DISSERTATION

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ECONOMIC EVALUATION OF STRATEGIC BIOGAS INVESTMENT OPTIONS
A CASE STUDY IN THE REGION OF LARISSA, GREECE

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EXECUTIVE SUMMARY

Background and objectives

Nowadays energy issues have a high priority position in the political energy agenda, due to the depletion of fossil fuels reserves and the increasing environmental issues. The use and promotion of renewable sources of energy as a solution becomes more and more urgent as a viable solution to meet states environmental targets. In the Greek energy scene, agricultural and animal waste constitute a biomass resource of high availability and play an important role for the satisfactory and sufficient energy production with respect to the environmental targets that have to be met. With the biomass sources staying in a priority position in the European political agenda of renewable forms of energy, the need for adoption and implementation of biomass conversion technologies such as anaerobic digestion is essential. There is a variety of opportunities on biogas sector representing a complex decision making process, therefore it is necessary for companies potential investors in this field to be aware of key drivers and barriers, and economic results of financial indicators when implementing a biogas technology, in order to make the best investment decision. Under this framework the aim of this work is to present an analysis of the socio-economic and institutional context along with financial analysis of a strategic biogas investment option, so as to arise and strengthen the interest of potential actors in the Greek bioenergy sector. The main objectives were to identify factors that are key drivers or barriers for the implementation of biogas investment and to highlight influences that the internal or external environment exerts on the strategic behavior of biogas actors. Then the financial analysis of the suggested project for the construction of a biogas facility follows, to identify if the investment is feasible or not.

Methodology to meet objectives

The case study methodology allowed us to examine the specific case of a unit and to collect information and data about perceptions from the interviews with key representatives of the company. Moreover additional data provided concerning, waste issues, biomass quantities and efficiencies contributed to right and rational assumptions of costs and benefits for the financial analysis of a 1.2 MW biogas unit. After the financial analysis, key indicators such as break even point, NPV and IRR have proven that the investment is economically feasible and really attractive for a potential biogas entrepreneur. What is more in a sensitivity analysis attempt, a second scenario was proposed were the unit would operate as centralized of 3MW capacity this time. New assumption costs and revenues were calculated and the feasibility of the second project was proven. So in this way, the sensitivity of the results to changes in the assumptions used is also evaluated. The paper ends with a discussion and interpretation of the results and draws out some conclusions for decision makers.

Value and contribution

The scope if this study is regional and more specifically is adjusted up to certain parameters and variables for a specific unit that served the main purposes of the case study methodology applied. This cattle breeding and slaughtering units is a potential investor on biogas. However, if required the same methodology can be replicated for similar cattle-breeding units that are potential investors in biogas schemes. This paper can not only provide additional information about RES and more specifically about biogas technology but also to be used to raise awareness and inform actors in a biomass digestion scheme. Moreover, it provides a perfect method for assessment of perceptions for biogas actors in similar cases and for definition of a context for the investment. Nevertheless, in the financial parts, the model, the economic indicators can further be calculated with just a substitution of the suitable prices for the variables. So a potential investor can easily compute the financial performance of a possible investment for same biomass characteristics, plant size and time horizon of the project as well.

Overall conclusions

In general from the whole dissertation we can conclude that the investment on a biogas facility is extremely profitable and feasible. However, the general policy and socio-economic context in Greece for the diffusion and the implementation of anaerobic digestion technology is also another factor that contributes to the success or the failure of a biogas project.

Some expectations

In general the paper contributes to a better understanding of the importance of investing in alternative sources of energy such as biogas. Based on the results it serves as a basis for further research in the field and enable the reader to gain further knowledge on bioenergy matters.

Limitations

It is however to be kept in mind that this study has also some limitations. The study is mainly confined to the city of Larissa, Greece which constitutes though a typical agricultural area. Most importantly the stakeholders’ opinions about factors affecting biogas implementation are based on literature and on opinions form the specific unit investigated. They may be consistent but in order to be generalized, we feel that additional research on a regional level is required to acquire a thorough understanding of public perceptions on bioenergy options.

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LIST OF ABBREVIATIONS

AD: Anaerobic Digestion
BEP: Break Even Point
CHP: Combined Heat and Power
CRES: Nationa Center Of Renewable Energy Sources
EJ: Exa Joule (10^{18} Joules)
IEA: International Energy Agency
IRR: Internal Rate of Return
kWh: Kilowatt Hour
ktoe: Kilo tons of Oil Equivalent
mtoe: Million Tons of Oil Equivalent
MW_e: Mega Watt electrical
MW_{th}: Mega Watt thermal
NPV: Net Present Value
TCI: Total Capital Investment Costs
TOC: Total Operational Costs
PPC: Public Power Corporation
RAE: Regulatory Authority of Energy
RES: Renewable Energy Sources

Chapter 1 Introduction

1.1 Background and problem statement

Nowadays, the global energy production scene passes through significant phases and rapid changes. The most striking ones, are the climate changes due to environmental pollution, the depletion of fossil fuels and the boosting of new infinite sources of energy , the so called renewable. One of the major environmental problems of the society is the constant increase of waste produced whose limitation and treatment constitute a political priority and part of the total efforts for the decrease of environmental pollution, the levels of carbon dioxide emissions and the stabilization of climate changes. As part of the international effort for environmental rescue the United Nations through the Kyoto protocol set the main targets and regulations for the curbing of greenhouse gases and other waste pollution. Additionally, the European Union strives to limit the amount of waste generated at the minimum level, by implementing new initiatives, by cultivating an environmental friendly culture and encouraging a shifting towards sustainable consumption patterns. (Nikolaou et al, 2003).

Towards this direction more and more companies that deal with waste issues decide on investing in more eco-friendly technologies for the exploitation of renewable forms of energy and more specifically to treat and exploit sufficient amounts of biomass. More specifically biomass constitutes a form of renewable which mainly includes organic material such as energy crops, agricultural or forest residues, animal manure, the organic fraction of municipal waste and certain types of industrial waste. It is without doubt that biomass has positive impacts from a social, economical and environmental point of view. Bioenergy production can play a significant role in rural development with creating more employment openings. Moreover, it can provide a crucial solution for climate issues and healthier life. But the significance of biomass as emerging trend lies in the fact that vast quantities of otherwise unexploited organic substance with zero value can now create through their digestion with suitable technologies an end market with a variety of products such as combined heat and power production, methane, and even organic fertilizers. In the Greek scene if we take into account the high amount of biomass reserves in the agricultural areas, we can estimate that an investment on a biomass conversion technology such as anaerobic digestion for electricity, biogas and heat power production would be an opportunity for potential investors in the bioenergy sector. Of course the general framework for the implementation of this investment has to be examined through the understanding of stakeholder's perceptions about this source of energy, while the economic of this investment are essential as well. It is without doubt that environmental considerations are likely to form an integral part of competitiveness and sustainable development of business. Therefore, environmental or waste management and the investment on strategic biogas or other renewable options will be seen as a prerequisite and a necessity for the survival of a company.

1.2 Outline of thesis

This dissertation work continues with the second chapter that provides a transparent overview of literature and relevant researches that have been conveyed on the bioenergy field will be further analysed in order to provide a sufficient theoretical framework. A literature review for the current situation in the energy sector follows, the main problems concerning the waste storage will be discussed, and the main renewable sources will be mentioned with a particular interest for the generation of biogas with the use of biomass as a primary resource. More specifically definitions about renewable, biogas, and the main technologies for converting biomass to biogas, will be given. To continue, I will critically appraise the need for the investment by presenting quantitative data and indexes for the European countries that have already invested on technologies for biogas generation. Moreover, the literature review will include the current situation in the Greek energy sector and a profiling of companies that could possible invest on this technology as an alternative way to manage their waste, to produce electricity and heat and to gain profits at the same time. Furthermore, some aspects of the strategic management will be discussed in order to gain a further insight in the way these specific companies evaluate an alternative strategy, decide to develop it and actually implement it in order to overcome problems like waste storage and gain a competitive advantage through an eco-friendly approach.

In chapter 3 the methodology part, an analysis of the main research questions and objectives along with the method and design of the main approach to answer and attain them will be presented. In the data analysis parts the main techniques for the critical evaluation and analysis of the collected data will be described. The main perceptions as identified through the interview will be further discussed and the socio economic framework along with a Swot analysis for the biogas investment will be presented. In the fifth chapter a biogas project for the case study will be proposed while its feasibility and profitability will be further examined. Then a second scenario for a project of higher capacity will be presented that will enable the sensitivity analysis and the comparison of results and of financial indicators. Finally at the conclusions the main conclusions recommendation will be presented and discussed.

Chapter 2 Literature Review

2.1 Energy situation in Europe and the world

Since global warming has emerged as a critical issue for the international community, developed countries are committed to reduce their greenhouse gas emissions up to 2020 as Europeans commissions’ targets mandate. What is more, the constant use of fossil fuels causes serious environmental problems such as air pollution from the emission of greenhouse gases. On the same time the restricted reserves of fossil fuel that are spread over in a few countries along with their price fluctuations lead to a fragile energy supply with fears for their shortage in the near future (Iakovou *et al*, 2010). Likewise, significant attention has been given on the negative impact of conventional methods of electricity generation as damaging both on the environment and health, fact that provokes public outrage. Considering the fact that, renewable energy sources play a pivotal role in the main strategies for curbing greenhouse gas emissions and partially replacing fossil fuels we can easily understand why the need for researching new alternative sources of energy is now more than ever imposed (Iakovou *et al*, 2010).

After the oil crises of 1973 and 1979 and the awareness of global environmental problems posed by conventional energy sources, European Union (EU) in a general attempt of environmental protection and security of energy stocks has established new environmental standards by which individual industries or economic sectors are being obliged to produce or use a specified quantity of renewable energy. Moreover, as many European covenants and political decisions require, various economic sectors and industries are obliged to produce a desired quantity of renewable forms of energy, the bioenergy. These policies were established by a set of political decisions and directives taken form the EU and the other Member States in 1997 and 2002 during the United Nations Conference on Kyoto and Johannesburg. Basically this targets for sustainable development as defined by the White Paper or the Kyoto Protocol mandate the gross energy consumption of RES. After the approval of the Climate Change and Energy package the main objectives and targets of the European energy framework were set until 2020. More specifically the targets include a curbing of greenhouse gas emissions of 20%, a contribution of renewable to energy consumption of 20%, and a 10% share of biofuels use for transport (Walla and Schneeberger, 2008). Towards this direction the European Union as a leader in the restriction of greenhouse effect has published a series of covenants and directives. For instance the EC directive (2003/30/EC) supports the promotion of biofuels for road transportation, and the EU directives for electricity generation from renewable (2001/77/EC). (Siemons *et al*, 2004)

As Poeschl et al, (2010) support the minimization of exposure to volatile fossil fuel's prices will come from the energy recovery from renewable and from a more competitive energy market as well. A major challenge that the EU states that they have to deal with is the efficient implementation of bioenergy systems in order to improve the use of alternative energy forms and meet the bioenegy targets (McCormick et al, 2007). Therefore, Iakovou et al (2010) claim that, offering adequate incentives and a series of measures will stipulate the expansion of this form of energy. In a relative sense, as the authors of a report for the European commission (Siemons et al, 2004) argued, governments and states promoted the renewable sustainability in terms of tax exemptions, financial incentives and avoided greenhouse emissions as a valuable component of renewable energy sources (RES). To go a bit further, Perry (2008) et al suggest a series of policies to overcome barriers like economic conditions through grants and incentives, technology know how through policy measures and pilot programs. The policy schemes include green energy credit policy, incentives, and cost share loans and so on. The survey of Brown et al, (2007) proved that a combination of these policies and the design of green energy incentive plans generated the highest financial returns.

In a similar vein, many detailed reviews and discussions concerning the critical factors of bionenergy implementation systems can be found in (McCormick et al, 2007,Del Rio,2011, Krausmann et al , 2008) where apart from barriers and drivers, strategies that can support the diffusion of bioenergy technologies are further discussed.

In a survey for the current situation and the future trends of bioenergy in Europe the author supports the idea that a stringent policy from the part of governments would encourage the investment on biogas with the use of biomass as a primary source, while it would discourage other technologies for conventional forms of energy (Del Rio, 2011). Moreover on the technology front, Del Rio supports that R&D programmes, innovative instruments and technologies should be financed by national or venture capital funds since some renewable technologies have large potentials at high investment costs.

2.2 Current situation in the Greek energy sector

It is an undeniable fact that, the renewable sources of energy occupy a significant position in the Energy agenda. Moreover, during the last decade a positive climate has been created to replace conventional energy sources and contribute to the greenhouse and the use is associated with a range of environmental problems. The growth and further penetration of RES contributed not only to energy system and environmental protection but also to the attainment of energy or environmental commitments of the country. Nowadays, the Greek energy sector has noted significant changes that can mainly attributed on widely expansion of RES and to the European and national policies imposed on the environmental and energy sector. The promotion of RES is not only based on the significant potential of them in Greece but also to the national priorities for curbing of emissions and for electricity generation from other forms of energy.

Currently, the main supportive mechanisms as established by the Greek energy policy are the guaranteed price for electricity and the public financing RES projects. The developing policy through the national program for investment funding and the development Law are the main reinforcing mechanisms for sustainable development. Moreover, the center of the Greek policy is determined by the principal goals as have been set by the Ministry of Development. Some of these objectives are: the ensuring of a sufficient energy supply in the Greek market, the reduction of dependency from oil and other imports of fossil fuels, the increased use of renewable and gas through a strong system of production and distribution. What is more, the reinforcement of international linkages of the country so as Greece to become an international energy center and the implementation of energy infrastructures through investments and financing programs (Sioulas et al,2008).

From 1950 to 1994 the Public Power Corporation (PPC) was considered the only company producer and transmitter of electrical power in Greece. Until today, the main source for electricity production that will continue to play an important role to the future is lignite, with the main extraction mines to be in Amyntaio, Florina and Megalopolis. However due to the old-fashion conventional technology and the finite quantities of lignite, electricity should stem also from RES in an attempt to meet the country's electricity needs and towards a green sustainable development. Therefore a set of policies in national and European level should be decided in an effort to boost the interest on RES and more specifically on bioenergy.

More specifically, the driving forces for the Greek bioenergy market were the EU legislations for the ban on land filling of combustible wastes (Directive,1999/31/EC), the regulation that limits the waste emissions form plants and industries (Directive, 2000/76/EC) and the law for utilization of RES (Directive 2001/77/EC). (Panoutsou, 2008)

More specifically, according to Directive 2001/77/EC "on the promotion of electricity produced from renewable sources in the internal electricity market" (OJ L283/27.10.2001) was an indicative target of 20% of renewable energy consumption and a 40% of electricity generation from RES was mandated for Greece. Due to the high needs for electricity consumption as calculated form the Ministry of Development , approximately 14 billion KWhe must be produced from renewable with the biomass sources possessing the 1,8% of the total electricity production from RES (Panoutsou,2008). What is more, according to the Greek law 2773/99 about the liberalization of Greek electricity market, it was assumed that independent electricity producers could have a 10-year contract with PPC to sell electricity from RES in an effort to cover electricity demands and the EU and national energy targets.

Additionally a series of European directives such as the Biofuels directive, the Landfill and Waste Incineration Directives and the Directive on CO2 emissions were adopted form the Greek government and transformed to Greek laws that today constitute the energy policy context in Greece. However until today the bioenergy sector in Greece can be characterized as fragmented since there are non technical factors that hinder further development of the res and bioenergy sector. According to the Admire rebus project for the barriers in implementation of RES, the lead times of technology caused by administrative procedures were computed for countries like Greece, and they constitute possible barriers for the implementation of the renewable form of technology (Del Rio, 2011). In addition, the scarcity of funding sources for research and development is urgent in an effort for better resource allocation and boosting of investments. Under this framework, financial support policies have been set by the Greek government such as the New development Law that set a series for subsidies for investments on the bioenergy sector.

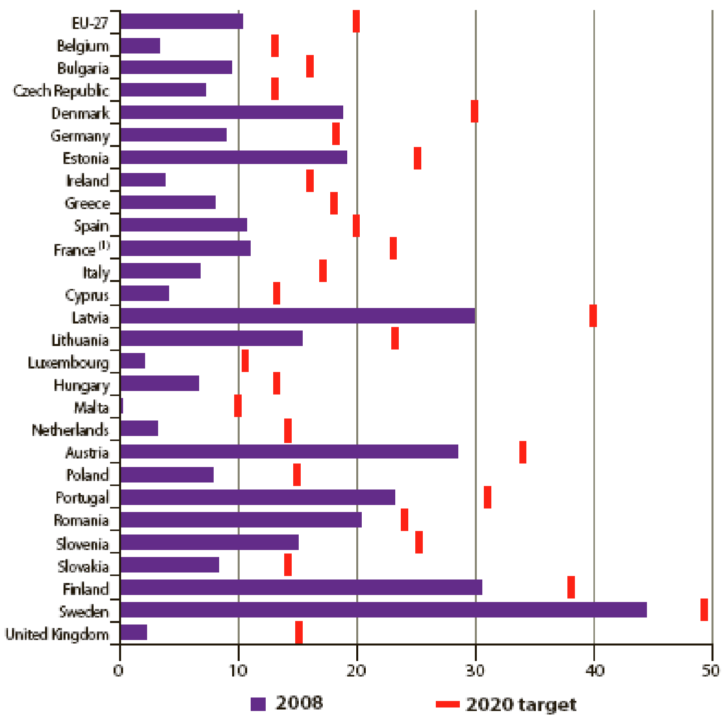
2.3 Renewable Sources of Energy (RES)

Nowadays the need for exploiting the large potential of renewable imposes a strategic scheme to reduce the gap between energy demand and supply and promote energy conservation and sustainability (Buragohain, 2010). As Evans and other researchers (Evans et al, 2010) state, new energy sources have been sought that ensure constant supply and stable prices in contrast to limited fossil fuels and their price volatility. Thus, the development of renewable energy sources and more specifically, waste biomass utilization has emerged as a promising alternative for improving energy production and the planet's energy system (Iakovou et al, 2010).

Renewable sources of energy are the unconventional forms of energy that remain infinite in the vacuum contrary to fossil fuels and other traditional sources. The main forms of renewable are: solar, wind, hydropower, geothermal, biomass and wave (tidal) energy it is believed and today they constitute the solution to the problem of non-renewable fossil fuels that still dominates the EU energy mix. Renewable utilization and especially wind, solar and biomass energy utilization has experienced a significant rise from the 12% to 18% of the total energy, and today RES constitute the basis of ecological economics and the green development model that certain states attempt to implement. However, Demirbas et al, (2009) and Reijnders (2006) carried out surveys on the sustainability of biomass, which still raises the question whether the quantity of renewable can remain infinite in the foreseeable future.

Despite some disadvantages or scepticism from researchers other support that renewable technologies have the benefit of decreased vulnerability associated with fluctuating energy costs due to the restricted dependence on fossil fuels. Also, renewable technologies are a safe way of energy production as can decrease the risk of power outages due to power grid reliability and safe on site storage. What is more, as Bailey et al, (2008) argue RES constitute an alternative income solution and activity for farmers and other entrepreneurs, creating in this way new job posts.

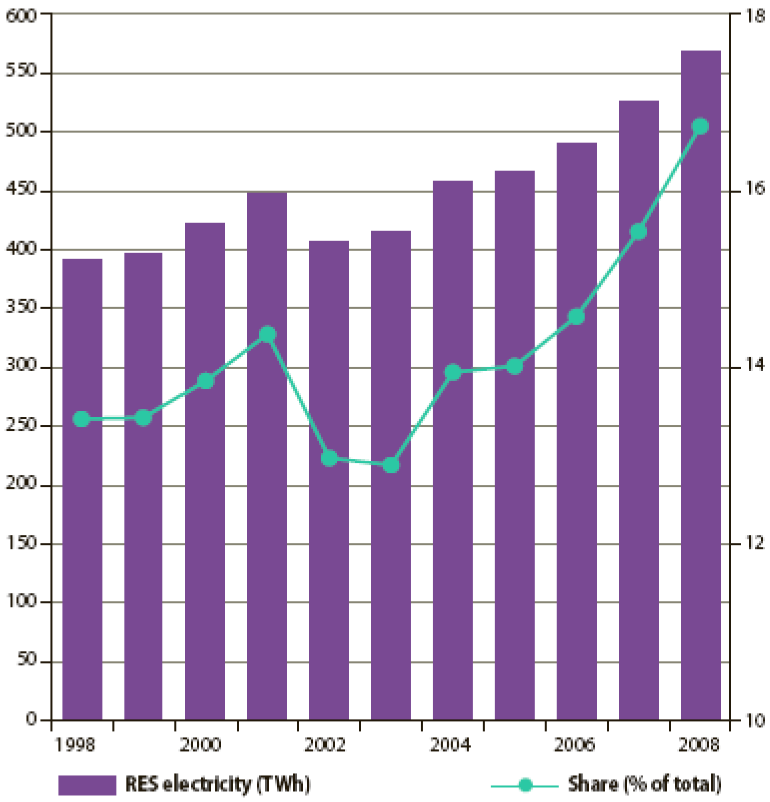
Fig. 2.1: Share of RES in gross final energy consumption and target for 2020 (%)



Source: Eurostat

As we can conclude form the above graph for the year 2008, the energy produced from renewable sources occupied a 10.3 % share of the gross final energy consumption of EU-27. The highest share was recorder for Sweden (44.4%) while the lowest for Malta (0.2%). However the largest increase was noted by Austria for the years 2006 till 2008 the share of RES to total energy consumption has increased by 4%.

Fig. 2.2: Contribution of electricity from renewable to total electricity consumption, EU-27



Source: Eurostat

It can be concluded form the above table that the Electricity generation from RES in the EU-27 has reached a peak of 560 TWh for the year 2008 as shown by the above graph. We can also note the significant increase in the electricity from RES generation that from a level of 380 TWh in 1998 has arrived to 560 TWh in 2008 noting a 45% increase.

2.4 Bioenergy

According to Bakos et al. (2008) the main sources of bioenergy are agricultural and livestock residues. The annual bioenergy potential is about 2900 EJ, although only a fraction could realistically be used on a sustainable basis and at competitive prices. Thus the problem is not the availability of biomass resources but the sustainable management of energy to those who need it to provide them with modern energy services. This implies that both production and use of bioenergy must be modernised. (Bakos et al, 2008). According to another survey about public perceptions on biomass the author suggested the several sources of heterogeneity in bioenergy. More specifically there are different feeding materials that are used as primary sources, and are converted to different final products through various technologies either in a household or in an industrial level (Rohracher, et al, 2004).

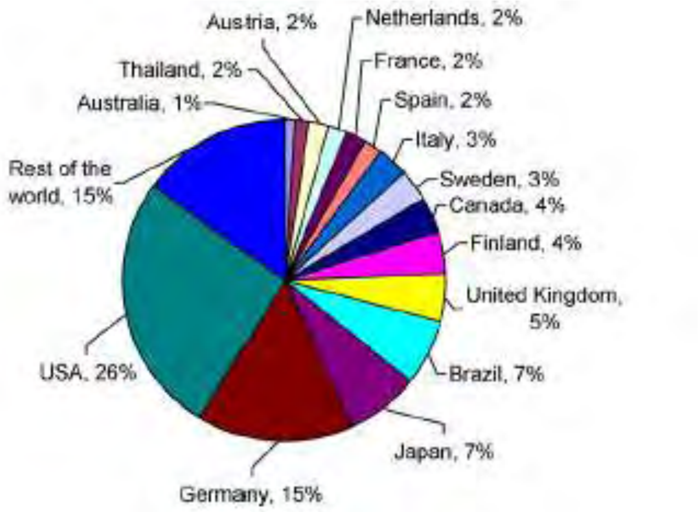
2.5 Biomass

According to Evans et al (2010) biomass is an organic material that includes among others, energy crops, agricultural or forest residues, animal manure, the organic fraction of municipal waste and certain types of industrial waste. In a similar vein, a very detailed review about biomass potential and availability can be found in another survey, where the author describes the main biomass resource types (Hoogwijka et al, 2002). Dinica (2009) in her research discriminates biomass resources in primary and secondary, with primary source to be organic wastes from agriculture, forestry and so on. In secondary biomass resources the organic content has already been harnessed once and is constituted by organic wastes or wastes from industrial or agricultural applications, such as food and drink industries, farming companies with animal manure that can produce biogas, or disposal sites of solid waste that can produce landfill gas.

Biomass's strong appeal is due to its potential worldwide availability along with its conversion efficiency to other forms of energy such as biogas, electricity and heat. Moreover, as Bakos (2008) states, biomass constitutes the only fuel available for electricity generation from combustion on a carbon dioxide neutral basis, or for heating in domestic or industrial sector. For all the aforementioned reasons, interest in renewable energy sources (RES) and especially in biomass was revived at about 1970 due to the energy crisis and the imposed need for fossil fuels' substitution. What is more, an emerging trend is the notion that converting biomass to bioenergy can overcome the main problems of waste management, since bioenergy facilities can utilize biomass and reduce risks of pollution from waste.

Some authors in their research (Evans et al, 2010) , pointed out that biomass resources with approximately 220 billion tones of annual production and with 2900 joules of annual bioenergy potential constitute the world's largest energy source. As the use of biomass is widespread in 62 countries worldwide the major share of produced energy lies within USA which is the dominant biomass electricity producer at 26% of world production, followed by Germany (15%), Brazil and Japan (both 7%). (Evans et al, 2010).

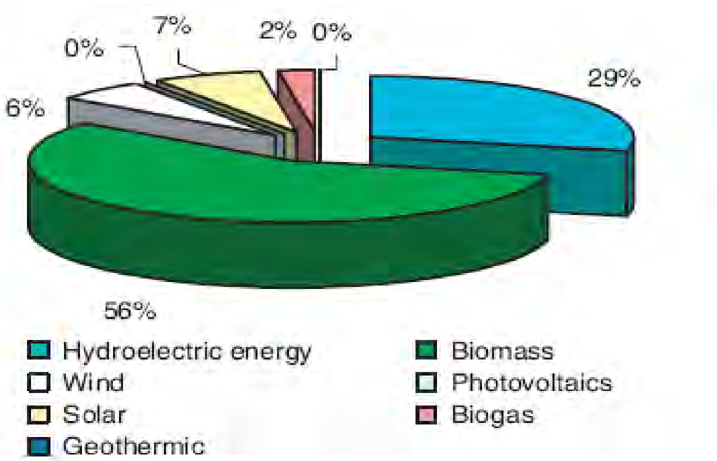
Fig. 2.3: Global distribution of biomass energy use in 2008



Source: Evans et al, 2010

As Hoogwijk et al(2002) suggest in their study biomass market share is expected to reach the 10-50% till 2050 if this form of energy become available at low competitive costs. Bakos (2008) in his survey has focused on the examination of biomass potential form energy crops along with the determination of competitive prices for other biomass sources.

Fig.2.4: Energy production from all forms of Renewable Energy Sources in Greece (KTOE,2003)



Source: Skoulou and zabaniotou (2007)

The above figure represent the energy production from RES for the year 2003, where we can see biomass contributing to the total energy supply with the major share. The main final energy products from biomass are electricity, direct heating or even a combination of two of them along with biofuels and biogas. Direct heating is the most widespread application, but bio-electricity production and biofuels are currently gaining considerable interest among energy policy makers. The production of second-generation biofuels obtained by waste biomass is an efficient alternative solution for waste disposal and generation of clean electric (Iakovou et al,2010). More specifically in another survey (A.V. Bridgwater, 2011) the author describes fast pyrolysis as an efficient and environmentally acceptable technology that convert solid biomass to biooils, a transportable liquid of high energy content. Trough subsequent treatment, refining and chemical processing biooils can be upgraded to biofuels such as diesel, gasoline, kerosene, with the generation of heat and power at the same time (A.V. Bridgwater, 2011). At present biofuels constitute the only renewable sources of liquid road transportation fuels with primary sources grains and sugar crops or cellulosic biomass that can also be converted into liquid biofuels. The main benefits that biofuels offer are the security of energy supply, the economic sustainability and development or even industrial growth and employment opportunities. (Tran et al, 2011)

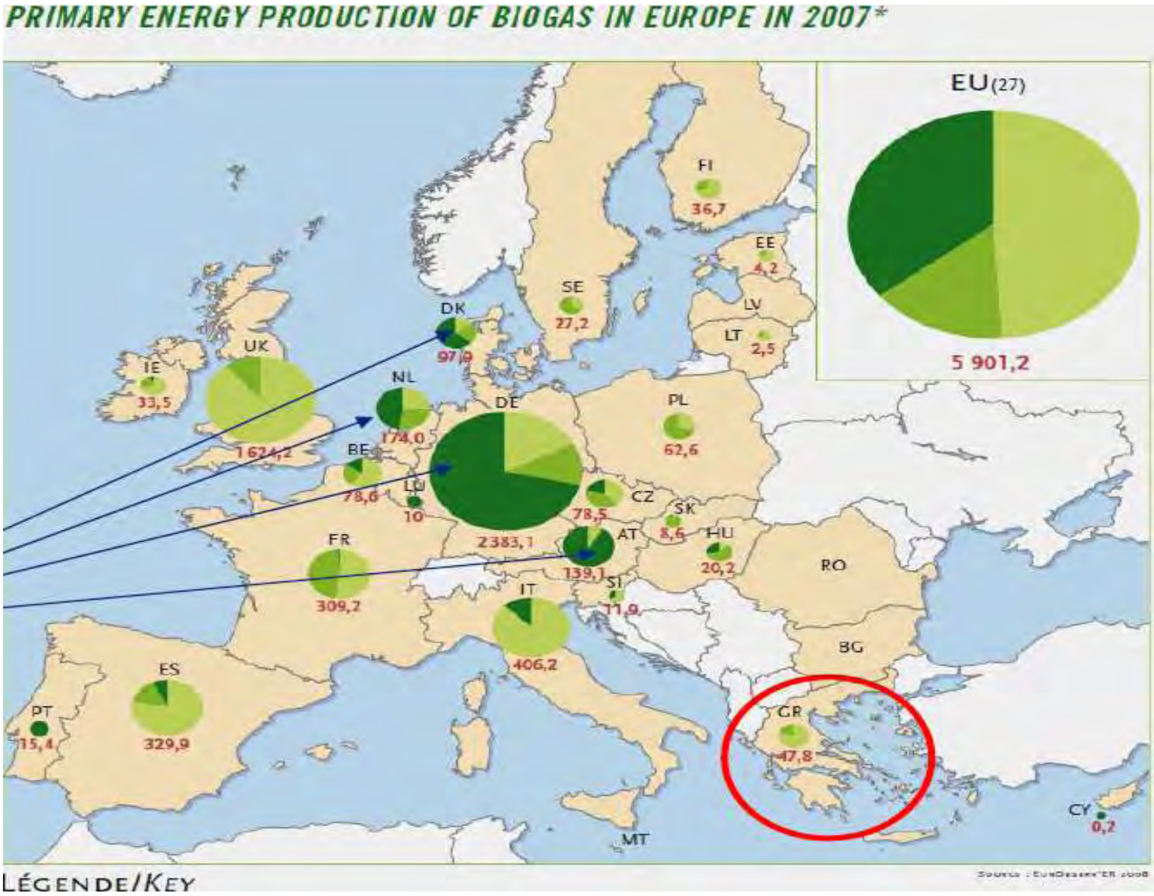
In fact only biomass is suitable for the generation of such a large variety of by products such as electricity and heat, compost, biofuels and biogas. Because of this extensive production chain its potentiality is larger than wind and solar power while on the same time the ability of storage makes it useful despite time. Moreover, the systems of biogas production with the use of biomass as a primary source contribute to the sustainable development of the agricultural and livestock units or even of food processing industry and to the economic improvement of the region.

2.6 Biogas

Furthermore, biogas coming from the anaerobic digestion of organic feedstock or wastewater sludge is a mixture of methane and carbon dioxide plus traces of gases such as hydrogen and ammonia suitable for energy production. Moreover animal waste, energy crops, food or municipal waste constitute primary sources of this form of energy. Biogas generation from some kind of industrial wastes such as dairy industries, food/beverage industries, olive presses or slaughterhouses is an attractive alternative for the Greek industrial sector too. Its difference from fossil fuels is based on the clear method of production. Moreover biogas main characteristics are similar to those of natural gas. So biogas can be used as a substitute of natural gas with use of the existent technical infrastructure.

In many cases, the easily biodegradable organic compounds can be processed through anaerobic digestion that entails feedstock supply and pre- treatment, gas utilization, recovery and use of final product for electrical or thermal energy production (Poeschl et al, 2009). The most important application of biogas today is the generation of electric power, despite the potential fluctuations in energy consumption. So in case of lack of electricity stock, higher amounts of biogas can be used to overcome problems of electricity ups and downs. Apart from electricity, during the fermentation of biogas heat is released that can be used from the landfill unit to cover its private energy needs. The rest of it is available for public use as a good alternative solution to the constant price increases of fuel and gas. Moreover, with the termination of the whole procedure the end product is a bio ecological fertilizer friendly to the environment. On the other hand, in Europe, the sector of biogas presents a fast evolution and development while the biogas market expands constantly. In many EU countries there are some industrial biowaste processing installations, landfill gas facilities or even biogas process volumes at the wastewater treatment plants.

Fig. 2.5: Biogas production in EU-27 in 2007



Source: biogas barometer (2008), EUROBSERV'ER

The above picture, maps the biogas energy production in the different countries of the European Union where the total biogas produced was approximately 5900 ktoe for the year 2007. While as we can see in the red circle, the total biogas production for Greece is 47,8 ktoe.

Biogas produced from Landfill gas

Biogas produced from Sewage sludge gas

Other biogas units (decentralised agricultural plant etc)

Red figures show total production in KTOE for each country

Currently Germany is the undisputed leader in the application of biogas technology mainly after the implementation of the renewable energy sources act that basically supported biogas investments through subsidies, grants and energy tax reliefs (Poeschl et al., 2010). Germany’s generous feed-in-tariffs for renewable energy are typically given the credit for promoting investment in on-farm anaerobic digestion. But the particular biophysical and socio-economic character of farming in the country provided the fertile ground for these financial incentives to take root. Energy security has also been a major driver for the promotion of renewable energy in Germany since it imports over 60% of its energy needs. (Wilkinson,2011) For instance, in Germany till 2009, more than 4000 landfill units of biogas were operating, a fact that contributed to the creation of 10000 jobs and to the economic growth of the country through the export of the suitable technology (Poeschl et al, 2009). In the case of landfill station gas is collected from the fields and through suitable equipment is converted to electricity. This process is widely adopted in Europe as it constitutes a perfect way for curbing of greenhouse gases.

On the same time in the market of other European countries, the main volume of biogas that is originated from agricultural anaerobic digestion plants is rather small but with potential of further development. The European countries where on farm biogas plants are most developed include Germany, Austria, Sweden and Denmark (Bailey et al, 2008). Concerning the Danish bioenergy sector, the Danish government procures financial incentives that resulted in an increase in biogas generation and in the number of centralized plants till 2025 triple (Wilkinson, 2011). The Sweden case is of significant interest, since 2007 approximately 233 unit of biogas are operating and a total of units of combined digestion or biological treatment with a total generation of 0,15 TWh per year (Eurobserv’er,2008). In addition, on farm or community biogas applications are widely expanded in North America and Europe with Germany, Austria, Switzerland and the Netherlands occupying leading positions. However, as Sims et al support, building sophisticated and revolutionary biogas systems is also getting more and more attention in China and India (Sims et al., 2004). In addition, worldwide there are almost 1000 anaerobic digestion schemes that are currently operated for industrial waste treatment. Under industrial circumstances, biogas plant has been deployed from beverages and food,meat,dairy or even pharmaceutical and paper industry fro wastewater treatment by anaerobic digestion (Sims et al., 2004).

Compared to other forms of energy, biogas generation from animal manure has a high potential in agricultural regions, where it is difficult for on farm operations that are dispersed all over the countryside to fulfil their needs in electric power. During the last 30years, the generation of this renewable form of energy has been developed through different pathways in technical knowledge and ideas and a lot of changes concerning design and functionality (Raven and Geels,2010). So animal manure and other forms of waste, which constitute a serious threat for the stability of the environmental chain can now be converted into biogas energy with an array of different technologies.

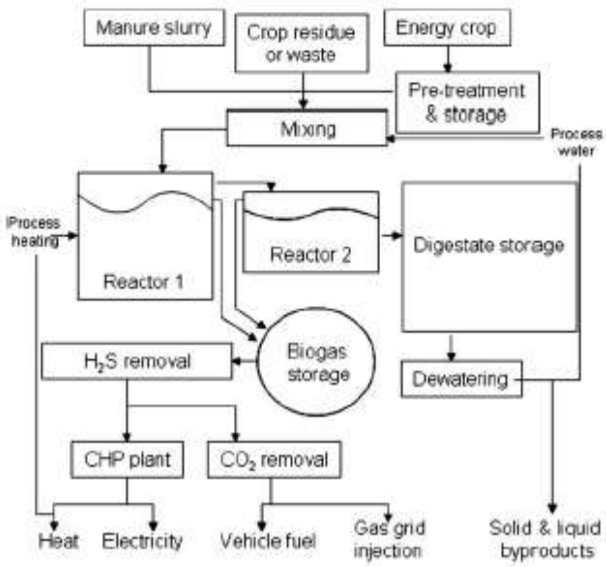
According to researchers' (Iakovou et al,2010) survey on conversion technologies, those are the intermediaries between biomass fuels and the final energy product while their cost and time effectiveness depends on the companies research and development programs. Some main technologies that are known so far for the production of bioenergy are: combustion, gasification, pyrolysis, liquefaction, fermentation and anaerobic digestion. For a thorough understanding of the conversion of waste biomass to energy we will further describe some of those processes. More specifically, combustion is the most conventional process for the fermentation of biomass to produce electricity and heat, along with the generation of biogas through a steam cycle that is completed in two phases. At first the whole energy conversion process is initiated by a chemical in the fuel which is turned into energy carried by steam in a boiler. Then this form of energy is converted into electricity with the use of a steam turbine and generator (Kumar,2010).

2.7 Anaerobic Digestion

Anaerobic digestion occupies a growing role in the energy mix and currently constitutes the most common and most beneficial of other technologies. More specifically, as Wilkinson (2011) supports in his research, AD is a biological process by which organic material are treated in the absence of oxygen and are converted directly into 'biogas', a mixture of mainly methane and carbon dioxide. The three major sources of waste that constitutes feedstock for Anaerobic Digestion plants are the animal manure, the agricultural and the industrial waste. What is more, considering wet biomass the only conversion technology that can deal with it, is anaerobic digestion. So if a company possesses sufficient quantities of wet organic biomass the AD is the prefect solution to invest.

The whole process takes place in the biogas digester which in fact is the heart of the biogas plant. For approximately three weeks the animal manure or the other sources of waste are stored in the digester. Then anaerobic microbes convert part of the manure into methane and carbondioxide and to the final product the biogas. Biogas can be used in combined heat and power units (CHP), for generation of heat that can cover energy needs in local areas, or for injection in a natural gas grid. The second end product is processed manure, form of liquid or solid digestate which can be used as a fertilizer (Raven and Geels, 2010). Finally biogas can be used for the generation of high quality gas used as a vehicle fuel, a practice very common in Sweden (Wilkinson, 2011).

Fig.2.6: Typical process- flow diagram for the anaerobic digestion process



Source: Wilkinson, 2011

It is evident that the AD process can serve various purposes with the variety of end products that it generates. AD is suitable for soil fertility as the end-product the digestate can be further used as a substitute of mineral fertilizer. Likewise AD is a widely applied process for sewage sludge treatment and energy recovery through the generation of biogas.

The implementation of on-farm AD plants for manure digestion exists in two main models. ‘Farm scale’ plants involve process animal manure co-digestion from one single farm or sometimes from a few neighbouring farms. The resulting biogas issued on site to heat stable or produces electricity, while processed manure is used on the land. Moreover farm scale plants are usually constructed on dairy or swine farms. On the other side of the spectrum, ‘centralised’ biogas plants are larger and co-digest animal manure collected from multiple farms along with other industrial residues from approximate regions (Wilkinson, 2011). Centralised plants are often of large scale with digesters of high capacity and chemical competencies. However, having a centralized biogas plant could be proven economic unviable due to high transportation costs of manure (Monteiro et al,2011). So the central position of biogas infrastructures aims at diminishing the transportation costs and time for the loading of manure and other biomass sources form adjacent units to the centralized biogas scheme. The most centralized plants are community projects where local farmers, dairy units and local authorities cooperate to find a common viable solution. Contracts and agreements have been signed were the amounts of biomass procured, and the distribution of profits and end products are agreed. In this way the centralized ad represents a whole integrated system of energy production with a lot of environmental, social and economic benefits for both farmers and society.

Talking about benefits Brown et al, (2007), support that biogas generation through anaerobic treatment not only reduces emissions of greenhouse gases, methane and other pathogens but also manure odours and other harmful organic acids. In addition, apart from biogas production, the anaerobic process contributes to the waste treatment and the soil fertility given that digesters can convert organic waste to biofertilizers suitable for soil and crop enhancements (Poeschl et al, 2009). In another survey Brown et al, 2007 discuss the cost and benefits of this technology, such as the main fixed costs of AD, namely the cost of the digesters, the engineering financing cost, the variable costs such as plant operation, biogas distribution and so on. Moreover the environmental and market benefits include reduced gas emissions, security of energy supply, better resource allocation and green profile of the company.

2.8 Biogas Market

Despite the significant attention that AD received in the 80s, AD plants failed to be adopted mainly due to unfavourable operation costs and poor technological designs. However, the capital intensive nature of biomass technology complicates the financing of biogas plants, while many conversion technologies are still under trial and in a pilot stage fact that can deter investment. In addition combustion technologies have high operating costs but are proven to be more profitable in the long run than others. Hopefully these problems were overcome with financial incentives and governmental initiatives for investing on biogas utilization, and through the introduction of more robust designs and adequate training (Wilkinson, 2011).

In the Greek market of renewable the picture is quite different as the produced biogas derives mainly from landfills, wastewater treatment plants and from the industrial sector. More specifically municipal waste are disposed and decomposed in landfills producing gas. Thus, landfill gas, an attractive system for producing electricity and heat and is already an established technology in Greece. In Greece during the 80s made many efforts have been made for the efficient use of biogas generated from animal waste treatment of organic waste and agricultural industries - mainly olive mill waste. Most of these projects failed after the initial excitement and safety have vanished. Lack of information, of adequate infrastructure, and economic incentives was the basic reasons for this failure. (Zafiris and Sioulas, 2009). Concerning the agricultural waste such as cattle-pig-poultry manure, the Greek livestock farming is extensive and the produced manure remains unexploited while its increasing volume poses a serious environmental and economic threat. Moreover farming sector is a big manure producer thereby, the greenhouse emissions are mostly linked to agriculture production activities. Therefore in an attempt to reduce greenhouse gases and produce electricity from other renewable sources of energy, anaerobic treatment of waste can both generate biogas and reduce waste management problems that occupy more and more farmers and animal breeders. Moreover given that farms consume high amounts of energy in order to fulfil their daily operations' needs, the production of biogas and heat and power can also be used for private consumption (Pukšec* and Neven Duiζ). Therefore the potential of biogas in the Greek farming sector is of high importance.

Therefore potential users or investors on biogas generation facilities may mainly be stakeholders of livestock units, namely cattle-pig and dairy units, medium or large ones. It is worth mentioning that the agricultural sector in Greece is undeveloped if compared to other EU states and the lack of an organized common agricultural policy is a fact. Moreover, biogas technology concerns established regimes in different sectors such as agriculture, electricity, gas, waste. Therefore as Markard et al (2009) note, the development and the implementation of the technology is challenged by regulations, and power structures of these sectors that in fact operate as actors for the implementation of biomass digestion technology. The transportation of the organic waste from the waste combustion location to the biogas unit is a complex process where many contractual agreements have to break up and new institutional regimes to take place. Nevertheless, the last decade the need for replacement of conventional ways of electricity generation seems imperative so an opening and in activities of biogas stakeholders is necessary. Since green energy production from on farm biogas operations is cost efficient farm profitability and environmental stability can be achieved (Brown et al, 2007). Within the last years a lot of investments have been noted in the farming sector and the energy issues have gained significant attention.

In 2007 fifteen biogas plants operate in Greece with a capacity of electricity generation from biogas of 37.4 MW. Although Greece has a promising potential of organic wastes and especially animal manure currently there is no farm scale biogas plant while the existent technology and infrastructure is exploited more for waste treatment than for energy production Towards this direction, it is worth examining whether this kind of companies should develop a biogas plant as a viable option and a promising solution for the future. Under this spectrum since the potential in the whole Greek area is almost 17 millions tones, 10 units could be created with high potential of energy and methane production (Skoulou and Zabaniotou, 2007).

The benefits of investing on bioenergy projects are many. In a study Stidham and Brown (2011,) suggest that this projects create new opportunities in places that have been hit with a long term recession. Apart form economic benefits the idea of energy independence can overcome problems like national energy security reserves or even polarization that characterize forest management. Moreover the operation of the energy facility the transportation and so on can create an end market, new jobs that can revitalize communities. The variety of end products such as heat or power can even used for the needs of the unit or can be sold after contract to the PPC while the compost or fertilizer is widely used for fertilization on the fields and on farming activities and is suitable for soil amendments as its has a high constitution of nutrients (Yiridoe et al, 2009). Additionally, on-farm anaerobic digestion of feedstock can help reduce these greenhouse gases and especially methane or other pathogen microorganism that enter into water system and put at risk the health of a whole community. Also odour control of animal manure and other waste is a major consideration in livestock operations, especially for units that operate near to urban settlements.

On the other hand there are problems and disadvantages associated with biogas. Sometimes, technology may be untrialed and mechanisms are vulnerable and often may break down. What are more high initial capital costs, or the high transportation costs may deter investment. More specifically as Zafiris and Sioulas (2009) support the average cost is € 4.000-5.500 pre KWe. While the subsidies and the grants are arriving only at the 40% of the total investment costs or the 1600€/kw, deterring in this way the motivation to invest. To all this problems we could add, bureaucratic mechanisms and procedures that slow down the licensing permits, while the monopoly of PPC operates as a barrier too. The lack of awareness of information about projects and investment on RES and the general weakness of the Greek policies to legislate motivating policies are the main problems that an investor has to deal with.

2.9 Relevant Researches and surveys on the biogas field

Ayoub et al, (2006) proposed a general bioenergy decision system (gBEDS) as an effective tool in planning for bioenergy production and defining a feasible biomass value chain along with the main environmental and social factors that enable stakeholders to decide for the project. In the same direction Gan and Smith (2010), developed an analytical approach for optimal bioenergy plant size and production costs and supported that decisions on bioenergy use should be based on the optimization of the whole supply chain. Likewise in their research Kumar et al attempt a techno-economic assessment for combined heat and power generation by searching the optimal conditions for the investment. To continue, Kim et al, (2011), examine all the parameters and the decisions that if combined under certain scenarios profit maximization will be achieved and Monte Carlo simulation has been used. Apart from all simulating models, linear programming was used to calculate costs along the biomass supply chain. Likewise, a large number of studies highlight economic and technical issues of generating power from biomass, while on the same time present principal factors that influence the viability of biomass projects. (Buljit Buragohain, 2009). In their paper Hoogwijk et al,(2008) explore the long-term regional and global cost–supply curves of short-rotation energy crops and liquid fuel and electricity produced from such biomass. These curves give insight in the long-term economic and market potential of biomass energy. Moreover, Rentzizelas et al, (2006) aim at present a decision support model for the optimal exploitation of biomass and the generation of electricity and heat power. Practically with this model an investor can efficiently assess the optimal investment variables such as land, plant size, and operational costs in financial terms that can fulfil energy demand in the area of Thessaly. In a similar vein a techno economic assessment of biomass plant was made with the use of different biomass types. Many research studies deal with the projected availability and the trends of potential biomass sources in the future along with constraints of this availability. (Krausmann et al, 2008, Hoogwijka et al, 2008,Hoogwijk et al , 2003,Thrän et al,2010).

Similarly, researches have proved that one of the most important barriers in biomass exploitation is the cost of the supply chain and the technology to convert biomass into useful forms of energy. Naturally many efforts for simulation and optimization of a specific biomass supply chain from collection, transportation till storage took place, given that significant cost reductions could originate from more efficient logistics operations (Rentizelas et al, 2006). In their paper Browne et al (1998) examines the interest in the use of biomass and all the activities involved in logistics planning and supplying. Then expected costs and the various benefits or impacts from the biomass supply chain are further analysed and calculated. What is more, Iakovou et al, (2010) in their research, tackle with the design and management of waste biomass supply chain in a strategic, tactical and operational level. Decisions at the strategic level include contractual agreements with investors, the location and capacity of plants and facilities and concern all stakeholders that are interested in a biogas plant.

In a previous study, Evans et al,(2006) several key indicators were identified and assessed such as price of produced electric power, total carbon emissions and social issues that affect the sustainable power generation from biomass. Moreover previous researches have included a detailed investigation on the sustainability of biomass energy system through the development of the BEAM (Bio-Energy Assessment Model) model, suitable for the evaluation of various technological processes and their environmental impact (C. Krotscheck et al, 2000). What is more, the study of Gasol et al (2008,) examines the economic feasibility of energy production through the digestion of poplar energy crops in Spain. Whereas the regional analysis of Pukšec* and Duiζ for the Croatian farming sector , presents a geographical distribution of the biogas potential and a cost assessment of a biogas power unit. Similarly, Dagnall and Pegg (2000) present a resource mapping of collectable animal manure in an attempt to estimate the biomass potential. The use of a geographical information system (GIS) is of high value for biogas developers as it enables them to decide for potential location of biogas plant both at a regional and at a national level. As Markard et al. (2009) argue in their research the aim of the context or environmental analysis is to identify the most important parameters or influential factors that exert impacts on the adoption and implementation of innovative solutions such as anaerobic digestion.

McCormick and Kaaberger,(2007) examine different cases of barriers or drivers of bioenergy implementation and more specifically of biogas plants. To go a bit further they suggest a series of policies to overcome barriers like economic conditions through grants and incentives, technology know how through policy measures and pilot programs. Additionally Poeschl et al (2010,) support that feedstock supply chain and transportation costs are key factors for the viability of the investment. Nonetheless the survey computes the total energy potential of biogas systems for gas and electric power generation. The functional analysis of Negro et al, (2006,) is an attempt to explain the failure of implementing and adopting biomass digestion solutions in the Dutch innovation system. Furthermore, the authors propose a set of policies that the government has to put in action and make supportive arrangements in order to establish a healthy an competitive biomass market. Mwirigi et all, (2009), investigated and identifies the main influential factors for the adoption of the biomass digestion technology for dairy cattle farmers. As the main adoption constraints that were highlighted and further examined were awareness, education, land security, capital costs, livestock quantities and adopted governmental policies. The analysis followed has actually proved the reliance of adoption upon those factors, so the technology promotion is necessary.

Moreover, Adams et al, 2011 present a series of drivers and barriers that influence the bioenergy development project in UK. More specifically they examined the relevant importance of each factor for several stakeholders groups such as farmers/ suppliers, developers/owners of a biogas unit, primary or end users of bio energy products and other government stakeholders. The results of the analysis were presented with the form of spider web diagrams for better reflection and comparison of the factors with each other. In a similar vein, presents key barriers for the diffusion of biomass digestion technologies, such as economic constraints, availability of feedstock and logistic costs. Additionally, Wilkinson (2011), examines the influential factors for the anaerobic digestion adoption in Germany and Australia. Furthermore the author strives to describe the general social, institutional and economic context that triggered the interest for on farm AD adoption in Germany. Through this contextualization, a further understanding of drivers or barriers of adoption can be developed, for both countries.

Greiner and Gregg (2011), strive to fill the gap from the existent adoption literature that has focused on socioeconomic and demographic factors associated with farmers, developers and operators such as availability of land and feedstock or the personal capacities of the farmer and mainly is preoccupied with cultural, and environmental impediments for the implementation of biogas technology. Then main ‘resource constraints’ highlighted were lack of land, labour, technical expertise, and external financial support. Importantly, the survey crystallizes the socio-economic environment in which farmers, entrepreneurs and developers of biogas units operate, as important for the encouragement or impediment of entrepreneurial action. Similarly ‘financial incentives’ include favourable policies adopted by the government such as cost sharing, tax deductibility or feed –in-tariff laws and in general positive policy measure that enhance the adoption and encourage investments on RES.

Concerning SWOT analysis as Dwivedi and Alavalapati (2009) support, it is a strategic management tool that is further used to highlight potential strengths, weaknesses, opportunities or threats for an organization or a firm. The Swot matrix can efficiently reflect factors that may impede or motivate a decision making process. However, the importance of each of these factors cannot be measured quantitavely so it is difficult to judge how much influence each factor exert on strategic decisions. What is more the authors analyzed the perceptions of four stakeholder groups about biomass digestion projects development. Then the most important factors perceptions were categorized as strength or weaknesses in a swot matrix and further analyzed with the use of Analytical Hierarchy process (AHP). This efficient strategic tool is both used for planning approaches or strategic management and marketing purposes while at the same time can serve as a baseline for the general context where a investment will be applied. Furthermore Snakin et al (2010) present a bottom up and top down analysis of decision making process for Finnish farmers. The general framework under which a decision process is taken was further analysed and the main factors for investment development were determined for each group of the respondents. More specifically the decision process is influenced by policy framework like CAP (common agricultural policy), by environmental sources, subsidies and other business lines and bioenergy seems as the perfect remedy for all the challenges that a farmer has to deal with.

In addition, Tran et al, (2011) present a perfect financial analysis and discuss the net returns on investment for biofuel generation from sugarcane and banagrass. To continue, in Brown et al, (2010) investigate the economic viability of investing on biogas for dairy and pig (swine) operations in a Canadian region by taking into consideration the farm size, the livestock type and by using the most common methods such as NPV, IRR and payback period for decision making. In addition, cost efficiencies that stem from economies of scale for on farm biogas generation along with the general benefits of the anaerobic digestion of animal manure were further discussed. The costs and benefits analyzed reject the key energy and non-energy benefits that motivate farmers to establish and operate anaerobic digesters. Similarly Poeschl et al , 2010, evaluated the energy efficiency for different biogas systems and technologies and for waste management strategies. Stidham and Simon –Brown (2011) explore the social context of biomass investments with a focus on social aspects and perspectives of stakeholders on potential motives or constraints of a bioenergy project. They further argue that understanding stakeholder's opinions is vital for the viability of the project. Favourable policies and positive public opinion is essential for project's implementation. However the social acceptability of the projects does not guarantee success as there are still barriers to be overcome. What is more, Raven and Geels,(2007) argue that a general social context has to be broaden with new infrastructures supporting research and development programmes, and subsidies or regulations, so as new technologies like anaerobic digestion can be established and further developed as innovations.

On the other hand, in this dissertation work, we strive to provide a socio economic and financial context where a biogas investment may successfully be applied. So all the results and the empirical evidence demonstrated from the case study can be considered by potential investors of similar projects, bioenegy industry and even by community and local authorities for policy design and program implementation. Since the linkage between the social context of a biogas investment and the financial estimation is something relative new, there have been few studies to examine both the influential factors of decision making for an investment and the financial indicators for the profitability of the project at the same time. Therefore, this research focuses on adding value to the biogas generation knowledge base and present possible future directions on potential investors of as biogas facility.

Chapter 3 Objectives and Methodology

3.1 RESEARCH QUESTIONS AND OBJECTIVES

At present biogas energy sector is in the focus of attention among other renewable energy sources mainly due to the high availability of biomass as a primary source in the world's energy supply. The existence of so many opportunities on the bioenergy field represents a rather complex decision process. So it is vital for companies who would like to invest in biogas strategic option to be aware of key opportunities and constraints to exploit the advantages of biomass conversion technology in an attempt to make the best investment decision. Under this framework the principal aim of this dissertation is to examine the case of a livestock and slaughterhouse unit in the region of Larissa, in Greece with regard to a possible investment on a biogas production facility. So the objective of this thesis is to conduct a case study regarding a Thessalia company potential investor in biogas energy sector. Therefore the main research aim is expressed as follows:

Principal research aim: To explore benefits and economic feasibility of possible implementation of an on-farm biogas production investment under certain farming and financial conditions

There are two main questions that constitute in fact the principal aim of this paper and can further be used to achieve it. In order to be answered we have to express them as specific research questions such as the following:

R.Q1: What is the current social, economic and institutional context within which the biogas investment may be considered to be implemented for the examined case study?

R.Q2: How can a possible financing mechanism affect the financial performance and the economic feasibility of the biogas investment project?

Concerning the first research question, a good understanding of bioenergy market in a European, national and local level is an essential background for policies supporting the introduction and wider use of bioenergy but also helps to bring costs further down as a result of increased adoption rates and economies of scale. Therefore an examination of public awareness and a further insight on the acceptance and public perception of bioenergy technologies would be rather useful. Towards this direction further objectives derived from the first question have emerged:

Objective 1: To identify and analyse the key factors, drivers or barriers that influence implementation and performance of the biogas investment project

Objective 2: To highlight the influences that the socio-economic environment exert on the strategic decision making of biogas investors

So in order to define the current economic social and institutional context in which the investment will be implemented key criteria factors have to be discovered for the company investor that may affect the decision making process for alternative energy production schemes. So the first research objective for this dissertation is to identify and discuss key drivers and barriers for the implementation of bioenergy systems, and more specific of technology for biogas generation. A better understanding of critical factors and of their merging, interaction and importance for the implementation of biogas schemes is rather valuable for any investor interested to adopt bioenergy and more specifically biogas technologies. Going beyond to why this factor exist and most importantly if it affects the investment behaviour, lies at the heart of this research objective. Furthermore, the research presented here provides a view of the adoption sphere by crystallizing the key barriers or motives as perceived by potential investors on biomass projects. A further step is to explore how an impediment may jeopardize the attainment of the intended projects outcomes and how a set of policies and measures implemented may motivate the investment and support adoption of the technology proposed.

So basically from a total of livestock units in Thessaly and more specifically in the region of Larissa we choose the case of a slaughterhouse as a potential biogas investor. Then the profiling of this company in terms of location, capacity, quantities of primary sources such as organic waste and biomass is necessary. Then the examination of waste issues, awareness of anaerobic technologies for electricity generation from unconventional sources of energy can be rather useful. A lack of awareness and (maybe unfounded) fears may result in resistance to bioenergy projects, even if they are economically viable and technologically robust. Quite similar, public perceptions of benefits in terms of biogas contribution to the prosperity of the area of Thessaly (economic benefits), to the improvement of social living conditions (social benefits), and ecological benefits may significantly influence the decision making process so they have to be further examined in an effort to define the content of the investment. Then in an attempt to highlight the internal and external influences of the environment the creation of a SWOT analysis for the company potential actor in a bioenergy scheme is essential.

In order to accomplish the second question, a financial analysis along with the evaluation of feasibility is necessary. Therefore the more specific objectives in order to evaluate if the investment is feasible and profitable are:

Objective 3: To prepare data, make necessary assumptions and carry out financial analysis of the examined investment options

Objective 4: To investigate feasibility and profitability of the investment under the specific conditions and assumptions made

Objective 5: To examine how sensitive the financial performance of such a biogas investment project would be to key parameters' changes

So basically the second research question aims at finding out how a financial mechanism affects the total feasibility and financial viability of a biogas investment. The purpose is to present an overview of the costs and benefits associated with a bioenergy scheme investment option, so as to inform potential investors about the specific economic costs or benefits that these technologies offer. Then to investigate the economic feasibility of biogas energy generation facility from anaerobic digestion for the specific unit examined. The financial performance was evaluated by considering primary resources, unit's capacity and by computing financial decision criteria like net present value (NPV) and internal rate of return (IRR).

To continue with the sensitivity analysis, the principal goal is to examine how a change in the plant size and capacity may affect parameters such as costs, electrical efficiency generation and revenues and how this affect the outcome of the investment. So basically an expansion of the initial project to a project of higher capacity will be proposed. Finally, a comparison of the two projects for different capacities will highlight which plant size is more cost effective for different levels or capacity and biomass sources availability.

3.2 METHODOLOGY

In this dissertation we apply our ideas about factors that influence a biogas investment and our methods of financial analysis, in the empirical case of a cattle-breeding and slaughterhouse unit that can invest on a on- farm biogas generation facility. Therefore, the unit of investigation and main subject of analysis is a slaughterhouse in the municipality of Larissa in the general region of Thessaly. The methodology of a case study was followed by analysing a particular farm-slaughterhouse, potential investor on a biogas project. The specific company of further analysis was purposively selected since our main goal was to collect a total viewpoints and useful data and information for the company by its stakeholders.

The target population was the cattle-breeding and livestock units in Larissa and close region districts of the municipality of Larissa since this region constitutes a typical agricultural area with vast amount of waste produced due to large number of livestock units and farms that exist. Additionally, through anaerobic digestion the viability of exploiting biomass sources will be secure only for medium to large scale animal breeding units where the waste production is significant. This fact can justify the need to select a unit of a large scale and animal capacity. What is more, as Skoulou and Zabaniotou (2007) support in their survey the waste production from cattle units is so high arriving at a volume of 22 million m3 waste in the whole Greek area. So our attention is mainly targeted on units in the Larissa region with large number of cows at their disposal due to the high unexploited manure sources and their energy efficiency. Furthermore, in an attempt for higher capacity and efficiency apart form solid waste, wet or liquid residues , such as slaughtering or blood residues we are targeted to choose an animal breeding unit that will also operate a slaughterhouse.

So the main procedure followed to purposively select the unit of our interest and survey can be described as follows. A visit in the veterinary public service in the city of Larissa allowed us to gather information about the existence of livestock units in the prefecture of Larissa but more specifically for the municipality of Larissa. So with the last registration the number of livestock units in Larisa in adjacent regions is approximately 8000 a number very low compared to previous registration of 1990. Concerning the slaughterhouses in the region, they were four in the region of Larissa (koulouri), in Gyrtoni, in Tyrnavos and in Mesochori. We choose the first company the slaughterhouse of Larissa for matters of proximity and for the high availability of sources. In addition, the region of Larissa was chosen due to the existence of high agricultural and animal breeding activities and of large biomass availability as well. What is more, in the future the region will play a critical role in the covering of bioenergy or electricity needs and in the general effort for substitution of conventional forms of energy. Nevertheless, the energy needs of the region are high with an increasing rate due to the existence of farms, industries and so on. So the selection of a unit to be constructed in the region of Larissa is of strategic importance for both the region and the Thessalia valley in general. It is without doubt that the results and the findings of this project can be applied to similar cases as well with some suitable parametric changes. In general since these types of companies have a wide variety of both solid and liquid waste and substrates are considered suitable sample for our project suggestion on biogas investment.

3.2.1 Research Design

First of all, I have conducted an exploratory study in order to gain further insight in the contemporary literature concerning biogas investment with the use of biomass as a primary resource. An exhaustive bibliographic study of the existing surveys and studies at an international level along with the examination of a wide variety of records, documents and secondary data were held at this point in order to draw some conclusions about the implementation of bioenergy technologies in Europe. Existing energy conversion technologies, future perspectives and opportunities at a European national or regional level have been investigated along with the general institutional framework and legislation. The information collected was further used to obtain all the theoretical background and to further formulate a sufficient waste management model based on biomass digestion facility for biogas energy production.

Concerning the principal aim of this dissertation that is to examine the case of a slaughterhouse unit in the region of Larissa with regard to a possible investment on a strategic biogas option situation analysis two main strategies will be employed on this behalf. The first research strategy is to conduct a descripto-explanatory interview with the use of structured questionnaire as an instrument. More specifically structured interviews were conducted with key representatives of the company based on the critical positions of the firm's organorgam. Since the company constitutes a potential investor for biogas facility interviews with those stakeholders have been proved rather useful for collection of relevant information and insights about the variety of opinions in the company concerning the investment. We aimed at conducting more than one interview within the firm so as to gather different opinions and perceptions between the different organizational levels of the company. The interview participants were purposively selected based on the organogramm of the company and their organizational position and duties, since our main objective was to collect a total of different viewpoints form different groups. So the questionnaires have been addressed to five key stakeholders of the company and more specifically to the owner, to the production manager, to the financial manager, and the two members of the waste management team in order to identify their awareness about investing on biogas and their perceptions about possible benefits of this new technology. In addition, this structured interviews were conducted in order to identify perceptions and the strategic context under which the decision making process on bioenergy project is made. These interviews have provided qualitative data useful for further analysis and up to this point a further analysis of strategic implications that contribute to the final firm's decisions is allowed.

The data collection has been accomplished through a pre-tested interview schedule, with one type of questionnaire and a personal observation schedule. The duration of each interview was set to be for a relatively short period of time, approximately 30 minutes and the meeting has been arranged based on the stakeholders' timetables and spare time and after a telephone and a first visit to the facilities. What is more, all the questionnaires included a cover letter that explained the main scope and purpose of the research and the high confidentiality of the responds that will be used only for academic purposes. What is more the questionnaires were anonymous since no names or addresses were included only some demographical characteristics. Finally the interviews were scaled for the 30 of September after contacting with the chairman of the unit and all the participants signed the confidentiality document while all the notes taken during the interview were typed as soon as possible.

As Miwirigi,(2009)supports the interview schedules is a very efficient survey method well known for its high response rates and the high data quality. However the time consuming character of interviews schedules motivated us to employ the method of structured interview with the use of a questionnaire. Questionnaires are mostly used in survey strategies however this tool can also be applied in a case study like the one that takes place in this dissertation. According to Saunders interviews is a very useful research tool for the collection of valid and reliable data and information relevant to the research questions and main objectives of the survey. The main advantage of this method is that opinions can be easily gathered however there is always the risk of biased answers (Mejier et al, 2007). In order to avoid this significant drawback, similar researches, records and information about influential factors were used for data triangulation and cross mind. Moreover, as other limitations of our proposed methodology we could mention the possibility for misunderstanding of meanings, the questions wording, and so on. So theses issues were practically solved through the questionnaire design where each factor was rated according to a scale, a clear description for each factor was given during the interview and additional remarks could be noted.

The three main categories of interviews are the structured, the semi-structured and the unstructured or in-depth interviews. More specifically, the key characteristic of structured or standardised interviews is the use of questionnaire with a predetermined series of questions. Those questionnaire are referred to the bibliography as interviewer –administered questionnaires since the researcher-interviews is responsible for the efficient administration of the survey and the record of responses with the use of pre-coded answers and a standardised schedule. The main data collected through the social interaction and discussion of the researcher and the respondent are most of the times quantifiable and can be used for further quantitative analysis.
Concerning the semi-structured interviews the list of themes and questions asked may vary from interview to interview depending on the general flow of the discussion. While in the in-depth interviews, the respondent has the opportunity to freely express his thoughts with no predetermined order of issues that have to be examined. Concerning the response rates, the interview schedules were selected over simple questionnaires due to the high response rates and effectiveness in data collection (Mwirigi et al,2009).

In our case we have conducted a structured interview and more specifically, face- to – face interviews with the use of an interviewer-administered questionnaire with the five key stakeholders and managers of the company. Since questionnaire works better with standardised questions, it can be used for descriptive or explanatory research. The first section of the interview was dealing mainly with the general characteristics of the unit and more specifically, geographical location, available animal or other organic waste produced form the daily operations of the slaughterhouse. A set of open questions was used to write down main waste issues, unit’s characteristics and so on. Apart form the number and species of animal in the unit, the respondents were also asked to give exact information about the tonnes of feedstock substrates produced per day and per year of operation. In a similar vein, additional information about other quantities of biomass stock from other similar adjacent units or farms in the region was demanded. The scope of this information required was to define the profile of the company in terms of: plant location and size, quantity of waste per year-biomass, potential of biogas generation with the use of biomass as resource.

The second section was designed to identify and highlight possible waste management issues that the company has to deal with. To investigate waste problems in companies:
More specifically, the interviewees were asked to describe briefly the process for waste management for both animal manure and other slaughtering waste along with the cost and time

needed for the integration of this procedure. In an effort to understand the waste situation in the company, the respondents described the main problems that have to deal with waste issues or possible legislation issues or fines due to the insufficient waste treatment of their operation. What is more, additional information about the cost and time for collection, transportation and storage of biomass sources form other local industries were supplied. So a clear description of waste issues such as how they handle with waste storage, what will happen with green certificates or fines from European and national legislation, was made.

The third section of the structured questionnaire was designed to assess the investor's attitude and awareness on biomass conversion technology and more specifically on anaerobic digestion adoption for biogas and electricity production. Questions were asked about a variety of factors that could influence the decision making process and the implementation of a biogas scheme as well. In an effort to assess the entrepreneur's ability and desire to invest on biogas options, the main drivers or barriers that could incentivize or impede the biogas implementation were examined from a social, economical, financial and institutional point of view. So the questions were divided into sections of socio-economic factors, financial factors, legal and environmental factors in an attempt to make the interview and the data analysis easier. During the interview schedule the respondents were asked to rate form a range of 'critical important' to 'not important' the main factors that can affect their decision behaviour. Choices such as 'critical important', 'important', 'moderate', 'not important' were offered as possible answers for each of the factors investigated. Through those questions a further analysis of public perceptions of benefits in terms of biogas contribution to the prosperity of the area of Thessaly (economic benefits), to the improvement of social living conditions (social benefits), and ecological benefits was achieved. What is more we don't have to neglect to mention that the selection of questions for the interview was based on a total of similar researches on this field such agency for RES (eubionet, 2010), www.biogasin.org, www.bioprom.net , www.forestrynepal.org, www.iamo.de , and so on.

Through the use of questionnaire the aggregation of primary qualitative data is possible, aiming at further analysis, idea synthesis and knowledge integration. Qualitative data, are non-numeric information based on meanings and conceptualization that can not be quantified. Their analysis results in non standardized data that require further classification. All the information collected during the interviews contributed to the updating of the above mentioned bibliographic research and crystallized the present status of bioenergy sector in Greece. To continue, the information acquired through interviews was further examined in an attempt to shed light on stakeholders perspectives about factors that influence the investment decision process and that can operate as potential drivers or barriers, of biogas technology adoption. The main process used was a qualitative analysis for further process of information. What is more the general research method used was the deductive approach since the formulation of the main research questions and objectives were made after the use of the existing theoretical background. In addition this framework enhanced the organization and analysis of collected data and is base on personal expectations and a mix of theory. What is more a Saunders et al. (2009) suggest the descriptive framework is based on the variables and issues examined and the preassumed relationships between them.

3.2.2 Swot analysis

However in order to complete the description of the socio economic framework of the investment we have to highlight internal or external influences that the environment exerts on biogas actors. More specifically all the above factors examined will be group as potential strengths ,weaknesses ,opportunities or threats in a SWOT matrix created for the company examined. It is an undeniable fact that, Swot is an effective tool that constitutes the baseline to diagnose potential opportunities or threats and sketch future trends or strengths (Terrados et al, 2007). Since decision making is a rather complex process based upon a set of factors, it would be rather useful to examine and highlight these factors and the whole decision process respectively so that companies will be ready to use its bioenergy potential quantities. So an overview of causalities and the most important factors is essential. After data analysis from the structured interviews the results and the general meaning of responses have been further employed in order to construct a swot analysis. According to specific answers from the company's stakeholders the main strengths and weaknesses along with potential threats or opportunities from the external environment have be noted. So basically responses were further analysed and factors that influence biogas technology implementation were extracted under each swot category. This analytical strategic tool permitted the comprehension of the current biogas situation and sector and serves as a basis for the attainment of the proposed project goals. The reality as define by the swot scheme was a baseline for the real status of renewable and more specifically of biogas market. Finally the situation diagnosis through the swot matrix will serve as an outline and base for strategy formulation and for in-depth analysis of the Greek energy market in terms of competition, prices and future demand that affect revenues.

3.2.3 Financial Analysis

After the definition and the description of the current socio-economic and institutional context in which the biogas project will be implemented, a project about the investment on biogas generation facility will be suggested. The project with a capacity of 1,2 MW and sufficient biomass quantities as primary resource, constitutes a strategic and innovative solution that can affect the whole environmental chain in the Thessalia area. The main methodology followed is to make proactive research for the installation of a biogas infrastructure in the specific case examined, by using records and information collected through questionnaires. The reports and financial data analysis have been done with the use of spreadsheets and pc softwares such as EXCEL taking into consideration all the financial and technical data that describe the investment. Concerning the second part of the assignment the main aim is to make a financial analysis in order to evaluate if the investment is feasible and valuable. The main sources are used as a guide is the European's commission guide about investing on projects (2008) and the Benninga's book and excel software for the processing of computerized data. More specifically the following steps will contribute to the answer of the main objectives.

On the feasibility analysis potential constraints in terms of human capital, plants and installations were stressed out along with sufficient evidence from available technology, production plan, capacity of the unit that will range from 1to 2 MW and specific geographical characteristics of the plant. To continue, in order to further proceed with the calculation of economic indicators I had to define first: the total investment costs, the total operating costs and the revenues. Afterwards, costing models of the biogas plant facility have been developed, along with an overall economic model considering, total capital costs, logistic costs and revenues from energy sale and logistic costs. Then, economic profitability of the biogas facility has been estimated specific key performance indicators like Net Present Value (NPV), Internal Rate of Return (IRR) and break even point of the investment. Likewise, I have conducted a parametric analysis with the use of higher plant size to check the sensitivity of the project. The selection of influential socio economic and financial factors have been selected for the basic factor analysis but have also to include a more creative point of view with regard to new ,expanded variables such as larger capacity ,plant size and so on. Under this framework a second project of higher capacity 3 MW was suggested. The same steps for the financial analysis as in the first case we followed and economic indicators were calculated. This sensitivity analysis, allowed us to conclude how electric efficiency, capital cost or revenues change with the increase of plant size and capacity. At the end pairwise tables have compared the financial performance indicators for both the two projects. Finally many conclusions will be excluded from the financial appraisal, in terms of economic benefits, competitiveness of the Greek energy sector and sustainable development of the national economy.

Fig. 3.1: Methodological Procedure

Social-economic context of the project

SWOT analysis,
Drivers-Barriers

Project identification

Objectives
Unit power capacity
Geographical characteristics

Feasibility analysis

Evidence from plant, technology,
Personnel requirements

Financial analysis
Total investment/operating cost
Revenues-Sources of financing
NPV- IRR
Break even point

Final appraisal
NPV>0 or NPV<0
Conclusions

Sensitivity analysis
Suggestion of 3 MW project
Financial analysis
NPV- IRR
NPV>0 or NPV<0
Conclusions

Conclusions- recommendations
Comparing results for the two projects
General conclusions

Source: EU-Guide on Cost- Benefit analysis (2008)

In the following chapter, background and the general socio-economic and institutional framework of an on-farm biogas project will be reviewed and examined through interviews that will provide to us with information about perceptions and influential factors that incentivize or impede decision making process for a biogas investment. So basically the necessary context where a biogas project can be suggested and implemented will be provided and sufficiently determined in the following factor's discussion.

Chapter 4 Socioeconomic and Data Analysis

4.1 CASE STUDY FOR SLAUGHTERHOUSE IN LARISSA

The socioeconomic and then the financial analysis developed is implemented for the case study of a swine- breeding unit and slaughterhouse in the municipality of Larissa, of the prefecture of Thessaly, Greece. Thessaly is one of the most appropriate cases for implementing the model, since it is the largest plain in Greece, in which the agricultural and breeding sector are widely developed and constitutes a representative sector in a national level. The availability of many biomass types from agricultural till manure and slaughter residues constitutes a key factor for our approach/analysis.

4.1.1 General characteristics of the company

The company that constitutes the main object of our research, study and financial analysis is a swine-breeding unit and slaughterhouse in the region of Larissa. The legal form of the company is a SA and the ownership status is of two owners. The central activity of the company is the breeding of swines and the slaughtering of all species of animals. More specifically, apart from the slaughtering, cleaning and cutting of the unit's animals the company is responsible to satisfy the needs of other similar units in the region such as pig, cattle or dairy farms. The capacity of the unit is 2500 pigs, 3000 cows, 7000 lambs and 1000- 1500 sheeps. But the unit actually possesses approximately 2500 pigs and 3000 cows. What is more, the respondents were asked to indicate the quantity of waste and manure produced everyday by each type of animal, which is approximately 125 tones/day for swines and 51 tones/day for cows. Apart from animal waste the company has other sources of waste too and specifically 1 tone/day of solid fat and 19,18 tones/ day of slaughterhouse waste. The following table represents the total capacity of the unit and the main sources of waste along with their relative amounts expressed in tones per day.

Table 4.1: Energy efficiency of substrates

Breeded animals Substrate	Daily quantity of waste in tones t/d	Annual quantity of waste in tones t/a	DS Tones per day t / d	Dry organic substance (oDS) in % of DS	oDS Tones per day T / d	Efficiency of gas in m³/kg of oDS	Daily efficiency of gas in m³/d	Methane in %	Energy potential per day kwh/d	Electrical efficiency 40% of energy potential kwh/d el	Thermal Efficiency 42% of energy potential kwh/d th
2.500 Swines	125,00	45.625	8,750	86	7,525	0,50	3.762	60	22.572	376,20	395,01
3.000 Cows	51	18.615	15,300	80	12,240	0,45	5.508	55	30.294	504,90	530,14
Fat solid	1	365	0,780	90	702	1,1	772	57	4.400	73,33	77,00
Slaughterhouse waste	19,18	7.000	3.836	84	3.222	0,6	1.933	60	11.598	193,30	202,96
Total	196,18	71.605	28,666	82,6	23,689	0,5	11.975	57,5	68.864	1.147,73	1.205,11

4.1.2 Waste issues of the company

If we take into consideration these high number of animal and the huge amount of feedstock, manure and other waste produced during the slaughtering procedure the company must deal with a variety of waste issues. During the interview process the stakeholders enlightened us with the whole procedure followed for waste treatment. More specifically the animal manure and waste pass necessarily through the biological treatment that the company possesses in its facilities. However, since the biological treatment mechanism is old and outdated the handling of sewage and waste is not so efficient. In addition the capacity of this mechanism is restricted and cannot respond to the needs of the company for handling of so high quantities of waste. Furthermore, the slaughtering residues such as blood and other fluids and animal manure as well are treated by the biological cleaning too. Then, the fat from the slaughtered animals is managed through a rentering line with large quantities of hot boiling water around 250 degrees, a process very cost and time consuming. No matter how financially disadvantageous this method is, the company is obliged to implement it as the national legislation mandates.

To continue, the average cost for collection, storage and handling of other similar units waste was indicated. By calculating staff costs, costs of heating fuel for steam and hot water (rentering), refrigerator costs, costs of trucks for transporting, sewage sludge operating costs are approximately 850.000-900.000 Euros per year.

It is natural as in the majority of farming activities that the problems from waste treatment are a burden for the company and the region as well. Answering to our question about the existence of environmental problems caused by waste, the company's stakeholders indicated as the most significant, the environmental pollution, the contamination of groundwater and the intense odors. The owner's perception for the on-farm waste problems and mostly water and air quality issues was considered as a positive factor towards the consideration of biogas investment. Apart from environmental concerns waste treatment cause a series of problems for the company too especially concerning storage and time spent for the manure handling. So since the company is aware of the costs and time spent for waste management can easily decide to invest on anaerobic digestion which guarantees time and cost saving.

Concerning the Greek legislation about waste treatment all the respondents answered that they are totally aware of the Greek laws and regulations and strive to be compliant with those. Nevertheless, due to the huge amounts of waste , and the lack of an efficient method to treatment, the biological cleaning is neither sufficient nor efficient , the company has sometimes be responsible for accusations about pollution problems and has to deal with local authorities and press. Apart from Greek legislation, European directives especially after the Kyoto protocol and the launching of the White paper for green investments, obligate all farming , livestock units and industries to take a good care of waste issues and carbon emissions. Under the European Hygiene (EU) Ordinance no. 1774/2002, liquid manure is a harmful by-product with predictable risks (Poeschl et al, 2010). Also there is regulation for fertilizer and limits for nutrients on the groundwater. Instead of this organic fertilizer is cheaper, environmentally sustainable and on the same time eco-friendly. In case that the company is compliant with all the national environmental targets then it can be certified with green certificates procured by the EU and are a pre-required certificate for the eco-friendly company's operation.

Furthermore the company's stakeholders answered that they are aware of the existence of green certificates. In fact the payments for electricity from biogas generation include the value price of electric power and the value of green certificates as well which is around 125 euros per Megawatt. With this scheme subsidy free operation for a long time is possible and production costs are minimized and balanced from the income generated from biogas production. So in this way a company can achieve lower subsidies or future free subsidy operation (Poesch et al, 2011).

4.2 FACTOR ANALYSIS

4.2.1 Drivers or Barriers

An initial analytical step is the identification of a variety of regimes, contexts, norms, values and other factors relevant to the investment and the anaerobic technology implementation. Then we have to take into account that the decision making process is influenced by factors that can be categorized to socio economic, financial, environmental or regional and legal factors. What is more, the firm's characteristics in terms of size, capacity and feedstock availability is previously described along with national or global policies and trends and other technological advances or trends may also affect the entrepreneurial action. At the regional, analysis level should not remain stable but should also consider future trends or opportunities and ongoing transformations (Markard et al.2009)

It is an undeniable fact that there are numerous and diverse drivers or barriers that affect implementation of bioenergy projects. A range of these factors that influence the investing behaviour and the decision making process has been further discussed though the literature and will be extensively examined and analysed through the case study approach. The case of the slaughterhouse was proven rather useful as a method to assess what influences the successful implementation of a biogas scheme and what are the main motivations for these schemes. In an effort to confirm the main motives or barriers identified through the literature a set of questions were posed during a structured interview to the company's stakeholders. More specifically, through the question, the respondents were asked to estimate the degree of importance so the most critical drivers and barriers for the implementation of biogas unit were highlighted.

In an effort to understand the general environment where the company operates, it would be rather useful to categorize the main factors that affect the decision making process for the company to invest on biogas or not. A grouping of factors can include: farm related factors, socio-economic, financial or financing factors and legal factors that constitute the policy framework of the investment. The company's profile and characteristics entail availability of primary energy sources such as fields, infrastructures and amount of animals, waste issues and so on. The socio-economic aspect includes factors such as awareness, education level, and cultural behaviour while financial maintain the main capital and operating costs along with the possible return on investment and expected profits from the sale of products. Concerning the legal factors, in fact they are the set of measures and policies in a local, national and European level along with the approval procedure. Institutional structures such as norms or regulations may hinder ir support the realization of biogas investment options. Finally environmental factors deal with the possible environmental benefits in terms of reduction in greenhouse emissions and improvement of the water ground, the green profile of the investor and the company as well. In general potential factors with negative impact to bioenergy development are financial problems during the lifespan of the project, lack of financial support through the procurement of a grant or a subsidy, the licensing and approval process along with the mistrust that sometimes exist between developers-investors and local authorities. Certainly possible environmental impacts such as noise or odour and technical problems can possibly impede the successful adoption of a biogas technology. (Adams et al, 2011). The factors examined during the interview that is drivers or barriers for a possible decision to invest on a biogas option can be summarized in the following table.

Table 4.2: Drivers and Barriers

Factors	Drivers	Barriers
Farm related	-Availability of land -Availability of feedstock	-Unavailable land -Unavailable feedstock
Socio- economic	-Awareness -Education level -Available income -Attractiveness of the market -Technology trialability	-Uncertain costs of construction and maintenance -Competition form other investments
Financial- Financing	-Return on investments -Revenues from sales -Availability of financial support -Expected profits -Expected costs	-Uncertainties of financial support - Limited return on investment - Limited profitability -Small economic indicators -High interest rate
Legal	-Favourable policy in a regional, national and European level -Favourable financing conditions	-Unclear legislative limitations -Public opinion -Bureaucratic mechanisms
Environmental	-Environmental benefits -Desire to be green -meet governmental energy targets	-Noise, odours from operation - Negative environmental impacts

According to previous researches in the energy field, there is a significant relationship within size of the company and its land and interest on biogas, with larger farms showing greater interest than smaller ones. The large animals breeding units have high potential to implement digestion technology while the smaller have to deal with capital cost issues. The availability of farmland is considered an important factor in willingness to invest on biomass digestion practices. Herd size and farm acreage have to be sufficient in order to handle with manure disposal that otherwise cause serious nuisance or environmental problems. In general surveys have hypothesized that a farm or slaughterhouse with a large acreage on its disposal probably will not be as willing to invest as a farm with smaller herd size. However, in our survey the respondents rated the lack of available land as a very ‘important factor’ that could impede the investment. So this answer indicates that unavailable land negatively affects the willingness to adopt anaerobic digestion.

The Greek farming system plays and important role for the diffusion and adoption of on farm anaerobic treatment units. Apart from animal production that is housed in a free-stall barn, animal productive units are targeted also to the biomass generation. Biomass production is achieved by the efficient capture of manure and organic fats or bioenergy crops. This is due to the fact that animal breeding and biogas production are highly correlated and on the same time complementary activities, since the quantity of livestock waste production that serves as an input and feedstock for the biogas unit depends upon the availability of land size (Wilkinson, 2011).

4.2.2 Socio-economic Factors

As Mwirigi et al (2009) argues high levels of technology awareness and education motivates people, increases their interest on new unconventional technologies for energy generation and makes them more adaptable to new ideas. Low levels of education and awareness act as constraints for the adoption, and can only be overcome through improvements in the level of awareness with a series of measures to raise information on bioenergy. So probably the most effective methods for learning about bioenergy options were practical experience, ideas or advice form other farms that have already implement it. So word-of-mouth recommendation from friends, relatives or other operators who have already installed a unit is considered one of the most important factors for investing behavior. So large farms with a lot of animal and land in their disposal is more possible to be interested to invest. Therefore, education on renewable and good information or even trial and performance of digestion technology may even improve this interest. Astonishingly, while other surveys on bioenergy awareness (Rohracher, et al, 2004), showed low level of biomass awareness, our respondents were totally aware of the anaerobic digestion technology and its possibility to treat organic waste and to generate biogas, electric power and heat. Moreover, they weren't only aware but have visited an anaerobic digester in process and experts have explained them the whole procedure. So the company is probably in the persuasion stage and is considering really seriously making the decision and then starting planning the biogas unit.

At the beginning the respondents were asked to rate the critical importance of factors that constitute potential drivers for the investment. Factors like the attractiveness of a growing market and its opportunities, the available land and feedstock, the existence of financial support and the profitable return on investment were further assessed through a scale from 'critical important' to 'not important'. Concerning the attractiveness of the growing market, three of the respondents answered that they found this factor 'very important' while the rest two the members of the waste team noted this factor as 'important'. In addition, the respondent found the opportunitities of the growing biogas market an 'important' factor that would probably incentivize the decision making for a biogas investment. These answers basically mean that a well structured bioenergy market with a lot of potentials for future development operates as a motive for the stake holder's entrepreneurial action. So the ability to enter and be established in an expanding market seems an important opportunity for the developer of the project and the actual motive to invest on a biogas scheme. What is more, the availability of land was noted as 'very important' and the availability of feedstock and other organic primary sources was noted as 'very important' driver as well, since the existence of land and feedstock is the prerequisite in order to maintain a biogas unit. Considering the fact that, the market is new and unstable and the demand of biomass exceeds the supply, the availability of feedstock is very important. Then the existence of a financial support with the form of a subsidy or a grant was judged as of 'critical importance' from the owner and the waste team, as in this way the company may be enhanced to invest if a subsidy or a financial aid is approved. However the production and financial manager has noted this factor as just important may be due too the lower profits from the sale of electric power if a company is subsidized. What is more, as the development Law mandates only the 40% of the initial costs can be financed. The profitable return on investment was ranked as 'very important' factor from all the interviewees since the ability to make a profit is essential for the decision making of an investment. Of course the environmental benefits of the unit those are undeniable where rated as important too. This fact is worthy considering the fact that the company was striving to find an effective method to deal with its waste issues and the environmental impacts of them in the region. The main aim of the unit was to reduce carbon emissions and on the same time to find renewable sources of energy as solution to energy security stocks. So it is natural that a factor like environmental effects contributes in such a way to the decision support of the investment, since it constitutes the perfect solution to the slaughterhouse unit's main waste problems.

Our survey apart from motives has also hinted technological, socio economic, legal and financing factors as impediments for the investment and the adoption of anaerobic digestion treatment. Lack of land availability was rated by some as 'very important' and by others as 'important', while lack of feedstock was scaled as 'important' factor meaning that, the available land and the sufficient quantities of feedstock is vital for the beginning of the biogas unit. Concerning the land use, the energy crops require large arable areas in order to produce sufficient amount of biomass and energy as well. In our case, different biomass sources such as waste need less land available and mostly land for the biogas infrastructures. The slaughterhouse unit possesses a land large enough where the digester and the rest of the technical equipment can be established. The advantage of this unit is that it will be built on farm, alleviating in this way fuel issues or high costs to collect quantities of biomass wastes that are dispersed in the region. More specifically, every company that wishes to invest on bioenergy needs specific quantities of biomass supply in order to be approved through the licensing process. The main amounts of biomass are further examined in order to find the specific ingredients and dry content and the possible amounts of heat and power that can be generated from their digestion are estimated. Only if the energy content of feedstock supply is sufficient, only then the biogas investment can proceed. What is more, the insufficient feedstock supply not only works as an important barrier but is also linked with the economics of biogas generation. The supply fluctuations may be proved harmful for the cost or the prices of biogas. As Adams et al (2011,) support, suppliers or developers of biogas units require a stable and constant demand but on the other side of the chain the end-users of energy require a constant supply as well. Otherwise they can turn towards other renewable sources of energy with harmful consequences for the bioenergy market. To go a bit further in market conditions, especially the biomass demand faces huge direct competition from other industries such as fibres, chemicals and especially from food or feed crops. This means that concerns have arisen for the sustainability of biomass resources since Greece is still reliant on import in order to meet energy needs and targets. So in an effort to response in the constantly changing and competitive market bioenergy developers need to respond with flexible and revolutionary approaches. (Adams et al, 2011). Therefore the factor of available biomass and of land in order to build the biogas facilities is necessary.

Another barrier identified by the respondents was the lack of technical expertise and support. Other interviewees rated as 'important' while others found this factor as 'moderate' for the project's implementation. Since the bioenergy field is a new sector and especially in Greece the lack of skilled and well-trained workers and experts for biogas system is a fact. If compared to more developed and competitive industries such as Germany, Sweden or Austria, Greece doesn't have the prerequisite amount of skilled workforce. Since biogas schemes are totally new and innovative for the Greek reality the lack of experienced operators, installers, manufacturers and maintenance workers is without doubt. However, an increase in skilled bioenergy experts seems necessary to meet renewable energy targets and to motivate investments on this field. Furthermore, a well-trained personnel guarantees the safe and efficient operation of the plant. With the creation of new job posts in the energy sector knowledge and experience on similar projects will be diffused and established. Moreover, apart from lack of knowledge and technical expertise the technology trial ability has be proven a major barrier, since some biomass technologies that are unproven or untrialed may be proved commercially unviable. The respondents stated that this factor is 'not important' may because they have already seen and tested a digester on process. For the Greek bioenergy market which is still in an infancy stage and there is a slow developing rate of biogas projects it is apparent that technical expertise and trialability is essential. The main barrier for developers appear to be technological, since the hesitance or the uncertainty of investors probably stem form the anaerobic technologies that often are not profitable or reliable. It is a general fact that power or equipment reliability strongly affects the decision to implement energy production and conservation techniques. So those concerned about efficiency of energy options were less likely to implement those technologies. As Poeschl et al, 2010 argue technology will continue to improve the sustainability and the economics of biomass conversion systems but it will remain the most significant uncertainty in the future of renewable sources. Biogas investors need to feel safe and secure that has chosen the right investment pathway, so the security of technology demonstration projects is vital.

In addition, uncertainties concerning the costs of development and operation were highlighted as 'moderate' from the majority of stakeholders. It is a fact that the mechanical equipment and the facilities required to support it, is rather costly both for the development and the operation process. The new infrastructure requirements include, digesters, biomass installations storage and transportation means. High capital costs associated with the adoption of the anaerobic digestion equipment may be proven major barriers since they are not always economic or practical. There are also concerns about how viable are these technologies for the conversion of biomass to a great variety of energy products (Dwivendi et al, 2009). However, the specific company examined has all the financial potential and capability to acquire the necessary technology. Moreover, it is understandable that when introducing emerging technologies economies of scale can be achieved as after a point, costs will start to reduce and profits will continue to rise. In the case of biomass procurement from external sources or farmers of the region then, logistic costs for feedstock transportation is uncertain too. Production costs, yields and feedstock market prices are associated with energy density and content and is a major factor that increases supply costs. So in an effort to minimise those transportation costs biomass quantities should be located around the conversion point.

So considering the high up-front capital costs, the uncertainty of grant funding was considered a barrier since without a grant regime developers would be difficult to invest. For biomass electricity production and biogas generation the cost of production require a grant funding system to incentivise the electric power generation from renewable and to ensure or support potential investors. In our case probably the company will avoid a grant since in this way it succeeds a higher price sale of electricity and of the other final products and therefore higher return on investment. So this fact can basically explain why the majority of respondents have rated this barrier as of moderate importance.

Concerning the competition from investments on other unconventional methods for energy generation the factor was demonstrated by the interviewees as ‘moderate’ and ‘not important’. The development of bioenergy schemes is highly based upon its cost competitiveness against fossil-based fuels. There are many examples of projects like biodiesel that are financially able to compete with fossil-based diesel. Fuel prices are a variable that influences the cost or price of electricity generation from both conventional and renewable counterparts. But higher fuel prices are a factor that favours the competitiveness of unconventional sources of energy (Del Rio, 2011). So the successful development of biogas pathways like the individual project that is the centre of our research will depend on the ability to compete with long term with fossil-fuel prices. (Adams et al, 2011). To go a bit further complementary investments create synergies or spill-overs like the case of wind power actors and biogas stakeholders that maintain a lobby for better financing conditions of technologies (Markard et al, 2009).

In the question about if initial capital cost would influence their investment behaviour, the respondents gave a definite positive answer. The initial investment costs for alternative forms of energy are much higher than those of the conventional forms of energy. (Del Rio, 2011). Biogas technology and other renewable technologies are highly capital intensive resulting in high total costs. Apart form initial cost, total costs also include operating and maintenance costs. Despite the high costs, unconventional sources of energy have high learning rates and research and development on the field of biogas technology can contribute to the equation of capital costs with the costs of the conventional forms of energy. On the other hand, expected maintenance costs were considered ‘probable’ to influence the decision making process. So since expenses for initializing and supporting the investment are high the cost of energy is difficult to cover the difference, and this is another reason why developers may be indifferent for energy conservation options (Bailey et al, 2008).

In addition, respondents answered that the expected profits/losses would definitely influence their decision to invest. The profitability of the project depends upon the relative size of the project, the capacity of the unit in terms of biomass as a primary resource and the amount of KWh of electric power produced. The electricity price per kilowatt (kWH) that can be received during the project economic lifetime is a valuable factor for the profitability of the investment. According to, feed-in law tariffs basic rates are decreasing with the size of the plant, and with the years that pass. Also, price premium are paid depending on the type of the primary source, and for the production of combined heat and power. What is more, the profitability is based upon the suitable technical equipment used, with the anaerobic digestion to be the most cost and time efficient form all the other renewable forms of technology. Furthermore, according to the national legislation, the permission from Regulatory Energy Authority (RAE) can only be given if they is a guarantee on purchase contract with the Public Electricity Corporation (PPC) for at least five years. This contract is a guarantee for a minimum certainty on return on investment and profits. Since the primary resources such as organic waste are provided at no cost the profitability of the project is estimated to arrive approximately up to 10% - 12% (Dinica, 2009).

The respondents highlighted that available grant money as a type of information probably would not affect their decision to invest. The meaning of this factor is that in case of a grant then the sell price of the electric power would be lower and this would affect the project’s profitability in the long term. Of course it is without doubt that investment grants for biogas technologies are valuable for the feasibility and viability of the project. The importance of the grants can be further highlighted if we consider the fact that high capital costs operate as stumbling blocks for bioenergy systems. To continue, the by-product uses/markets would definitely play a critical role. As the respondents answered this factor would definitely influence the investment decision and behaviour. The main products from anaerobic digestion are gas production, electricity energy power and heat recovery. Additionally, with the biogas production, methane, carbon dioxide and water are generated. As some of the by-products, we could refer hydrogen, certain hydrocarbons, and excess thermal and power energy for the process. In case of energy required from the grid or other sources and amount of the electric power could be sold. However the insufficient network of grid, the lack of transparent procedures and the long duration of the authorization process and the costs of grid connection are some of the problems that the company must deal with in order to offset its products (Del Rio, 2011).

Testimony from experienced investors constitutes a factor that definitely influences positively the decision process. As with every innovative mechanism it has to be first trial and tested, and after some experiments and show offs the investors are convinced to buy it.

'Environmental impacts' and possible effects would definitely influence the decision making process as our respondent declared. However, through further discussion with the interviewees we concluded that even if farmers they are aware of the benefits of anaerobic treatment, they may decide not to invest at the end mostly due to the high capital cost of purchasing and maintaining the technical equipment (Bailey et al, 2008). The anaerobic technology is an environmentally friendly closed process, despite the negligible emissions of the digester and gasifier mechanism. The main odorous or noxious discharges are eliminated during the treatment process. At the end of digestion residues with small volume of solids and trace minerals are environmentally benign and can be further used as fertilizer or even for manufacture building material. In general the ability to use all forms of organic waste as a primary source to recover something valuable such as energy , combined heat and power and to leave a small quantity of a benign and unharmful by product is of great environmental significance and extremely useful for future environmental friendly processes.

Financial return on investment was a 'very important factor' identified by respondents in this group, due to the potential impacts on business structure. Sometimes the expected profit margins for biomass feedstock can be low or even negative, so a requirement for financial supporting mechanisms from government is urgent (Adams et al, 2011). With this grant early stage development and commercialization of renewable energy equipment is possible. Otherwise low return on investment and uncertain profits constitute a significant barrier for the biogas project implementation and success (Wilkinson, 20011). Concerning the Payback period half of the respondents rated as important factor for investment since the time that the investment needs to pay back the initial capital costs is necessary and can motivate a potential investor. On the other hand, the rest found that payback period is a factor of moderate importance for the adoption of a technology like Anaerobic Digestion.

Poeschl et al, (2010), have pointed out that there are significant subsidy scheme and plans for biogas unit investors. Measures like these include investment subsidies and grants for the start up phase of the project. Furthermore, in their research Poeschl et al, (2010), have computed the comparative costs for electric power generation from both fossil fuels and renewable. As it was proven through the survey the electricity production from renewable is far more expensive than fossil fuels so the need for subsidy is urgent and totally justified. This subsidy is actually a type of guarantee for feed in of electric power production to the national grid for a period of at least 20 years. However, the payment will be decreased annually by 1% in an effort to pressure investors to work profitably and then gain a gradual independence. So government grant levels are not important factor according to the owner's opinion and the other two managers, while waste team has noted this factor as 'important'. What is more in case that the unit operates with renewable raw material ,or cogenerates heat and power from liquid manure ,then an additional payment is guaranteed for encouraging commissioned decentralized units that operate to the benefit of rural development. In addition the interest rate on construction loan was rated as moderate factor for the investment. Under environmental or energy saving program, low interest loans for construction of a biogas unit would operate positively for small on farm biogas plants. In our case the unit of 1,5 Kilowatt that may be constructed needs a low interest rate that for most of these investments is low and stable. On the other hand large scale projects are financed by power utility companies and manufacturers.

Income from product and by-product sales were both determined as critical factors for the project's success. It is an undeniable fact that renewable energy constitutes a source of income for developers of the biogas unit, through the sale of energy products like electric power or thermal energy generated. Furthermore, through the biomass digestion apart from biogas, products such as cool air and water can be used to fulfil the unit's need for cooling and watering. What is more additional income can be achieved through the sale of by-products such as the organic digestate that is suitable for farming activities. In fact the cost, profits and even the capacity needed for the treatment of additional feedstock or other industrial wastes form local industries or units are totally different. According to the respondent, there are large quantities of waste available in the region that could be used for anaerobic treatment after singing a contract with the responsible companies. In financial analysis we will also examine the case of additional feedstock as primary resource and its results in the Net present value and the other economic indicators and to the projects viability and profitability as well.

In general we could say that the results of the analysis have proven a strong dependence and correlation of the adopting behaviour and implementation process with the socio- economic status of the investors. What is more, the anaerobic technology is still in a premature phase and need a lot of support from the local and national authorities in order to boost the interest for investing on renewable sources of energy. So promotion strategies are vital to overcome adoption constraints and establish the use of bioenergy projects.

4.2.3 Financing conditions and Policy Framework regulations

The policy framework includes the policies in a local, national and EU level along with legislations and regulations that act positively or negatively for the investment. Then the respondents were asked to indicate the degree that totally agree or disagree with the main financing and policy factors that influence the projects implementation. The existence of public money with the form of subsidies or grants was considered as neutral while others noted that they disagree that this factor can affect the biogas implementation projects. The reason for these answers is probably the facts we have already mentioned and the reduction of electricity sell price after a grant has been provided. What is more, all the respondents totally agreed with the statement that the favourable local region policy is essential for the successful adoption and implementation of anaerobic digestion systems. It is feared that in case of absence of efficient local policy for bioenergy development the whole initiative may be put at risk and fail at the end. Most of the times policy makers should be concerned about the security stock and its declining trends which constitute critical information for the formulation of effective policies. Efficient regional policies are vital for the sustainable development of biogas systems and the highlighting of stakeholders perceptions for policy framework may be proven rather useful for policy makers. So understanding of perceptions can both guarantee the implementation of effective policies and can eliminate conflicts and improve cooperation (Dwivedi and Alavalapati 2009). Some local initiatives such as community involvement with environmental programs, polices, cost sharing and tax deductibility for on-farm bioenergy activities are policy instruments essential to the successful investment on renewable forms of energy. The financing renewable energy remains an important and critical issue. Nowadays more and more potential investors are interested in investing on Green projects. The secure and adequate funding is a factor strongly related to biogas investments. The two basic tools for public funding are: the Development Law 3229/2004 as amended by article 37 of law 3522/2006 (Government Gazette). Moreover there is a set of regional finance programs for the period 2007-2013 under the Operational programme Competitiveness. Investments on RES can also receive financial support from other programs managed by the Ministry of Rural Development. The Investment Law 3299/2004 as amended by

Article 37 of Law 3522/2006 and new law 3908/2011 covers all private investments made in Greece (on all sectors of economic activity). The Law has a regional character and is specific for electricity and heat generation investments environmental protection or waste management projects. Furthermore, there is the program Competitiveness that draws resources from the fourth Community Support Framework and provides public support for RES and energy saving, substitution of conventional fuels and related to the energy operations. Apart from this there are other subsidies measures through the pricing policy as imposed by the law on RES 3851/2010.To go a bit further, the Commission underlines the need for a Directive on biogas with specific objectives in terms of biogas from the agricultural sector. In addition, national and regional planning in order to remove legislative and administrative obstacles of biogas implementation is essential.

Apart from regional policies favourable policies in a national level is essential too as our interviewees have respond that they ‘totally agree’ that favourable policies affect bioenergy projects to succeed. Another incentive would be the tax exempt of biogas from energy tax. In fact this tax relief compensates the difference between the production or operating costs and the market prices of biogas energy. Furthermore, other favourable policies such as the CO2 tax for vehicles fuels that exceed the limit of CO2 emissions, should encourage the investment on biogas among other competing renewable forms of energy (Poeschl et al, 2010,). However, tax reliefs and other incentives are not enough for the attainment of national environmental targets or to expand the utilization and establishment of renewable against conventional forms of energy. Other policies should be implemented as well. In a general effort to meet the national target of producing approximately 12.5% of electric power from renewable Greek government should regulate a set of measures and incentives so as to support the implementation phase of biogas projects. The right and efficient application of supportive strategies will result in high prospects for expanded biogas adoption. For instance green certificates, feed-in- tariff for electricity sold to the national grid work energy taxes work as a driver for expansion of renewable options. In general agreed national policy measures are critical to make bioenergy projects sufficiently competitive against fossil fuels and carbon based energy forms. Unfortunately usually there is a contradiction within the regional policies and the priorities of the ministry for the national target orientation. As Snakin et al, (2010) support in their article policy coherence is the most crucial factor for the development of bioenergy projects.

Furthermore, in addition to the aforementioned combination of national instruments, other measures in the European level such as carbon prices may be proven rather useful to boost the usage of renewable forms of technology. The European commission has set a series of measures such as the Kyoto Protocol, and a set of regulations for the right and environmental friendly operation of industries and on-farm activities. One of these regulations is the EU Nitrates Directive (91/676/EEC) designed to protect the surface and ground waters from the nitrates and other hazardous substances that stem form agricultural or animal breeding sources. So basically the installation and operation of anaerobic treatment schemes enable Greek farmers and owners of livestock units to comply with the regulation that requires new storage facilities, or transport of hazardous waste away from the company. These requirements have motivated the investment on biogas technology as a perfect solution for waste treatment, since building tanks for manure storage is not only cost prohibitive but inefficient too. Whereas the biogas systems is a valuable income source for the entrepreneur and a viable solution to meet the EU targets and regulations (Wilkinson, 2011). In addition, supportive funding European programs are vital for the boosting of interest on renewable investments.

In order to initiate and build biomass gasification plant a license and approval process is pre required. The Greek licensing procedure and mostly the approval of license for establishment of a unit in renewable is a complex bureaucratic procedure. The rigid and ambiguous mechanisms create an average time from the application day till the approval of approximately one year or 15 months to be more exact. The main steps are the planning permission from local authorities, the application and the final contract for connection with the grid network, permissions for the collection and treatment of organic and no organic hazardous waste, permissions for the planning and construction of the biogas unit and so on. What is more there are administrative barriers that cannot easily be overcome such as the number of authorities involved and the lack of coordination between them , the long lead times to obtain necessary permission along with the lack of sufficient knowledge and information about benefits of RES (Del Rio, 2011). Therefore it is natural, that the whole duration is really long till 24 months sometimes and the outcome of the procedure creates an uncertainty since those delays may have serious effects on projects profitability (Mejier et al, 2007). So the respondents totally agreed with the statement that favorable licensing procedure is essential for the project's implementation (Sioulas et al, 2008). To go a bit further as our respondents have mentioned they judge the Greek legislation as obstructive for the successful implementation of biogas projects, and especially during the permission process approval, an opinion mainly based and totally justified if we consider the bureaucratic rigid mechanisms.

What is more, the respondents agreed that the favourable credit conditions from banks and other investors is necessary for the mobilization of financial resources both internal and external. Only two form the respondents answered that this factor is neutral for the AD implementation. In general lack of trust to developers and investors, lack of awareness and understanding of biogas facilities and of their benefits affect the general image of bioenergy schemes to banks and other credit institutes. So badly organised processes, with a lot of shortcomings in the planning, development and communication phase may result in a denial of financial support by banks. What is more, industrial waste collectors face the problem of securing long term availability of raw material. This could be a problem because the waste recycling market is highly competitive and contracts with producers of waste are rarely for periods exceeding five years. Quite often, before a bank offers to finance the work of the biogas plant must demonstrate long-term economic success of the project through a calculation or a study in efficiency. So proofs about the entrepreneurs' capacities and experience along with guarantees for the safe and profitable project operation are essential for achievement of financial support from external sources.

4.2.4 Environmental factors

Possible reduction in carbon emissions and greenhouse gases was rated as a factor of critical importance or 'just important' for the decision to invest. In general the biogas systems result in significant curbing of greenhouse gas and carbon emissions if compared to the electricity generation in the conventional way. It is estimated from the literature and relevant techno-economic assessments (Thornley et al, 2009) that approximately a 90% reduction can be achieved per unit of electricity generated for units of relatively small capacity.

Concerning the general environmental benefits the respondents showed a positive response rate in agreement to the benefits of the project and their influence. Generally environmental organizations are supportive towards bioenergy projects but they will show resistance if the region is threatened. So these organizations face the dilemma to support or confront biogas units in case of problems like emissions, odours, traffic and so on (Rohacher et al, 2004). On the other hand, the anaerobic digestion process produces an odourless mixture of methane and carbon dioxide the so called biogas. The products and by products of anaerobic digestion such as the treated liquid can be stored without any odour concerns or other harmful environmental impacts. It has been proven that AD is a very efficient process for the elimination of excessive odours mainly due to the existence of anaerobic bacteria. A liquid collection system can also collect and avoid gas or fugitive dust emission that associate the manure and other waste treatment. In general the ability to use something invaluable such as waste as a primary source to produce something valuable such as combined heat and power and to leave as a by product a small amount of benign material has both environmental and social benefits.

What is more, the meeting of national targets was noted as very important while from others was noted as ‘moderate’ factor as the company strives to be compliant with Greek environmental laws and targets for greenhouse gas restriction, and boost of renewable energy used. Concerning the promotion of energy security, it is considered as an important factor for the company’s stakeholders since security stocks perseverance as conventional methods aren’t efficient, fossil fuel have limited sources while RES are infinite and yet unexploited**.**

In addition, in our case the respondents rated the factor ‘sense of community responsibility and environmental concern’ as of critical importance since their decision is taken under a care-based ethic and not just a reaction to financial constraints or opportunities. So there is a strong likelihood for those farmers’ entrepreneurs to be interested in implementing anaerobic digestion option for energy generation. As (Bailey et al, 2008) support, this behaviour may be partially due to the fact that there is a strong and significant correlation between farmers environmentally concerned and farmers interested and able to invest and adopt energy efficiency improvements and renewable energy technologies. Desire to be seen as green is a factor strongly relate with farmer values and cultural patterns of the company’s philosophy. In many cases the owners of livestock units see their landscape and the livestock capacity of their units as a productive asset able to offer profits to the company and not idleness. The solution of biomass treatment in order to generate energy as a marketable product can satisfy the needs for profits and improve the profile of the company as an environmental friendly unit both to the region and to a national level as well. Nevertheless, eco- system services and conservation energy methods can also improve the entrepreneur’s profile to the local authorities and to the environmental organizations of the region that otherwise may cause troubles to the efficient operation of the unit.

4.2.5 Demographic factors

Our respondents all of them are men with the owner to be approximately 55 years old and the rest of them belonging to the 41-50 age group. According to, some studies (Bailey et al, 2008), groups of people like younger persons, with medium to high income and with a good level of education background were more likely to be concerned about environmental friendly projects and investments. So those concerned about viable and eco-friendly options were eager to invest on renewable sources of energy and technologies. Additionally other surveys have concluded that middle and low income levels are less concerned about energy conservation systems and less likely to invest on bioenergy schemes. So in an effort to motivate those groups and change their behaviour, favourable policies that will raise awareness is essential. However as Mwirigi et al, (2009) state changes of behaviour and motivation are more difficult to be implemented in investors of higher ages.

It is difficult to convince farmers that are about to retire to make changes that provide long term benefit especially if they wish to stop operating in a short time. The length of the farmer's planning horizon is expected to influence adoption decisions for technologies that require a large capital investment. In the most of investments, age acts negatively in the decision making. In general the older the farmer the shorter will be the planning horizon, since every investor expects benefits in the short term. In our case the entrepreneur is in his middle 50 and does not plan to retire within the next five years so it is really possible to decide positively.

In general high levels of education motivate developers to invest on a biogas unit. The education variable ranges from high school to a doctoral title with our respondent to be university graduate. It is undeniable that education act as a motive for the decision, but its above all the experience and the personal characteristics of the developer such as culture and environmental concerns that motivate him. What is more income and business profits were highlighted as another positive contributor to the adoption of the technology as the relationship between adoption and income is significant and correlated. As Mwirigi et al stated, farm or livestock unit owners were more likely to adopt the technology if their income was medium or high. Moreover, another survey Bailey et al, (2008) suggest that moderate to high incomes in combination with education will contribute to openness in investing behaviour towards bioenergy schemes. Alternatively, limited income, act as a constraint for the implementation of technical innovations for biogas generation. So this implies that the need for an external source of financing such as external capital for the plant construction is urgent.

4.3 SWOT ANALYSIS

What is more, significant attention must be given to factors that influence the entrepreneurial decision process. In general, as Mejier et al (2007) support the investment decision on an anaerobic technology is influenced by the general context in which the investment is implemented. So factors both in the internal and the external environment may exert influence on the strategic decisions. Therefore in an attempt to understand the reasonable behind entrepreneurial action we have to expand the conceptual framework and to further analyse critical motives or constraints that affect investment behaviour. Under this framework a general description of the strengths, weaknesses, opportunities or threats of the biogas project will follow. The swot factors will contribute to a better understanding and sketching of the socio economic context that was described and analysed previously.

4.3.1 Strengths and advantages of biogas market

A biogas plant not only provides the ability to utilize the energy potential of biogas, but also contributes to the overall processing of waste and other organic fractions and residues produced during the breeding and slaughtering procedure. Biogas production has interrelated economic, environmental and social benefits, such as reduction in fossil fuel and oil imports, lower emissions of greenhouse gases (CO2, CH4, NOx), money saving and increased employment in the primary sector. The energy use of waste agricultural animal units, and specific industrial organic waste and organic municipal solid waste can become a central biogas plant with main products as biogas and organic fertilizer solution seems attractive for Greece.

Another strength is the cost effectiveness of the unit, that is mainly due to the fact that the raw material (agro-livestock waste, manure and slaughtering residues) is of zero or negative value and due to the fact that biogas unit's products have and undoubtedly business value. Biogas as a renewable source of energy falls on Law regulations concerning the provision for sale of electricity and the sale of surplus heat can yield additional revenue. Moreover, the production of solid organic residue can be considered as a source of revenue if the residue will be separated, evaporated and sold as a liquid or solid fertilizer. Significant economic and environmental benefits include: reduction of organic waste, self efficiency from renewable, reduction of odor pollution, economic saving and profits for the primary sector and so on and should be noted as major strengths as well. What is more, the availability of arable land and the availability of adequate quantity of feedstock and biomass for digestion is considered as a critical strength for the operation of the biogas scheme. Since the availability of livestock manure and of other organic fraction is a prerequisite for the viable function of the unit, the existence of adequate primary biomass resources works as an additional strength. In addition, the investment is considered rather profitable, as the returns on investments are guaranteed and secure. So the profitable investment is strength for the livestock and slaughterhouse unit.

In terms of personnel if we consider the answer given by the interviews we can conclude a similarity and cohesion of opinions and thoughts even though they are different people with different organizational responsibilities within the firm's structure. In case of various opinions the project would be rather complex to succeed since diverse opinions is too difficult to undertake the project (Mejier et al, 2007). It is without doubt that diverging opinions can hamper cooperation and may even result in a project abortion, while a common understanding and a good climate of cooperation and team working within the business environment will enable the attainment of goals.

4.3.2 Weaknesses of the biogas market

On a similar vein, lack of available land to build the biogas infrastructures or lack of adequate primary sources such as organic waste and animal manure could be considered as barriers and on the same time as weaknesses for a biomass digestion investment. In the case of slaughterhouse unit, output is a function of the volume of waste from the unit and is guaranteed by the existence of such substrates and upgrading of the unit. Also, the biomass sources are not only available but also adequate enough so it cannot be considered as a weakness.

Another barrier identified that should be noted as a significant weakness is the lack of technical expertise and support. Especially in the Greek bioenergy sector the lack of skilled and well-trained workers and experts for biogas system is a fact. Biogas schemes are totally new and innovative and pre-require a certain amount of skilled workforce such as experienced operators, installers, manufacturers and maintenance workers. However, the existence of skilled and well trained personnel is vital for the efficient operation of the biogas plant. Concerning the company, the lack of knowledge and technical expertise is an undeniable fact. The company does not possess knowledge and technical expertise neither on waste management issues nor on biogas schemes. In addition the slaughterhouse unit lacks of a well established and developed Green Team that would tackle with important issues such as energy or waste management. Therefore, there is not a coordinated communication and effort through the organization's levels in order to implement a common environmental policy or activity. As Welford (1998) suggests employees should be trained and encourage to understand waste issues and their role and responsibilities towards the greening processes. The ongoing training approach can play a key role on increasing employees' awareness towards green issues or waste management techniques. In addition high capital cost may operate as barriers and weaknesses that can overcome by co-financing costs, grants, and low interest funding.

4.3.3 Threats and barriers of biogas market

As possible obstacles for the installation of biogas plants in the Greek market we could mention social acceptance, competition form other renewable sources, bureaucracy and the general policy or financing framework that may discourage investments. Concerning social acceptance, Greece suffers from a high level of resistance from local communities and administrative bodies regarding the installation of renewable energy in general and biogas in our case. In addition, unfavorable policies towards implementation and diffusion of biogas schemes may constrain the development of bioenergy investments. The whole mechanism is also influenced by the lack of spatial context meaning that the administrative obstacles are compounded by the lack of planning. In general, the unfavorable policies in a regional, national or European level may act as a key constraint and threat for the efficient operation of biogas plants. Especially in our times where the economic crisis constitutes the most important barrier and threat for investments the need for access to soft and low interest loans, grants for infrastructures and facilities or premium tariffs and other economic incentives in now more than ever before urgent. In addition the Greek common agricultural policy is extremely weak and farm subsidies, quotas or support programmes are not well-established enough. So basically farmers or livestock breeders and general professionals with activities of the primary sector do not yet have sufficient incentives available to them in order to become energy producers on a large-scale. As another external threat we could mention bureaucracy and the intricate framework and licensing approvals that are too complicated and need a lot of effort to be simplified. For the operation of the biogas plant 1,2 mw / el there are stages on the licensing process to be implemented to advance the project to operational phase. More specifically the licensing process has a duration form approximately 18 to 24 months and requires the following actions:

- Request for connection to the grid network
- Expression supply connection to the power plant system
- Building permits
- Authorization to collect organic waste transport
- License management of hazardous and non-organic waste
- Association contract and sale of electricity to the system
- Veterinary license
- Request for temporary connection of the station with a PPC
- Connect the station with PPC
- Environmental conditions
- License production of PPC
- Authorized unit
- License installation unit

Concerning financing, the actual investment costs in connection with the threshold levels of expenditure and the maximum public grant potential recipients of state development tools

(Development3299/2004, NSRF) were hitherto hampered the financing RES projects. The biogas projects require high investments. The funding is therefore a key element to ensure the sustainability of the project. The financing scheme of a biogas plant project differs from country to country but generally used long-term soft loans. There are often common mortgages. The floating rate loans are low interest loans, which give the investor against inflation through he redefinition of unpaid debts in accordance with the inflation rate. The payback is over 20 tyears. This type of loan has proven to be most suitable for biogas plants, meet the requirements for long duration, low rate and low initial doses. The disadvantages of such loans is that raised by ordinary sales of bonds, the purchase price of the stock market, which entails a risk of devaluation, which can cause some uncertainty in the planning stage. As a final significant threat concerning the external environment of the investment we could mention the Greek bioenergy market which is still in an infancy stage with a slow developing rate of biogas projects. What is more, anaerobic technologies that are often untriable, unreliable and not always profitable make investors to hesitate about the profitability of their investment and the efficiency of energy options.

In addition the over approval and offering of permits make competition really high but currently do not regard the company as there are significant delays and backlog in the licensing process to other companies as well. The slow development of energy production from RES in Greece can easily be overcome by new institutional and legal framework and green growth

There is now a fairly mature energy market in Greece on biogas. Nevertheless it needs further strengthening as in the Greek energy industry exist a wide variety of key competitors. The monopoly on electricity power and provision from the Public Company of electricity (PPC) weakness the solid legal framework. The uniform regulation of waste disposal costs, thus increasing the cost of investments together with the political monopoly of PPC creates uncertainty and delays to investors. The main competitors are:

A) the construction industry for wastewater treatment
B) the new industry of biogas that is mainly based on conventional ways of biogas generation, high price of grain, old technologies that make these plants less efficient and more costly for maintenance.
C) Other competitors relative to biogas and electrical power production are the Helector Company that owns landfills in Ano Liosia in Athens and in the region of Tagarades in Thessaloniki, and the public water service in the island of Crete that possesses waste treatment facilities in the region of Chania and Heraklion. The position of market leader in biogas recovery in Greece currently holds the Company HELECTOR, but mainly

deals with the recovery of biogas from landfills and wastewater treatment and the processing and separation of municipal waste. The company has currently thrived in farming and industry recovery biogas because of the great economic potential for the company to create biogas in the landfill and the further evolution in landfills.

4.3.4 Opportunities and trends of the biogas market

As a first opportunity for the company we could mention the attractiveness of the growing bioenergy market. The new bioenergy market is totally new and with a variety of opportunities for diversifying of activities and job openings. It is a fact that, the declining support from European level and from the CAP in the national level has prompted farmers and other professional of the Greek primary sector to seek additional sources of income and to diversify their activities. Therefore these conditions have put on emphasis on initiatives on alternative forms of energy such as bioenergy (Wilkinson et al, 2011).

The constant improvement of the regulation framework and the sufficient financing conditions along with the development of a safe development framework are factors opportunities that determine the trends of the bio energy growing market. More specifically the current regulation for RES promotion along with the subsidies for biogas and other similar projects are factors that favour the development of biogas sector. In addition, the imposable need for the environment protection and the European directives as proposed by Kyoto Protocol. Also new financing tools for investments on green development and rationale use of environmental sources have also pushed the market to an opening. However these changes happen in a slow rate and are not yet apparent since the market is in its first steps. In addition the promotion of RES in Greece is base upon its high potential that still remains unexploited and to the national priorities for increase of electricity generation from renewable. The main mechanisms for the biogas market support are apart from financing framework and funding programs the general decisions and policies for the promotion of biogas production and combined heat and power from industries. What is more it is assumed that the demand for electricity production has increased by 50% while there is a forecast for higher demand levels for the 3-4 years. The investment interest is expected to boost for the foundation of combined heat and power stations. So it is an undeniable fact that, positive perspectives for the biogas market are created that will increase the electricity production from biogas. To al these factors the undeniable innovative nature of the biogas schemes and the whole idea for biogas investment is a new opportunity for the Greek biogas sector.

Table 4.3: Swot Analysis

STRENGTHS	WEAKNESSES
1.Contribution to the environmental protection 2. Maximum productivity performance 3. Contemporary equipment 4.capable and well performing staff 5.Certain costumer basis for certain period 6. Secured raw materials	1.Small capacity of the project 2. Small amount of electricity produced 3. Cost of funding and financing 4. time-consuming and bureaucratic licensing process
OPPORTUNITIES	**THREATS**
1. European commision's decisions and legislation for environmental protection 2. Current legislative framework – new law for RES 3. Inevitable run out of conventional energy sources 4. Considerable biomass potential aspect in Greece 5.Continuous demand for bioenergy products 6. Investment framework with a focus on green development	1. Approval-allowance of too many production permits for other competitive RES projects 2. Possible entrance for more enterprises-competitors in the industry in a few years 3.Slow growth and evolution of R.E.S. production in Greece

As propositions for the company in order to overcome weakness or threat we could mention that the successful function is ensured by the available organic feedstock that the company possesses. What are more cooperation's and private and investor's funding is vital.

The Cooperators and partner's network and previous experience for the deduction of bureaucracy and time are necessary to overcome bureaucratic problems that may slow down the procedure. There are already delays and abeyances in the licensing procedure so patience is vital.

Chapter 5 Financial Analysis

5.1 PROJECT SUGGESTION AND IDENTIFICATION

The previous section with the interview and the analysis part have highlighted the profile of the company, the main waste issues and problems that the stakeholders have to confront and the availability of huge amount of unexploited feedstock and other biomass resources. What is more, the general socio economic and legal context of a biogas investment was defined along with the main factors and perceptions of stakeholders that may have an impact on decision making process for investing on a biogas scheme. The main objectives of the livestock and slaughterhouse unit in the region of Larissa is to diversify its activities in the developing bioenergy market and on the same time to reduce the environmental problems associated with the waste and manure treatment. As a proactive and viable solution to these environmental problems and risks the company shall consider the possibility of installing an anaerobic digestion scheme and mechanism suitable to biologically treat animal manure and other waste for generation of biogas, electric power and heat. The implementation of a biogas unit of 1.2 MW/el capacity constitutes an alternative and efficient investment suggestion for the company's presence and identity in the region of Larissa and Thessaly Prefecture. The central policy of the project is to create a route of development in the bioenergy industry through the reasonable waste treatment for the generation of clean energy with the minimal environmental impacts. The biogas unit of the livestock unit and slaughterhouse in Larissa will operate efficiently in an effort to offer environmental friendly biogas generation, at low prices and establish in this way biogas as a competitive source of energy in the bioenergy sector.

Under this concept the main aims and objectives of the project are to utilize waste streams and to produce bioenergy in an effort to achieve a certain level of self energy efficiency and profitability of the company. To go a bit further the projects objectives should be coherent with the national and European targets and frameworks and contribute in this way to the broad goals and environmental policies. The biogas unit will have as an object and central activity the management, treatment and transport of every kind of organic waste residues form slaughtering along with by products from livestock units. The unit will generate innovative products such as biogas, heat and electric power through the anaerobic digestion of biomass sources. Power capacity of 1,2 MW will be achieved through the efficient collection and processing of biogas for maximum capacity of production. More specifically, the planned biogas plant shall be operated with the input material of liquid manure from swines and cattles manure, solid fats, blood and other liquid residues from slaughterhouse and food waste (total feedstock of about 71.000 tonnes/year). These input materials come mainly from the company's plant and everyday operations.

The optimal location for a biogas plant is determined by both environmental regulations and economic factors. According to environmental legislation a biogas facility is allowed to be constructed far from water or nature protection areas. What is more, noise, odours or potential traffic caused by the units operation may arise concerns and worries in the region. So local acceptance and reassurance that the project will not have harmful impacts for the region and the landscape is essential for the implementation of biogas investment. Furthermore, economic facts such as the road infrastructure or the total transport costs of feedstock or of final products must be taken into consideration too (Poeschl et al, 2011). In general these kinds of projects and facilities are mainly located in areas with high levels of livestock concentration, where there are actually running on farm or centralized treatment facilities of organic waste or pig slurry with high processing capacity. In our case the unit of biogas production will operate effectively on farm, meaning in the existent land and infrastructures of the slaughterhouse in the region of Larissa. The biogas scheme will be constructed adjacent ot the main facilities of the livestock unit so there will be minimal investment on trucking and transportation infrastructure, required to collect the animal manure and other waste from the main building and deliver it to the digester. Additionally this plant site has a well design road infrastructure and access so traffic problems can be overcome. Then the substation of PPC is located nearby to the plant so distribution of electric power will be easy. What is more the site is well away form located or business areas so social disapproval can be avoided.

Concerning the project's impacts, the investment of this type of technology will not only reduce environmental risks from greenhouse gas emissions and other pathogens but will also generate financial revenues for the company. Additionally the biogas technical equipment offers an opportunity of mixing waste and manure to generate biogas for the units energy needs and to distribute nutrients for farming applications into the local arable lands. The general benefits and impacts of the project include, environmental benefits both for the company and the region as well, boosting in revenues and economic contribution to the company and society well being and perhaps new job openings and economic opportunities for the community as well.

Considering benefits in a industry, regional and national level it is essential to identify the boundaries of our economic analysis of the project. More specifically an energy plant or waste management project is mostly of local interest but can be examined and discussed from a broader perspective as a part of an integrated network and can be applied in similar cases of companies in a local or even national level.

5.2 FEASIBILITY ANALYSIS

5.2.1 Phases of the programming-planning and implementation of the project

To start scheduling and implementing a biogas project the following steps and processes must be done. First of all, comes the idea of the project and the project identification as it has already been described above and then a feasibility study follows. Under the right conditions in terms of requirements in inputs, technical equipment and financial conditions or agreement for waste supplies the project can be implemented successfully. Then a detailed planning of the whole production process and all the procedures followed must be determined and examined by the project' managers. To continue the licensing process is a very important and usually time spending procedure as in the framework of permits to generate electric power, and independent power producer must apply to the Hellenic Regulation Authority for Energy (RAE) for a biogas plant and wait for approximately 14 months the approval. Of course after the permission is achieved, the biogas scheme can be constructed, operated and be maintained, while possibilities for expansion or reinvestment can be reexamined for further profitability.

The first step in developing an idea to install a biogas project is to determine and find out and list the available types and quantities of organic wastes that can serve as a primary source for the project in the region. There are two main categories of biomass resources that can be used as feedstock in a biogas plant. The first category include products derived from farms and agricultural or animal breeding activities such as animal feces, dung manure, pulp, energy crops, or other residues from vegetable farm and agricultural waste. The animal manure and the energy crops are the most common primary sources for a biogas plant the second category consists of organic waste from the industry such as municipal solid waste and waste form the food industry or pharmaceutical industry. The suitability of raw materials must be estimated in terms of potentiality in methane, the digestibility, possible contamination with chemical, biological or physical contaminants and also in economic terms (eg price, spends collection and transport). The successful programming and planning of a biogas project presupposes the decision of the type of the investment, meaning on farm or centralized biogas scheme. In the case of one supplier, the farm occupies the needed amounts of biomass sources that have to be adequate in order to produce sufficient energy amounts. In the case of many suppliers, a group of farmers of the same region may cooperate and co-invest in a centralized biomass digestion unit. In both cases the reassurance of adequate feedstock and substrates for the fermentation and the efficient operation of the digester. Concerning the second case , where the unit with actually operate a centralized unit of combine heat and power generation, the following steps are necessary for the smooth and effective duration of contracts: guaranteed amount of supply and ensured quality of delivered biomass, regulated payment along with the delivery of the load and so on.

It is an undeniable fact that the key issue to establish a bioenergy scheme is to secure sufficient waste and biomass resources. Given this fact it is not surprising that the existence of abundant primary sources or contracts with potential suppliers is necessary for the development of biogas facilities. The combined heat and power installations with a total capacity between 1 to 3 MWe are the typical on farm biogas schemes. These facilities are mainly fed up with a variety of different substrates such as farm livestock manures, liquids from slaughtering and industrial organic wastes and solid fats from food processing activities. The primary feedstock suitable for the anaerobic digestion is animal manure, such as cattle manure and dung, pig slurry, which are really harmful substances. Apart from these solid fats, other waste and liquid residues from slaughtering constitute secondary feedstock. What is more, according to the primary data gathered during the interview part with the company's stakeholders the main primary sources are totally suitable for anaerobic treatment. The physical composition and the high solids content of the manure and other feedstock used create all the suitable conditions for more efficient and greater biogas generation. The suitability of primary sources is not only due to feedstock characteristics but due to its energy efficiency content as well. In addition the feasibility of the project strongly depends on the energy outputs that can substitute costly fuels or fertilizers and conventional energy sources as well. This is the real value of biogas. Apart from tonnes of waste produced per day or per year, data concerning the content in dry substance, methane and biogas, electrical and thermal efficiencies were also provided by the company and are reflected in the following table.

Table 5.1: Energy efficiency of substrates

Breeded animals Substrate	Daily quantity of waste in tones t/d	Annual quantity of waste in tones t/a	DS Tones per day t / d	Dry organic substance (oDS) in % of DS	oDS Tones per day T / d	Efficiency of gas in m³/kg of oDS	Daily efficiency of gas in m³/d	Methane in %	Energy potential per day kwh/d	Electrical efficiency 40% of energy potential kwh/d el	Thermal Efficiency 42% of energy potential kwh/d th
2.500 Swines	125,00	45.625	8,750	86	7,525	0,50	3.762	60	22.572	376,20	395,01
3.000 Cows	51	18.615	15,300	80	12,240	0,45	5.508	55	30.294	504,90	530,14
Fat solid	1	365	0,780	90	702	1,1	772	57	4.400	73,33	77,00
Slaughterhouse waste	19,18	7.000	3.836	84	3.222	0,6	1.933	60	11.598	193,30	202,96
Total	196,18	71.605	28,666	82,6	23,689	0,5	11.975	57,5	68.864	1.147,73	1.205,11

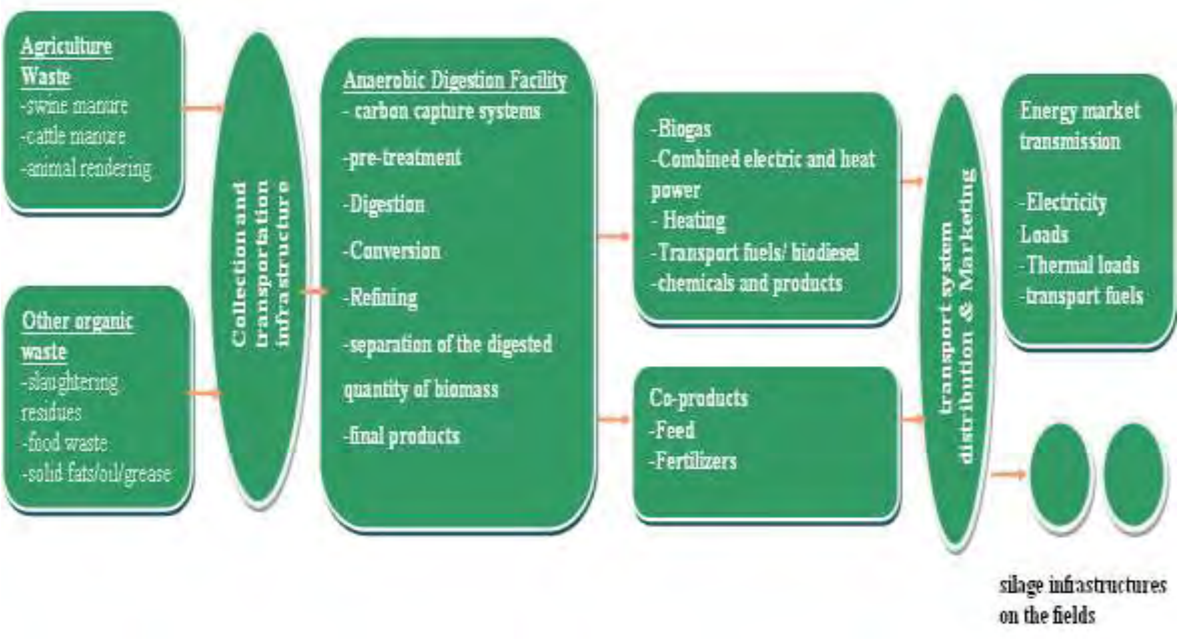
5.2.2 Biogas production potential

If we take into account the primary data and the efficiencies estimated for the company's substrates along with the following table with the general efficiencies for cattle and swine manure we can easily assume and further conclude that approximately 2500 pigs result in an energy potential of 22572 Kwh/day and 376.2 Kwh/day of electrical efficiency. The daily efficiency in gas is also very high at 3762 m³/ day while for cows is calculated at 5508 m³/ day. Similarly, the energy potential and electrical efficiency are also high arriving at 504.9 Kwh/day. This plant is treating a total of 196,18 tonnes of slurry per day and having a potential capacity of 1147,73 kwh of electricity/day. The organic loading rate of the plant ranged from 20000 to 23000 tones/ day, and the daily average yield ranged from 10.000 to 11000 of biogas/m3 of slurry. Therefore, in order to define the suitable size of facilities in MW of electricity power it is necessary to examine the primary sources in terms of content of dry substance, biogas production and potential of electricity generation. (Brown et al, 2007)

Nearby livestock units of the region produce huge amounts of degradable organic substance and can also be considered as suppliers for the biogas unit. Primary data concerning additional substrates from local companies were provided by stakeholders during the interview. These additional sources entail apart from cattle and swine manure, sheep manure, energy crops, waste from dairy, food and drink industry and additional slaughtering residues. However, the company has to decide if it will accept additional amounts of feedstock from neighbour livestock units with a tipping fee as a payment but with additional quantities of energy produced. The case of procuring with additional feedstock supplies will be further examined as an alternative scenario in the sensitivity analysis part. There we will have the opportunity to identify and discuss huge differences in the financial results due to a small difference in the inputs and the capacity of the digester as well.

The company with the construction of the on farm power plant in its land will be established as an independent power producer and a self sufficient energy unit. The products of the biomass digestion will be a tri-generation of electricity, heat and cooling power. in addition the anaerobic digestion of animal manure can both generate biogas and energy and on the same time reduce the environmental issues associated with waste that constitute a serious threat. Electric power will be supplied to the national grid but will be further exploited to meet energy needs of the unit and of other local units. What is more, a combined biogas heat and power scheme can recover hot water or steam from the digester mechanism and to generate heat and power energy that are mainly used to maintain optimal temperature conditions for anaerobic digestion facilities. An amount of the generated heat can be further used to heat water of the digester up to 90oC or to sterilize the digestate. What is more, the thermal energy generated can also be transported off-site for heating needs of regional farms or industrial uses and for domestic applications as well. (Yiridoe et al, 2009).

Fig 5.1: The main streams and system of an on farm biogas facility (taken from White Paper Big East)



In addition, by-products such as the liquid digestate can be applied as a nutrient fertilizer for local farms or can be further processed to generate organic compost suitable for soil fertility applications or amendments (Dagnall and Pegg, 2000). The above scheme is actually a representation and an outline of the total flow and integrated network and pathways in an on farm biogas facility like the one that we propose in this paper.

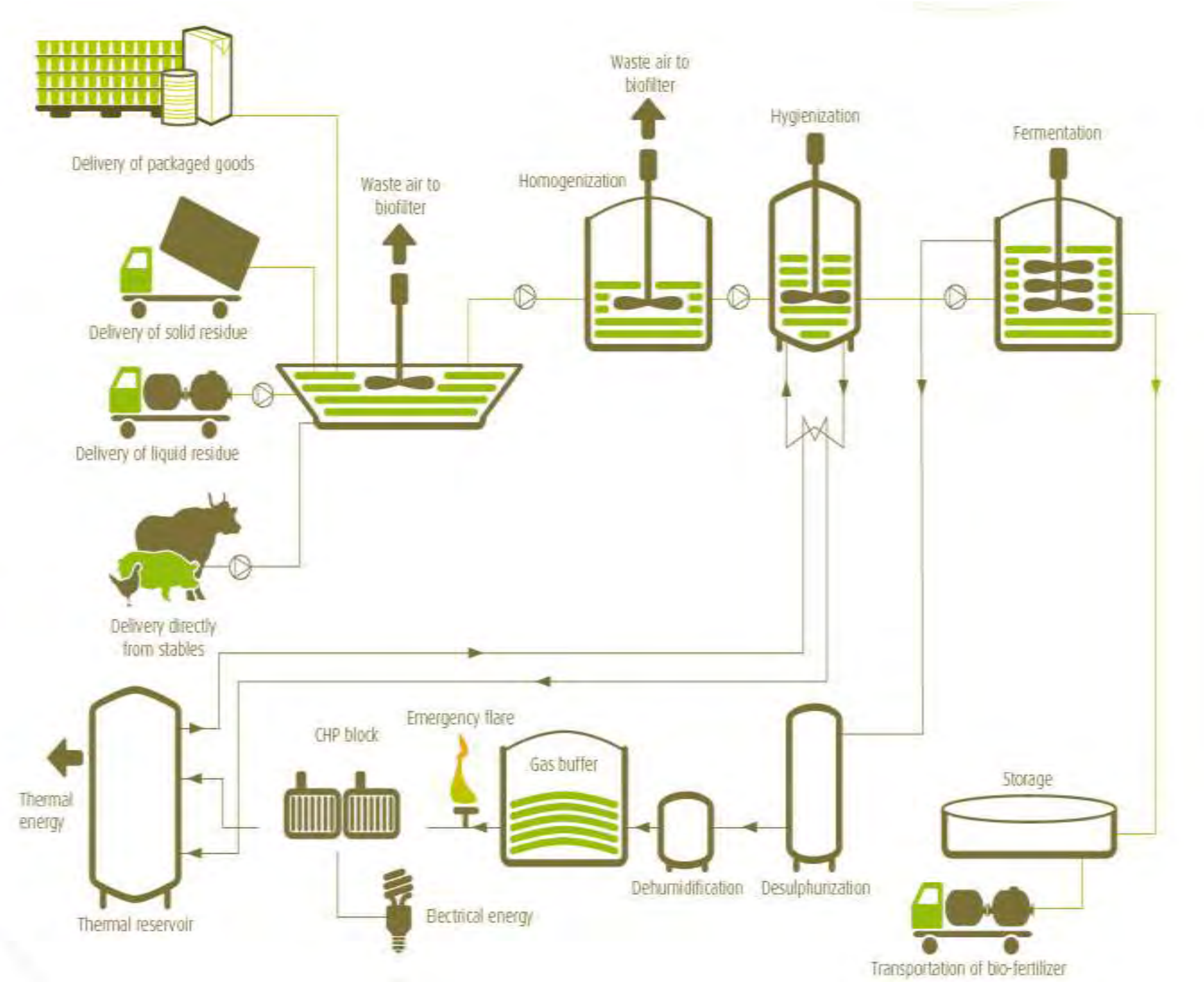
In this way the on farm digestion process is a whole integrated bioenergy production system through the treatment of organic waste and recycle of nutrient substances. The biogas system can prove that the whole process creates environmental and economic benefits both for farmers and the society as well. Some of those are the generation of renewable source of energy, the safe and environmental recycling of manure and other organic waste and the creation of suitable fertilizer for soil amendment.

As other co-benefits of biogas production we could mention reduction of pathogen micro organisms, curbing of greenhouse gasses emissions and manure odours and general economic benefits for the unit (Brown et al, 2007). Other operational advantages include, less dependence on energy imports from other countries as electricity from biogas can be produced within 24 hours and the unit is self energy sufficient. In addition, this continuous source of heat and power guarantees constant prices and neutral form carbon. The gas can be easily stored and further processed to produce organic fertilizer not harmful to the groundwater horizon.

5.2.3 Technical equipment and layout of the anaerobic digestion

An anaerobic digester which is the heart of anaerobic digestion is actually a vessel with a suitable size to grow and maintain a population of anaerobic bacteria that feed on organic wastes placed in the unit. These methane bacteria are called anaerobic because they grow with the lack of oxygen, feed on and decompose organic waste, and generate methane which as a useful fuel by-product. The anaerobic digestion process can be simply grouped into four steps. The first step is the transport, delivery, storage and pre-treatment of feedstock, solid or liquid residues and animal manure. As a second step the waste is homogenized, hygienized, and fermented which is the sequential break down and decomposition of manure and other waste by groups of bacteria, and it is easily recognisable due to intense manure odours. Then, the product generated form the first phase is further processed by methane bacteria in order to produce biogas which is a mixture of methane and carbon dioxide. Then biogas is desulfurized and is transferred to the CHP block to produce electricity and to the thermal reservoir to produce thermal power. To continue, the digestate product that is produced along with the biogas is stored and can be furthered processed with the separator to liquid and solid substances. Then wet fertilizer can be produced or compost that is further stored. Finally biogas is stored and can be furthered treated to produce electrical, thermal power or biofuels and other by products.

Fig. 5.2: Anaerobic digestion phases



Source:Big East, CRES,2010

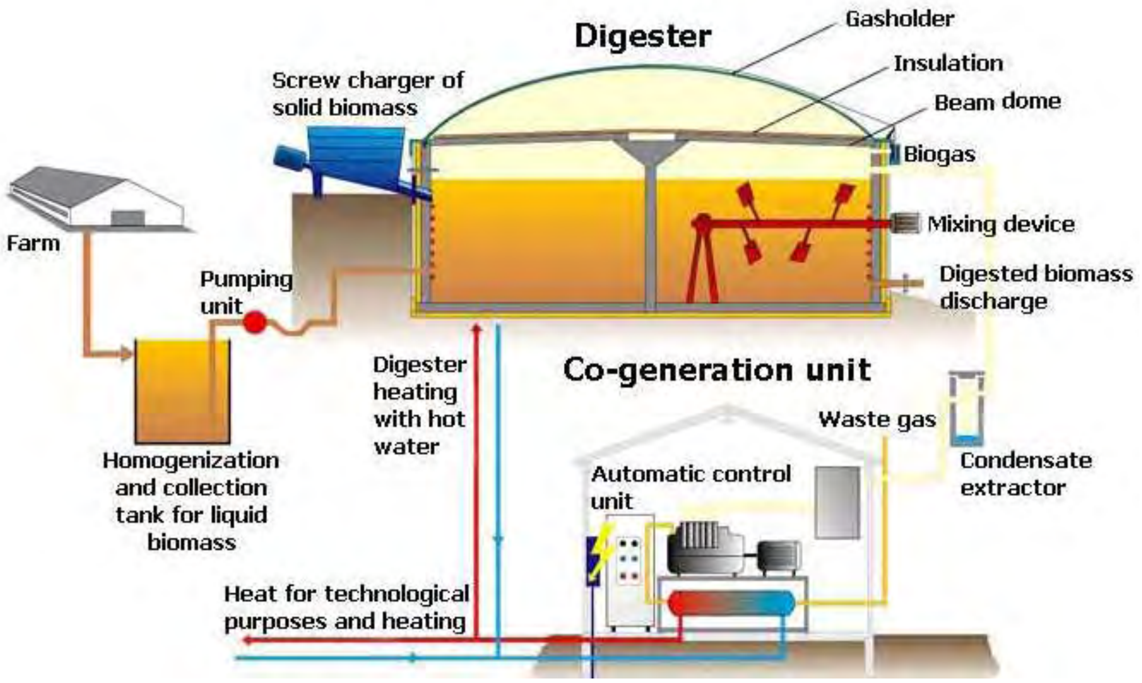
The main components of an anaerobic digester system includes manure collection, pre-treatment, an anaerobic digester vessel, biogas recovery system, and biogas handling and use equipment. In general the main mechanical components of on-farm biogas plants derive mainly from the agricultural equipment. For instance, the animal feed screw-mixer is used to convey feedstock into the digesters. However, for swine operations with a flush manure collection system a covered lagoon digester is more suitable for converting manure slurry to energy than a mix digester. After waste enters to the anaerobic lagoon they are separated form solids through a solid liquid separator mechanism. On the other hand, large-scale biogas plants that handle with non-standard feedstock, such as slaughter house residues, use more reliable and innovative technical equipment. The main technical components for gas production are a steam boiler, an air-heater, a cooler and a gasifier. As additional equipment for the AD system are an air compressor, two heat exchangers, a gas turbine and a steam turbine. (Poeschl et al, 2010) What is more, a manure storage tank is assumed. The majority of biogas stations where the biomass quantities are supplied have a limited space and facilities for storage. In the case of energy crops that are used as biomass due to their relatively short period of harvesting and their large quantities the need for adequate storage room is essential. In the case of animal manure and other substrates the large amounts produced per day also require storage facilities or intermediate points that can meet the supply needs over the course of the year. More specifically the slaughterhouse unit of Larissa occupies around 23 square meters of arable land while for the 1,5 MW facilities the company need to possess around 17 to 18 square meters. Furthermore, the size of the storage space is very important for the efficient logistic operation and the transport arrangements. In case of small on site stockholding the importance of rapid and flexible transport system and the spread of deliveries to meet a few days supply is critical (Brown et al, 1998)

More specifically, the biogas plant slaughterhouses Larissa will consist of the following main components as described below:

- feed substrate
- Primary unit of sharpening by using the solid-liquid-fermentation process
- Stir in raw upsurge
- Collector of stones and sand
- Feed pump
- Heating system of the primary sharpening
- Bioreactor
- Heating and Power system of the bioreactor
- Area of secondary fermentation
- collector gas
- Level of membrane gas
- Ventilation, heat holding roof (optional)
- Housing resistant to rain, UV and weather
- Central control system
- central cogeneration plant during the heat

- distribution of heat
- Drainage and removal of digested substrate
- internal and external insulation

Fig.5.3: Technical components of the anaerobic digestion scheme



Source:Big East, CRES,2010

Based on the substrates and the quantities given on the above table, the biogas plant is modeled and further analyzed as follows:

Primary unit of sharpening

The primary sharpening is the solid-liquid-fermentation process adjusted for time spent up to 2 days. Typically, the adequate sharpening has an average duration of 8 to 12 hours. The unit is supplied with about 240 m3 substrate per day with a safety stock of 15%. So we can easily calculate the volume of feedstock in the sharpening system after 2 days. The optimal operational temperature is approximately 25 oC. The fully automated control system of primary sharpening for temperature control, feeding times and quantities of power is part of the central system for control unit.

Anaerobic Digester

An anaerobic digester is basically a containment vessel designed to improve the growth of methane bacteria. The manure characteristics and the feedstock collection process basically influence the type of technology and digester that will be used. The digester can be a simple tank or a more complex scheme, may be vertical and totally mixed or unmixed, but it should be flexible and suitable for the process. In addition the digester operates at suitable temperature range, heated by exchangers and stirred by blowing biogas to the bottom of the digester.The sizing of the bioreactor is especially important in order to compute and reassure adequate reserves due to the variability in the supply and quality of the substrate. The changes in the climate conditions may affect the content of dry and wet substance in the animal effluent resulting in variations in biogas efficiency. Nevertheless, the low solid matter in swine manure and the losses in efficiency during the entrance of new inputs can be easily overcome with the suitable bioreactor size. What is more with the right configuration of the digestion space the treatment of dry organic substance will be easier and more efficient. Furthermore apart from, the bioreactor and the sharpening unit there is secondary unit for treatment fermentation and additional storage of 8 more days extra time spent. As Wilkinson (2011), argues a 1 MWe biogas facility with a retention time of 20 days requires a bioreactor capacity of 7500 m3 to handle a sufficient amount of blended, wet feedstock. (Brown et al, 2007). The digester is equipped with a completely indestructible mixing system, which needs no maintenance. Through this system stirred and dissolved sediment and surface layers are stirred and dissolved. This type of mixing does not destroy but retains the structure of the methane bacteria in the bioreactor. The bioreactor also includes a heating system to maintain optimal temperatures for the efficient operation of the biogas scheme.

Storage and preparation for digestion of the substrates.

In the facilities there will be a storage tank of adequate holding capacity for slurry and other wet or blood residues form slaughtering that can be kept for approximately 8 to 10 days. There will also exist an additional storage of solid substrate like animal waste dung and so on and a specific line for mixing the dry and wet substances as a pretreatment procedure. The pretreatment can be achieved to a mixing tank or a solid separator and will be used to adjust slurry and manure items so as to be suitable for the process requirements

In the biogas unit the digested substrate is injected into the area of secondary fermentation which surrounds the bioreactor. Due to the time spent in this area, which is also covered by the membrane gas collection significant quantities of methane can still be released, fact that contributes to better performance of the unit. Apart from this the space of secondary fermentation can be co calculated as an additional storage tank of the fermented substrate. Then the collector of biogas covers the bioreactor and the secondary fermentation space and the biogas can be filtered through sensors and filters. Biogas is then compressed and pumped and can be further used as for heating, cooling or electrical generation.To continue, through biogas desulfurization, sulfur is created in the substrate that can be further processed to produce fertilizer.

5.3 FINANCIAL ANALYSIS

It is an undeniable fact that, both economic and financial analysis estimates the profitability of a project and the viability of the investment. However, economic analysis measures the project’s effect on a national level while the financial analysis estimates the profitability of a biogas operating entity in a microeconomic level. The approach of biogas scheme economic evaluation as a macroeconomic examines the investment in the wider context of the economy's development policies whereas from a microeconomic point of view specific local economic conditions are considered. In our case, we will occupy with investments at an on-farm level in the district of Larissa, but a widespread adoption in the region would affect positively the total energy balance of the country. As a first step we aim at describing the wider political institutional and the socio-economic context of the bioenergy projects. Nevertheless, this ‘contextualization’ is prior to examine how applicable different scenarios and contexts especially if we consider drivers or barriers of the investment in regional and national levels. In general, during the decision making process for a new technology adoption, entrepreneurs examine the relation between expected revenues and costs and if the former exceeds the latter they decide to invest. So basically this study, will serve as a cost- benefit guide to explain the way for a successful biogas investment. From a financial or private accounting stance, costs and revenues are calculated from the investor’s perspective, market prices are used and other assumptions were made. Finally the overall profitability was measured using widely acceptable key indicators such as net present value, internal rate of return and break even point. If a project is not financially sustainable, economic benefits will not be realized. (Tran et al, 2009). In our case the economic evaluation of the combined heat and power scheme for the livestock and slaughterhouse unit in Larissa is necessary to assess the viability and attractiveness of the examined project. What is more financial analysis can use decision support systems and tools in order to provide useful and sufficient information for managers. They can cost effectively urge entrepreneurs or investors to choose and invest on a renewable technology. (Yiridoe et al, 2009)

5.3.1 Assumptions and economic variables

It is without doubt that the following assumptions must be done in order to proceed to the economic and financial evaluation of the project. The data and information were developed after the interview and the gathering of all relevant information and are representative and realistic estimates of the basic variables and parameters needed for the financial calculations. Possible standard conditions such as the following must be considered:

• Supply of biomass, manure and other primary organic waste. The relevant quantities of the substrates have be given and are reflected on the above table analytically

• Main cost components that include the main cost parameter/s of the biogas scheme

• Cost, supply and storage of the biomass and the primary sources.

• Total investment costs: represent the initial cost of investment in Euro for every technical component and for the licensing process aw well.

• Total operating costs: are in fact the costs per unit of production

• Revenues from sales of products like electricity and fertilizer

• Main geographical area for constructing the biogas digestion and storage facilities are assumed to be, the land possessed by the unit which is approximately 23 square meters and almost 16 of them will be used for the infrastructure.

• Time horizon for construction, operation and payback period of the unit: for the licensing procedure almost 14 months are required while the construction period is assumed for 1 year

• Finance: possible grants, loans or subsidies as alternative financing schemes could be considered in our case, however for reasons of simplicity we assume that the financing of the unit comes from the same capitals of the company.

The economics for producing either gas or combined heat and electricity were evaluated at a biomass feed rate of 196,18 tonnes per day and a capacity of approximately 1,2 MW per day of operation. The period for construction was assumed to have duration of 1 or 2 years the most. While projects of that scale are planned to operate and be efficient for a time horizon of approximately 20 to 25 years, we assume that the plant life is 25 years. In this 25-year period for the NPV calculation, the connection with the PPC is guaranteed for the first 10 years with a possibility of expansion for the next 10 years. Additionally the first year of the investment is assumed to be the year 2011, and the payback period is almost 3 years so we consider the revenues for the years 2012, 2013 and 2014 respectively. The plant was assumed to operate around 334 days per year and the hours of the year are 8760 while we assume the total operating hours to be 8000h.

Furthermore, no allowance or assumption is made for payment of taxes or depreciation, except as is allowed for setting a value for the discounted rate. (Gasol et al,2008). The interest rate was set to be 10 %.

Time horizon

The first logical step to estimate and plan the investment costs is to define the time horizon for the project. By time horizon we mean the number of years that will be forecasted or the useful life that have to be long enough to encompass the initial costs.

Costs

Capital costs for the licensing and the constructing period include analytically:
The licensing procedure and the building permits based on prices form the constructing market and manufacturers. The planning and supervision of the project form professionals were assumed based on the normal salaries of project managers and supervisors. Additionally, connection charges and grid connection issues are prices taken from CRES and the PPC for the Greek biogas market. Concerning the manufacturing costs, some assumptions were made for the cost of the technical components based on the literature and relevant information for similar units of the same capacity. (McIlveen-Wright et al,2011, Amigun, and von Blottnitz,2010, C. Walla_, W. Schneeberger,2008). The grass values of capital costs were taken into account for this analysis. This means that the cost included building, contingency and other additional costs.

Operational costs include the basic fixed costs which are the insurance cost of the unit, unpredicted expenses and cost of biologically supervision of the unit. The cost of insurance unit are calculated by using a rate of 0, 5 % on the initial capital costs so approximately 21000 €/a. The unpredicted expense were assumed to be stable and on average 24000 for each of the three following years. The maintenance costs for the technical equipment were assumed to be 135.000 for the maintenance of facilities, digester while the cost for the biological control of the unit is estimated at 30000. In addition, the cost of payroll personnel's salaries is estimated based on the number of workers. Two of them are truck drivers and three of them will be occupied in the unit so a total of 5 workers result in a total payroll expense of 120.200.

Then variable costs such as cost of operation of the unit, the cost of collection and transport of primary sources and the expenses for the organizations of local administration.Unit operating costs (PPC): Considering the units operational expenses for the electric power sale to PPC we can assume that for a daily operation of 11 hours approximately 90 kw/h are consumed and annually 788.400 kW. So for an electric power price of 0,088 €/kW the annual cost paid to the PPC is 69.380. In a similar way the costs for operation can be computed for the following years of 2013,2014 with an additional price change of 5%.The cost of collection &

transportation of raw Materials by taking into consideration the two trucks the number of transports, and the fuel price will be assumed at a level of 56000 for 2012. Additionally the expenses for local authorities are estimated on a base of 3% from the electricity sales. So they will be almost 71000 for 2012 and for the rest of the years can be computed respectively. It is without doubt that financing scenarios or subsidy options applicable in the examined case study could be taken into consideration but for practical reasons the computation of economic indices and variables are based mainly on the owners capital investment costs.

Revenues

An important criterion for the viability of any electric power generation unit installation is the cost of energy per KWh produced, in other words the sale price for the quantities of electricity produced by the biogas scheme in KW or MW per hour. (Katsigiannis and Papadopoulos, 2005). It has to be noted that the electric power prices and the energy prices in general are based on the latest PPC's electricity prices, as noted by the CRES and the white paper. What is more concerning the pricing policy there are two cases: the autoproducer's tariff system where there is same pricing system for the electricity surplus that they sell to the grid with the in depended power producers that they are selling their entire production to the grid. There are also certain sales contract agreements for R.E.S production of electrical power with duration of 10 years and a capability of expansion for another 10 years.

More specifically concerning the sales of electric power the capacity of the unit is approximately 1,2 MW or 1200 KWh. However, taking into consideration the 40% of electrical efficiency and potential losses during the operation and the fermentation we assume an average amount of electricity produce of 1032 kw/h. What is more, the year has approximately 8760 hours but we assume with the idle time and maintenance hours around 8000 hours of efficient production.

So the amount of energy produced annually can be easily computed as:

1032 kw/h * 8000h= 8.256.000 kw/a.

To go a bit further the price of energy per kw produced is 253 €/MW or 0.253 €/kW

So with an easy calculation the total revenues for the whole year are:

8.256.000* 0,253= 2.088.768 €/a

To continue the combined heat and power scheme, apart form electric power it can also generate as already mentioned , organic fertilizer or compost that can be sold to regional farms for soil amendment and other agricultural improvements of activities. We assume that approximately 37 tonnes/ per day are produced and annually around 13.505 tones. In addition we assume a typical price of 20 €/ tone so our annual profits from the digestate sales will be around 270.100

Concerning the possible sales form utilization of thermal power for industrial cooling or heating purposes or for fibre drying it is without doubt that a sufficient amount of thermal energy is produced. In different cases, it could be transferred through a pipe system to regional dairy or livestock units or even greenhouses, but in our case the additional costs for these constructing facilities or network are not considered. However, we will not assume any sell price since the generated heat will used only to cover the thermal needs of the biogas facilities. Therefore a total of 2.358.868 euros are the total revenues produced from the power and fertilizer sales for the biogas unit.

Table 5.2: economic indices and variables

Economic indices and parameters	**Value**	**Units**
Initial investment year	2011	year
Economic plant life	25	years
Construction period	1	years
Payback period	3	years
Operating hours	8000	h/year
Operating days	333	d/year
Inflation rate	1,5 to 2	%
Energy price	0,253	€/kwh
Increase of energy price	0	%/year
Fertilizer price	20	€/tones
Personnel	5 workers	
Trucks used	2	
Insurance costs (% TCI)	0,5%	%/year
Increase of operating costs	5%	%/year

Financing

The biogas projects require high investments. The funding is therefore a key element to ensure the sustainability of the project. The financing scheme of a biogas plant project differs from country to country but generally long-term soft loans are used. The floating rate loans are low interest loans, which reassure the investor against inflation through the redefinition of unpaid debts in accordance with the inflation rate. The payback is over 20 years. This type of loan has proven to be most suitable for biogas plants as it meets the requirements for long duration, lowrate and low initial doses. The disadvantages of such loans are that the stock price is raised by ordinary sales of bonds, a fact that entails a risk of devaluation, which can cause some uncertainty in the planning stage. The project's success depends on a few factors that can be configured and be influenced by strategic decisions regarding investment costs and operational expenses. Choosing the best technology based on the amount of investment and operating costs is very difficult. The project's success is also influenced by some factors that can not be controlled, such as:

- The borrowing loan conditions.
- Access to the network and the purchase of electricity produced.
- The conditions for the price of raw materials to world markets (eg energy crops).
- Competition for raw materials from other areas.

However in our case we will not assume any financial assistance with the form of loans or subsidies from external sources.

5.3.2 Structure of financial analysis

1. Total investment costs
2. total operating costs: fixed or variable financial return on investment cost
3. sources of financing
4. financial sustainability
5. financial return on capital
6. feedstock production
7. gross net revenue
8. break even price

(Tran et al, 2008)

5.3.2.1 Total Capital investment costs-TCI

The Total Capital Investment is basically the total capital investment of the foundation and of building the biogas power station. They are basically the fixed investments that have to be invested for the power plant buildings facilities and technical equipment. It also includes the start up costs for the licensing period such as the cost for pre-paratory studies, design and project supervision, expenses for consulting services, training or research and development, grid connection and building permits. Added to this, there is an allowance for the working capital and offers to social security organizations, capital fees and contingency. Additional capital costs during the constructing period are included, starting from the biogas site and its boundaries, including the normal infrastructure such as roads, offices, warehouse and storage or control rooms and so on. In general TCI costs have been calculated as the sum of direct and indirect costs. Concerning direct costs there are service, instrumentation and unit preparation costs while indirect include start up and mechanical engineering costs.(Caputo et al,2005).

Concerning the licensing period, the licensing procedure is very costly, along with the building permits and the grid connection issues. Given that electric power have to be exported in large amount, a sufficient connection to the grid through cabling and a sub-station is necessary. It is without doubt that grid connection, equipment and associated grid establishment activities will cost. Cabling costs, length of lines are also crucial factors and constitute a significant capital cost. For estimating purposes we assume a cost for the grid connection of 35.000 and a total licensing cost of 772.000. Nevertheless, electricity companies may be reluctant to procure information about prices since those are considered to be commercially sensitive data. Clearly it is very beneficial for every biogas unit to be built approximately to a sub station and on acceptable boundaries from the city as well. (Dagnall and Pegg,2000). The capital investment decisions are mostly about the location and the size of the biogas unit along with the main technical equipment. The principal components of the capital cost of an anaerobic digestion system are as described above: a gasifier, a gas cooling and cleaning unit. Other components include civil construction, biomass collection, pre-treatment and storage units, ash removal structure and distribution network for transportation of electricity and other by-products to local area. It is without doubt that a set of other factors such as the useful life of the equipment, the capacity utilization of the unit, the biomass price and availability and fuel transportation cost can strongly influence the cost for power generation. . A main characteristic of biogas technology and of other unconventional mechanisms is that the majority of the expenses need to be financed from eternal sources during the start-up phase. When selecting between a wide range of renewable technologies, combustion may seem more profitable in the long run than pyrolysis or gasification, despite higher capital costs. Pyrolysis as well is considered as the most capital intensive technology for generation of electrical power. In our case, investment costs for biomass to energy conversion technology exceed the rest of other technologies mainly due to the high volume of primary sources and the increased requirements of technical equipment. Nevertheless, the high capital intensive nature of anaerobic digestion along with the pilot phase may complicate the financing for construction or even deter investment. (McIlveen-Wright et al, 2011). This is problematic especially for Greece where financial crisis and the general pessimistic investment environment do not favour large investments of this scale.

What is more, as Brown et al (2009) state the high initial capital costs of anaerobic digestions are often associated with potential economies of scale. Practically, this means that the high start up and fixed costs for the acquirement of land, facilities and technology are spread over an increasing number of animals and their substrates and on huge amount of organic waste from the unit as well. Although the biogas industry is usually characterised by zero or low primary cost and mainly due to the transportation cost, large-scale production will also be restricted by local feedstock resource availability. In addition the energy efficiency, the gas and electrical power generation accounts for up to 60% of production costs, so it is without doubt that the green energy production can be rather cost effective as it can improve the projects profitability and economic feasibility. (Brown et al, 2009)

The construction, design and economics of biogas plants are well examined by many techno economic assessments (Amigun et von Blonnitz, 2010, Katsigiannis, Papadopoulos, 2005). Many researches suggest that the economics lie in high capacity plants that don't need financial supports while others argue that low cost waste and fiscal incentives offer greater economy. A range of investments for different power plant was considered through the literature review and other sources, and average data were selected in an effort to approximate realistic economic values (Gasol et al,2008, Brown et al,2009, Wilkinson ,2011, CRES). So the investment data range is very high but suitable for the economic and financial study. In this study every effort was made in order to validate and estimate the capital cost data in an accurate calculation base. The absolute accuracy of this data is mainly based on the primary sources given by the company during the interview and on published information and quotations form relevant researches in this field. Therefore the cost estimates should be valid and applied for similar cases. Given this table and offers form German manufactures such as BINOWA, PLANET and so on the capital costs can be assume with a total cost of 3.428.000 for the construction phase. In 2010, the capital cost for a typical 500kWel biogas plant in Germany was <€2000/kWel, by 2006 it had risen to about €3500/ kWel. (Wilkinson, 2011). So it is natural that for a price of 3500/ kWel and a production of 1200 kW the total construction costs are estimated at 4.200.000 euros. The following tables summarize the cost and revenues as assumed and described previously.

Table 5.3: Total Capital Investment Costs

Organizational & establishing costs - expenses (in €)	**Licensing Period (A)**	**Construction Period (B)**
Costs for pre-investment studies and licenses		
licensing procedure	357.000	-

Constructive and building licenses - Payments and contributions for the insurance funds	300.000	**-**
Facilities planning - overseeing project	80.000	**-**
Connection with the Public Electricity Corporation	35.000	**-**
TOTAL (A)	**772.000**	**-**
Buildings - Facilities - Machinery		
Slurry tank	**-**	40.000
Solid substrates tank	**-**	70.000
Raw materials' mixture product line	**-**	400.000
System for anaerobic digestion	**-**	1.300.000
Base for production of thermal and electrical power CHP (Combined E. - Thermal Energy)	**-**	750.000
Base torch	**-**	65.000
Base for gas processing	**-**	85.000
Tank liquid residues	**-**	40.000
Waste Separator (liquid - solid residues)	**-**	60.000
Main industrial building	**-**	120.000
Central control system	**-**	360.000
Working equipment	**-**	13.000
Security Systems Unit	**-**	45.000
Staff training	**-**	10.000
Landscaping	-	70.000
TOTAL (B)	-	**3.428.000**
GRAND TOTAL (A + B)	**4.200.000**	

5.3.2.2 Total operating costs

The total operating costs are in fact the direct production costs and more specifically the costs for consumption, collection, storage and transportation of raw materials and services , the general costs, maintenance and insurance costs and in general the needs in money , time and personnel for the energy generation. (Wang et al, 2010,). Furthermore, total operating costs have been determined as the sale and distribution expenditures, biomass and digested by-products disposal or transportation costs, biomass and other primary sources purchase costs, (Caputo et sl,2005). All these components comprise the bulk of operating costs. According to the bibliography the plant maintenance costs and operating costs were calculated and assumed to be approximately 70.000 with a slight increase for the next two years mainly due to the mechanical components that will start to depreciate. Also, insurance and other minor plant costs were calculated as 3% of total plant investment. (Gasol et al,2008)

To continue, concerning the purchase costs of biomass and other raw materials, we can assume in our case that it is zero since the organic waste and biomass source that the slaughterhouse unit possesses is of zero value and are basically useless residues of the company's operating activity. So it is of great significance that the company can produce from something that seems useless in the first place and of zero or negative value, a product so invaluable such as biogas and combined heat and power.

The economic evaluation of manure transport to the biogas plant was based on: the investment costs for the purchase and establishment of trucks and loading systems, the maintenance and reparation costs related to lorries or truck used and to labour costs or fuel consumption for transport. More specifically the operating variable costs include fuel consumption by tractors such as diesel or oil for the engine, repairs or maintenance activities. In an effort to model costs for transportation, the daily needs in tracks to supply the products was assumed, diesel and fuel costs by trucks were computed considering the distance covered between the biogas power plant and the cultivations or the farms that purchase by products and the number of routes made by a truck during the transportation period as well. Sometimes delivery cost may become a significant bottleneck or barrier when planning the biomass supply chain. Hence, maximum transportation distances vary with the volume transported and the current market value of the digested manure and by-products. The higher the biomass price the higher the affordable distance and delivery expenses, so a large saving potential can be achieved if distances were optimized and logistic systems were improved. In general a centralized management of transportation can allow optimization of time and distances and minimization of costs and will result in a better economic situation. In our case, the on farm management of digested manure is an interesting alternative given the fact that the company strives for effective logistics and improved supply chain system at low costs. (Flotats et al,2009)

Concerning the maintenance costs of the gasifier system of the unit, are the higher operating costs. This is natural if we consider the fact that the digester is the heart of the anaerobic digestion scheme, therefore it must be well-established and maintains with tactical services and control to reassure its efficient operation. Occasionally and if it is necessary spare parts are replaced by new pieces of technology.

The labour charges and the number of personnel occupied are also administrative expenses that the company has to deal with. According to Gasol et al,(2008) the author support that a unit of 10 MW needs 8 workers to operate efficiently. In a similar vein we can consider this number of plant workers in order to estimate and assume that the unit can occupy 2 or 3 workers. Assuming both the same number of truck drivers as the trucks used to supply the power plant and driver salary, labour cost was calculated. The following table represents the main operating costs for the unit for the years 2012, 2013 and 2014.

Table 5.4: Total Operating Costs

	2012	**2013**	**2014**
Cost for the electricity buy from the Public Electricity Corporation	69.380	73.108	76.640
Cost for the plant's insurance	21.000	21.000	21.000
Cost for the buy of raw materials	-	-	-
Cost for the transport of the raw materials	56.000	61.600	67.760
Cost for the maintenance of the plant's equipment	135.000	140.000	146.000
Payroll cost	120.200	132.220	141.790
Cost for the biological maintenance of the plant	30.000	30.000	30.000
Payments for the local authorities	71.000	75.000	81.000
Unpredictable expenses	24.000	24.000	24.000
TOTAL	**526.580**	**556.928**	**588.190**

In general the price of manure and biomass quantities strongly depend on the size of the plant, the distance and transportation costs and the size of farm and arable land as well. The variability in feedstock and raw materials and the high delivery costs are factors that strongly affect the feedstock and biomass cost and price. In our case, the quantities of feedstock are based to the animal number while the quantities of organic wastes and other residues depend on the operating activities of the company, and more specifically the number of slaughtering per day. In addition, these factors along with biomass density, content and energy efficiency and its production cost affect significantly not only manure prices but also profitability of the unit. (Evans et al,2010). The lower costs the waste is provided the highest the profits from biogas and power generation. What is more Evans et al, strongly argues that the economics of the biogas unit lies upon the low production cost of waste and other feedstock that affect and increase profitability. In addition Evans et al, (2010) support that units that handle with high amount of biomass and dry substance ,in our case is approximately 8 tones per day, are economically viable and able to achieve sustainability.

<u>Availability</u>

When we discuss about availability we mean the proven exploitable reserves of raw materials that are ready available and vital for the efficient operation of a plant. The availability of primary sources is considered as an essential decisive factor for the energy resource selection that has to be sustainable and non-stop as its stoppage may cause major problems. Moreover, Hoogwijka et al, (2003) highlight important factors for the availability of biomass such as the availability of arable land or the number of animals. The rate of biomass production combined with the rate of exploitation and digestion affect significantly the sustainability of primary sources. The slaughterhouse unit possesses sufficient waste stocks such as animal and slaughter residues, dung animal manure and other organic waste. The available quantity of dung is based upon the number of animals and the manure requirement, while the slaughter residues depend on the number of slaughters that take place everyday. (Evans et al,2010)

<u>5.3.2.3 Revenues from products sales</u>

In Greece the price of energy is small compared with the corresponding average in the EU For instance for Greek consumers with annual consumption of 2.500 -5.000 kWh a quantity of energy of 100 kWh costs around € 10 while in the Eu-27 the average price is € 16.034. The new Law on the RES (Law 3468/2006) promotes renewable energy, by simplifying the whole licensing procedure which is deeply bureaucratic. Moreover, it sets the new generation environment and the new guaranteed price of energy from RES that is 73 € / MWh that is a bit low for biogas projects. Through a detailed research, the prices of biomass resources were estimated based on the heat value and electricity generation per megawatt hour .In an attempt to estimate the cost of the main product biogas and electricity we can assume the price of 220€ / MWh which is comparable to natural gas. The biogas pricing policy which is entirely in connection with the triangle quality - reliability - accountability, takes into account the first bills and pricing policies and institutional framework (N.3851/2010) in order to present a realistic solution on the production and sale of energy. With the formation of this pricing policy, the company strives to acquire and maintain its competitive advantage in the bioenergy market, as the price and reliability are among the dominant elements. Concerning Greek biogas market and based on the information given by the PPC and the Regulatory Authority of Energy (RAE), the pricing framework, can be presented in the following table:

Table 5.5: Pricing framework for RES

1) Biomass for power stations with capacity <= 1 MW	200
2) Biomass for power stations with capacity > 1 MW and <= 5 MW	175
3) Biomass for power stations with capacity >5 MW	150
4) Biogas generated form biomass (agricultural and organic waste and residues) with capacity <=1 MW	220
5) Biogas generated form biomass (agricultural and organic waste and residues) with capacity >1 MW	200

For the calculation of revenues the value of electricity quantity that is sent out is necessary. The electricity exported is the power generated by the power station minus the power required to meet the energy needs of the unit (D.R. McIlveen-Wright et al, 2011). Prices are used as a substitute for energy resource costs and reflect the scarcity of raw materials and the supply or demand forces in the market. Additionally prices are influenced by national policies and government subsidies. (Wang et al, 2010)

The Break-Even Selling Price (BESP) is the price tariff that the company must charge for the electricity that is selled to the grid in order to sales equal to capital costs, and so the company operates at the break even point. In this point the net present worth is zero while the net annual income includes the revenues from sending out the energy or other by-products generated as well as the cost of primary sources, operating or maintenance costs and administrative expenses. So for purposes of the financial evaluation of the project, a conservative value of electricity price was assumed. Based upon the price of energy estimated to be paid by the Public Power Corporation (PPC) to purchase electric power which is approximately 253 €/ kWh and considering the 1500 Kwh produced , and the 40% of electrical efficiency the quantity of electric power can be easily computed. To go a bit further given that the hours for a year are 8760 but due to hours spent for maintenance or as idle time, the main operation hours are assumed to be 8000h. The heated digester system can also produce heat power with approximately 42% efficiency. The electricity and thermal energy generated can be used to meet thermal and electrical needs of the unit or can be circulate through pumps to regional livestock units or greenhouses for their operations. Furthermore, the produce compost or fertilizer is basically the digested effluent that remains on the digester after the process that can be dried and packed and sold to the agricultural market for soil fertilization, enhanced irrigation techniques and utilization of nutrients. However, this could require high transportation costs which would increase with the number of transports and the distance from the plant to adjacent farms for sale.

As the author of (Wilkison et al, 2011) supports the three most important factors affecting the profitability of AD plants now are total capital costs, the cost of primary source which is in our case zero and to the energy efficiency.The annual benefits for the years 2012, 2013 and 2014 were evaluated based on the current electric tariffs for Greek biogas schemes, and the prices of by products as defined by the Law for RES and by the national grid and are summarized in the following table.

Table 5.6 : Revenues

	2012	**2013**	**2014**
Sales revenues - incomes			
Revenues from the sale of electrical power	2.088.800	2.151.460	2.216.000
Revenues from the sale of ecological fertilizer	270.100	291.710	315.050
Services revenues	0	0	0
Total Revenues - incomes	**2.358.900**	**2.443.170**	**2.531.050**

Table 5.7: Profits before taxes & depreciation (in €)

	2012	2013	2014
Revenues	**2.358.900**	**2.443.170**	**2.531.050**
Costs	**526.580**	**556.928**	**588.190**
Profits (before taxes and depreciation)	**1.832.320**	**1.886.242**	**1.942.860**

In the above table cash outflows of operating costs are deducted from the revenues to calculate net profit from operation. There are calculated both for the three years of the payback period. It is apparent that electricity generation provides undeniable benefits to the investor. It is without doubt that the main source of revenue for the proposes biogas plant has been the sale of electricity.The price is based on the contractual agreement with the PPC, but in case of a higher agreed price we can assume the higher revenues provided.

5.3.2.4 Economic Indicators

The economic calculations were achieved with the use of an Excel-based software and Benninga S,(2011) notes for the empirical computing of expenses and costs. The economic examination of plant configurations has been carried out based on total capital investment costs(TCI), total operating cost (TOC) and revenues from electricity sale (R). With the program execution, numerical indices such as total operational expenses, total revenues from sales, total capital costs along with interest rate and years were used and given numerical values.

In this way, the economic viability of the biogas solution has been evaluated and the results of the computation are reflected on the following table with the Break even point and NPV and IRR values. In a first look the values of the economic indicators such as break even point, NPV and IRR reflect thar the project seems attractive enough from a financial point of view.

Breakeven price of feedstock and other biomass sources is that price so as net revenues equals zero or costs and benefits are equal. The breakeven price is computed as cost divided by yield where yield we mean feedstock and substrates and their conversion to energy efficiency. (Tran et al,2011). The variable costs are the operating cost for PPC, the transportation costs, and the payments to local authorities, while the rest of them are the fixed costs. So basically the break even point is calculated considering the operational costs as a base.

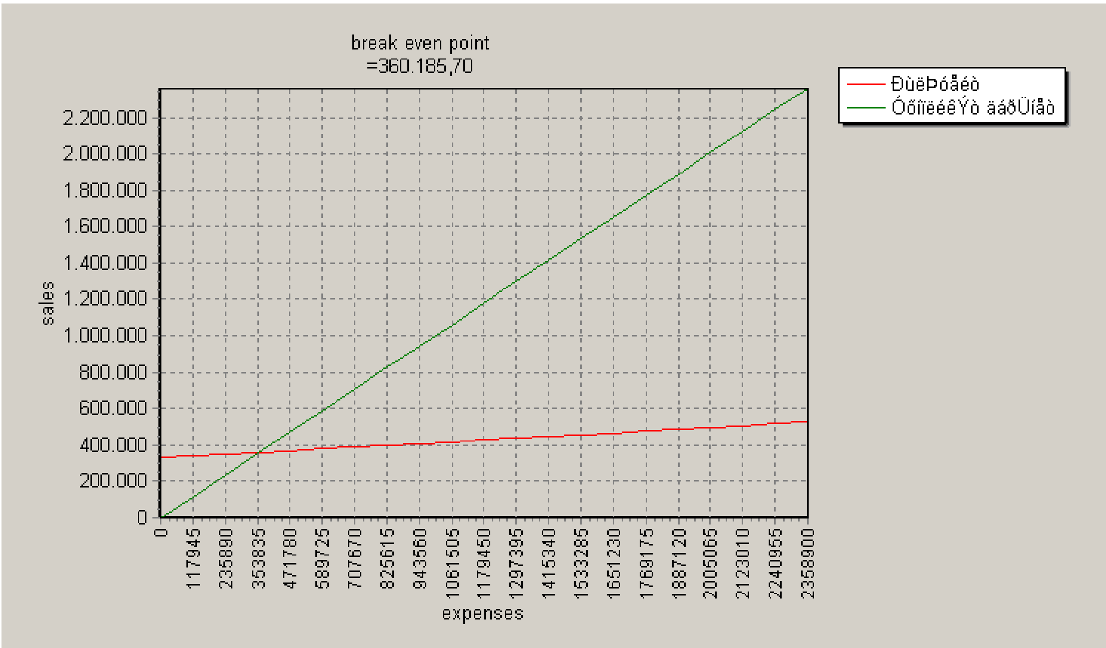
Table 5.8: Break even Point

BREAK EVEN POINT		
SALES	2.358.900,00	Euro
FIXED COSTS	330.200,00	Euro
VARIABLE COSTS	196.380,00	Euro
BREAK EVEN POINT	360.185,70	Euro
BREAK EVEN POINT (% of sales)	15,27	%
BREAK EVEN POINT in months(*)	1,83	months

(*)it is assumed that sales are equally distributed within the year

Concerning the break even point as we can see form the above table (5.8) , the company breaks even in a volume of activity or sales of 360.185,7 €. This in fact means that in this point revenue from sales are equal to costs or otherwise profits are zero. For sales more than this amount, the biogas unit operates profitably, while for volume of activity under this point the biogas plant will have losses.

Figure5.4: Graphical Representation of Break Even Point



The slope of the line gives the variable cost per unit of activity while the uppermost line represents the total costs. At zero activity, the expenses and the revenues are zero and there are only the fixed costs that the business still has to pay them despite profits. As the volume of activity increases the expenses increase too. The profit or loss which is the difference between sales and expenses is shown by the vertical distance of the lines. At the break even point there is no vertical distance between the two lines, so as there are no costs or sales and the activity breaks even. At this point sales equal to expenses and profits or losses are zero. For a volume of activity below the break even point we have losses of the biogas unit, while when the unit operates above this point we have profits. (Atrill and Laney, 2006)

Table 5.9: Break even analysis

REPORT FOR FUNCTIONAL AND TOTAL BREAK EVEN POINT	
FUNCTIONAL REPORT	**2011**
SALES (S)	2.358.900
FIXED - STABLE EXPENSES (F)	526.580,00
VARIABLE EXPENSES (V)	196.380,00
FUNCTIONAL BREAK EVEN POINT (F / (S-V)) %	**10,91 %**
SENSITIVITY ANALYSIS	
-regarding sales	69,4 %
(1-(F+V)/S) 100%	
-regarding variable expenses	83,3 %
((S-F)/V -1) 100%	

The above table represents the functional break even point which is calculated from the fixed and variable costs and the level of sales of electricity and fertilizer.

The net present value of the income is the sum of the net annual income over the lifetime of the plant, discounted back to the present day value, using a given discounted cash flow rate. The present day is taken as the first day of operation of the power station. The present day value of the capital investment is the total capital costs appreciated over the construction and commissioning times of the plant using the given discounted cash flow rate.

The main type that computes the present value of the total investment over a 25-year period was estimated as:

$$PVC_{ij} = \sum_{t=1}^{n} \frac{TCP_{ij}}{(1+r)^n}$$

$$PVB_{ij} = \sum_{t=1}^{n} \frac{GR_{ij}}{(1+r)^n}$$

In general the most usual decision criteria that are commonly implemented to evaluate the financial feasibility of strategic investment on renewable options include net present value, internal rate of return and payback period (PP). (Yiridoe et al,2009). The importance of these key indicators is mainly attributed to the consideration of different data and scenarios during the feasibility analysis. In addition, these criteria when computed they include the time value of money and the return on investment to the plant's owner. The consistency in results can be proved rather valuable for the confident conclusions about the viability of investment and the sensitiveness of analysis to external or internal factors.

Factors like this were asked during the interview with the company's stakeholders and include the return on investment, the payback period, the discount rate, the revenues from sales of products and by-products and the capital or maintenance costs. What is more, external factors like a possible change in price or to discount rate due to the high competition in the growing bioenergy sector and their impact on financial performance of the project can be examined too. More specifically, from the five respondents the three of them, the owner , the waste manager and the financial manager have judged the return on investment as of critical importance while the rest of them as 'important'. The payback period was noted from the owner and the economist as important while from the rest as a moderate factor that will influence the investment. What is more concerning the subsidies levels they were assumed to be unimportant factors from both the owner and the economist while the other answered moderate. Obviously, the owner and the accounting direction are aware of the subsidies alternatives and may be they have checked it as an option that may not be profitable enough. Concerning, the interest rate on loans or other time of external financing all the respondent have answered that this factor is of 'moderate' influence. Concerning the costs and benefits as assumed and calculated they reflect the motives or barriers for an investment decision. If the latter exceeds the former then the unit has profits and the entrepreneur is motivated to invest. In addition the sales of products such as electricity or fertilizers was as very important form all of the interviewees an answer totally justifiable as the long term success of the project is based on the competitiveness of the products. Finally by-products were judges as moderate factor while from other as just important.

The economic and financial assessment in this study was mainly based on estimated values such as costs and revenues with an emphasis on their robustness to factors that influence the on farm biogas recovery. So the economic evaluation of strategic biogas options for the livestock unit examined was investigated by taking into consideration the availability of primary sources, the main costs and revenues for the investment and the key indicators such as NPV and IRR. (Yiridoe et al, 2009). From an economic point of view the overall approach is to assess average annual costs and revenues by incorporating real values and data for primary sources requirements and other parameters as inputs.

The aim of the financial evaluation is to assess key indicators of net revenues based on the project's cash flow predictions. A particular emphasis is given on the Financial Net Present Value (FNPV) in terms of return on investment cost or capital and on the Financial Internal Rate of Return. Those two are the preferred economic indicators. Under the NPV criterion, an investment in order to be feasible, the discounted revenues have to exceed the discounted costs. The net present value of the project should be close to or above zero. In case of a negative NPV, it indicates that the project does not procure sufficient revenues to the owner so as to cover the invested capitals. As we can see from the table the NPV was calculated at 3.113.497 euros. Therefore, we can conclude that the projected cash flow from the AD digester is positive and

So the discounted value of the net returns exceeds the capital costs. What is more NPv is not only positive but also high enough that in a case of investment costs higher than expected, the project still remains feasible. However, as we can see from the NPV equation, this indicator incorporates the time as the amount is discounted with a discounted rate. Therefore a variety of different values for the discount rate can be examined in order to evaluate how this mechanism affect the financial results and how sensitive the investment is on external factors like discount rate. Concerning the internal rate of return (IRR), it estimates the capital cost that can be sustained over the life cycle of the project. Under the IRR criterion an investment is economically viable when the IRR is greater than the given discount rate. So in our case the rate of return should be equal or higher than the interest rate (10%). Here it is computed to be 35.94% higher than the discount rate so the investment is acceptable. In addition, the IRR for this case is large enough so the investment is very competitive since in order to choose within two investments the most powerful is that with the highest IRR. In general when a biogas project receives an IRR lower than 9%, experts argue that the projects facilities and costs must be re examined and ameliorate. On the other hand, in case that the IRR is higher than 9% then the facilities and the projects operation is efficient and the project worth to continue to the next phase of programming. It is of high significance to retest and check the values of indicators and then redesign a process or make new assumptions in order the project to be profitable. In this way the entrepreneur can take an idea about the reality and the real implementation and economic performance of his investment.

Although the PP decision criterion is simple to calculate, it does not consider the payoffs for the entire life of the project. In general in order an investment be acceptable the payback period should be less than the project life (15 years). On the other hand, investors may be interested in the time frame within which investment outlays can be recovered. Results of the financial feasibility of on-farm anaerobic biogas recovery for the base scenario analysis (i.e., without non-market co benefits) are presented first.

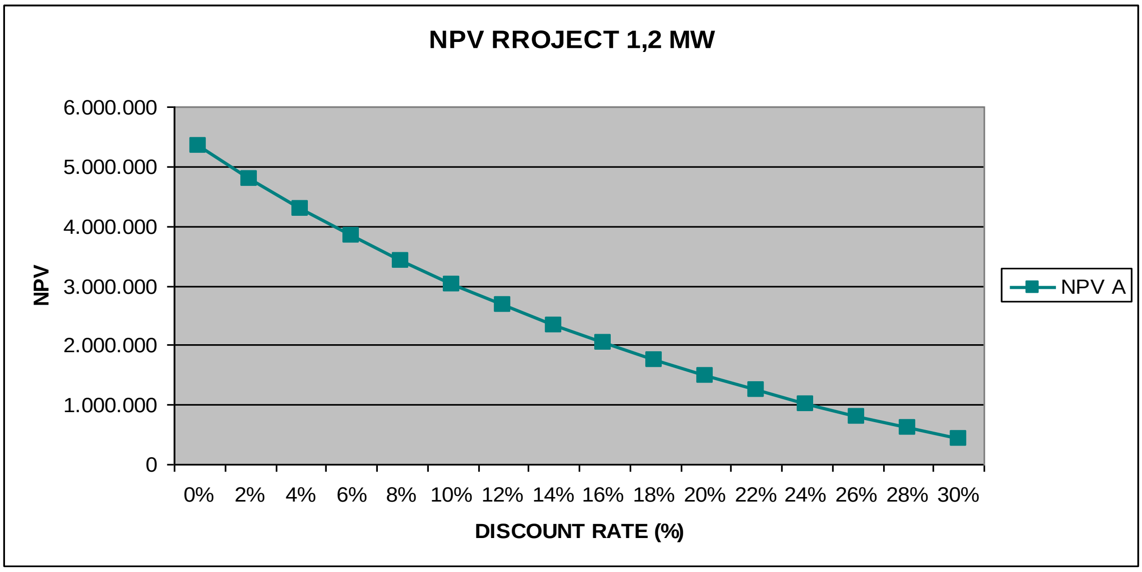
Table5.10: Net Present Value (NPV)- Internal Rate of Return (IRR)

Data							Investment
Cost of initial investment	-4.200.000,00 €						
Annual Cash flow	1.832.320,00 €	1.886.242,00 €	1.942.860,00 €	1.942.860,00 €	1.942.860,00 €	1.942.860,00 €	
Stable discount rate	10%	10%	10%	10%	10%	10%	
Year	0	1	2	3	4	5	
Cash flows without discountin	-4.200.000,00 €	1.886.242,00 €	1.942.860,00 €	1.942.860,00 €	1.942.860,00 €	1.942.860,00 €	
Cash flows with discounting	-4.200.000,00 €	1.714.765,45 €	1.605.669,42 €	1.459.699,47 €	1.326.999,52 €	1.206.363,20 €	
NPV	3.113.497,07 €						**Accepted**
NPV with type check	3.113.497,07 €						**Accepted**
Check	0,00 €						
Index IRR	**35,94%**						**Accepted**

(Assumption: Fixed discount cash flow rate at 10%)

The above table suggests that there are cost efficiencies for livestock and slaughtering operations of the company, mainly due to economies of scale that characterize the on farm anaerobic schemes. The Net present value is higher than the investment cost so the project is worthwhile. The high cost efficiencies are also translated into the high electrical power and biogas produced due to the capacity and the availability of resources. In general the results for the basic scenario prove that it is economically viable. If we try to graph net present value for different inerest rate values, we can actually see the sensitivity of NPV for different discount rates. As the discount rate get higher the npv gets lower and at the cross point with the x– axis we get the IRR which is almost 35%.

Figure 5.5: Sensitivity of NPV to Discount Rate changes



5.4 SENSITIVITY ANALYSIS

5.4.1 Scenario for 3 MW unit

During the interview the respondents were asked to define and estimate the other organic waste produce form similar units, farms or industries of the region. Primary data concerning additional substrates from nearby companies were provided by stakeholders during the interview. These additional sources entail apart from cattle and swine manure, sheep manure, energy crops, waste from dairy, food and drink industry and additional slaughtering residues. The following table 5.1 summarizes the answers of the interviewees concerning the existence of sufficient organic wastes in the region. What is more through the interview we have concluded that the company is in the planning and programming phase and has already some information about the energy efficiency of those additional substrates. The variety of waste that lies within animal manure energy crops, dairy, wine industry or slaughtering residues are in fact sufficient amounts of primary sources suitable for a biogas operation plant

If we take into account the primary data and the efficiencies estimated for the company's biomass sources along with the following table with the general efficiencies for cattle and swine manure we can easily assume and further conclude that approximately 1560 pigs result in 80 tones of waste more per day and an energy potential of 14.088 Kwh/day and 243,60 Kwh/day of electrical efficiency. The daily efficiency in gas is also very high at 2348 m^3/ day while for cows is calculated at 3943 m^3/ day. Similarly, the energy potential and electrical efficiency are also high arriving at 374,99 Kwh/day. In addition, the huge number of sheeps and beef from similar dairy industries adjacent to the plant result in tones of waste per day that remain unexploited. The electrical efficiency for them is 742 and 228 Kwh/day respectively. This plant is treating a total of 522,59 tones of slurry and other waste per day and is having a potential capacity of 3692,34 kwh of electricity/day. The organic loading rate of the plant has a total of 74.910 tones/ day, and the daily average yield is approximately 37.631 of biogas/m3 of slurry.

So as we can see form the data procured nearby livestock units are produce of huge amounts of organic substance and waste and can be considered as suppliers for the biogas unit. However, the company has to decide if it will accept additional amounts of feedstock from neighbour livestock units with a tipping fee as a payment but with additional quantities of energy produced. In this case the entrepreneurs must decide if he wishes to invest on a biogas plant of a larger scale. We can assume form the new data inputs that the total of organic waste is approximately 2 times more than the organic waste of the main livestock unit so in fact the capacity of the plant should be doubled. Therefore we can assume that alternatively the company can invest on a 3MW biogas scheme. So basically the case of procuring with additional feedstock supplies will be further examined as an alternative scenario in this part of the sensitivity analysis part. There we will have the opportunity to identify and discuss huge differences in the financial results due to a small difference in the inputs and the capacity of the digester as well. In other words, the investment's robustness can be highlighted through slights changes in the primary sources and the projects capacity. After the financial analysis of the expanded project, a comparison of results will evaluate and contribute to an understanding of which investment is more profitable. It is without doubt that new capital, operational costs , revenues and profits must be assumed, but the rest of parameters such as time horizon, interest rate and so on we remain the same.

Table 5.11: Energy efficiency of substrates expansion phase

Breeded animals Substrate	Daily quantity of waste in tones **t/d**	Annual quantity of waste in tones **t/a**	Dry Substance (**DS**) in %	**DS** Tones per day **t / d**	Dry organic substance (**oDS**) in % of **DS**	**oDS** Tones per day **T / d**	Efficiency of gas in **m³/kg** of **oDS**	Daily efficiency of gas in **m³/d**	Methane in **%**	Energy potential per day **kwh/d**	Electrical efficiency 40% of energy potential **kwh/d el**	Thermal Efficiency 42% of energy potential **kwh/d th**
1.560 Swine mothers	78	28.470	7	5,460	86	4,696	0,50	2.348	60	14.088	243,60	249,47
2.434 Cows.	109,53	39.978	10	10,953	80	8,762	0,45	3.943	55	21.686	374,99	384,02

6.846 beefs	102,69	37.482	25	25,672	80	20,538	0,38	7.804	55	42.922	742,19	760,08
Dairy product waste	40	14.600	6	2,400	90	2,160	0,75	1.620	53	8.586	148,46	152,04
1.000 acres of energy crop	27,4	10.000	30	8,220	96	7,891	0,60	4.735	52	24.622	425,76	436,01
8.000 sheeps	26,32	9.607	30	7,896	80	6,317	0,38	2.401	55	13.205	228,33	233,84
Winery waste	16,44	6.000	15	2,466	87	2,145	0,56	1.201	68	8.167	141,22	144,62
Slaughtering waste	26,32	10.000	20	5,264	84	4,422	0,55	2.432	55	13.376	231,29	236,87
Kitchen waste	95,89	35.000	25	23,972	75	17,979	0,62	11.147	60	66.882	1.156,50	1.184,37
total	522,59	191.137	17,66	92,303	81,15	74,910	0,502	37.631	56,74	213.534	3.692,34	3.781,32

Biogas plants with capacity 500 kW and up to 5 MW are considered as large scale units. The technological components and equipment as well as the economics of a biogas system with 3 MW capacity has major differences from the previous suggested project of the 1,2 MW small-scale stand-alone system. These differences are mainly based on distinct factors such as the more efficient technology required due to the larger capacity and efficiency on energy and other by-products generation. The possibility of this project to be connected to the gird and to sell power the state and the region is the same or even higher through a buy back policy. At these high level capacities the only option is the cogeneration projects with high pressure digesters and steam turbines. Furthermore, the cost model for the economic and financial assessment of the viability of this plant is the same as in the previous case. The model parameters are listed in the following table and are similar to the first project. For capacity utilization factor we can assume the corresponding hours to 8000h for 333 days of the year. However, the extra equipment costs need to be estimated against the new capacity of the unit and the value of the extra electric power produced. In this case , it is natural that the capital costs will almost be doubled as the capacity of the unit doubles. So from 4.200.000 € Total capital costs, in this case we consider approximately 9.000.000 €. More specifically the costs for the licensing procedure are increased by 100.000 € while the costs for the construction period have an increase of 50%.

The main capital costs are due to the digestion system that in fact is doubles as we will establish now two digesters instead of one and the costs are doubled.

In a similar way total operational costs are assumed. Concerning the Cost for the electricity buy from the Public Electricity Corporation we assume a total consumption of approximately 200 kW per hour since the unit will be of higher capacity and have larger electrical needs. So with a computation of the operating hours and the price of electricity which is around 0,088 we assume a cost for PPC of 149.000€. The insurance cost of the unit we be similarly computed as the 0,50% of the total investment costs. So the insurance costs can be computed at the level of 40.512 €.The purchase cost of primary sources is still at zero level while the transportation costs are calculated as following. The biomass collection area is located with radius of almost 10 km while the biogas unit is considered as the centre where all the substrates of regional industries or farms arrive as primary sources for the digester. Therefore collection and transportation of primary sources from adjacent industries and farms becomes an additional cost factor. So to assume and compute the transportation costs we assume this distance, the fuel costs, the number of deliveries, 2 more trucks and drivers. Obviously, the contribution of collection and transportation expenses to the overall operational cost increases as the capacity of the plant increases. For instance, for a 3 MW capacity plant, the annual transportation costs are approximately 140.140 €. Moreover, the number of personnel now arrives at 10 with 6 the staff for the unit and 4 the truck drivers. Therefore we can assume a double labour costs arriving at 240.000€. Concerning the payments to the Local authorities and the unpredicted costs are assumed to be 177.00 € and 48.000 € respectively. In a similar way the costs for operation can be computed for the following years of 2013,2014 with an additional price change of 5%.

Similarly the revenues are considered to get almost tripled for both the electric power produced and the fertilizer sold while the total revenues are estimated to be 5.915.590€. After the final assumption of total operating costs the profits before interest or depreciation can easily be computed arriving at a level of 4.766.663 € ,so practically increased by 3 millions €. In a similar vein sales can be calculated for the following years of 2013,2014 with a rate increase of approximately 5%.

Table 5.12: economic indices and variables

Economic indices and parameters	Value	Units
Initial investment year	2011	year
Economic plant life	25	years
Construction period	1	years
Payback period	3	years
Operating hours	8000	h/year
Operating days	333	d/year
Inflation rate	1,5 to 2	%
Energy price	0,253	€/kwh
Consumed electricity price	0,088	€/kwh
Increase of energy price	0	%/year
Fertilizer price	20	€/tones
Personnel	10 workers	
Trucks used	4	
Insurance costs (% TCI)	0,5%	%/year
Increase of operating costs	5%	%/year

Table 5.13: Total Capital Investment Costs

Organizational & establishing costs - expenses (in €)	**Licensing Period (A)**	**Construction Period (B)**
Costs for pre-investment studies and licenses		
licensing procedure	370.000	-
Constructive and building licenses - Payments and contributions for the insurance funds	310.000	-
Facilities planning - overseeing project	90.000	-
Connection with the Public Electricity Corporation	45.000	-
TOTAL (A)	**815.000**	-
Buildings - Facilities - Machinery		
Slurry tank	-	96.000
Solid substrates tank	-	167.000

Raw materials' mixture product line	**-**	954.000
System for anaerobic digestion	**-**	3.220.000
Base for production of thermal and electrical power CHP (Combined E. - Thermal Energy)	**-**	1.718.000
Base torch	**-**	155.000
Base for gas processing	**-**	196.000
Tank liquid residues	**-**	90.000
Waste Separator (liquid - solid residues)	**-**	139.000
Main industrial building	**-**	286.000
Central control system	**-**	860.000
Working equipment	**-**	31.000
Security Systems Unit	**-**	10.000
Staff training	**-**	10.000
Landscaping	-	163.000
TOTAL (B)		**8.185.000**
GRAND TOTAL (A + B)	**9.000.000**	

Table 5.14: Total operating costs

	2012	**2013**	**2014**
Cost for the electricity buy from the Public Electricity Corporation	148.955	166.585	181.882
Cost for the plant's insurance	40.512	40.512	40.512
Cost for the buy of raw materials	-	-	-
Cost for the transport of the raw materials	140.140	154.150	169.565
Cost for the maintenance of the plant's equipment	311.850	320.100	329.000

Payroll cost	240.000	262.000	285.500
Cost for the biological maintenance of the plant	42.000	42.000	42.000
Payments for the local authorities	177.470	183.718	190.439
Unpredictable expenses	48.000	48.000	48.000
TOTAL	**1.148.927**	**1.217.065**	**1.286.898**

Table 5.15 : Revenues

	2012	**2013**	**2014**
Sales revenues - incomes			
Revenues from the sale of electrical power	5.143.250	5.297.550	5.456.470
Revenues from the sale of ecological fertilizer	772.340	826.400	891.510
Services revenues	0	0	0
Total Revenues - incomes	**5.915.590**	**6.123.950**	**6.347.980**

Table: 5.16 Profits before taxes & depreciation (in €)

	2012	**2013**	**2014**
Revenues	**5.915.590**	**6.123.950**	**6.347.980**
Costs	**1.148.927**	**1.217.065**	**1.286.898**
Profits (before taxes and depreciation)	**4.766.663**	**4.906.885**	**5.061.082**

In the above table cash outflows of operating costs are deducted from the revenues to calculate net profit from operation. There are calculated both for the three years of the payback period. The annually electricity production is multiplied with the price per KWh can give as the total revenues for the year 2012.In this way, the economic viability of the biogas solution has been evaluated and the results of the computation are reflected on the following table with the

Break even point and NPV and IRR values. In a first look the values of the economic indicators such as break even point, NPV and IRR reflect thar the project seems attractive enough from a financial point of view.

Breakeven price of feedstock and other biomass sources is that price so as net revenues equals zero or costs and benefits are equal.(Tran et al,2011). The break even point is very high at a level of sales of 740.788 €.

Table 5.17: Break Even Point

BREAK EVEN POINT		
SALES	5.915.590,00	Euro
FIXED COSTS	682.362,00	Euro
VARIABLE COSTS	466.565,00	Euro
BREAK EVEN POINT	740.788,27	Euro
BREAK EVEN POINT (% of sales)	12,52	%
BREAK EVEN POINT in months(*)	1,50	months

(*)it is assumed that sales are equally distributed within the year

Figure 5.5: Graphical Representation of Break Even Point

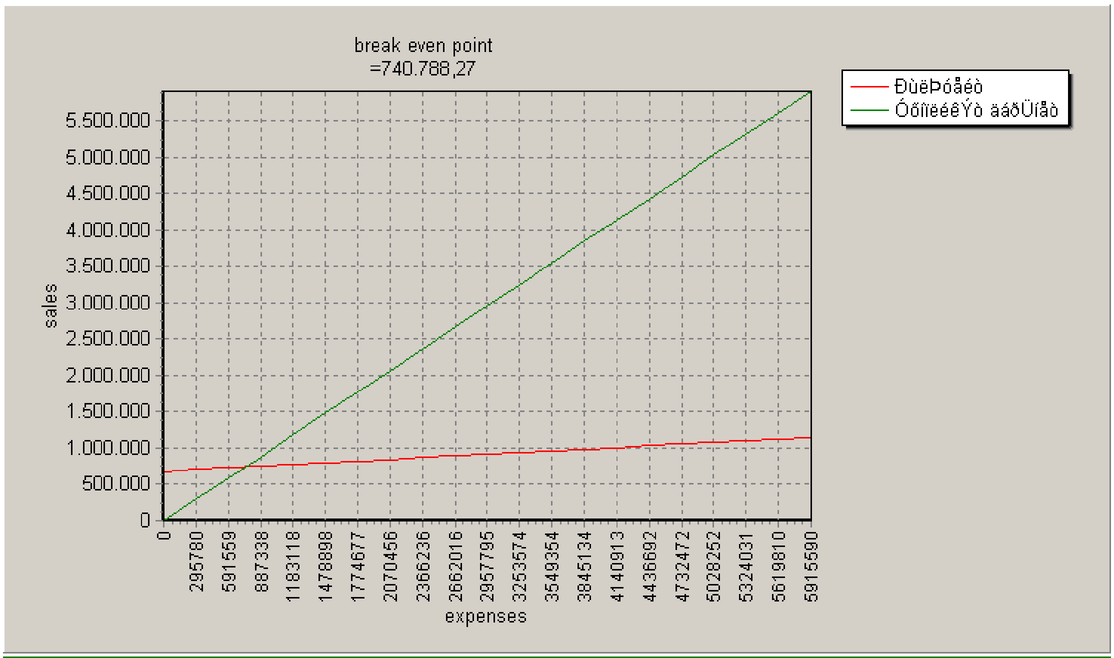


Table 5.18: break even analysis

REPORT FOR FUNCTIONAL AND TOTAL BREAK EVEN POINT	
FUNCTIONAL REPORT	**2011**
SALES (S)	5.915.590
FIXED - STABLE EXPENSES (F)	1.148.927,00
VARIABLE EXPENSES (V)	466.565,00
FUNCTIONAL BREAK EVEN POINT (F / (S-V)) %	**21%**
SENSITIVITY ANALYSIS	
-regarding sales	72,6%
(1-(F+V)/S) 100%	
-regarding variable expenses	92,1%
((S-F)/V -1) 100%	

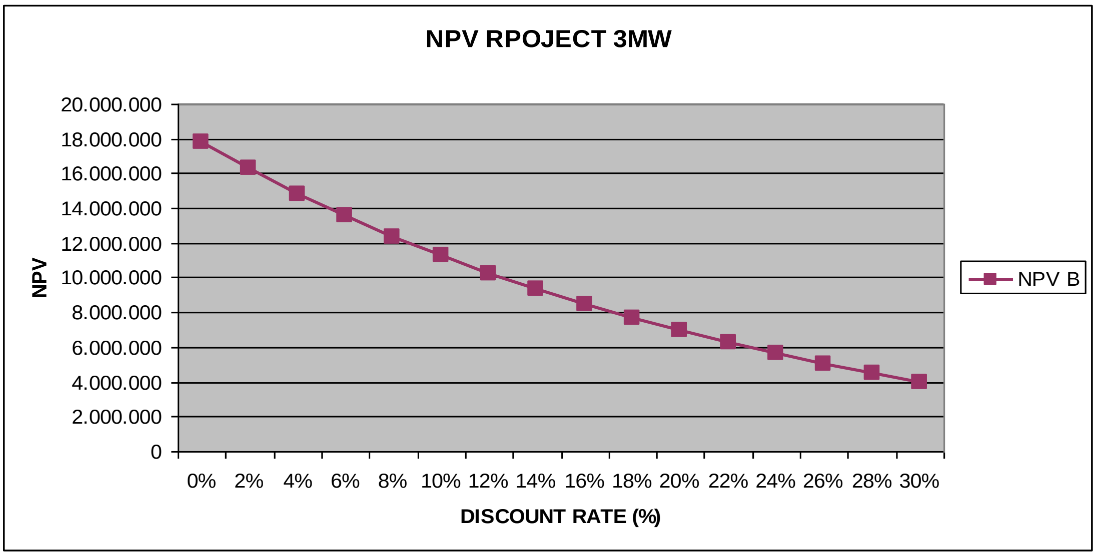
Table 5.19:Net Present Value (NPV)- Internal Rate of Return (IRR)

Data							**Investment**
Cost of initial investment	-9.000.000,00 €						
Cash flow for each year	5.143.250,00 €	5.297.550,00 €	5.456.470,00 €	5.456.470,00 €	5.456.470,00 €	5.456.470,00 €	
Constant discount rate	10%	10%	10%	10%	10%	10%	
year	0	1	2	3	4	5	
Cash flows (without discount	-9.000.000,00 €	5.297.550,00 €	5.456.470,00 €	5.456.470,00 €	5.456.470,00 €	5.456.470,00 €	
Cash flows discounted	-9.000.000,00 €	4.815.954,55 €	4.509.479,34 €	4.099.526,67 €	3.726.842,43 €	3.388.038,57 €	
NPV	11.539.841,56 €						**Accepted**
NPV of type	11.539.841,56 €						**Accepted**
Check	0,00 €						
Index IRR	**52,72%**						**Accepted**

(Assumption: Fixed discount cash flow rate at 10%)

As we can see from the above table and considering the fact that the net present value of the project should be close to or above zero the project is worthwhile since the NPV is very high and approximately 11 million €. Concerning the IRR we can see a high difference form the assumed interest rate of 10%, as it is very high up to 51,72%. The results can prove that the additional start-up costs of the oversized digester and facilities can be stabilized by the additional revenues from electricity production and fertilizer sales. In addition the oversized plant and facilities may be proven rather useful in case of a future expansion, that for the current time of construction may be unforeseeable. The Net present value is higher than the investment cost so the project is worthwhile. The high cost efficiencies are also translated into the high electrical power and biogas produced due to the capacity and the availability of resources. In general the results for the basic scenario prove that it is economically viable. If we try to graph net present value for different interest rate values, we can actually see the sensitivity of NPV for different discount rates. As the discount rate get higher the npv gets lower and at the cross point with the x– axis we get the IRR which is almost 52 %.

Figure 5.6: Sensitivity of NPV to Discount rate value changes



It is without doubt that, as plant size and capacity of biogas scheme increases, so as the electrical efficiency and generation increases. So evidently for higher amounts of substrates the capacity of the digester needed gets double and so as the total investment costs and revenues. This increase in efficiency means less energy consumption and better cost and resource allocation in the long run. If we can try to compare the financial results both for the first case of the 1Mw unit and the second expansion phase of 3 MW we can see some differences that can easily be explained from the different quantities of primary sources, the costs or benefits from sales and the additional amounts of energy produced. In the first case the profits before tax and depreciation are around 2 millions € while on the 3MW case around 4, 5 millions €. This can be interpreted by the fact that due to higher capacity, the electricity sales have achieved a level of

20.329.050 KW/year and 38.617 tones of fertilizer. So due to changes in the capital and operating costs, and on sales the break even point is also quite different for case two and approximately 740.000 € meaning an increase by 350.000 €.

Concerning the other decision criteria we can conclude that the NPV for the first scenario is 3 million while for the second scenario has almost increased by 4 times and for both of the cases the investment is acceptable since both the NPV are positive. Now if we want to go a bit further and decide between these two projects that can achieve the same objective we have to compare the NPV of project 1,2MW with the NPV of project 3MW. Basically the npv rule is that the present value of the projects cash flow is the economic value of the project today if the interest rate is correctly assumed. So in an effort to decide which project to undertake we can see that both of them are worthwhile since the NPV is positive but the 3MW project has a higher NPV so the investor can choose this alternative If he has the capital costs needed at his disposal.

The results suggest for both the two scenarios suggested that when digestion is considered simply for waste management and treatment then the feasibility is marginal, as it mainly serves environemtal reason and not profitability scopes. However, if AD process is viewed in a wider context, then profitability makes it rather attractive investment.

Alternatively we can use the IRR decision criterion which in fact is the discount rate for which the NPV equals to zero. (Benninga S, 2011). The IRR rule says that the project is appropriate to choose if the IRR is higher than the assumed discount rate. So we can conclude that both the projects are worthwhile since the IRR1 equals to 35, 94% while the IRR2 equals to 52, 72 % that are both higher than the 10 % discount rate. The logic of the rule is that the higher is the IRR the better, since you get more profits than you require. Now if we wish to choose the better between the two projects we would choose the project of 3 MW due to higher IRR. So if we try to choose between the two of them of course the second project is more profitable since the economic indicators are significantly higher, however additional high capital costs have to be considered. The increasing cost of the 3MW project may put the viability and economic feasibility at risk. It should therefore be implemented only after secure contracts and good deals with the suppliers so as transportation costs and by products sell have been defined.

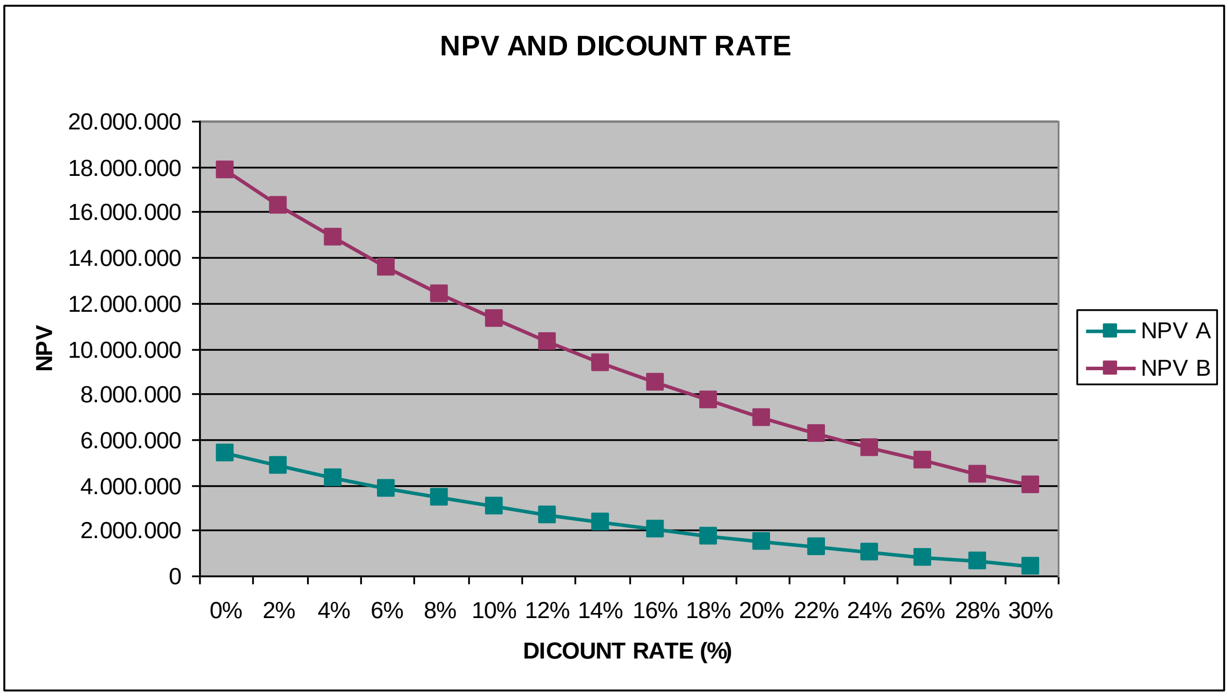
The following table summarizes the financial indicators and the main parameters for both the two projects.

Table 5.20: Comparative financial results for both size plants

Item	Parameter	Biogas unit 1,2 MW	Biogas unit 3 MW
Substrates	Total amount of organic waste tones/year	**71605**	**191.137**
System installation costs	Total capital costs	**4.200.000**	**9.000.000**
	Total operating costs	**526.580**	**1.148.927**
Energy production	Electricity generated kw/year	**8256.000**	**20.329.050**
	Fertilizer produced tones/year	**13. 505**	**38617**
Revenues	Sales of electricity €/year	**2.088.800**	**5.143.250**
	Price electricity €/kwh	**0,253**	**0,253**
	Sales of fertilizer	**270.100**	**772.340**
	Price €/tones	**20**	**20**
Decision criteria	NPV ($)	**3.113.497,07**	**11.539.841,56**
	IRR (%)	**35,94%**	**52,72%**
	Break even point	**360.185,70**	**740.788,27**

The following figure represents an comparison of the NPV curve for both the prohects when a financial mechanism like discount rate changes. In the future due to some macroeconomic changes these high changes of discount rate may happen so it is really useful how sensitive is net present value for both the projects. When the interest rate is low the project B has higher NPV but as the discount rate gets higher the NPV of project B diminishes with a faster pace than project A. the crossover point were the two curves will be meet is approximately at 60% as disount rate.In general the projects are mutually exclusive but since the results are not contradictory we can easily select project B due to higher NPV and IRR criterion.

Fig 5:7 Comparative NPV and Discount rate



Chapter 6 Conclusions

6.1 CONCLUSIONS AND IMPLICATIONS

One of the main environmental problems of today's society is the increasing production of waste. In many countries, sustainable management and waste reduction have become major policy priorities and constitute an important part of efforts to reduce environmental pollution, greenhouse gas emissions and mitigate global climate change. Moreover, energy stocks security has a strong influence on climate changes or challenges, since the proposed ways for greenhouse curbing lead to a diminishing dependence on fossil fuels. The past practice of uncontrolled landfill is no longer acceptable. Neither the controlled disposal in landfill nor incineration of organic waste is the preferred technology, since environmental standards today are much more rigorous and the challenge is energy recovery and recycling of nutrients and organic matter.

The existing sources of biomass on the planet provide an idea of the global potential of biogas. This potential has been estimated by various experts in relevant biogas researches, according to various scenarios and assumptions (Krausmann et al, 2008, Hoogwijka et al, 2008,Hoogwijk et al , 2003,Thrän et al,2010). Regardless of the outcome of these considerations, the final conclusion was that only a small fraction of this potential is actually used and exploited, so a significant increase in biogas production is essential. It is an undeniable fact that, the biogas energy and green manure biomass contribute significantly to the protection of natural resources and climate change. Moreover, the infinite availability of biogas makes one of the most promising sustainable energy carriers of the future.

The purpose of this study is first to identify the fundamental elements that underpin any possible future biogas investment plans for the case of a Thessalian slaughterhouse company to achieve company's strategic objectives and next to financially evaluate the proposed investment schemes by considering the effectiveness of the existence or absence of certain financial mechanisms for a proposed planning period of three years. The presentation of the company and setting targets based on all relevant information gathered by the service – business, as well as a thorough investigation regarding the wider industry is initially carried out. In preparing the business study we considered the answers to questions provided through a semi-structured questionnaire, about the company's structure, projected financial position and progress and development. It is believed that the company can succeed in winning a good share of the broader industry which is still in its infancy, always respecting the quality and safety standards, offering a quite satisfactory profitability for a time horizon of at least three years based on estimated costs that are necessary for its smooth operation at a satisfactory level, while at the same time it can achieve implementation of its strategic developmental goals.

The success of the operation, viability and the effective progress and development would arise from three key features:

1. Human factor
2. Innovation and differentiation
3. Quality - Functionality - environmental protection

These will form the main benefits of the anaerobic process and investment as well. Market benefits such as the great variety of products and end uses are responsible for the high profits that can be achieved through electricity, heat or fertilizer sales. Also environmental benefits such as reduced pathogenic organisms or odours, reduced contamination or groundwater and curbing of greenhouse gas emission can reduce legal problems and reinforce the green image of the company towards the society and the public opinion while they guarantee a sustainable environmental development. What is more, benefits are in a regional and national level as well, as apart from environmental benefits, the economic well being of the region through new job openings is a fact.

A range of key factors that may influence the decision making process for a biogas investment and the implementation of an anaerobic digestion technology, have been identified and clarified through the literature background and the case study review as well. After, the identification of the main drivers or barriers examined through the use of the theoretical background and relevant researches in this field, these factors were assessed through structured interviews. The main structured interviews were held with the use of a questionnaire which was addressed to five respondents from the company's staff: the owner-chairman, the production manager, the financial manager, and two members from the waste management team. Further analysis and data interpretation offered useful insights into the most critical constraints, drawbacks and barriers, as well as potential opportunities and motives as highlighted by the interviewees. In fact these factors constitute the general context in which the project will be implemented. In other words, the factor analysis has provided a well-defined socio-economic, institutional and financing framework in which biogas investment options that may be realized successfully can be rigidly evaluated.

A wide variety of connections and linkages have been signalised within socio-economic drivers or barriers and investor's behaviour. More specifically, level of awareness was proven to be very high for all the respondents since all of our interviewees were not only aware of biogas technology, but had already seen an anaerobic digestion in operation. Since the word of mouth from other investors in this technology works as a motive, entrepreneurs may be more easily convinced to invest on a biogas plant. Apart from awareness other social or demographics characteristics such as levels of education or years to retire are important factors too that have to be considered. A possible retiring would put an end to all future plans of a company, while good education levels usually make investors more open-minded to invest on alternative and innovative ideas.

Concerning the drivers, the most important of them as noted by all the respondent, were the availability of land and feedstock, the attractiveness of the market and the profitability as well. It is without doubt that the establishment in a growing market is a great opportunity for new investors. Since the market is in its infancy stage, careful manoeuvres from the entrepreneur must be done while the availability of primary sources is a prerequisite for a competitive project. Considering the fact that, the market is new and unstable and the demand of biomass exceeds the supply, the availability of feedstock is a very important strength for the company.

On the other hand, the main barriers investigated were the lack of available land and feedstock, the lack of technical support and other technological uncertainties and the uncertainty of costs and of a possible grant. For the respondents the most significant barriers were seemed to be technology based. The unproven nature and untriable technology and the lack of technical expertise to support and maintain the AD equipment constitute a potential barrier for the technology implementation. Moreover, the uncertainty over maintenance costs is very important along with a possible lack of feedstock. It is a fact that technology will remain a significant uncertainty in the foreseeable future of renewable. However, biogas investors need to feel safe and secure that have chosen the right investment pathway with medium maintenance costs of the equipment and guaranteed profits from operation, so the security of technology demonstration projects is vital.

In addition, the respondents judged the majority of factors that are related to economic and financial considerations as of critical importance for the viability of the project. Questions about initial capital costs, expected revenues from products and by-products sales, products end uses, profitability of the project, return on investment and payback period were asked to the interviewees. More specifically, initial investment costs, expected revenues from sales of products and by products, and expected profits or return on investment were the three factors that were highlighted from all the respondents as critically important. So this in fact means that those parameters such as total investment costs, revenues and return on investment will be of high significance for the financial analysis part as well. Rationale capital costs, and revenues and profits sufficient to cover the high investment costs in a short period of time, will encourage the company's chairman to actually invest. Moreover, profits are based on the capacity of the project and the efficiency of the AD process and on the price of electricity produced as well. It is without doubt that since the price is definite and a contract is signed with the PPC for electricity sales, the profits are guaranteed. On the other hand, increasing construction costs or the rising costs of maintenance and operation may underpin the development of the project. So even though the majority of respondents highlighted the available grant as a factor of moderate importance, we cannot exclude the possibility of a financial mechanism that would support the high start up costs. To go a bit further, the economic drivers are considered as of critical importance from all the respondents, justified by the fact that the company's survival and well being is based on the profitability of its operations. In general we can conclude that the socio economic factors are totally bonded with the widely adoption and implementation of the biogas technology, and to the investment decision making as well.

Concerning the legal framework factors like the favourable policies on a local, national and European level, the licensing procedure and the financing conditions from banks and institutions were examined. The majority of respondents totally agreed that the favourable policies on a national and European level are essential and vital for the project. Otherwise, the biogas investment scheme and in general investments in the bioenergy sector may be put at risk. Local initiatives and measures such as tax deductibility of biogas, guaranteed and favourable feed in tariffs and other governmental supportive mechanisms may raise the investing interest on RES and more specifically on biogas. In addition, bureaucratic mechanisms and other conditions during the licensing procedure were judged as of significant importance and could obviously impede an investment. Finally concerning environmental considerations, the respondents note the most important ones are the curbing of greenhouse gases emissions and the desire to be seen as green. Furthermore, the feeling of green social and environmental friendly behaviour was apparent to all the respondents, which is a fact that reflects the Green culture that is established in the company examined in this study. So we can conclude that the examined factors both in the internal and the external environment may exert influence on the strategic decision making process. In an effort to define completely and better understand the institutional and socioeconomic context of the project we further analysed and sketched this drivers and barriers as SWOT factors. As strengths for the company we have conclude the high availability of land and feedstock, the capable personnel and in general the three production factors, namely capital, land and human factors which constitute the most important strengths for the company. Furthermore the capacity of the plant and the efficiency of equipment along with the zero value of primary sources are undeniably major strengths. In the weaknesses category the small amount of electricity produced may work as weakness as the profitability of the project in this case would be restricted. Furthermore, the lack of trained and experienced personnel is a fact that the company has to overcome. As possible obstacles and threats for the installation of biogas plants in the Greek market social acceptance, competition form other renewable sources, bureaucracy and the general policy or financing framework that may discourage investments are consistently identified. Furthermore, approval-allowance of too many production permits for other competitive RES projects, possible entrance for more enterprises-competitors in the industry in a few years and slow growth and evolution of R.E.S. production in Greece may constitute significant threats too. In general, the unfavorable policies in a regional, national or European level may act as a key constraint and threat especially in our times where the economic crisis is a fact and the most important impediment for investments. In addition the Greek common agricultural policy is extremely weak along with the general environmental policies on wastes issues. At the time of preparing this dissertation, a series of other weaknesses faced include the fierce competition exerted by the incumbent biogas operators to prevent new players from entering the market and the PPC monopoly. In a similar way, the emerging biogas market is still in its infancy so the basic impacts of this industry are still under scrutiny, a fact that can be a threat for the sustainable development for these projects. Unintended consequences such as, competition for primary sources, environmental impacts on water noise or air pollution and biodiversity may also threaten the project.

From an opportunity point of view ongoing transformations in the biogas energy sector are triggered by changes in the growing bioenergy market, in launching agricultural activities with energy crops cultivations and further price rises of conventional forms of energy. In general European Commission’s decisions and legislation for environmental protection ,current legislative framework and the new law for RES, considerable biomass potential aspects in Greece and the continuous demand for bioenergy products are some of the main opportunities highlighted. Moreover, favourable financing and legal framework on development and investments in conjunction with national or community packages for financial support with a focus on green development may potentially enhance biogas investments.

It is without doubt that through the factors' analysis and discussion, the necessary context within which a biogas project can be suggested, investigated and implemented can be adequately formulated and sufficiently determined. Furthermore, the main waste and environmental issues that the company deals with are apparent along with aggregative data for the main organic waste and feedstock sources that the company produces during its slaughtering operations. The main objectives of the livestock and slaughterhouse unit in the region of Larissa is to diversify its activities in the growing bioenergy market and at the same time to eliminate the environmental problems associated with the waste and manure treatment. Therefore, as an innovative and viable solution to these environmental problems and risks, the installation of an anaerobic digestion scheme and mechanism suitable to biologically treat animal manure and other waste for generation of biogas, electric power and heat was suggested. Power capacity of 1,2 MW will be achieved through the efficient collection and processing of a total amount of feedstock of about 71.000 tonnes/year, that come mainly from the company's plant and everyday operations. In our case the unit of biogas production will operate effectively on farm, meaning in the existent land area and infrastructures of the slaughterhouse in the region of Larissa with an acceptable distance from the city's residential areas.

The implementation of a biogas unit of 1.2 MW/el capacity constitutes an alternative and efficient investment suggestion for the company's business activities in the region of Larissa and Thessaly Prefecture. Considering benefits on a sector-based, regional and national level, it is essential to identify the boundaries of our economic analysis of the project. More specifically an energy plant or waste management project is mostly of local interest but can be examined and discussed from a broader perspective as a part of a potential integrated network and can be applied in similar cases of companies on a local or even national level. In the feasibility analysis part the main technical characteristics of the equipment used, the available substrates, their quantities and efficiency for biogas, methane, electricity and heat and power generation were further analysed. In addition the whole AD process was further discussed, the main streams followed during the procedure were analysed along with the facilities and equipment to be built and utilized to support the biogas productive operations.

To continue with the financial analysis part, the main methodology followed was basically a cost-benefits analysis where the costs and benefits analyzed, reflect key motives or barriers that influence the investor's decision. As a first step the main assumptions for economic variables were made including: costs, revenues, prices of electricity, time horizon, interest rate, payback period and other variables too. Initial capital costs for both the licensing and the construction period were estimated using justifiable assumptions, along with the main operational costs. The construction costs included the main costs for the technical equipment of the AD, while the operational refer to transportation, maintenance, insurance, labor costs and so on. In a similar way revenues from electricity produced and fertilizer's sales were computed with the specific price of electricity per KWH assumed to be 0.253 €/kWh. During the decision making process for a new technology adoption, entrepreneurs examine the relation between expected revenues and costs and if the former exceeds the latter they decide to invest. In other words the expected profits with a 3-year horizon were calculated proving in this way the profitability of the investment.

In addition, the economic viability of the biogas solution has been evaluated and the results of the computation are reflected on the Break even point and NPV and IRR values. Concerning the break even point the company breaks even in a volume of activity or sale of 360.185,7 €. This in fact means that at this point revenues form sales are equal to costs or otherwise profits are zero. For sales more than this amount the biogas unit operates profitably, while for volume of activity under this point the biogas plant will have losses. The aim of the financial evaluation is to assess key indicators of net revenues based on the project's cash flow predictions. A particular emphasis is given on the Financial Net Present Value (FNPV) in terms of return on investment cost or capital and on the Financial Internal Rate of Return. For the specific project (of 1.2 MW capacities) the NPV was calculated at 3.113.497 euros, while the IRR is computed to be 35.94% higher than the discount rate (10%) so the investment is acceptable and feasible. So we can conclude that the economic indicators such as break even point, NPV and IRR reflect that the project seems attractive enough from a financial point of view.

According to the respondent, there are large quantities of waste available in the region that could be used for anaerobic treatment after signing a contract with the owners of adjacent units, industries or farmers, which can be potential suppliers. In financial analysis we have also examined the case of using additional feedstock as primary resource. Thus, it was further assumed that the company may invest in a biogas unit of double capacity, namely up to 3 MW. In this case the total of substrates exploited and further treated for electricity and fertilizer production are 522, 59 tones of slurry and other waste per day and the plant can have a potential capacity of 3692, 34 kwh of electricity/day. It is without doubt that new capital, operational costs, revenues and profits must be assumed, but the rest of parameters such as time horizon, interest rate and so on remain the same. In this case total investment cost, operational costs, but revenues as well, are almost doubled from the previous scenario. In addition profits has been doubled so in a similar way beak even point has arrived at approximately 750.000 €, significantly higher than the first break even point. This fact is totally reasonable if we consider the proportional increase in both costs and revenues. So basically at a level of sales of 750.000€ the biogas unit break evens and for sales above this point, it operates profitably while for level of activity below the BEP it will have losses. Considering the fact that the net present value of the project should be close to or above zero the project is worthwhile since the NPV is very high and approximately 11 million €. Concerning the IRR we can see a high difference from the assumed interest rate of 10% as the IRR is up to 51%. In general the economic indicators of the project can soundly demonstrate the viability and profitability of the proposed project.

We can also conclude that the second project scenario of investing in a plant of higher capacity with additional feedstock supplies that will actually operate as a more centralised plant constitute basically the sensitivity analysis part. Huge differences in the financial results due to a small difference in the inputs and the capacity of the digester as well can be noted and further discussed. In other words, the investment's robustness is highlighted through slight changes in the manure volume and the project's size and capacity. In addition a comparison of results and economic indicators for both the two projects gave us a further understanding of which investment is more profitable. It is without doubt that, as plant size and capacity of biogas scheme increases, the electrical efficiency and generation increases but the cost and revenues increase accordingly. The comparison of the two projects have shown differences that can easily be explained because of the different quantities of primary sources, the costs or benefits from sales and the additional amounts of energy produced. In the first case the profits before tax and depreciation are around 2 millions € while on the 3MW case around 4, 5 millions €. This can be interpreted by the fact that due to higher capacity, the electricity sales have achieved a level of 20.329.050 KW/year and 38.617 tones of fertilizer. So due to changes in the capital and operating costs, and on sales the break even point is also quite different for case two and approximately 740.000 € meaning an increase by 350.000 €. In addition, the assessment carried out demonstrates that an increase of 4million to the investment costs implies a variation for revenues and all the indicators as well.

The NPV for the first scenario is 3 million while for the second scenario has almost increased by 4 times and for both of the cases the investment is acceptable since both the NPV are positive. So we can conclude that both projects are worthwhile since the IRR1 equals to 35, 94% while the IRR2 equals to 52, 72 % that are both higher than the 10 % discount rate. The logic of the rule is that the higher is the IRR the better, since you get more profits than you require. So if we try to choose between the two of them of course the second project is more profitable since the economic indicators are significantly higher, however additional high capital costs have to be considered. The increasing cost of the 3MW project may put the viability and economic feasibility at risk. It should therefore be implemented only after secure contracts and good deals with the suppliers so as transportation costs and by products sales have been defined. The results also suggest for both scenarios suggested that when digestion is considered simply for waste management and treatment then the feasibility is marginal, as it mainly serves environmental reasons and not profitability purposes. However, if AD process is viewed in a wider context, then profitability makes it a rather attractive investment.

In general we could state that the results of the analysis have proven a strong dependence and correlation of the adopting behaviour and implementation process with the socio- economic conditions. Furthermore, the anaerobic technology is still in a premature phase and need a lot of support from the local and national authorities in order to boost the interest for investing on renewable sources of energy. So promotion strategies are vital to overcome adoption constraints and establish the use of bioenergy projects.

6.2 RECOMMENDATIONS

In this study awareness was not an important factor that would constrain the decision to invest in biogas production, since all respondents were already aware of the AD technology. However, it is a significant factor in general that policy makers have to take into account when planning promotion policies. In different cases lack of knowledge or restricted information about this new technology, its technical characteristics and its benefits would probably impede its adoption. Moreover governmental policies should support a holistic program of promotion that could tackle all the socio-economic, legal and financial factors that have been identified through relevant study as barriers and limiting concerns. More specifically this program, would involve supportive arrangements for the economics and the funding of the investment, like economic incentives such as fixed feed in tariffs, capital investment grants or soft loans and so on. Furthermore, the supportive institutional context, with regulations like the New development Law and the Investment law can guide entrepreneurs in their investment behaviour and resolve bottlenecks or uncertainties about the AD and the viability of a biogas scheme. Based on the findings of this and other related studies, financing and high capital costs are limiting factors for the investment on biogas. Therefore potential investors in order to overcome this obstruction may need to form cooperations and alliances in order to achieve creating more funding alternatives and possibly agree on the construction of a centralized biogas plant. In general the waste management industry is calling for a new waste policy to facilitate this sector to successfully evolve in the most efficient way and promote environmental stability and sustainable development.

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APPENDIX
Survey Instrument

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Questionnaire of research for biogas plant investment

In order to complete my dissertation paper in the joint Master of Science in Management Programme of the University of Staffordshire (UK) and the Technological Educational Institute of Larissa, Greece, is necessary to complete the following questionnaire. This questionnaire is an integral part of research for the economic evaluation of strategic investments in biogas. We would like to reassure you that all the information filled in the questionnaire are totally confidential and used solely for academic purposes. Thank you in advance for your participation.

Name of the company: ____________ ____________ __________

Main object of activity: ___________ ___________ ___________

Address: ____________ ____________ ____________ __________

Region: ______________ ___________________________________

Date of visit: ______________ _______________________________

PART A: General characteristics

A1.What is the main object of your activity? Please, briefly explain

____________________________ ________________ ________________________

A2.Where is your farm located?

____________________________ ____ _

A3.What is the capacity of your unit?

____________________________ ______________ ______________ ______________

____________ ________________ ______________ ______________ ______________ _

A4. What is the legal / ownership status of your company?

Private	☐
Unlimited Company	☐
SA	☐
Limited (LTd)	☐

A5. Which types and how many animals of each type does your company possess?

a)____________________________ ____

b)____

c)_______________________________ _____________________________________

_______________________________ _____________________________________

A6. Please indicate the quantity of manure produced by each type of animal

a)____________________________tones/day______________________ tones /year

b)____________________________tones/day______________________ tones /year

c)____________________________ tones /day______________________ tones /year

d)____________________________ tones /day______________________ tones /year

A7. What other types of waste are produced in your facilities?

a)____________________________ ____

b)____

c)_______________________________ ______________________________________

d) _______________________________ ______________________________________

A8. Please indicate the quantities of waste produced in your facilities?

a)____________________________ tones/day______________________ tones /year

b) ____________________________ tones /day ______________________ tones /year

c)____________________________ tones /day ______________________ tones/year

d)____________________________ tones/day ______________________ tones /year

A9. Are there any other similar units and facilities in the region that may produce waste?

What kind of waste? How much?

a)____________________________ ____

b)_______________________________ ______________________________________

c)_______________________________ ______________________________________

d) __ ___________________________ ______________________________________

PART B: Waste management issues

B1. How do you presently manage the animal manure produced? Please, briefly describe

___________________________ ______________ ______________ ______________

____________ ________________ ______________ ______________ ______________

B2. How do you manage the waste from slaughtering? __________________________

______________ ______________ ______________ ____________ ________________

______________ ______________ ______________ ______________ ______________

B3. Please indicate the relevant cost for collection, storage and handling of your unit waste.

a)___________________________ ______________________________________

b)______________________________ _____________________________________

c)______________________________ ____________________________________

d) __ __________________________ _____________________________________

B4. Please indicate the average cost for collection, storage and management of other similar units waste.

α)___________________________ ______________________________________

b)______________________________ _____________________________________

c)______________________________ ____________________________________

d) __ __________________________ _____________________________________

B5. Please describe any problems (if any) caused by your company's waste in the region.

a)___________________________ ______________________________________

b) _____________________________ _____________________________________

c) ______________________________ ____________________________________

d) __ __________________________ _____________________________________

B6. Are you aware of the Greek legislation about waste treatment, and if yes do you follow it? ___________________________ ______________________________________

_____________________________ _____________________________________

______________________________ ____________________________________

B7. Are you aware of the EU directive for waste treatment?

Yes ☐ **No** ☐

B8.**Has your farm been involved in legal action concerning waste issues?**

Yes ☐ **No** ☐

B9. Are you aware of green certificates?

Yes ☐ **No** ☐

PART C: Factors that affect investment on biogas technology

C1. Have you ever heard about the possibility of producing biogas, electric power and heat from organic waste treatment?

Yes ☐ **No** ☐

C2. Have you ever heard about waste treatment through anaerobic digestion?

Yes ☐ **No** ☐

C3. How would you describe your level of knowledge regarding anaerobic digestion? (Check any that apply)

This is my first time hearing about anaerobic digestion	☐
I have heard about anaerobic digestion from other farmers or industry people	☐
I have read about anaerobic digestion in trade publications and journals	☐
I have seen an anaerobic digester in operation	☐
Anaerobic technology has been explained to me by an expert	☐
I have researched anaerobic digestion extensively	☐

Other: ____

C4. Have you considered investing on anaerobic digestion technology in your farm? (Check one box)

I am in the process of collecting information about anaerobic digestion ☐

I am in the process of planning and constructing an anaerobic digester. ☐

I currently use anaerobic digester technology in my farm. ☐

I have used anaerobic digester technology in my farm in the past. ☐

Not at all. ☐

<u>Socio-economic factors –market conditions</u>

C5.How do you assess the general impact of biogas projects? ______________________

____

C6. Please estimate how important is each of the following factors-drivers for the decision to invest on biogas technology

	Very important	**Important**	**moderate**	**Not important**
1.Attractiveness of an emerging bio energy market				
2. Future market opportunities and potentials				
3. Availability of land or feedstock supply				
4.Existence of financial support				
5. Profitable return on investment				
6.Possible environmental benefits				

C7. Please estimate how important is each of the following factors-barriers for the decision to invest on biogas technology

	Very important	Important	Moderate	Not important
1.Lack of land availability				
2. Lack of feedstock availability				
3.Lack of technical expertise				
4. Lack of operating experience				
5. Uncertainties of financial support				
6. Uncertain construction and operational costs				
7. Competition from alternative investment options				

C8. Regardless of your current plans, if you were considering adopting a technology such as an anaerobic digester, how important would the following investment considerations be for your decision?

Investment considerations	Very important	important	moderate	Not important
1.Return on investment				
2.Payback period				
3.Government grant levels				
4.Interest rate on construction loan				
5. Income from product sales				
6.Income from by-product sales				

C9. Regardless of your current plans, if you were considering adopting a technology such as an anaerobic digester, would the following types of information influence your decision?

Information on	**Definitely No**	**Probably No**	**Probably Yes**	**Definitely Yes**
1. Initial capital cost				
2. Expected maintenance costs				
3. Expected profits/losses				
4. Available grant money				
5. By-product uses/markets				
6. Testimony from experienced investors				
7. Environmental impacts				

Other/comments:____

Financing Factors

C10. Please indicate the degree of agreement with the following statements for the realization of biogas projects from your personal point of view!

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
1) Public money is important					
2)favourable policies from the local/regional level are essential					
3) favourable policies from the national level					

are essential					
4) favourable policies from the EU level are essential					
5)Favourable approval and licensing conditions are essential					
6) favourable credit conditions from financial institutions and banks are essential					

Other/Comment: ____

Legal factors

C12. Do you view the Greek legislation as having an obstructive influence on the realisation of Biogas projects? yes no

Explain: ____

C13. Please evaluate whether the influence of legislative requirements is obstructive within the following, different biogas project stages:

a) Development and planning
b) Authorisation (incl. environmental regulation)
c) Construction
d) Operation of bioenergy plant (incl. emissions)
e) Treatment of residues

Environmental Factors

C14. Regardless of your current plans, if you were considering adopting a technology such as an anaerobic digester, how important would the following environmental considerations be for your decision?

	Critical important	**Very Important**	**Moderate**	**Not important**
1.Possible reduction in carbon emissions				
2.General environmental benefits				

3.Meet national energy targets				
4. Promotion of energy security				
5.A sense of community responsibility and environmental concern				
6.Desire to be seen as “green”				

C15. Please indicate which of the following benefits from digestion technology is most important to you and your company:

- **Product Sales** ☐
- **By-product Sales** ☐
- **Odour Reduction** ☐
- **Enhanced Nutrient Management** ☐

C16. Please indicate which of the following benefits from digestion technology is most important for the industry as a whole:

- **Alternative Fuel Production** ☐
- **Competitiveness** ☐
- **Reducing Greenhouse Gases** ☐

PART D: Demographics

D1. **Gender:**

Male
Female

D2. Age:

< 30

31-40

41-50

51-60

61-70

> 70

D3. Do you plan to retire or exit the slaughter house industry within the next 5 years?

Yes
No

D4. **What is the highest level of education you have completed?**

Some high school

High school graduate

College graduate

Master's degree

Doctoral degree

D5. What were your gross receipts from your activity in 2010?

Less than €250,000

From €250,000 to € 500,000

From €500,000 to €1,000,000

From €1,000,000 to €2,000,000

From €2,000,000 to €4,000,000

From €4,000,000 and more

Thank you in advance for your help!