Economic Evaluation of Strategic Biogas Investment Options – Case Study in the Region of Larisa

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Abstract
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. 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 constant expansion and introduction of a suitable mixture of renewable energy sources in the state's energy balance is a necessity in order to meet 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.However, the successful adoption and implementation of technologies for biomass anaerobic digestion and conversion to biogas and other biofuels remains a challenge. Under this framework the aim of this study is to present a systematic technoeconomic analysis of the socio-economic and institutional context along with financial assessment of a strategic biogas investment option, so as to arise and strengthen the interest of potential actors in the Greek bioenergy sector. At first place, the main research objectives are to identify key drivers or barriers for the implementation of biogas investment. More specifically, the main influences that the internal or external environment exerts on the strategic behavior of biogas actors were examined and highlighted through theoretical background and structured interviews with a focus on the specific case of a slaughterhouse unit in the region of Larissa. To continue, the findings from the first research part constitute reference points for SWOT analysis where the main driving forces or barriers of a biogas investment decision are reflected. Then the economic and financial analysis of the suggested project follows with the use of key economic indicators such as Net Present Value, internal Rate of Return(IRR), and Break-Even Point (BEP) in order to identify the feasibility and economic viability of the investment.

Keywords: Biogas, Strategic Investment Analysis, Animal Waste, Biogas Economics, Renewable Energy Sources

Introduction

Nowadays, the global energy production scene passes through significant phases with the most striking ones to be the depletion of fossil fuels and the boosting of new infinite sources of energy , the so called renewable. Renewable sources of energy are the unconventional forms of energy such as: solar, wind, hydropower, geothermal, biomass and wave (tidal) energy and today they dominate in the EU energy mix. 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 the Kyoto's Protocol targets and regulations mandate (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. According to Evans et al (2010), biomass constitutes a form of renewable that includes organic material such as energy crops, animal, agricultural or industrial waste and residues. The existing sources of biomass on the planet, provide an idea of the global potential of biogas which is a mixture of methane and carbon dioxide and other gases released during biomass anaerobic digestion. More specifically, as Wilkinson (2011) supports in his research, anaerobic digestion is a biological process by which organic material such as animal manure and agricultural or industrial waste are treated in the absence of oxygen and are converted directly into 'biogas'. Undoubtedly, 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 (Krausmann et al, 2008, Hoogwijka et al, 2008,Hoogwijk et al , 2003,Thrän et al,2010).
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. Undoubtedly, 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. Since environmental considerations form an integral part of competitiveness and sustainable development of business, environmental or waste management and the investment on strategic biogas or other renewable options will be seen as a necessity for the survival of a company.

Methodology

In this paper, the main subject of investigation and analysis is the empirical case of a cattle-breeding and slaughterhouse unit, a potential investor on an on-farm biogas generation facility in the municipality of Larissa in the general region of Thessaly. 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 Additionally, since 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 and energy efficient. This fact can justify the reason why this large scale and animal capacity unit was purposively selected for further research.

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 were employed on this behalf: a descripto-explanatory interview with the use of structured questionnaire as an instrument and the financial analysis of a biogas investment with the use of fundamental economic indicators.

The interview participants were purposively selected based on their organizational position and duties, since our main objective was to collect a total of different viewpoints from key representatives within different organizational levels. So we have conducted structured, face- to –face and 30-minute interviews with the use of an interviewer-administered questionnaire with the five key managers and more specifically with the owner, the production manager, the financial manager, and the two members of the waste management team. These interviews have provided qualitative data such as perceptions about possible benefits and the strategic context of a biogas investment project. In an attempt to avoid all possible limitations, the questionnaire was designed in such a way so as every factor examined to be clearly described and easily rated to a scale. In the first section of the interview through a set of open questions we strived to define the profile of the company in terms of: plant location and size, animal capacity, waste issues such as quantity of feedstock substrates produced and potential of biogas generation with the use of biomass as resource. The second section of the interview was basically a clear description of waste issues such as cost, time, possible legislation problems that stem from waste treatment. In the third section of the structured questionnaire, a variety of factors drivers or barriers for the implementation of a biogas scheme, were examined from a social, economical, financial and institutional point of view. So the questions were divided into sections of 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' socio-economic factors, financial factors, legal and environmental factors. To continue, in order to complete the description of the socio economic framework of the investment we have to all the above factors were grouped as potential strengths ,weaknesses ,opportunities or threats in a SWOT matrix created to highlight internal or external influences that the environment exerts on a biogas investor.

Concerning the second part of the assignment the main aim was to make a financial analysis in order to evaluate if the investment is feasible. Potential constraints in terms of human capital, installations and capacity of the unit were stressed out along with the basic total investment costs, the total operating costs and the revenues. 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. 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 a 1,2 MW 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. 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. At the end pairwise tables have compared the financial performance indicators and the sensitivity of results to changes for both the two projects.

Case study for the slaughterhouse in Larissa

The socioeconomic and then the financial analysis developed were implemented for the case study of a swine- breeding unit and slaughterhouse in the municipality of Larissa, of the prefecture of Thessaly, Greece.

The unit has a capacity of 2500 pigs and 3000 cows with a quantity of everyday manure produced to be 125 tones/day for swines and 51 tones/day for cows along with 19 tones of slaughterhouse waste. If we take into consideration the huge amount of feedstock, manure and other waste produced during the slaughtering procedure the company must deal with a variety of waste issues and legislation mandates. During the interview process the stakeholders enlightened us with the whole procedure followed for waste treatment that is basically a biological treatment mechanism rather costly and time consuming. 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.

Factor Analysis and SWOT Analysis

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 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 1: 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**

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. 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.

Table 2: 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. Current EU and national legislative framework –new law for RES 2. Inevitable run out of conventional energy sources 3. Considerable biomass potential aspect in Greece4.Continuous demand for bioenergy products5. 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**

Project suggestion

The main objectives of the livestock and slaughterhouse unit 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. So 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 of 1.2 MW/el capacity suitable to biologically treat animal manure and other waste for generation of biogas, electric power and heat. 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.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). The following figure shows on farm digestion process as a whole integrated bioenergy production system through the treatment of organic waste and recycle of nutrient substances.

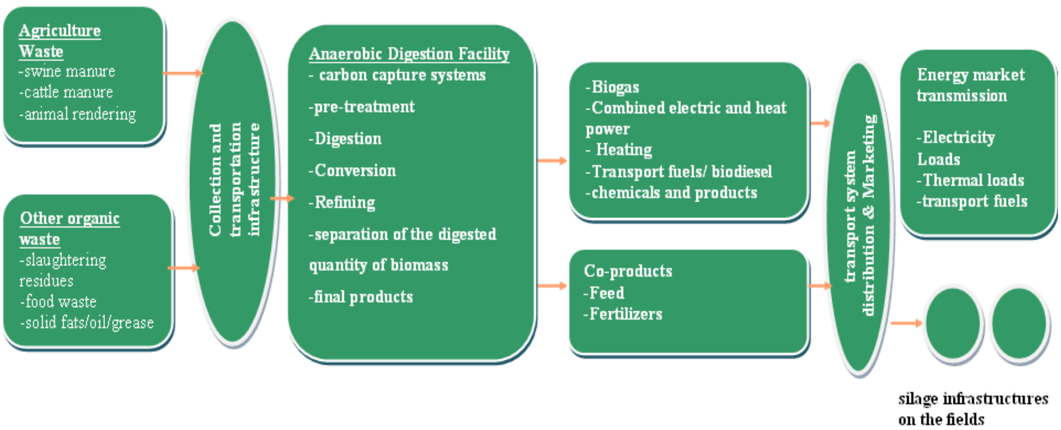


Figure 1: The main streams and system of an on farm biogas facility (taken from White Paper Big East)

Financial Analysis

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.

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. 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. The interest rate was set to be 10 %.Connection charges and grid connection issues are prices taken from CRES and the PPC for the Greek biogas market.

Table 3: Economic indices and variables

Economic indices and parameters	**Value**	**Units**
Initial investment year	**2011**	**year**
Economic plant life	**25**	**years**
Construction period	**1-2**	**years**
Payback period	**3-4**	**years**
Operating hours	**8000**	**h/year**
Operating days	**333**	**d/year**
Inflation rate	**1,5 to 2**	**%**
Energy price	**0,253**	**€/kwh**
Electricity produced	**1032**	**kw/h**
Increase of energy price	**0**	**%/year**
Fertilizer price	**20**	**€/tones**
Fertilizer produced	**37**	**tonnes/ per**

		day
Personnel	**5 workers**	
Trucks used	**2**	
Insurance costs (% TCI)	**0,5%**	**%/year**
Increase of operating costs	**5%**	**%/year**

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 from relevant technical assessments (McIlveen-Wright et al,2011, Amigun, and von Blottnitz,2010, C. Walla_, W. Schneeberger,2008).. 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. According to construction cost-offers from German manufactures such as BINOWA, PLANET and so on in 2010 capital costs for a typical 500kWel biogas plant in Germany was <€2000/kWel, by 2011 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 4: Total Capital Investment Costs

Organizational & establishing costs - expenses (in €)	**Licensing Period (A)**	**ConstructionPeriod (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		
Machinery	**-**	**1.178.000**
System for anaerobic digestion	**-**	**1.300.000**

Base for production of thermal and electrical power CHP	**-**	**750.000**
Main industrial building	**-**	**120.000**
Staff training	**-**	**10.000**
Landscaping	**-**	**70.000**
TOTAL (B)	**-**	**3.428.000**
GRAND TOTAL (A + B)	**4.200.000**	

Operational costs include the basic fixed costs which are the insurance cost of the unit, the sale and distribution expenditures, biomass and digested by-products purchase, disposal or transportation costs (Caputo et al, 2005). 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. According to Gasol et al,(2008) a 10 MW unit 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: 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**

In Greece the price of energy is small compared with the corresponding average in the EU. 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 the cost of biogas and electricity produced can be easily computed. 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.

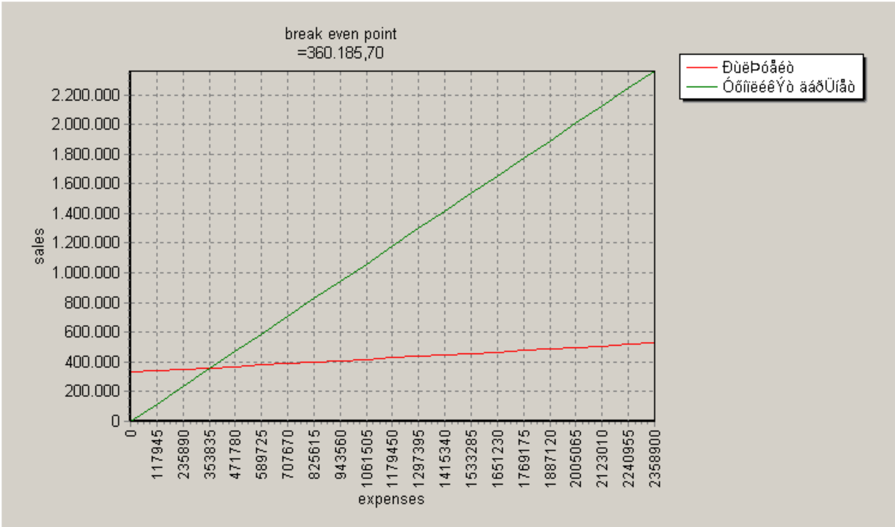
Table 6: Revenues

	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**

Concerning the break even point as we can see form the following table, 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.

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		

Figure 2: Graphical Representation of Break Even Point



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).

Table 7: Net Present Value (NPV)- Internal Rate of Return (IRR)

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

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. 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. 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%.

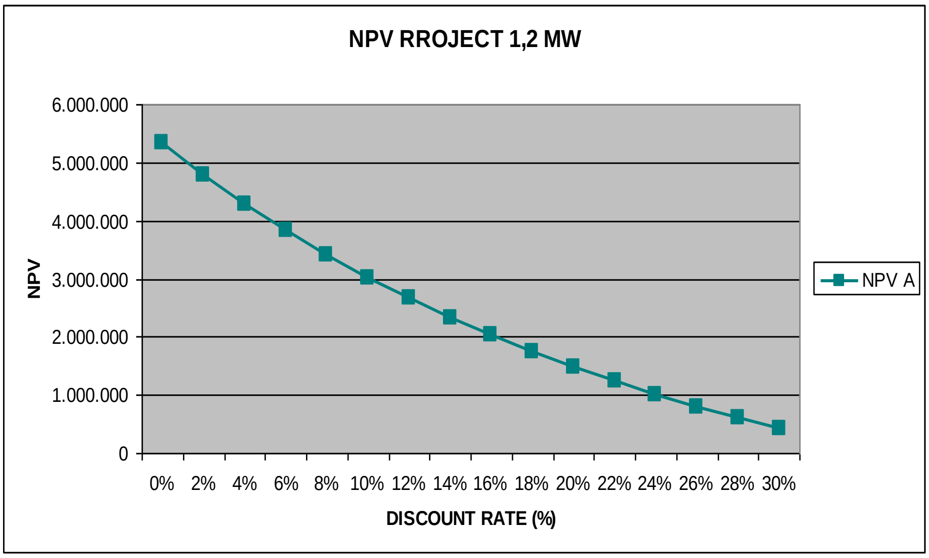


Figure 3: Sensitivity of NPV to Discount Rate changes

The existence of additional amounts of feedstock from neighbour livestock units of a total of organic waste approximately at 522 tones/day allowed us to propose an alternative company's investment on a 3MW biogas scheme. 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. The same assumption was made as in the base scenario and is summarized in the following table.

Table 8: Scenario of expansion phase

Total Investment Costs	Total operating Costs	Revenues	Profits	BEP
9.000.000	1.148.927	5.915.590	4.766.663	740.788,2

Table 9: 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
		526.580	1.148.927
	Total operating costs		
Energy production	**Electricity generated kw/year**	8256.000	20.329.050
	Fertilizer produced tones/year	13. 505	38617
Revenues	**Sales of electricity**	2.088.800	5.143.250
	€/year	0,253	0,253
	Price electricity	270.100	772.340
	€/kwh	20	20
	Sales of fertilizer Price €/tones		
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 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.

The following figure represents an comparison of the NPV curve for both the projects 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.

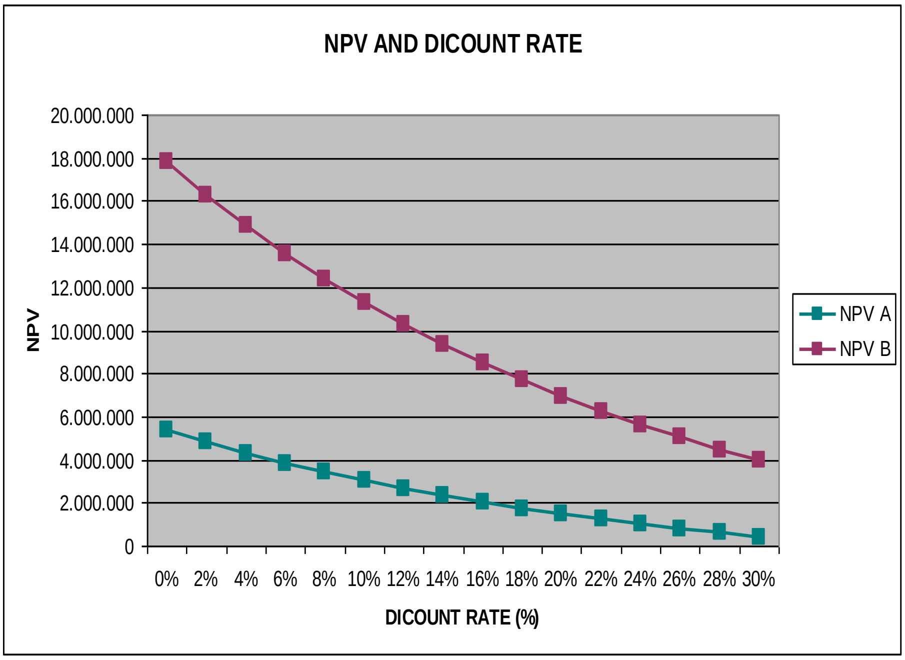


Figure 4: Comparative NPV and Discount rate

Conclusions

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 Thessalia 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. 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. A wide variety of connections and linkages have been signalized within socio-economic drivers or barriers and investor's behavior. 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. 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. Concerning the drivers, the most important of them as noted by all the respondents, 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 maneuvers 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. 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. 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, the majority of respondents totally agreed that the favourable policies on a national and European level are essential and vital for the project. 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. 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.

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.

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.

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. 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. 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: Market benefits, environmental and finally social benefits.

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. 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.

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 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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