

# BIOGAS IN VIETNAM

A proposed business model in biogas sector

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PHAN THI THANH THAO: Biogas in Vietnam

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## ABSTRACT

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The purpose of this thesis was to discover a biogas opportunity in the Mekong Delta area in Vietnam. The discussed biogas production is derived from organic waste and targeted to fulfill the demand for gas for cooking in condition of non-pipeline system. However, different products from this production were introduced to maximize the technology profitability. Another aim was to propose a business model to foreign investors who own advanced technologies in biogas production.

Qualitative research method and deductive approach were used in the thesis. In the theoretical part, some general informations of a business opportunity in biogas sector were presented. A theory of open business model will be introduced to support to a proposed business model later on. In the empirical part, the data of biogas context in Vietnam and the Mekong Delta was collected through some interview and other primary sources. The market analysis part was a detail of the Vietnam biogas market and some useful information which could help foreign investors to understand deeper about Vietnam regarding to biogas business. Additionally, the stakeholder management was presented.

An entry mode was recommended. A value network was drawn to explain the integration of the proposed business model with value chain and stakeholders. A combination of a new business model with innovated technologies in biogas sector was resulted in a centralized biogas Joint-venture company.

Key words: a centralized biogas plant, bottling biogas, business model, value network, the Mekong Delta, Vietnam, transportable biogas, biogas for cooking, organic waste, compressing biogas.

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## LIST OF ABBREVIATIONS

AD	Anaerobian Digestion
ADB	Asian Development Bank
BOT	Build Operate and Transfer
CER	Certified Emission Reduction
CDM	Clean Development Mechanism
CHP	Combined Heat and Power
CNG	Compressed natural gas
CPI	Customer Price Index
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GEF	Global Environment Fund
LNG	Liquefied natural Gas
LPG	Liquefied Petroleum Gas
JV	Joint Venture
MPI	Ministry of Planning and Investment
MSW	Municipal Solid Waste
NGO	Non-governmental Organization
ODA	Official Development Assistance
PM	Prime Minister
RECC	Research Center of Energy and Environment
R&D	Research and Development
USD	United State Dollar
VBA	Vietnam Biogas Association
VND	Vietnam dong
WB	World Bank
WTO	World Trade Organization



## 1 INTRODUCTION

More awareness of climate change is driving the increased adoption of renewable energy in this world. The supply issues of non-renewable energy and environmental hazard of waste accelerate the pace of biogas investment in many countries. In the developing countries, such as Vietnam, where people are facing a big shortage of energy and a huge waste problem, but lacking advanced technologies and capital, energy recovery from waste is a very helpful solution for this community and a good business with very promising return on investment.

The title of this writing indicates clearly what will be studied and researched in these papers; it's about a Centralized Biogas Plant in Vietnam in the Mekong Delta area, and a proposed business model for that business. In the first part of this chapter, the writer will answer two following questions:

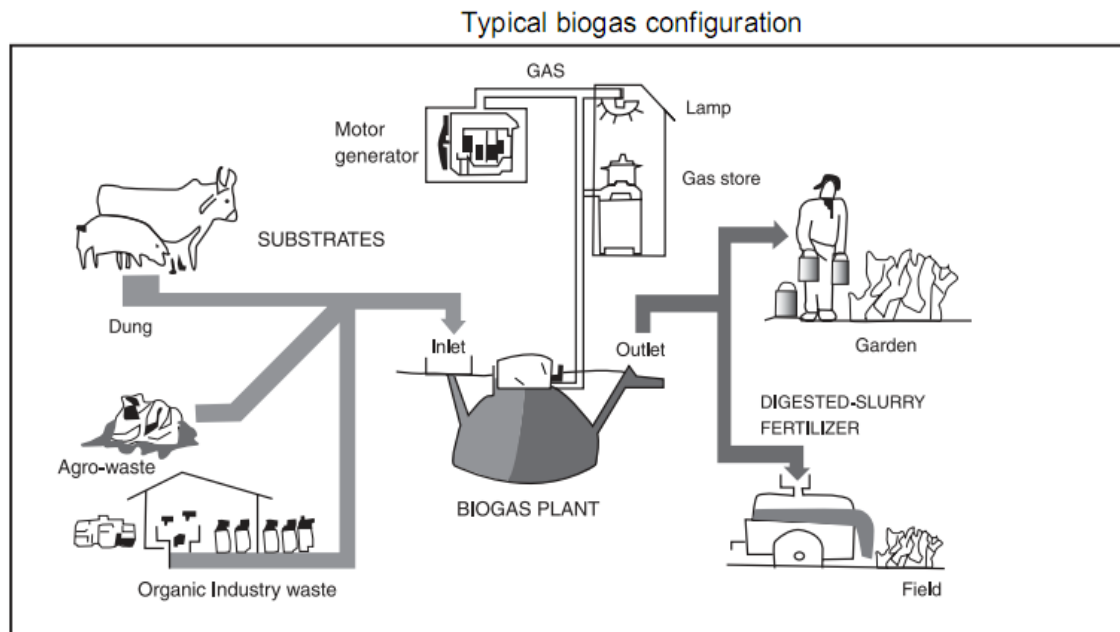
- Why do I select biogas?
- Why do I select Vietnam, in the Mekong Delta area?

In the following parts of this chapter, the objectives, scopes of this research will be mentioned. There are also the research method and approach that the author uses to answer all the research questions of this thesis.

### 1.1 Background

#### 1.1.1 Biogas overview

Biogas is the gaseous emissions from anaerobic degradation of organic matter, such as plants or animals, by a consortium of bacteria. Biogas is principally a mixture of methane ( $\text{CH}_4$ ) and carbon dioxide ( $\text{CO}_2$ ) along with other trace gases. Methane is the principal gas in biogas. Methane is also the main component in natural gas, a fossil fuel. Biogas can be used to replace natural gas in many applications including: cooking, heating, steam production, electrical generation, vehicular fuel. [[www.biogas.ifas.ufl.edu](http://www.biogas.ifas.ufl.edu), 2.2011].



Source: GTZ Biogas Basics.

**Figure 1: Typical biogas configuration**

[APCAEM, Recent developments in biogas technologies for poverty reduction and sustainable development, p.13]

Biogas can be produced from a wide variety of available organic materials and wastes, including sewage sludge, animal manure, municipal and industrial organic waste, parts from ethanol production, crop residues, and especially grown energy crop and more, in an environment that contains little to no oxygen. Typically, this naturally occurring bacterial decay is underground or in areas where the access to oxygen is limited by gas displacement. [www.infofastlane.com/biogas, 9.2011]. From the below figure, we can see that one ton of biowaste feedstock could produce  $100\text{m}^3$  biogas which contains about 61% methane. This figure just presents some of biogas substrates. There is a long list of biogas substrate studied by BiWaRE (Biomass and Waste for Renewable Energy) during the project of building a Decision Support System in the appendix 2 at the end of these papers.

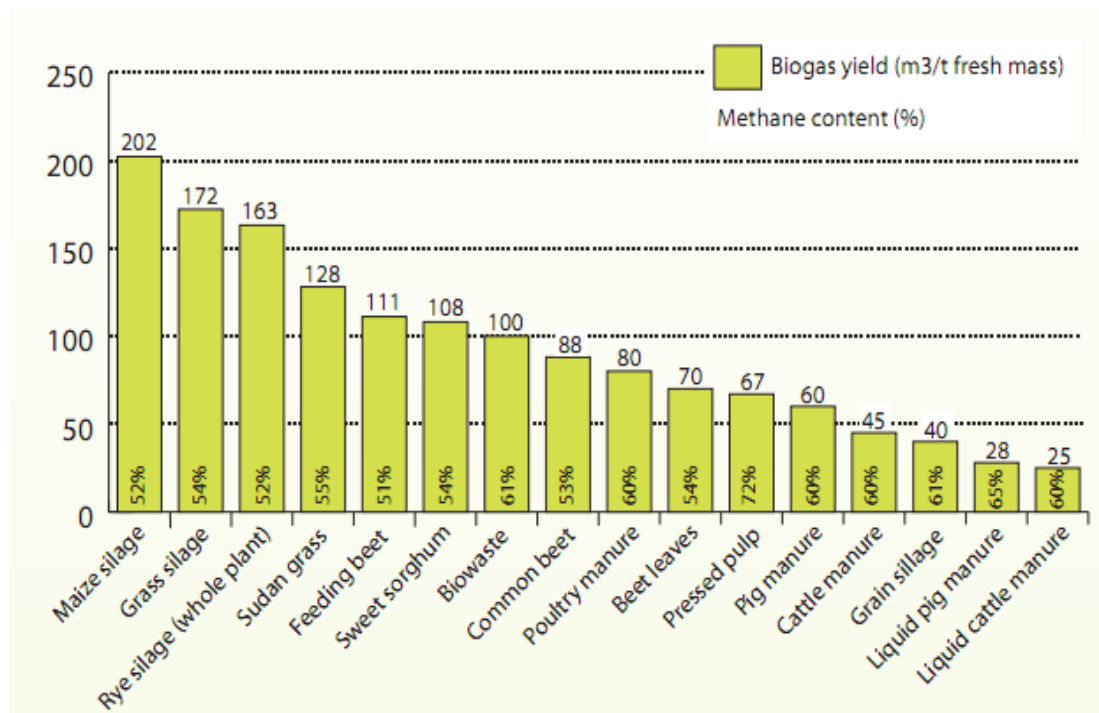


Figure 2: Biogas yield and methane content of various substrates

[[www.fnr-server.de](http://www.fnr-server.de), 2.2011]

There are different technologies to obtain energy from organic matter such as combustion, gasification, anaerobic digestion. The products of these conversion technologies are heat, electricity, fuel, and by-product of fertilizer.

Biogas has similar characteristic to natural gas. The properties of biogas are pressure and temperature dependent. It is also affected by the moisture content and other major factors such as:

- Change in volume as a function of temperature and pressure
- Change in calorific value as a function of temperature, pressure and water vapor content
- Change in water vapor content as a function of temperature and pressure.

The calorific power of biogas is about 6 kWh/m<sup>3</sup>. This corresponds to about half a liter of diesel oil. The net calorific value depends on the efficiency of the burners or appliances.

### 1.1.2 Biogas benefits

All activities in the world are much relied on energy sources. People need electricity, fuel, and gas for their eating, sleeping, reading, driving, and of course for their businesses also. Nowadays, energy from renewable sources is the focus of many institutes and busi-

ness organizations. Producing non-fossil fuels is a solution for future that helps people reduce the dependence on fossil energy which is estimated to be in the rapid exhaustion and causes environmental pollution. Biogas can provide a clean, easily controlled source of renewable energy from organic waste materials for a small labor input. It can replace firewood or fossil fuels, which are becoming more expensive as supply falls behind demand. [[www.energymap.dk](http://www.energymap.dk), 5.2011]

Many business organizations are aware of economic benefits of biogas. A biogas plant can transform organic waste into high quality products, energy for heating which will be sold as natural gas in local market, electricity which will be used to run the plant and fertilizer which will be sold to farmers. This business will provide jobs to local people and also opportunities to relevant businesses, such as local transporters, chemical suppliers, who support the plant.

The environmental benefits of biogas are accepted globally. Biogas offers a substitution for fossil energy. It reduces methane emission into the atmosphere, and it is clean treatment of waste. Considering the local impacts of a biogas plant, a big benefit is in its nature. As a biogas plant is a closed system and treated materials are not in contact with atmosphere the typical negative impacts to neighborhoods are minimized in totally different scale than with other waste management systems. As a waste management solution, a biogas plant is clearly a forerunner by taking the advantage of waste raw materials to produce high quality fertilizers and energy.

Biogas is a chance to reduce organic methane and fossil CO<sub>2</sub> in the atmosphere. Methane is the key component in biogas. It is 21 times more powerful a greenhouse gas than CO<sub>2</sub>, but it can be turned into CO<sub>2</sub> and water during the incineration of biogas.

[[www.biogasmax.eu](http://www.biogasmax.eu), 5.2011]

Biogas production can reduce the pollution potential in wastewater by converting oxygen demanding organic matter that could cause low oxygen levels in surface waters. Nutrients, like nitrogen and phosphorous are conserved in biogas effluents and can be used to displace fertilizers in crop production.

Beside these, biogas is also known as a way to reduce the workload, mainly for women and children, in firewood collection and cooking. In developing countries, there are many projects of biogas to improve the energy stove and kitchen condition.

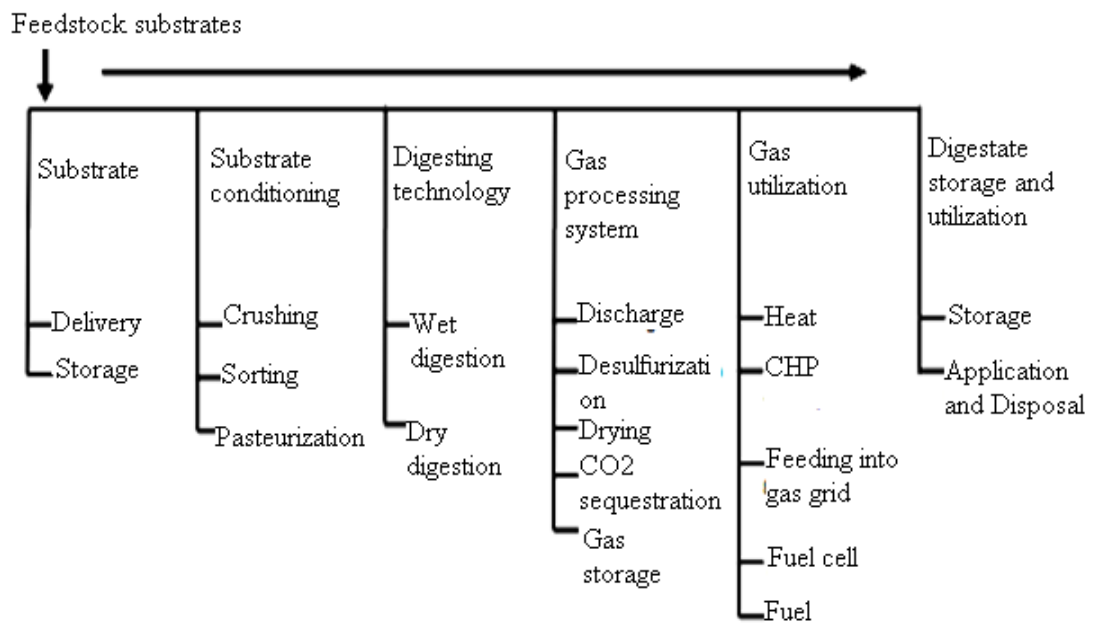
### 1.1.3 Biogas development in the world

The global megatrend is driving the biogas industry growth [Global Intelligence Alliance, 11.2010]. Nowadays, people are more ready to face to the global problems of the inevitable end of fossil and natural gas, the climate change. They focus more and more on biogas which is a sustainable and renewable energy. There are more study and utilization of technology supporting the biogas industry growth in order to reduce the dependent on fossil and natural gas as well as to limit methane emission from the fermentation of organic matter in waste.

Biogas industry is growing at different speed in different areas in the world. As mentioned in the webinar on “How to profit from biogas market development” by Global Intelligence Alliance, the biogas market in Europe is growing at two-digit rate, and the most biogas utilization is electricity generation. There are some changes in Europe biogas market, upgrading biogas to be equivalent to standard natural gas. But the sharing of this application is still limited. For example, in Germany, the biogas market leader in Europe, there was only 7% of its plants were feeding the upgraded biogas into the existing natural gas network. The biogas market in US is developing at limited level. The number of biogas plant is modest comparing to its biogas potential. The biogas recovery from landfill and livestock are the fastest growth in this market. There is also biogas recovery from wastewater treatment and organic waste [[www.energimyndigheten.se](http://www.energimyndigheten.se), 5.2011]. In East Asia and Pacific, where electricity and modern cooking solution are considered as two steps needed to climb in order to achieve universal access to modern energy, biogas recovery from livestock is where the most development is. China’s and Vietnam’s experiences demonstrate the potential of expanding biogas energy system to households who own livestock [[siteresources.worldbank.org](http://siteresources.worldbank.org), 7.2011].

The current applicable biogas technologies focus on the utilization of heating, electricity generation and vehicle fuel as presented in the below figure. This means that the cooking utilization in condition of unavailable pipeline has not been taken in place. This can be

explained because this problem does not exist in the developed countries, where advanced biogas technologies has been developed well, but in the developing countries.

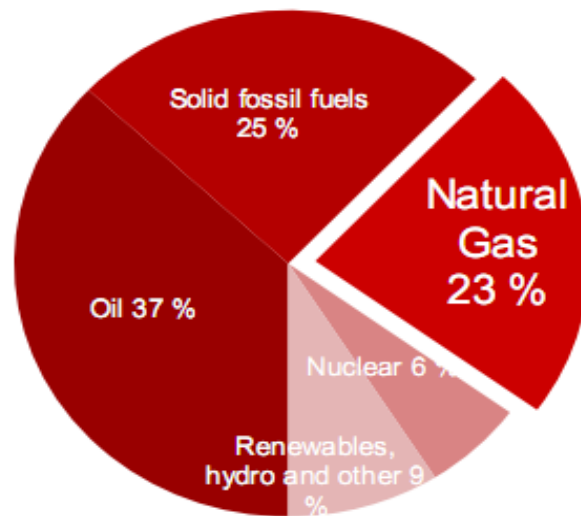


**Figure 3: Process step of biogas technologies**

[T. A. Seadi et al 2008, p. 60]

However, the common challenge is upgrading technology which is still challenging the cost structure of biogas. More players enter biogas market and develop biogas product following the need of natural gas, which is reported to make up about 23% of global primary energy production, as shown in the bellow figure, and get shortage. Meanwhile, biogas has the similar characteristics as natural gas after being upgraded. So in future, biogas is forecasted to be used as natural gas. And the bright future of biogas industry is for the high technology players.

## Global Primary Energy Production



Source: US Environmental Protection Agency

Figure 4: Global primary energy production

In the webinar from Global Intelligence Alliance in June 2010, Biogas is evaluated as a sustainable business in a starting point of an exponential market growth curve. The company with the right expertise and timing can capture its share of the billion that are invested in the infrastructure in the coming year. The primary profiteers of the biogas industry growth are anaerobic digester, especially those in Asia today, biogas condensation and upgrading technology developers, centralized and specialized plant producers, and distributors of biogas. The secondary profiteers of this are suppliers of power plants and process equipment, maintenance services, chemical companies developing the production yield and efficiency of biogas. [[www.globalintelligence.com](http://www.globalintelligence.com), 9.2011]

As a global trend, the larger sites will improve the efficiency of power generation, profitability of biogas upgrading and the utilization of by-products. It's said that "Price volatility of gas and oil will be the main driver of biogas industry; a sufficient price increase of gas and oil will make biogas profitable everywhere." [Kim Soderman from Finnish Biogas Association, 2010].

The need of transportable biogas is rising, especially in developing countries such as India, Pakistan, Nepal, Vietnam. There are websites where present information of compressing and bottling biogas such as <http://www.environmentalengineering.in/Biogas.htm>

, or such as <http://www.agricultureinformation.com/forums/consultancy-services/12303-biogas-can-bottled-cylinder-like-lpg.html> . It mentions that there are more than five unit in India have already commercialized this method, or [http://www.idosi.org/wasj/wasj1\(2\)/12.pdf](http://www.idosi.org/wasj/wasj1(2)/12.pdf) a case study to bottle biogas in cylinder in Pakistan. A project of biogas compressor was conducted by a group in the University of Michigan in 2008 [http://deepblue.lib.umich.edu/bitstream/2027.42/58672/1/me450w08project29\\_report.pdf](http://deepblue.lib.umich.edu/bitstream/2027.42/58672/1/me450w08project29_report.pdf) . However, an official report of the efficiency of these projects has not been found.

If you are an expert in biogas industry, then you may say that it seems too early to think of compressing and bottling biogas to be transportable to every kitchen at the moment. However, there is no reason to say that idea will never be commercialized. As the study case of Xerox that Henry William Chesbrough described in his book of “Open innovation: the new imperative for creating and profiting from technology” 2006, this company selected technologies that fit its business model and eschewed those that did not. These rejected technologies were later commercialized outside of Xerox’s value chain. Coming back to this thesis, there is a huge demand for gas for stoves in areas where piping systems are not available and electricity is serious lacking. So compressing biogas is a challenge for a winner. The picture below shows a global outlook of biogas for next future.

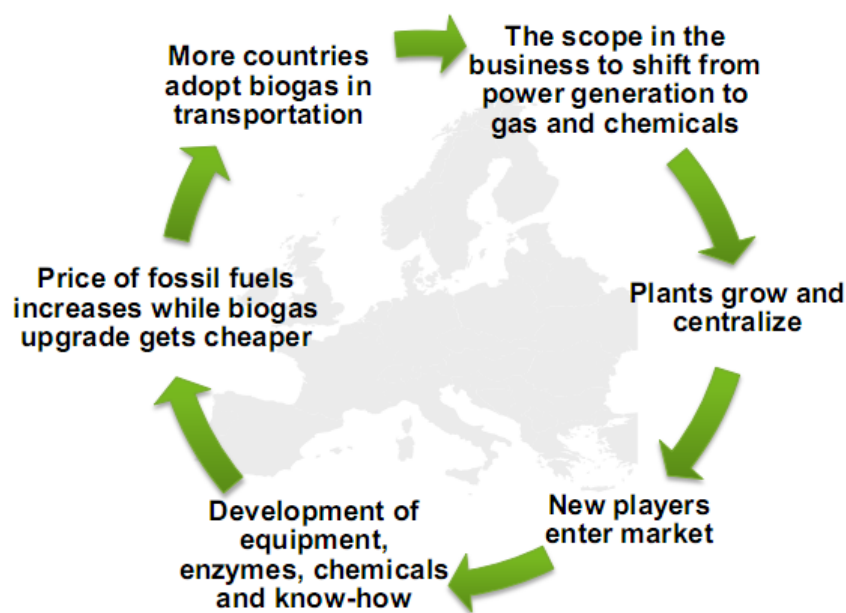


Figure 5: Global look of biogas

[Global Intelligence Alliance, 11.2010]



Developing countries have more opportunities to approach the advanced technologies in renewable energy industry when there are more nations signing and ratifying the Kyoto Protocol which aims at global warming. Thank to one of the "flexibility" mechanisms defined in the Kyoto Protocol that is the Clean Development Mechanism. It allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tone of CO<sub>2</sub>. These CERs can be traded and sold, and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. [[cdm.unfccc.int](http://cdm.unfccc.int), 10.2011]

#### 1.1.4 Biogas development in Vietnam

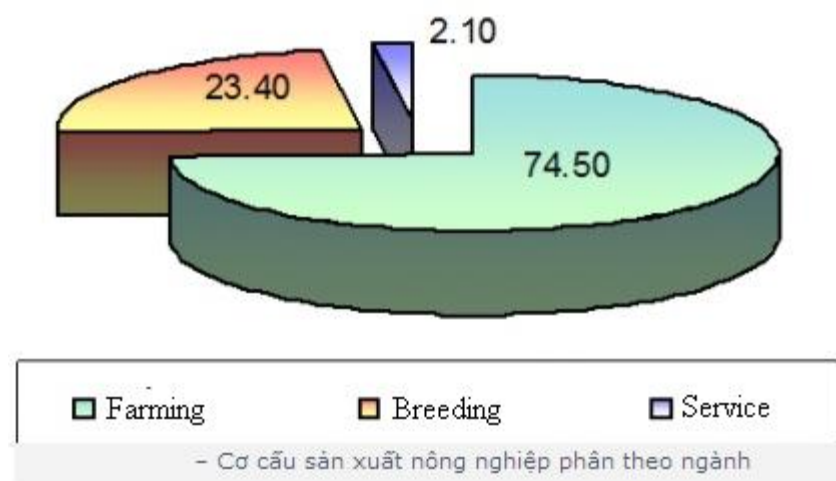
Vietnam is an agricultural developing country. It is the second biggest exporter of rice in the world. There are some areas in this country where farming is centralized such as Red River Delta in the North and the Mekong Delta in the South. But in breeding industry, there is no big centralized area. Livestock owners are families mainly. The population of Vietnam has been increasing sharply during recent decades. With more than 90 million people, this developing country has an increasing demand of energy and increasing organic waste to be solved. As a report from ADB, Vietnam is richness and variety of energy resources, nonetheless, the capacity on energy extraction, production and distribution are limited. [[www.yeumoitruong.com](http://www.yeumoitruong.com), 8.2011]

Waste is a huge problem in Vietnam. The current discharged waste is estimated at.. per day. And it is estimated to be increased at 15% yearly. The problem is more serious in rural areas, where 80% wasted, equivalent to about 12 million ton per year, has not been collected well is reported. [[vtc16.vn](http://vtc16.vn), 10.2011]. Waste volume in the Mekong Delta is estimated at 3,7 million ton per year, and about 90% of those has not been treated well. [[www.baomoi.com](http://www.baomoi.com), 11.2011].

Biogas plants have been present in Vietnam for decades. Although since about 2000, there has been an increase in interest from NGOs and donors for this technology. As in other countries, several different models of bio-digesters have been introduced, from the simple plastic tube to the fixed dome systems. Biogas is mainly produced at family sized biogas plant. Recently, some companies apply it for electricity generation. [[www.yeumoitruong.com](http://www.yeumoitruong.com), 6.2011]. Vietnam is a big market for combustible gas because electricity is serious lacking in this country. There is a great need to make biogas be

transportable to every kitchen because of many reasons that will be presented in the market analysis in this paper. It is a good business opportunity to have a biogas plant for producing biogas from organic waste, cleaning biogas to meet the minimum required properties of combustible gas, and compressing it into cylinders to be transportable to every kitchen.

Biogas is recognized as a solution to turn the waste problem in Vietnam into value products and fill the local customers' expectation of energy. As mentioned above, biogas is originated from organic stuff. And Vietnam is an agricultural country. The agriculture contributes about 21% to Vietnam GDP. In the structure of agriculture, farming makes up 74.5%, breeding is 23.4%, and service is 2.1% as shown in the figure below:



**Figure 6: Structure of Agriculture in Vietnam**

[Ho Thi Lan Huong from Vietnam energy institute, 2008]

In Vietnam, some biogas projects to produce gas from organic waste are under study, but there is no implementation yet due to lacking know-how. The potential of this market has been recognized recently. The investors will come there sooner or later. However, the earlier you are the more competitive elements you get. In Finland, there has been anaerobic technique and experience in capturing energy from waste recovery. There is no barrier to stop this advance technology from creating business in Vietnam to earn money.

Lacking energy and waste solution are two big problems in Vietnam. People have to face electricity cuts very often. Especially in the south of Vietnam, where the dry season lasts about six months a year, people get about twenty-four hours of electric cuts per week in

urban areas and more than forty-eight hours per week in rural areas. Another issue is the huge waste volume which is treated with less advanced technologies and pollutes environment. According to a survey conducted by the expert association in different areas of the country, approximately 80% of landfills are unprompted, unhygienic. The land-filling process does not comply with the current provisions and the regulations of Vietnam. They are causing serious environmental pollution. The government wants to limit the land-fill. [[www.baomoi.com](http://www.baomoi.com), 10.2011]

Vietnam has huge potential of biogas production from different resources such as animal dung, waste water, and organic waste. But the development of biogas is rather slow. The biogas was reported to have been studied and applied since 1960s, but at very small scale. After 1975, there was a national program of renewable energy to promote the biogas studies and utilization. Until now, there are about 222,000 family sized biogas plants. However, biogas in Vietnam is mainly produced from livestock. [[www.windenergy.org.vn](http://www.windenergy.org.vn), 11.2010]

There were few recognized reports of biogas until after 1995, when many universities, institutes and organizations have taken interest in this industry. There has been a lot of studies and projects of biogas such as:

- The project of biogas utilization for domestic cooking to reduce wood consumption and to protect the environment. The project was conducted during 2001 – 2003 at Quang Ngai province, and was support by the Global Environment Fund (GEF).
- The project of developing energy efficiency stoves and biogas stoves in Middle and North of Vietnam, supported by Netherland Development Organization during 2001-2003.
- The CDM project of biogas for breeding industry in whole country of Vietnam, supported by Netherland government during 2003 – 2007. At the beginning, the project was supposed to last from 2003 to 2005 and deploy in twelve provinces. In 2006, the project was expanded larger in twenty provinces and had 43,000 small size biogas plants built. The programme will be ended by beginning of next year as planned.

[[devi-renewable.com](http://devi-renewable.com), 5.2011 ]

The biogas application is still at small size. According to 2010 report from Vietnam Biogas Program Division, about 72,486 family size biogas plants in Vietnam were built during 2007 and 2010. The feedstock of these biogas plants are animal dung only. These family biogas plants are the result of a supporting program from local governments and foreign investors. It helps livestock farms getting more benefit from raising animal and saving environment. The biogas utilization is for lighting and cooking at site.

At family size, the feedstock is from livestock only. The following are some of those projects.

- The CDM project “Biogas program for livestock industry in some provinces of Vietnam” in the period of 2003-2011. This project has been supported by the Netherland’s government and the livestock department of the Ministry of Agriculture and Rural Development. So far this is the biggest biogas program in Vietnam. In the first phase (2003-2006), the program was implemented in twelve provinces and 18,000 biogas plants were built with a total capital of 17.7 million USD, equivalent about 12.65 million euro. In the second phase (2006-2011), the program has been continued in thirty five provinces. It provides renewable energy services to 800,000 people. As of December 21<sup>st</sup> 2010, the program has completed 100,000 biogas plants. The program also promoted the development of biogas fixed dome type with brick and cement that their life-time can be extended to at least fifteen years.
- Research Center of Energy and Environment (RCEE) Joint-stock company, a Danish Vietnamese consulting company, built the project of developing biogas market in the period 2006-2009 in the North. 3,160 biogas plants were built with technology VACVINA and total cost of 240,000 USD, equivalent to about 171,428 euro.
- There are some projects on researching the improvement of biogas technology for wastewater treatment, animal waste, by the Research and Consulting Center of the Trade and Industry Department in Ninh Thuan province and Quang Nam, in the

middle of Vietnam, in Ba Ria Vung Tau, the south of Vietnam, and in Tay Ninh, the southwest of Vietnam.

At industrial scale, biogas is produced from wastewater manufacturing process or recovered from landfill. Biogas has been used to generate electricity. Some of biogas projects typical industrial scale includes:

- The CDM project of wastewater treatment and biogas production for CHP in Tay Ninh province has been run since 1.2011. This is a co-operation between the Nuoc Trong Cassava Joint-stock Company and Rhodia Energy GHG, a Chemical Group in France. Total investment was about 20 billion vnd, equivalent to about € 666,700. Its capacity is 2,000,000 m<sup>3</sup> biogas per year. This is the first biogas plant based on wastewater in Vietnam. [[khoahoc.com.vn](http://khoahoc.com.vn), 10.2011]
- The CDM project of “Go Cat landfill quality improving project” run in Ho Chi Minh City since 2000. This was a co-operation between Vermeer, a Netherlandish company, and the environment sanitation company Citenco. The total investment amount was about 242 billion vnd, equivalent to about € 8,066,700, in which there was 176,9 billion vnd, equivalent to € 5,970,000, was granted by Netherland’s Government, and the rest amount was from the city budget. The waste treatment capacity was 4000-5000 ton per day. Biogas collected from this landfill is used in CHP. [[citenco.com.vn](http://citenco.com.vn), 11.2011]. However, due to serious environmental pollution, this plant has been closed from 7.2007.

#### 1.1.5 Biogas development in the Mekong Delta area

The Mekong Delta area is one crowded population of Vietnam. Its population was 17.2 milion. It has strenght in agriculture. It includes twelve provinces and one city as bellow:

Provinces: An Giang, Ben Tre, Bac Lieu, Ca Mau, Dong Thap, Hau Giang, Kien Giang, Long An, Soc Trang, Tra Vinh, Vinh Long.

City: Can Tho



**Figure 7: Proposed area for a centralized biogas investment**

The Mekong Delta in Vietnam has a rich resource for biogas production. The biggest waste volume is discharged in the south of Vietnam. It produces about 60% of the solid waste in Vietnam [Ministry of Construction, 2010]. . The average discharged waste per person is reported at about 0.78kg per day [www.vea.org.vn, 1.2011]. So the discharged waste volume in this area is about 42,120 ton per day. It calculated as below:

Vietnam population is about 90,000,000

Total waste per day in whole country is  $90,000,000 \times 0.78 = 70,200$  ton/day

Total waste per day in the Mekong Delta area is  $70,200 \times 60\% = 42,120$  ton/day

And the waste here contains a high percentage of organic waste. The composition of waste is summarized in table below:

**Table 1: Waste composition percentage**

<b>Waste composition</b>	<b>Percentage</b>
Organic	64.70%
Wooden	6.60%
Paper	2.10%
Plastic, rubber	15.40%
Textile	4.20%
Others	7.00%

[Collected from internet]

The Mekong Delta of Vietnam is considered as the rice basket of Vietnam. It contributes about 30% of agriculture production in this country. This area is the main force of rice exporting in Vietnam. And as mentioned above, Vietnam is the second biggest rice exporter in the world. People in this area are easily inspired by the modern life style, so they want more energy to fill their need. The economy in this area is mainly agricultural and discharges a huge volume of organic waste. There are some big provinces in this area such as Tien Giang, Hau Giang, Ben Tre, Long An, which contribute large percentage of Vietnam agriculture.

The biogas is applied in the breeders only. About 900 biogas plants were built in 2010 in Mekong River Delta area in households who breed more than five pigs. The fixed dome type is common construction of biogas plants. It is built with concrete material such as brick and cement. There was a financial supporting program for biogas improvement from local government in that each household who join the program received 1,200,000 VND, about 42euro, to build the plant [[sotainguyenmt.angiang.gov.vn](http://sotainguyenmt.angiang.gov.vn), 6.2011]. Recently, there is a new type of biogas plant is composite dome as shown in the picture below.



**Figure 8: Composite fixed dome for family size biogas plant**

Biogas is getting more common in the Mekong Delta and more sustainable in animal husbandry as a supplement, to farm activities on a household-scale (up to about 20 pigs, for instance). Using gas instead of other types of fuel is well accepted by local farmers because of its savings on fuel and the convenience of biogas compared with fire wood or kerosene. However, in the Mekong delta, there is much less attention and attraction from the owners of larger scale animal farms to the utilization of biogas. The biogas digester seems to be the most suitable solution to treat the waste from animal farms. However, in this small and medium scale, the amount of biogas produced is much higher than the domestic demand for cooking, lighting.

There are more CDM projects in recent years. Some of those are biogas CDM projects producing biogas from wastewater treatment in Mekong Delta River area such as in An Giang province, invested by the Trading Company Hoai Bac Hoai Nam; in My Quy industrial zone in Long Xuyen City with a total investment of 1.9 million USD, equivalent 1.36 euro; and a project in Binh My with total investment of 680,000 USD, equivalent 485,714 euro.



## 1.2 Research objectives and scope

The main objective of this thesis is to propose a business model for a centralized biogas plant in the Mekong River Delta of Vietnam.

Sub objectives of this thesis are:

- To open a direction bound for transportable biogas in the condition of impossible piping system.
- To recognize the core activities of a centralized biogas plant in Vietnam.
- To propose an appropriate entry mode for foreign investors into Vietnam biogas market.

In this thesis, the author will try to answer the following questions:

Main question:

- What is an appropriate business model for a centralized biogas plant in Mekong River Delta of Vietnam?

Sub-questions:

- How feasible is the Mekong Delta for a centralized biogas plant?
- Who are the customers and main stakeholders in the business model of a centralized biogas plant in Vietnam?
- What are the core activities of this business?
- What is an appropriate entry mode for foreign investors into Vietnam biogas market?
- What is local government's response to biogas industry?

## 1.3 Research approach and research method

This study uses qualitative research method and deductive approach. In the theoretical part, information is collected from secondary sources including previous reports from authorized organization, authorized website, webinar, and from secondary sources such as previous study result, handbook of biogas, books.

The research will be built in coherence and logical structure to support the idea of transportable biogas in condition of non-available piping system.

#### 1.4 Limitation

In this research, a demand for biogas for cooking is discussed. The demand for other biogas utilizations, such as electricity, district heating have not been taken into focus. The target market is the Mekong Delta area in Vietnam. The biogas context in the target market will be presented to support business opportunity in Vietnam's biogas sector. The business model has been proposed based on Henry Chesbrough's theory of open innovation. The related roles of business model are defined. However, the revenue is not clearly estimated at the time of researching because there is no previous similar business activity.

#### 1.5 Summary

The thesis is to propose a business model for a centralized biogas plant which recovers energy from waste with high percentage of organic content.

Biogas is selected for this research because:

- It fullfills the sustainable development trend of the world.
- It has great benefit in economics and environment.

Vietnam is target market because:

- It is an agricultural developing country, with large and increasing population.
- Its economics is growing which leads to the increasing of material consumption and waste discharge.
- It lacks advanced technologies in biogas industry.

The Mekong Delta area is the location of the plan because:

- It is the biggest delta and produces largest agriculture volume in Vietnam.
- The waste with high organic content in this area is the most in Vietnam.
- The population is large.

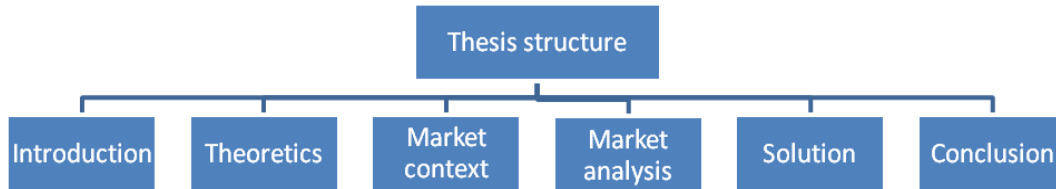
And finally, why is it a centralized biogas plant which recovers energy from organic waste?

- There is no big livestock farm in Vietnam which can supply for a centralized biogas plant.
- There is huge and huge organic waste volume waiting for a sanitary treatment.

Further findings which support for this selection will be described later in this writing.

## 1.6 Thesis structure

The thesis includes six chapters as bellow



**Figure 9: Thesis structure**

Chapter I describes the background of study, objectives, scope, research approach, research method, and the limitation of the study. It aims to answer the question what, why, how, and at where the project is studied. And it presents some general information of the thesis also.

Chapter II presents the literature review of biogas. It is a brief of the biogas development on the world and in Vietnam. It is about what people have achieved in biogas sector. And it is the ground for the trend and the future reach of biogas. The next parts in this chapter are about the theory of open business model and stakeholders analysis.

Chapter III describes the current biogas context in Vietnam and Mekong Delta River area of Vietnam. It is about the trend, current market segments of biogas, and the response of local government in this industry.

Chapter IV is the market analysis. The findings during market research are summarized and analyzed. The market analysis tools which are used in this chapter are PESTLE and Porter's five forces. The analysis aims to identify a sound business opportunity.

Chapter V is the key contribution in this paper. Based on the literature of a centralized biogas plant and theory of an open business model written by Henry Chesbrough, a proposed business model for biogas sector in Vietnam is described. Besides that, entering strategy is discussed also.

Chapter VI includes the conclusion of the writing and the writer's suggestion of a future research.

## 2 INTRODUCTION TO BIOGAS OPPORTUNITY

In this chapter, some understanding about biogas industry will be presented. The purpose is to know:

- What is the advantage of a centralized biogas plant comparing to biogas collecting from landfill.
- What processes are needed in a centralized biogas plant.
- What are available technologies for a centralized biogas plant?
- What theory will be used to build a business model for this centralized biogas plant.

How to recognize the stakeholders in biogas sectors and make decision of entry mode?

### 2.1 Introduction to a centralized biogas plant

To build a centralized biogas plant, it is important to understand biogas systems and their key components. Besides that, it is good to understand why biogas production is better than collecting biogas from landfill. This chapter will give the common understanding of the link between biogas and waste treatment, and the general overview of biogas plant components.

#### 2.1.1 From waste treatment to biogas production

As a global trend of biogas development, anaerobic digestion, which has been widely using manure and slurry treatment for a long time, becomes an attractive treatment of organic waste from food industry and farm and municipal solid waste. Biogas can be collected from landfill. However, a biogas production is a better way to produce this renewable energy. This part will clarify why not people should just stop at waste treatment but go further to biogas production.

##### 2.1.1.1 Landfill and biogas

Landfill, often known as sanitary landfill, is one advanced waste treatment mode in which organic waste is buried in an anaerobic under ground place. This condition converts organic waste into biogas which is used as a renewable energy.

Organic waste mentioned about in this thesis is the waste with major organic content. It is discharged everywhere there is life in the world. Together with the fast increasing population and need of people, its volume is increasing sharply while the treatments are limited in some area because of lacking advance technology. The most used method is landfill which emits bad smell, pollutes the air, underground water and soil, and occupies lot of space. Therefore, organic waste has been a burden for some organization and society. Recently, the economic point of organic waste has been discovered. That is the energy recovering from organic waste disintegration.

Organic waste can boost the economy of biogas plants. Also socio economy benefits will increase. All suitable waste should consequently be used in biogas plant [cf. Torkild Birkmose et al 2007, p.7]. There are different scales of biogas plants from very small one to big one such as family scale, farm scale, and centralized co-digestion plants. The input of biogas process is all things originated from agriculture as mentioned in the table below.

**Table 2: Methane yield of different feedstock material for biogas**

<b>Methane yields of different feedstock material</b>		
<b>Feedstock</b>	<b>Methane yield [%]</b>	<b>Biogas yield [m<sup>3</sup>/tFF*]</b>
Liquid cattle manure	60	25
Liquid pig manure	65	28
Distillers grains with solubles	61	40
Cattle manure	60	45
Pig manure	60	60
Poultry manure	60	80
Beet	53	88
Organic waste	61	100
Sweet sorghum	54	108
Forage beet	51	111
Grass silage	54	172
Corn silage	52	202

\* FF=fresh feedstock

[T. A. Seadi et al 2008, p. 42]

Biogas plants can solve the environment risk of organic waste treatment. A huge organic municipal solid waste has been land-filled, and recently there is a special application in biogas recovery from the existing landfill [cf. T. A. Seadi et al 2008, p.30]. Organic fraction in MSW is digested in anaerobian environment and turned into gas. Anaerobic digestion itself is a natural process. However, there are some accelerative chemicals using in biogas production to boost the digesting pace faster than it does in the natural environment of landfill. This is great integration of waste treatment and biogas production. Organic waste is the feedstock in biogas processing. Therefore, air pollution and soil pollution due to bad odor and waste water leaking can be reduced, and utilization of biogas includes gas generation, electricity generation, and fertilizer.

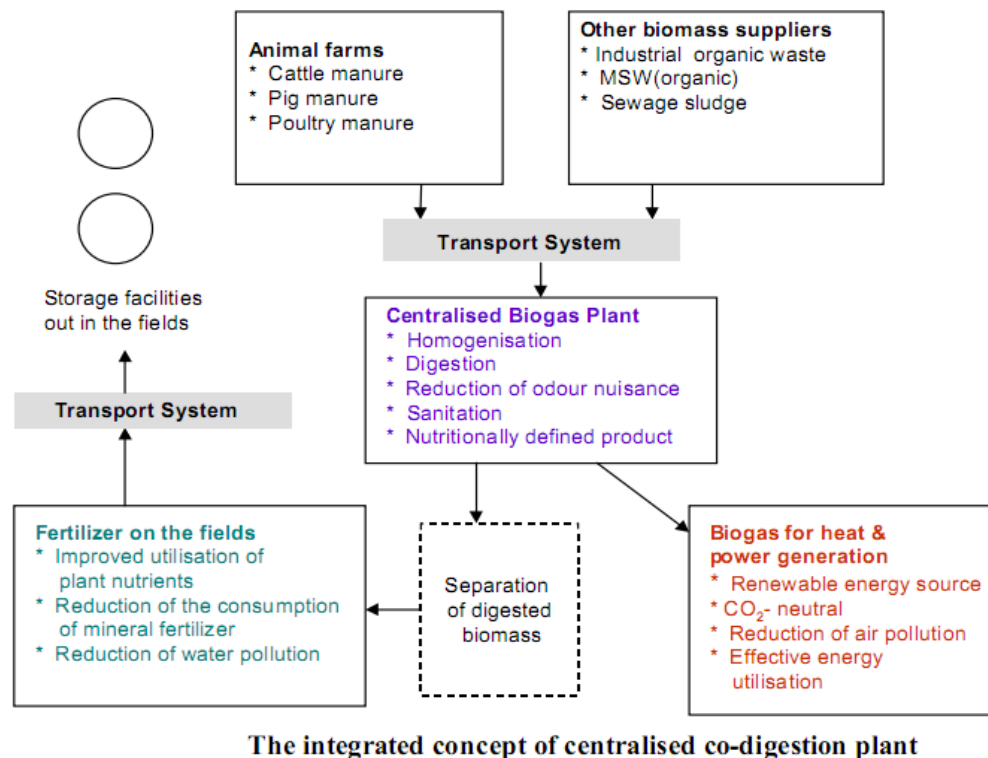


Figure 10: Integration of Waste treatment to Biogas plants

[T. A. Seadi et al 2008, p. 36]

The crude biogas captured from sanitary landfill or from biogas plant can be used in the same purposes as shown in the figure below.

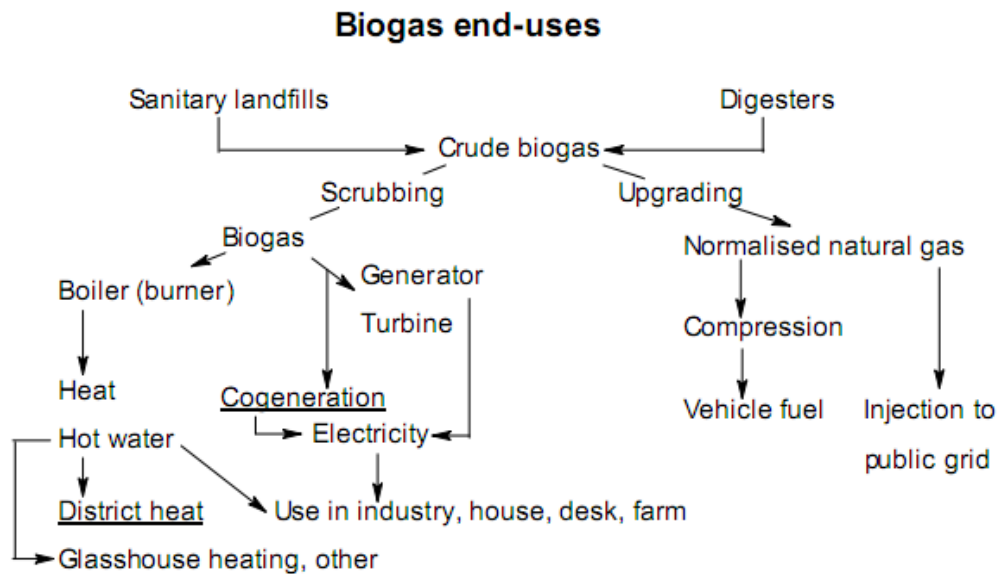


Figure 11: Overview of biogas utilization

[T. A. Seadi et al 2008, p. 41]

Basically, there are four methods of biogas utilization. They are production of heat and steam, electricity production, vehicle fuel, and production of chemical. In this thesis, the focus is production of heat. Low requirements are set for this utilization. Biogas is a flammable mixture in that methane makes up large percentage. It also contains some other unwanted elements such as  $H_2O$ ,  $H_2S$ ,  $CO_2$ .

Table 3: Gas quality requirements for different biogas utilization

	APPLICATION	H <sub>2</sub> S	CO <sub>2</sub>	H <sub>2</sub> O
Requirements to remove gaseous components depend on the biogas utilization.	Gas heater (boiler)	<1000 ppm	no	no
	Kitchen stove	yes	no	no
	Stationary engine (CHP)	< 1000 ppm	no	no condensation
	Vehicle fuel	yes	yes	yes
	Natural gas grid	yes	yes	yes

[Margareta Persson et al 2006, p.9]

One thing which should be taken into account is that the methane content in a biogas plant is the highest, while the biogas captured from landfill contains more unwanted air pollution elements such as nitrogen.

**Table 4: Overview of content of the biogas produced at different types of plants**

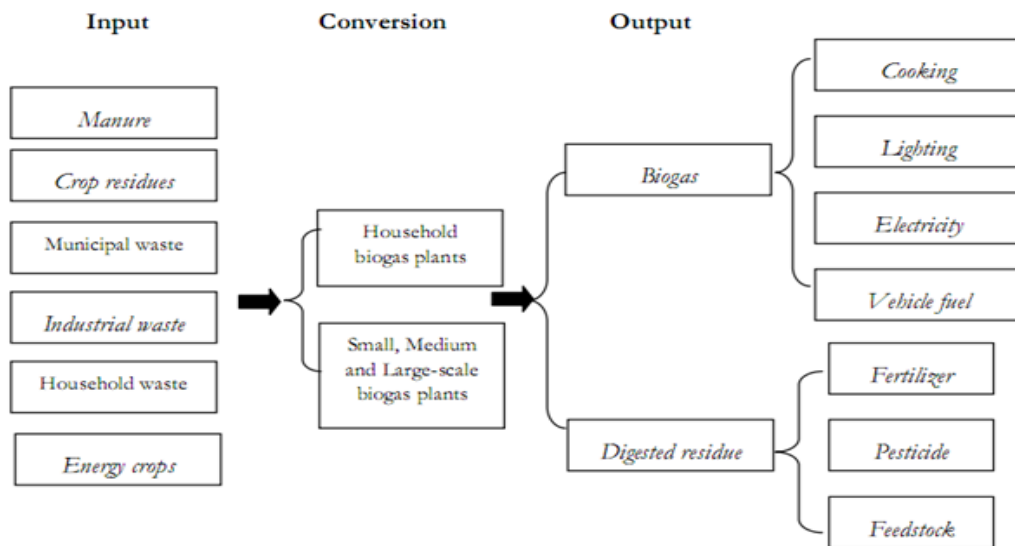
Component	Entity	Centralized Biogas plant	Landfill
Methane(CH <sub>4</sub> )	Vol %	60-70	45-55
Carbon dioxide(CO <sub>2</sub> )	Vol %	30-40	30-40
Nitrogen(N <sub>2</sub> )	Vol %	<1	5-15
Dihydrogen sulphide(N <sub>2</sub> S)	ppm	10-2000	50-300

[Margareta Persson 2006, p. 4]

#### 2.1.1.2 Biogas production overview

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Biogas is a combustible gas consisting of methane, carbon dioxide and small amounts of other gases and trace elements. Biogas originates from biogenic material and is one type of bio-fuel. Feedstock for biogas production is very diverse, ranging from animal dung and slurry to organic waste. Organic waste means all kinds of waste from food and agricultural industries, and from household. The amount and quality of biogas also depend on the feedstock types. Organic waste is believed to produce a high percentage of methane gas. (cf. Seadi, et al, 2008). Figure below is an overview of biogas system, from various feedstocks to various utilizations.





*Overview of a biogas system*

Figure 12: Biogas system overview

The key process in biogas production is anaerobic digestion which converts the input of organic waste into the valuable product of biogas with variable usages. Biogas is produced through different steps happening in the digester as bellow:

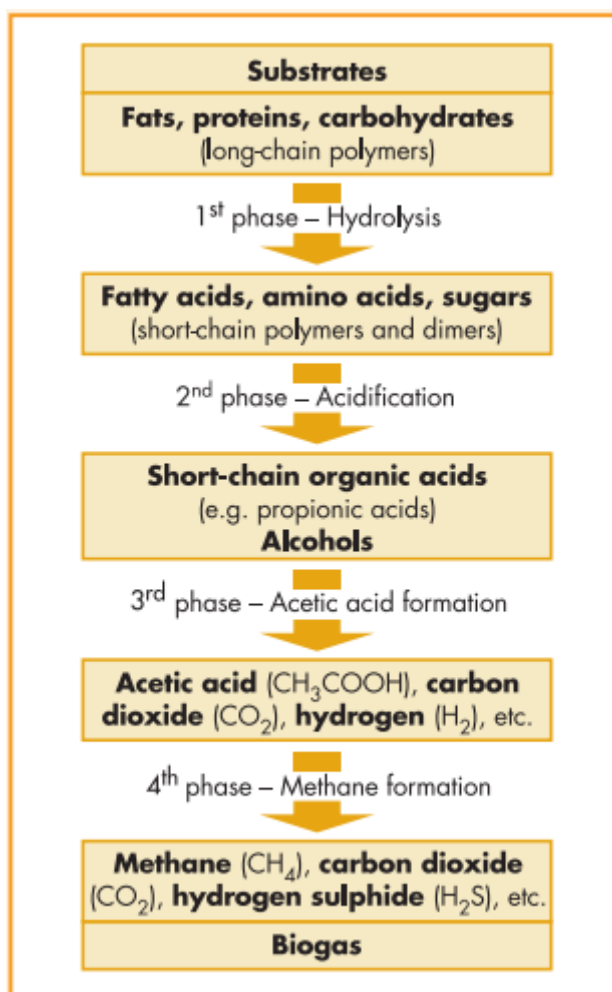


Figure 13: A simplified diagram of how biogas is produced in digester

[[www.fnr-server.de](http://www.fnr-server.de), 2.1011]

Anaerobic digestion comprises four main steps.

- Hydrolysis: to break down feedstock as complex organic materials into simple organic substances.
- Acidification: A biological reaction where simple monomers are converted into volatile fatty acids
- Acetic-acid formation: A biological reaction where volatile fatty acids are converted into acetic acid, carbon dioxide, and hydrogen.
- Methane-formation: Conversion A biological reaction where acetates are converted into methane and carbon dioxide, while hydrogen is consumed

Biogas typically comprises about 60% methane (CH<sub>4</sub>) and about 40% carbon dioxide (CO<sub>2</sub>). Upgrading biogas by reduce CO<sub>2</sub> to < 2% and increase CH<sub>4</sub> to 98% makes biogas caloric value closed to natural gas.

**Table 5: Specification of raw biogas / upgraded biogas**

<b>Specification of raw biogas / upgraded biogas 'green gas'.</b>			
<b>Component</b>	<b>Entity</b>	<b>Biogas</b>	<b>Green gas</b>
Methane CH <sub>4</sub>	Vol. %	45 - 70	> 97
Carbon dioxide CO <sub>2</sub>	Vol. %	30 - 45	< 1
Nitrogen N <sub>2</sub>	Vol. %	1 - 15	< 2
Hydrogen sulphide H <sub>2</sub> S	ppm	10 - 4.000	< 5 mg/m <sup>3</sup>
Oxygen O <sub>2</sub>	Vol. %	0.2 - 0.5	< 0.5
CF hydrocarbons	Mg/m <sup>3</sup>	0 - 3.000	< 10 ppmv
Water H <sub>2</sub> O	RH %	100	< 0.03 g/m <sup>3</sup>
Temperature	Degr. C.	10 - 60	
Caloric value	kWh/m <sup>3</sup>	6 - 7.5	Max. 11

[Margareta Persson, 2007, page 2]

Because of the ingredients like water vapour, hydrogen sulfide, carbon dioxide and dirt particles, biogas can not be used directly after the extraction from the plant. However, after removing water vapour and carbon dioxide the biogas can be used like any clear natural gas. The bellow table is the minimum properties for combustible gas. This is also applies to the use of biogas. For other utilization of biogas, such as vehicle fuel, further gas upgrading and conditioning measures are necessary.

**Table 6: Minimum properties for combustible gases**

Heat value (lower heat value)	H <sub>u</sub>	≥ 4 kWh/m <sup>3</sup>
Sulphur content (total)	S	≤ 2,2 g/m <sup>3</sup> CH <sub>4</sub>
or H <sub>2</sub> S-content	H <sub>2</sub> S	≤ 0,15 Vol.-%
Chlorine content (total)	Cl	≤ 100,0 mg/m <sup>3</sup> CH <sub>4</sub>
Fluoride content (total)	F	≤ 50,0 mg/m <sup>3</sup> CH <sub>4</sub>
Sum of Chlorine and Fluoride	(Cl + F)	≤ 100,0 mg/m <sup>3</sup> CH <sub>4</sub>
Dust (3 ... 10 µm)		≤ 10,0 mg/m <sup>3</sup> CH <sub>4</sub>
Relative humidity (at lowest intake air temperature, i.e. condensation in intake pipe and gas control path)	φ	< 90 %
Flow pressure before entry into the gas control path	p <sub>Gas</sub>	20 ... 100 mbar
Gas pressure fluctuation		< ± 10 % of set value
Gas temperature	T	10 ... 50 °C
Hydrocarbons (> C5)		< 0,4 mg/m <sup>3</sup> CH <sub>4</sub>
Silicon (at Si > 5 mg/m <sup>3</sup> CH <sub>4</sub> oil analysis of metal content < 15 mg/kg oil observed)	Si	< 10,0 mg/m <sup>3</sup> CH <sub>4</sub>
Methane e count (Biogas MC approx. 135)	MZ	> 135

[T. A. Seadi et al 2008, p. 87]

## 2.1.2 Types of biogas plant

The biogas type is divided basically based on a digester structure. There are 3 types of biogas plant:

- Floating gas-holder type
- Fixed dome type
- Bag type

### 2.1.2.1 Floating gas-holder type

This is a movable gasholder. A digester tank or a well is made out of concrete and it is called the digester tank T, which has two parts: the inlet and the outlet. The inlet is from where slurry is transported to the tank, which has a cylindrical dome H made of stainless steel. This dome floats on the slurry and collects the gas generated. That is why such a biogas plant is known as floating gas holder type. Fermentation of the slurry takes for about 50 days. The pressure inside H increases when more gas is formed by bacterial fermentation. The gas is then transported out through outlet pipe V. The decomposed matter moves into the next chamber in tank T. By using the outlet pipe this is then removed to the overflow tank, which is used as fertilizer for cultivation purposes.

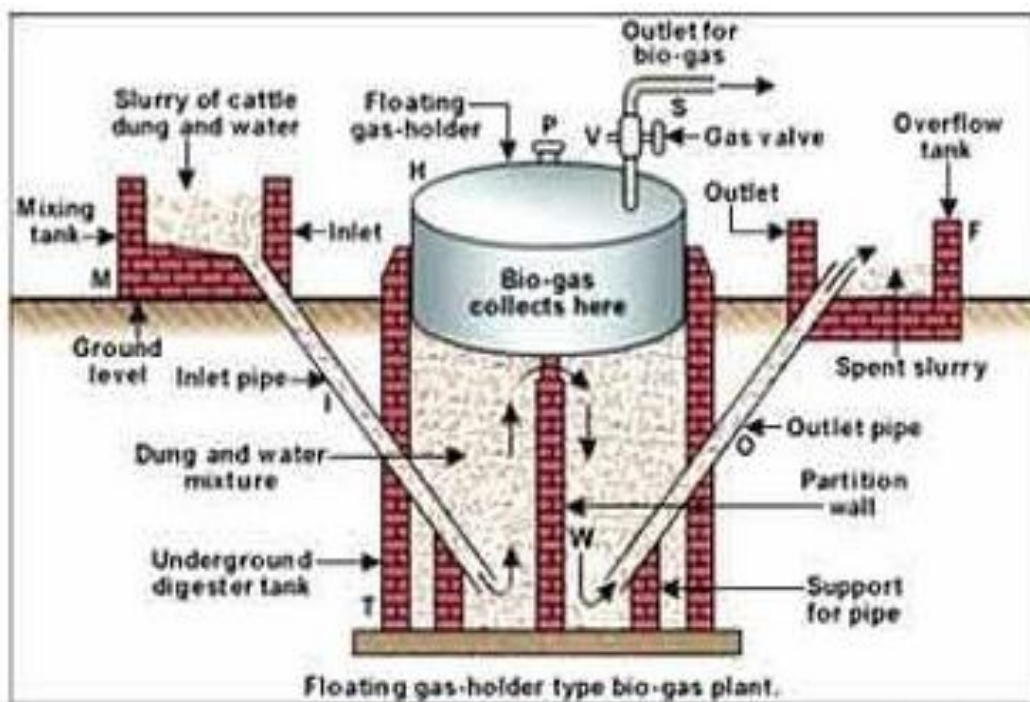


Figure 14: Floating gas-holder type

[[www.industrialgasplants.com](http://www.industrialgasplants.com), 9.2011]

The advantages of this type are: Gas pressure is regulated by the weight of the gasholder. The gasholder helps in stirring/ scum breaking. It's easy to construct, easy to repair, easy to disposal of exhaust slurry due to gravity flow. Meanwhile there are some disadvantages which metallic gasholder is exposed to the atmosphere and cause heat losses. As it dip in the slurry anti corrosion treatment is required. Periodical painting of gas holder is required to avoid rusting. [www.pcret.gov.pk, 5.2011]

#### 2.1.2.2 Fixed dome type

This is a fixed-dome gasholder. Here also, a well and a dome are made out of concrete, which is called the digester tank T. Since the dome is fixed, this gas plant is known as fixed dome type. The manufacturing process is similar to the floating holder type bio gas plant, where the slurry expands and overflows into the overflow tank F.

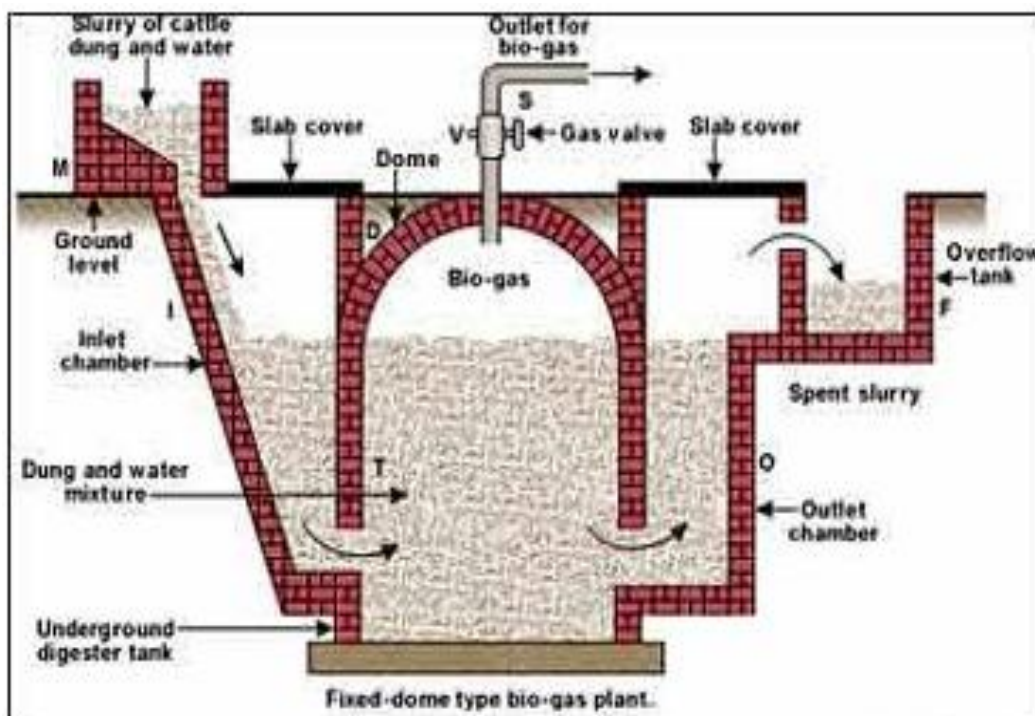


Figure 15: Fixed dome type

[[www.industrialgasplants.com](http://www.industrialgasplants.com), 9.2011]

The advantages of the fixed dome gasholder are: utilizing the plant space due to it being underground, fairly steady temperature inside the digester can be maintained, and post installation maintenance like painting or plastering is seldom needed. Meanwhile there are more disadvantages in this type. The construction needs special skills. Stirring and scum breaking is generally difficult. Gas pressure control is difficult. Leakage of gas from hairline crack developed in the dome. A good quantity of gas produced in the slurry displacement chamber is not captured and emitted in the air. Exhaust slurry is to be taken out manually. [www.pcret.gov.pk, 5.2011]

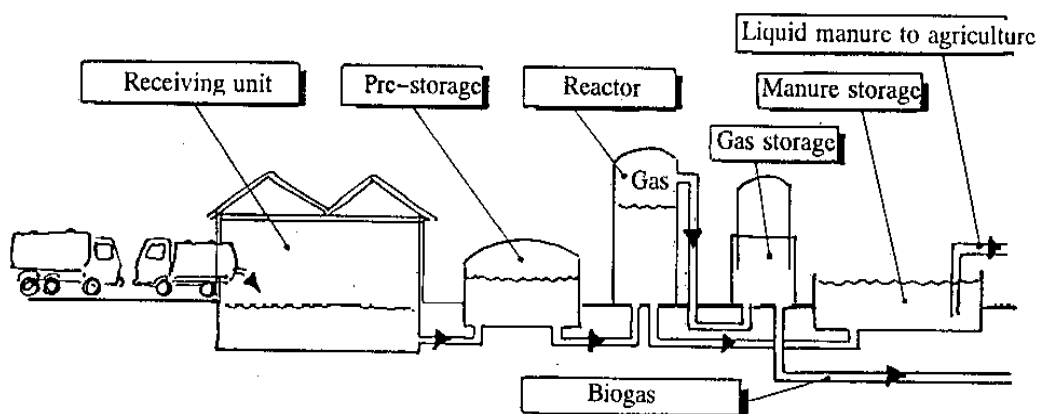
### 2.1.2.3 Bag type

The bag-type biogas plant is a portable unit. Made of rubberized nylon fabric, such a plant can be easily placed at any location. The appropriate type is selected on the basis of technical requirements like distance between kitchen and cattle shed, location, availability of dung and water, preferences of the beneficiaries etc.

The advantages of this type are that it's good for experimental projects and/ or family size due to low cost, easy to install. It's not suitable for large size biogas plant.

### 2.1.3 Main components of a centralized biogas plant

Biogas can be formed in a natural environment. However, biogas can also be produced in a biogas plant where organic material is put into a completely airtight tank (SGBF, SGC & SGA, 2008). There are many key components in a centralized biogas plant. In order to have good yield of biogas, each component must be well constructed and maintained. The bellow picture shows a draft design of a centralized biogas plant, where combines relative components to run a smooth biogas process.



Design of joint biogas plant.

Figure 16: Design of centralized biogas plant

[[www.greenstone.org](http://www.greenstone.org), 7.2011]

In general, biogas production can be divided into four stages as bellow:

Process stage 1: Feedstock receiving unit

Feedstock storage and conditioning

Feeding system

Process stage 2: Digester heating

Digester

Process stage 3: Biogas storage

Biogas cleaning

Process stage 4: Biogas utilization

The process stage 1 contains components which support a smooth AD process and ensure for quality as well as quantity of biogas yield. The process stage 2 is where the biogas production happens. The process stage 3 is where to store and cleaning biogas according to the end use and also to utilize the digestate.

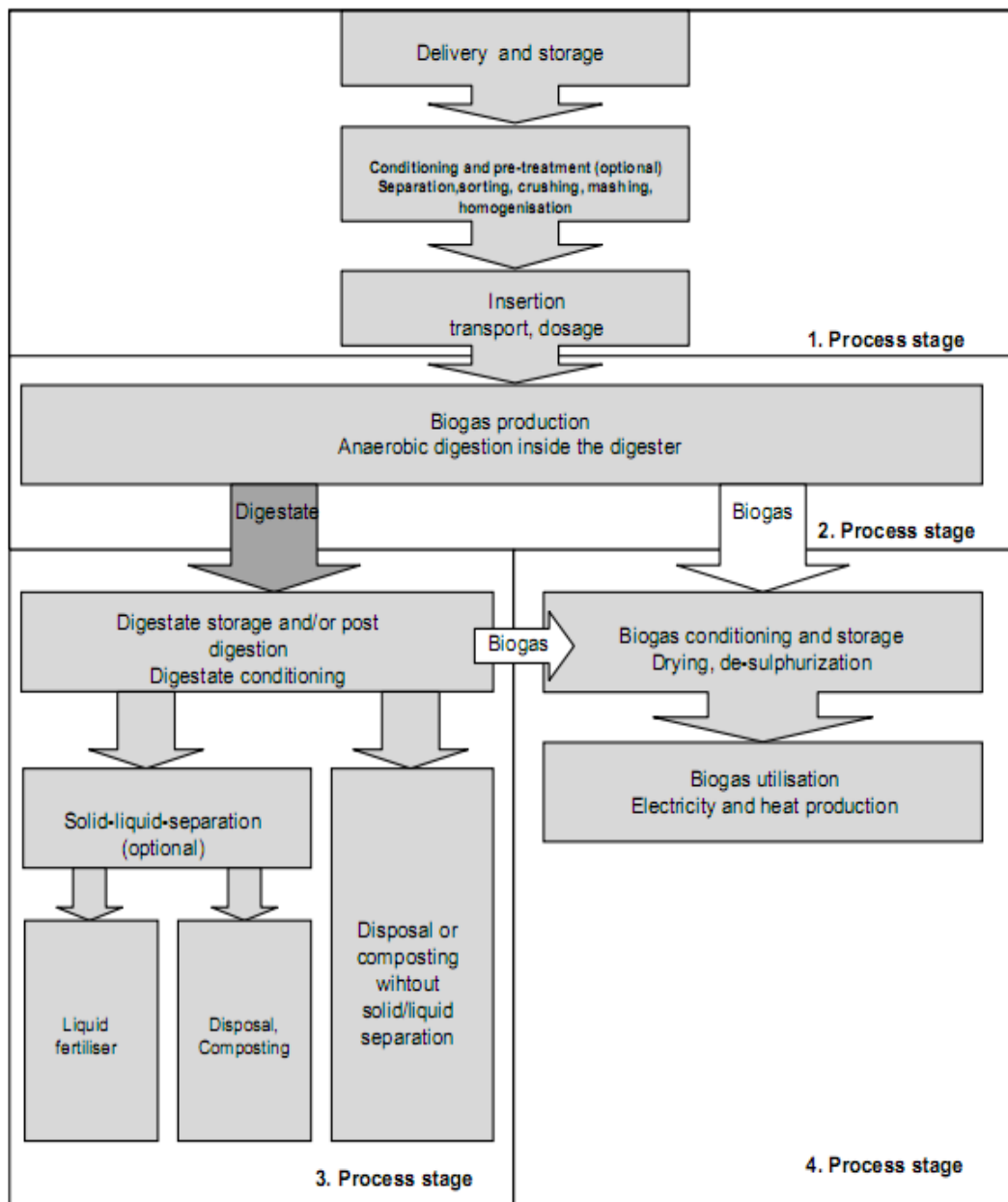


Figure 17: Process stages of agricultural biogas plant

[Jakel 2002]

### 2.1.3.1 Feedstock receiving unit

Biogas can be produced from a broad range of feedstock that is suitable for anaerobic digestion. Biogas can be made from most biomass and waste materials regardless of the composition and over a large range of moisture contents, with limited feedstock preparation. Feedstock for biogas production may be solid, slurries, and both concentrated and dilute liquids. The range of potential waste feedstock is broad including municipal wastewater, residual sludge, food waste, and food processing wastewater, dairy manure, poultry manure, and aquaculture wastewater, seafood processing wastewater, yard



wastes, and municipal solid wastes. In fact, biogas can even be made from the left over organic material from both ethanol and biodiesel production, from residual sludge from wastewater treatment plants. [<http://biogas.ifas.ufl.edu/feedstocks.asp>, 2011]. It's important to ensure and continuous supplying quantity of suitable feedstock for the smooth operation of a biogas plant. And it's necessary to separate waste in the biogas plant to exclude in-organic stuff which reduces the quality of fertilize and quantity of biogas yield.

#### 2.1.3.2 Feedstock storage and conditioning

The feedstock storage is required primarily to compensate seasonal fluctuations in the supply of the plant. It also facilitates mixing of different co-substrates taking part in the anaerobic digestion. The type of storage media is chosen according to the type of feedstock used. The size of storage facilities is determined by the quantities to be stored, delivery intervals and the daily amounts fed into the digester. In order to avoid soil pollution, appropriate precautions should be taken to prevent possible leakage and contamination of the water during the storage period.

Feedstock conditioning influences the flow and the efficiency of AD process. The main aim of the conditioning is to fulfill the demand of sanitation and to increase the digestibility of feedstock and biogas yield. [cf. T. A. Seadi et al, 2008, p.50]

#### 2.1.3.3 Feeding system

After storage and pretreatment, the AD feedstock is fed into the digester. The feeding technique depends on the feeding types. In general, there are two kinds of feeding technique. Pumpable feeding technique is for pumpable feeding such as slurry or organic waste with high water content. Other is non-pumpable for non-pumpable feeding such as fibrous material, straw. The feeding flow can be continuous or discontinuous. Special attention of feeding system is the temperature of feedstock. The temperature difference between new feeding stock and operation digesters causes losses of gas yield. There are some techniques to solve this problem such as using heat pump or heat exchanger to pre-heat or cool the feedstock before feeding into the digesters. [cf. T. A. Seadi et al 2008, p. 68]

#### 2.1.3.4 Digester heating

Constant process temperature inside the anaerobic digester is one of the most important conditions for stable operation and high biogas yield. Larger temperature fluctuation leads to imbalance of the anaerobic digestion process and in worst cases to complete process failure. Temperature fluctuation must be kept as low as possible. In order to achieve and maintain a constant process temperature and to compensate for eventual heat losses, digesters must be insulated and heated by external heating sources. [cf. T. A. Seadi et al 2008, p. 74].

#### 2.1.3.5 Digester

The core of a biogas plant is the digester where the decomposition of feedstock happens in absence of oxygen, and where biogas is produced. The common characteristics of all digesters are that they are air proof reactor tanks, a system of feedstock input and a system of biogas and digestate output, and a system of sediment removal. In some area, where the weather difference of seasons is big, anaerobic digesters have to be insulated and heated.

Commonly, there are two basic kinds of biogas digester as mentioned in the part 2.1.3.3 Feeding system. They are a batch digester and a continuous digester. A batch digester is, as its name, loaded with batch of fresh feedstock which is digested and then removed completely. Compared to other system, batch digestion has the advantage of low operation cost. However, its disadvantages are high process energy consumption and maintenance cost. A continuous digester is fed constantly. The feedstock moves through the digester either mechanically or by the pressure of the newly fed substrate pushing out the digested material. In this type, biogas production is constant and predictable. A continuous digester can be a vertical one, a horizontal one, or a multiple tanks system. The most common one is vertical digester. [cf. T. A. Seadi et al 2008, p. 76]

#### 2.1.3.6 Stirring technologies

The digester content must be stirred several times per day. The aim of stirring is to mix the new feedstock with the existing substrate inside the digester, to prevent formation of swimming layers and of sediments, to bring the micro-organisms in contact with the new

feedstock particles, to facilitate the up-flow of gas bubbles and to homogenize distribution of heat and nutrients through the whole mass of substrate. Stirrers can run continuously or in sequences. There are three kinds of stirrer, hydraulic stirrer, pneumatic stirrer, and mechanical stirrer. [cf. T. A. Seadi et al 2008, p. 82]

#### 2.1.3.7 Biogas storage

Biogas production must be maintained as stably and constantly maintained as possible. Inside the digester, biogas is formed in fluctuating quantities. Various types of biogas storage facilities are available today. The simplest one is the biogas storage established on top of digesters, using a gas tight membrane, which has also the function of digester cover.

#### 2.1.3.8 Biogas cleaning and upgrade

When biogas gets out of digesters, beside main compound of methane ( $\text{CH}_4$ ) and carbon dioxide ( $\text{CO}_2$ ), it is saturated with water vapour and has various amounts of hydrogen sulfide ( $\text{H}_2\text{S}$ ). Hydrogen sulfide combines with the water vapour in biogas forms sulfuric acid that can cause damage to mental equipment which it contacts to.

The biogas is cleaned from hydrogen-sulfur and water to reduce the risk of corrosion, and upgraded by removing carbon dioxide to increase calorific value. The cost depends on the size of plant. It gets lower cost at the bigger plant size.

Currently, in developed countries, most biogas utilization is for electricity and heating. The most used technologies are for biogas cleaning. For vehicle engine and natural gas grid, cleaned biogas must be upgrade to increase the methane content. The total cost for cleaning and upgrading biogas consist of investment cost and operation and maintenance cost. In the case of investment cost, an important factor is the size of the plant. The total investment cost increase with increased plant capacity but investment per unit of installed capacity is lower for larger plants, compared to small ones. In the case of operation cost, the most expensive part of the treatment is the removal of carbon dioxide ( $\text{CO}_2$ ) [cf. T. A. Seadi et al 2008, p. 48]

➤ Desulphurization

This technology is required for heating purpose. The following table gives an overview about eight different desulphurization methods. The green marked methods are evaluated as the most important ones for biogas upgrading systems.

**Table 7: Overview of desulphurization methods**

No.	Method	H <sub>2</sub> S - Output-concentration	Neces-sity of O <sub>2</sub>	Internal / External	Primary desulph.	Precision desulph.
1	Internal biological H <sub>2</sub> S reduction (in the digester)	50 - 200 ppm	Yes	Internal	X	
2	External biological H <sub>2</sub> S reduction (out of the digester in a sprinkling filter)	50 - 200 ppm	Yes	External	X	
3	Combination of external biological H <sub>2</sub> S reduction with lye scrubber	20 - 100 ppm	(Yes)	External	X	
4	Chemical precipitation using iron salts (sulphide precipitation)	100 - 150 ppm	No	Internal	X	
5	Chemical precipitation using iron hydroxide	100 - 150 ppm	No	Internal	X	
6	Iron oxide or iron hydroxide (in an external column)	< 1 ppm	(Yes)	External		X
7	Adsorption / catalytic oxidation using impregnated activated carbon	< 1 ppm	Ja	External		X
8	Zinc oxide	< 1 ppm	No	External		X

[Micheal Beil and Uwe Hoffstede, 2010, p.20]

Desulphurization can be done by either biological method or chemical method, taking place inside or outside the digester. Each method has its own advantage as well as disadvantage.

Biological method is one of the most used methods of desulphurization. It can be done inside the digester or outside the digester. In case of inside, Oxygen is provided by air injection pipes in the top of the digester which is placed on the opposite side of the biogas output. The oxygen, then, oxidized hydrogen sulphide biologically to be acidic products (H<sub>2</sub>SO<sub>3</sub>) or free sulphur (S) with water. The reactions occur on the reactor wall, so there is the risk of corrosion. For this reason, the process is often taking place outside of the digester in a separate reactor tank. In these biological methods, oxygen injection must be control well under 2~5% of the biogas volume produced at any time. Otherwise, it can lead to gas explosive.

The third one is combination of external biological desulphurization with a lye scrubber, for example NaOH. It is a two step process. Firstly,  $H_2S$  is bonded by the lye. Then air is injected and the biological degradation takes place. This method can help to achieve higher purities than the first two methods, but higher cost.

The next two methods are chemical desulphurization inside digester. A chemical substance, an iron salt solution or an iron hydroxide ( $Fe(OH)_3$  or  $Fe(OH)_2$ ), is added to the feedstock mixture inside the digester. The sulfur is chemically bounded during the AD process, preventing the release of hydrogen sulfide into biogas. The advantage of these two methods is low investment cost, no air injection. Between these two, the method of using iron hydroxide is lower operation cost and easier to control.

Chemical desulphurization can take place outside of the digester also. In this method, the chemical substance is one of the above two methods. There are two reactions in this system. Firstly, the reaction of the chemical substance with  $H_2S$  produces ferrous sulfide ( $Fe_2S_3$ ). Then, ferrous sulfide reacts with oxygen and water to produce iron hydroxide or iron oxide and elemental sulfur which has to be removed out of the reaction tank or column. Air injection is needed for the reaction.

The next method mentioned above is adsorption using impregnated active carbon. This method can give a precision desulfurization and has high operation cost.

The last method is zinc oxide ( $ZnO$ ). There is a reaction of  $H_2S$  with  $ZnO$  to produce water and  $ZnS$ . This method also gives out the low outlet concentrations of  $H_2S$ .

#### ➤ Drying

The quantity of water contained in biogas depends on temperature. A part of the water vapours can be condensed by cooling of the gas. Cooling of the gas is done before injecting it into gas holders or gas tanks to make gas to be transportable. The water condensates can be collected in a condensation separator.

#### ➤ Upgrading

Upgrading biogas is removal of carbon dioxide ( $CO_2$ ) and increasing the methane content of biogas. Various technologies can be applied. Upgraded biogas can be injected and

distributed through the natural gas grid, after it has been compressed to the pipeline pressure [cf. T. A. Seadi et al 2008, p. 49]. Upgrading biogas requires a high initial investment and maintenance cost.

#### 2.1.3.9 Preparation for transportable biogas

In many cities, methane gas is piped to end-users for heating generation and fuel. However, this thesis targets at areas where a piping system is not available. The technology of making biogas transportable is viable according to some biogas experts. There must be innovation to commercialise transportable biogas as it is understood that compressing biogas to make it transportable is not economically at the time of researching.

#### 2.1.3.10 Digestate storage

The digested substrate is pumped out of the digester through pumping sequences. When it is used as fertilizer, it is collected into storage tanks. Since up to about 20% of the total biogas production can take place outside the digester in the digestate storage tanks, storage tanks should be always covered with a gastight membrane for gas recovery. [cf. T. A. Seadi et al 2008, p. 56]

#### 2.1.3.11 The control unit

The biogas yield from waste varies greatly dependant on the type and quality of waste, digester technology and the correct operation of the facility. In order to maximize the biogas yield, there must be a good control unit. The control unit is a computerized system of monitoring and controlling. A biogas plant is a complex installation with close interrelationships between all parts. The control unit helps to recognize deviations from standard values and to make possible early intervention and corresponding corrective measures.

The monitoring process includes the collection and analysis of chemical and physical parameters. The following parameters should be monitored as a minimum:

- Type and quantity of inserted feedstock
- Process temperature inside the digester
- pH value of the substrate adding into the digester

- Gas quantity and composition
- Short-chain fatty acids content; this monitoring facilitates evaluation and optimization of the anaerobic digestion process.
- Filling level in digesters and in storage containers

The control of biogas plants is increasingly automated through use of specific computer based process control system.

## 2.2 Theory of open business model

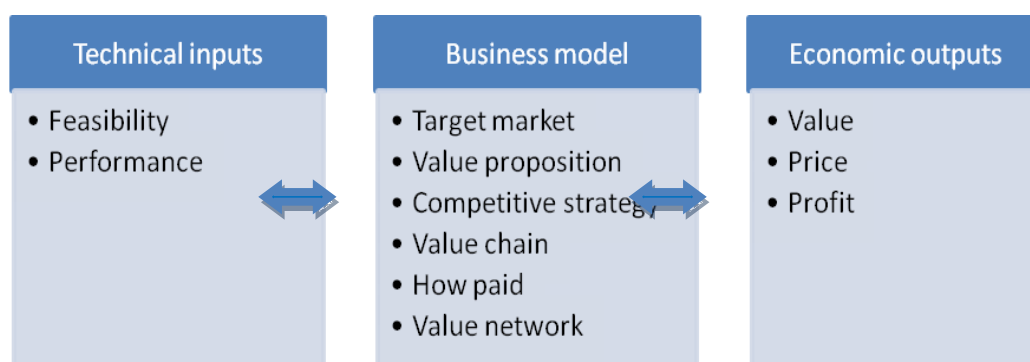
In this part, theory for an open business model is presented. The study is inspired by the idea of Chesbrough Henry about an open business model. The following details in this part are about the role of business model, the key stakeholders and their impact, as well as the entry strategy for foreign investors to enter the biogas market.

A business model is a general description of how a business operates. The essence of a business model is that it defines the manner by which the business enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit: it thus reflects management's hypothesis about what customers want, how they want it, and how an enterprise can organize to best meet those needs, get paid for doing so, and make a profit. [ [www.innovation-creativity.com](http://www.innovation-creativity.com), 10.2011]

A business model performs two important functions: it creates value and it captures a portion of that value. It creates value by defining a series of activities from raw materials through to the final consumer that will yield a new product or service with value being added throughout the various activities. The business model captures value by establishing a unique resource, asset, or position within that series of activities, where the firm enjoys a competitive advantage. An open business model uses this new division of innovation labor – both in the creation of value and in the capture of a portion of that value. Open models create value by leveraging many more ideas, due to their inclusion of a variety of external concepts. Open models can also enable greater value capture, by using a key asset, resource, or position not only in the company's own business model but also in other companies businesses. [Chesbrough Henry, 2006]

### 2.2.1 The role of business model

The role of a business model is to convert technology into economic value. As Henry Chesbrough and Richard S. Rosenbloom mentioned in their writing, to extract value from an innovation, a start-up needs an appropriate business model because familiar business models, in many cases, can not be applied. In practice, very few individuals, if any, fully understand the organization's task in their unit. The technical experts know their domain and the business experts know theirs. The business model connects these two domains as shown in the bellow diagram:



**Figure 18: Role of the Business Model**

[Chesbrough Henry 2006, p.69]

Players in biogas market need not only a higher technology to excell. They need also an appropriate business model to thrive. The potential value created in biogas industry is equivalent to the one of natural gas. In order to capture all of this potential value, business has to move on an innovation path from the input feedstock through to the end use. In some market, biogas seems to be saturated, such as the emerging development in Europe. There are too many players and the biogas market does not change much. The European companies focus strongly on home countries and area. But if that business is developed into new market, new business opportunity can be derived. [[www.crossborderbioenergy.eu](http://www.crossborderbioenergy.eu), 2.2011].

An Open business model can help to utilize all business intelligences, save R & D cost by using both internal and external resources, and capture more value from market. In order to get the most benefit in business, the functions of business model must be active all.

### 2.2.2 The functions of business model



In their research, Chesbrough Henry and Richard S. Rosenbloom also list six main functions of a business model:

- Identifies a market segment
- Articulates the value of the proposed offering
- Focuses on the key attributes of the offering or competitive strategy.
- Defines the value chain to deliver that offering
- Creates a way for getting paid
- Establishes the value network needed to sustain the model

#### 2.2.2.1 Identifying market segment

The first function is identifying market segment. Market segment is the group of customers to target, recognizing that different market segments have different needs. Sometime, the potential of an innovation is unlocked only when a different market is targeted. Market segment comprises of the users to whom the technology is useful as well as the purpose for which it will be used. A business model target a group of customers or a market segment to whom the proposition will be appealing and from whom resources will be received. Defining a set of customers is important in order to decide which technological attributes to target in development and thus where scientist and engineers should focus their activities. In case of intermediate market exchanges however, the target market for the offerings may not be so clear. [[www.quickmba.com](http://www.quickmba.com), 10.2011]

#### 2.2.2.2 Articulating value proposition

The second function in articulating value proposition is the description of customer problem, the products that address the problem, and the value of the products from customer's perspective. Value proposition is the value created for users by the offerings based on the technology. From the customer's point of view, value proposition refers to what customer problems would be solved and how big of problem they are to the customers. In case of the intermediate exchanges, the value proposition may not be so clear. [[www.quickmba.com](http://www.quickmba.com), 10.2011]

#### 2.2.2.3 Defining the value chain structure

The third function is defining the structure of the firm's value chain. Value chain structure is the firm's position and activities in the value chain and how the firm will capture part of the value that it creates in the chain. Structure of a value chain is required to create and distribute the offering, and to determine the complementary assets needed to support the firm's position in this chain. Value chain delivers value proposition to market segment. Value chain must create value and it must allow the firm to claim some sufficient portion of that value from that chain to justify its participation. [[www.quickmba.com](http://www.quickmba.com), 10.2011]

#### 2.2.2.4 Specifying the revenue generation

The number four function is specifying the revenue generation mechanism for the firm. Revenue generation is the way how revenue is the cost structure, and target profit margins. This includes estimation of the cost structure and target margin of producing the offering, given the value propositions and value chain structure chosen. It defines the architecture of the revenue. [[www.quickmba.com](http://www.quickmba.com), 10.2011]

#### 2.2.2.5 Establishing the value network

The fifth function is describing the position of the firm within the value network linking suppliers and customers. Position in value network is identification of competitors, complementors, and any network effects that can be utilized to deliver more value to the customer. Building strong connections to a value network can leverage the value of a technology. When we can leverage the value of a technology, it means that we use both internal and external resources for development, and we can shorten the development budget in term of cost and time. This is a key factor to build a better cost structure than the one we have when only internal resource is used for development stage.

There are many experienced companies in biogas industry in Europe, and they are strong in different technologies because they develop biogas industry under the local support scheme. For example, Germany companies are strong at energy crop based biogas plant, UK companies are good at waste treatment plants, and Sweden companies are advanced in upgrading technologies. The strategy of using both internal development of the business and external development in open business model can strengthen the business intel-

ligence and quickly create more value to full-fill the need in target market. [[www.quickmba.com](http://www.quickmba.com), 10.2011]

#### 2.2.2.6 Formulating the competitive strategy

The last function is formulating the competitive strategy. Competitive strategy is the way how the company will attempt to develop a sustainable competitive advantage, for example, by means of a cost, differentiation, or niche strategy. It helps the innovating firm to gain and hold the advantage of their ideas over the rivals. Key factors for sustaining competitive success includes ability to gain differential access to key resources, creation of internal processes that are valuable to customers and hard to imitate by competitors, and the past experience and future momentum of the firm in the market. [[www.quickmba.com](http://www.quickmba.com), 10.2011]

### 2.3 Stakeholders analysis

A stakeholder is a person, a group or an organization that has direct (primary stakeholder) or indirect (secondary stakeholder) stake in an organization because it can affect or be affected by the organization's actions, policies, objectives [[www.businessdictionary.com](http://www.businessdictionary.com), 10.2011].

Stakeholders can be classified as primary stakeholders, secondary stakeholders, and key stakeholders. Primary stakeholders are those ultimately affected, either positively or negatively by an organization's action. Secondary stakeholders are the intermediaries that are persons or organizations who are indirectly affected by an organization's actions. Key stakeholders, who can also belong to the first two groups, have significant influence upon or importance within an organization. [[www.businessdictionary.com](http://www.businessdictionary.com), 10.2011]

Stakeholder analysis in conflict resolution, project management, and business administration, is the process of identifying the individuals or groups that are likely to affect or be affected by a proposed action, and sorting them according to their impact on the action and the impact the action will have on them. This information is used to assess how the interests of those stakeholders should be addressed in a project plan, policy, program, or other action. Stakeholder analysis is a key part of stakeholder management. [[www.businessdictionary.com](http://www.businessdictionary.com), 10.2011]. Stakeholder analysis is important because the stakeholders can have a strong influence on the success or failure of one's business.

Whenever the needs and expectations of the stakeholders get affected, it may be impossible to carry out the business successfully as they may hinder the growth and progress of one's business [Young 2006, p.69]. Therefore, it is a very essential step to understand who are the key stakeholders and to have a good management strategy, because a good stakeholder management can be able a business to stabilize its position in market and maximize its value.

### 2.3.1 Stakeholders identification

The first step in your stakeholder analysis is to brainstorm who your stakeholders are. As part of this, think of all the people who are affected by your work, who have influence or power over it, or have an interest in its successful or unsuccessful conclusion [[www.mindtools.com](http://www.mindtools.com), 10.2011].

In order to identify all stakeholders for a centralized biogas plant, it's essential to know about the main step of establishing a centralized biogas plant and how biogas production goes. Form the first part in this chapter, an overview of biogas production has been presented. And here bellow is the main step of a biogas project:

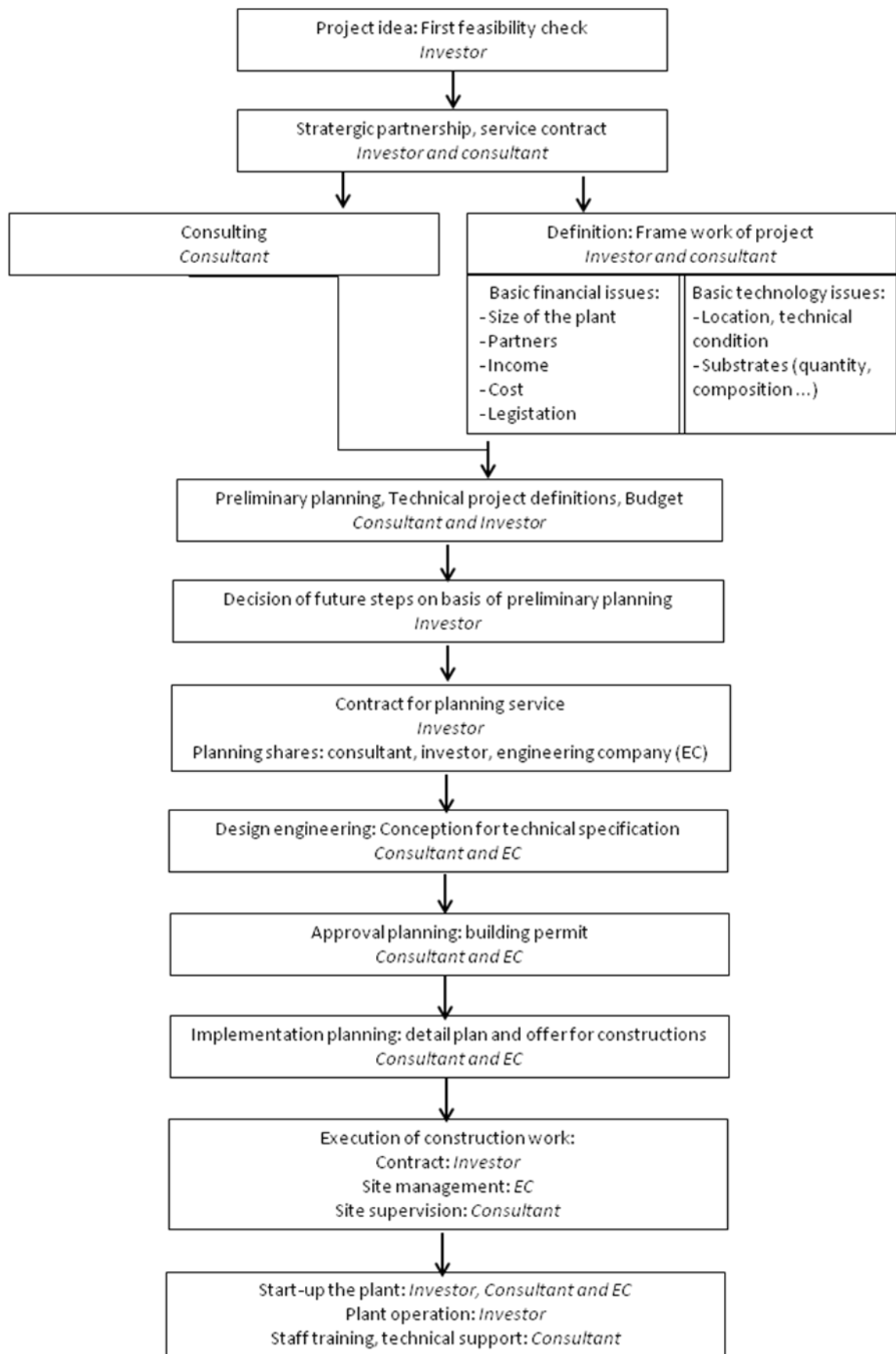


Figure 19: Main steps of a biogas project

[T. A. Seadi et al 2008, p. 97]

### 2.3.2 Stakeholder mapping

The next step is to work out their power, influence and interest, so you know who you should focus on. It helps to develop a good understanding of the most important stakeholders and work out a strategy to win the support from them. All this analysis can be mapped as the template below:

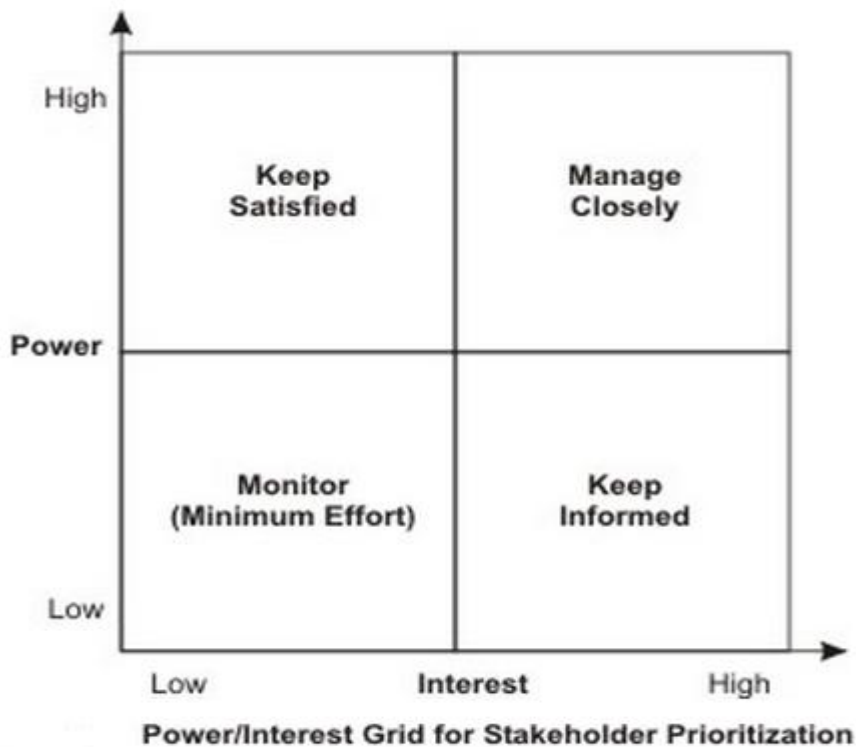


Figure 20: Power/ Interest grid for Stakeholder prioritization

[[www.mindtools.com](http://www.mindtools.com), 10.2011]

The position of stakeholders on this map shows some action that should be taken with them as following:

- High power and high interested stakeholders: these are the people you must fully engage and make the greatest effort to satisfy.
- High power and less interested stakeholders: put enough work in with people to keep them satisfied, but not so much that they become bored with your message.
- Low power and low interested stakeholders: keep them adequately informed, and talk to them to ensure that no major issues are arising. These people can often be very helpful with the detail of your project.

- Low power and less interested stakeholders: again, monitor them but do not bore them with excessive communication.

[[www.mindtools.com](http://www.mindtools.com), 10.2011]

In order to sort them out and posit them on this grid, communicating with the stakeholders is essential to understand their opinion and feeling about the project.

#### 2.4 Entry modes strategy

The market entry mode strategy is one important factor to bring success to international business [Coade Neil, 1997, p.31]. It is one of six key factors for success in international business as shown in the figure below.



Figure 21: Key factors for success in international business

[Coade Neil, 1997, p.xiii].

The modes of entry can be classified as equity and non-equity modes of entry based on the amount of resource commitment that is necessary to establish operation in the foreign market [Kumar V. And Subraniam V. 1997]. The equity mode category, also known as FDI, includes wholly-owned operations and partially-owned operation. Wholly-owned operations are green-field entry and full acquisition. Partially-owned operations are joint-venture and partial acquisition. The non-equity mode category includes market oriented modes which is title of direct export, indirect export and intra-corporate transfer, and contractual

modes which is title of franchising, licensing, strategic alliance, contract manufacturing, management contract and turnkey project. Bellow figure is the classification of the common market entry modes.

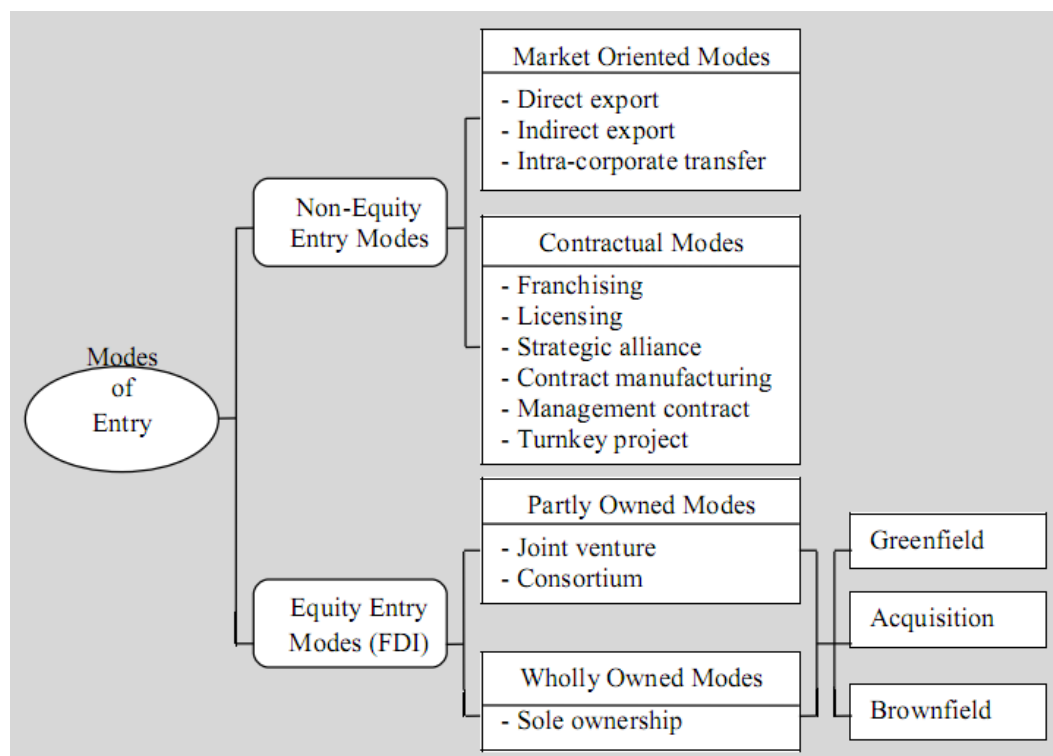


Figure 22: Classification of entry modes

[Mohammadreza A., Mohd N. I., Syed Z. A., 2009, integrated from the sources of Kumar V. And Subramaniam (1997), Lotayif (2003), Pan and Tse (2000)]

Each entry mode has its own strong and weak points. In case a business has a well codified knowledge and strong property rights engine, licensing could be a good choice to access to new market at low investment cost and avoid trade barriers. When trade barriers are low and home location has cost advantage, then exporting may be an appropriate choice. FDI are strategic entry modes if the investors try to have more participants in the business activities in the target markets. When a business wants to access to the technologies of local market, control over foreign operation and own technologies, acquisition could be a good enter strategy. Joint-venture could be a selection when both parties have some performance incentives and want to have a significant control over operation because of some special reasons such as technology.



The choice of an appropriate entry mode into new markets is a key strategic decision for international business [Klaus E. Meyer and Saul Estrin 2001]. The decision of how to enter a foreign market can have a significant impact on the business result. It can help to promote the brand if a suitable entry mode is selected. And it could be a very high investment cost and or lose market share if a wrong mode is taken in place [www.quickmba.com, 9.2011]. For business which proposes a new product, service to fill the current need in a new market, the solution is often a non-equity mode in order to penetrate market at low risk. However, for the business which require complex supporting technologies, in order to cross the boundary and be internationalized, the joint-venture or wholly-own subsidiary could be applied. In some case, if the infrastructure and know-how in the target market meets the minimum requirements of the business, then exporting could be applied, for example the exporting biogas strategy of Ecofys. Green field entry is a high risk option to enter a new market. Except that the entry modes are prevented by the local legislation, there must be entry modes analysis before making this important decision. In any case, the character of entry modes must be considered. Bellow table is a summary of entry mode characteristics.

**Table 8: Characteristics of various entry modes**

	Modes of entry				
	Exporting	Contractual agreement	Joint-venture	Acquisition	Greenfield investment
Risk	Low	Low	Moderate	High	High
Return	Low	Low	Moderate	High	High
Control	Moderate	Low	Moderate	High	High
Integration	Negligible	Negligible	Low	Moderate	High

[Kumar V and Subramium 1997, p.64 ]

In recent decades, FDI has become the primary entry modes of international investment or the default modes of entry to new market [Cheng, 2006]. Firms have to analyze the required resources for their business objectives as well as legal in target markets in order

to make an appropriate decision of entry mode. Biogas market in Vietnam is widely opened to the advance technology in order to take more advantages of this industry. There are more foreign investments in joint-venture. For example the investment of Kemco from Korea, in the Saigon Agriculture manufacturer to construct the biogas power generation, apply biogas system from livestock farm of this manufacture to generate electricity and supply for itself in order to practice cost saving. In this project, Kemco supported funding about 75% of investment cost and supplied all equipments. [[cafef.vn](http://cafef.vn), 11.2011].

## 2.5 Summary

Biogas is discharged from organic waste in anaerobian condition. Collected biogas from landfill is lower in quality and quantity comparing to the one produced in a centralized biogas plant. Moreover, a centralized biogas plant can limit the bad odour and other environment impact which landfill may cause.

There are three common biogas types and twelve key components in a centralized biogas plant. One of those components is preparation for transportable biogas which is a technology challenge for players in Vietnam market. This point will be described further in the proposed business model part.

The being business model is built based on the opened business model theory of Henry Chesbrough. It motivates players to use internal and external resources in R & D and offers more opportunities to get the returns from the target market.

Recognizing the stakeholders in biogas sectors and making decision of entry mode to enter a new market is very essential in business.

### 3 BIOGAS CONTEXT IN THE TARGET MARKET

In this chapter, a close look at biogas context in the southwest of Vietnam will be presented. It is a complicated picture of what Vietnamese people are doing in the biogas sector, what they are expecting to be done, who are the target customers, and what are the response of local government toward biogas industry.

#### 3.1 The trend in Vietnam

Nowadays, biogas is utilized mainly for domestic cooking and lighting. About 2% of those who have a biogas plant use it for water heating and about 1% for production activity. Recently, biogas utilization for electricity generation has been applied in some households who breed more than 15 pigs, but not much. There are some successful studies of small size electricity generators of 0.5-10kW.

Biogas has been applied in different purposes than domestic cooking, but at small scale. Beside the main application of biogas stove and lighting, there are about 2% of those who own family sized biogas plants use biogas for water heating, and about 1% of those use it for production activities. There is also biogas application of electricity generation in the families who breed more than fifteen pigs. The Energy Institute together with many universities and sub-institute such as Ha Noi Polytechnic University and the sub-institute of the Engineer Corps, Ho Chi Minh City Polytechnic University and Da Nang University, are the units that have been successful in studying the small size electricity generators of 0.5-10kW. These machines have been used mainly by small private companies.

People, who own the family size biogas plants, are trying to consume more biogas yield as they know that their current application does not use up their biogas yield. They don't pay much attention to the fact that exceeded biogas causes more than 20 times greenhouse effect than CO<sub>2</sub>, but they note that it has bad smells. So there are more and more studies which focus on improving four-stroke engines run with gasoline or diesel, which are available in Vietnam market, in order to make these engines be able to run with biogas. They add one more spare part in these engines which allows switching it from using gasoline or diesel to using biogas. The advantage of these improved engines is competitive price, the simple improving method, familiar to the users. However, the disadvantage is a consideration. The efficiency of machine is not high, estimated at 50-60%, and there

must be a bag of air to stabilizing pressure during its operation. [[devi-renewable.com](http://devi-renewable.com), 9.2011 ]

In Vietnam, industries which have got high organic content including sugar industry, cassava processing factories, food processing industry, beer industry, domestic and urban solid waste landfill are now recognized as suitable industries for anaerobic treatment process and biogas production. Some projects of biogas plant have been conducted in some of those factories to generate electricity. Some of those are Dong Nam A beer company in Ha Noi with one biogas plant for treatment of waste water from beer processing, Lam Son Sugarcane Company in Thanh Hoa province with one biogas plant to treat waste water, Quang Ngai Agriculture and Food Product Joint-stock company. The technology applied in these biogas plants is benchmarked from Thailand, India and some other [www.globalmethane.org, 9.2011]

Vietnam is also one of target markets for Clean Development Mechanism (CDM) project.

### 3.2 The trend in the Mekong Delta of Vietnam

The biogas demand in the Mekong Delta is high and increasing. Vietnam is a high population density country. It has more than 90.5 million people [Wikipedia, 7.2011]. The population of the Mekong Delta is about 20% of this country. The number of households in Mekong River Delta is 4,302,231 according to the Vietnam General Statistics Office. The population increases at ratio of 1.3% per year. The biogas consumption for domestic cooking is about 150 – 300 liters per person daily [www.unapcaem.org]. The estimated demand for biogas for domestic cooking based on the population in the Mekong Delta is as table below. However the current used quantity is far below the estimated gas demand because lot households can not afford the gas price and they have to use biomass stuff:

Population	Estimated gas demand (liter/day)	Estimated demand increasing %
~ 18,100,000	2,715,000,000 ~ 5,430,000,000	1.3% yearly

(Collected from internet)

In recent years, some people have the need of bottling biogas to make it be transportable because they see the margin between biogas cost and natural gas for domestic cooking.

But they did it in the wrong way which causes danger to end users. Biogas has been injected into small gas holders by some gas sellers un-officially with purpose of making more profit from the large different cost between natural gas and biogas. It was said that biogas cost is about 30 – 40% of natural gas cost. The problems from the biogas holders are low caloric value, corrosion and rotten egg smell due to H<sub>2</sub>S in biogas. The most serious is corrosion because it leads to gas explosion and injures the users.

There is some attention from foreign investors in the biogas potential in the Mekong Delta area in recent years. Some of those are Renewable Energy from Waste and biomass, its short name is BIWARE, which is a one year project conducted by scientific institutions from Vietnam, Greece and Germany in 2005- 2006. The project aimed to design a supporting system for investment decision making in biogas sector. it also included research on the feasibility of biogas feedstock.

### 3.3 Identify the biogas market segments

A market segment is a sub-set of a market made up of people or organizations with one or more characteristics that cause them to demand similar product and/or services based on qualities of those products such as price or function [[www.businessdictionary.com](http://www.businessdictionary.com), 10.2011]. The market segment in this thesis is about a group of people who have gas demand. As biogas is supposed to be used as natural gas, LPG market is potential market of biogas. Actually, Vietnamese people, especially for the ones who own livestock, are trying to utilize as much as biogas as possible in order to reduce the dependence on LPG which is getting very expensive.

The customer market can be segmented on the following customers' characteristics:

- Geographic
- Demographic
- Psychographic
- Behavioral characteristic

The industrial market is segmented on the following characteristic:

- Business type
- Location
- Behavior characteristic

[[www.netmba.com](http://www.netmba.com), 10.2011]

In this thesis, the market segment is the result of the observation of domestic cooking market in Vietnam together with the energy production context in this country.

In this study, the customer market is segmented geographically. The customers in close distance, near to a location of a centralized biogas plant, will be prioritized. Cooking is an essential need of every household. There are different solutions for this need such as electricity, gas, wood and other biomass stuff. The economy of Vietnam is growing, and people are seeking for more advanced and clean kitchens. Nowadays, more people ignore using the traditional material like wood, leaves, rice straw in cooking. Electricity is not the first selection because of electricity shortage in Vietnam. There are more and more people who want to use gas in cooking. The main gas usage in households is for cooking. In the similar characteristics, biogas is used for this purpose mainly. Vietnam is considered as a new market of gas because the increasing quantity and consumption are high. Every year, about 5 million gas stoves and a half of that number mini portable gas stoves were reported to be bought in Vietnam [[maylocnuockangaroo.com](http://maylocnuockangaroo.com), 10 2011]. Vietnamese people consumed more gas for their cooking than before. Gas demand in this market is reported to be increased about 20% per year. However, the average gas consumption per person is still lower than the one in ASEAN [[sgtt.vn](http://sgtt.vn), 10 2011].

In this research, industrial market is segmented by business type. The gas usage in industry is quite varying. In food industry, it is also used for cooking through different large size stoves and ovens. In services, such as restaurant, the gas usage is same as the one in households but at the large size. For other industries, it is used for metal processing, welding and cutting steel, producing glass. In farm, gas is used to dry farm product and hatch eggs. Biogas is also used as non-energy in chemical industry. And new demand of using biogas to generate electricity for internal use has risen sharply.

### 3.4 The Vietnam government's response

National strategy on solid waste management until 2020 has stated the specific targets that 90% of solid waste will be collected and treated to protect the environment, in which 85% will be recycling, reuse, renewable energy or made into organic fertilizer.

#### 3.4.1 To biogas industry

The biogas industry is considered as one renewable energy which offers good solution to protect environment. Vietnam policies and regulations include biogas in the environment industry and renewable energy and treat the related activities in biogas sector with the same law, same policies, and same regulations.

Vietnam government considers environmental industry as one of the top priorities to increase economy growth and decrease property percentage. Especially in biogas industry, they have recognized its benefits to society and environment. Biogas can help to treat waste and also can create new product by reuse organic composition in waste. And it will not only comply with local government policy of environment protect but also interest local residents. Biogas technology can offers people energy and fertilizer. It gives them chance to improve their living condition such as gas cooker. It also helps to reduce chemical fertilizer which is giving negative to environment in long term.

In Vietnam, the Ministry of Industry and Trade's Energy Department is responsible for the development of its energy policy. The Vietnamese National Energy Policy, which was published in September 2004, sketched priorities for the period 2000 – 2020. It raises attention on renewable energy by stating that “development of various forms of renewable energy needs to be encouraged”. Some decisions have been issuing to be a ground and support for new and renewable energy as well as to protect environment as bellow:

The Vietnam government's Decision No. 1855/QD-TTg 2007 presents the Vietnam energy development strategy up to 2020 and vision towards 2050. In those, the targets for renewable energy share are 5% in 2020 and 11% in 2050. In this decision, the development orientation of renewable energy is defined generally. There have not been special policies and incentives for a centralized biogas plant based on organic waste as this is a very new business activity in Vietnam. It has not been assessed properly due to lacking experience and technology. The government mentioned in this decision that there must be expert units to investigate and complete the data in order to make good investment plans. [[tailieu.vn](http://tailieu.vn), 10.2010]

The project "Development of the industry environment in Vietnam" was approved under the Decision No. 1030/QD-TTg 2009. The overall goal of the project is to develop the environmental industry into an industry capable of a level of technology, equipment, services and products to meet the requirements of environmental protection to deal with

environment, pollution control, and overcoming depression, limiting the increase of pollution and improving environment quality. From now to 2015 it is the construction phase, approval and implementation of development planning industry environment, development of the industrial business environment, the research organization, transfer and application technology environment capable of meeting the basic tasks of environmental protection, sustainable use of natural resources to raise awareness and responsibilities of organizations and individuals in the development of environmental industries. According to this Decision, the State will support the state credit for developing the industry and encourage environmental organizations, individuals and foreign investment in developing this industry. Enterprises operating in industrial environments enjoy the most preferential policies on land, capital tax, as prescribed by law. Attracting and preferential policies for foreign experts, especially people of Vietnam in foreign countries involved in the development of environmental industries in the country along with promoting education, training and capacity force in the country and abroad for staff working in the environmental industry [[www.entrepreneurstoolkit.org](http://www.entrepreneurstoolkit.org), 10.2011]

Even though there is no specific policy and regulation for biogas industry, there is high attention from Vietnam Government in renewable energy and environment protection. All environment and renewable energy policies and regulations are understood to be applicable on biogas business activities. Beside the two above decisions, the Law no. 50/2010/QH12 was signed by National Assembly Chairman and ratified on 17.6.2010 with the objectives of Energy Saving and Efficiency. In the sixth clause of chapter 1, it defines a strategy to use and to speed-up the investment of renewable energy.

Vietnamese government noted the effect of appropriate policies and incentives to the development speed of environment industry. They are trying to build and adjust the policies to encourage the investment and innovation in this industry. They have decided to establish some organizations which work as a platform for players and research to support government in building good policies and incentives. Some organizations have been established in order to push the sustainable development and biogas such as:

The Vietnam Biogas Association (VBA) was launched in Hanoi on April 9 2011, following the decision number 1380 QĐ - BNV on 01/12/2010 by the Ministry of Home Affairs. The VBA plays an important role in connecting individuals, organizations and gov-



ernment offices in raising ideas to improve the institutional system, and policy concerning the biogas sector. Besides, it also integrates into international economy with biogas organizations in the world following respectful, equal and mutually beneficial principal and following Vietnamese law; contributing to the economic growth and greenhouse emission reduction. Up to now, over 100 individuals and organizations have registered for VBA membership. [[en.baomoi.com](http://en.baomoi.com), 10.2011]

The Vietnam Institute of Energy was established under Decree No. 62/2008/ND-CP dated 12/05/2008 of the Government. The institute acts under the license of science and technology activities of A-321 issued by the Ministry of Science and Technology and the electricity activity licenses by the Ministry of Industry 822/GP-BCN. One of the institute's duties is to research in general the energy resources, the natural conditions, the economic and social environment, in order to provide the Government a scientific basic for policy developing, strategic planning, and development planning of energy. The institute has six divisions, and one of those divisions is the New and Renewable Energy Center which take whole responsibility on the new and renewable energy within the organization of the institute. [[www.ies.vn](http://www.ies.vn), 10.2011].

Biogas is listed in the special incentive sectors. The biogas mentioned in the Decision No. 1855/QD-TTg 2007 is about energy originated from bio-waste. There have not been specific policies as well as incentives for a centralized biogas plant. This can be understood because of the limited biogas technologies and experience. Issuing the new suitable policies and incentives for a new industry is a time-consuming job. However, as it is combined into the special incentive sectors, it can be applied with the following current investment incentives:

**Table 9: The summary of current investment incentives**

Types of investment incentives	Under list of special incentive sectors
<b><i>I. Tax incentives</i></b>	
1. Corporate income tax	Standard corporate income tax rate applicable to projects outside the incentive sectors and locations is 28%
1.1 Exemption and reduction of corporate income tax for:	

Newly-established business entity for new investment project	Four year tax exemption starting from the first profit making year, 50% tax reduction for the next nine years.
Resettlement business entity	Two year tax exemption, 50% tax reduction for the next two years for a business entity moving out of urban areas due to land planning (common application)
1.2 Corporate income tax rate for:	
Newly-established business entity for new investment project	10% tax rate in 15 years if having special impacts over the economy, tax rate of 10% is applied to the whole project's life. (Decided by the Prime Minister).
Ongoing business entity	Allowed to transfer losses to coming years deductible to taxable income for a maximum of five years (common application)
2. Value added tax	Tax rate of 0% for some sections, including science and technology activities.
3. Export – import duties	Exemption of import duties in five years for import of project's fixed assets.
4. Natural resource royalty	This depends on the locations. Maximum of 50% reduction of natural resource royalty in three years starting from the first year of exploitation.
5. Land use tax	Exemption of land use tax in 15 years maximum.
<b><i>1. Investment support</i></b>	
1. Technology transfer	Contribution by technology in investment projects, support technology innovation by the National Technology Innovation Fund
2. Training support	The government encourages and supports to establish a training support fund, the training support fund is not for profit, entitled to tax exemption and reduction as stipulated in tax laws, training cost of the business entity will be recorded in reasonable cost items for calculating taxable corporate income.
3. Development investment support and	A number of support types investment con-

investment services	sultancy, managing consultancy, technology transfer, market information supply, participation in organizations and associations, investment promotion, etc.
4. Support for infrastructure development inside and outside industrial parks/ export processing zones.	State budget to be used to support infrastructure development and other supportive policies.
5. Customer clearance support	Foreign investors/ experts and their dependants are granted multi-entry visas for a maximum of five years period per issuance.

[[www.iisd.org](http://www.iisd.org), 10.2011]

The government encourages businesses to build and produce renewable energy as well as facilities which can support the usage and development of renewable energy. The government also allows individuals and economic organizations, domestic as well as international, collaborating to invest and exploit the new and renewable energy resources on the basis of mutual benefit. However, as Professor Dr. Nguyen Huu Dung, from the Urban and Industrial Environment Institute of Vietnam also mentioned, there have not been specific and clear policies and incentives to attract the investors from different economic sectors to solve and create value from waste. [[giaiphapmoitruong.com](http://giaiphapmoitruong.com), 10.2011]

#### 3.4.2 To waste management

The government is facing the waste problem with limited technologies. The Vietnam government's Decision No. 1873/QĐ-TTg 2010 approves the master plan of the solid waste disposal construction in Mekong River Delta, a new key economy area, up to 2020. The decision encourages all economic sectors to invest in building and managing the solid waste collection and treatment. [[www.chinhphu.vn](http://www.chinhphu.vn), 10.2011]. This is a prompt decision to solve the solid waste problem which is increasing sharply. And the technologies to solve the waste are still open solutions for investors by statement "Choose the suitable technologies and equipments according to the local conditions". Professor Dr. Nguyen Huu Dung, from the Urban and Industrial Environment Institute of Vietnam, said that according to the national strategy, the selection and application of an advanced and suitable technology will orient to energy recovery and by-products from solid waste, and the limitation of landfill technology.

The source of capital for investment in construction of solid waste disposal and ancillary works including:

- Capital budget.
- ODA, foreign financial assistance.
- Capital investment credit.
- Capital investment from domestic and foreign.
- The other lawful sources.

### 3.5 Summary

The biogas trend:

- Biogas technology is developed in conjunction with sustainable development of agricultural economics.
- National standard technology specifications are very important for a successful for extension of biogas program.
- Biogas production in large scale is necessary for VN in the coming years

Market segments:

- Kitchens of households and food service are the big market and long loyal customers, as gas is one essential need for their cooking activities.
- Farmers are
- Other firms include CHP owners, recycling firms who need plastic and or metal for their production process, chemical firms and any other firms who need CO<sub>2</sub> and nitrogen, and need CO<sub>2</sub> and Nitrogen. CHP owners need raw biogas for electricity generation.
- Different industrial markets such as chemical industry, farming, restaurant, and other, with different gas utilization are reachable markets if an advanced technology allows biogas be bottled.

Government's response:

- Consider biogas as one of environment industry and renewable industry in term of applicable policies and incentives.
- There are many encouragement and supporting policies for businesses whose activities aim to protect environment, save energy, produce renewable energy.

- There has not been a focus policy in developing renewable energy as there has not been a completed overall evaluation of renewable energy of the country.
- Willingness to update laws, policies, and regulations in order to push the renewable energy development and protecting environment.

## 4 MARKET ANALYSIS

The market findings and analysis will be found in this chapter. The discussion is based on the foreign investors' point of view. The assumption is that the foreign investors own the required advanced technologies for making transportable biogas. The market finding includes interview result and market observation. Interview results are collected via net communication. The market analysis tools of PESTLE and Porter's five Forces are used together to analysis the macro and micro business environment in Vietnam. The purpose of this analysis is to draw a complete picture of biogas market in Vietnam, especially in Mekong Delta River area.

### 4.1 Macro business environment analysis

This part focuses on analysis of political, economic, social, technological, environmental and geographical factors which make up the macro business environment. This analysis will shape the overall picture of the business environment with all advantages and drawbacks in Vietnam at present, which is believed that all investors being interested in doing business in this market are expecting.

#### ➤ **Political**

This is an overview for Vietnamese political regime and foreign investment law. Vietnam with a single party, Communist State, has been successful in retaining the political stability over last decades. This success contributes to differentiate Vietnam from other developing countries. However, politicians also assess Vietnam to possess high risk of the political instability in long-term because of the current single party system. The Vietnamese legal system in general still contains inconsistencies and overlapping and conflicting at several points, leading to difficulties, even misinterpretation in application and enforcement at the grass-roots level. Having identified this challenge, the Vietnamese Government is implementing the Strategy on the Development of the Legal System until 2010 with a vision to 2020. The Strategy first focuses on reviewing the entire system of normative acts to remove those that are overlapping, conflicting or out-dated, ensure the constitutionality, consistency, enforceability, openness, transparency, and accessibility of the normative acts. [[www.vietnamembassy.us](http://www.vietnamembassy.us), 10.2010]. In fact, this government has tried to reform step by step to make the system more efficient in operation. Plenty of bureaucra-

cies have been cutting down. Constant efforts have been carried out to improve and fulfill gaps of legal framework such as imposing the foreign investment law and performance guidelines, security and competition regulations, low or free import tariff policy on equipments associated with the environmental technology industries, regulations of purchasing and procurement related to export and import of equipment, as well as of technology transfer, education and training policies, infrastructure strategies, and political stability policy. to call for foreign investment. The accession to WTO is regarded as the most striking evidence of Vietnam's attempts to join the international business environment. To catch up with the global trend of sustainable development, the local government has formulated a lot of strategic plans to attract more investment with priority on advanced and friendly environmental technologies. The Ministry of Planning and Investment (MoPI) is the agency of the Government responsible for development planning and investment policies (i.e. investment incentives). Investment incentives are available for projects that focus on the following activities: production of new materials or new energy; production of high-tech, bio-tech, in-tech; use of, or R&D on high technology or modern technology. [Business Advantage Vietnam, 2010].

In the meeting held by Prime Minister Nguyen Tan Dung, many experts and sponsors affirmed that the Vietnamese Government's efforts to cope with the global economic recession and soaring inflation.

As part of these efforts, the Government earlier this year adopted Resolution 11 detailing key solutions to inflation control, macro-economic stabilization, and social welfare issues. The participants noted that these measures have produced positive results

➤ **Economic**

This factor contains both attractive opportunities and challenges that seem to be unpredicted in this marketplace. Let's review statistics of core economic indexes of Vietnam market from 2007 to 2009 and forecasts for next two years by HSBC so that we can analyze the economic factor more systematically and fully.

## Vietnam forecasts

	2007	2008	2009	2010f	2011f
GDP growth (% y-o-y)	8.5	6.2	5.3	7.2	5.8
Private consumption (% y-o-y)	9.6	7.6	3.4	5.8	5.0
Government consumption (% y-o-y)	9.0	5.8	6.5	5.0	3.0
Investment (% y-o-y)	23.0	13.2	3.2	8.0	6.0
Industrial production (% y-o-y)	18.2	15.9	8.6	10.9	7.3
Gross domestic saving (% GDP)	32.5	32.6	31.9	32.0	31.7
Unemployment rate, end-year (%)	4.6	4.7	5.2	5.0	4.7
CPI, average (% y-o-y)	8.3	23.0	7.8	9.8	7.5
Base rate (%)	8.25	8.50	8.00	11.00	11.00
Broad money supply M2, average (% y-o-y)	43.2	25.0	35.0	28.0	25.0
5-yr yield, end-year (%)	8.73	10.00	11.68	14.50	12.00
VND/USD, end-year	16017	17483	18479	19800	19800
Current account balance (% GDP)	-9.8	-11.6	-7.0	-8.8	-6.2
Foreign Direct Investment (% GDP)	9.3	14.5	9.2	5.9	7.1
Consolidated government balance (% GDP)	-5.0	-5.0	-8.0	-7.0	-5.5
Gross public external debt (% GDP)	23.4	23.6	24.5	25.5	25.0

Source: HSBC



Figure 23: Overall Vietnam economic statistics

Let's begin with GDP growth. As illustrated earlier, Vietnam's average economic growth rate is 7.5% per annual during last decade. The robust economic growth rate and its inevitable consequences make sure that market needs and size related to four sectors are in good conditions to do business with in accordance with Vietnam development strategies until 2020.

Next are the challenges from the view of capital market. ODA has been the major source of financing for most of Vietnam's environmental projects. Two leading sponsors in this field are WB and ADB. Meanwhile, public investment from state budget is predominantly poured into state-owned economy groups which hardly do business efficiently. A new funding for environment projects, especially in family biogas plants from animal manure which are consider as the simplest investment in term of technology and finance, is CDM. The major investors during recent years are Japan and Netherland government. Eventually, the business space which requires high investment of technology and finance management such as a centralized biogas still remains sparse.

Another matter comes from FDI disbursement. Indeed, the high and steady economic



growth rate in many years makes Vietnam successful in FDI attractiveness. The big annual FDI capital flows have been pumped in Vietnam market recent years. Secretary-General Supachai Panichpakdi of the United Nations Conference on Trade and Development (UNCTAD) quoted his agency's recent survey, saying that Vietnam was the sixth most attractive location for FDI over the 2007-2009 period. However, due to the weakness of macro managerial performance, the disbursement is quite poor as shown in Figure 25 below while environmental businesses are underdeveloped due to lack of capital.

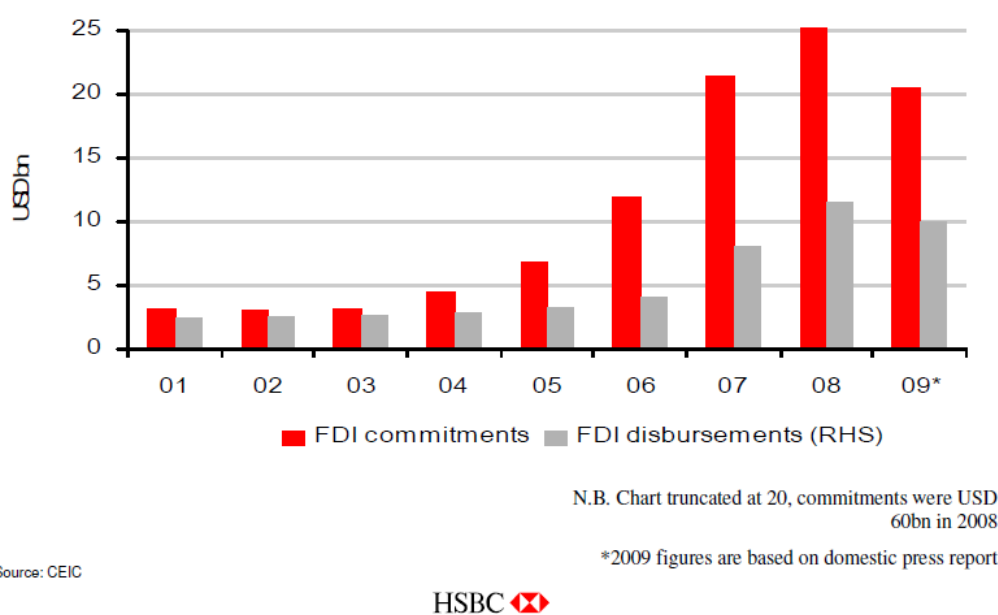


Figure 24: FDI commitments and disbursements

[Source: Vietnam Outlook 2010, HSBC 2010]

Fortunately, the amount of annual remittances of Vietnam is also another considerable fund for the capital need at present. World Bank estimated the remittances of Vietnam in 2011 would reach more than 5 billion EUR (7.2 billion USD). Therefore, it is believed that if the local government has immediate support in term of regulations and policies to help the private sector approach the money market easier as well as treat more fairly in getting loans from local banks, the financial issue for environmental projects can be resolved.

Present monetary and exchange rate policies have been producing challenges for players in this market. It is a fact that the inflation has remained at high level since 2008. For the past nine months, headline inflation rose on average 18.2% y-o-y, and food prices, which make up about 40% of the CPI basket, rose by on average a staggering 35.0% y-o-y. In

the meeting hold by Prime Minister Nguyen Tan Dung on 6.9.2011, he said that the inflation tends to dip and is expected to be kept at 18% this year. The Government plans to pull it down to one digit next year. [[www.mpi.gov.vn](http://www.mpi.gov.vn), 10.2011]

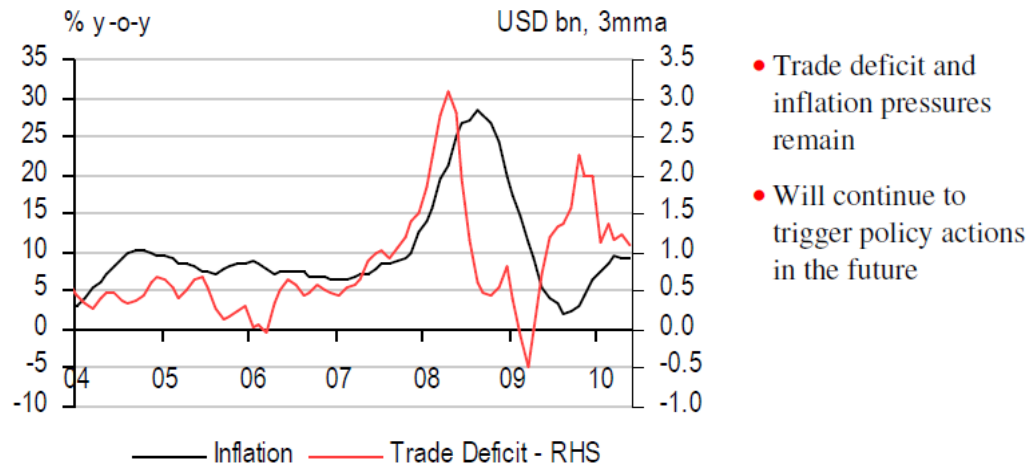


Figure 25: Inflation and trade deficit

Source: Vietnam Outlook 2010, HSBC 2010]

The Vietnam Dong has been devaluated, which creates concerns about an overheating economy, the balance of payments and a high inflation rate will probably “keep the currency under stress. [Bloomberg, 25.09.2010] CPI has sky-rocketed continuously, for example, +22.97% in 2008 (highest CPI rate from 1992) compared with 2007, +6.88% in 2009 compared with 2008, and +9.19% in 2010. [Vietnam General Statistical Office, 2010] In addition, local banks have been in the interest rate war from 2008 as figure 16 shows below.

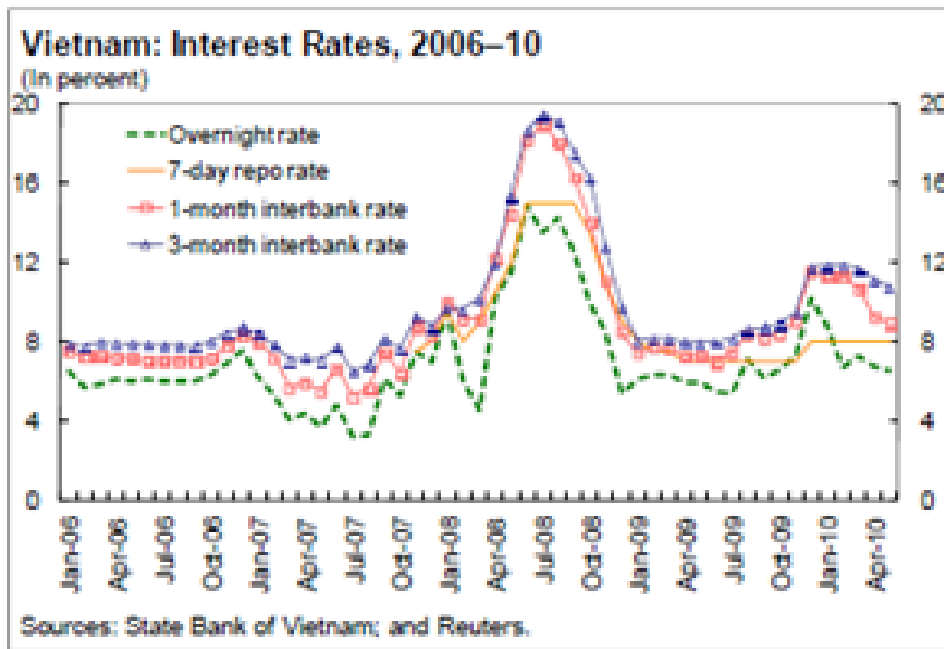


Figure 26: Interest rates in Vietnam

[Vietnam Staff Report for the 2010 Article IV Consultation, IMF 2010]

And this war began again in 2010. These are warnings of macroeconomic instability of Vietnam. It can reduce belief of investors and increase ability of leaving the market if local government has no response to tighten these policies.

Viet Nam ranked 140th/181 in terms of ease and costs of making tax payments. The figure below shows the main indicators for paying taxes. They are:

- The total number of payments per year;
- The time it takes to prepare, file, and pay (or withhold) the corporate income tax, the value added tax and social security contributions (in hours per year); and
- The total tax rate, which measures the amount of taxes and mandatory contributions payable by the business in the second year of operation, expressed as a share of commercial profits.

Table 10: Indicators for paying taxes in Vietnam

Tax or mandatory contribution	Payments (number)	Notes on payments	Time (hours)	Statutory tax rate	Tax base	Total tax rate (% of profit)	Notes on total tax rate
Employer paid - Social Security contributions	12		372	16%	contract salaries	18	
Corporate income tax	5		233	25%	taxable profits	16	
Employer paid - Health insurance contributions	0	paid jointly	0	3%	contract salaries	3.4	
Income tax from transfer of land use rights	1		0	25%	capital gains	1.3	
Employer paid - Unemployment insurance	0	paid jointly	0	1%	contract salaries	1.1	
Business Licensing Tax	1		0	fixed fee (VND 1,000,000)		0.2	
Fuel tax	1		0	5%	fuel consumption	0.2	
Value added tax (VAT)	12		336	10.0%	value added	0	not included
<b>Totals</b>	<b>32</b>		<b>941</b>			<b>40.1</b>	

[[www.doingbusiness.org](http://www.doingbusiness.org), 11.2011]

Vietnam Government is trying at inflation curbing, macro-economic stability, reasonable growth combined with growth model renovation and economic restructuring. At the second session of the 13th National Assembly on 21.10.2011, PM Dung stated that regarding major norms, the Government would strive to pull down inflation rate to one digit next year and 5 - 7% by 2015. The GDP is expected to expand at least 6-6.5% in 2012 and 6.5-7% on average throughout the period. Seven key solutions were defined in this session in order to achieve the target. One of those key solutions is speeding up science and technology development and enhancing effort in environment protection and improvement. [[www.mpi.gov.vn](http://www.mpi.gov.vn), 11.2011]

Following the Vietnam economic analysis, I will highlight the economic growth in The Mekong Delta. The percentage of population living in rural area in the Mekong Delta is 77%, 7% higher than the Vietnam average percentage. This area has provided more than 1 / 3 the value of agricultural production in the country, mainly rice products, seafood and fruit. Economic growth rate of the period 2001 - 2005 was 10.5%, of the period from 2006 to 2010 was 12%, so the average period from 2001 to 2010 was about 11%. The growth rate of agriculture is 3.3%. Regarding attracting foreign investment from 1988 to 2010, the total number of the validity FDI projects was 565, equivalent € 6.84 billion,

made up 4.9% FDI in the country. Particularly in 2010, total foreign direct investment are 98 projects with total registered capital of € 1.32 billion, about 9.2% FDI in the whole country. Regarding retail sale of consumer goods, in 2010, the total turnover was about 277.5 trillion vnd, equivalent € 9568.965 billion. 2001-2005 average growth rate was 17.5%. 2006-2010 average growth rate was 23.3%. [[www.mekongdelta.com.vn](http://www.mekongdelta.com.vn), 11.2011]

#### ➤ **Socio-cultural**

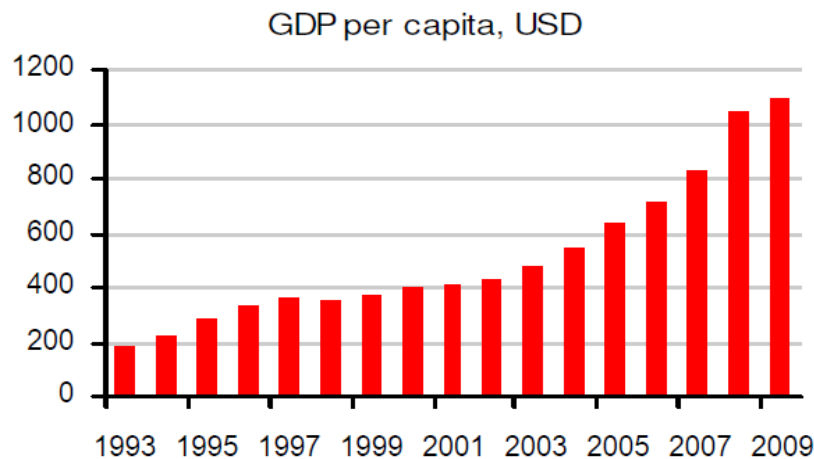
Vietnam is the 14th most populous country. The population is about 90,549,390 by July 2011. Birth rate is 17.07 births/1,000 populations as estimated in 2011. Urban population makes up about 30% of total population. The rate of urbanization is about 3% annually. [[www.cia.gov](http://www.cia.gov), 11.2011]

The pool of working-age local Vietnamese talent is relatively large. Around 42 million Vietnamese are of working age, of which about half are under 35. Ten million of these candidates live in urban areas. Every year, about one and a half million new workers enter the labor market (labor force growth 3.5- 4% a year), of which more than half a million are university graduates with abundant job opportunities.

Government sets short term goals for municipalities to train local workers and long term goals for educational institutes to create a training system in order to produce skilled workers. The labor cost is low and vary. For instance, manual worker monthly pay is 65 €, engineering can get up to 200€ /month, and administration officer can get up to 500€/month. Employer should also pay 2% of employee salary to health insurance. [Cf.vietnam-ustrade.org 2010]. However, finding candidates with truly proficient English language skills, office applications, technically skills or good soft skills is still a big challenge. [cf. Vietnam Business Guide]

The Vietnam's robust economic growth results in a considerable increase of personal income. Nowadays, Vietnam was removed from the list of low income countries and becomes a middle income one. Figure 17 below depicts GDP per capital statistics in Vietnam from 1993 to 2009.

## Success over a tough period: Vietnam is now a middle income country!



Source: CEIC, HSBC

HSBC 

**Figure 27: GDP per capital**

[Vietnam Outlook 2010, HSBC 2010]

The continuous GDP per capital growth surely leads to higher living standards, especially in term of environmental requirements. This promises to create a sizeable market for environmental businesses.

Another element of the social factor that should be taken into account is the labour market. Vietnam has around 42 million local labor as of 2010, and the number of which is growing at 3.5 - 4% a year. [vietnam-ustrade, 2010] The unemployment rate in 2010 remains around 2%. [fbnc, 2010] One of the most attractive factors to the foreign investors is very cheap labour costs.

- Manual workers 45 €
- Wages in foreign invested companies in 2004 65 € to 70 €
- Engineer is about 200 € to 230 €
- Administrative officer 450 €

[Vietnam-ustrade.org 2010]

In addition, the Vietnamese workforce is disciplined, hard-working, and fast-learning. Vietnamese society appreciates the importance of education and households always try

their best to bring their children possibly highest educational background. More and more Vietnamese students go abroad for study as well as foreign training and education establishments set up their operations in Vietnam. Local universities and vocational training schools have been also running academic programs in environmental technologies in order to partly meet the labour market. Furthermore, the government also imposes policies to invite Vietnamese overseas, the talents all over the world to contribute to the development in Vietnam. All these efforts aim to fulfill market needs of experts and skilled employees, as well as to provide productive and skillful workforces for Vietnam in coming time instead of the competition based on mainly low labor cost.

➤ **Technology**

This part discusses about technology including related supporting infrastructure. There are some types of waste in Vietnam: Solid waste: Rubbish, Hospital, Industrial, and Agricultural Waste. Waste water from Hospital, Industrial zone, Solid waste arising for urban life... In 2009 the total amount of Vietnam solid waste arising from the urban life was estimated at 25,000 tons per day and reached 37,000 tons per day in 2015 and 59,000 tons in 2020. The agriculture contributes about 21% to Vietnam GDP. The farming makes up 74.5% of the structure of Vietnam agriculture. The breeding is about 23.4% of this country's agriculture structure. There are a few medium-sized breeding areas. The most of livestock owners are households. The organic contained waste is high, estimated at 64.7%. [Ho Thi Lan Huong, Vietnam Energy Institute, 2008].

There is space for improvement in the Vietnamese waste management. About 70 % of solid waste is collected in urban areas. The households and companies have to pay waste fees for the collection. However the treatment is not very sustainable. Almost every solid waste goes to landfills. [Nguyen 2005, Watson 2004]. The most used waste treatments are dump, disposal, composting and landfill. Just one of those, which is one of CITENCO's subsidiaries in Ho Chi Minh City, apply the biogas technology to collect biogas from landfill.

The Mekong Delta is located in the south, a key area for agriculture, especially for rice, fruit, and vegetable. Environmental pollution is threatening this new key economic center of Vietnam. In 2010, PM Nguyen Tan Dung signed a decision No. 1873/QD-TTg 2010 to

approve the master plan of the solid waste disposal construction in Mekong River area. This appeals a circumstance that biogas technologies have not been developed well in Vietnam.

Generally, elements relative to the technological factor and infrastructure system remain limited and backward. However, recent action plans of the government have paid majority of state budget, FDI, ODA, and CDM for improving this status. Development of supporting industries has been taken into account. Especially, two high-tech parks have been put in operation in Hanoi and HCMC to attract advanced technology industries. Several similar projects in other provinces like Dong Nai and Binh Duong are in preparation period. Releasing the Technology Transfer law in November 2006 is another remarkable proof for high-tech investment intensives.

The national power grid has covered 100% of districts and 95% of communes [vietnam-embassy-usa, 2010]. Nevertheless, due to power shortage, particularly in dry season, problems relevant to power cuts have been placing stress on business activities.

Industrial parks - From the end of 2007 to the end of 2008, the number of industrial parks in Vietnam increased from 179 to 194. Of this figure, 110 industrial parks are in operation (covering 26,400 ha) while the remaining 84 are under construction and land compensation. Thirty-two industrial parks (16 percent of the total) are invested by foreign enterprises, representing a total investment of USD1.8 billion. In 2008, industrial parks in Vietnam attracted 3,300 foreign direct invested projects worth USD39.2 billion and 3,100 domestic projects with a total investment of VND185,000 billion, creating more than one million jobs. [Vietnam Infrastructure Limited Annual Report 2009, Vinacapital]

Telecommunications - By the end of 2009, mobile penetration is expected to surpass the 100 percent threshold, which implies a portion of the population with two or more wireless numbers, while the number of internet users should rise to 31.5 million by 2012, or 34 percent of the population. Service providers like VNPT, S-Telecom, Viettel, Hanoi Telecom and newcomer GTel are expected to invest in expanding their network infrastructure – to meet the growing demand, to improve and enhance services and coverage, and to maintain competitiveness. Four mobile operators – Mobifone, Vinaphone, Viettel, and EVNTelecom and Hanoi Telecom – received 3G licences from the Ministry of Culture and Information in April 2009, and five operators are currently trialing WiMAX ser-



vices: Vietnam Data Communications (VDC) in Lao Cai Province; Vietnam Multimedia Corporation (VTC) in Hanoi and Ho Chi Minh; FPT Telecom; Electricity of Vietnam (EVN) Telecom; and Viettel. [Vietnam Infrastructure Limited Annual Report 2009, Vinacapital]

**Transportation** - The development of the transport sector has contributed positively to the economic growth of Vietnam over the past decade, through better links to markets, education and health facilities. Foreign investment in transportation infrastructure is encouraged through incentive plans such as BOT and BT project structures, but restrictive policies and regulations usually result in projects being inefficient, and delays in implementation are common. In the short term, the government has approved a list of projects to initiate that will require USD4.5 billion for the construction of 10 sea ports, USD8.5 billion for 1,000km of expressway, and several billion USD for new and upgraded airports.

**Air transport:** In 2008, the Vietnam aviation industry transported a record 10.2 million passengers, up 15 percent from 2007, while transported cargo held steady at 130,000 tons. Going forward, international air traffic is expected to continue to grow at 12 percent yearly, while domestic air traffic is projected to grow at 15-16 percent yearly through 2020. As the economy further diversifies, the number of international and regional routes will increase. In addition to Vietnam Airlines and Jetstar Pacific, three new domestic airline licenses' have been granted, allowing competition to increase over the coming years. This should increase service quality and efficiency and result in lower prices for air travel. Some individual aircrafts have been allowed to import into Vietnam. This is a signal of opening policy of air transporting.

**Roads and expressways:** The road network in Vietnam totals 230,000km. The administration of the road sector is complex, with different agencies responsible for financing and implementation, and others for investment and maintenance. Road traffic is mainly concentrated on national roads and around the major urban centres. Car ownership is still low and road traffic is dominated by motorcycles, creating a major challenge to transport planners and policy-makers, especially in large urban areas. Expressways and toll roads are expected to solve traffic problems along key corridors by separating high-speed traffic from slower, local traffic.

**Ports and shipping:** Vietnam has over 90 sea ports, typically developed and managed by state-owned enterprises. The larger ports were developed by the Vietnam Maritime Ad-

ministration (Vinamarine) and handed over to Vietnam National Shipping Lines (Vinalines) for operation. Provincial and municipal governments manage about 20 ports. The main ports are Haiphong in the north and Saigon in the south, but both are estuarine ports, located 30km and 90km inland, respectively. Access is therefore limited to smaller ships. The annual throughput of the ports has increased rapidly, from 56 million tons in 1998 to 155 million tons in 2006. Ports in the area surrounding Ho Chi Minh City still account for two-thirds of total throughput. While foreign ownership of ports is allowed, foreign participation in the provision of port and shipping services is limited to joint ventures where the foreign share in the enterprise does not exceed 49 percent. Ship agency services are not open to any degree of foreign participation. [Vietnam Infrastructure Limited Annual Report 2009, Vinacapital]

### ➤ Legal

Vietnam protects the ownership of invested capital and other legal rights of foreign investors. Moreover, it encourages foreign investors to invest in the following sectors and regions:

- Sectors :
  - Production of exports;
  - Animal husbandry, farming and processing of agricultural produce, forestry, and aquaculture;
  - Utilization of high technology and modern techniques, protection of ecological environment and investment in research and development.
  - Labor intensive activities, processing of raw materials and efficient utilization of natural resources in Vietnam;
  - Construction of infrastructure facilities and important industrial production establishments.
- Regions:
  - Mountainous and remote regions;
  - Regions with difficult economic and social conditions.

Foreign investors may invest in Vietnam in any of the following forms: Business cooperation, Joint venture enterprise, and Enterprise with one hundred (100) per cent foreign owned capital. [Vietnamembassy.org.uk, 10.2011]

Corruption is endemic in Vietnam at all levels of government and a major barrier to foreign investment. The authorities regularly pledge commitment to aggressively fighting corruption, and had encouraged the media to act as a watchdog, but these efforts lost steam after several journalists were detained for reporting on major scandals. Vietnam ranked 121st out of 179 countries in Transparency International's Corruption Perceptions Index for 2008. However, it is improving. As reported, Vietnam was ranked 116th in 2010. [[www.transparency.org](http://www.transparency.org), 10.2011]

Bureaucracy still exists everywhere in supporting policies, from tax, credit, land, technology, training, trade and legal matters. It could be said that bureaucratic control over effective business operations is actually a chronic disease. Vietnam ranks the fourth in eastern Asia with Bureaucracy score 8.13 while India scores 9.41 out of 10 on the top of Bureaucracy index. [[www.heritage.org](http://www.heritage.org) , 10.2011]

➤ **Environment**

The past year saw significant developments that confirm Vietnam's strong commitment to developing the clean environment sector. From stronger laws to increased public awareness, Vietnam has taken clear steps to promote investment in environmental utilities and technologies. In January 2009, a government decree offered incentives to projects that relate to the environment, including environmental protection, environment-friendly initiatives, and waste recycling. These incentives include preferential treatments such as free land-use rights, zero or low tax rates, and support for purchases of materials and sales of products. Moreover, the decree also offers a new financing channel, the Vietnam Environment Protection Fund, as an alternative to the Vietnam Development Bank, allowing investors to seek low interest rate financing. As public awareness and expectations for environmental standards rise, demand for new projects and services will increase. Several significant corporate environmental violations, resulting in fines and legal action, have caught public attention. Investment opportunities exist not only in new projects but also projects to upgrade and/or replace existing facilities which cannot meet environmental standards. [Vietnam Infrastructure Limited Annual Report 2009, Vinacapital]

The economic boom produces problems for Vietnam. Once all economic sectors are encouraged to grow to contribute to the country's economic development, as well as since personal income and living standards are improved, it inevitably leads to enormous waste generation, particular in urban areas. In addition, the significant increase of population, low responsibility sense, lack of close management and technical solution are reasons to really cause waste management to be very challenging in Vietnam today.

The temperature and weather in Vietnam is an advantage for biogas production. Dry seasons, from November until April, and wet seasons, from May to October, are the most significant attributes of the climate in the south. During the wet season, short and heavy downpours occur. [Guidevietnam 2010]

#### 4.2 Micro business environment analysis

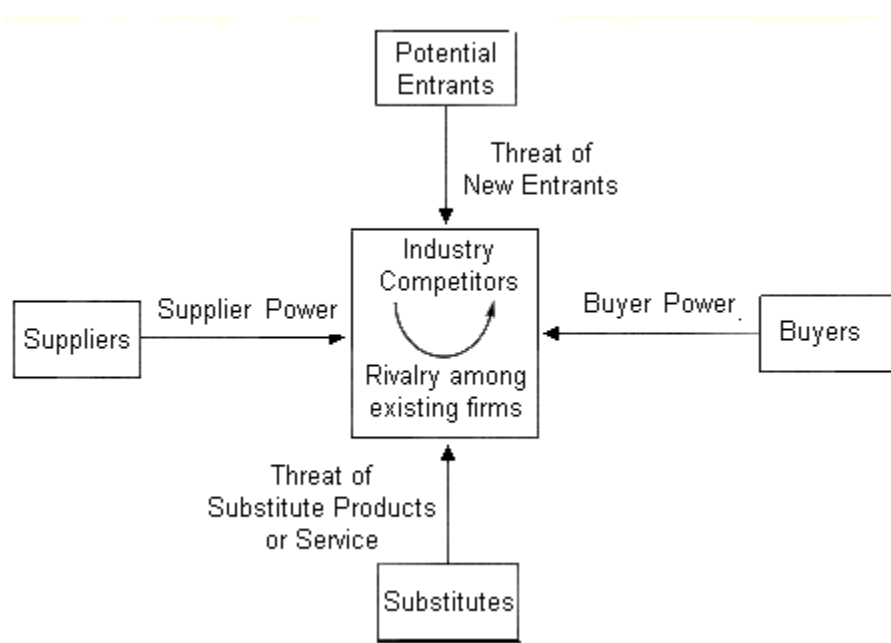


Figure 28: Porter's five forces

[ [www.quickmba.com](http://www.quickmba.com) , 12.2010]

##### ➤ **Supplier power**

A centralized biogas plant based on organic waste is a combination of various inputs which include plant construction, digesters, pit storages, lagoon or storage tanks, agitators, pumps, CHP unit, feeding system, waste separator, gas holder, gas cooling and gas cleaning system, control units, feedstock, chemical, etc. These inputs are supplied by

different suppliers. And the supplier power is different between them. The suppliers of those inputs could be divided into two categories; “being depended” and depending. “Being depended” suppliers are the ones who take biogas sector as the key market segment of their business or who have few customers to serve. For example, the suppliers of digesters, agitators, CHP unit, waste separator, gas holder, gas cooling and gas cleaning system, control unit. The growth of biogas industry could drive the growth of those businesses. With the advantage of being in the developed countries, the investors will be able to select good suppliers. And those facilities could be imported into Vietnam at the preferential importing duties as mentioned in the part 3.1.4. While the other, “depending” suppliers, have many options to satisfy their need of benefit, for example, the suppliers in sectors of chemical, construction. However, there are many suppliers in those sectors so the switching cost is not high. The attention should be the continuous feeding stock of organic waste, because in Vietnam there are only state environmental sanitation companies who can collect waste. A strategy to going well with feeding stock will be presented in the part 5.2. So in conclusion, the supplier power to a centralized biogas plant based on organic waste in Vietnam is **low**.

#### ➤ **Substitute products**

The key products from this centralized biogas plant can be various and serve different market as well as supply different industry sectors. The main focus in this research is biogas for cooking, so this will occupies the most analysis part.

There are not many substitutes which can serve the need of cooking in Vietnam. The modern substitutes are gas and electricity, and the price of those is high and increasing. As market researching result, 96 of 105 households in urban areas replied that they used gas for cooking except rice cooking which they use electric cookers, 4 of those owned electric cookers but still used gas stoves as main tools, 2 of those used kerosene stoves, and 7 of those had just switched to using coal because of expensive LPG. The traditional substitutes are getting ignored as the living standard is rising following economics growth. Vietnamese people are seeking for advanced kitchens at low cost. In rural areas, 30 of 70 households who did not own family biogas plant replied that they used gas for cooking. The others said that they would own a gas stove if they had more income or the cost of using gas stove is lower than now. The gas stove business growth at high level

which can demonstrate for the high stable need of gas for cooking. Therefore, the reliable substitute product in cooking market could be LPG, and in near future may be CNG and LNG as Vietnam Petrol group has a plan to produce pilot CNG and LNG in 2013.

Switching to LPG may happen when biogas causes danger to end users. In Vietnam, in recent years, some people who own the family size biogas plants try to bottle biogas into small bottles of about 1kg to sell to portable gas stove users. They did not label those bottles. The buyers got these without notice and sometimes because of cheap price. Of course this activity is taken un-officially and illegally. So the quality and competitive cost of bottle biogas will definite the loyalty of using biogas for cooking.

Other products and services from this biogas production are quite specific and the switching possibility is quite low because those products are the result of advance technologies which the investors of the centralized biogas plant will own. So the threat of substitute product is **medium**.

#### ➤ **Buyer power**

The Vietnamese buyers are facile customers in the market of household goods. As a Vietnamese, I was born and live a long time in this country so I can say that I understand Vietnamese buyer attitude quite well. Most buyers consider price at their first try, then re-order if the quality of first try could satisfy their need at their expectation. If the product is beyond their expectation, then it is a wow that they will definitely introduce and even persuade their friends and relative to try. Bottle biogas will impress buyers because it is produced from waste which pollutes their living condition. So in this market, the buyers are easily persuaded.

The fact that the number of gas stove users is increasing pushes gas consumption. Most urban Vietnamese use gas stoves because electricity is in short supply. Rural people are also seeking for modern and sanitary kitchen when they have chance to earn more income. As reported by a newspaper, in the Mekong Delta, straw, corn pulp and some other crops residue, which are used to be traditional energy in the kitchens of local people, are now used by a few people. Some residents in Dong Thap province said that cooking with crop residue requires people to sit in kitchen for longer time, and they prefer to use modern facilities such as gas stove and electric rice cooker to save time for going to work and

earn more money. [[www.biethet.com](http://www.biethet.com), 9.2011]. This opinion is similar to many other residents in Long An, Tien Giang, Dong Nai where the interviews were conducted. So the customers are huge and increasing.

➤ **Degree of rivalry**

A centralized biogas plant based on organic waste is totally new in this developing country. The high potential biowaste resources are waiting for investors with advance technology. Biogas from manure is for family size and some breeding farm and aims to self-service only. As judged by a professor in Can Tho University, who is the dean of the environment faculty, there is no possibility for a centralized biogas plant based on manure because of no big breeding farm and the fluctuant meat price. People dare not invest in a business if the feeding is foreseen unstable. Few local biogas players are cassava and beer companies. They build biogas plant to save their production cost only. Bottling biogas is also considered impossible technology in Vietnam as many experts. In conclusion, the degree of rivalry is **low**.

➤ **Threat of new entrant**

The barriers to entry Vietnam's biogas market are low-medium when considering the government policies and regulations. There are many incentives and policies supporting the environment and renewable energy industry. The entrant of new competitors will not happen in short term because it requires infrastructure construction and innovation in technology. In other word, it needs financial investment and R &D to establish a centralized biogas plant based organic waste in Vietnam. The current small plants have no chance to grow and sell same product as they are limited by technology.

### 4.3 Business proposal

As reported by many experience companies in biogas sector in Europe, a larger sites will improve the biogas profitability and reduce investment cost.

**Table 11: Reference of investment cost**

	Per day treatment capacity		
Investment costs:	300 m <sup>3</sup>	550 m <sup>3</sup>	800 m <sup>3</sup>
-Biogas Plant	5,5 mil €	7,9 mil €	9,6 mil €
-Vehicles	0,4 mil €	0,6 mil €	1 mil €
Inv. Costs per m <sup>3</sup> biomass treated per year	55 €/m <sup>3</sup>	44 €/m <sup>3</sup>	37 €/m <sup>3</sup>

[Kurt Hjort Gregersen 2008, p.33]

Moreover, the cost of an appropriate technology to upgrade, compress and bottle biogas is known as a very high level. In order to launch this new technology economically, a large size centralized biogas plant based on organic waste should be invested. However, in order to maximize the technology profitability, besides selling by-products of biogas production, other business activities should be conducted such as collecting redundant biogas from family biogas plants or selling the biogas collectors to family biogas plant owners, selling raw biogas or biogas collecting service to CHP owners.

The figure below shows general information of potential business in biogas sector in Vietnam. The information in white boxes mentions the available biogas feedstock in Vietnam, the applicable transformation of biogas and technologies which can be built in Vietnam, and the biogas utilization. The information in blue boxes is the current activities in Vietnam biogas sector. After going through the biogas background of Vietnam, biogas context and market analysis, in considering the global development trend of biogas industry and global environment warning, I would like to propose a business opportunity of a centralized biogas plant in the Mekong Delta River area of Vietnam. The plant aims to produce biogas from organic waste, and delivery to kitchens in condition of unavailable pipeline. The information in the red and green highlight is my business proposal.



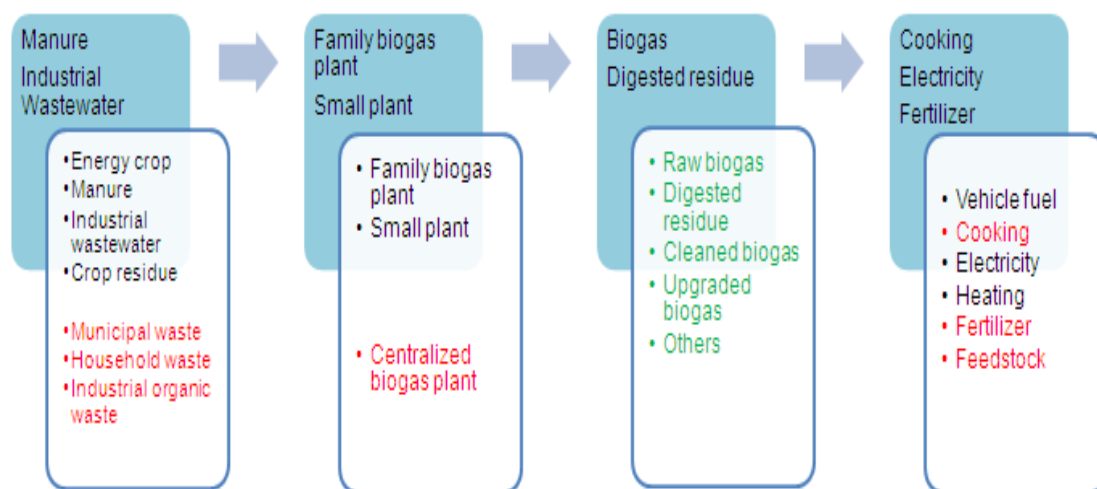


Figure 29: Business proposal

- Business statement: Renewable energy for every sanitary kitchen in developing country
- Scope of business: To make bottling biogas commercially economical.
- Business location: Mekong Delta area in Vietnam.

Within this research, I have not studied which province is the best location. There has not been an available research of biogas potential based on organic waste in this area. However, I suggest Tien Giang province to be the first choice because of following reasons: Firstly, it is strong at fruit and vegetable farming in this area. Secondly its population is the third biggest and sixth biggest in this area. Thirdly, this province is many investment advantages such as below: [[www.tiengiang.gov.vn](http://www.tiengiang.gov.vn), 9.2011]

- “Gateway location”: Tien Giang is located between the southwest and southeast of Vietnam. The supplying flow of agriculture products from the Mekong Area to Ho Chi Minh City and other provinces has to pass through it mostly.
- Good infrastructure: My Tho port.
- Good preferential to encourage investment



Figure 30: Map of the Mekong Delta area

- Business size: A centralized biogas plant based on organic waste.
- Entering strategy: JV with a local environmental sanitation company to establish a centralized biogas plant. This is to ensure continues feeding-stock and easily way to comply with Vietnamese laws. The investors are from Finland, or any developed country with advanced technology. And they need a complementary partner to fit well into local market.

#### 4.4 Summary

There are some advantages as well as drawbacks in the investment of a centralized biogas plant in Vietnam, especially in the Mekong Delta area.

Advantage:

- Low supplier power and buyer power;
- Low rivalry level;
- Medium substitute product;
- Low-medium threat of new entrant in short term, in long term is not so obvious to estimate.

- The laws in Vietnam run after technology. Vietnam Government rank biogas in both the environment industry and renewable energy industry. Investors can take advantage of having no specific law, policy, incentive for biogas sector because they can apply the laws, policies and incentives of environment industry and renewable energy industry.
- Tropical weather supports AD process and saves cost of heating AD tanks.

Drawback:

- The level of doing business easily in Vietnam is evaluated at medium due to corruption. However, the TICP index of Vietnam is rank up.
- Biogas production based on organic waste is rather new in Vietnam.
- There is no national gas pipeline system.

## 5 BIOGAS PLANT IN THE MEKONG DELTA AREA IN VIETNAM

### 5.1 Proposed business model

The centralized biogas plant based organic waste which supply bottled biogas for cooking has no previous business operation in Vietnam nor other countries. The technology is still under innovation to be economic for bulk production. With assumption of available suitable technology, I designed this business model.

Business models can never be right; they are always imperfect and incomplete. Being wrong is a part of the nature of the business model as the real world is richer, more complex, and stranger than the model that we build about it. However, they can be useful for communication and analysis [Bridgeland and Zahavi 2009, p.19]. In this part, the writer aims to build a business model of a centralized biogas plant which has feedstock of organic waste and/ or waste containing high organic percentage. The purpose is to give the investors an overview of who could be the target customers, and how to earn money by providing them with value. The model may not be a perfect and complete one, but it reflects the biogas market, current and forecast trend, in Vietnam under the writer's point of view.

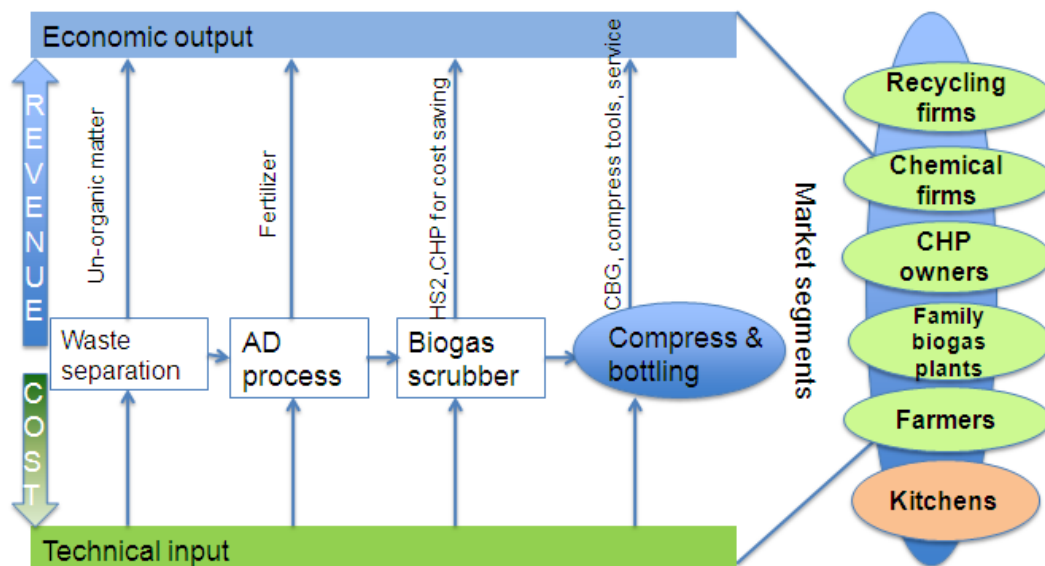


Figure 31: A business model proposal for a centralized biogas plant in Vietnam

This model can be explained briefly as following. In general, it has three domains. The first one is technical input. In this domain, business consumes capital, time, R&D re-

sources which are required for running the being centralized biogas plant. The second one is transformation which applies to all technical input to create value for the target market. This is a very essential domain in the way it helps business to maximize every capability of business intelligences to serve as much as possible all potential market segments. In order to maximize the capability of business intelligence, the potential customers must be well recognized and understood. And the last one is the economic output. It draws out the way or ways, depending on the business objectives, to capture the value from their target market.

There is flexibility in this model which is the possibility of adjustment to align the ability of business with the market segments. And an advanced technology of compressing and bottling biogas at competitive cost can push this business to the leader in the biogas industry. But if you do not own this technology, you can outsource to get it in use. It creates a total new market of biogas utilization.

From the transformation point of view, there are four main steps in this business:

The first step is feedstock input. It includes receiving and conditioning, waste separating. The waste is collected from different sources. Solid municipal waste will be transferred from the urban environment companies who are permitted by government to treat waste. Other material will be collected by the plant such as the waste from farms, food processing companies, and vegetable market. The plant needs technology to separate waste into different categories; organic matter for AD process; others for recycling industry such as metal, plastic, hard paper, wood.

The second step is AD process. The plant needs an advance technology together with supporting chemical treatment to accelerate the AD time and biogas yield. The output of this step is raw biogas and the by-product of digest residue used as fertilizer.

The third step is biogas scrubbing. There are some available economy technologies for this process as introduced in the chapter two. The clean biogas after this process can be used to generate electricity for cost saving. The extracted elements from raw biogas, such as CO<sub>2</sub>, sulfuric, could be sold to the chemical industry.

The last step is making biogas be transportable. The supporting technologies allow business to create different products than biogas, such as the consultant service, tools of biogas collecting from different plant, service of biogas collecting.

The following six parts will explain in detail who are the target customers that this business aims at, and how it creates the value and offer to the target market as well as captures the value from that.

### 5.1.1 Target customers










Kitchens	Farmers	Recycling firms	Chemical firms	CHP owners	Family biogas plant owners
<ul style="list-style-type: none"> <li>• CBG for households</li> <li>• CBG for food services</li> </ul>	<ul style="list-style-type: none"> <li>• Fertilizer for farming</li> </ul>	<ul style="list-style-type: none"> <li>• Plastic and metal for recycling companies</li> </ul>	<ul style="list-style-type: none"> <li>• CO<sub>2</sub> and nitrogen for the firms who need these for their production</li> </ul>	<ul style="list-style-type: none"> <li>• Raw biogas</li> </ul>	<ul style="list-style-type: none"> <li>• Raw biogas collecting service</li> <li>• and/ or raw biogas collecting facilities</li> </ul>




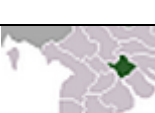
Figure 32: Market segments for a centralized biogas plant in Vietnam

There are six market segments those are kitchens, farmers, recycling firms, chemical firms, CHP owners and family size biogas plant owners.

The first and key market is **kitchens**. I prefer to call "kitchens" which includes households, restaurants and other food services where cooking activities are conducted. According to research result, about 90% households in urban areas use gas stoves. This percentage is about 50% in rural areas. This is the biggest market segment of the business. The size of this market depends on the capacity of the centralized biogas plant. It is not limited by geography in Vietnam. However, the first focus could be households and food services in the Mekong Delta where the plant will be located. If the biogas plant has bigger and bigger capacity, the market can be expanded to areas where people need gas stoves in their kitchens. As market observation, the most demand for domestic cooking in Vietnam is gas stove. So the domestic market size is huge.

Table 12: Estimated market size of gas for cooking

Locations	Population	Potential gas demand for cooking	Estimated sales per day
Whole Vietnam	90,549,390	7,696,698	€ 7,482,901
Whole Mekong Delta area	17,191,470	1,461,275	€ 1,420,684
 Can Tho	1,188,435	101,017	€ 98,211
 An Giang	2,142,709	182,130	€ 177,071
 Bac Lieu	856,518	72,804	€ 70,782
 Ben Tre	1,255,946	106,755	€ 103,790
 Ca Mau	1,206,938	102,590	€ 99,740
 Dong Thap	1,666,467	141,650	€ 137,715
 Hau Giang	757,300	64,371	€ 62,582
 Kien Giang	1,688,248	143,501	€ 139,515
 Long An	1,436,066	122,066	€ 118,675

Soc Trang 	1,292,853	109,893	€ 106,840
Tien Giang 	1,672,271	142,143	€ 138,195
Tra Vinh 	1,003,012	85,256	€ 82,888
Vinh Long 	1,024,707	87,100	€ 84,681
Reference sources:	<a href="http://www.wikipedia">www.wikipedia</a>	<a href="http://www.unapcae.org/publication/F-Biogas.PDF">http://www.unapcae.org/publication/F-Biogas.PDF</a>	

The second market segment is **farmers**. They are the required market to be served in order to solve the digested residue, fertilizer. Vietnam is an agricultural developing country and strong at agricultural product exporting, so the need of fertilizer in whole Vietnam is huge, estimated at two million ton per year.

The third segment is **recycling firms** who need plastic and metal waste for their production. This is also a required market to smooth away the stuff which can not be digested. The return in this market does not reply on the need because plastic and metal wastes are always attractive. In Vietnam, many people own money by gathering plastic and metal waste on streets and waste dumping ground. The return is not clear to be forecasted because it depends on the waste composition in real. However, it contributes in the deployment of National strategy on solid waste management, in which, 85% of solid waste is targeted to be recycled, reused. On the other hand, it contributes to polishing the branding of sustainability. It helps also to build a larger network in which the centralized biogas plant can consolidate its position by creating more dependents.

The fourth segment is **chemical firms** which include the firms who need CO<sub>2</sub> and nitrogen for their chemical products, who may be the chemical supplier of the centralized biogas plant, or for their production procesing such as metal producing. In Vietnam, CO<sub>2</sub>



has been collected as a by-product of a bioethanol factory in Bu Dang District and sold to Messer. The initial required capacity of CO<sub>2</sub> is 70 tons per day, and expected to increase to 200 tons per day. The size of this segment is quite promising.

The fifth segment is **CHP owners**. Using biogas recovery from wastewater to produce electricity is a new market in Vietnam. It helps to solve pollution from the wastewater of their production activities and save cost for those firms. They need raw biogas as a buffer stock because in some cases their CHP capacity, due to different reasons, could not supply them enough electricity. The company can buy raw biogas from family size biogas plants and sell to those CHP owners, or can offer them the service of raw biogas collecting in the same follow. The company also can offer them a raw biogas collecting facilities if they can create a biogas collector which fit all size of biogas plants. However, these markets will come after the business has succeeded in the first centralized biogas plant, energy recovery from organic waste, and delivered bottled biogas to market.

The last market segment is the **family-size biogas plant owners** who breed more than 50 pigs and have redundant biogas. These customers have a need to release the redundant biogas. There are two versions of filling this need; if you have a tool to capture the biogas from family size plants, then you can offer them this service; if the tool could be duplicated to fit all facilities in the family size plants, then you can offer them the tool also. The last market links with the success in the bottling technology of the centralized biogas plant, and connect to the fifth segment. The market sizes of last two segments are not clear to be estimated. The growth of these two markets are not easily for the company to intervene because it depend on many objective elements such as the government supporting on breeding area, the competence of biogas production from wastewater. However, the last two markets help to maximize the technology profitability.

### 5.1.2 Biogas value chain

Value chain describes the activities that take place in a business and relates these activities to competitive strength of the business. The biogas value chain below explains the primary activities in a centralized biogas plant which are directly concerned with creating and delivering value to end use.

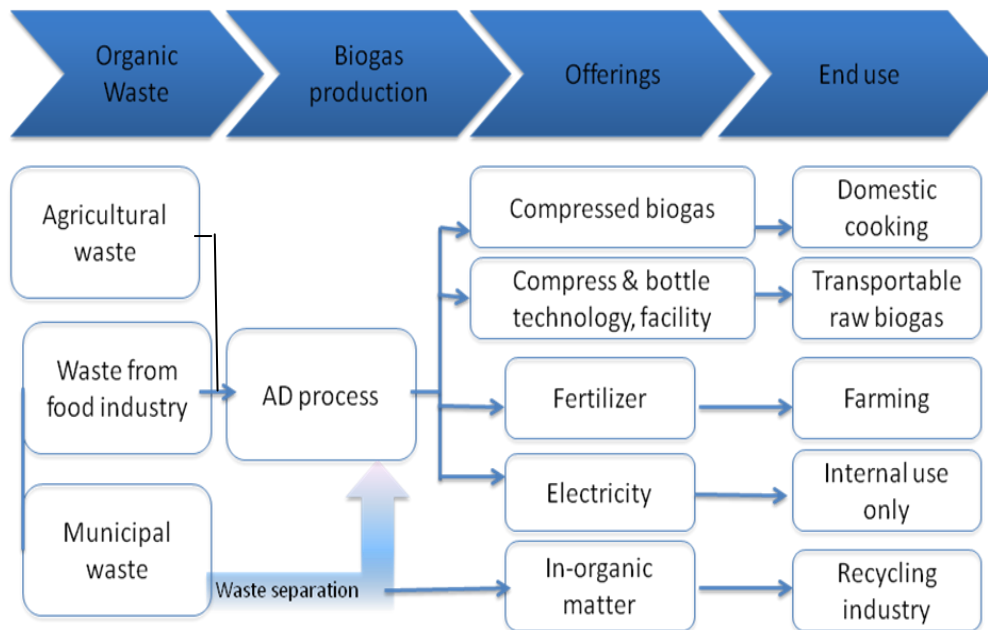


Figure 33: Value chain of biogas produced from organic waste

Understanding the market demand through the previous part helps a business define what could be the primary activities of the plant. As analysis result, the end uses of a large scale biogas plant in the Mekong Delta could be domestic cooking, transportable raw biogas, facility of transportable biogas, upgrading technologies, farming, waste treatment and internal biogas application for cost saving.

High technology of upgrading and bottling biogas is a crucial element in this value chain. The primary product in the centralized biogas plant is transportable biogas to every kitchen in condition of unavailable piping system. The biogas must be upgraded to the equivalent of standard natural gas and injected into the bottle because piping system is not available in Vietnam.

Advanced technology also offers business opportunity to create more value for its target market. As analysis in the previous part, there are many redundant biogas yields from family sized biogas plants which have more than twenty pigs. An appropriated technology is an extra business opportunity to collect this biogas quantity from different sites and transport it to demanders. The demanders may be the companies with biogas plant which use it to generate electricity for internal use and lack raw biogas. They may be also chemical companies who want to extract chemical elements in biogas for different purposes. If the technology allows to design a gas collector and compressor which fits with

different facilities in different biogas plants, then this value could be delivered to the market.

By-product of this process is high quality fertilizer which can be sold to farmers. Digester residue is considered to be a high quality fertilizer which impoverishes soil less.

### 5.1.3 Value proposition

Recognizing those problems helps to define the best method to create and offer the value to the market. The main problems that are recognized in the target market can be summarized as follows. The first one is the huge quantity of organic waste which has not been treated well and causes the social and environmental pressure on local government to solve it. This impacts to the living environment and the health of local residents directly. The second is high cost of gas for cooking. The gas price keeps increasing due to the dependence on imported gas as reported by General Director of Vinagas Co. Company, Mr. Le Phuc Dai [[vnexpress.net](http://vnexpress.net), 7.2011]. The last problem links much to greenhouse gas pollution as methane emission causes about 21 times more greenhouse effect than CO<sup>2</sup> emission does. The figure below illustrates how this business model can articulate the product and the customer problems.

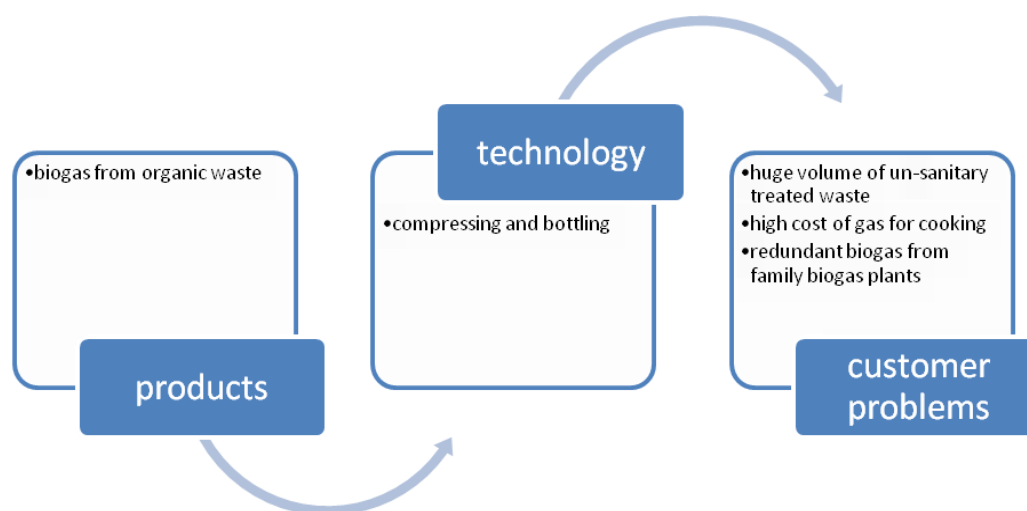


Figure 34: Value proposition

### 5.1.4 Revenue generation

As there is no previous similar business activity and the cost of upgrading and bottling is now estimated as a high capital investment, so within this research the revenue is not

easily estimated. However, based on the required components of a centralized biogas plant, reference check list of AD project, and business model, I can only define where the cost will go to and from where the return is.

The cost includes:

- Plant construction
- Technology consultant
- Waste storage and separating
- AD chemical
- Biogas scrubbing technology and construction
- Biogas compressing and bottling technology and construction
- Doing business fee

The return is from:

- Waste treatment
- Selling fertilizer
- Selling in-organic waste for recycling
- Selling CO<sub>2</sub> and nitrogen
- Selling biogas for domestic cooking
- Selling upgrading technology
- Selling bottling technology
- Selling bottling service
- Cost saving from electricity generation

Revenue of first production year could be estimated based on the current price of LPG, compost, CO<sub>2</sub>, nitrogen, plastic and metal waste. These indicators are supposed that the technology cost is twice the construction cost. Understanding that the larger sites will be the lower investment cost will be, but I mean to calculate the construction at the medium biogas scale, while the capacity is calculated at large scale. This is to buffer for the unknown technology cost which has been considered as high level.

**Table 13: Estimated of 1<sup>st</sup> year revenue**

Market		Vietnam	The Mekong area in whole	Tien Giang
Population	pp	90,000,000	17,191,470	1,672,271
Estimated discharged waste	Ton/day		42,120	4,097
Estimated biogas yield	m <sup>3</sup> /day		2,725,164	265,086
Estimated CBG	kgs		706,499	68,723
Estimated Gas demand	kgs/day	7650000	1,461,275	142,143
Target price ( as LPG)	Euro/kg		€ 0.97	€ 0.97
Potential CBG sales	Euro/year		€ 250,708,937	€ 24,387,285
Potential CO <sub>2</sub> sales (35%)	Euro/year		€ 3,829,537	€ 372,512
Potential Nito sales (3%)	Euro/year		€ 328,246	€ 31,930
Fertilizer sales	Euro/year		€ 128,115,000	€ 12,462,169
In-organic matter sales	Euro/year		€ 76,869,000	€ 7,477,301
Bottling service	ND			
Total estimated sales /year			€ 459,850,720	€ 44,731,197
Estimated construction (55e/m <sup>3</sup> )	Euro		€ 149,884,020	€ 225,343
Estimated cost of technology, maintenance, production	Euro		€ 299,768,040	€ 450,687
Total estimated cost	Euro		€ 449,652,060	€ 676,030
EBIT/ year			€ 10,198,660	€ 44,055,167

The above revenue does not include all sales of the company. However, it reveals that the pay-back is less than one year.

### 5.1.5 Value network

The figure below describes the key connection of a centralized biogas plant and other suppliers, complementors, and competitors regarding biogas production sector. The connection is built by the value flow and cash flow. The stakeholders are different at different stage of biogas production.

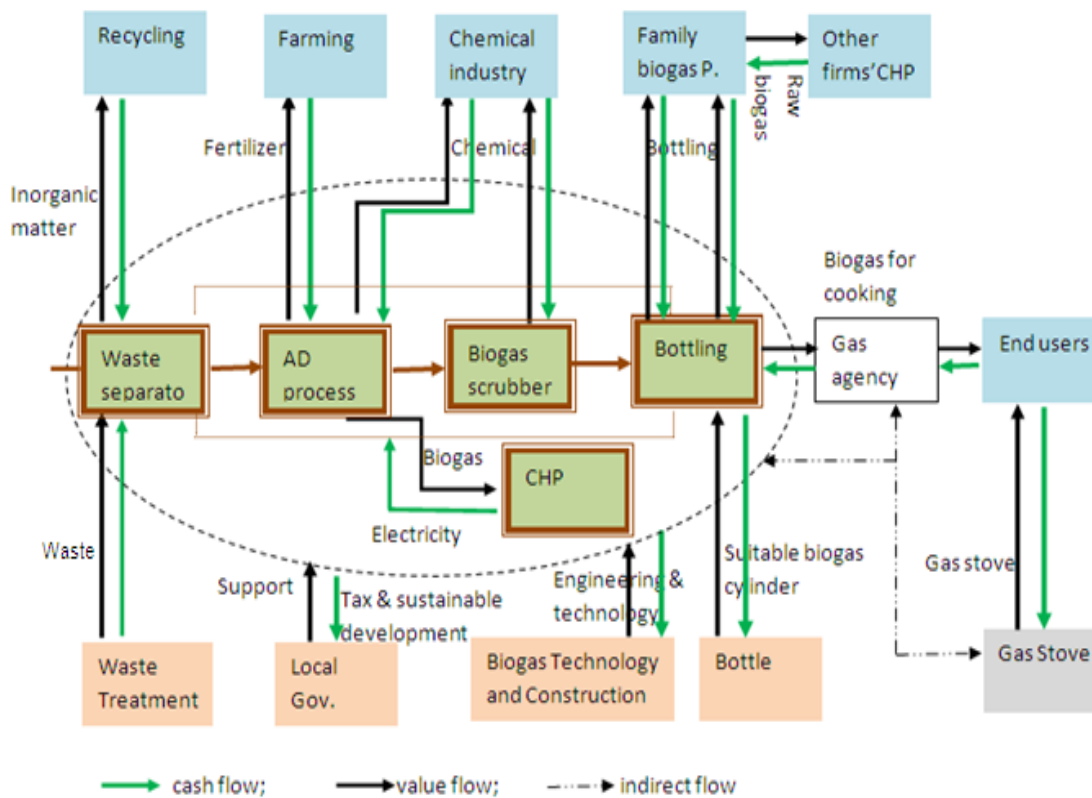


Figure 35: Network of a centralized biogas plant in Vietnam

The value network can help to create more value and shorten the time of offerings by leveraging the technical value of complementors. If we know how to get the benefit from good consulting and benchmarking from good biogas engineering, we can save time and cost in R & D. There are many experienced companies in biogas industry in Europe. And they are strong in different technologies because they develop biogas industry under the local support scheme. For example, German companies are strong at energy crop based biogas plants, UK companies are good at waste treatment plants, and Swedish companies are advanced in upgrading technologies. The strategy of using both internal development of the business and external development in open business model can strengthen the business intelligence and quickly create more value to full-fill the need in the target market.

#### 5.1.6 Competitive strategy

Going through this writing, the most repeated words are biogas advanced technology which allows bottling biogas. When the business owns this technology, it tries the best to serve as much as possible all market segments in which the value created by this technol-

ogy could fill their need. In this way, the business can make itself differentiate from other players in the biogas sector as well as limit the express of others.

## 5.2 Stakeholder management

The biogas market is changing and more stakeholders will be involved in this industry. In the point of view of this study, the biogas market in Vietnam will be changed from a more socioeconomic than commercial market to a more commercial than socioeconomic market because the biogas production size and utilization are changed. Before 2005, most biogas projects were supported by government and non-profit organizations aiming to help poor people in rural areas. At the moment, there are mostly family size biogas plants in households who own livestock. In this context, the investors are governments, NGOs, SNV – Netherland Development Organization, and the households. Nowadays, there are some private businesses in this new industry. Therefore, the stakeholders in this industry will be changed and become more complicated.

### 5.2.1 Stakeholder listing

Regarding a centralized biogas plant which produces biogas from organic waste in Vietnam, the stakeholders can be identified into three categories as following:

- Key stakeholders:

These are the ones who take part in establishing the business. The centralized biogas plant is a cooperation of investors and the local environment sanitation company based on fundament of advanced biogas technologies. So the key stakeholders who take part in establishing the centralized biogas plant are advanced biogas technology owners, investors and the local environment sanitation company. The investor and technology owner may be the same. It is compulsory to maintain this cooperation between key stakeholders by contracts.

- Primary stakeholders:

The primary stakeholders are ones who impact and/ or are impacted directly by the business. I would like to divide them into two categories; private and public.

In the public category, they are Prime Minister, Provincial People's Committee, Ministry of Planning and Trading; Ministry of Sciences and Technology, Ministry of Natural Re-

sources and Environment, Ministry of Construction, Ministry of Agriculture and Rural Development, Ministry of Industry and Trade, Ministry of Finance.

In the private category, they are employees, banks, customers and suppliers. Customers include households, food services, chemical firms, CHP owners, family biogas plant owners, and farmers. The suppliers are chemical companies, gas bottle/ cylinder companies, biogas facility engineers, traders, consulting companies.

➤ Secondary stakeholders:

The secondary stakeholders who impact indirectly to the business could be divided in two categories too. In private category, they are local gas agencies, institutes and universities, gas stove suppliers. Besides, the competitors are natural gas suppliers and LPG suppliers.

In public category, they are the Ministry of Finance, the mass media, local community, and investors' home country which is a developed country.

**Table 14: The list of Stakeholders in Vietnam biogas sector**

Category	Function	Group	Stakeholders
Key	Establishing		Biogas investors (BI), the local state sanitation environment company (SEC).
Primary	Supporting	Public	Ministry of planning and investment (MoPI)
			Prime Minister (PM)
			Ministry of Construction (MoC)
			Ministry of Agriculture and Rural Development (MARD)
			Ministry of Industry and Trade (MIT)
			Ministry of Sciences and Technology (MoST)
			Ministry of Natural Resources and Environment (MoNRE)
			The provincial People's Committee (PPC)
			Vietnam Biogas Association (VBA)
		Private	Employees (Emp)
			Banks
Customers: Households, food services, farmers, recycling firms, chemical firms, CHP			



			owners, Family biogas plant owners (CU)
			Suppliers: Biogas production component suppliers, biogas construction, biogas consulting companies, chemical suppliers, bottle suppliers (SU)
Secondary	Supporting	Public	Ministry of Finance (MoF)
			The media (Med)
			Local community (Lco)
			The government of investors' home countries (GIHC)
		Private	Local gas agencies (GA)
			Renewable energy institute and Universities (I&U)
Gas stove suppliers in Vietnam (GS)			
	Competing	Private	Petro Vietnam (PVN), Saigon Petro (SP)

### 5.2.2 Stakeholder analysis

To increase the level of easily doing business in a target market, it is important to understand the stakeholders' perspective and roles. Then the company will have appropriate management strategies for each. The table 15 below explains the roles of stakeholders and the level of the stake. The short descriptions in the table are:

Stake in the project: the role of the stakeholders in the project

Potential impact: At what level the stakeholders impact the project.

Win criteria: what the project can deliver to stakeholders corresponding to their perspective.

Expectation for the project: what the project expects to receive from the stakeholders.

**Table 15: Stakeholder analysis**

Stakeholder	Stake in the project	Potential impact	Win criteria	Expectation for the project
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Biogas investors (BI)	Establish and run the centralized biogas plant	High	Branding, High profit, Experience in investing into developing countries.	Technology investment: Advance technologies of biogas production based on organic waste and bottling.  Finance investment: strong capital
The local state sanitation environment company (SEC)	Establish and run the centralized biogas plant	High	Branding, High profit. Know-how. Waste treatment	Stable feedstock.  Advantage of close relationship with local authorities.
Ministry of Planning and Investment (MPI)	Business registration.	High	Contribution of renewable energy into the national development strategy	Easily doing business
Provincial People's Committee (PPC)	Ratify the project	High	Sustainable waste treatment.  Renewable energy.  Economic growth.	Support to approve the project feasibility and submit it to Prime Minister (PM) for final approval.
PM	Approve the feasibility of the project	High	Contribution of renewable energy into the national development strategy.  Sustainable waste treatment.  Renewable energy.  Economic growth.	The project approval.
Ministry of Construction (MoC)	Access the plant construction area and draw.	High	Contribution of renewable energy into the national development strategy.	Easily doing business
Ministry of Agriculture and Rural	Test and approve new fer-	Medium	Contribution of agriculture and	Approval of fertilizer which is produced from diges-

Development	fertilizer. Issue standard of fertilizer		rural development	tate.
Ministry of Industry and Trade	Examine the safety techniques. Issue, amend, extend, revoke production permit.	High	Contribution of renewable energy into the national development strategy.	Easily doing business
Ministry of Science and Technology	Grant intellectual property.	High	Contribution of renewable energy into the national development strategy.	Easily doing business. Protection of know-how.
Ministry of Natural Resources and Environment	Access and issue certificate of land use of the project. Access the implementation of policies and laws on environmental protection.	High	Contribution of renewable energy into the national development strategy. Soil protection.	Easily doing business. Popularise the fertilizer of biogas production to local community
Vietnam Biogas Association	Supporting	Medium	Good benchmarking	Supporting
Banks	Capital market	Medium	Capital cost	Capital supporting
Employees	Operate the production processes in plant	Medium	Incomes	Skill
Customers	Economic input	High	Valuable and high quality products	Satisfaction
Suppliers	Technology input	Medium	Business expansion	Professional. Advanced technologies.
Ministry of Finance	Tax collection. Inspect the implementation of	Medium	Tax Customs duties	Easily doing business

	customs duties			
The media	Broadcast	Medium	Information links to renewable energy	Advertisement
The local community	Access the effect of project on local environment	Low	Better living environment	Positive reflection
Local gas agencies	Distribute gas to every kitchen	Low	Sale on commission	Distributing services
Renewable energy institute and universities	Support	Low	Good benchmarking	Support
Gas stove suppliers in Vietnam	Supply gas stoves to "kitchens"	Medium	Stable business	Stable business
PVN, SP	Competitors	Low-medium	Advance technologies	Price policy: LPG price increasing. Fossil fuel shortage.

### Key stakeholders

Key stakeholders are the ones who establish the centralized biogas plant. The joint-venture is between a foreign investor (or investors) and a local state sanitation environment company. The local company own the feedstock, and the foreign investors own technologies.

### Primary supporting public stakeholders

There are many processes done before establishing a plant. The feasibility and sustainability of the project have to be approved by the local Provincial People's Committee (PPC). Then local PPC will submit to PM to get the final approval because of its large investment and its impact to the local community as well as the national development. After that, the business plan and business registration will be submitted to MPI for approval. The project have to be submitted to MIT for production permit, to MNRE to get the license of using land, to MoC to get permit of construction, to MoST to register the

copy right of products and standard of products, to MARD to get the standard of fertilizer, to tax office, a representative of MoF, to get tax code. These primary public supporting stakeholders encourage construction of a centralized biogas plant because it pushes renewable energy development, solves waste problems, contributes in gas price stabilization, and creates jobs for local residents as well. The power of these stakeholders is high, and their interest is high by default because it contributes to the growth of the country, and there is no doubt that the society as a whole can benefit from the use of biogas. For example, farmers become energy hosts due to the fermentation of green material [[www.fnr-server.de/](http://www.fnr-server.de/), 11.2011]. Even crop energy is not targeted in this research, but organic waste is originated from farming activities. These stakeholders have strong interest in a centralized biogas plant based on organic waste as it helps to contribute more revenue for them.

#### ● Primary supporting private stakeholders

This group includes all customer groups, suppliers, employees, and banks. They connect directly to the centralized biogas plant in different purposes. Their benefits are more or less tight to the growth of the company.

#### ● Secondary supporting public stakeholders

This group includes MoF, the media, the local community, and the government of investors' home. The banking management of MoF will impact to the capital cost of the business. However, MoF need a strong business for taxation. Local community will impact and be impacted by the business activities in the way they react to the environment which, as a result of the plant, is getting better or exceeds their expectation. As the CERs that the Clean Development Mechanism could bring to the developed country, the host country motivates the technology shifting to the developing country.

#### ● Secondary supporting private stakeholders

These are local gas agencies, renewable energy institutes, gas stoves. The activities of the centralized biogas plant will bring the same effect to these stakeholders as to the company itself, but in different way and level.

#### ● Secondary competitors

Competitors are PVN and SG who are supplying LPG to Vietnam market. In short term, there is no strong impact from these competitors because of following reasons. First, PVN has a plan to supply natural gas if the pilot of compressing and liquefying natural gas in 2013 successfully. The fact that they have not owned suitable advanced technologies makes them less confident in business of natural gas. So they need a good benchmark of methane compressing and/ or liquefying. Second, increasing LPG price, a reflection of supply shortage, does not give them more profit but more things to deal. Biogas production in Vietnam will reduce their burden of gas supply shortage. However, in long term, the management strategy to control these stakeholders should be studied more.

### 5.2.3 Stakeholder mapping

The key stakeholders, as mentioned above, are the founders of the centralized biogas plant. They hold high interest and core responsibility in establishing and operating the business. Other primary stakeholders and secondary stakeholders are posited based on their power and interest in the centralized biogas plant. The bank holds high power as it offers the capital. It is known that the unit cost per biogas capacity is reduced as the plant size increases. The initial investment capital in large-scale biogas technology is large. However, the capital cost for an environment project is low at incentive rate. I put bank in the position of “keep satisfied” because of the importance of capital. The Vietnam Ministry of Planning and Trading is in the same position because it made approval for establishment of the centralized biogas plant. Other local authorized organizations are placed in the position of “manage closely”. They have the high power and also high interest in the centralized biogas plant because the plant meets their mission. Customers are in this position also because they are the target of the business. They have high power of the buyer, and they have high interest in these business activities as the sustainable and responsible branding make them do. Then continuing with the position of “keep informed”, most biogas suppliers are placed here. The centralized biogas plant brings them more business so they hold more interest than power. The stakeholder mapping below presents where on the power/ interest grid those stakeholders are and how should the company react in order to take the most advantage in this circumstance.

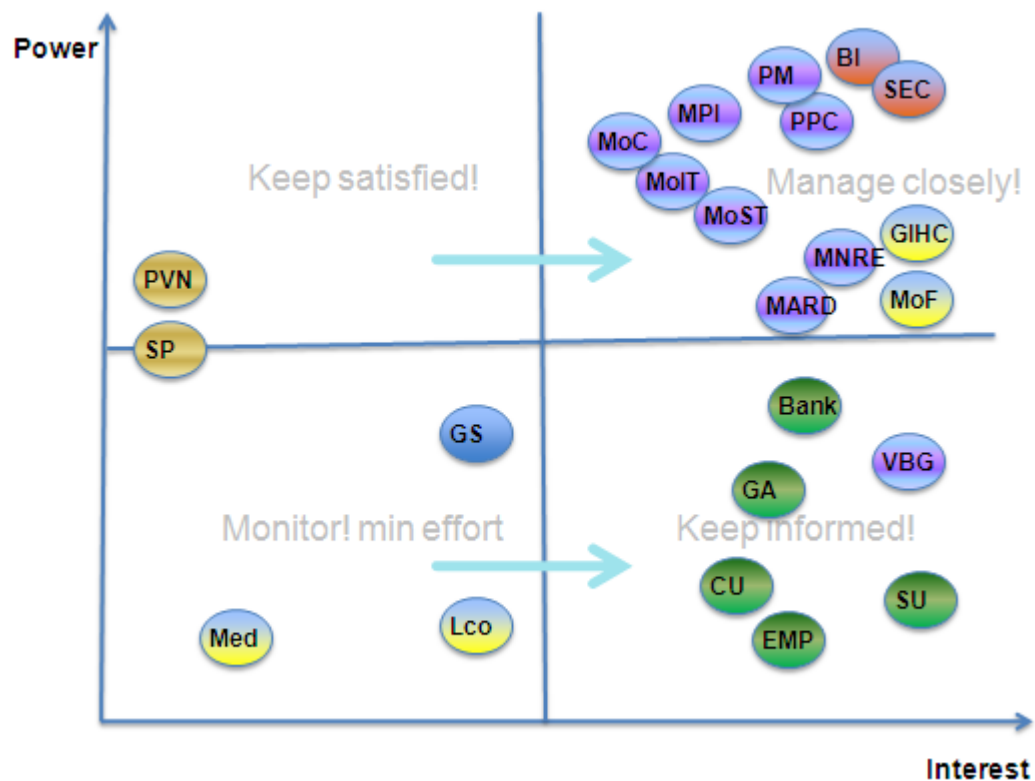


Figure 36: Stakeholders mapping in Vietnam biogas sector

Legend:

- Key stakeholders: 
- Primary supporting public stakeholders: 
- Primary supporting private stakeholders: 
- Secondary supporting public stakeholders: 
- Secondary supporting private stakeholders: 
- Secondary competitors: 

### 5.3 Risk management

#### 5.3.1 Risk identify and analysis

##### ➤ Technological risk

Competent biogas technologies: The identified technological challenges are cost reduction of upgrading biogas, bottling biogas, digester controlling as the feedstock is mixed of organic material. Those challenges can be solved. However lacking competent tech-

nologies make quality control of products a risk. This is high risk as it is the essential element to the success of the business.

Supporting services: The centralized biogas plant in Vietnam is a pioneer. So the supporting infrastructures and services sometimes do not meet the requirement of the business. This is medium risk as it is obviously to be planned for at the beginning. The partner, the environment sanitation company, is a local who is familiar with dealing with the local issue.

➤ **Financial risk**

Long term investment: the initial investment capital is large. As there is no previous similar case, the business has to buffer pilot cost. This is medium risk as it obviously gets support from different environmental protection funds.

➤ **Environment risk**

Methane emission during upgrading process: when biogas is upgraded, a small amount of methane is also separated from gas. Since methane causes about 21 time stronger greenhouse gas effects than CO<sub>2</sub> does, the methane losses should be kept low. It is not a high risk as it can be control.

### 5.3.2 Risk response

➤ **Technological risk**

- Competent biogas technologies: Investors in the centralized biogas plant should draw a detail of foreseen technical problems in the contract with biogas engineers, closely followed-up by a cooperating consultant. There must be a good maintenance plan also.
- Supporting services: Arrange local human resources to deal with local issue.

All the follow-up information must be recorded and reported on periodically.

➤ **Financial risk**



- Long term investment: Investors should seek for the environment protection funds from World Bank, ADB, Vietnam Agribank. They should take full advantage of the financial supporting programs. There must be competent financial manager to follow up all the financial issues. All the tracking information must be filed and reported periodically.

➤ **Environment risk**

Methane emission: a measurement system should be installed and followed-up the indicators in order to take action in time.

## 6 SUMMARY

The research objective is to propose a business model for a centralized biogas plant in the Mekong Delta of Vietnam. The plant aims to convert organic waste into valuable products of CBG, high quality fertilizer, CO<sub>2</sub> and nitrogen. The technology innovation offers not only transportable biogas but also bottling service. The business idea is established through the market analysis during the first and second phases of the study program. It is consolidated by the market researching and expert consultants.

The research aims to clarify what is an appropriate business model for investment into Vietnam's biogas sectors. The information of biogas feasibility in the Mekong Delta has been presented. The crowded locations with strong agricultural economy are an advantage for large scale biogas plant based on organic waste. Moreover, the tropical temperature is a cost reduction in digestion and a plus in the biogas system. The big demand for gas for cooking, essential needs, is a huge market for the business. The thesis also analyses the main stakeholders, micro and macro business environments to have an appropriate business strategy.

The value chain has been drawn out to show all core activities of the business. In each process, the input technologies are taken full advantage of in order to create the maximum value of offerings. In return, the revenue generation is listed. However, as it is a pioneer activity and the technology is in innovation, the revenue estimation is not so clear at the time of research.

The writing also describes the related laws, policies, incentives in the target market which support the business. The biogas industry is a new sector in Vietnam. There have not been special regulations for it. However, as advised by the authorized people in the target market, the environment and renewable regulations can be applied to business activities in the biogas sector.

Recommended topics for future research: Revenue generation in a centralized biogas plant based which produces biogas from organic waste and bottles biogas for cooking.

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## APPENDIX 1

## Interview questions for field research

Local authorized units; Planning and Investment Department of Tien Giang, Resources and Environment Department of Tien Giang :

1. The price of gas for cooking is increasing fastly. Do you think it is important to stabilize gas price?
2. What do you think about the topic “Centralized biogas plant – Renewable energy recovery from organic waste”? Is it in the same orientation of the economics development of the local province?
3. Has any biogas project based on organic waste been studied? If yes, is any project under progress?
4. This topic is a combination of waste treatment and biogas production. Which authorized departments must be involved in the opening and closing the plant?
5. What form of cooperation does local government expect from foreign investment into the biogas industry?
6. What incentives are there for the investment in biogas?
7. How long is the maximum investment time for a project with foreign investment factor?

Academic and technical units; Can Tho University, Tien Giang Center for Technology and Biotechnology, New and Renewable Energy Center of Vietnam:

8. What do you think about the potential of a centralized biogas plant in Vietnam and especially in Mekong Delta River area?
9. Has any biogas project based on organic waste been studied?
10. What do you think about the potential of biogas from organic waste in the Mekong Delta River area of Vietnam?
11. What do you think about the topic “Centralized biogas plant – Renewable energy recovery from organic waste”?
12. What do you think about the bottling biogas to make it be transportable in Vietnam?

Family size biogas plant owners:

13. How many livestock do you breed?
14. Do you apply any technology for biogas cleaning?
15. How do you think about the biogas quality from your biogas plant?
16. Do you have redundant biogas? If yes, what do you do with it?
17. What do you think about think about the possibility of selling that redundant bio-gas yield?

Households in Dong Nai province, in Long An province, in Tien Giang province, in Can Tho City, in Ho Chi Minh City

18. How many people are there in your house?
19. What kind of energy do you use for cooking?
20. How do you think about the current price of gas for cooking?
21. How much gas quantity do you use per month?
22. How much money do you spend per month for cooking energy?

## APPENDIX 2

Suitability of substrates for biogas process [cf. BiWare project]

No	Type	Biogas process	Available in southwest of Vietnam
	<b>Agro based crop substrates</b>		
1	Algae	+	x
2	Barley straw	(+)	
3	Beet tops	+	
4	Beet tops, (sugar beet)	+	
5	Beet, sugar beet	+	
6	Beet, (fodder)	+	
7	Blood meal	+	x
8	Cane trash	+	x
9	Clover	+	x
10	Elephant grass	(+)	x
11	Flax	(+)	x
12	Grass	+	x
13	Grass silage	+	x
14	Hay	+	x



15	Hemp	+	x
16	Maize silage	+	x
17	Maize straw	+	x
18	Oat straw	(+)	
19	Potato tops	+	
20	Rape straw	(+)	
21	Rapeseed shred	+	
22	Rice straw	(+)	x
23	Rye straw	(+)	
24	Sunflower leaves	+	x
25	Water hyacinth	+	
26	Wheat	+	
27	Wheat straw	+	
	<b>Animal husbandry</b>		
28	Cattle manure	+	x
29	Cattle manure (with straw)	+	x
30	Chicken manure	+	x
31	Chicken manure (with straw)	+	x
32	Horse manure (with straw)	+	
33	Pig manure	+	x
34	Pig manure (with straw)	+	x
35	Sheep manure (with straw)	+	
	<b>Municipal and industrial waste</b>		
36	Animal cadaver meal	+	x
37	Biowaste	+	x
38	Cereal mash	+	x
39	Clippings (sedge)	+	x
40	Fat (from fat separators)	+	x
41	Filtration silica gel (beer)	+	x
42	Float fat	+	x
43	Flotation sludge	+	x
44	Foliage / leaves	+	x
45	Food waste	+	x
46	Fruit pulp (fresh)	+	x
47	Kitchen waste	+	x
48	Loppings	+	x
49	Market waste	+	x
50	Mash of apples	+	
51	Mash of fruits	+	x
52	Molasse	+	x
53	Molasses mash	+	x
54	Oil seed residue (pressed)	+	

55	Pomace of apples	+	
56	Pomace of fruits	+	x
57	Pomace of grape	+	
58	Potato mash	+	
59	Potato peel waste, raw	+	
60	Potato pulp	+	
61	Potato slop	+	
62	Raps extraction residue	+	
63	Rumen content (pressed)	+	
64	Rumen content (untreated)	+	
65	Sewage sludge	+	x
66	Slaughterhouse waste	+	x
67	Spent grains from beer	+	x
68	Spent hops (dried)	+	
69	Stomache contents (pig)	+	x
70	Straw	(+)	x
71	Vegetable waste	+	x
72	Vinasse	+	
73	Whey	+	
74	Yard trimming	+	x

## Legend

+	suitable
(+)	limited suitability
x	available