergence of opportunity for the production of mixed biomass pellets (MBPs), using as raw material the energy crop cardoon (*Cynara cardunculus*, L.). Supply of raw material will be secured by contractual agreements with local farmers.

Initially, CYNERGY PELLETS was aiming in the productions of pellets for the residential heating sector, in an effort to exploit lower production costs for lower price than wood pellets to the end-user. However, this proved to be impossible as market research revealed the existing industry standards and requirements in order the produced pellet to be characterized as Class A1 pellet (A1 is the only suitable type for small scale furnace applications, i.e. residential heating sector). Proximate and ultimate analysis on the energy crop cardoon, have shown that cardoon pellets do not possess the chemical properties required for the production of A1 pellets due to higher ash and chlorine content. Using MBPs for combustion in small scale furnaces of the residential heating will sooner or later cause malfunctions in operation. Hence, a shift in market orientation was considered essential.

Alongside the residential heating sector, a huge pellet market has been developed in recent years. It is the industrial pellet market, originating from the demand of the biomass power plants in Europe. Superior combustion technologies in the energy sector, allow the utilization of lower quality pellets, known as industrial type pellets. Thus, focus was given in the production of industrial type pellets for sale to biomass power plants.

Research on the Greek biomass sector revealed that is about to boom, as from 27MW currently operating in Greece, until June 2011 have been cleared for operation biomass power plants equivalent to the production of approximately 400MW. These facts, in relation to biomass availability, have led to the selection of the location within the prefecture of Evros, where four biomass plants have been cleared and are due to operate in 2013.

The production processes for MBPs are not different from those of the wood pellets and only minor modifications in equipment setup are necessary in order to adapt to the raw material and optimize performance.

For the estimation of the capital costs for the investment, real quotes from equipment vendors and construction companies where acquired in summer 2011. Incentives funding was prepared in accordance to Greek Incentives Law (N.3908/2011), while production costs and other relevant data used in the estimation of operational and other costs, are market prices at the time of preparation of the business plan.

Hypotheses in cashflow estimation are conservative in nature in an attempt to minimize risk exposure of the investment. Concerning the investment decision, the net present value rule was applied to discount the ten years estimated cashflows, while terminal value of the firm was estimated as the liquidation value.

Finally, further research is recommended in the possibility of adoption in advanced pre-treatment processes, such as torrefaction. Torrefaction turns biomass from hydrophilic to hydrophobic making on the one hand open space storage a possible reality, reducing vastly the capital costs for the investment (raw material storage building unnecessary) and on the other hand decreasing the power demand in the peletting process.

CYNERGY PELLETS is a feasible and profitable investment. The availability of raw material in the selected location and market prospects in the green energy sector in Greece will result in the high operational profitability of the plant and the desired return for the investor.

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APPENDIX

Notice to the reader

The attached material is an integral part of this business plan. These prospective financial statements involve anticipated future events. These matters are not susceptible to precise determination. Our calculations generally depend on subjective judgments and uncertainties which increase with the length of the future time period we are examining. Much of the information available to us is based on estimates and assumptions provided by third parties. Accordingly these prospective financial statements should not be relied upon as guaranteeing a specific result, but rather only as a means of assessing the relative desirability of alternative courses of action, a range of price and anticipated income or cash flow, as the case may be.

Case B financial projections are omitted for reasons of economy of space and are available upon request.

CYNERGY PELLETS

Projected Income Statement (€)

Income Statement	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Revenue	819,000	1,610,700	2,093,910	2,560,740	2,730,000	2,730,000	2,730,000	2,730,000	2,730,000	2,730,000
-Cost of Sales	756,616	1,282,946	1,604,292	1,911,802	2,024,116	2,023,768	2,025,344	2,024,232	2,026,016	2,027,870
Gross Profit	**62,384**	**327,754**	**489,618**	**648,938**	**705,884**	**706,232**	**704,656**	**705,768**	**703,984**	**702,130**
- Distribution Costs	190,046	201,379	208,400	214,926	217,138	216,790	217,086	217,382	217,887	218,462
-Gen. Admin. Expenses	59,722	59,531	59,415	59,302	59,261	59,261	59,272	59,283	59,294	59,305
EBITDA	**(187,385)**	**66,843**	**221,803**	**374,710**	**429,484**	**430,180**	**428,298**	**429,103**	**426,803**	**424,364**
- Depreciation	286,050	286,050	286,050	286,050	286,050	286,050	218,524	83,490	83,490	83,490
- Amortization	60,000	60,000	60,000	60,000	59,999	-	-	-	-	-
EBIT	**(533,435)**	**(279,207)**	**(124,247)**	**28,660**	**83,435**	**144,130**	**209,774**	**345,613**	**343,313**	**340,874**
- Finance Costs	-	-	-	-	-	-	-	-	-	-
EARNINGS BEFORE TAX	**(533,435)**	**(279,207)**	**(124,247)**	**28,660**	**83,435**	**144,130**	**209,774**	**345,613**	**343,313**	**340,874**
- Tax	-	-	-	5,732	16,687	28,826	41,955	69,123	68,663	68,175
+ Tax relief	-	-	-	5,732	16,687	28,826	41,955	69,123	68,663	68,175
NET INCOME	**(533,435)**	**(279,207)**	**(124,247)**	**28,660**	**83,435**	**144,130**	**209,774**	**345,613**	**343,313**	**340,874**

Framework Conditions

Selling price: 130€/t

Tax rate: according to Greek Legislation

Accumulated tax relief available: €336.340

CYNERGY PELLETS

Projected Balance Sheet (€)

	Opening Balance	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
FIXED ASSETS											
Intangible Assets	300,000	240,000	180,000	120,000	60,000	1	1	1	1	1	1
Tangible Assets											
- PPE	3,063,400	2,777,350	2,491,300	2,205,250	1,919,200	1,633,150	1,347,100	1,128,576	1,045,086	961,596	878,106
CURRENT ASSETS											
Trade Receivables	-	204,750	402,675	523,478	640,185	682,500	682,500	682,500	682,500	682,500	682,500
Inventory	-	245,700	483,210	628,173	768,222	819,000	819,000	819,000	819,000	819,000	819,000
Cash	1,345,360	791,391	467,588	450,980	595,094	934,218	1,344,525	1,738,748	2,117,963	2,462,874	2,805,904
TOTAL ASSETS	**4,708,760**	**4,259,191**	**4,024,773**	**3,927,880**	**3,982,701**	**4,068,869**	**4,193,126**	**4,368,825**	**4,664,550**	**4,925,971**	**5,185,511**
EQUITY											
Share capital	3,363,400	3,363,400	3,363,400	3,363,400	3,363,400	3,363,400	3,363,400	3,363,400	3,363,400	3,363,400	3,363,400
Retained Earnings (Acc. Loses)	-	(533,435)	(812,642)	(936,889)	(916,468)	(857,021)	(754,328)	(604,865)	(358,615)	(114,005)	128,867
Incentives Law Reserve	1,345,360	1,345,360	1,345,360	1,345,360	1,345,360	1,345,360	1,345,360	1,345,360	1,345,360	1,345,360	1,345,360
General Reserve @5%	-	-	-	-	1,433	5,605	12,811	23,300	40,581	57,746	74,790
CURRENTS LIABILITIES											
Short Term Loan	-	-	-	-	-	-	-	-	-	-	-
Accounts payable	-	83,865	128,655	156,009	182,169	191,710	191,652	191,809	191,741	191,933	192,136
Dividends Payable	-	-	-	-	6,807	19,816	34,231	49,821	82,083	81,537	80,958
EQUITY & LIABILITIES	**4,708,760**	**4,259,191**	**4,024,773**	**3,927,880**	**3,982,701**	**4,068,869**	**4,193,126**	**4,368,825**	**4,664,550**	**4,925,971**	**5,185,511**

CYNERGY PELLETS

Projected Cashflows (€)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Cash flows from operating activities										
Net profit before tax	(533,435)	(279,207)	(124,247)	28,660	83,435	144,130	209,774	345,613	343,313	340,874
(Less) income tax	-	-	-	-	-	-	-	-	-	-
Depreciation	286,050	286,050	286,050	286,050	286,050	286,050	218,524	83,490	83,490	83,490
Amortization	60,000	60,000	60,000	60,000	59,999	-	-	-	-	-
Decrease (increase) in receivables	(204,750)	(197,925)	(120,803)	(116,708)	(42,315)	-	-	-	-	-
Decrease (increase) in inventory	(245,700)	(237,510)	(144,963)	(140,049)	(50,778)	-	-	-	-	-
Increase (decrease) in accounts payable	83,865	44,789	27,354	26,160	9,540	(58)	157	(67)	192	203
Net cash from operating activities	*(553,969)*	*(323,803)*	*(16,608)*	*144,114*	*345,932*	*430,122*	*428,454*	*429,036*	*426,994*	*424,567*
Cash flows from financing activities										
Net cash in investing activities	-	-	-	-	-	-	-	-	-	-
Cash flows from investing activities										
Dividends paid	-	-	-	-	(6,807)	(19,816)	(34,231)	(49,821)	(82,083)	(81,537)
Net cash used in financing activities	-	-	-	-	*(6,807)*	*(19,816)*	*(34,231)*	*(49,821)*	*(82,083)*	*(81,537)*
Increase (decrease) in cash	(553,969)	(323,803)	(16,608)	144,114	339,125	410,306	394,224	379,214	344,911	343,030
Cash at beginning of period	1,345,360	791,391	467,588	450,980	595,094	934,218	1,344,525	1,738,748	2,117,963	2,462,874
Cash at the end of period	791,391	467,588	450,980	595,094	934,218	1,344,525	1,738,748	2,117,963	2,462,874	2,805,904

Framework Conditions

Inventory: 30% of yearly production

Receivables: 3months credit to clients

Payables: 1 month credit by vendors

Dividend policy: 25% dividends - 75% retained earning (after subtracting 5% of net income as General Reserve)

CYNERGY PELLETS

Operational Costs (€)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Raw material	352,800	693,840	901,992	1,103,088	1,176,000	1,176,000	1,176,000	1,176,000	1,176,000	1,176,000
Harvesting	35,280	69,384	90,199	110,309	117,600	117,600	117,600	117,600	117,600	117,600
Transportation	29,400	57,820	75,166	91,924	98,000	98,000	98,000	98,000	98,000	98,000
Personnel	328,459	328,459	328,459	328,459	328,459	328,459	328,459	328,459	328,459	328,459
Electricity	102,979	202,526	263,284	321,982	343,264	343,264	343,264	343,264	343,264	343,264
Maintenance	38,672	76,056	98,872	120,916	128,908	128,908	131,486	134,064	136,642	139,221
Pellet Transport	2,100	4,130	5,369	6,566	7,000	7,000	7,000	7,000	7,000	7,000
Consultants	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000	39,000
Insurance	54,174	54,174	54,174	51,487	51,487	51,487	51,487	48,799	48,799	48,799
Traveling	4,175	4,105	4,269	3,916	3,479	2,783	2,087	1,392	1,113	974
Advertising	15,205	10,571	7,742	5,009	4,018	4,018	4,018	4,018	4,018	4,018
Office supplies	1,140	793	581	376	301	301	301	301	301	301
Administration expenses	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Total	**1,006,385**	**1,543,857**	**1,872,107**	**2,186,030**	**2,300,516**	**2,299,820**	**2,301,702**	**2,300,897**	**2,303,197**	**2,305,636**

CYNERGY PELLETS

Operational Costs (€) – Raw material – Harvesting - Transportation

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Ha planted	700	910	1,183	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400
Raw material availability		6,300	12,390	16,107	19,698	21,000	21,000	21,000	21,000	21,000	21,000
Cost of raw material		352,800	693,840	901,992	1,103,088	1,176,000	1,176,000	1,176,000	1,176,000	1,176,000	1,176,000
Harvesting cost		35,280	69,384	90,199	110,309	117,600	117,600	117,600	117,600	117,600	117,600
Transportation to site		29,400	57,820	75,166	91,924	98,000	98,000	98,000	98,000	98,000	98,000
Total Cost		417,480	821,044	1,067,357	1,305,321	1,391,600	1,391,600	1,391,600	1,391,600	1,391,600	1,391,600
Operational efficiency		23.97%	47.15%	61.29%	74.95%	79.91%	79.91%	79.91%	79.91%	79.91%	79.91%

Framework Conditions

Yield (t/ha)	15	
First year yield on crop	60%	
Second year and after	100%	
Harvest (€/ton)	8	
Transport (€/ton)	6.67	
Cost (€/ton)	Delivery	
- at factory gate	70	30%
- with transport & harvest	50	70%

Truck return (loading, trip, unloading)	3	hours
Average trip	80	km
Bulk density (t/m^3)	0.1	
Max truck load (m^3)	120	
Required trips (full operation)	1750	trips
Harvesting period	45	days
Truck average daily trips	8	
Required trucks at harvesting	5	
Truck fee € per km	0.2	

CYNERGY PELLETS

Operational Costs (€) – Human resources

Salaried personnel	***January***	***February***	***March***	***April***	***May***	***June***	***July***	***August***	***September***	***October***	***November***	***December***
General Manager	1	1	1	1	1	1	1	1	1	1	1	1
Plant Manager	1	1	1	1	1	1	1	1	1	1	1	1
Logistics Manager	1	1	1	1	1	1	1	1	1	1	1	1
Administration	1	1	1	1	1	1	1	1	1	1	1	1
Workers												
Feedstock handing	3	3	3	3	3	9	9	3	3	3	3	3
Weigh master	-	-	-	-	-	3	3	-	-	-	-	-
Operator	3	3	3	3	3	3	3	3	3	3	3	3
Driver	1	1	1	1	1	3	3	1	1	1	1	1
Total	**11**	**11**	**11**	**11**	**11**	**22**	**22**	**11**	**11**	**11**	**11**	**11**

	January	***February***	***March***	***April***	***May***	***June***	***July***	***August***	***September***	***October***	***November***	***December***	***Total cost***
General Manager	4,300	4,300	4,300	6,450	4,300	4,300	6,450	4,300	4,300	4,300	4,300	8,600	60,200
Plant Manager	2,850	2,850	2,850	4,275	2,850	2,850	4,275	2,850	2,850	2,850	2,850	5,700	39,900
Logistics Manager	2,000	2,000	2,000	3,000	2,000	2,000	3,000	2,000	2,000	2,000	2,000	4,000	28,000
Administration	1,400	1,400	1,400	2,100	1,400	1,400	2,100	1,400	1,400	1,400	1,400	2,800	19,600
Feedstock handling	3,600	3,600	3,600	5,400	3,600	10,800	12,600	3,600	3,600	3,600	3,600	8,100	79,779
Weigh master	-	-	-	-	-	3,600	3,960	-	-	-	-	-	9,180
Operator	3,600	3,600	3,600	5,400	3,600	3,600	5,400	3,600	3,600	3,600	3,600	7,200	61,200
Driver	1,400	1,400	1,400	2,100	1,400	4,200	4,900	1,400	1,400	1,400	1,400	2,800	30,600
Total	**19,150**	**19,150**	**19,150**	**28,725**	**19,150**	**32,750**	**42,685**	**19,150**	**19,150**	**19,150**	**19,150**	**39,200**	**328,459***

**including Easter, vacation and Christmas bonus*

CYNERGY PELLETS

Operational Costs (€) – Electricity & Maintenance costs

Equipment	**Power Demand (kw/h)**	**Consumption (kw p.a. in full operation)**	**Utilization Period (years)**	**Maintenance costs (p.a. on investment)**
Debaling-Screening	88.0	523,600	15	7.00%
Hammer Mill	88.0	523,600	15	7.00%
Pellet Mill (excluding conditioning)	240.0	1,428,000	15	8.50%
Counterflow cooler	12.0	71,400	15	7.00%
Peripheral Equipment	86.4	514,080	15	7.00%
Total	**514.4**	3,060,680	-	-

	Maintenance (% p.a. on investment)
Site infrastructure	0.50%
Buildings	2.00%
Transport Vehicles	
- Truck	10.00%
- Loader	15.00%
- Forklift	10.00%

Energy consumption was adjusted with a simultaneity factor of 85% (reports from wood pellet industries), as well as the operational efficiency of the plant each year.

Conditioning costs are included in the peripheral equipment. An additional estimated cost of €1,080 p.a. was added for hot water demand at the conditioning stage.

CYNERGY PELLETS

Operational Costs (€) – Pellet distribution

Framework conditions

Truck return (loading, trip, unloading)	3 hours
Average trip	100km
Bulk density (t/m^3)	650
Max truck load (ton)	24
Required trips	875 p.a.
Truck average daily trips	1
Available trucks	1
Fuel cost (€ per km)	0.08
Distribution cost (€ per ton)	0.33

The distribution of pellets in bulk to the energy plants will take place with the owned truck. One trip is required as the daily output is 24t.

Operational Costs (€) – Other expenses

Other Expenses	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Insurance	54,174	54,174	54,174	51,487	51,487	51,487	51,487	48,799	48,799	48,799
- Assets	*26,874*	*26,874*	*26,874*	*24,187*	*24,187*	*24,187*	*24,187*	*21,499*	*21,499*	*21,499*
- Product	*27,300*	*27,300*	*27,300*	*27,300*	*27,300*	*27,300*	*27,300*	*27,300*	*27,300*	*27,300*
Traveling	4,175	4,105	4,269	3,916	3,479	2,783	2,087	1,392	1,113	974
Advertising	15,205	10,571	7,742	5,009	4,018	4,018	4,018	4,018	4,018	4,018
Office supplies	1,140	793	581	376	301	301	301	301	301	301
Administration expenses	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Total	**77,695**	**72,643**	**69,766**	**63,787**	**62,285**	**61,589**	**60,894**	**57,510**	**57,232**	**57,093**

Analysis on the consultant fees and other expenses has been provided in the main body of the business plan.

CYNERGY PELLETS
Depreciation (€)

	Capital Cost	Depreciation coefficient	Annual Depreciation Amortization
Site infrastructure	***108,000***	***3.00%***	***3,240***
- Land	-	0.00%	-
- Land development	108,000	3.00%	***3,240***
Construction	***1,605,000***	***5.00%***	***80,250***
- Pellet Line Building	270,000	5.00%	13,500
- Pellet Storage	360,000	5.00%	18,000
- Raw Material Storage	900,000	5.00%	45,000
Planning	***300,000***	***20.00%***	***60,000***
Equipment	***1,082,400***	***15.00%***	***162,360***
Debaling-Screening	144,000	15.00%	21,600
Hammer Mill	164,800	15.00%	24,720
Pellet Mill	400,000	15.00%	60,000
Counterflow cooler	25,600	15.00%	3,840
Peripheral Equipment	348,000	15.00%	52,200
Transport Vehicles	***268,000***	***15.00%***	***40,200***
Total	***3,363,400***		***346,050.0***

The linear method of depreciation was utilized according to Greek legislation. Residual book value of 1euro was left for the assets after total depreciation (see balance sheet).

CYNERGY PELLETS

Working Capital (€)

Requirements for:	Days	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
(1) Raw material Inventory	**180**	205,881	404,898	526,368	643,720	686,268	686,268	686,268	686,268	686,268	686,268
(2) Pellet inventory	**90**	186,563	316,343	395,579	471,403	499,097	499,011	499,400	499,126	499,566	500,023
(3) Client credit	**90**	201,945	397,159	516,307	631,415	673,151	673,151	673,151	673,151	673,151	673,151
(4) Cash requirements (payables)	**30**	49,307	60,319	67,040	73,092	75,446	75,446	75,658	75,428	75,640	75,852
- Raw material credit (farmers)	**30**	34,313	67,483	87,728	107,287	114,378	114,378	114,378	114,378	114,378	114,378
Working Capital Required		**609,382**	**1,111,236**	**1,417,566**	**1,712,343**	**1,819,584**	**1,819,498**	**1,820,099**	**1,819,595**	**1,820,246**	**1,820,915**

Cost Allocation in Income statement

	C.O.G.S	Distribution	Administration
Personnel	37.70%	53.64%	8.65%
Electricity	100.00%		
Pellet transport		100.00%	
Maintenance	74.60%	24.98%	0.42%
Fees	30.77%		69.23%
Insurance	100.00%		
Traveling	50.00%	50.00%	
Advertising	100.00%		
Office supplies			100.00%
Administration expenses			100.00%

CYNERGY PELLETS

Investment valuation

	Pre Start up	Construction	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Terminal Value
EBIT (1-t)			(533,435)	(279,207)	(124,247)	28,660	83,435	144,130	209,774	345,613	343,313	340,874	
-Capex	(943,000)	(1,075,040)											
+Depreciation			286,050	286,050	286,050	286,050	286,050	286,050	218,524	83,490	83,490	83,490	
+Amortization			60,000	60,000	60,000	60,000	59,999	-	-	-	-	-	
-Changes in WC			(187,385)	66,843	221,803	367,903	409,668	395,949	378,476	347,020	345,266	343,406	
=FCFF	**(943,000)**	**(1,075,040)**	**(374,770)**	**133,686**	**443,606**	**742,613**	**839,152**	**826,129**	**806,774**	**776,122**	**772,069**	**767,770**	3,684,011
PV of FCFF	(943,000)	(934,817)	(283,380)	87,901	253,633	369,210	362,789	310,573	263,736	220,622	190,844	165,027	791,853
NPV	**653,657**												
IRR	**19.8%**												

Framework Conditions

The terminal value was calculated as the liquidation value of the book value of assets at year 10. In the calculation of the liquidation value inflation 3% and remaining useful life of 5 years on PPE was used.

Hurdle rate of 15% was used in NPV calculation.