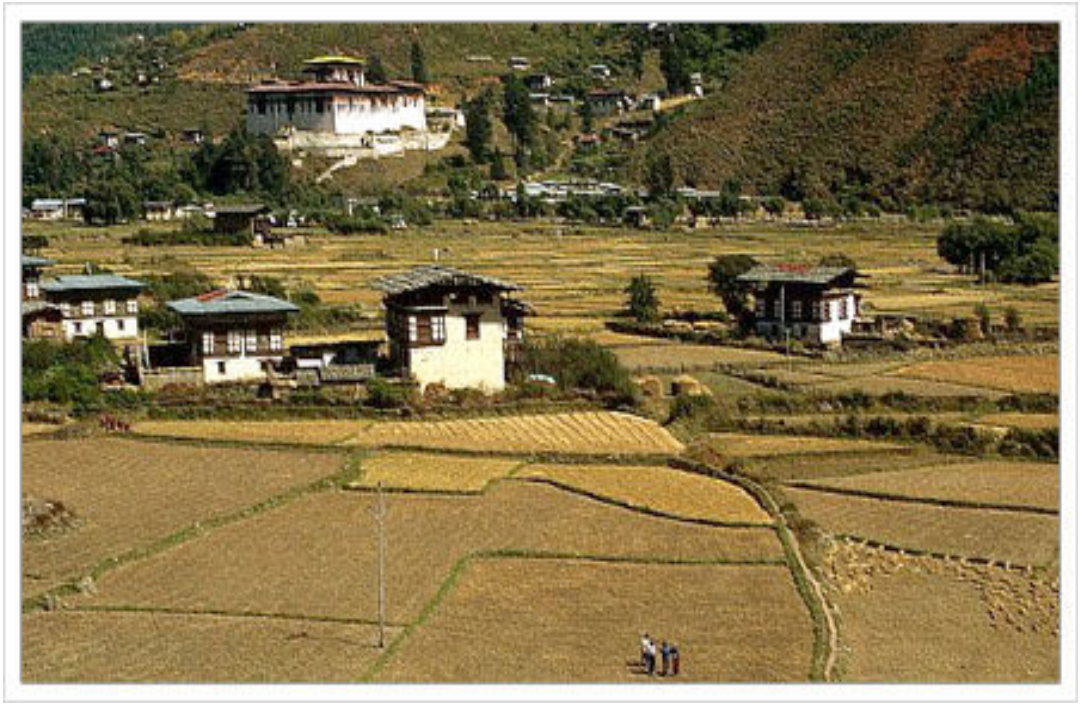
Feasibility of a Biogas Programme in Bhutan



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Executive summary

This report presents the findings and recommendations of a study conducted by SNV the Netherlands Development Organization to assess the feasibility of biogas programme in Bhutan. The report is prepared based on the meetings with government officials, households and field observations which were carried out in the second week of December 2008.

A small scale biogas programme for domestic use looks feasible in Bhutan however, there are challenges as well. About 20,000 biogas plants are technically feasible especially in southern parts and inner mountain valleys. There are sufficient cattle for dung and cattle raring practice is more permanent in nature. Investment return on biogas in relation to LPG, firewood and electricity is higher therefore found financially beneficial. Government interest and commitment in promoting biogas is another strong factor for possible success of the programme.

The market is not big enough to attract private sector. Variation on temperature within short geographical distance might be another challenge while selecting potential households. The technology is new in the country therefore needs to build up capacity within the implementing organisations. Motivating households for adopting biogas might be another challenge at the beginning however, households seem positive with new technologies. Provision of subsidy and soft loan can help to attract more customers.

Department of Livestock looks appropriate organization to implement the programme however, collaboration with Renewable Energy Division will be essential. A pilot programme may be useful before launching a full fledge biogas programme to develop confidence within implementing organizations.

A tentative outline of the full fledge biogas programme is presented in this report. About 1,500 plants can be installed within 3 years especially in warm temperature areas. About 37 million NU is estimated as investment costs for these plants. It is assumed that about 50 percent of the plants may require credit. About 25,000 NU is estimated as construction costs of a 6 m3 plant of which about 9,000 NU per plant can be provided as subsidy to farmers which helps to reduce the investment costs. The plant design GGC 2047, popularized in Nepal, is proposed to adopt in Bhutan and gradually improved as per local conditions through research and development activities.

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Abbreviations

BBP	Bhutan Biogas Programme
BDFC	Bhutan Development Finance Corporation
BPP	Biogas Pilot Programme
BSP	Biogas Support Programme, Nepal
CDM	Clean Development Mechanism
DoL	Department of Livestock
DoE	Department of Energy
EIRR	Economic Internal Rate of Return
FIRR	Financial Internal Rate of Return
GGC	Gobar Gas Company of Nepal
GNH	Gross National Happiness
GI	Galvanized Iron
Ha	Hector
HH	Household
Kg	Kilogram
LPG	Liquid Petroleum Gas
Ltrs	Liters
MoA	Ministry of Agriculture
Mt	Metric Tones
Mtrs	Meters
MW	Megawatt
M3	Cubic Meter
NU	Ngultrum (Bhutanese currency)
RED	Renewable Energy Division
SNV	Netherlands Development Organisation
US $	United States Dollar

Exchange rate used: 1 US $ = 47.00 NU

PART –A
Feasibility of Biogas Programme

1 Background

Royal Government of Bhutan has shown keen interest on promoting biogas technology in Bhutan. In this regard, Ministry of Agriculture requested SNV/ Netherlands Development Organisation to carry out a feasibility study on biogas therefore, this assignment was carried out by Sundar Bajgain, Senior Biogas Advisor of SNV.

The SNV Advisor visited Bhutan on 07- 13 December 2008 to collect information and assess the possibilities for biogas.

A meeting with the Secretary of Ministry of Agriculture along with other officials was held in the ministry. Similarly, other meetings with Head of Department of Livestock along with his colleagues and Head/Chief Engineer of Renewable Energy Division, Department of Energy was held. In all meetings the officials have expressed deep interest on promoting biogas in Bhutan therefore, requested to explore the possibilities of biogas in Bhutan and recommend on way forward.

The officials in all meetings expressed the following reasons for a need of biogas programme in Bhutan.

- Bhutan's rural population is depending mainly on firewood as source of cooking energy. Firewood collection from the forests is becoming difficult these days since people are not allowed cutting trees in the national forests. Community forest allows its members collecting dead trees and twigs only which is more time consuming and difficult. Furthermore, government aims to protect the natural forests with the access of alternative sources of energy to the households.
- LPG is another source of cooking energy however, it is becoming expensive these days and won't be a long term solution.
- Electricity can be another solution but it is hard to reach every rural household with greed connection. Cooking of complete meal from electricity is also not in practice in Bhutan and house holds still need other sources of energy for cooking beside electricity.
- Government is keen to promote clean energy technologies with the view of worsening global climate change and protecting environment. Bhutan has already initiated carbon fund projects and believes that biogas can be another good carbon project in the future.
- Government is planning to develop a programme intending the cattle more stabling rather than allowing them free grazing in the fields which will help to collect more dung and promote biogas technology.

Keeping these reasons and request in mind, the report is prepared in three parts. The first part discusses on the feasibility of biogas in Bhutan. The second part briefly touches and recommends the Pilot Biogas Programme where as the third part presents the outline of implementation modality of the proposed programme.

1.2 Objective

The main objective of the study is to assess the feasibility of biogas programme in Bhutan and recommend the possible implementation modality.

The information related to this study was collected from number of sources:

a. Secondary information like reports, government publications, websites etc
b. Meeting with government officials, field office staff and households during 7-13 December 2008.
c. Information collection on materials costs from the local markets.

The report is prepared on the basis of factual information however, the writer used his own experience in some cases where information was not available. The writer did not visit southern part of Bhutan believing that the southern part is similar to other potential biogas countries like Nepal therefore, derived the conclusion based on his own experience.

2. Country introduction

Bhutan is a landlocked country surrounded by India to the east, south and west and China to the north. With an area of 38,394 square kilometers, Bhutan is a mountainous country rising from southern plains of 160 m above sea level and extending into the northern mountain peaks of over 7,500 m high. Over 72 percent of the country is covered with natural forests. The country may be divided into 3 climatic zones corresponding to its altitudes. The climate is humid and subtropical in the southern plains and foothills, temperate in the inner Himalayan valleys of the southern and central regions and cold in the north. Temperatures vary according to elevation. Temperatures in Thimphu, located at 2,200 meters above sea level in west-central Bhutan, range from approximately 15° C to 26° C during the monsoon season of June through September but drop to between about -4° C and 16° C in January. The south is more temperate and ranges the temperature between 15 to 35 degrees Celsius.

Figure-1 Map of Bhutan

As per the population census of 2005 the total resident population of Bhutan is 634,982 with total 126,115 regular households.[1] The rural and urban population is 79.0 percent and 21.0 percent respectively. People live in 1,000 small villages of 20 Dzonkhags (Districts) and 197 Gewogs. The average population density is 16 persons per square kilometer. The average size of Bhutanese household is 4.6 persons. About 75 percent of rural residents have access of safe drinking water whereas about 86 percent rural people use latrines.

[1] Results of Population & Housing Census of Bhutan 2005, Office of the Census Commissioner, Royal Government of Bhutan

2.1 Agriculture sector

Bhutan's economy is predominance of the agriculture, livestock and forestry. The population is increasing by 2.9 percent per year and the agriculture consists largely of subsistence farming and animal husbandry. About 7.7 percent of the total land is considered as agriculture land and the potential for additional land to agriculture is limited due to the rugged terrain. The cropping pattern varies across the country. In western Bhutan, high altitude rice is the primary food crop. Similarly wheat and buckwheat are the major food crops in central Bhutan while maize is the main source of food in the eastern Bhutan. Oranges, apples are produced in some areas.

Forests are part of the Bhutanese farming system and help to conserve agricultural productivity. The farmers sustain their farm productivity by regular application of organic manure developed through recycling animal bedding with dung.

About 90 percent of the rural households own livestock. The total livestock population is about 4000,000 that include cattle, buffalos, horses, yaks, mules and donkeys[2]. Livestock are an integral part of the Bhutanese farming system and support agriculture through provision of manure and draught power. The value of livestock as a source of cash income is increasing with better marketing of milk, butter and cheese.

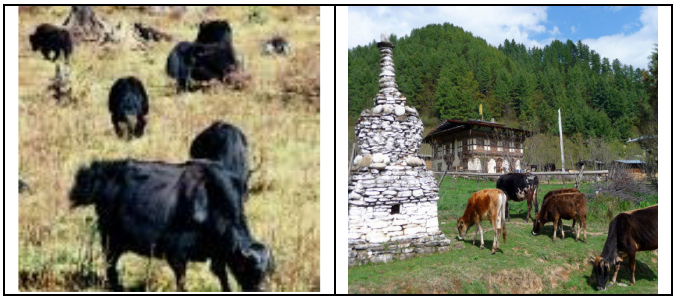


Figure-2 Cattle in rural areas

Households in the eastern and central part of Bhutan have more livestock per household than in the western, northern and southern part of Bhutan.

The government plans to improve and lease -out the pasture lands for better control on grazing and to improve the productivity of the pasture lands and livestock. Currently, about 4 percent of the total land is used as pasture lands. The present size of pasture land is about 2.5 ha per livestock in the alpine region, 0.4 ha per livestock in the temperate region and 0.2 ha per livestock in the subtropical region. This pasture land size indicates that the southern part where cattle population is relatively higher has limited pasture lands thus farmers are forced to more stabling their cattle.

2.2 Energy supply

Bhutan is progressing very well in producing hydro electricity which became one of the major earning sources of Bhutan. Bhutan, currently is producing 1,490 MW hydropower

[2] Department of Livestock 2008

however, aims to produce another 7,000 mw and export to India by 2020. Bhutan is giving high emphasis on producing and exporting hydro electricity since production of hydro electricity is cheapest in Bhutan. However, one of the objectives set in the Tenth Five Year Plan is to identification and utilization of alternative sources of energy in Bhutan. Over 57 percent of the total population has access of electricity which is mainly use for lighting and heating. The tariff of electricity for domestic customers is in 3 categories depending on amount of consumption which is between 0.75 to 1.70 NU per kw/h[3]. It is learnt that majority of the rural households pay about 150 NU per month for electricity. According to the Bhutan Energy Data Directory 2005, Bhutan is at the top list of per capita electricity consumption in South Asia amounting to 1,174 kw hour per year.

The second source of lighting is kerosene which is used by over 36 percent of total population (52 percent in rural areas). Kerosene is highly subsidized (10 NU per liter) and distributed in a fixed quota system. Each household receives 10 ltrs of kerosene per month.

About 3 percent of population use firewood as source of lighting whereas same number of households is enjoying Solar Home System for lighting.

In case of cooking fuel, three main sources were considered. 37.3 percent of the total households use firewood (56 percent in rural areas). Although Bhutan is rich with natural forests, access of firewood is becoming difficult these days. This is mainly due to the government decision not to allow cutting trees with the view of conserving the natural forests. House holds need sometime more firewood for space heating rather than cooking. Therefore, the pressure on the forests is increasing.

30.6 percent (21 percent in rural areas) households use electricity, the second largest source of cooking energy. Although government is trying to reach all households with access of electricity by 2014, still many rural households might be difficult to connect with greed due to the scattered houses in rugged mountain areas. They still will need to be depending on firewood or other alternative source of energy.

A significant portion of households, 25.6 percent, are using LPG (15 percent in rural areas) for cooking their meals. LPG has to be imported from India and becoming more expensive these days. About 500 mt of LPG is being imported to Bhutan every year however, the demand is much more higher.

[3] Department of Energy Bhutan website

Figure 3 Forests-source of firewood and transporting LPG bottles

The Energy Data Directory compiled by Department of Energy in 2005 states that rural electrification has, however, contributed to decrease in firewood consumption in houses with 30 percent.

3. Biogas in Bhutan

Biogas is new for most of the Bhutanese households however, an attempt was made during late 80s to introduce biogas technology installing about 54 biogas plants in Southern Bhutan. There is no concrete information on the status of these plants however, following information was obtained from Mr. Nar Bahadur Khatiwara, Engineer of Renewable Energy Division.

The model selected for these plants was Deenbandu type-fixed dome digester of 4m3 and 6m3 capacity. When consulting with the villagers, it was found that the majority of the biogas plants stop functioning after few years of installation mainly due to gas leakage from the digester and moisture trap. Some of them worked for more than15 years without major problem. The first plant constructed as a demonstration plant functioned till 2006. It is assumed that this first plant worked longer due to high quality construction. After the failure of these plants, no further attempts for promoting biogas was made in Bhutan.

As per Mr. Khatiwara, following could be the main reasons of failure and low acceptance of biogas plants in Bhutan.

- High cost of the digesters. (Due to low income of the villagers, it is difficult to effort USD 300-400 per plant)
- Lack of technical expertise for installation and maintenance works.
- Lack of training and awareness programme to the users.
- Lack of coordination and follow up of the activities among the stakeholders involved.
- Unavailability of spare parts for replacement.
- Difficulty in collection of cattle dung

While these days many other Asian countries are promoting biogas successfully, Bhutan now has again realized that biogas can be an appropriate source of energy for rural households and there should not be any reason not to be successful in Bhutan. With these realizations, Bhutan will soon be developing Renewable Energy Policy which will guide how to promote renewable energy in Bhutan. Bhutan is also moving forward with receiving carbon funds through Clean Development Mechanism for its hydro projects and considers that biogas can be another good source of carbon revenue.

Recently, Department of Energy, Renewable Energy Division has identified a site for constructing a pilot plant with the aim of up-scaling the technology in the country. Similarly, Department of Livestock has also identified 3 locations for constructing pilot biogas plants with the aim of serving households with biogas in high altitude areas. These initiatives clearly show that there is willingness of promoting biogas technology within the government level.

3.1 Benefits of Biogas plants

Benefits of biogas, in context of Bhutan, are similar to other Asian countries. Biogas mainly saves money with replacing firewood and LPG however it will have lots of intangible benefits. In general biogas can have following positive aspects:

- Biogas is a clean and easy source of cooking energy and does not produce bad smells.
- It saves time of cooking and fuel wood collection from the forests.
- It replaces LPG, kerosene, dung cakes and saves money.
- It helps to preserve forest by saving firewood.
- Biogas can be used for lighting.
- Biogas reduces indoor air exposures and improves health conditions especially of women and children.
- It helps to maintain clean surroundings using cattle dung into the digester. Toilet connection to the biogas improves sanitation conditions of the rural community.
- Bio-slurry is an excellent organic fertilizer for crop production.
- Cooking utensils are easy to clean and do not get too dirty while cooking with biogas.
- Cooking from biogas is safe

Benefits from biogas in terms of monetary value can be summarized below:[4]

SN	Benefit	Quantity	Amount (NU)	Remarks
	For Households			
1	Firewood savings	2,200 kg/year	2,200	Time of collection or cash
2	LPG savings (bottle)	2 bottle/year	1,000	Additional to the firewood (average)
3	High nutrients fertilizer saving	1,200 kg/year	1,200	10% additional nutrients of total dung used

[4] Data collected from households during field visits

4	Kerosene savings (or electricity)	120 Ltr/year	1,200	Mainly for lighting in case of no electricity
5	Reduction on indoor smoke exposures	LS	400	Estimate derived from other programme
	For National/Global			
6	Carbon emission reduction	3 tones/year	1,500	

Figure-4 Benefits of a biogas plant

However, there are some negative aspects of biogas plant.

- Needs to keep always required number of cattle.
- Feeding dung and water everyday is sometime difficult and extra work.
- It does not produce gas if the temperature is too low.
- Investment at the beginning becomes difficult to the low income households.
- Biogas plant can not be moved in case household wants to move another place.
- Natural calamities like earthquake, landslides, floods can damage plant and difficult to repair.
- Fixed amount of gas is produced everyday and will not be available in case more gas is required.

4. Biogas potential

While looking into the possibility of biogas technology in Bhutan, one generally should consider technical as well as economic aspects of biogas programme. These aspects generally ask the following questions:

a) Is there sufficient dung available at the households?
b) Is water available to mix with dung?
c) Is temperature suitable for biogas generation?
d) Are construction materials easily available?
e) Can households pay for biogas plant?
f) Is biogas socially acceptable?

These questions are briefly discussed below.

4.1 Availability of dung

Bhutan has about 400,000[5] domestic animals (cattle, buffalo, yak, horse, mule and donkey). These cattle are kept mainly for milk, manure and draught power. Cattle are kept more on permanent nature however, in the cold areas cattle including people migrate to warmer places in winter. Most of the households let cattle for free grazing during day time therefore collection of dung at farm yard is less. It is estimated that about 6 kg[6] of dung per cattle per day is available at yard however, if these cattle are stabled then the availability of dung can reach up to 8 kg per day. A trend is observed that households intend to keep more hybrid cattle rather than ordinary cattle which eventually produce more dung. It is estimated that about 3,200,000 kg of dung can be produced every day

[5] Data from Department of Livestock
[6] Observation and information collected from households during field visits

from these animals however, not all dung is available at the yard. It is estimated that minimum 5 adult cattle will be required for smallest size biogas plant (4 m3) that fulfills the cooking requirement of 3-4 hours per day. Considering the population and number of households, it can be concluded that dung is sufficiently available in rural Bhutan.

4.2 Availability of water

Water is another pre-condition for biogas plant. The cattle dung needs to be mixed with equal amount of water and feed the plant every day. At lest 30 ltrs of water will be required for smallest size biogas plant however, not necessarily the water should be of drinkable quality. The water source in Bhutan is mainly from artisan, stream and piped water. Water is not easily available everywhere however, most of the houses are located to the close vicinity of water source and are not far from 20 minutes walking distance. However, biogas plant may increase workload to households for fetching additional water for biogas plant.

4.3 Temperature

Bhutan is mountainous country and temperature varies from place to place. The southern plains, foothills and valleys have (sub) tropical climate and temperature reaches sometime to 37 degrees Celsius. This climate is suitable for biogas generation. These places are relatively densely populated and fertile. The mid and northern parts are colder and temperature drops below 0 degree in winter. However, the mountain valleys like Punakha, Wangdue are relatively warmer and still could be suitable for biogas. About 38 percent of the households are estimated to be in below 1800[7] mtr altitude which is considered suitable temperature for biogas generation.

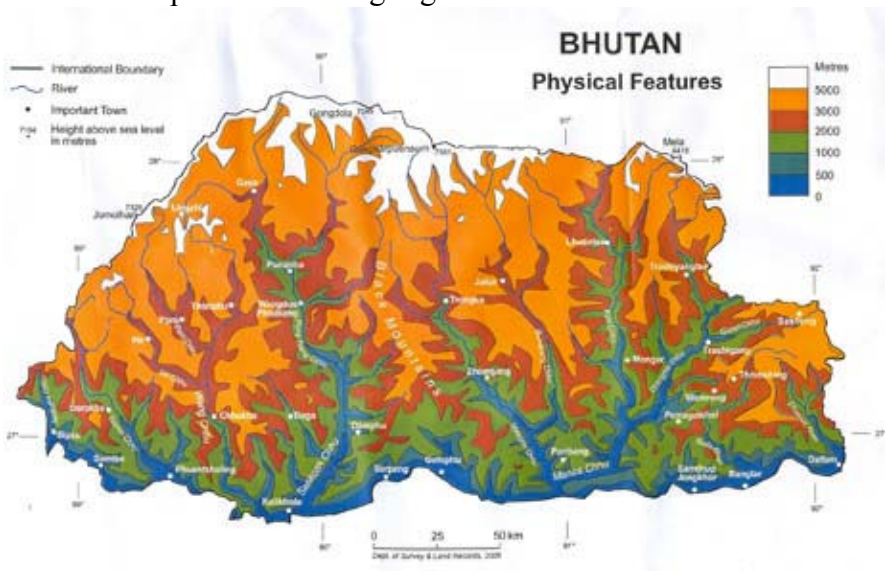


Figure-5 Physical map of Bhutan showing different climatic zones[8]

The map above indicates that the southern part along with some mountain valleys have suitable temperature for biogas generation.

[7] Directory of cities and regions of Bhutan.
[8] Bhutan Portal. Website of Royal Government of Bhutan

4.4 Availability of construction materials

Cost of biogas plant depends on the availability of local construction materials. These materials are mainly stones, sands, gravel, cement, pipes and biogas appliances. Stones, sands and gravels are easily available in construction sites and household can manage to collect them providing their own labors. Cement and pipes are easily available in local markets however, transportation facilities to the construction sites are limited. Biogas appliances can be produced in Thimpu otherwise needs to be imported from Nepal or Bangladesh. Construction masons are available locally but are relatively expensive than other countries.

4.5 Purchasing capacity of households

The recent data on household income and expenditures was not available however, based on the Household Income and Expenditures Survey 2000, the real per capita income of Bhutan is 1,321 US $. Population below poverty line (612.1 NU per capita per month) is 25.3 percent whereas population below upper poverty line (748.1 NU per capita per month) is 36.3 percent. The cost of biogas is still expensive for average rural farmers comparing to their income level. While asking households during the field visit whether they can pay for biogas plant, the answer was mixed. Two households who were ready for installing biogas plant under pilot programme was asking what would be the total costs and how much supports will be available to them.

4.6 Social acceptance

Since biogas is completely new for general Bhutanese people, it is rather difficult to estimate the social demand of biogas however, the information from various sources revels that Bhutanese people are quite receptive on new technology. Most of the Bhutanese keep their cattle at the ground floor of their home and use the dung without hesitation as fertilizer. Some time they make dung cakes from the cattle dung and use for cooking purpose. Therefore, it can be assumed that biogas will have no problem of social and cultural acceptance in Bhutan.

4.7 Cost of biogas plant

Cost of biogas plant in Bhutan is similar to other neighboring countries. Being a mountainous country and having stones available everywhere, it is proposed to adopt the biogas design promoted in Nepal. The plant shall be constructed using bolder, cement, sand and gravel. Bricks are not easily available and need to be imported from India therefore, are expensive. Local masons are available but needs training for biogas construction. Other construction materials are available in the market. Biogas appliances can be produced in local workshops however, importing from Nepal or Bangladesh is also possible. Based on the Nepal GGC model plant, the tentative cost of 6 m3 biogas plant is estimated to be about 25,000 NU[9] (531 US). Details of cost breakdown are in Annex- 2.

An attempt to compare the costs of various sources of energy use in Bhutan is presented in figure – 6. The costs comparison graph helps to understand overall yearly costs on domestic energy use in Bhutan.[10]

[9] Information collected from local markets
[10] Information collected from households

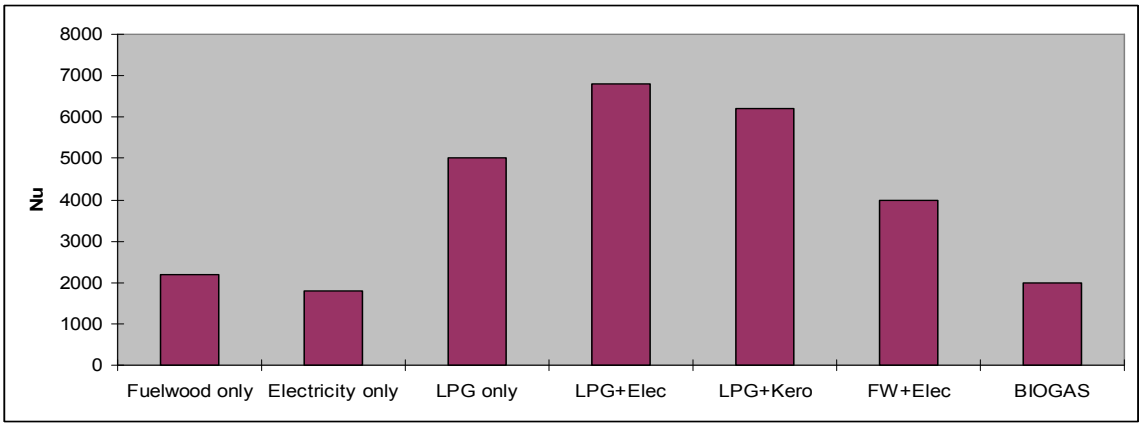


Figure-6 Costs comparison of various energy use

The most promising source of energy which will be expanded further in Bhutan will be hydro electricity. Electricity is cheap in Bhutan and all households who are connected with hydro electricity use electricity for cooking rice. This tendency may not be changed even biogas is introduced. However, meals other than rice are cooked either on firewood or on LPG. There are some initiatives on promoting Solar Coker and Improved Cook Stoves in remote mountain areas but are in limited scale. In this context, it can be concluded that the adoption of biogas by households depends on the tariff of electricity.

4.8 Investment subsidy

Biogas plant in Bhutan will require subsidy. The logics behind the need of subsidy are:

- Biogas is a new technology for Bhutan. Subsidy can be a strong tool for biogas promotion.
- The investment cost on biogas is not small for common rural households. The investment cost can be lowered with subsidy and can be within a range of affordability of common rural households.
- Biogas can have several social and environmental benefits in national and international level and subsidy can compensate the investment of households for these benefits.

An attempt to calculate the Financial Internal Rate of Return is done based on the data for a biogas of 6 m3. The total investment is assumed to be 25,000 NU with additional 2 percent maintenance costs every year. The costs include masons, labors, construction materials and appliances however, does not cover any additional construction fees or service charges for the plant constructor. The life time of the plant is considered for 15 years.

The financial benefits for users from biogas are considered mainly from fuels for cooking and lighting like firewood, electricity, kerosene and LPG. Financial savings from firewood is found the lowest however, savings from LPG is seen the highest one. The average savings combining of all (partial use of all sources) from biogas is estimated to

be about 3,400 NU per household per year. Fertilizer, health, time savings and carbon benefits are not considered while calculating FIRR.

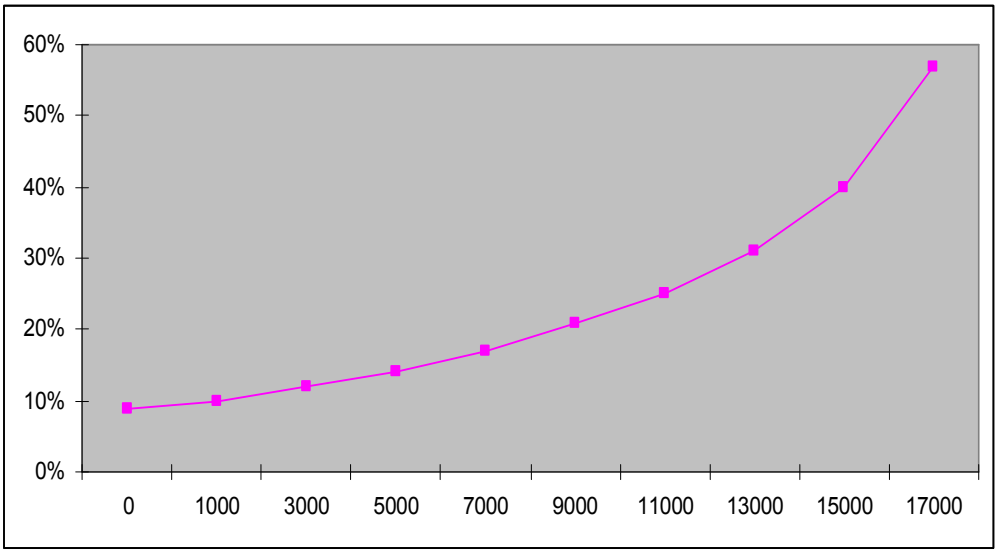


Figure -7 FIRR on biogas against Subsidy

The sensitivity analysis on the amount of the subsidy indicates that the FIRR falls between 17 to 21 percent while subsidy is considered between 7,000 to 9,000 NU per plant. Looking into the Financial Internal Rate of Return (FIRR) and EIRR from biogas plant, about 9,000 NU can be a justifiable rate of subsidy at the beginning of the programme. This rate can be adjusted (reduced) later on upon the economic level of Bhutanese households.

While calculating Economic Internal Rate of Return (EIRR), beside financial benefits from fuels, savings on fertilizers, reduction smoke indoor smoke exposure and carbon revenues are considered. Time saving is not considered because it is calculated under fuel wood savings. Toilets connections are not counted however it may have significant sanitation benefits if connected.

The EIRR starts from Firewood (8 percent) and adding all benefits finally reaches to 78 percent.

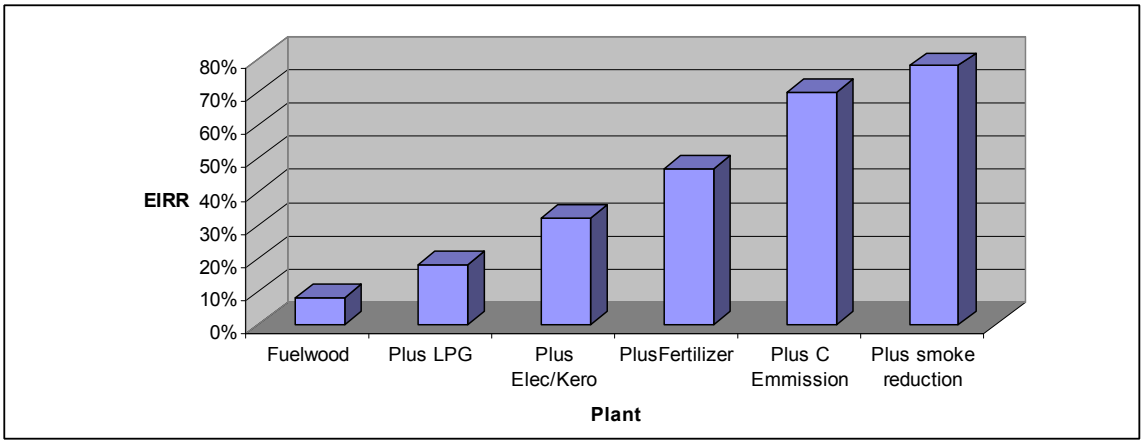


Figure – 8 EIRR of 6 m3 Biogas plant

4.9 Credit provision

Credits from banks are not common in rural areas however, Bhutan Development Finance Corporation has been established for providing credit to the rural households. Some farmers receive loan for agriculture and livestock purpose. The interest rate is generally 12 percent. Investment on livestock and agriculture returns the cash income through selling the products but biogas is different. Biogas saves lots from expanses but does not generate cash. In such case farmers will need to pay back the biogas credit from other earnings therefore, both financial institutions and farmers might be reluctant for using loans. However, provision of soft credit will be required for biogas.

4.10 Technical market potential

Taking into account the above parameters, the technical potential of biogas plants in Bhutan can be 20,032 which is calculated as per the table below:

Particulars	**No of Households**
Total households in Bhutan[11]	126,115
Households in rural areas [12]	87,804
Households with favorable temperature (less than 2000 mtrs altitude) [13]	47,407
Households with more than 5 cattle in favorable temperature areas [14]	20,032
Biogas Potential Households	**20,032**

Figure- 9

[11] Results of Population & Housing Census of Bhutan 2005, Office of the Census Commissioner, Royal Government of Bhutan
[12]Results of Population & Housing Census of Bhutan 2005, Office of the Census Commissioner, Royal Government of Bhutan
[13] Directory of cities and regions in Bhutan. www.fallingrain.com/world/BT
[14] Data from Department of Livestock

Out of the total 126,115 households in Bhutan, 87,804 households are in rural areas. It is assumed that most of the urban households have no cattle or less than 5 cattle therefore, are not feasible for biogas. Out of the 87,804 rural households, on average about 54 percent[15] (47,407 households) are considered potential housed based on relatively favorable temperature. These households generally get temperature between 15 degree to 32 degree Celsius are located below 1800 mtr altitude. Forty six percent households, however have sufficient cattle, are assumed to be in cold areas and are not suitable for biogas. Further, out of the 47,407 households, only 42 percent (20,032 households) are estimated to have more than 5 cattle thus are considered technically feasible for biogas.

5. Opportunities and Challenges

The Biogas programme has both opportunities and challenges as well. Following can be the main opportunities and challenges in relation to the Biogas programme in Bhutan**.**

5.1 Strengths/ opportunities

1. Government of Bhutan is very keen and committed on promoting biogas technology. Department of Livestock has very wide network and sufficient staff and facilities to promote this technology. The Department of Energy, Renewable Energy Division has already initiated to introduce biogas technology in Bhutan. It looks both Departments will work together to promote biogas technology.

2. Southern part and some mountain valleys are suitable for biogas.

3. Cattle are kept in permanent nature which will insure the continuity of availability of dung for biogas.

4. Livestock Department is introducing programme on increasing stall feeding practices. This will help to get more dung for biogas generation.

5. Households seem much receptive on new technology.

6. Construction materials (stones, gravels, sands) are easily available and are cheap
7. Local workshops can produce the biogas appliances with some training and assistance.

8. A benefit from biogas in compare to investment is very high.

9. Microfinance through Bhutan Development Finance Corporation is possible since this organization is already providing loans to the farmers for livestock and other purpose and have networks in every Dzonkhags.

5.2 Threats/ Challenges

[15] Directory of cities and regions in Bhutan.

1. Biogas can not be produced every where due to low temperature even though sufficient cattle are available. There is tendency of seasonal cattle migration in some areas which will affect biogas plant operation due to the shortage of dung.

2. Hydropower is (will be) well distributed in rural areas and still cheap compared to other Asian countries. Households widely use electricity for cooking. Therefore, it might be difficult to convince households for biogas since they have no complains with the existing source of cooking energy.

3. Construction and maintenance services will be difficult because of lack of motor roads to the scattered houses. Construction costs will be higher if biogas needs to be constructed in remote areas.

4. All households will not be in a position to pay up front cash for biogas and micro credit system needs to be in place.

5. Biogas technology is new for Bhutan and needs to develop capacity within the implementing organization.

6. Biogas market is not big enough in Bhutan thus private sector might not be interested to be involved in plant construction.

6. Recommendations

The following are the main recommendations:

1. Comparing to other Asian countries, biogas market is not that big in Bhutan however, looking into the population size of the country biogas can reach 15 percent of the total households. Therefore, biogas can be promoted in Bhutan establishing a unit within relevant Government Department. Department of Livestock looks appropriate organization for programme implementation however, coordination with Renewable Energy Division is essential. It is also suggested that involvement of local construction companies on biogas construction and maintenance will help to sustain the biogas programme.

2. Biogas technology is new for Bhutan. Few plants in different climatic zones may be good to establish as pilot plants however, it is proven that biogas will work if good quality plant is constructed and sufficient dung is fed regularly. The pilot plant is recommended to develop confidence within institutional level and obtaining concrete information on biogas for further planning.

3. A suitable biogas model is being promoted in Nepal which is proven as a good model for mountains. Therefore, it is suggested to introduce the same model in Bhutan. Based on the performance and local context the design can be gradually modified or improved later on through research and development activities.

4. Bhutan can tremendously benefit from the experience of Nepal in relation to technology and knowledge transfer. A collaboration with Biogas Support Programme of Nepal would help to start the programme quickly.

5. Biogas technology has to establish good image among the communities first before wider promotion therefore, it is wise to start biogas construction from the South (warm temperature areas) where probability of success is much higher.

6. Households might need subsidy for purchasing biogas plant and about 9,000 NU (about 36 percent of total costs) per plant would be justifiable for subsidy.

7. Provision of soft loan to the households would help to minimize the financial burden to purchase biogas plant. Bhutan Development Financial Corporation can play an important role in providing biogas credit to the households. It would be useful to learn from the experience and working procedures on micro finance from Bangladesh and Nepal.

8. While constructing plants, high attentions need to be provided to maintain quality construction. Quality control, after sales services (regular maintenance), training to the users on operation and maintenance and bio-slurry utilizations are the key factors for success of the biogas programme.

9. It is suggested to collect cattle urine from cattle shed and use for biogas plant mixing with cattle dung. This practice will help to minimize the shortage of water but also produce more gas and increase quality of fertilizer (slurry).

Part II
Biogas Pilot Programme

The Ministry of Agriculture has requested SNV to propose a Biogas Pilot Programme before starting an up-scaling programme. The SNV Advisor together with the officials from Department of Livestock visited 3 proposed sites for constructing pilot biogas plants. These sites were found as below:

1. **Household in Haa:** The proposed household in Haa has sufficient cattle for dung. The house is in very cold area and temperature drops below zero degrees Celsius in 4-5 months. It also gets snow in winter. The owner does not stay at the house and is completely rented out. The area is surrounded by national and community forests but people buy (by sharing labor) firewood from local saw mill. This site is not recommended for a pilot plant because: a) the temperature does not support for biogas generation, and b) the owner does not stay at home and might not be in a position to operate the plant regularly.

2. **Household in Paro:** The proposed household in Paro is a dairy house and has lots of cattle. The dung is sufficient for a 10 m3 plant. The family resides at home and is very interested for biogas construction. The household uses 3 bottles of LPG every month besides electricity and firewood. Firewood is expensive and relatively difficult to collect. Household looks rich and has sufficient farm fields. The area is densely populated. The temperature generally is sunny at day time however, in winter drops sharply and reaches 0 degree Celsius. Paro is one of the largest and fertile valleys of Bhutan and the altitude is about 2,300 mtrs. All parameters for establishing a pilot plant in this site are suitable except the temperature. Local people have suggested that the day temperature is quite warm therefore, the night time temperature will not much affect on overall temperature. Keeping all these matters in account, it is suggested to construct one pilot plant in this site with the necessary provision of keeping the biogas digester warm. Some precaution could be: a) construction of digester deeper under ground, b) more than 1 feet of earth feeling over the dome c) keeping dry materials like hey, straw etc over the dome or using hip composting methods over dome d) feeding of materials at evening after keeping warm the mixed dung during day sun light.

3. **Household in Thimpu:** Thimpu is colder than Paro however the day sunlight is sufficient. The proposed household is in a shady place therefore does not get sufficient sunlight. The household is interested for biogas and poses sufficient cattle however, is not suitable for a pilot plant mainly due to temperature and location.

A proposed programme for piloting some biogas plants is presented below.

Objectives:
The objectives of the Biogas Pilot Programme can be as follows:

1. To test whether biogas generation in Bhutan is successful in different climatic conditions
2. To test whether the biogas model is appropriate for Bhutan
3. To assess the actual cost of biogas plant
4. To assess how the households respond in relation to the demand
5. To recommend for biogas up-scaling programme.

Piloting sites

Site and size selection is very important for successful biogas programme. It is even more crucial in piloting phase. Therefore, it is proposed to select 5 households who have at lest 5 permanent adult cattle and are in warm temperature. The sites should be sunny (non-shaded place) and close to the source of dung. Size of plants can vary depending on number of cattle and requirement of gas to the households. 6 m3 might be the common size plant for average Bhutanese households. If there are more cattle and family size is bigger then the size of plant can be 8 m3. It is proposed to install one plant each of following Dzonkhags:

Chhukha
Samdrupjongkhar
Samtse
Paro
Punakha

Paro and Punakha are relatively colder areas but represents quite substantial households. It would be good to see whether biogas plant works successfully in these areas.

Plant Design

There are several designs of biogas plant available in different parts of the world however, it is proposed to construct the GGC model plant of Nepal which can be more suitable for Bhutan. This is a fixed dome design constructed entirely at site using cement, stones and concrete. The temperature of lower Bhutan and mid-hills of Nepal is similar therefore the design of provisioning 70 days retention time would be appropriate. Digging deep pits for digester construction become some time difficult in rocky mountains however, careful attention on site selection may overcome this problem.

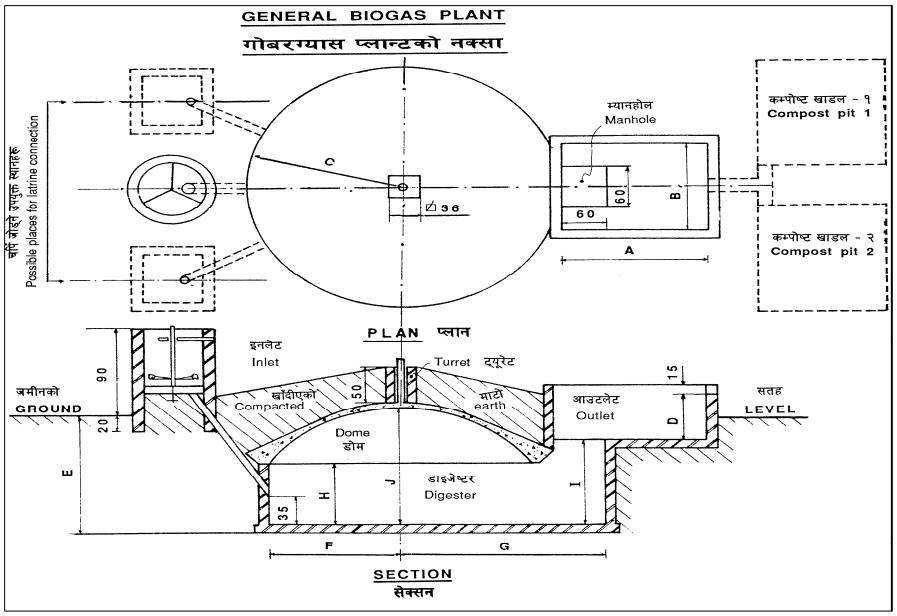


Figure- 10 Drawing of Nepal GGC 2047 Biogas Plant

Construction

The detail bill of quantity and tentative costs for constructing biogas plants is in Annex-2. The total tentative construction costs may around 25,000 NU however, it may differ from place to place due to transportation costs. The cost does not cover the supervision, monitoring and administrative costs of implementing organization. All construction materials are available locally except biogas appliances. 5 sets of biogas appliances can be brought from Nepal or Bangladesh.

It is proposed to approach BSP Nepal for asking an experienced biogas technician who can visit Bhutan for short period and support for plant construction with local masons. In the mean time the BSP biogas technician can train a group of local masons and supervisors.

Financial support

Since these plants are for piloting purpose, the majority of the costs need to be subsidized. It is proposed that the labor costs and collecting stones, sands and gravel should be managed by the household. In such case household should bear about 9,000 NU (35%) of the total costs. In any case, the plant should not be completely free to the household.

Implementing Organization

Livestock Department has wide networks and staff for monitoring the plants therefore, proposed for implementing the pilot programme however, Renewable Energy Division can play a role on technical supervision, quality check and review of design and feedback to Livestock Department. Both Departments need to work in a coordinated way. Livestock Department might need to assign a Coordinator responsible for overall coordination and implementation of Pilot Programme.

Part 3
Outline of Bhutan Biogas Programme

As per the request of Ministry of Agriculture, a tentative outline of Bhutan Biogas Programme is presented below. The programme can be detailed later on upon positive results of Pilot Programme.

Name of the Programme: Bhutan Biogas Programme (BBP)

Objective
Promoting biogas plants as sustainable and clean source of household energy in rural Bhutan.

Specific objectives

- to strengthen organizations for sustainable development of the biogas sector,
- to construct the number of quality biogas plants by 1,500,
- to maximize all benefits of the biogas plants,
- to ensure the continued operation of all biogas plants constructed under the program,

Period – 3 years

Construction targets : **1,500**
1st year : 100
2nd year : 400
3rd year : 1,000

Total investment costs : **37,500,000 NU (797, 872 US)** @ 25,000 NU
Farmers contribution: 24,000,000 NU (510, 638 US) @ 16,000 NU*
Subsidy : 13,500,000 NU (287,234 US) @ 9,000 NU

*Credit in case required: 12,000,000 NU (255,319 US) @ 50% of HH

Programme implementation costs: 6,000,000 (127660 US) @ 4,000 NU per plant

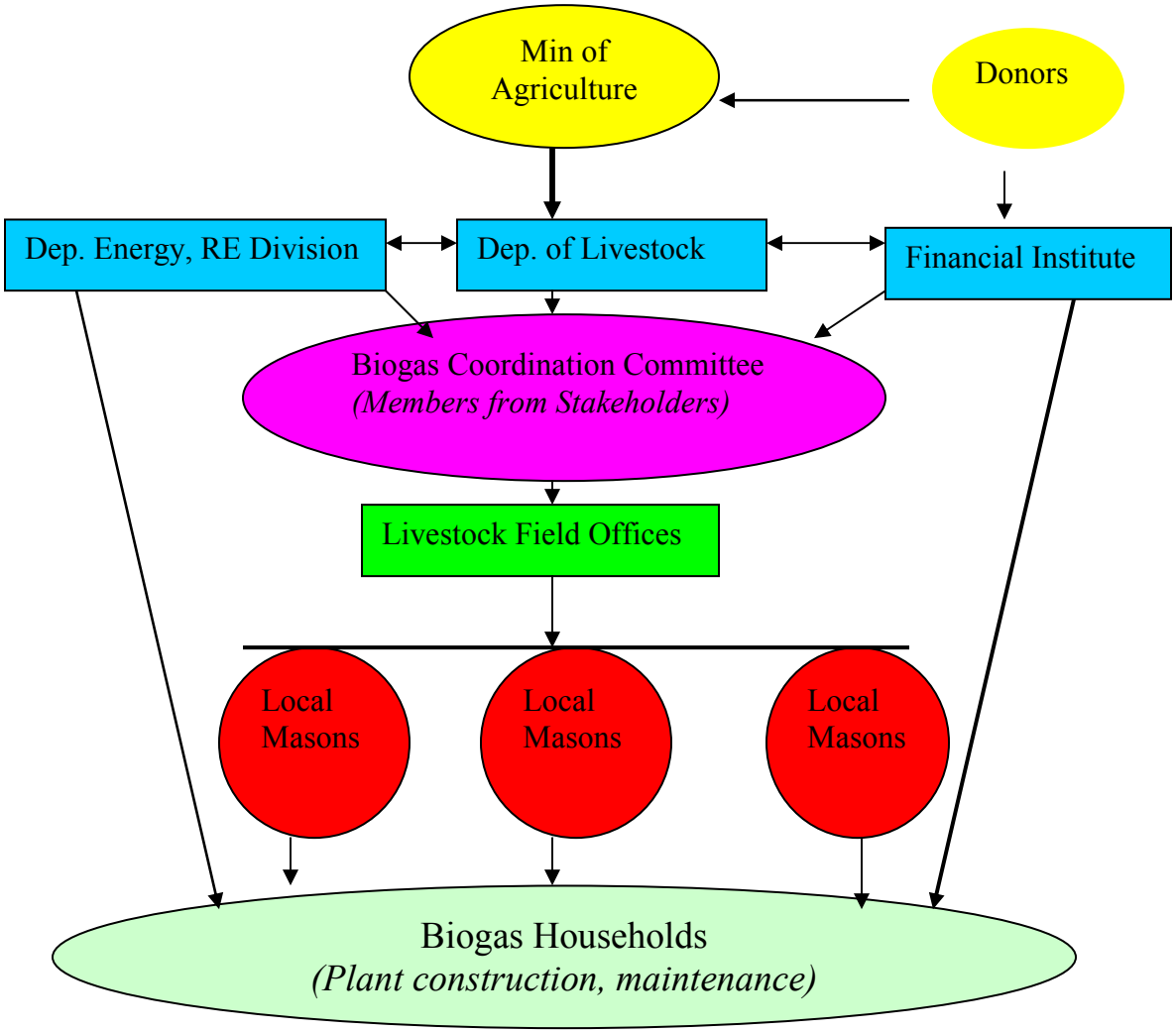
Main activities to be carried out:
There are number of activities need to be carried out under the programme. These activities can be divided to appropriate stakeholders based on the expertise. Tentative division of responsibilities is indicated in the table below**:**

SN	Activity	Responsible organization
1	Promotion, marketing and demand collection of biogas	Department of Livestock together with local masons
2	Training to the masons, supervisors and users	Mason and supervisor need technical training and that can be provided by Renewable Energy Division

		together with Department of Livestock. Users training needs to be provided by Department of Livestock involving its Block Supervisors and local biogas masons.
3	Quality check and monitoring	Quality check, feedback on defaults for improvement and technical monitoring should be carried out by Renewable Energy Division however day to day monitoring of activities should be done by Department of Livestock
4	Bio-slurry management and utilization	Department of Livestock with the involvement of Agriculture Extension Division
5	Research and development, appliances manufacturing	Renewable Energy Division, local workshops
6	Programme management, (coordination among departments and stakeholders, managing funds)	Livestock Department
7	Credit management	Financial institution (Bhutan Development Finance Corporation)

Developing private companies for construction, maintenance and appliances production for biogas will be the best way towards sustainable and market oriented biogas sector.

Tentative Institutional Set-Up



Local masons can be converted into Private Companies in later stage

Annex- 1

Estimated Potential Biogas Household by Dzonkhags

		A[16]	B[17]	C[18]	D (A/C)	E[19]	F= (E*D/100)	G(F/B*100)
	Dzongkhag	Total Cattle	Total HH	Number of Rural HH	Average Cattle per HH	HH below 2000 mtr altitude	HH with more than 5 cattle and below 2000 mtrs	% of HH potential for biogas
1	Bumthang	15,584	2,870	2,130	7.3	-	-	0.00
2	Chhukha	32,006	14,482	7,690	4.2	6,921	2,907	20.07
3	Dagna	15,435	3,485	3,178	4.9	2,225	1,090	31.28
4	Gasa	13,868	727	643	21.6	64	64	8.84
5	Haa	15,471	2,290	1,866	8.3	187	155	6.76
6	Lhuentse	15,996	3,001	2,765	5.8	415	241	8.02
7	Monggar	33,619	7,348	6,114	5.5	3,668	2,018	27.46
8	Paro	22,050	7,118	6,552	3.4	328	111	1.56
9	Pemagatshel	10,302	2,937	2,575	4.0	1,288	515	17.53
10	Punakha	10,057	3,387	3,060	3.3	1530	505	14.91
11	Samdrupjongkhar	18,842	8,363	6,167	3.1	5,550	1,721	20.57
12	Samtse	36,634	11,634	9,418	3.9	8,476	3,306	28.41
13	Sarpang	21,127	8,211	5,685	3.7	5,117	1,893	23.06
14	Thimphu	17,442	19,689	3,961	4.4	594	261	1.33
15	Trashigang	44,639	10,813	9,687	4.6	1453	668	6.18
16	Trashiyangtse	13,877	3,764	3,223	4.3	1,934	832	22.09
17	Trongsa	10,406	2,739	2,211	4.7	1327	624	22.76
18	Tsirang	12,124	3,651	3,278	3.7	1639	606	16.61
19	Wangdue	24,230	6,227	4,773	5.1	2148	1,095	17.59
20	Zhemgang	15,544	3,379	2,828	5.5	2,545	1,444	41.43
	Total	**399,253**	**126,115**	**87,804**	**4.5**	**47,407**	**20,035**	**15.88**

[16] Data from Department of Livestock 2008

[17] Results of Population & Housing Census of Bhutan 2005, Office of the Census Commissioner, Royal Government of Bhutan

[18] Results of Population & Housing Census of Bhutan 2005, Office of the Census Commissioner, Royal Government of Bhutan

[19] Calculated based on the data from Directory of Cities and Regions in Bhutan www.fallingrain.com/world/Bt

Annex- 2

Materials and Estimated Costs for a 6 m3 Biogas Plant[20]

Unit Price	Materials	Quantity	Costs	Source
940	Stone (m3)	5	4,700	Local market
25	Sands (bag 50 kg)	70	1,750	Local market
35	Aggregate (bag 50 kg)	35	1,225	Local market
250	Cement (bag 50kg)	14	3,500	Local market
70	MS rod (kg 10 mm)	15	1,050	Local market
70	Binding wire (kg)	0.5	35	Local market
250	Dome pipe	1	250	Local market
50	GI Fittings	12	600	Local market
650	Gas pipe (GI 1/2" in pc)	2	1,300	Local market
350	Main gas valve	1	350	Nepal
200	Water drain	1	200	Nepal
200	Gas tap	1	200	Nepal
550	Stove	1	550	Nepal
600	Dung Mixer	1	600	Nepal
40	Hose pipe	1	40	Local market
200	Inlet pipe (mtr)	3	600	Local market
10	Teflon tape	3	30	Local market
150	Emulsion paint	1	150	Local market
300	Mason	11	3,300	Local market
200	Skilled labor	11	2,200	Local market
150	Labors	10	1,500	Local market
LS	Transport etc		900	
	Total costs		**25,030**	

Note: *Costs are in Bhutanese Currency (NU)*
Costs may vary from place to place depending on transportations costs

[20] Price collected from local markets and BSP Nepal

Annex-3

Cattle Population in Bhutan[21]

	Dzonkhag	Cattle	Buffaloes	Yak	Horses	Mules	Donkey	Total
1	Bumthang	10,595	151	3,418	1,280	129	11	15,584
2	Chhukha	31,355	59	-	465	122	5	32,006
3	Dagna	14,966	30	-	410	24	5	15,435
4	Gasa	541	-	12,076	672	579	0	13,868
5	Haa	9,207	-	4,874	759	629	2	15,471
6	Lhuentse	13,676	-	456	1,669	189	6	15,996
7	Monggar	31,002	-	-	2,034	564	19	33,619
8	Paro	15,066	-	5,388	1,173	416	7	22,050
9	Pemagatshel	9,339	-	-	429	530	4	10,302
10	Punakha	9,372	-	-	648	28	9	10,057
11	Samdrupjongkhar	17,132	45	-	1,401	254	10	18,842
12	Samtse	35,783	642	-	181	28	0	36,634
13	Sarpang	20,582	237	-	304	4	0	21,127
14	Thimphu	6,030	-	10,088	1,084	229	11	17,442
15	Trashigang	28,530	-	11,813	3,685	596	15	44,639
16	Trashiyangtse	11,641	203	402	1,288	324	19	13,877
17	Trongsa	9,848	-	72	439	43	4	10,406
18	Tsirang	11,727	184	-	212	1	0	12,124
19	Wangdue	19,838	-	2,913	1,409	52	18	24,230
20	Zhemgang	13,669	-	-	1,425	442	8	15,544
	Total	**319,899**	**1,551**	**51,500**	**20,967**	**5,183**	**153**	**399,253**

[21] Department of Livestock, Bhutan

Annex- 4

List of data used in this report

Particulars	**Amount**	**Source**
Fire wood per kg	@ 1.00 Nu	Households
Kerosene per ltr	@ 10.00 Nu	Households
LPG per bottle	@ 500.00 Nu	Households/ local markets
Electricity per HH/month (average)	@ 150.00 Nu	Department of Energy/ Households
Organic fertilizer per Kg	@ 1.00 Nu	Households
Carbon credit per ton	@ 500.00 Nu	International markets
Labor wages per day	@ 150.00 Nu	Local markets
Interest rate on credit per year	@ 12%	Banks/ local persons
Expected minimum life of biogas plant	15 years	BSP Nepal project document

List of Persons Contacted

1. Mr. Sherub Gyaltshen, Secretary, Ministry of Agriculture
2. Dr. Karma Tenzin, Head of DoL Thimpu
3. Mr. Mewang Gyeltshen, Head/Chief Engineer, RED, DoE
4. Mr. Phurpa Dorji, Deputy Chief Livestock Officer, DoL Thimpu
5. Mr. Thinley Tenzin, DLO Haa
6. Mr. Golo Tshering ADLO Haa
7. Mr. Cheucho Tshering, ADLO Haa
8. Mr. Cheten Gyeltshen, ADLO Haa
9. Mr. Gokul Chhetri, ADLO Haa
10. Mr. Nar Bahadur Khatiwara, Engineer, RED, DoE
11. Livestock Officers, Paro
12. Prospective biogas household, Paro
13. Prospective biogas household, Thimpu
14. Prospective biogas household, Haa
15. Ms. Megan Ritchie, SNV Bhutan
16. Mr. Kencho Wangdi, SNV Bhutan

List of Reference

1. Biogas as Renewable Source of Energy in Nepal: Theory and Development. A B Karki, J.N Shrestha and Sundar Bajgain. BSP-Nepal.
2. Biogas Construction Manual, SNV/ Biogas Support Programme, Nepal
3. Directory of cities and regions in Bhutan. www.fallingrain.com/world/BT
4. Household Income and Expenditures Survey 2000, Government of Bhutan
5. Livestock data, Department of Livestock
6. Proposal on Pilot Biogas Programme, Renewable Energy Division, Bhutan
7. Results of Population & Housing Census of Bhutan 2005, Office of the Census Commissioner, Royal Government of Bhutan
8. Tenth Five Year Plan Vol-1, GNH Commission, Royal Government of Bhutan 2008
9. Website- Portal, Government of Bhutan
10 Website- Department of Energy, Government of Bhutan