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The Economics and Policy of Biogas Production

A Vietnamese Case Study

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1. Introduction

As the affects of climate change and other environmental phenomena are becoming more apparent, the so called green forms of energy have been gaining more momentum. Many countries have been trying to decrease their dependence on conventional sources of energy (crude oil and fossil fuels) and increase the use of renewable energies. The volatile prices in the oil market also contribute to this change; one of the main factors for the initiation of the Indian biogas program was the oil crisis in the 1970s (Moulik, 1985).

There is currently no country that relies completely on renewable energy; in order to achieve this, high levels of investment and technological progress is required. A viable alternative needs to provide a net energy gain, have environmental benefits, be economically competitive, and producible in large amounts (Hill, et. al., 2006). Compared to developed countries, developing countries have a better opportunity to rely on renewable energy because energy consumption is generally higher in developed countries.

In developing countries many rural households rely on traditional biomass materials such as wood, charcoal, agricultural waste, etc to satisfy their domestic needs of energy. This technique has many negative consequences such as, time wasted to gather biomass materials, increases environmental pollution, and may cause some serious illnesses (Teune, 2007). One of the energy alternatives is to produce biogas from livestock waste.

The process of converting livestock waste to biogas is done through anaerobic digestion. Anaerobic digestion involves the breakdown of organic matter which creates biogas (mainly methane and carbon dioxide). There are three main stages for anaerobic digestion: hydrolosis, fermentation, and methangenesis. In the first stages

the organic waste is broken down into soluble compounds. Then in the second stage these compounds are converted to alcohols, fatty acids, acid, and gas. Finally methane, carbon dioxide, and water are produced by bacteria called methangens. (Cantrell, et al., 2008). The United Nations Development Program (UNDP) 1997 report recommends the use of decentralized biogas plants. Compared to other plants biogas plants are cheaper, do not cause environmental pollution (Wan Ho, 2005).

The World Bank estimates that about 50 percent of Vietnam's population lives in rural areas. Livestock farming is very popular; this practice is a major contributor to global greenhouse gas emissions. 20.7 percent of Vietnam's GDP is from agriculture, and 51 percent of the Vietnamese labor is involved in agriculture. These numbers specify that even though agriculture may not be the most significant sector in the overall GDP, it is socially and political significant since it affects so many people.

Region	Water buffalo (1000 head)	Oxen (1000 head)	Pig (1000 head)	Domestic fowl (1000 head)
Red River Delta	115.5	771.6	7293.2	69983
North-East	1220.2	790.1	4988.2	46424
North-West	468.2	295.9	1301.4	11136
North Central	733.5	1180.3	3512.4	35163
South Central	163.0	1105.6	1961.1	14373
Central Highland	88.6	721.3	1507.2	9552
South East (Dong Nam Bo)	72.2	828.1	2624.6	16618
Cuu Long River Delta	43.1	713.5	3513.9	47017
Total	**2996.4**	**6406.8**	**26702.0**	**247266**

Source: *ISPONRE Strategy Report* (2009)

Table 1: Livestock population per region

Table 1 summarizes the 2008 population for the various livestock in Vietnam. The overall total is 2.9 million buffalos, 6.4 million oxen, 26.7 million pigs, and 247.2 million domestic fowls. From these numbers one can conclude that the potential for biogas utilization in Vietnam is fairly high. According to the Food and Agriculture Organization livestock production is responsible for 18 percent of the global greenhouse emissions (Castel, et. al., 2006). At a national level proper policy on livestock management can improve environmental and economic conditions.

Discarding untreated animal waste has many negative consequences. The first main negative constraint is the air pollution. The livestock sector, mainly the manure produced is responsible for gas pollutants in the environment. The main gases that are released are hydrogen sulfide, methane, ammonia, and carbon dioxide. These gases among other gases can also cause serious human and animal health problems. There are also nitric oxides that are released which may cause acid rain. Untreated animal waste can also cause problems in the water and soil quality affecting the quality and quantity of agriculture products (Castel, et. al., 2006).

Vietnam is rich in natural resources and its economy relies heavily on fossil fuels and oil. Most of Vietnam's coal reserves are located in the north eastern province of Quang Ninh. They also have vast reserves of Lignite coal and Peat coal in the Red River Delta and Mekong River Delta respectively. Approximately 200,000-300,000 tons are annually produced. 245,000 – 290,000 barrels of oil are produced in Vietnam (in 6 various operational fields). There is also potential for hydro-power plants and solar energy (MONRE, 2005).

Vietnam also has a lot of potential for renewable energy. Heavy rainfall and many rivers make hydro-power plants a viable option. There are over 400 small hydro stations; it is also believed that around 100-500 family hydro power generators

are being utilized. The Vietnamese government has also invested in solar energy; there are currently 5 photovoltaic power stations in Vietnam (MONRE, 2005).

The history of biogas In Vietnam can be divided into 4 time periods. The first is 1964-1975, in this period the first biogas plants where constructed however financial and technical capabilities limited their effectiveness. Research on the various components where started by various government agencies (such as Ministry of Industry and the Department of Animal Husbandry). The second period is 1976-1980, in which extensive research was done on various biogas digesters. The third period, 1981-1990, the National Research Program on New Energy Sources was commenced. Around 2000 family sized biogas unites where built across Vietnam during this time. The final period covers 1991- till now. This period was the most significant towards biogas development in Vietnam. With the help of various international donors, the government started various projects on small scale biogas plants and livestock waste management around Vietnam. By 2007 around 73,000 bio gas units were present in Vietnam. The Vietnamese government is planning to have 140,000 units by 2010. Regarding biogas Vietnam is behind the likes of China and India however there is still potential to increase its capacity (Tuyen, nd).

1.2 Problem Analysis

Livestock waste causes some serious environmental and health problems and the lack of treatment increases these problems. 70% of Vietnam's population lives in rural areas and many of them raise cattle as it has proved to be a profitable business. This has lead to an increase of livestock population causing more untreated waste to be discarded without adequate treatment.

Type Of Livestock	2000	2005	2008	Average Growth rate 2000 - 2008 (%)
Buffaloes	2,900	2,920	3,000	0.42
Cattle	4,130	5,540	6,725	6.28
Dairy cows	35.0	104.1	160.1	20.93
Horses	126.5	110.2	103.5	-2.48
Goat/Sheep	543.9	1,314.2	1,777.6	15.95
Pig	20,190	27,430	26,700	3.56
Poultry	196,100	219,910	247,000	2.93

Source: *ISPONRE Strategy Report* (2009)

Table 2: Livestock Population (1000s)

The table above shows the various livestock population for the years 2000-2008. With the exception of horses all livestock populations show an increasing growth rate. Cows and Goat/Sheep have the highest rate with 20.93 % and 15.95% respectively. One technique of treating manure is to use it as a raw material for biogas. Biogas from livestock waste has been gaining momentum over the years in Vietnam. The Vietnamese government has been enthusiastic and a significant number of biogas digesters have been installed throughout the last ten years. The main objective of these biogas projects are to decrease the amount of pollution and also provide an alternative source of energy for the users. According to the economywatch.com the following are advantages that can be enjoyed by using biogas:

- Eco friendly energy production
- Workload reduction in rural areas
- Improvement in hygiene
- Conversion of livestock waste to fertilizer
- Environmental benefits at a global scale/protect the earth's natural resources

Household biogas digesters are the most popular size in Vietnam. Most of the livestock farms in Vietnam are small scale and the digester helps manage the animal waste and provide a cheap source of energy. There are also a few large scale digesters operating in large scale livestock farms. The fundamental question is does it pay to produce biogas for the user? This depends on the digester itself and it will be considered as a good option by the user if the overall benefits outweigh the costs.

1.3 Objective

Based on the information in the introduction and problem analysis the main objective of the research is *"is to conduct a cost benefit analysis of a biogas digester and perform a sensitivity analysis on the discount rate to investigate its influence."*

To help fulfill the objective the following research question and sub research question need to be considered

GENERAL RESEARCH QUESTION

- What are the main possible benefits that can be enjoyed by the users of the biogas?
- What are the main costs that the users are faced with?
- What is the impact of biogas on the daily lives of the users?

SUB-RESEARCH QUESTIONS

- The farmer's opportunity cost for overtaking the biogas program? (Alternative use for space used for the biogas digester, alternative for time spent, etc.)
- What factors influenced the user's decision to use biogas?
- What are the socio-economic for the users?
- How much Biogas is produced? How much input is needed?
- How much fertilizer is produced? What is its market value?

- What resources are saved by using biogas? What is there monetary value?
- What are the main uses for the biogas produced?
- What is the most cost effective source of energy compared to biogas production?
- What is the role of the government and other organizations in the biogas program
- Which discount rate should be considered?

1.4 Methodology

In order to answer the research questions stated the following methodology will be obtained. The methodology is developed on the basis of the problem analysis and objectives

1.4.1 Cost Benefit Analysis

The main part of my research will be to determine the various costs and benefits that are associated with a biogas digester. Once all the various costs and benefits are identified the net present value (NPV) will be calculated, and discounted over the number of years the digester is expected to last. Once the NPV is determined a sensitivity analysis on the discount rate will be performed in order to realize its affect on the NPV.

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+i)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+i)^t} = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} \qquad (1)$$

B_t = Benefits at time t
C_t = Costs at time t
i = Discount Rate
t = Duration of project

1.4.2 Literature Review

Many countries in the region have already adopted successful biogas programs. China and India are the pioneers of biogas in the region, and potential is high in other countries such as Thailand, Nepal, and Vietnam. The literature review will contain experiences from these countries that will help evaluate the overall biogas situation in Vietnam.

1.4.3 Data Collection

In order to identify the various costs and benefits data needs to be collected. Different sources will be used, available statistics by MONROE, various development organizations, Nong Lam University Library, interviews with the various biogas users and actors in biogas policy. The following information will be asked to households in an unstructured interview with the help of a local Vietnamese translator.

Household

- Average income/size of household
- Costs incurred in installation and labor
- Opportunity cost for space designated for the biogas digesters
- Opportunity cost for labor
- Livestock management costs
- How much biogas/fertilizer they have access to
- Market Price of fertilizer (fertilizer from the anaerobic process of livestock waste)
- Costs incurred for biogas products (stove, lamp, etc.)
- Government support?

2. Literature Review`

China is considered to be the most advanced East Asian Country in biogas, there were 15 million active biogas systems in China in 2004; the government aims to have 27 million active biogas systems by 2010. The Ministry of Agriculture is in charge of biogas implementation in China. Ms. Zhao Lixin from the Center for Energy and Environmental Protection Technology and Development (CEEPTD), performed a study in Shipai Village, China in which she investigated the affects of biogas systems on the livestock farmers of the village. The study found that more than 90% of the 227 utilize a biogas system of some sort. The gas is used mainly for cooking and lighting, this has saved the villagers on electricity and gas costs. The use of the slurry as a fertilizer enabled the villagers to save on chemical fertilizers and pesticide costs. The improved sanitary condition increased livestock production which improved the profits substantially (Van Nes, 2006).

The Chinese government legislated policy to help implement a nationwide biogas program in China. They imposed price controls on certain materials in remote areas, this was mainly designed to help the poorer households install a biogas system. They also offered special low interest loans for households that were willing to expand their livestock farms and install a biogas system. In 2006 the Chinese government passed a decree called the Law on Renewable Energy. The main features of the law develop markets for renewable energy, planning and exploitation of renewable energy sources, support for industry and technology, sharing costs, prices and investment capital, and design appropriate energy taxes. The law also called for the formation of Management Committees all over China to help develop policies for specific regions, and technical support for the all the biogas users (ISPONRE, 2009).

The Indian Ministry of Non-Conventional Energy Sources implements the National Biogas program with the help of the Manure Management Program. In addition to these two governmental organizations, many international organizations and NGOs play an active role in the national biogas program. These various agencies offer support to biogas users by providing financial assistance, training courses, technical and service centers. About 3.67 million biogas units were active in India by 2004 (Van Nes, 2006).

The national biogas program has been integrated with other programs; such as the rural sanitation program, clean water program, etc. Many of the Indian policy on biogas dealt with allocating funds to help users build their own systems. Such measures included low interest loans, payment plans to be paid after installation, subsides on biogas appliances (cookers, lights, electric generators, etc.), and grants depending on the user's socio-economic condition (ISPONRE, 2009).

Nepal's Biogas Support Program (BSP) implement biogas in Nepal with the help of the Dutch Development Organization (SNV), there were about 111,395 biogas digesters nationwide in 2003. The biogas program is relatively new, however it is one of the fastest growing in East Asia. One of the main indirect benefits or the biogas program is the number of people being employed in the biogas related fields (technicians, suppliers, financial institutes that solely deal with biogas funds, etc.) (Bajgain & Shakya 2005).

Nepal's case is not similar to India and China, mainly because of the large support from international donors. In addition to SNV the German Government also provided a lot of financial support. Nepalese policy on biogas focused more on market development by paving the way for private sector investments. Nepal has currently 62 private biogas construction companies, 5 factories producing appliances,

and over 140 state and private financial organizations that are help the users by providing low interest loans (ISPONRE, 2009).

Many of the national biogas programs (including the ones mentioned above) encountered many obstacles in implementing their biogas system. The main constraint is the financial one. In a SNV study done on Bangladesh, high investment costs and the lack of funds for grants and credit hindered the initial stages of the program until the proper resources were allocated. (Boers, et. al., 2005). Similar problems were found in Thailand, the nature of biogas projects in Thailand were relatively small making the transaction costs much higher (Prasertsan and Sajjakulnukit 2005). This was also consistent with Nigeria's experience (Akinbami, et. al., 2000) and Nepal to a certain extent (Bajgain and Shakya 2005).

Another common constraint were the social factors. Introducing biogas technology may be met by stiff resistance from the potential users. Change often takes time, especially in a setting were traditional practices have been used for many years. In Bangladesh farmers found it hard to cope with the animal waste and use it for biogas (Boers, et. al., 2005). The lack of awareness on biogas led to stiff resistance in Thailand (Prasertsan % Sajjakulnukit 2005). Nigeria had a more serious problem, the current practices of the livestock farmers made it difficult to collect waste to be used in biogas, the livestock farmers would mostly graze their cattle in common land used by more than one farmer. A biogas system would require the cattle to graze in a fixed area so that it would facilitate the collection of waste (Akinbami, et. al., 2000).

Technical barriers also hampered the biogas program in Thailand. The lack of standards on biogas systems and equipment made it harder implement the biogas program nationally, new technologies are not distributed efficiently (Prasertsan &

Sajjakulnukit 2005). Bangladesh is also a victim from many technical issues including, decreasing cattle, insufficient waste available, lack of training, and technological failures (Boers, et. al., 2005).

Both Bangladesh and Thailand had an inadequate institutional arrangement to implement a biogas system. As seen from the Chinese and Indian examples there are many activities that are required, and the lack of planning and an improper institutional set up can retard the whole process. There are many sources to this problem; they are also linked with the other constraints mentioned. For example the lack of political will power and resistance from prominent businessmen in Bangladesh affected the inadequate institutional arrangement (Boers, et. al., 2005).

3. National Vietnamese Biogas Strategy

3.1 Objective

Realizing the potential benefits to the environment and overall economy, the Vietnamese government intends to implement a comprehensive strategy for application and expansion of technology on treatment of domestic animal waste. According to the Ministry of Environment there are approximately 100,000 biogas digester in the year of 2009, the Vietnamese government's plan is to reach 140,000 digesters by 2010. The strategy was formulated by Institute of Strategy and Policy on. Natural Resources and Environment (ISPONRE). ISPONRE is an institution under the Vietnamese Ministry of Natural Resources and Environment that deals with policy and planning. The strategy is designed to harmonize the animal husbandry with the Vietnamese economy. They aim to do this by promoting biogas research and development, expand the scale and biogas number, and coordinate various activities with the different actors involved. *(all information in this section is taken from the ISPONRE biogas strategy report, unless stated otherwise.)* (ISPONRE, 2009).

The main objective of the strategy is: "*Ensuring the sustainable development in animal husbandry in order to meet the needs of socio-economic development, at the same time achieve the objective on environmental protection, contribute for the sustainable development of the country, and improve the living standards of people."*

The four sub-objectives are:

- Completing institutional and legal framework in order to encourage the application of environmental protection measures in the animal husbandry sector
- Promoting the application of technology for the treatment of domestic animal wastes in Vietnam
- Building instruments supporting the expansion of technology for the treatment of domestic animal wastes

- Creating a convenient environment for the application and expansion of technology for the treatment of domestic animal wastes.

In this section the measures taken to fulfill the State's objectives will be discussed as well as the actors involved in implementing this strategy. The strategy was based on the successful Indian and Chinese biogas programs. ISPONRE does not deal with the actual activities; they only designed the strategy in coordination with the various ministries and agencies.

3.2 Legislation

Environmental law is not that extensive in Vietnam. There has been two major environmental protection acts, in 1993 and 2005. The 1993 policy contained the official Vietnamese definition of environmental protection: *"Environmental protection as stipulated in this law includes activities aimed at preserving a healthy, clean and beautiful environment, improving the environment, ensuring ecological balance, preventing and overcoming adverse impacts of man and nature on the environment, making a rational and economical exploitation and utilization of natural resources."*(*Law on Environmental Protection* 1993) In line with this definition most of the articles in this 1993 environmental protection act dealt with planning and monitoring issues. In summary this environmental act was the initial framework of a more comprehensive environmental act.

The act was extensive and covered the various roles of the households, business, and different economic sectors in environmental protection. It covered the role of the state in monitoring and recording various statistics in air pollution, water pollution, land degradation, and other issues. It defined the role of the state in investing for environmental protection as well as the creation of policies that encourage environmental protection. There was not a lot of policy that dealt with the

livestock sector however it did prohibit the following: *"Discharge of grease or oil, toxic chemicals, radioactive substances exceeding permissible limits, wastes, dead animals or plants, harmful and infective bacteria and viruses into water sources"* (*Law on Environmental Protection,* 1993) .

The environmental act of 2005 was a continuation and it mainly deals with activities of environmental protection as well as the framework to develop environmental standards. It also mandates the creation of sector specific environmental laws in order to make all the sectors of the Vietnamese economy sustainable.

Currently the livestock farmers are not bound by any law covering their practices. There are no laws that deal with biogas or renewable energy, according to the biogas coordinator of ISPONRE various components of renewable energy is on the agenda of policy makers. A legal framework needs to be written in order to guide the farmers into healthier practices that minimize environmental damage. ISPONRE suggests including the households and local governments and communities (farmer unions, veteran society, woman union, etc.) in the planning stages of the policy. This will facilitate the implementation of policy and create a channel of communication between the policy makers and the affected citizens. The policy should specify the roles and responsibilities of animal husbandry households, organizations, and legal authorities for environmental protection in the livestock sector

3.3 Economic Instruments

Economic instruments can be used to encourage households to install biogas systems. The Vietnamese government is currently using an instrument help reduce water pollution. An environmental fee is applied for the livestock waste water in

Vietnam. It's calculated on the composition of water, for example the water is tested for suspended particles, heave metals, and various water pollutants. The higher the pollutants, the higher the environmental fee will be. This encourages water pollution reduction. This same sort of fee can be implemented on animal waste discharged in the environment. The idea is to imitate the same strategy for the environmental fee, the more untreated waste is discharged the higher the environmental fee.

The second and third instrument deals more directly with the initial investment required to implement a biogas system. A low interest rate on loans that deal with biogas and its technology can encourage farmers to utilize biogas. There are many local and international organizations that deal with micro-finance; in this case the organizations need to be organized in order to cover as much farmers as possible. The third instrument is to provide grants to encourage the farmers to install a system. The grants should also be included for research on various technological aspects of biogas, training courses, maintenance, etc.

The final economic instrument is to grant farmers that use technology to treat the domestic animal waste (including biogas systems) with a scheme that reduces their taxes. According to the current Vietnamese regulations all business, individual, and organizations that are involved with some sort of production are responsible to pay taxes. Livestock farmers who use technology to treat domestic animal wastes, including using a biogas system from livestock waste will have a tax reduction.

3.4 Biogas Market & Network

In addition to these economic instruments the strategy also advocates the development of a biogas market and network. The biogas system requires a lot of products and possibly service. Besides the material of the biogas digester and

installation there are many biogas appliances that can be used to complement the household's biogas digester. A fully developed biogas market can attract domestic and international investors, which will increase the biogas promotion and could increase the number of users. The strategy recommends the research of the following points in order to facilitate the development of a biogas market:

- Identify the scale of biogas plants (individual digesters, small, medium, etch.)
- Supply and household's access to the input (dung)
- Investigate rural income in the various rural areas of Vietnam
- Potential of private sector to invest
- Establish a qualified biogas construction/maintenance team
- Establish a market for purchasing and selling biogas

Promoting a market for the methane produced from the biogas process is still not a very common practice. There has been some extensive research in India and certain pilot markets were created. Storing the biogas will require another process in order to extract the carbon dioxide, hydrogen sulfide, and vapor components. There are many techniques to extract these chemicals; an Indian study concluded that water scrubbing is the simplest and cheapest technique (Kapdi, et. al., 2003). The strategy recommends to research this area because this will allow the biogas to be used away from the digester site. This can play a key role in extending biogas utilization to urban areas.

As mentioned above the biogas system requires different expertise and technologies. Different digesters realize different production scales as well as different operation techniques. There is also extensive research done in other Asian countries and the strategy suggests incorporating all this information within the biogas network. This network will include technicians and the various governmental and nongovernmental organizations involved in biogas. Representatives from the three

levels of government; central level, provincial level, and district level will be included in the network. The network will also be responsible for teaching technicians and creating a database where all the information of biogas can be found. The network will facilitate which technology would be the most suitable to be used in the different regions of Vietnam. It will also cooperate with biogas market by introducing new technologies.

3.5 Resources

Capital will not only be needed for the actual installation of the digesters, but will also be required for other activities such as research and the institutional arrangement. Currently the Vietnamese government allocates 1% of the total national expenditure for environmental protection, 5%, less than 10 billion VND of that fund is used for application of new technology for the treatment of environmental pollution. The government also expects the private sector to play a bigger role in research and the dissemination of technology. The next 15 years the government will concentrate on the following 3 financial issues:

1. State investment will focus on maintenance of biogas plants and training human capital on new technologies. A small portion will be used to assist livestock farmers in the poorer areas.
2. At the provincial level, local governments will offer financial support management of biogas plants and promotion of biogas in order to increase users.
3. Capital from livestock farmers will be used to buy additional material such as valves, pipes, etc.

3.6 Implementation

To fully implement this strategy, different ministries will have to be involved in order to complement the comprehensive Vietnamese biogas program. The strategy consists of a short term plan and a long term plan. The long term plan is designated for activities till year 2020, and the short term plan are for activities to be implemented prior to 2020. The first task that needs to be achieved in the short term plan is the creation of institutions to help realize the strategy. A steering committee was set up that consists of representatives from the Ministry of Natural Resource and Environment, Ministry of Agriculture and Rural Development, the Ministry of Trade and Industry, the Ministry of Science and Technology and the Ministry of Public Health. The steering committee were tasked with creating a summary of the current institutions that can participate in the strategy as well as the framework for new institutions needed to aid in the national biogas program.

Since biogas is already present in Vietnam the first task in the short term plan is to accumulate data and information on the existing biogas plants. The ministry of Finance and local governments were in charge of creating a biogas development plan which will focus on constructing biogas plants, buying equipment, and paying for the various tasks (maintenance, operation, etc.)

The steering committee created 6 programs that need to be achieved in order to fully implement the strategy. The programs are planned to be completed by 2020 (the programs corresponding to the short term are scheduled to be completed before 2020) and involve various ministries of the Vietnamese government. The first program that is scheduled to be completed by 2010 is the *Development and implementation of policies supporting the development of science, technology and service on application, of biogas technology.* The ministries of Science and Technology, Industry, Trade, and Public Health are involved in this program. The

second program is also scheduled to finish in 2010 and it is the *Program on development of human resource for the expansion of biogas technology in treatment of domestic animal wastes in Vietnam.* The ministries of education and training, and public health are involved with the inclusion of the various farmer associations affected.

These two programs cover all the aspects of biogas, science, technology, application, and human resources. The idea is to develop all these areas so that they will be able to accommodate an increasing number of biogas digesters until 2020. The first program is designed to establish operational indicators and criteria as well as technical norms in the treatment of domestic animal waster for the different livestock scales. The second program is meant to design a manual for management, operation and maintenance for the available biogas digesters. The idea is to unify and harmonize the various components and practices throughout Vietnam.

Once the components are unified, the short term plan mandates the creation of Animal Husbandry Development Management Units all over Vietnam. This will facilitate communication with the farmers and help guide the farmers on livestock management. The offices will also help realize the strategy by recording the results of technology application as well as promoting the technology. The main objective of these management units is to ensure the fulfillment of the strategy at the micro level.

The legislation mentioned earlier is planned to be completed in the year 2012 under the program *Development and promulgation of some basic legislative documents on protection of the environment in animal husbandry*. The ministries of public health and justice will be involved in this program. This program is straightforward and its main goal is to introduce supporting polices and decrees. The third program, solely deals with research. *Program on research for and application*

of biogas technology, this will be done in collaboration with the ministries of public health and industry. This program is designed to investigate new technologies and practices. They will be responsible for promoting research and technology transfer activities. New technology will be researched by implementing pilot models and spreading information on the successful models, and equip farmers with knowledge so they can make the decision on the most suitable technology to be used.

The fifth program is designed to be implemented by the year 2020 and it's the *Development and promulgation of some policies on taxes, fee, price subsidization, and supporting research for and application of biogas plant*. The ministries of finance and planning & investment will be involved in this program. The objective of this program is to manage the finance in line with research and application. The various components that needs investment should be identified in order to diversify them as much as possible. The financial aspects are also researched in this program and mainly the possibilities for delivering micro credit and finances to the poorer areas and households. Training falls into this category and the program will identify the various issues that need to be covered in training. A mechanism that increases the budget for research will be developed which will allow more funds to be allocated to research in the future.

The final program to be completed in 2020 is the *program on enhancing capacity for monitoring and efficient treatment of socioeconomic, technical situations in the development of biogas technology in the Vietnamese animal husbandry sector.* This program will be implemented in collaboration with the ministries of industry, trade, finance and science & technology. This program is designed to overlook the strategy in practice. This is necessary because the monitoring will be used for the

strategy evaluation. This will be essential in proposing changes and improvements. The following issues need to be monitored and recorded.

- Monitor the results of the strategy and the impacts of policy and programs on treatment of domestic animal wastes
- Level of performance and outcome for application of technology
- Capital mobilization, and budget
- Effect and socioeconomic impacts of programs on poorer households

3.7 Other Actors Involved

Besides the governmental organizations there are a number of international organizations and non-governmental organizations that are involved. They mostly focus on providing technical and financial support for the implementation of biogas projects in selected areas. The Dutch Development organization is the most active international organization, their project will be explained in detail in the next section. The strategy suggests the following actions to be covered by organizations outside the government (*Agriculture Subcommittee Meeting* 2009):

- Implement applied researches to guide farmers in changing production structure, domestic animal structure, improve animal husbandry techniques, and facilitate the application of new technology
- Ensure that information is provided to the state in disseminating guidance, technology transfer, market and price information
- Mobilization non-state budget in order to be in line with government investment and avoiding unnecessary investment
- Improve biogas technology and make farmers more efficient in biogas production

4. Users that were used in this study

In collaboration with the Ministry of Agriculture and Rural Development the Netherlands Development Organization (SNV) initiated the "Biogas Program for the

Animal Husbandry Sector of Vietnam" in 2003. The main objective of the project is the *"Improvement of living livelihood and standard of rural area in Vietnam through exploration of direct and indirect economic benefits of biogas technology at household level" SNV User Survey* (2009).

This project is operating throughout all of Vietnam. In 2009 the project was responsible for 77,000 operating biogas plants in 39 provinces. They are aiming to install 164,000 biogas plants in 50 provinces reaching 800,000 people *SNV User Survey* (2009). Every year they conduct a User Survey with 5 main objectives:

1. Survey the products and services provided by the Biogas Program
2. Assess the social, economic and environmental impact from the utilization of biogas plants.
3. Assess the socio-economic condition of the clients, categorize the clients into three groups:
    - Relative poorer households
    - Average households
    - Well-off households
4. Survey what biogas products are being used by the farmers (stove, filter, lamp, electric generator, etc.)
5. Deduce a demand for biogas from the survey results.

The survey was taken in 7 provinces the biogas program was present in Vĩnh Phúc, Hưng Yên, Nình Bình, Quảng Ngãi, Bình Định, Bến Tre, and Bà rịa-Vũng Tàu. By the time of the survey (October 2009) 84 % (4095) of the 2009 target of the biogas plants was completed in the selected provinces. 211 households were surveyed and the average size of the biogas digester was 11.22 m^3. The household's were small-medium scale livestock farmer (5-30 heads/heard) and the biogas plant models being used is KT1 and KT2 (explanation in biogas digester section). The costs of the biogas plants come from various sources. The funding of the biogas plants comes from the program itself.

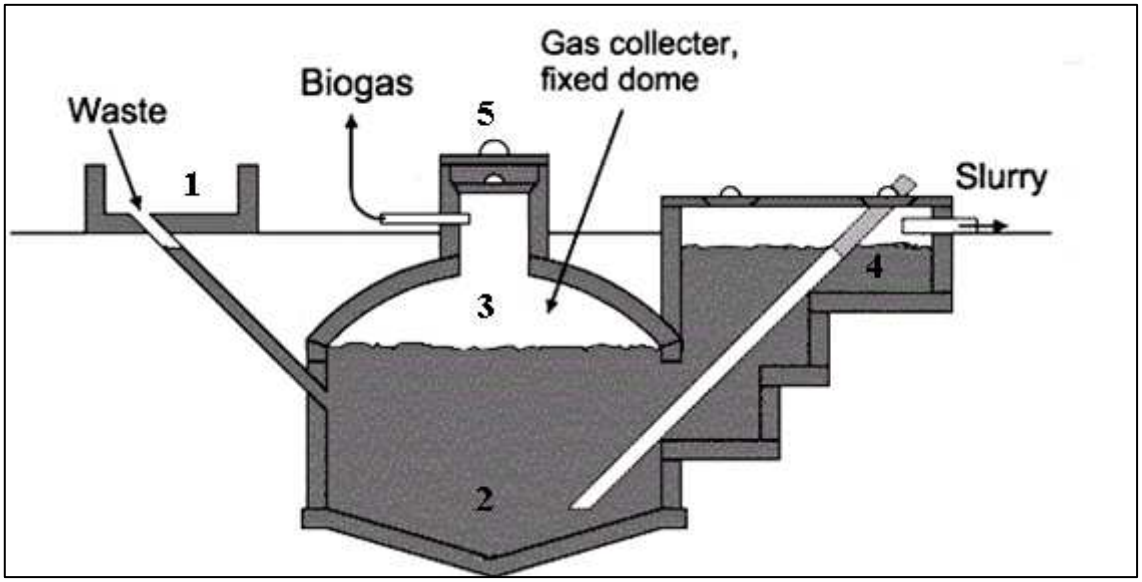
I also conducted interviews in two districts on the outskirts of Ho Chi Minh City, Tan Uyen District, Binh Duong Province and Cu Chi District, Ho Chi Minh City.

I interviewed about 20 households and I was interested in learning their experience and overall views towards operating a biogas digester. The results were similar in each district. There were very few differences and most of the households shared the same type of experiences.

4.1 Biogas Digesters

Biogas digesters are more common at the household level in Vietnam. There are various types of biogas digesters that can be used. The following section will describe the most common biogas digesters in Vietnam. It is important to note that many of the digesters used in Vietnam are either modifications or replicas from other digesters that are used in other Eastern Asian countries with a more prominent biogas program.

4.1.1 Fixed Dome Biogas



Source: http://fastonline.org/CD3WD_40/BIOGSHTM/EN/APPLDEV/DESIGN/DIGESTYPES.HTML

Figure 1: Fixed Dome Biogas Digester

The diagram above is of a fixed dome model. The main components of the digester are located underground. Placing the digester underground enables the production of biogas all year round. Other digesters that are exposed to the outside environment cannot function during the rain. This is especially a big advantage in Vietnam since their climate consists of a 4-6 month rainy season. It also takes up less space and the waste inlet can be close to the livestock pen which facilitates the collection of dung. The livestock waste is mixed with water and put into the digester (1). The main tank (2 and 3) is where the anaerobic digestion takes place. The biogas rises (3) and is stored in the tank; there is a pipe on the top (5) connected to the household. The biogas waste remains into the tank (2) and also in the displacement tank (4). Picture 1 in the bottom is where the biogas waste is collected. One of the drawbacks of this system is that the biogas waste does not all come out and eventually the main tank will overflowed with biogas waste. However according to a biogas engineer it takes many years for the tanks to get completely filled up.

Source: Author

Picture 1: Biogas Waste Output

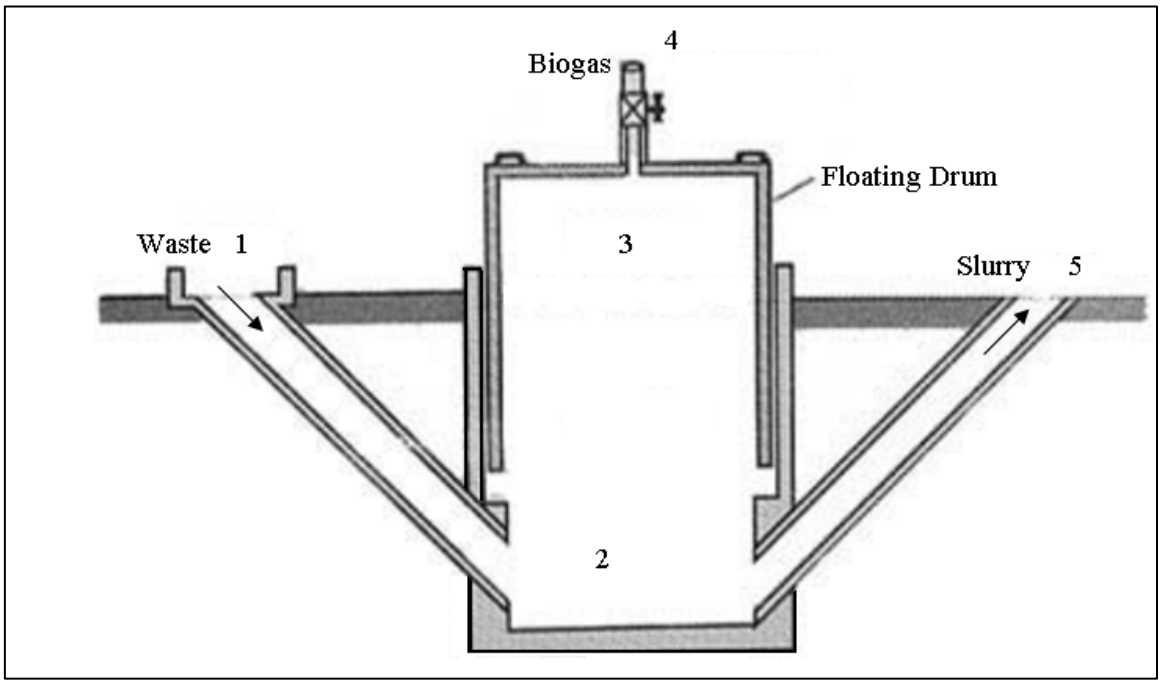
This is a very common type in Vietnam. The KT1 and KT2 are two models of a fixed dome biogas digester that are very common in Vietnam. They are also the

models used in the SNV project. The Vietnamese Ministry of Agriculture and Rural Development use these models in most of their biogas programs throughout the country. This system was originally designed in China. Several million digesters were constructed throughout China. Variations of the fixed dome model can also be found in India, Tanzania, Nepal, and any other country that has a biogas program. (Lawbuary, n.d)

This system is common because according to the literature it is easy to construct using local materials, low initial costs, long life span, saves space, and construction can create employment. The disadvantages are gas leaks frequently, amount of gas can be unknown in the beginning, plant operation not easy to understand, and high technical skills are required for some certain aspects of constructions (such as making the main tank air tight for gas).

The advantages and disadvantages listed above were found in various literatures. Even documents from the Vietnamese government were consistent with them (MONRE, 2005). All the households I interviewed in the two districts had a fixed dome biogas digester. However according to most of the farmers it was very easy to use, and most of them with the exception of 3 households built the biogas digester on their own. The three households that were aided in building the digester were helped by an engineer. Most of the households had been operating their systems for 2-5 years and during that duration no major problems occurred. Only one farmer had a problem the connection between the displacement tank and the main tank, but he fixed it with the help of his neighbors.

4.1.2 Floating Drum Biogas



Source: http://fastonline.org/CD3WD_40/BIOGSHTM/EN/APPLDEV/DESIGN/DIGESTYPES.HTML

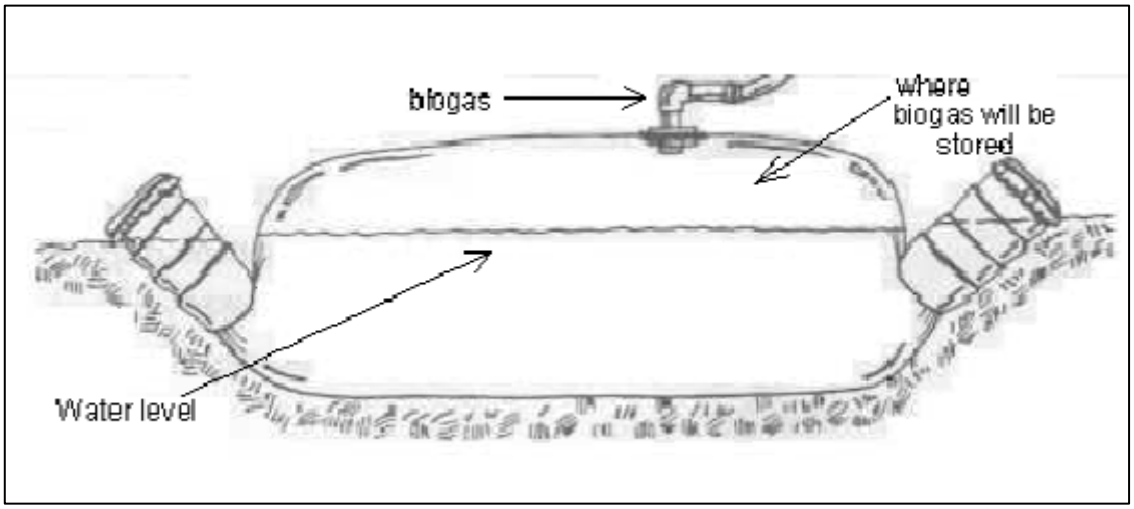
Figure 2: Floating Drum Biogas Digester

The Diagram above is of a floating drum biogas digester. It is partially underground and consists of a tank and floating drum. The waste is mixed with water and put in the digester (1). The anaerobic digestion takes place in the bottom of the tank (2). The system collects gas, and as more gas is produced the drum floats upward (3). As the gas gets consumed the drum submerges back in the ground. The slurry comes out of the system (5), like the fixed dome digester the tank needs to be cleared out every few years.

This digester is originally Indian and there are many modifications of it in India. The original model is called the KVIC model and it is the most popular one in India. All the other floating drum digesters are modifications of this digester. The differences are the size and shapes of the main tanks. These models are straightforward and easy to operate, the amount of gas available is easily noticeable from the position of the drum, and it is easy to clean out the tank because the floating

drum can removed easily. The fixed dome requires more work since the tank is completely submerged in the ground whereas the floating drum is only partially submerged. The biggest drawback is that this type of digester is relatively expensive and requires a lot of maintenance. In order for the digester to operate smoothly it needs to be painted and the rust needs to remove regularly. Its life span is also short especially in tropical coastal countries where it only lasts about 5 years.

4.1.3 Plastic Biogas Digesters



Source: *MONRE Technical Report* (2005)

Figure 3: Plastic Biogas Digester

The plastic biogas digester is the cheapest alternative out of the three. It can be made out of plastic or rubber and has many names such as balloon and polyethylene biogas plant. The bag is sealed and is used as both a digester and gas storage. The waste is mixed with water and put in the bag, as depicted in the diagram above the water and waste only partially fill the bag. The picture on the next page is of an actual plastic biogas digester in a farm in Vietnam. As seen in the picture, there is a pipe connected to the end of the plastic bag which collects the biogas. In this case the water level cannot exceed the hole for the pipe. The gas is collected in the upper part of the balloon. The gas pressure can be increased by pressuring the plastic bag.

Source: Author

Picture 2: Plastic Biogas Digester

This was originally designed in China but because of its cheap price and simple operational requirements it can be found in any country where biogas digester can be found. Its installation is simple which makes it an important incentive for installing it is also. The biggest drawback with this digester is during the rainy season it cannot be used, the biogas waste can only be removed when it's not operating, and it has a short life span. Picture 2 shows how farmers in Vietnam cover the plastic biogas digesters to protect it from the outside environment.

These three types of biogas digesters are the most common in Vietnam. There are many other modifications from these and also other types. There is constant research on biogas in the various universities in Vietnam, Can Tho University in the Mekong delta area has worked on a few biogas digesters and they can be found around the Mekong delta. As mentioned before there are many biogas programs in other Eastern Asian countries that have been operating for a longer period than Vietnam's program, there is also constant research in these countries and there is a lot of cooperation between the countries (all three of these digesters are not originally from Vietnam)

In the two districts I visited the fixed dome digester was the most common. I did not see the floating drum and about 5 of the households I interviewed had the

plastic biogas digesters. The main tank in the fixed dome digesters varied from 5 m^3-10m^3. Since most of the digesters were built by the households themselves they chose the most adequate size. The digester's cost varied from 8 million dong-10 million dong. This cost included everything pipes, equipment for digester, gas cooker, and building material. There was no certain life span but the most of the households expected the system to last 10-15 years.

The plastic biogas digester users were using this system only because it was much cheaper. However they all said if they had the money or support they would have chosen the other system. This system costs 1.5 million-3 million, which is a substantial difference for the average Vietnamese farmer. Since producing gas in winter is not feasible and safe many of them design big plastic bags and cover it like shown in the picture in the previous page, so that they can store some of the gas during winter.

5. Survey/Interview Results

5.1 Finance/Costs

Material	Quantity	Cost (1000 VND)
Cement	1.1 tons	1512
Solid Brick	3500 pieces	3150
Sand	3 m^3	600
Gravel	1.5 m^3	300
Pipes (entrance, exit, and gas collecting)	3.5 m	580
Steel	15 kg	180
Conductor Wire	30 m	210
Manometer	1 piece	40
Valves	1 set	100
Biogas Using Device		
Biogas single cooker	1	500
Lamp	1	70
Labor		3760
	Total	11002

Source: *SNV User Survey 2009*

Table 3: Costs of Materials in Ben Tre Province

The information in this section is mostly from the SNV report and the results of my interviews, unless stated otherwise. There are various materials that need to be bought in order to successfully build a biogas system. Loans and funds are normally granted from a local or district government/community group rather than the national government. As mentioned in the Vietnam Biogas Strategy section the Ministry of Finance and Ministry of Planning and Investment are in the process of developing policies on taxes, price subsidization, and research. The biggest role the national government can play that will directly affect the farmer is price subsidization. Table 3 summarizes the materials and costs needed to build a 10 m^3 fixed dome biogas digester in the Ben Tre province.

The labor will be required to do various activities such as digging the earth, setting the brick and cement, and setting out the pipes and so on. This can easily be

done by the farmer himself, which was the case of both districts I visited Tan Uyen and Cu Chi.

The materials to create the digester without the labor cost are 6,672,000 VND in the Ben Tre province. The materials for the same 10 m^3 digester in Vinh Phuc province are 3,352,000 VND. There is a substantial difference between these two figures and there are a few factors that contribute to this difference. One of the factors is the geographical location; Ben Tre province is located in the Mekong River delta in the south. Vinh Phuc is located in the Red River delta in the North of Vietnam. If the material is not from the same region then the transportation costs can increase the final price of the object.

The Income per capita in Vinh Phuch and Ben Tre provinces are 6,480,000 VND and 7,368,000 respectively. This could contribute to the reason why the materials are more expensive in one area. Nevertheless, both incomes are relatively low and both would need assistance to purchase a biogas digester. The national government could subsidize some of the expensive material such as the brick and cement; this would decrease the costs by 4,662,000 VND in Ben Tre.

The SNV project also offers financial aid as part of the program. Initially each household that joins the program will receive 1 million VND under the condition that they build the digester before 2009. After 2009 the grant raised by .26 million VND; totaling 1.26 million VND. 177 out of the 210 households surveyed in the SNV report received the cash assistance. In order for a household to be eligible for the cash assistance they have to register themselves with the local Commune People's Committee as well as the project which takes up to 120 days.

In addition to the money from the project some local governments in cooperation with other unions such as the farmers union, women cooperative, etc.

have offered a 1.5 million VND grant to biogas users. Not all districts offer this sort of financial aid. In the second district I visited Cu Chi; there was a local financial incentive for farmers willing to invest in a biogas digester. The money was given through the Women's Union. The union offered grants and loans with no interest for farmers. For example one of the households I interviewed installed a digester that costs 15 million VND including the cooker and all the other materials required. In fact, this was most expensive digester I observed on the field. The initial deal was a 14 million loan in which the farmer pays back every month 250,000 VND and a 1 million VND. Once 9 million VND was paid the remaining 5 million VND was written off as a grant.

According to a member of the people's community of the Cu Chi district the money for this program was granted from the Department of Environment and Natural Resources of Ho Chi Minh City. This program was available in all the districts of Ho Chi Minh City. The main objective of this was to increase the number of biogas users in order to reduce the negative consequences on the environment caused by livestock farms. This program started in beginning of 2009 and they initially reimbursed farmers who installed digesters before the commencement of the program. They then started to spread the money to farmers who did not have a biogas digester.

The first district I visited, Tan Uyen in the Binh Duong province, there was no financial program or incentive offered to farmers wishing to install a biogas digester. Some of the farmers I interviewed borrowed money, interest free, from wealthier friends and family but none had access to financial loans from any institution or government. There is no reason why financial support exists in one area and not in another area. From what I understood from various meetings with representatives in

ISPONRE, Ministry of Agriculture and Rural Development, and some of the farmers is that they are still in the process of spreading these sorts of financial programs/incentives throughout the country. The programs start off in the "influential areas" such as farms in the major cities' province of Hanoi and Ho Chi Minh City and eventually these programs will reach other districts including Tan Uyen.

The private sector is also involved in providing support for some farmers. Toyota Vietnam initiated the *GO Green* program which aims *"to provide community education on environmental protection, contribute to a cleaner environment, and reduce environmental damage."* To achieve this, the program will assist individuals and communities that face environmental problems by creating environmental protection activities such as national parks and reservations. This program was implemented in the cooperation with the Ministry of Education and Training and the Vietnam Environment Protection Agency; Toyota Vietnam have donated US $ 2 million for this program. 80 million VND of the program fund has been allocated to aid families in installing biogas digesters. The project has reached 24 households Hanoi. The program will also aid Da Nang University to research electricity production from biogas fuel (The Bioenergy Site 2008). Da Nang University is considered to be one of the most prominent universities that deal with biogas. There are many other universities in Vietnam an active role in biogas research. Many other universities have been active in researching the various aspects of biogas production, from technical issues to socio economic issues. (*Agriculture Subcommittee Meeting* 2009)

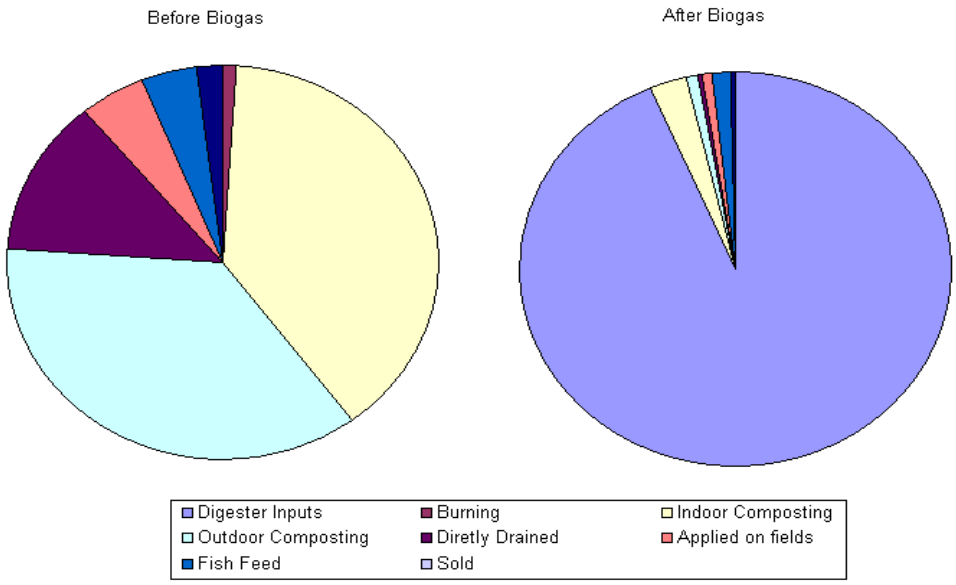
5.2 Reasons for Installing a Biogas System

Vietnam is a very large country and spreading information is not that easy especially in the remote rural areas. There were 4 channels of information that enabled farmers to learn about biogas and its benefits. The first two were sponsored by the government and this was through radio and television. There were many programs and commercials explaining the biogas system, benefits, and the role in can play in their everyday life. The third is through engineers and entrepreneurs, in the Tan Uyen district an engineer came and explained the biogas system and its benefits to some of the farmers. The engineer sold the material for the biogas and also offered to install the system for a fee. The fourth channel is through word of mouth. The two districts I visited people are very close to each other, when I asked the households how they heard about the biogas system many of them answered from neighbors or friends.

There were two main reasons households invested in a biogas system from the two districts I interviewed. The first one was to improve the environmental condition, mainly to improve the negative odors caused by the livestock waste and reduce pollution. Many of the farmers are concerned with the environment and this also consistent with the results of the SNV user survey. Almost all the households surveyed considered reduction of pollution important or very important. Only 2 households considered it to be a normal problem. 64 households were willing to invest in a pollution reduction activity.

Figure 4 show what farmers in the SNV sample did with the livestock waste before and after the installation of the biogas system. Before the biogas system 74.9 % of the waste was treated by making compost inside or outside of the animal cages.

12.7 % of the waste is directly discharged on the field untreated. After the biogas system 95 % of the waste was directly used in the digester.



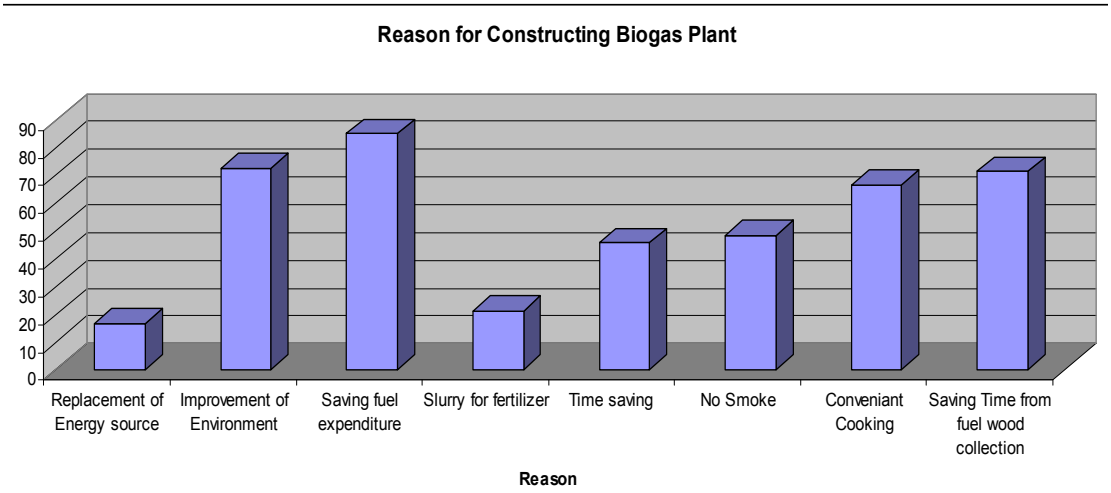
Source: SNV User Survey, 2009

Figure 4: Treatment of waste before and after biogas systems installed

The second main reason for installing the biogas system is because of how convenient the system was. According to many of my interviewees once the digester is installed the only remaining work is to mix the waste in the digester. This process enables them to save time (from collecting firewood) and money (from gas). Before the farmers had biogas they used to buy there gas, a household of about 7 people used to buy approximately 15 kg of gas for about 250,000 VND for a few months. Many of the households did not use the gas in a consistent manner because many of them relied on firewood. The price of the gas varied from house to house which indicated that each household had their own source.

Figure 5 summarizes the results of why the households in the SNV survey installed biogas systems. They are somewhat consistent with my findings on the field.

72.5 percent of the respondents claim that improving the condition of the environment was one of the reasons for installing the system. Saving fuel expenditure was the most popular reason, 84.7 percent followed by saving time (generally), saving time from wood collection and convenient cooking. All these factors are what make the system convenient.



Source: SNV User Survey 2009

Figure 5: Reasons for Constructing Biogas Plant

5.3 Benefits

Biogas is mainly used for cooking, the alternative source for cooing would either be cooking gas or firewood bought or salvaged from nearby fields. The biogas produced is also used for lighting and heating. Biogas is normally used to heat the newly born piglets. 207 households in the SNV survey use a biogas stove. 57 households use the biogas for lightening, and only 4 houses used the biogas in electricity generators. Table 4 shows the average money saved per household in each one of the districts sampled in the SNV survey.

Item	Total	Vinh Phuc	Hung Yen	Ninh Binh	Binh Dinh	Quang Ngai	BR-VT	BT
Salvaged firewood	46.73	14.55	34	22	25.67	47.33	33	147.1
Bought firewood	69	150.33	29	55	48	63.33	117.67	21.29
Gas	28.32	26.67	16.33	19.33	24.7	31.5	65	15.16
Charcoal	8.93	36.67	17.48	2	4.33		2.33	0
Peat	8.19	33.33	10.27	12.67	0	1.33	0	0
Total	**161.17**	**261.55**	**107.08**	**111**	**102.7**	**143.49**	**218**	**183.55**

Source: SNV User Survey 2009

Table 4: Average Money Saved per household (1000 VND)

The salvaged firewood was valued at the current price of firewood. The higher amount of gas and firewood saved in monetary terms indicates how important the two main sources were for cooking prior to the installation of a biogas system. Charcoal and peat are also used, all these resources are not used anymore after biogas installed. This allows the household to save money and the table indicates that households save from 100,000 VND to about 250,000 VND depending which district they are in. These numbers represent the alternative energy value and opportunity cost of biogas.

The slurry fertilizer is another product that if used correctly can be viewed as a valuable benefit. The slurry fertilizer is not that popular among the farmers. In figure 5, 21 percent of the users in the SNV survey considered the slurry/fertilizer as an influential reason in installing the biogas system. This was one of the lowest numbers; the results were also similar in the households I interviewed. The slurry was not utilized completely.

There have been studies on the affect of the biogas slurry (bio fertilizer) on various crops in Vietnam. The various crops were rice, cabbage, and tomato. Compared to the chemical fertilizer, the bio fertilizer increased production by 678 kg per hectares. 70 US$ per hectare was saved on chemical fertilizers and pesticides.

Cabbage yielded 55.3% with the biogas slurry, and 170 US$ was saved on chemical fertilizer. In the tomato case the bio fertilizer was mixed with chemical fertilizer and the experimental group produced about 13 tons per hectare more, saving about 58 US$ per hectare on chemical fertilizer and pesticides (von Eije, 2007). Using the bio fertilizer correctly can both increase agriculture production and reduce money spent on chemical fertilizer; currently the small scale digesters are not using the bio fertilizer to its full potential.

The situation was similar in the two districts I visited. The biogas itself saved the households from purchasing cooking gas and firewood. The firewood can either be bought or collected. The Gas price varies and comes in different quantities. The gas is normally sold in cylinders of 3 kg or 6 kg, and cost about 15,000 VND a kilogram (this is just under 1 US$). The biogas system substituted the cooking gas and firewood saving both money and time for the household. The use of bio fertilizer was also not as significant as it should be. Some households would use it on their small plots of land or discard the bio fertilizer in the environment.

The biogas system improves environmental conditions and it often improves the quality of health of the household members as well as their livestock. The human health effect was not really felt in the districts I visited. However there have been studies in other areas of Vietnam on this case. In a study done by Nguyen Quoc Chinh of the Faculty of Economics and Rural Development of Hanoi Agriculture University, she investigated the health perceptions of 12 farmers. She asked them to compare the symptoms of runny nose and headaches before and after biogas systems were installed. She also asked the rate of doctor visits for the two periods. 66% of the respondents claimed they had runny noses on a non regular basis, 100% of them said they had none after the system was installed. Before the biogas system 8% had

regular headaches, 58% had headaches sometimes, and 8% believed they had headaches at a normal rate. After the biogas system none of them had bad headaches, and 91% believed they had a normal rate of headaches, and 8% had headaches sometimes. 16 percent of the respondents claimed they were visiting the doctor at an increasing rate, as opposed to a 100 % of the respondents said their visits to the doctor was not at an increasing rate. These figures indicate a positive influence on human health. In addition to the cost benefit analysis, human health and the environment can also be seen as positive effects of biogas systems

The animal health is also improved. I was not able to get data from the districts I visited on this aspect however the SNV compared the livestock production between the biogas users and non biogas users. The table below shows the average number of livestock between biogas users and non biogas users in the SNV report.

Livestock	Biogas user	Non-biogas user
Buffaloes (head/household)	0.51	0.32
Pig (head/household)	26.65	18.12
Poultry (head/household)	71.40	21.62

Source: SNV User Survey.

Table 5: Livestock Populations Between biogas Users and Non Biogas Users

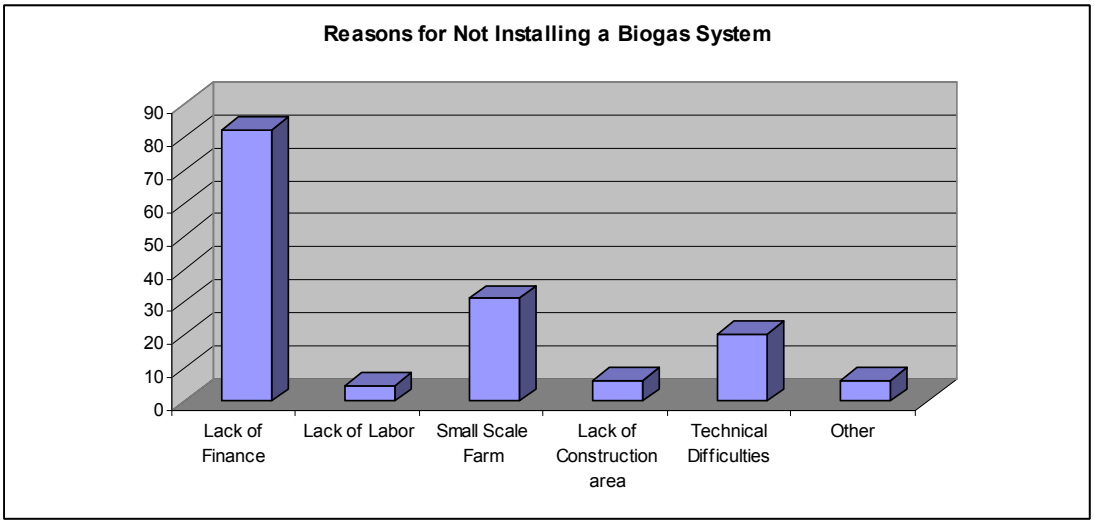
For biogas users every 2 households had an average of one buffalo; whereas about every three non biogas users had one buffalo. The pig and poultry populations are more straightforward. Biogas users had an average of 26 pigs and 71 poultry. Non biogas users had an average of 18 pigs and 21 poultry. It may seem that the improved animal hygiene leads to a direct increase in production. It would be pre-mature to come up with this conclusion, however, we can conclude that biogas digesters will

facilitate an increase in production if other factors are introduced (investment, new livestock, etc.)

The biogas production can also play a major role in income diversification. Most of the households I interviewed produced more gas then they needed. Some of the households would release the excess methane gas in the air. This will be discussed in more detail in the problem section. The excess of biogas production can encourage farmers to produce other products. In the second district I visited Cu Chi, all the households produced rice wine and used the biogas in the process. The main reason households turned to this production is because they have the raw materials, and the most costly material, the gas, was in excess. The farmers would produce in average of 10 liters a day, most of it was used for their families but they also had the option to sell it the market. A liter of rice wine sells for about 1 US $.

5.4 Constraints

Although biogas is popular in Vietnam there are many barriers that retard its growth and limit its positive externalities. The figure below summarizes the reason why the non-biogas users in the SNV sample don't have a system.



Source SNV User Survey, 2009

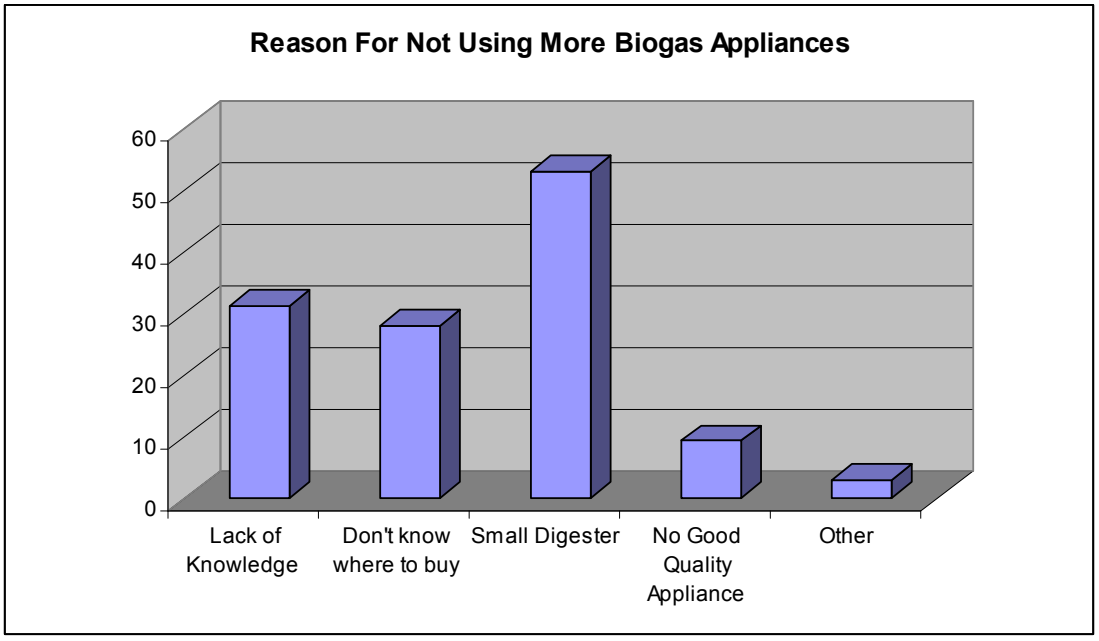
Figure 6: Reasons For Not Installing a Biogas System

The main reason is the lack of finance (82%). It is evident from the figure that the other factors are not as important as the finance. 31 % of the respondents claimed that their small scale farm was an obstacle and that was followed by technical difficulties (20%). As mentioned in the finance section, allocating funds in order to aid farmers in building biogas systems is the most effective way to increase biogas utilization.

Allocating funds is not the only problem, another major problem is the improper and lack of usage of the biogas gas, the methane. After installing the biogas systems a lot of households started to have access to more gas than they need. Some households were able to utilize the gas in new ways, such as producing wine. However some households either burned the extra gas off or just release the methane directly in the air. Since the gas cannot be stored, and there is a constant flow of input (waste and water) into the digester, the gas needs to be released to make room for the new gas being produced. According Le Toah, the chief technical director of the SNV biogas project households with more than 50 pigs face the problem of excess gas. The problem is releasing the methane in the air contributes to the accumulation of greenhouse gasses in the atmosphere. According to the Environmental Protection Agency methane is 21 more times effective in trapping heat in the atmosphere than carbon dioxide. This problem is only faced by a small number of households, however if such practices continue and increase over time, clean air and environmental objectives will not be achieved.

I asked the farmers if there is anything else they would like to use the biogas for. Most of them were not aware what they can use the biogas for besides cooking, heating, and lightening. Many of the farmers would be willing to utilize the biogas in other areas. One of the farmers I interviewed stated that he would like to use the biogas for everything possible. He would also be willing to increase his livestock in

order to be able utilize the biogas in an electric generator. The SNV also derived a demand for biogas consumed appliances from their sample. 51.4 % of the respondents wanted to use more appliances, 43 % were satisfied with their current arrangement, and 5.7 % have a low demand.



Source SNV User Survey, 2009

Figure 7: Reason For Not Using More Biogas Appliances

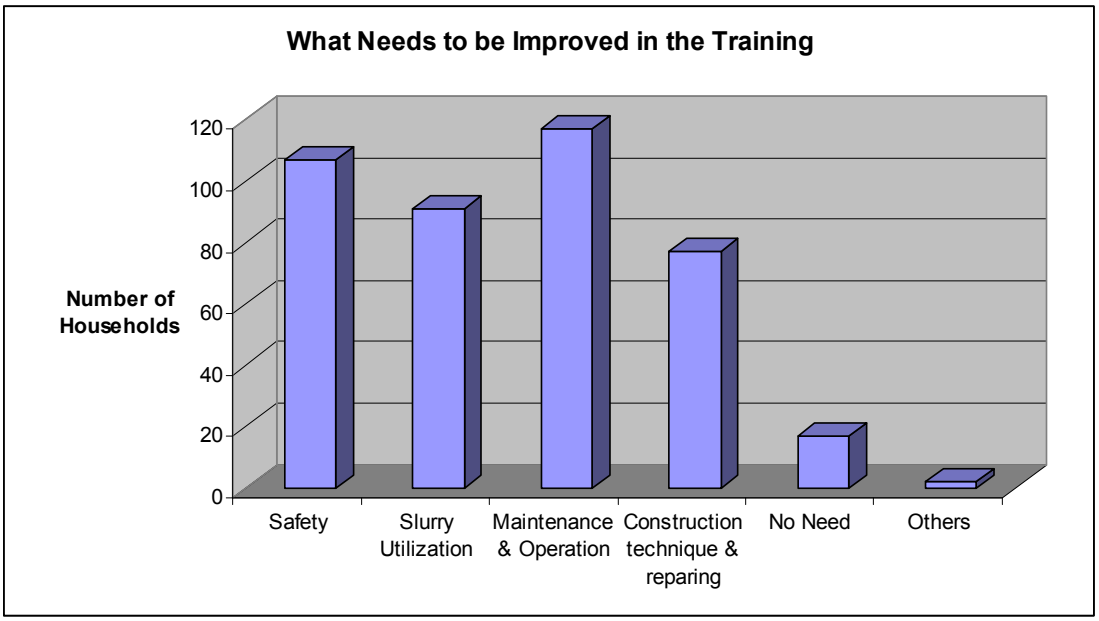
Figure 7 summarizes the reason why biogas users in the SNV sample do not use other appliances (respondents were able to select more than one answer). The main reason is the small digester (50%). The next 2 prominent factors are lack of knowledge and no knowledge of a market for biogas appliances. The average size of the biogas digester of all the respondents in the SNV survey is 11.2 m^3. Since there is no technique to store the gas in a container separate from the digester the users will eventually have to increase the size of their digesters if they would like utilize biogas more.

In order to use biogas more efficiently a suitable market for biogas appliances needs to be arranged as well as research in storing the gas. Since biogas is somewhat

popular in Vietnam a proper market for its appliances can be very profitable. If appliances like biogas lights, electric generators, and vehicles that are run by biogas were easily available, the farmers would be encouraged to use it since biogas production is relatively cheap than the other alternatives. According to Le Toah, biogas users in the future will have to decide if they want to increase the size of their biogas digester. He thinks storing biogas in a separate location is too risky and complicated. Especially during the wet season of Vietnam, any shortcomings in the management of the biogas storage could be catastrophic to the household.

Another constraint is the lack of use of the biogas waste. 21 % of the SNV sample considered the bio fertilizer an influential reason in using the biogas system. Only 45 households of the SNV sample used the slurry. The livestock is the main source of income for the farmers, many of them have very small plots of land which enables them grow vegetables and rice for personal use only. The results were also similar the districts I interviewed. Only a small portion of the households used the bio fertilizer, many would just discharge the waste outside in the environment when they had to clean their digesters. One farmer had a relatively large plot of land he would grow vegetables in the first district I visited. He did not use the biogas slurry because it was too hard to spread it around the whole plot because its transportation is very difficult. Its difficult transportation also makes it impossible for the households to sell the fertilizer in the market. Also in a study investigating the affects of bio fertilizer on tea production in Vietnam it was found that farmers did not like to use bio fertilizer because it requires a lot of labor because of its liquid composition. Chemical fertilizers do not have this problem, making it the preference to most farmers (von Eije, 2007).

The SNV offered two training courses for the users. One course was a biogas awareness course and the other one was a using and operating course. In these courses the participants received booklets and information on the biogas technology as well instructive books for the maintenance of the biogas system. These courses were free of charge and households had the choice if they wanted to participate. Only 4.4% of the households did not participate, 7 percent only participated in the awareness course, 50 percent in the using and operating course, and 39% participated in both courses. This indicates that households would be willing to participate if there was one system. Figure 8 summarizes what the households thought should be improved in the training course.



Source SNV User Survey, 2009

Figure 8: Improvements in Training

117 households though that the maintenance and operation needs to be improved. This was followed by safety, slurry utilization and construction. From these results one can deduce that the users are aware with problems and are willing to improve. For example about 90 households believe that they need more training on slurry utilization because they are aware of the benefits they can reap from it.

In the two districts I interviewed none of the households participated in any training course for biogas. If any of the farmers encountered problems or questions they would ask their fellow farmers or the engineer that sells the equipment. Even if they wanted to, they have no access to any training program. Most of the households said they would be willing to go to a training course or receive extra information about the whole biogas process.

6. Cost Benefit Analysis for Large Scale Digester

Most of the discussion has been about family size digesters. About 80% of the livestock sector is small scale producers. The characteristics of the users were explained earlier and it is safe to assume the same for most small scale producers. Large scale biogas digesters are the same as the small scale except they are bigger in size which allows more storage of gas. In this section I will perform a cost benefit analysis for a large scale biogas digester in the Trang Bom district, which is located in the south east of Vietnam. The population is 192,627 and is very economically active. All three sectors agriculture, industry, and service operate in this district and it is seen as one of the economic hubs of the south. Agriculture is the most important sector and it is also the most active one in this district (General Vietnam Statistics office).

The digester is a large scale fixed dome digester placed underground. As explained earlier this reduces the affect the climate has on gas production, and this is crucial since the wet season in Vietnam is approximately 6 months. There are 170,049 pigs in this district. There are three types of livestock farms, small livestock exclusively producing pig, mixed livestock farms, and large scale.

The data was taken from a research done by Dinh Thi Minh Ngoc for Nong Lam University, unless stated differently. According to Dinh Thi, about 75 percent of the waste is treated and 25% is discarded directly to the environment. There are two main ways to collect waste, the first one is to manually collect the waste, and the second is to place tunnels under the pig cages in order to facilitate the collection of the waste. The large scale digester that is being examined is part of a large farm that has about 2000 pigs. It operates all year, the pig waste is mixed with water and other treatments and mixed in the digester. The size of the biogas digester needs to be big enough to handle all the waste. According to Lien's study each pig depending on its

size produces 15-50 (0.015-0.05 m liters of waste). So the size of the biogas digester needs to be at least 1000 m^3. The actual digester has a capacity of 1222m^3. It needs about 30 days worth of animal dung to start operating, once these 30 days of dung is accumulated the digester should work continuously. The biogas waste is also cleaned out regularly and the slurry is used as fertilizer. It is assumed that the system operates for 20 years, there is no official time line however it's expected to last that long.

6.1 Identifying Costs

Construction	1467.45 (First year only)
Maintenance	0.25 (per year)
Labor	4 (per year
Electric Pump	3.84 (per year
Waste Treatment	45.36 (per year

Source: (Minh Ngoc, D.T., 2009)

Table 6: Biogas Digester Costs (1,000,000 VND)

The table above summarizes all the costs required to operate the large scale digester. The first cost is the construction cost, 1467.45 million VND and this includes everything required to build the digester, including wiring, cooker, lights, and other materials required in the initial installation process, this is paid the first year. Since this is a large scale farm labor from outside the household will be required. Labor is 4 million VND a year, the labor is required to clean the animal cages, mix the waste with water and mix in digester, and take out the biogas waste (slurry fertilizer).. Maintenance costs are about 0.25 million VND a year. An electric pump (included in construction cost) is required to pump the gas out. Since this is a large digester and the area is over 1000m^3, an electric pump is needed to make sure the gas comes out smoothly; this costs about 3.84 million VND a year (electricity cost). The final cost is the waste treatment. This is the most expensive cost and this includes all the materials needed to treat the waste.

6.2 Identifying Benefits

The table below summarizes the benefits of the biogas system. The benefits are presented in monetary terms and they are the amount of money saved per year compared to the situation with no biogas system. The values are in 1,000,000 VND

Natural Gas (fossil fuel)	8.64
Fertilizer	24.00
Fish Food	72.00
Sale of Waste	1.00
Sale of Product	456.96

Source: (Minh Ngoc, D.T., 2009)

Table 7: Biogas Digester Benefits (1,000,000 VND)

The farm has biogas lamps installed, and the biogas is mainly used to light the farm. The gas is also used for cooking and heating the animals, the biogas saves the farm 8.64 million VIND in gas costs. The final cost is the sale of livestock (product), as mentioned earlier on the biogas system improves the health condition of animals. It is only natural to have a lot of biogas waste in such a large digester, unlike the small scale farmers, in this case the fertilizer is utilized and the excess is sold to neighboring farmers in the district. The farm makes/saves 24 million VND per year. Some of the biogas waste is used to feed the fish in a pond near the farm, the fish is mostly used for personal use however the biogas system also provides food for the fish and this saves 72 million VND annually. The waste that is not used is sold for 1 million VND per annum.

Table 5 in the user section shows that biogas increases production and this will be even more evident in a large scale farm of 2000 pigs. The biogas system increases the reproduction rate of the pigs and this increases the sale distribution. It is reported that the biogas system increased the sale distribution on average of two more sales a week. This increases revenue and leads to an annual profit of 456.96 million VND.

6.3 Cost Benefit Analysis

The appendix has the complete table of costs and benefits and the cash flow. The cash flow in the appendix shows that the initial year the costs surpass the benefits, however the remaining twenty years the benefits exceed the cost. Without discounting any of the values it is evident that the investment will break even in the first two years. The second part of the table in the appendix has the discounted costs and benefits. In the table a discount rate of 10% is used, this is the official discount

rate of the Central Vietnamese Bank. This is relatively a high a discount rate therefore the future values of benefits and costs are lower. The NPV is the sum of the discounted cash flow in the table, and it is computed by the following formula:

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+i)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+i)^t} = \sum_{t=0}^{20} \frac{11814.60 - 2589.90}{(1+.10)^{20}} = 5352.33 - 1975.95 = 3376.38$$

B_t is the benefits at time t, C_t costs at t, i represents the interest rate of 10% and t is the time period of 20 years. The NPV is the difference between the discounted benefits and costs, which in this case is 3376.38 million VND which is approximately equal to 160,000 US $. The criteria for NPV is that it should be greater than 0, and in this case the NPV is much greater. The high NPV indicates that benefits will surpass costs over the 20 years of the biogas system.

The next ration I will look at is the net benefit investment ration. Since finance is not endless it is important to realize how much benefits will be accrued compared to costs put into the project. The formula bellow calculates this ratio:

$$N/K = \sum_{t=p}^{n} \frac{N_t}{(1+i)^t} / \sum_{t=0}^{n-p} \frac{-K_t}{(1+i)^t} = \sum_{t=1}^{20} \frac{10183}{(1+.10)^{20}} / \sum_{t=0} \frac{-(-958.30)}{(1+.10)^0} = 4334.68 / 958.30 = 4.52$$

N_t is the net benefits, only the positive annual benefits will be used from p to n (20) (p represents the years of positive net benefits), K_t represents all the costs in the year that exceeds the benefits from the year of commencement to the final year where investments costs are higher than net benefits. In this case only the commencement year (year 0) investment costs are higher than benefits. T is for the 20 year time period, and i is the discount rate. The N/K is 4.52, a project is considered to be profitable when the N/K exceeds 1, and in this case it is more than 4 times the minimum. These two values, the NPV and N/K indicate that the project is economically and financial beneficial and that benefits will surpass costs over the 20 years.

The cost benefit analysis did not include the social benefits that such a biogas system can offer. The adequate treatment of waste from 2000 pigs reduces the environmental pollution and hazardous health affects compared to the situation with no biogas digester. Now such affects can be included in a more comprehensive cost benefit analysis in which these factors are properly quantified. However if this was the case it would increase the benefits and therefore increasing both values of NPV and N/K, which would make the project even more attractive.

6.4 Discount Rate Sensitivity Analysis

As mentioned earlier, the discount rate, is one of the main determinants of the overall cost benefit analysis. The NPV value of this project surpasses the basic criteria of NPV being greater than 1. The internal rate of return (IRR) was calculated in order to find the discount rate that equates the discounted costs and benefits over the past 20 years. Any discount rate higher than the IRR would result in a negative NPV. The formula for calculating the IRR is as follows:

$$IRR = \sum_{t=0}^{n} \frac{B_t}{(1+.i)^t} = \sum_{t=0}^{n} \frac{C_t}{(1+.i)^t} = \sum_{t=0}^{20} \frac{11814.60}{(1+.i)^{20}} = \sum_{t=0}^{20} \frac{2589.90}{(1+.i)^{20}} = 0.53$$

The symbols are the same as the ones for the NPV, the idea of this formula is to equate the discounted benefits and Costs with only the discount rate unknown. From the formula the IRR was calculated to 0.53. This is a very high IRR, no cost benefit analysis would use a discount rate as high as 50%.

The figure below displays the relation between NPV and discount rate:

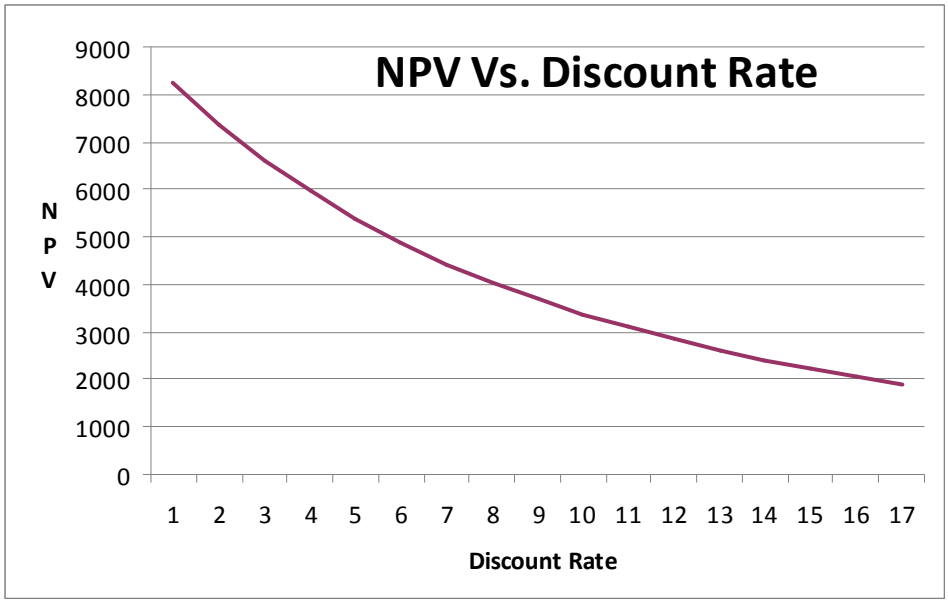


Figure 9: NPV Vs. Discount Rate

The relationship is an indirect one, the higher the discount rate the lower the NPV, a 1% discount rate results in the highest NPV which just exceeds 8000 million VND. The figure will keep declining until it reaches a discount rate of 53%, after that point the NPV will become in the negative. The criteria for accepting a project using the IRR is that accept projects where the discount rate used is less than the IRR. In this case any discount rate up 53% will be accepted, since 53% is very high and no cost benefit analysis will use such a discount rate it is safe to assume that the discount rate is not as influential since the discounted benefits will always exceed the discounted costs (unless a discount rate greater of 53% is used).

Conclusion

The results of the cost benefit analysis are straightforward and positive. Economically, large scale biogas digesters are feasible. It is also safe to conclude the same for small scale digesters. The only major costs incurred by the owners of the biogas system are the initial investment costs, the yearly costs are minimal compared to the annual benefits. The average farmer that uses a small scale digester does not really face any significant opportunity cost in using a biogas system. Most biogas digesters are placed underground, therefore the land is not completely used up, and only minor components of the system appear above ground. The labor is normally taken care of by a member of the household. The waste is properly treated reducing

environmental pollution, increasing livestock production and improving human health. The larger production is especially evident in the large scale livestock farms; in the cost benefit analysis the increase in sales was the main annual benefit.

One may safely conclude that biogas improves many aspects of the farmer's life. Unlike the countries mentioned in the literature review, social constraints were not that determinant in Vietnam. Looking at the number of people who voluntarily participated in the SNV training course indicate that there is a favorable attitude towards biogas. There are two main factors that contribute to the lack of social constraints. The first one is that even though Vietnam has a small number of digesters compared to India and China, policy makers in Vietnam have been toying with the idea since the 1970s. It's been 40 years since the commencement of biogas research and I believe that in this time the average Vietnamese citizen has been made much more aware of the biogas benefits. The positive experiences in neighboring East Asian countries are the second reason why social constraints were not that obstructive in Vietnam. Many of the projects in China, India, and Nepal have been successful and also publicized; this probably paved the way for social acceptance in Vietnam.

On the policy level, the Vietnamese government has been successful in learning the experiences of other Asian Countries. The SNV project is the perfect model for biogas strategy. Most of the biogas digesters are already installed and the SNV are following up and recording the experience of the users and keeping track of technical issues. Ideally, the whole of Vietnam should adopt a similar system. The SNV project is only confided to some provinces in Vietnam and not all. The two districts I visited were not part of the SNV project and one of them did not receive any sort of support while the second district received some financial support. The financial constraint is probably the biggest obstacles in the Vietnamese biogas program. According to the various people I interviewed in the Agriculture Ministry and ISPONRE all the districts have access to financial aid. In reality this was not the case, the first district I visited did not enjoy any sort of financial support. Therefore ISPONRE's 6th program that deals with the financial issues in the biogas strategy is essential in aiding poorer farmers to install biogas systems.

Another constraint which is currently hampering further biogas progress in Vietnam is the organization of information. The average Vietnamese farmer has a very limited choice in biogas technology. In the two districts I visited I observed a minimal of options for biogas technology. I observed that Vietnamese farmers have

two choices when it comes to the digester, the cheap option, and expensive option. The cheap option is a digester made from plastic, and the expensive is a verification of the fixed dome digester. There are various models, and various modifications of each model, yet Vietnamese farmers normally settle for what is available. The same can be said for appliances; currently cooking and lighting are the main uses of biogas. There are many other uses for biogas; in electric generators, in motors for transportation, etc. The large scale digester I investigated in the cost benefit analysis did not utilize an electric generator, which emphasizes the problem of lack of information. Farmers just don't know how they can improve their utilization of biogas.

The strategy does call for the creation of management offices all over Vietnam, and a biogas network. These need to be accomplished as soon as possible because they will facilitate the process for the farmers. They can also play a positive role in evaluating the biogas network. Without organized information and easy access improvements in the biogas strategy will be very slow and not as effective as it should be. This also corresponds to the final program in the ISPONRE strategy *"Program on enhancing capacity for monitoring and efficient treatment of socioeconomic, technical situations in the development of biogas technology in the Vietnamese animal husbandry sector."*

Solving all the mentioned constraints would improve the overall biogas situation in Vietnam. Farmers are excited about this technology and would be willing to use biogas in every possible way. This would increase the household's reliance on a renewable form of energy, with most of Vietnam's population living in rural areas this would have astonishing affects on the national economy. The best way to overcome these constraints is to create a comprehensive training course. In this training course the various technical aspects of the biogas system will be explained as well as possible uses for the biogas and the biogas waste.

Training is also included in the strategy, and this is really important. From what I was able to understand that only the SNV project participants had access to training. Indeed the two districts I visited had no access to any sort of training course. The government needs to promote training all over in order to exemplify the positive practices and negative practices. For example releasing methane in the air, some households do this, and if many households start doing this practice negative effects will be felt in the environment. Another issue that needs to be addressed in the

training courses is the use of the biogas slurry. Many households were found not to use the slurry correctly, and this can be changed if the farmers are made aware of its benefits compared to normal fertilizer.

Finally research is an ongoing process; there are already many successful research programs in various universities as well as in international agencies such as the UNDP, FAO, etc. By 2020 Vietnam should have the capabilities to increase biogas users and increase the countries source of energy from renewable sources while treating the waste of the expanding livestock sector.

Discounted Cost and Benefits

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Sum
Cost																						
Construction	1467.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1467.45
Maintenance	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	5.25
Labor	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	84.00
Electric Pump	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84	80.64
Waste Treatment	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	45.36	952.56
Benefit *(In terms of money saved)*																					Total Costs	2589.90
Fossil Fuel	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	8.64	181.44
Fertilizer	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	504.00
Fish Food	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	1512.00
Sale of waste residue	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	21.00
Increease In Sale of Product	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	456.96	9596.16
Discout Rate:	0.10																				Total Benefits	11814.60
Cash Flow	-958.30	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	509.15	9224.70
Discount Factor	1.00	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39	0.35	0.32	0.29	0.26	0.24	0.22	0.20	0.18	0.16	0.15	
Discounted Costs																						
Construction	1467.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1467.45
Maintenance	0.25	0.23	0.21	0.19	0.17	0.16	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.07	0.06	0.05	0.05	0.04	0.04	0.04	2.38
Labor	4.00	3.64	3.31	3.01	2.73	2.48	2.26	2.05	1.87	1.70	1.54	1.40	1.27	1.16	1.05	0.96	0.87	0.79	0.72	0.65	0.59	38.05
Electric Pump	3.84	3.49	3.17	2.89	2.62	2.38	2.17	1.97	1.79	1.63	1.48	1.35	1.22	1.11	1.01	0.92	0.84	0.76	0.69	0.63	0.57	36.53
Waste Treatment	45.36	41.24	37.49	34.08	30.98	28.16	25.60	23.28	21.16	19.24	17.49	15.90	14.45	13.14	11.94	10.86	9.87	8.97	8.16	7.42	6.74	431.54
Discounted Benefits																				Total Discounted Costs		1975.95
Fossil Fuel	8.64	7.85	7.14	6.49	5.90	5.36	4.88	4.43	4.03	3.66	3.33	3.03	2.75	2.50	2.28	2.07	1.88	1.71	1.55	1.41	1.28	82.20
Fertilizer	24.00	21.82	19.83	18.03	16.39	14.90	13.55	12.32	11.20	10.18	9.25	8.41	7.65	6.95	6.32	5.75	5.22	4.75	4.32	3.92	3.57	228.33
Fish Food	72.00	65.45	59.50	54.09	49.18	44.71	40.64	36.95	33.59	30.54	27.76	25.24	22.94	20.86	18.96	17.24	15.67	14.24	12.95	11.77	10.70	684.98
Sale of waste residue	1.00	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39	0.35	0.32	0.29	0.26	0.24	0.22	0.20	0.18	0.16	0.15	9.51
Increease In Sale of Product	456.96	415.42	377.65	343.32	312.11	283.74	257.94	234.49	213.18	193.80	176.18	160.16	145.60	132.37	120.33	109.39	99.45	90.41	82.19	74.72	67.92	4347.32
																				Total Discounted Benefits		5352.33
Discounted Cash Flow (SUM=NPV)	-958.30	462.86	420.79	382.53	347.76	316.14	287.40	261.27	237.52	215.93	196.30	178.45	162.23	147.48	134.08	121.89	110.81	100.73	91.58	83.25	75.68	3376.38

Source: (Minh Ngoc, D.T., 2009

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