**GTZ-PURE / Power Cell / Sustainable Energy Unit (SEU)**

Project Name:

# Promotion of Biogas Production and Use in Commercial Establishment


Report on

# Feasibility Study on Biogas from Poultry Droppings


Prepared By

**Bangladesh Centre for Advanced Studies (BCAS)**

in collaboration with

**Energy Consulting Services (ECS)**


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## Executive Summary


Bangladesh is a densely populated country with a population of about 140 million, about 72% of which live in the rural areas. The overall energy consumption in Bangladesh is still very low. In 2000, per capita consumption of commercial energy and generation of electricity were 200 kgoe/year and 120 kWh/year respectively. The energy consumption in the rural area is even much lower. The supply of natural gas is limited to urban areas, mostly in the eastern part of the country. Only about 5% of the population have access to natural gas, whereas about 32% to grid electricity. About 60% of total energy consumption of the country is being met from biomass. Agricultural residues, animal dung, trees, leaves, twigs, etc. are the main sources of biomass fuels. There are indications that consumption of biomass energy has already exceeded the regenerative limit and there prevails energy crisis in the rural areas of Bangladesh. Because of energy shortage, more and more agricultural residues and animal dung are being used as fuel depriving the soil of organic matter and essential micro-nutrients. As a result, soil fertility is declining and the farmers are becoming more and more dependent on chemical fertilizer. Moreover, use of biomass as fuel in traditional stoves is responsible for in-door air pollution causing health hazards to the users. It is apprehended that, with population growth, the energy crisis, environmental degradation, deforestation, declining of soil fertility, etc. will sharpen further if the things move as usual and no alternative measures are undertaken. Biogas offers a sustainable solution, at least in part, to all these problems Bangladesh is currently facing.

In the backdrop discussed above, GTZ-PURE has initiated a project “Promotion of Biogas Production and Use in Commercial Establishment” to support promotion of biogas use in suitable commercial establishments. It is intended to develop and test a marketing approach for promotion of biogas use with the focus on suitably sized poultry farms. Bangladesh Centre for Advanced Studies (BCAS) with Energy Consulting Services (ECS) as Sub-Consultant conducted the feasibility study during May – July 2005. This report presents the results of the study.

### Biogas Technology in Bangladesh

The first biogas plant in Bangladesh was installed in 1972. Since then several organizations have taken initiative to research, develop and disseminate biogas technology in the country. The most significant work has been done by IFRD of BCSIR and LGED. All major types of biogas plants - fixed dome, floating dome and bag type – have been installed in the country. Fixed dome type biogas plant has proved to be the most suitable and at the moment the only type of biogas plant that is being installed.

Several government financed biogas projects have been implemented with different degrees of success. Under these projects, more than 25,000 biogas plants have been installed throughout the country. Different types of raw materials like cow-dung, poultry litter, and human excreta are being used in these plants. Biogas from cow-dung or poultry litter is well accepted by the people. After initial hesitation, biogas from human excreta is also proved to be accepted.

Different approaches for dissemination have also been tried. Through trial and learning, Bangladesh has gained substantial experience on biogas technology. Different organizations have also worked towards capacity building. As a result, there is skill and know-how on the biogas technology. There is also awareness among the people about the advantages of biogas plants. There exists a conducive atmosphere for large-scale biogas programme.

However, very few biogas plants are currently being installed. There is no on-going public sector biogas project. Some private sector entrepreneurs are trying to construct plants on their own efforts as a part of their business. In some locations, they are providing after-sale services.

At the moment, some movements are being observed in the biogas sector. Grameen Shakti has undertaken initiative to disseminate biogas plants. BRAC also is conducting a research project on power generation from biogas in Manikgonj and Tangail districts. The Netherlands Development

Organization (SNV) has planned to start large-scale programmes for domestic biogas in a number of Asian countries including Bangladesh. Another initiative has been undertaken by the GTZ under its PURE project. The present study is a part of this initiative.

### Biogas Utilization in commercial enterprises

Dairy farms and poultry farms are run on a commercial basis. Biogas plants installed in the country are mostly based on cow-dung and poultry droppings. The focus of the study was poultry-based biogas plants. During this study, it was found that the poultry based biogas plants were situated in areas not covered by gas line.

Biogas is used as cooking fuel for the household mostly by owners, when the owners reside near the farm, and also by neighbours. The neighbours usually pay 300 Taka per month for a biogas connection. Besides household cooking, biogas is used for lighting, although to a less extent. There are also some cases where biogas is being used as fuel for productive purposes, e.g. preparation of food in big kitchens, preparation of sweetmeat, operating boiler and drying fish.

Biogas is also being used for power generation. Currently, no biogas generator is made in the country. In most cases imported petrol, LPG or natural gas generator is retrofitted for the use of biogas. However, there are problems regarding starting and continuous operation. The reasons are: the moisture and hydrogen sulfide contents. There is no experience in Bangladesh with removal of hydrogen sulfide. For removal of moisture, moisture traps are used by some.

## *Use of slurry*

Slurry from biogas plant is used as fertilizer and as fish feed. The use of slurry as fertilizer increases the crop production significantly. It is more productive than the undigested dung. Litter from poultry has almost no market value. The fish farm owners or vegetable cultivators usually collect the dried litter for free, sometime at a cost of about Tk. 0.50 – 1.00 per kg. Often it is thrown in the nearest ditch and washed away with monsoon water.

The market for slurry as fertilizer is yet to be developed. However, the farmers in the neighbourhood of biogas plants are increasingly recognizing the quality of slurry from biogas plants. Currently, it is sold in moist form (moisture content around 50%) at a price of 0.80 Taka – 2.00 Taka per kg and in dry form (moisture content around 25%) at price over 5 Taka per kg. Packaging of slurry as well as addition of nutrients according to needs will add to the value substantially.

### Test results

Poultry-based biogas contains 55% - 65% methane, 35% - 45% carbon dioxide and traces of other gases such as hydrogen sulfide, moisture etc., composition varying with the nature and retention time of slurry. Methane is the only useful gas. Carbon dioxide does not do any harm except its effect as greenhouse gas and diluent of methane. Moisture content causes difficulties during burning. Hydrogen sulfide is a corrosive gas and corrodes metals that come in contact. To remove the unwanted gas, scrubbing of biogas is necessary.

The easiest way to get rid of hydrogen sulfide is to allow it to react with any gas/solution/iron oxide. Red oxide (in the form of steel wool, for instance) may be used. The used up red oxide may be recycled through exposing it to air for some weeks. For scrubbing moisture, simple water trap may be used.

A large number of scrubbing technologies are available. They are popularly called “gas sweetening” technologies and are applied in the processing of natural gas. They are applied at relatively high gas pressures and are able to handle large gas volumes. Both regenerative and non-regenerative processes are available.

## Policies

Bangladesh has no specific biogas policy. However, National Energy Policy 1996, Draft Renewable Energy Policy and Draft National Energy Policy emphasize on harnessing biogas energy. National Energy Policy 1996 urged that conservation at end use level of biomass fuels is to be reached through technological intervention, primarily by dissemination of technologies like improved stoves and biogas digesters. The draft Renewable Energy Policy, which is yet to be approved and the new National Energy Policy (under preparation) have mentioned biogas technology more specifically.

The government has declared agro-based industries as a thrust sector and gives specific subsidy for poultry industry. Electricity consumption of poultry farms up to 1000 birds is charged at domestic tariff, whereas larger farms get a subsidy of 20% on electricity bill calculated on industrial tariff rate. Moreover, the interest rate for agro-based industries has been reduced to 8%.

Existing laws do not mention the production of biogas and its sale. Regarding power generation in private sector, GoB has approved several laws. Under the present law, electricity generation for own consumption (captive power) is allowed. It is also allowed to sell the generated electricity to the neighbors. Currently, Captive Power Policy Guidelines are being prepared by the Power Cell. It is expected that this policy will regulate the costs of electricity produced by private sector to be supplied to the grid.

Draft Renewable Energy Policy mentions that the sponsor may use the existing transmission and distribution systems upon payment of a mutually agreed upon wheeling charge. Utilities (BPDB, DESA, DESCO, REB) will buy electricity generated from grid-connected renewable energy projects through mutually agreed “Power Purchase Agreement (PPA)”. GOB will not regulate the price of electricity generated from renewable energy source.

## Technical potential of poultry litter-based biogas plants

It is rather difficult to get up-to-date and reliable data on poultry farms. A report from Poultry Sector Development Project gives a figure of 112,000 commercial poultry farms, which together produce about 5,900 tons of litter daily. Farms with less than 100 birds are not included in this estimation. Of these, 20% farms have a bird population of more than 1,000. The remaining farms are smaller in size and maintain 100 – 1,000 birds. It has been found that a poultry farm with more than 100 birds is technically suitable for a biogas plant.

## Financial Analysis

Financial analysis has been made for biogas plants based on 100, 250, 500, 1000, 5000, 10000 and 50,000 birds. It has been considered that gas and fertilizer will be sold. Power generation has also been considered for farms with more than 500 birds. The interest rate is 8%. It has been found that sale of gas and fertilizer makes all biogas plants viable. On the other hand, sale of only fertilizer or electricity does not make any plant viable. For farms with 500 and more birds, gas sale alone makes the plant viable. By bigger plants, sale of any two of the products - gas, electricity and fertilizer - makes it profitable; however, sale of fertilizer and gas (no power generation) is more profitable.

The prices of construction materials may vary over the period of time. Also the running costs (labor cost, cost of maintenance) may vary. As such sensitivity analysis has been done by variation in the price of investment, maintenance and labor cost, as well as in the sale of gas, electricity and fertilizer. It has been shown that with higher expenditure, IRR goes down and with higher selling price (in terms of income) IRR goes up. It has been found that the biogas plants are profitable in all cases of 20% expenditure hike and 20% income decrease, except the 100 birds plant. With expenditure decrease by 20% and income rise by 20%, IRR increases with plant size IRR is more sensitive to product sale than to expenditure increase.

The output of the biogas plant depends on the availability of raw material i.e. litter, which is dependent on the number of birds of the farm. In poultry farms, the number of birds may vary over time, which affects the profitability of the plant. With decreasing capacity utilization, IRR decreases significantly. In case of 100 birds, biogas plant is viable only if over 80% capacity is utilized and for 250 birds, the capacity utilization needs to be over 60%. It is interesting to note that even at 40% capacity utilization, the biogas plants with 500 and more birds are viable if both gas and fertilizer are sold. It is significant, because it offers the farmer some operational flexibility and also allows profitably installing and operating a bigger size biogas plant with the option of increasing the number of birds later.

## Major Findings

i) So far, about 25,000 biogas plants, mostly family-size, have been set up in Bangladesh. Most of them are based on cow-dung and poultry droppings. All the plants now in operation are fixed dome plants and their durability is reported to be more then 20 years. Oldest fixed dome plant in proper operation now in the campus of BCSIR was established in 1990.

ii) BCSIR and LGED have so far trained more than 1,800 engineers, supervisors and masons on the construction, operation and maintenance of fixed dome biogas plants. This is an important aspect for undertaking a dissemination project as there is sufficient number of expertise available all over the country.

iii) So far, over 2,000 poultry-based biogas plants have been constructed. Plants with birds ranging 100 – 5,000 are in operation.

iv) Interviews with the owners and neighbors of poultry farms reveal that construction of biogas plants in each poultry farm is a necessity because of the bad odor that poultry droppings spread in the area. Since poultry industry is booming in Bangladesh, poultry-based biogas plants also should be booming in future.

v) Financial analyses of plants for farms ranging from 100 birds up to 50,000 birds have been done. The results are shown in Figures 10.1 – 10.10. It can be concluded that

   a) With 100 birds using both gas and fertilizer, if sold at a price 300 Taka/connection and 0.80 Taka per kg of fertilizer, the plant is financially viable. However, with either of them alone, the plant is not financially acceptable assuming an interest rate of 8%.

   b) With 500 birds and above, all plants are financially acceptable with gas sale alone but none of the plants is viable if only electricity or only fertilizer is sold. But electricity and at least any one of other two (gas and fertilizer) makes the project viable, 50% of the gas assumed to be used for electricity generation.

   c) Sensitivity analyses with 20% cost increase in plant construction, operation & maintenance and 20% decrease in revenue received have shown that all plants above 250 birds are viable.

vi) Biogas plants are financially viable, even for a farm as small as 100 birds.

vii) Larger farms may go for electricity production, but selling of gas is more profitable.

viii) Most of the poultry farm owners are capable of financing biogas plants on their own. The small farmers will, however, prefer micro-financing. Most of them will avoid bank loan because of hassles associated with bank loan being approved and received. Micro-financing would be a very good option for them.

ix) Economic benefit derived from biogas plant in terms of fuel and fertilizer saving can have notable impact on national economy. Biogas technology may pave the way for booming poultry industry in the country.

x) Large biogas plants owners are selling biogas at a rate of TK 300-400 per connection. This is an encouraging aspect for the commercialization of the technology.

xi) Following drawbacks, which need be reduced / eliminated, have been detected during the field visits:

   a) Moisture and hydrogen sulfide contents of biogas should be removed for the better functioning of the cooking burners and electricity generators.

   b) In many plants charging rate and slurry / water ratio are not properly maintained.

## Recommendations of the Study

1. Since biogas technology is now well established with the availability of expertise in the country, the technology is set to take off provided financial support coupled with appropriate marketing measures is made available.

2. A promotional drive in a selected area, e.g. the upazila with the highest number of poultry farms should be undertaken immediately. The promotional work should have an objective of installing a biogas plant in every poultry farm of the upazila. However, for successful implementation, a marketing plan with appropriate strategies should be developed before embarking on this. It should also be followed by monitoring with corrective measures, if necessary.

3. (a) For cooking purpose, biogas has proven quite appropriate, even in the presence of small amount of moisture and hydrogen sulfide. It can therefore be safely recommended that a large-scale programme be undertaken for dissemination of poultry-based biogas.

   (b) Field visits have shown that, in almost all cases, initial construction cost is not readily available. For dissemination therefore, some kind of funding will be necessary.

4. In order to solve the above problems associated with hydrogen sulfide and moisture, some experiments should be carried out in a suitably sized plant.

5. Setting up of a biogas plant should be made mandatory for poultry farms and should be included in the national policy documents.

6. Measures to popularize fertilizer from biogas plants should be undertaken.

7. Know-how to add value to bio-fertilizer from biogas plant should be acquired and disseminated.

8. For updating the knowledge base of the technicians, training need be provided on a continuous basis.

9. A dedicated organization for biogas is necessary. This may be a Biogas Foundation. The objective of this organization will be to promote biogas plants all over the country in a concerted manner. It will coordinate all activities related to biogas e.g. policy, research, training, and dissemination. The Foundation will be run by a Board of Directors consisting of representatives from the Govt. and biogas related organizations.

10. A revolving fund to be administered by the Biogas Foundation will be created for multiplication of biogas plants and administration of biogas related activities. However, till the formation of the Biogas Foundation, a suitable organization may volunteer to create and administer the revolving fund.

**Recommendations of the Expert Group Meeting**

- Intensive activities for biogas technology dissemination would be started in Maona of Sreepur and Savar. These two areas would work as piloting area and demonstrate, hopefully, the success of biogas technology before the whole country so that other areas might follow this.

- Grameen Shakti would work in Maona and LGED in Savar.

- GTZ would provide money in the form of a revolving fund for the activities in Maona.

- At the current stage, no foundation would be formed, but a forum would be created, which would act as a pressure group. BCAS would work as the secretariat.

- BCAS would work on awareness building and monitor the progress.

- IPSU would provide support for 5 demonstration biogas plants in Savar and 5 in Maona, Sreepur.

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## Abbreviations and Acronyms

| | |
|---|---|
| BADC | Bangladesh Agricultural Development Corporation |
| BAU | Bangladesh Agricultural University |
| BARI | Bangladesh Agricultural Research Institute |
| BARD | Bangladesh Academy for Rural Development |
| BCCD | Bangladesh Commission for Christian Development |

| | |
|---|---|
| BCSIR | Bangladesh Council of Scientific & Industrial Research |
| BPC | Bangladesh Petroleum Corporation |
| BPPP | Biogas Pilot Plant Project |
| BRAC | Bangladesh Rural Advancement Committee |
| BRRI | Bangladesh Rice Research Institute |
| BSCIC | Bangladesh Small & Cottage Industries Corporation |
| DANIDA | Danish International Development Agency |
| DoE | Department of Environment |
| DoL | Department of Livestock |
| GHG | Greenhouse gas |
| GS | Grameen Shakti |
| HBRI | Housing & Building Research Institute |
| IFRD | Institute of Fuel Research and Development |
| IRRI | International Rice Research Institute |
| LGED | Local Government Engineering Department |
| LPG | Liquefied Petroleum fuel |
| NEP | National Energy Policy |
| REDA | Renewable Energy Development Agency |
| SEDA | Sustainable Energy Development Agency / Authority |

# 1. Introduction

## *1.1 Background of the Project*

Bangladesh is a densely populated country with a population of about 140 million, about 72% (BBS, 2001) of which live in the rural areas. Bangladesh is endowed with a proven natural gas reserve of about 450 billion $m^3$ and 1.7 billion tons of coal. The overall energy consumption is still very low. In 2000, per-capita consumption of commercial energy and electricity were 200 kgoe/year and 120 kWh/year respectively (Draft NEP 2002). The energy consumption in the rural area is even much lower. The supply of natural gas is limited to urban areas, mostly in the eastern part of the country. Only about 5% of the population have access to natural gas, and about 32% to grid electricity. More than 60% of total energy consumption of the country is being met from biomass (Islam, 2004). Agricultural residues, animal dung, leaves and twigs, and trees, etc. are the main sources of biomass fuels. There are indications that consumption of biomass energy has already exceeded the regenerative limit and there prevails energy crisis in rural areas in Bangladesh (Asaduzzaman and Latif, 2005). This is one of the causes of deforestation that is going on in an alarming rate.

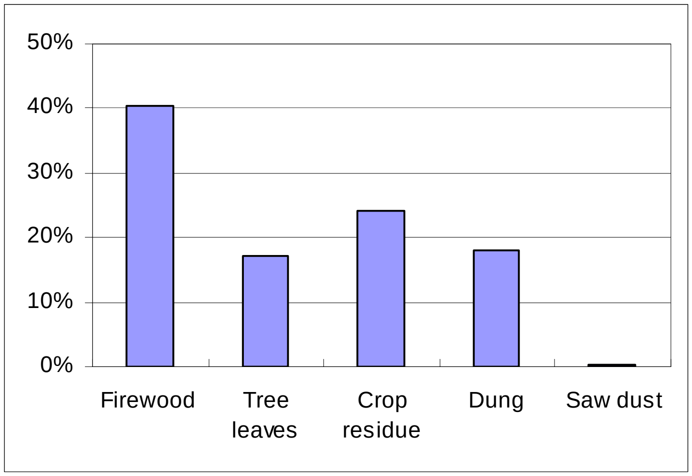


*Figure 1.1: Pattern of energy consumption in rural areas of Bangladesh (Asaduzzaman and Latif, 2005)*

Over 90% of energy consumption in rural areas of Bangladesh consists of biomass with a per capita concumption of 2.93 tonnes per year in 2004 (Asaduzzaman and Latif, 2005). Figure 1.1 shows the pattern of biomass consumption in rural areas. Firewood consists of mainly twigs, residues of timber production and used timber (trees and bamboos); The trunk of trees is usually used as fuel for the urban areas and brick industries. It is evident from the figure that agricultural residues and animal dung play a significant role in the rural energy scene. These have however an important alternative use as organic fertilizer. Because of energy shortage, more and more agricultural residues and animal dung are being used as fuel depriving the soil of organic matter and essential nutrients (Eusuf, 1993). As a result, soil fertility is declining and the farmers are becoming more and more dependent on chemical fertilizer. Organic matter content in 50% of agricultural land of Bangladesh has decreased to alarming less than 1.5%, which should be more than 3% (Sinha and Rahman, 2005). The results of this development are not only financial and economical losses to the people and country, but also to the environment and ecosystem. Moreover, use of biomass as fuel in traditional stoves is responsible for in-door air pollution causing health hazards to the users, mainly women and children who cook and stay much time in the kitchen.

It is apprehended that with population growth, the energy crisis, environmental degradation, deforestation, declining of soil fertility, use of chemical fertilizer and declining of agricultural yield will aggravate further if the things move as usual and no alternative measures are undertaken. Biogas offers a sustainable solution, at least in part, to all these problems Bangladesh is currently facing.

*Photo 1.1 : Biogas Plant*

*Photo 1.2 : Cooking with biomass fuels in rural areas of Bangladesh*

In the backdrop discussed above, GTZ-PURE has initiated a project "Promotion of Biogas Production and Use in Commercial Establishment" to support promotion of biogas use in suitable commercial establishments. It is intended to develop and test a marketing approach for promotion of biogas use with the focus on suitably sized poultry farms. With this aim, PURE called for proposals. In response to the call, Bangladesh Centre for Advanced Studies (BCAS) with Energy Consulting Services (ECS) as a Sub-Consultant submitted a proposal and was awarded the contract for conducting the feasibility study. The Terms of Reference (TOR) has been attached in Annex-1.

The study has been conducted by BCAS and ECS during May – July 2005. This report presents the results of the study.

## 1.2 Historical Development of biogas technology

The anaerobic digestion process producing biogas has been known since 18$^{th}$ century. However, it is being regarded as a useful method since the beginning of 20$^{th}$ century (FAO, 1999), when it found its first applications in the treatment of sewage and offensive material. With time, the utilization of anaerobic digestion has grown steadily. It provides exciting possibilities and solutions to such global

*Photo 1.3: Cooking with biogas*

concerns as alternative energy production, handling human, animal, municipal and industrial wastes safely, controlling environmental pollution, and expanding food supplies. Biogas technology not only supports national economies and the environmental protection, but also provides for a wide range of improvements in overall living conditions. Sanitary and health conditions are improved and the quality of nutrition is enhanced by improved energy availability.

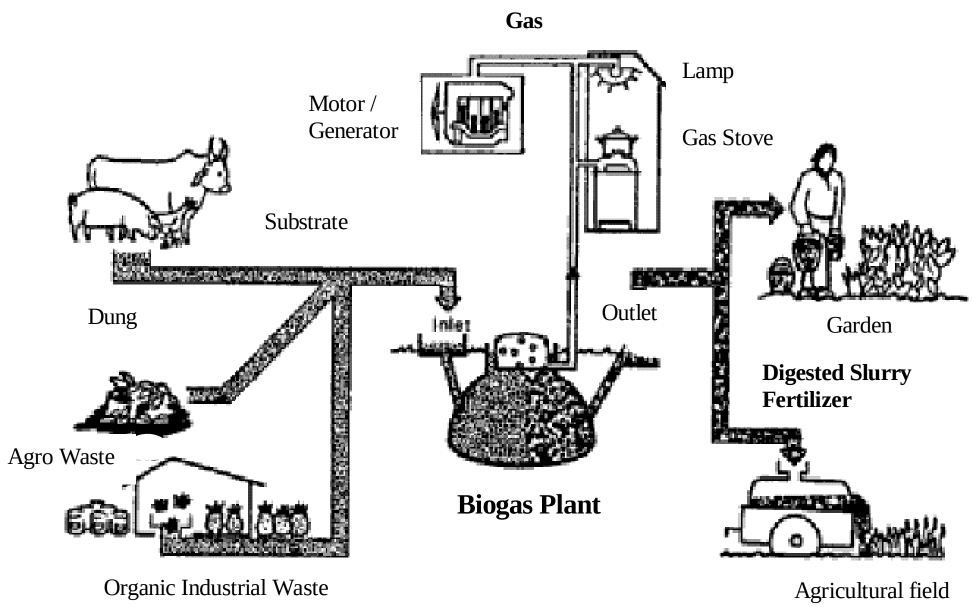


*Figure 1.2: Flow chart of a biogas plant (Rehling, 2001)*

For many years the rationale behind using biogas technology was the search for renewable sources of energy. In the meantime, other environmental protection aspects have gained additional importance. A technology which previously just filled a “niche” is now becoming a key environmental technology for integrated solid and liquid waste treatment concepts and climate protection both in industrialized and developing countries. Another major environmental target is the mitigation of deforestation and soil erosion through the substitution of firewood as an energy source with biogas.

## *1.3 Potential of biogas technology in Bangladesh*

Organic matters such as animal and human excreta, agricultural and industrial waste, water-hyacinth, etc. may be used as raw material for biogas plants. Bangladesh has plenty of these biomass resources. Table 1 gives a list of potential raw materials for biogas plants (Parveen, 1995).

**Table 1.1: Raw materials for biogas plants**

| Source | Types |
|---|---|
| Wastes from animal origin | - Cattle dung, urine<br>- Sheep and goat droppings<br>- Poultry litter<br>- Slaughter house waste (blood, internals)<br>- Fisheries wastes<br>- Etc. |
| Wastes from human origin | - Faeces, urine, refuse |
| Crop wastes | - Sugar cane trash<br>- Weeds<br>- Corn<br>- Straw<br>- Spoiled fodder<br>- Etc. |
| By-products and wastes from agriculture based industries | - Oil cakes<br>- Bagasse<br>- Rice bran<br>- Tobacco wastes<br>- Wastes from fruits and vegetable processing<br>- Tea waste<br>- Cotton dust from textile industries<br>- Etc. |
| Forest wastes | Leaves, twigs, bark, branches, etc. |
| Garbage | - Municipal wastes |
| Aquatic plants | - Water hyacinths<br>- Marine algae<br>- Sea weeds |
| Others | - Pressed Mud<br>- Waste water |

Bangladesh is predominantly an agrarian country. Most of the households keep livestock, although small in number and poor in quality. The way of land preparation and transport in rural areas, for which cattle are used, is being changed; mechanical devices such as tractors are being increasingly used. As such the use of cattle is decreasing. On the other hand, rearing of dairy cattle and poultry is being viewed as a means of alleviating poverty and in fact, dairy cattle and poultry are increasingly contributing to improving the livelihoods of landless and marginal farmers. Larger farms with hundreds of cattle are being set up. As a result, the number of cattle has remained almost constant at around 22 million over the last two decades.

The usage pattern of cattle dung in the country shows: fuel 34%, manure 46%, building materials 5%, and waste 15% (Eusuf, 1993). The portions used as fuel and fertilizer (in total 80%) may be made available for biogas production.

Poultry litter is another important raw material for biogas plants. Over the last two decades, poultry sector has grown rapidly in Bangladesh. However, poultry litter is being managed very poorly and being dumped in open pits near the farms. Poultry litter is being regarded as a problem for the poultry owners and neighbours, not only because it spreads bad smell, but also because the pits are breeding places for flies and insects and give poor aesthetic look. Organized human excreta may also be used as a raw material in biogas plants.

Water-hyacinth grows very rapidly and is capable of rapid multiplication in every place where water exists. It is menace in agriculture, fisheries and navigation and is available in plenty in the bils, haors, ponds, and rivers. Yield per acre is estimated at 20 tons per year (Eusuf, 1995).

**Table 1.2: Potential of biogas and organic fertilizer in Bangladesh (BCSIR, 2001)**

| Raw materials | Biogas ($10^6$ $m^3$/year) | Bio-fertilizer ($10^6$ tons /year) |
|---|---|---|
| Cow/Buffalo dung | 2971.1 | 60.20 |
| Poultry droppings | 191.6 | 2.05 |
| Human excreta | 1226.4 | 32.85 |
| Garbage | 115.00 | 1.72 |
| Water hyacinth | 740.00 | 10.00 |
| Pressed mud | 384.00 | 0.07 |
| Total | 5628.1 | 106.89 |

## 1.4 Objectives

The general objective of the study is to assess the feasibility of the application of biogas technology in the suitably sized poultry farms in Bangladesh. The specific objectives have been formulated as:

(a) To assess availability of raw materials in the suitably sized poultry farms.
(b) To examine technical and financial viability of biogas generation in poultry farms.
(c) To identify legal issues relating to the implementation of the project, its constraints and suggest mitigation if needed;
(d) To examine environmental aspects of the project and suggest mitigation if necessary;
(e) To assess socio-economic condition of the probable customers, their affordability and acceptability;
(f) To examine social, cultural and religious barriers if any and suggest probable mitigation if any.
(g) To review sustainability of the programme.

## 1.5 Methodology

The study was conducted following the methodology described below:

- Collection of documents on biogas projects (IFRD and LGED) and literature, including internet search
- Review of documents and literature
- Field visits to poultry farms in Sreepur, Savar, Manikgonj, Faridpur, Pabna, Bogura, Panchagar
- Interview with
    - organizations involved with biogas plants (LGED, IFRD, BRAC, GS, DoE)
    - experts on bio-gas technology (IFRD, LGED, BCAS, BUET, DoE)
    - owners of poultry farms with biogas plants
    - owners of poultry farms without biogas plants
    - neighbours of poultry farms/probable customers
    - biogas users, who purchase gas for cooking
    - members of Poultry Farm Owners' Association
    - policy and decision makers (Ministry, DoE, DoL)
- A participatory meeting with poultry farm owners, biogas plant owners, neighbors, representatives of local governments (30 participants) was held in Maona, Sreepur of Gazipur District
- Chemical analysis of poultry food, slurry and biogas
- Technical and financial analysis of collected data

- Meeting with banks (Dhaka Bank, Sonali Bank, Krishi Bank, and Islami Bank)
- Preparation of draft final report with some recommendations
- Experts Group Meeting
- Preparation of Final Report

# 2. Biogas Technology

## *2.1 Types of biogas plants*

Different types of anaerobic bacteria are responsible for anaerobic digestion of biomass and production of biogas. Temperature plays an important role in biogas production. The bacteria are able to work over certain temperature ranges. Mesophilic bacteria work best around 38°C, while the thermophilic types work around 60°C. Depending on the active bacterial type and temperature range, digesters may be classified into mesophilic digester and thermophilic digester. If temperature sinks, the gas production decreases. Thermophilic digesters require extra heating which adds to extra running costs, while a mesophilic one would only need a little extra heating during the winter period. Thermophilic digesters have a place in industry, however, when the feedstock temperature has already been elevated by the industrial process, such as the hot water used for washing abattoirs and fruit canneries.

Biomass can be fed into the digester in batches or continuously. Depending on feeding, a digester may be batch digester or continuous feed digester. A batch digester operates on a single charge until it is exhausted, i.e. when gas production comes to an end. At the end of the digestion cycle, the batch digester is emptied, cleaned, recharged and restarted for a new cycle. This cycle time, called retention time, depends on the biomass type. Operating the batch digestion system requires two or more digesters for a more or less continuous gas supply.

On the other hand, continuous-feed digesters have increments of fresh charge added and digested slurry subtracted on a daily (semi-continuous) basis to provide an ongoing replenishment of charge materials and water. The amounts withdrawn and replaced should be the same, otherwise the digester may become either over-loaded or under-loaded. These digester systems are less expensive. Most biogas plants operating nowadays are semi- continuous feed digesters.

Depending on the design, biogas plants may be classified into three basic types:

- floating dome,
- fixed dome, and
- balloon (or bag type).

<u>Floating dome biogas plant</u>

A floating dome plant consists of a digester and a moving gasholder. The gasholder floats either direct on the fermentation slurry or in a water-jacket of its own. The gas collects in the gas holder drum, which thereby rises. If gas is drawn, it falls again. The gas drum is prevented from tilting by a guide frame.

Advantages: Simple, easily understood operation, constant gas pressure, volume of stored gas visible directly, few mistakes in construction.

Disadvantages: High construction cost of floating dome, steel parts liable to corrosion resulting in short life (up to 15 years; in tropical coastal regions about five years for the drum), regular maintenance costs for painting.

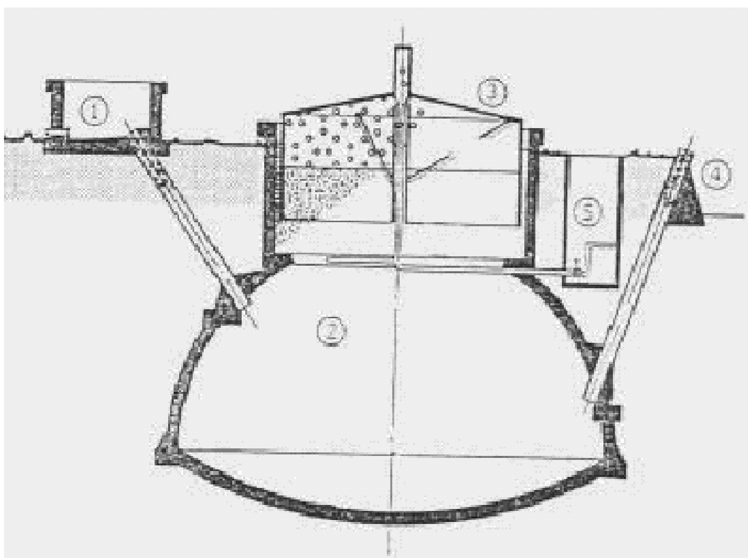


*Figure 2.1: Floating dome biogas plant (Sasse, 1988)*

<u>Fixed-dome biogas plant</u>

A fixed-dome biogas plant consists of an enclosed digester with a fixed, non-movable gas space. The gas is stored in the upper part of the digester. When gas production commences, the slurry is displaced into the compensating tank. Gas pressure increases with the volume of gas stored.

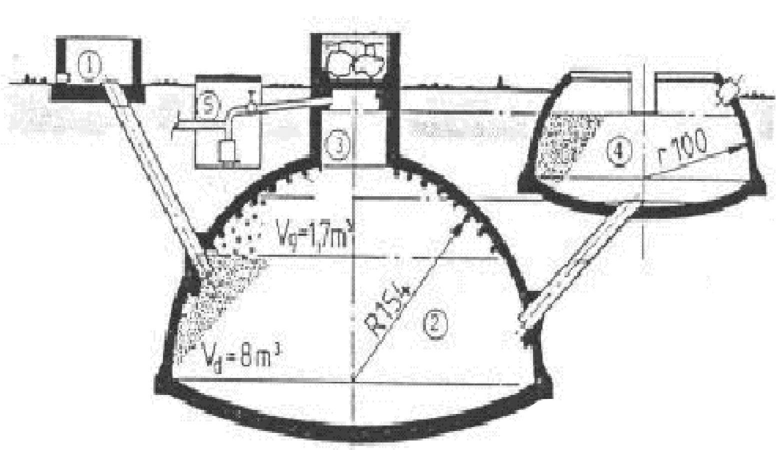

*Figure 2.2: Fixed-dome biogas plant (Sasse. 1988)*

Advantages: low construction cost, no moving parts, no rusting steel parts, hence long life (20 years or more), underground construction, etc.

Disadvantages: plants often not gas-tight (porosity and cracks), gas pressure fluctuates substantially.

Balloon Type biogas Plant

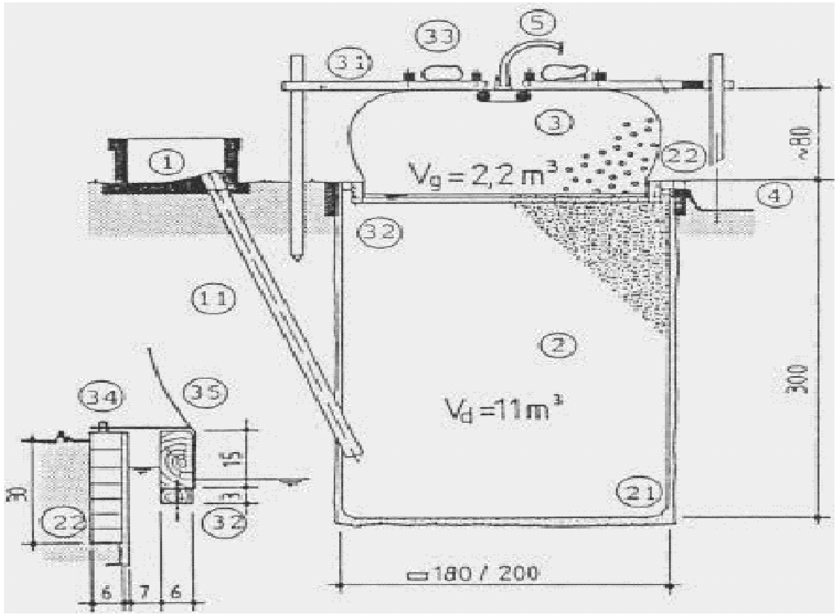


*Figure 2.3: Balloon type biogas plant (Sasse 1988)*

A balloon type biogas plant consists of a plastic or rubber digester bag, in the upper part of which the gas is stored. The inlet and outlet are attached direct to the skin of the balloon. When the gas space is full, the plant works like a fixed-dome plant. The fermentation slurry is agitated slightly by the movement of the balloon skin. This is favorable to the digestion process. Even difficult feed materials, such as water hyacinths, can be used in a balloon plant.

## 2.2 Experiences in the developing countries

Many developing countries in Asia, Africa and Latin America are working on biogas technology and harnessing the benefits of this technology. Among them, China and India have played the pioneering role in adopting this technology for the masses. Nepal has also achieved commendable success. Most of the biogas plants installed in China, India and Nepal are household type. The experiences of China, India and Nepal are discussed below in brief.

China

Work on biogas technology was started in China in 1930, however with little success. The first success came in 1958, when some plants were installed in Shichuan Province. The real breakthrough came in 1968, when the Government extended support to this technology. A massive effort was undertaken to develop low cost and effective biogas plants. Besides developing efficient and low-cost biogas plant, thrust was given on the dissemination of the technology. The government agency, BRTC, coordinated all biogas plant related activities. R & D on different processes and designs were carried out. As a result of intensive R & D, a design of low cost fixed dome biogas plant was finalized that was disseminated all throughout China. By now about 10 million biogas plants have been set up throughout China. Most developing countries are now following the Chinese fixed dome model in their biogas programmes.

India

The first biogas plant in India was installed nearly a century ago. During 1950s and 1960s, research on and dissemination of biogas technology began. However, wide-scale dissemination began in a concerted manner only in 1981 with the launching of the National Project on Biogas Development (NPBD) and its subsequent inclusion in the Prime Minister's 20 point programme. It gained further momentum with the establishment of the Department (now Ministry) of Non-conventional Energy Sources. The Ministry adopted a decentralized, multi-agency and multi-model implementation strategy for this nation-wide initiative. At the state level, the programme is implemented through a nodal agency responsible for achieving installation targets, managing finances, monitoring, etc. Other agencies involved at the District level and below are several government bodies such as the District Rural Development Agency, the Block Development Office, local private sector entrepreneurs, local government (*gram panchyats)*, dairy cooperatives and rural non-governmental organizations (NGOs). In addition, the national banks are also involved in the programme through the provision of soft loans to beneficiaries to partially meet construction costs. From the beginning, NGO participation has been an integral feature of the national biogas programme of India. Canada's PARTNERS in Rural Development (formerly Canadian Hunger Foundation), India's Action for Food Production (AFPRO) and their network of local NGOs, with assistance from the Canadian International Development Agency (CIDA) played an important role in development and implementation of India's biogas programme.

Floating dome plants, popularly called the KVIC (Khadi & Village Industries Commission) plants, were standardized in 1961 and were the first to appear in the backyards of Indian rural houses. Even though a few modifications were made with regard to alternate materials, by and large this design has remained unchanged over the years. The KVIC model is costly and tends to more failures due to corrosion.

These considerations led to the emergence of fixed-dome plants. Different variants, e.g. Gobar Ganesh, Pragati, Janata were developed and introduced. In spite of its cost advantage, these models were still beyond the reach of most rural households. In the search to further reduce costs, a concerted effort was made, which resulted in the development of Deenbandhu model. The digester is connected with feeding pipe (inlet) and outlet tank. The upper part, above the normal slurry level, of the outlet tank is designed to accommodate slurry displaced out of the digester with the generation and accumulation of biogas (Figure 2.5). Deenbandhu model is the most popular model in India.

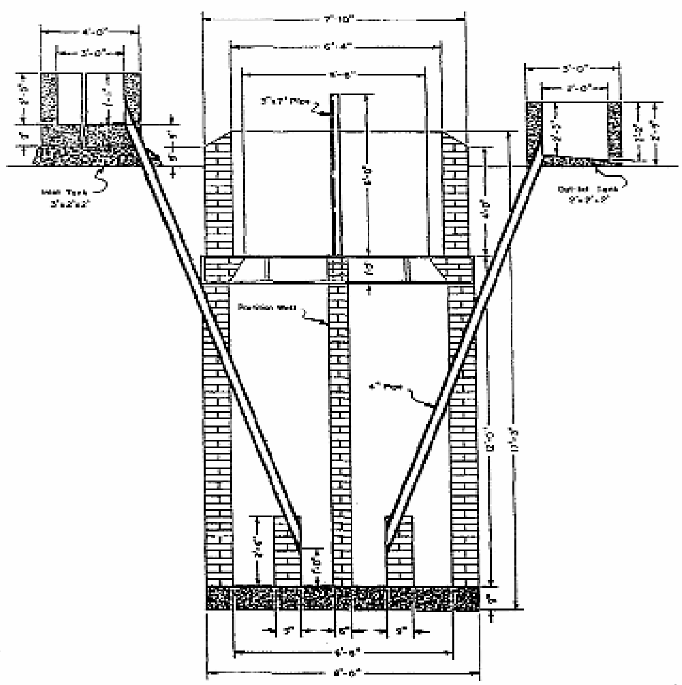

*Figure 2.4: KVIC Model (Lichtman, 1983)*

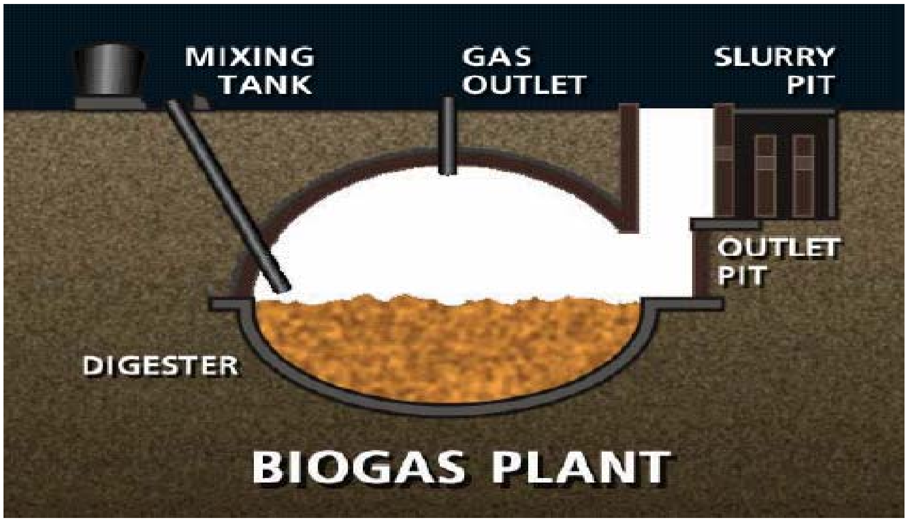


*Figure 2.5: Deenbandhu biogas plant (AFPRO, 2000)*

Till 1997 about 2.9 million biogas plants of different models were installed. It is reported that about 200,000 new plants are installed every year in India.

<u>Nepal</u>

In Nepal, biogas was first introduced on an experimental basis in 1955. The initial experiences showed the feasibility of biogas technology for meeting a significant portion of rural household energy needs. Inspired by this, several organizations of Nepal with technical support from the Netherlands Development Organization (SNV) started Biogas Support Programme (BSP) in 1992. It was financially supported by Directorate General for International Cooperation (DGIS) of the Netherlands and Kreditanstalt fuer Wiederaufbau of Germany. During the three phases (1992 – 2003), a total of 111, 395 fixed dome biogas plants were installed. The model is a simple modification of Chinese fixed dome model. Since June 2003, BSP is being run by Biogas Sector Partnership Nepal (BSP – N) with SNV as advisor. The target has been set to 200,000 biogas plants by 2009 (SNV, 2004).

### *2.2.1 Lessons learned from biogas projects of China, India and Nepal*

Experiences from biogas programmes of China, India and Nepal are valuable for designing and for successful implementation of any biogas programme in Bangladesh. Therefore, lessons from those countries are briefly mentioned below:

- China developed the present Chinese model fixed dome biogas digester long before and they are following the same model all over the country. Nepal is following the Chinese model with minor improvement based on their country situation. Most biogas plants of India are floating dome type, which has been developed by them long before. Recently, they are also constructing fixed dome biogas digester with some adaptation in the name of Deenbandhu model and Janata model.
- Most of the plants in Nepal and China are connected to toilet, but India is still facing social barrier in promoting use of night soil as raw material.

- Fixed dome type biogas digester is being used by China and Nepal, because it is durable and maintenance cost is negligible. Floating dome used by India is more efficient; construction is simple and the gas pressure remains almost constant.
- In Nepal, 60 companies are involved and in India private contractors and NGOs are involved.
- In India and Nepal, there is a provision of guarantee for after-sale services in the contract usually in the range of 5-10 years.
- In most cases, biogas is used for cooking. Some are using biogas directly for lighting hazak. Some large farm owners and research organizations are using biogas for producing electricity. But these are still at initial and experimental stages.
- In all the three countries, there is government will and commitment. As a result there is provision of government support in the form of subsidy.
- In all the three countries, there is strong policy support and institutional arrangement.
- Although there is provision of capacity building and human resource development, yet these are not adequate.

The above lessons lead to the following conclusions:

- Understanding the end-user / market needs are important to design a product that meets and addresses the concerns of users.
- Cost-effective and simple design should be introduced.
- Local people and NGOs should be integrated in the dissemination of the technology.
- After-sale service is essential.
- Financial incentives are needed to stimulate the market.
- Concerted efforts are necessary.
- Training to local masons is important.
- Successful implementation strategies require good collaboration between the implementers and nodal agencies.
- Projects should be formulated with the utmost care to integrate women from the beginning of the project.
- Procedures involved in mobilizing bank loans should be simple.
- Network structures and programme advisory committees help improve the overall performance of the project.

## *2.3 Experience with biogas in developed industrialized countries*

The main purpose of biogas plants in the developed industrialized countries is not the production of biogas itself, but the environmental concern. Biogas plants, now-a-days built in developed countries, are of big sizes and include, among others, heat recovery, gas analysis system, scrubber technology, booster, biogas flare stack, and control elements. They are used in co-generation plants for producing electricity and process heat for different purposes, e.g. district heating. Heat is also used for maintaining optimum temperature in the digester, especially during the cold days.

Complete turnkey plants are available for installation. All process engineering components – biogas co-generation units (CHP), pumping stations, and membrane facilities – are fitted into standard containers. On delivery the containers are ready to be connected. No buildings are required. Digesters are mostly made of concrete or steel and equipped with stirring devices. To be fully operational, the container only needs a concrete foundation on site and connection to the gas, energy, and heat supply. Biogas plants with electric outputs of 500 to 1,250 kW are supplied on regular basis on plug and play.

With sharper environment pollution control and thrust on renewable energy, biogas technology is experiencing new impulse throughout Europe. As already indicated, biogas technology is “in” not only for its economic benefits, but more and more for its environmental benefits. Almost all European countries are supporting biogas technology in a great way both directly and indirectly. For example, German Renewable Energy Legislation (Erneuerbare Energien Gesetz EEG) grants guaranteed royalties for electricity produced from renewable sources of energy. For the next 20 years, this provides a safe and sound basis for the planning of biogas plants. With the new waste disposal legislation coming into force in 2005, more support packages are coming for biogas plants. Other European countries are also helping the development of biogas technology.

*Photo2.1: Biogas Plant at Wolperthausen, Germany*
*(Gas production: 1800 m³/d, Electricity: 550,000 kWh/year)*

*Photo 2.2: Biogas plant at Mauternach – Luxembourg*
*(Gas production: 1000 m³/d, Generator: 1x50 kW, 1x 75 kW)*

### 2.4 New Development

Research on biogas technology is being done all over the world. Thrust is laid on developing processes that are more efficient in generating not only an alternative energy source, but also materials that are useful as fodder substitutes and substrates for mushroom and greenhouse industries in addition to traditional use as organic fertilizer (FAO, 1999).

As a result, several newer processes are being developed that promise to be more efficient. Thrust in biogas technology research is given on developing new bacteria that can accelerate the production of methane. Manufacture of standard concentrated and purified enzymes is relatively expensive. Apart from that, not all bacteria in a blend can turn all the organic substances in the biomass into methane. Researchers at the University of Bonn in Germany have developed a new process for increasing methane production in biogas plants and lowering manufacturing costs. Trials on fungi have been conducted as additional decomposition agents. The results showed that the fungi increase the biogas yield by thirty to fifty percent, if added in the right concentration. The production cost is only a fraction of the global market price for conventionally produced purified bacteria.

## 3. Application of Biogas Technology in Bangladesh

### 3.1. History of biogas development in Bangladesh

The first biogas plant in Bangladesh was constructed in 1972 at Bangladesh Agricultural University (BAU), Mymensingh campus for study purposes. This was followed by another plant in Phulpur that provided gas for cooking and lighting for a family of six members. Both these plants were floating dome type. IFRD of BCSIR started R&D on biogas technology in 1973 and constructed a family-size biogas plant (6.3 $m^3$ digester volume and 2.3 $m^3$ gas-holder volume) in 1976 following the design of India's Khadi and Village Industries Commission (KVIC) in the BCSIR campus (Eusuf, 1995). This was followed by a plant at the KBM College in Dinajpur in 1980. With the experience gained through the installation and operation of these plants, IFRD went for dissemination of the floating dome type technology. More than seventy plants were installed at the cost of the owners.

*Photo 3.1: Raj Poultry Farm, Faridpur*

In 1981, Environmental Pollution Control Department (EPCD), predecessor of Department of Environment (DOE) started a programme under a government grant and installed 110 plants of fixed-dome model and over 150 plants of floating dome type through hired contractors. Other efforts were undertaken by BSCIC (a number of plants), DANIDA (few trench and bag type digesters) and DLS (about 70 plants). Grameen Bank installed 17 plastic bag digesters. In 1985, Local Government Engineering Department (LGED) started study, research, development and extension of biogas technology.

Under the "Fuel Saving Project" financed by the Government and implemented during 1989-1991, IFRD trained local youths who constructed a total of 126 floating dome biogas plants. In 1992, the IFRD in collaboration with Dhaka City Corporation built an experimental biogas plant of 85 cubic meter digester volume at Dholpur for treatment of city garbage.

In June 1992, LGED constructed first Chinese-type fixed-dome model biogas plant in Karimpur village of Begumgonj, Noakhali. In the same year LGED constructed the first night soil based biogas plant at Faridpur Muslim Mission. In 1993, LGED constructed a biogas plant based on water hyacinth at Madaripur.


*Photo 3.2 : Biogas plant inlet*

In 1994, LGED constructed the first biogas plant from poultry droppings at Utter Khan, Dhaka and garbage-based biogas plants in ten towns. At the end of 1994, LGED constructed a total of about 200 biogas plants, out of which eight were floating dome type and the rest were fixed-dome type. Among these plants, 73 were based on night soil, one on water hyacinth, two on poultry droppings, 23 on garbage and the rest on cow dung.

The Government of Bangladesh undertook a Biogas Pilot Plant Project (BPPP). IFRD was selected as the implementing agency. 4664 and 17,194 fixed dome biogas plants were installed during the 1st phase (1995-2000) and 2nd phase (2000-2004) of this project respectively.

In the period from October 1998 to June 2003, the LGED implemented a parallel biogas project, under which 1,120 biogas plants were installed. Under “Secondary Town Infrastructure Development Project-II”, LGED installed 20 domestic biogas plants using human excreta only.

IFRD, BCSIR, LGED, DOE, DLS, BAU, BARD are government organizations, whereas Grameen Shakti and BRAC are non-government organizations. Figure 3.4 shows an approximate number of biogas plants installed till July 2005 by different organizations. It is to note that the figures published in the reports and journals differ to some extent. It is evident from the Figure that most of the biogas plants of Bangladesh have been installed by BCSIR.

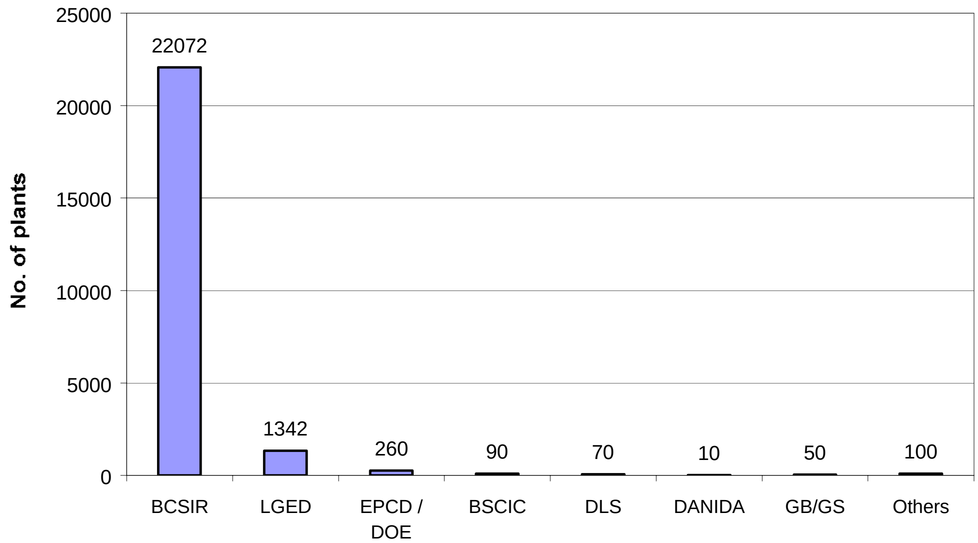


*Figure 3.1: Organization-wise biogas plants installed in Bangladesh*

*(http://www.ieiglobal.org/ESDVol7No2/cookstove.pdf, http://www.lged-rein.org/biomass/biopro_lged.htm)*

## 3.2 Experiences with different models

All major types of biogas technology have been applied in Bangladesh. Different approaches for dissemination have also been tried. Through trial and learning, Bangladesh has gained substantial experience on biogas technology. Fixed dome type biogas plant has proved to be the most suitable for Bangladesh. At the moment it is the only design that is being applied in the country. The model promoted by IFRD, BCSIR in both phases of the BPPP is the local variant of the Chinese fixed dome model. In the original Chinese model, the outlet for cleaning and maintenance work in the digester is on the dome as a manhole, whereas in the IFRD model, the same is located on the side. LGED made small modification of the BCSIR model by revising the shape of the outlet (from rectangular to round) and by putting an RCC ring beam.

Different organizations have worked towards capacity building. As a result, there is skill and know-how on the biogas technology. There is also awareness among the people about the advantages of biogas plants. As such it may be concluded that there exists conducive atmosphere to go for large-scale biogas programme.

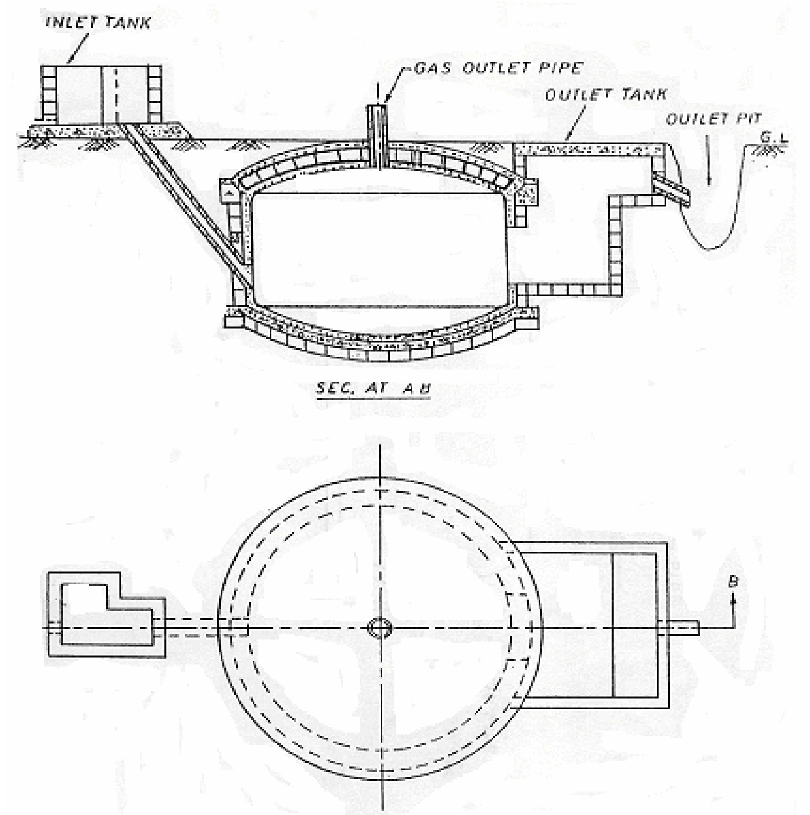


*Figure 3.2: Fixed dome biogas plant, BCSIR model (Aktaruzzaman, 1999)*

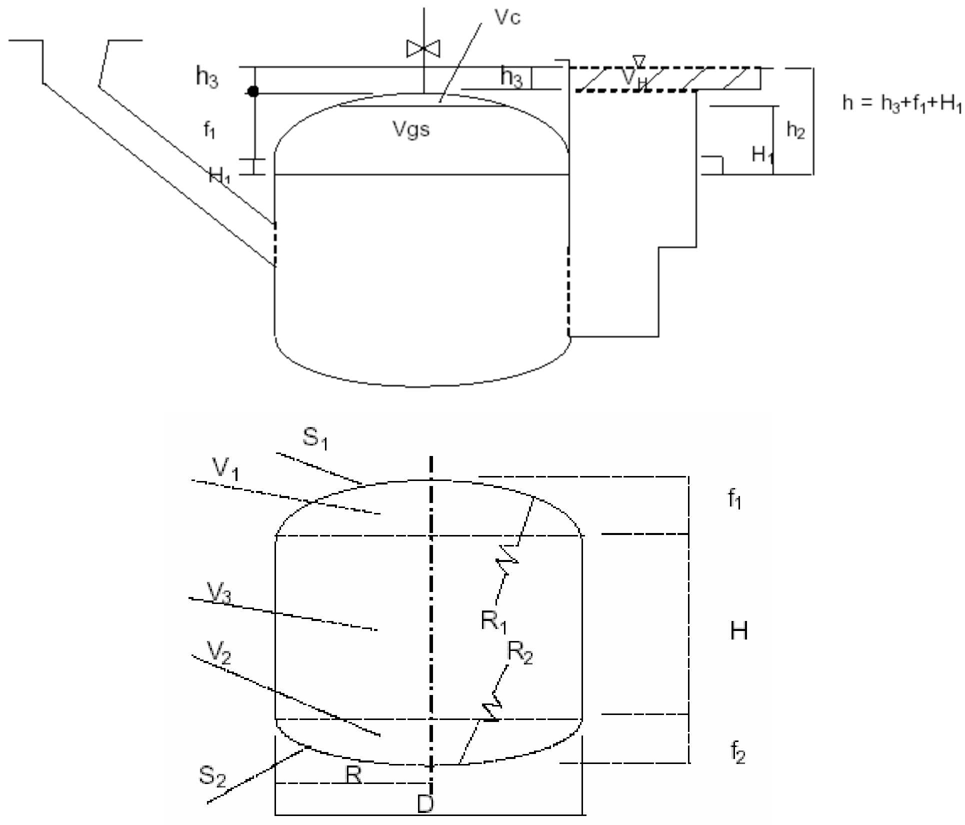


*Figure 3.3: Fixed dome biogas plant, LGED model (LGED web site)*

## 3.2 Operating conditions

The output of a biogas plant depends on the operating conditions. The optimum conditions for operating a poultry litter based biogas plant are given below (Adapted from LGED website):

- Total solid (TS) percent in the feed (6~10%)
- Loading rate (8~10 kg/$m^3$ digester volume/day)
- Retention time (~40 days)
- Pressure(60~120 cm water column)
- Diameter to depth ratio(1:1)
- Temperature (25~37$^0$C)
- Carbon to nitrogen ratio (25:1)

## 3.4 Cost of Biogas Plant Construction

IFRD estimated costs for different sizes of fixed dome biogas plants for its Biogas Pilot Plant Project (BPPP). These costs served as basic outlines for the field level implementers (constructors) and owners of the plants and are shown in Figure 3.4. Discussions with field workers have revealed that, the costs given in Figure 3.4 are valid and biogas plants may be constructed at these costs. However, the RCC ring beam for outlet as used by LGED, makes the plant costlier.

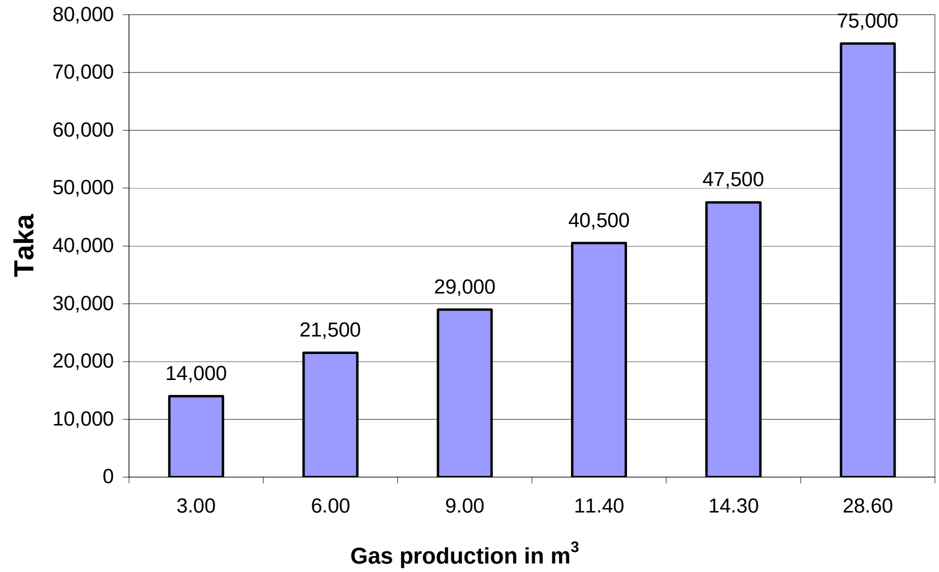


*Figure 3.4: Cost of biogas plant installation in Bangladesh (BCSIR, 1998)*

## 3.5 Socio-cultural Acceptability

Social and cultural factors play important roles in the successful dissemination of any technology for masses. If any technology is not socio-culturally acceptable to the people, who would use it, it can not be disseminated. In case of biogas technology, raw material used in the biogas plant (cow-dung, poultry litter, night soil, etc.) is important. The success or failure of an even good design and cost effective biogas technology will depend largely on the attitude of the people to the product biogas and slurry. Experiences with different types of raw materials applied in the biogas plants of Bangladesh are summarized below:

- Biogas from cow dung is well accepted by the people. Cow dung itself has no acceptance problem in Bangladesh. It has always been accepted by the people irrespective of religions and ethnic groups. The rural people do not hesitate to touch it by hands and are accustomed to prepare dung cake for using as fuel. It is widely used as construction material, as fertilizer and as fuel. The Hindus even regard cow dung as a material that makes unholy thing holy.

- Poultry litter does not enjoy similar acceptance as cow dung does. It smells bad. However, biogas from poultry litter is also well accepted by the people. Field visits and discussions showed that people of all religions would use this gas without any hesitation.

- Biogas from human excreta has some acceptance problems. Hesitation prevails even among planners, who confuse whether the people would use the biogas for cooking meals. However, through motivational work undertaken by LGED and IFRD, acceptance problems have been overcome. After consulting the holy Quran, religious leaders have declared that the gas is cleaned as it is burnt. Representatives from Islamic countries such as Saudi Arabia visited the orphanage of Faridpur Muslim Mission and were satisfied to see the replacement of the expensive wood fuel by excreta-based gas (Aktaruzzaman, 1999). There are several hundred operational biogas plants in Bangladesh, where human excreta is being used as one of the raw materials and the users have overcome their initial hesitation. It seems the usefulness and convenience of biogas compared to solid biomass have helped convince them.

## *3.6 On-going and Planned Projects*

A few biogas projects were undertaken in Bangladesh, which have been mentioned in the previous sections. There is no on-going biogas project at the moment from any government agency. IFRD submitted a proposal to the Government for a new project with a target of 50,000 biogas plants, which is yet to be approved by the Government. However, it has not been included in the budget for the Financial Year 2005/06. As such there is no public fund for any biogas project in the current year.

A few agency holders, who were engaged in the BPPP, are trying to construct plants on their own efforts as a part of their business. In some locations, they are providing after-sale services, like maintaining the plants against fee. Discussions during field visits have revealed that many households with sufficient number of cattle or poultry are willing to install biogas plants. However, there is a rumor that the Government will start a new project, which will contain subsidy. As such the people are hesitating to go for biogas plants fully on their own costs. In effect, very few biogas plants are currently being installed.

Very recently, Grameen Shakti has undertaken an initiative to construct 200,000 biogas plants within 2010. As start, Grameen Shakti has targeted to construct 500 plants within 2005 (Barua, 2005). This project does not contain any direct or indirect subsidy. Grameen Shakti is offering two options: cash payment and installment payment (micro finance). For installment payment, an additional cost in the form of service charge @8% per year is being collected. Grameen Shakti has already achieved a remarkable success in installing solar home systems through micro-finance option. The same model is being replicated in the biogas plant programme. It is expected that the micro-finance option will enable the cash-constraint households to go for biogas plants. The initial experience confirms this. Within two months, till end of July 2005, 20 plants were installed. The initiative is still in the primary stage. Grameen Shakti is recruiting skilled personnel for this project and employing them in prospective unit-offices spread throughout the country.

BRAC, along with a US based enterprise “Emergence Energy”, has come forward to install biogas plants. The aim of this venture is to do business through supplying electricity in the remote un-electrified area and by selling bio-fertilizer. Two pilot biogas plants have been installed at two different remote locations, namely at Paschim Kustia Village of Manikganj and at Sakhipur of Tangail District. Currently, experiments are being carried out on different technical and business aspects. If successful, BRAC and Emergence Energy intend to disseminate biogas plants all over the country on a commercial basis.

The Netherlands Development Organisation, SNV, has planned to set-up and implement large-scale programmes for domestic biogas in a number of Asian countries including Bangladesh. The objective of the project in Bangladesh is to undertake a national programme with a longer-term vision to develop a commercial, sustainable biogas sector. The project envisages setting up of 36,450 biogas plants within 2009. Preparations for the project are currently underway. It is expected that the project will commence in January 2006. The initial target has been set to install 2,100 biogas plants within 2006.

Another initiative has been undertaken by the GTZ under its PURE project. The present study is a part of this initiative.

### 3.7 Success stories and failures of biogas projects

Since the installation of the first biogas plant in 1972, about 34 years have passed. Several R & D and dissemination projects were undertaken during these years. BAU undertook the first initiative to research on biogas technology, but did not continue. R& D works were then done mainly by IFRD of

BCSIR. EPCD and LGED undertook also limited efforts. In educational institutions and universities, research activities on biogas technology are rather meager.

*Photo 3.3: Inlet tank of a biogas plant in Savar*

*Photo 3.4: Poultry-based biogas plant at Faridpur Muslim Mission being visited by the Study Team*

As discussed in Sec. 3.1, during 1972 – 1992, different organizations undertook initiatives in promoting this technology, however, without proper attention to appropriate technology and after-sale service. The results were very discouraging. An internal report of the Local Government Engineering Department in 1992 (Rahman et al.1996) says that about 75 per cent of the constructed biogas plants did not operate properly mainly because of design, construction and maintenance problems (Table 3.1). There is limited coordination among the researchers and implementing authorities. There is also a very limited follow-up action programme.

**Table 3.1: Biogas plants surveyed by LGED in 1992 (Rahman et al. 1996)**

| Organization | No. of biogas digesters | | | | Condition in 1992 |
|---|---|---|---|---|---|
| | Fixed dome | Floating dome | Balloon | Total | |
| BAU | - | 5 | - | 5 | Not working |
| BARD | - | 1 | - | 1 | Not working |
| BCSIR | 22 | 35 | - | 57 | 50% not working |
| EPCD | 110 | 109 | - | 219 | 85% not working |
| BSCIC | - | 92 | - | 92 | 80% not working |
| BADC | - | 5 | - | 5 | Not working |
| LGED | 89 | 8 | - | 97 | 10% not working |
| DANIDA | 2 | 4 | 4 | 10 | 60% not working |
| Other | 6 | 73 | 1 | 80 | 90% not working |

As stated in Sec. 3.1, the Government of Bangladesh undertook a Biogas Pilot Plant Project (BPPP) 1st phase with a target of 5000 fixed-dome biogas plants for the period 1995-2000. IFRD was the implementing agency. IFRD employed and trained 128 diploma civil engineers who were assigned responsibilities for motivation, installation and after-sale service throughout the country. In addition, 898 youths were trained to support the project. Memoranda of understanding were signed between IFRD and several other organizations like BRAC, LGED and DLS for training and dissemination of the biogas technology. The cooperation with BRAC was the most successful as it installed 1,200 biogas plants. This project provided a subsidy of Tk.5000 per plant and the rest of the cost was borne by the owner. At the end of the project, 4664 biogas plants were installed. An interim evaluation report made by IFRD in 1999 claimed 99% of the plants installed were in operation, while 91% of the owners could meet their household fuel demand through biogas. Slurry from the biogas plants was used in horticulture, pisci-culture and agriculture (BCSIR, 1999).

The 2nd phase of BPPP with a target of 20,000 plants was implemented by IFRD during 2000-2004. The subsidy amount was increased to 12,500 Taka per plant (7500 Taka to the owner directly and indirectly in the form of a service charge of 5000 Taka to the installer) and a different approach was followed. In place of NGOs and other public agencies as was practiced during the 1st phase, an agency system was introduced under which 50 agencies were engaged. They installed the plants and received the service charge. About 1,000 masons and youths were trained under the project. IFRD monitored the project. At the end of the project period, 17,194 plants were installed.

LGED implemented a parallel biogas project in the period from October 1998 to June 2003 aiming to install 1,900 domestic plants. The subsidy for this project amounted to 5,000 Taka, whereas IFRD provided at the same time 12,500 Taka. It proved to be rather difficult to motivate farmers for LGED biogas plant. As a result, the project was terminated prematurely after having constructed 1,120 biogas plants.

An evaluation report of BPPP (1st & 2nd phase) conducted by DPC group found that 88.5% plants constructed under 1st phase and 97.27% plants constructed under 2nd phase were in operation (BCSIR, 2004).

Monsof, as part of his Diploma-work at the University of Flensburg, undertook a survey of 80 biogas plants in Pabna District (Monsof, 2005), which were constructed under different projects (EPCD, BPPP 1st and 2nd Phases, LGED) at different times. Monsof found 50% of the plants were not working. Monsof identified following failures for non-functioning of the plants:

- Technical failure: Leakage/cracking in the dome & gas holder, incorrect leveling of different parts, design problem, inadequate capacity of gas storage chamber, faulty location of plants, moisture in gas, etc.

- Social Failure: Social barrier and land ownership.
- Management Failure: i) Management failure from the consumer, ii) Management failure from the technology providers.

Monsof found that 55% of the non-functioning of the plants was due to technical failures. Most of these failures occurred after four years of installation.

Although projects undertaken by IFRD and LGED have not fulfilled the target completely, the projects may be termed as successful because:

1. They have made the people throughout the country aware about the technology and its usefulness.
2. The projects have contributed to in-country capacity building and created quite a large number of skilled workers who are able to design and install biogas plants on their own.

The initial failures may be understood as “children diseases”. By now, biogas technology is a proven and well-accepted technology in Bangladesh. Fixed dome type plants have proved to be most appropriate and cost effective for the conditions in Bangladesh.

# 4 Experiences with biogas utilization in commercial enterprises

Dairy farms and poultry farms are commercial establishments. Biogas plants installed in the country are based mainly on dairy farms and poultry farms. Experiences with biogas utilization may be classified into (i) experience with production of biogas, (ii) experience with slurry, and (iii) experience with use of biogas. These experiences are associated with important issues like social acceptability issue, hygienic issue, environmental issue, fuel issue, cost issue, etc. Experience varies with locations of the plants:

- Area with electricity and gas grid,
- Area with electricity grid, but no gas grid, and
- Area without electricity and gas.


*Photo 4.1: Biogas plant with gas delivery pipe at Kazi Tea Estate, Tetulia*

To get opinions and share experiences, individual interviews were made with biogas plant owners, organizations (government and non-government) and biogas experts. A group discussion was also held with owners and neighbors of poultry farms, as well as owners and users of biogas plants and community leaders. During this discussion, the participants articulated their views and experiences. This chapter gives a summary of the experiences of field visits and group discussions.

## *4.1 Experience with the production of biogas*

Experiences with production of biogas include technology, design, cost, operation, maintenance, availability of raw material, environmental aspects, hygienic aspects, etc. The focus of the project was poultry-based biogas plants. During this study, it was found that the poultry-based biogas plants were situated in areas with electricity grid but no gas grid.

Most of the poultry farms in Bangladesh are small in sizes and employ in most cases only one or two persons for the operation of poultry farms, including maintenance, feeding and vaccination of the birds. In bigger farms, more persons are employed. Production of biogas does not cause much additional work, because the farm owners have to clean the farm and dump the litter in suitable pits for keeping their farm operational. The only additional work is to mix the litter with water. Therefore, the same persons who work in the farm can do the work associated with the biogas plant operation.

Poultry-based biogas is socially and environmentally well-accepted by the people. The raw materials are locally available. Skilled technicians are also available. The cost of a biogas plant is within the financial capacity of the farmers. However, cash constraints hinder the massive dissemination. Availability of cash in the form of bank loan or micro-credit will ease the situation.

*Photo 4.2: Biogas plant with gas distribution lines at RDA, Bogra*

The fixed dome biogas plants are a proven technology. Most of the users have good experience with the production of biogas. The biogas plants have a lifetime of at least 20 years. The oldest plant in Bangladesh was installed 15 years ago in the BCSIR campus and is still functional. In some cases, domes are exposed to atmosphere, which causes fall of gas production during winter period of November to January. The case of dome cracking is seldom.

The operation of biogas plant is easy. Usually, no maintenance is necessary. Some people have experienced that gas production decreases. In such cases raw material is either over fed or underfed.

## 4.2 Experience with use of biogas

*Photo 4.3: Boiler for preparation of poultry feed run by biogas at Raj Poultry Farm, Faridpur*

*Photo 4.4: Overhead pipe carrying biogas to a neighboring household at Savar*

In most poultry farms of Bangladesh, poultry feed is not prepared, rather bought from the market. Only a few large farms prepare feed, which needs energy as input. Preparation of poultry feed with biogas is cost effective.

The biogas is supplied to the households of the farm owners, who usually reside in the vicinity, and to the neighbors. It is being used mostly as cooking fuel. Biogas is convenient and less polluting. The women using biogas like it very much. The cost of biogas, when sold, is usually set in relation to the natural gas supply by gas utility. Currently, biogas is supplied at a price of 300-400 Taka per connection, whereas gas supplied by utility is 375 – 400 Taka depending on one or two stoves. Compressed natural gas for vehicle is about 8.30 Taka / $m^3$. Field visits reveal that biogas produced from litter of about 200 birds is adequate to cook two meals for an average rural household.

*Photo 4.5: Cooking with biogas*

Biogas from a few plants is being used for cooking food in institutions and for business enterprises. However, their number is very small. There is at least one case where biogas is used for preparing sweetmeats for sale.

*Photo 4.6: Commercial biogas stove used for preparing sweetmeats*

Biogas is also used for lighting. Hajjak light is popular in some plants. Biogas is also used for power generation. Attempts have been made by several private and public sector organizations to produce power from biogas. No generator is currently made in the country. Most attempts made are to retrofit petrol generator or LPG / natural gas generator, with limited success. The users have reported that they have problems with starting and continuous generation. In most cases, the generators cease to work after some hours. However, Bogra Poultry Complex is operating a retrofitted generator for the last five years and meeting his power needs. Although REB grid electricity is available in the area, he has discontinued the REB connection and now uses his own power.

*Photo 4.7: Hajjak light based on biogas*

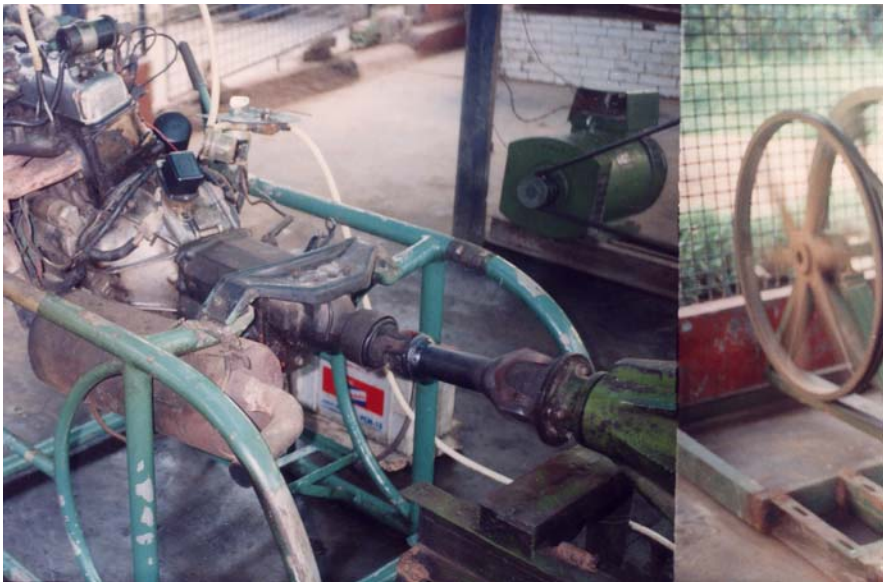

*Photo 4.8: Power generator (locally retrofitted) based on biogas at Bogra Poultry Complex*

*Photo 4.9: Biogas-based generator developed by Bogra Poultry Complex*

## 4.3 Experience with the use of slurry

As already mentioned, slurry from biogas plant is a good fertilizer. It is used as fertilizer and as fish feed in fish farms. The farmers have very good experience with the use of slurry and recognize the superiority of slurry over the chemical fertilizer. Through use of slurry, more yield of crop can be harvested. IFRD mentioned (quoting Chinese literature) that by using the digested slurry production of crops such as paddy, vegetables, potato, banana, onion, etc. can be increased significantly (Table 4.1).

**Table 4.1: Comparison of crop yields by using slurry and chemical fertilizer (BCSIR, 1998)**

| Crop | Yield by using chemical fertilizer | Yield by using slurry | Increase |
|---|---|---|---|
| | Ton/ ha | Ton / ha | % |
| Rice | 8.28 | 9.02 | 8.93 |
| Maize | 7.0 | 9.5 | 35.7 |
| Cotton | 3.13 | 3.97 | 26.8 |
| Vegetable | Less | more | - |

Photo 4.10 : Biogas slurry being used as fertilizer at Kazi Tea Garden, Tetulia

The use of slurry of a biogas plant as fertilizer increases the crop production significantly. It is more productive than the undigested dung. Farmers also mention that fresh poultry litter may even destroy the crops. The substitution of commercial fertilizers with slurry produced by biogas technology reduces the impacts on balance of payments. The consequence of reliance on digested slurry is that valuable nutrients and organic matter are led back to the soil in an improved stage, raising agricultural productivity and soil stability.

*Photo 4.11 : Vegetable cultivation with biogas slurry as fertilizer, Raj Poultry, Faridpur*

During field visits, the poultry farm owners were asked whether they used residue or not. The majority of the respondents mentioned that they used residue. During his survey, Monsof (Monsof, 2005) asked the farmers for which purpose they use slurry. He found the majority of the respondents (69%) used residue as fertilizer, 11% respondents used residue as fish feed and the rest 20% respondents used residue as both fertilizer and fish feed. Some of them did not use the slurry, but sold it. The market price of slurry is 0.80 Taka – 3.00 Taka per kg. In dry condition the cost is more than 4 Taka per kg. The farmers use slurry in dry condition, usually sun dried, whereby some nutrients are lost. Very few farmers know about the nutrients.

Technology for value addition is not currently available in the country. Packaging of slurry will add to value. Currently, one farm is marketing slurry in packets. Another company will launch bio-fertilizer sale soon.

Opinions of the farmers were sought on whether the use of residue decreased the expenditure on chemical fertilizer. The majority of the respondents who used slurry mentioned that their expenditure on chemical fertilizer was decreased.

# 5. Test results

Test results of biogas and poultry feed are given in Tables 5.1 and 5.2 respectively. The biogas was collected from a biogas plant in Maona and tested by IFRD, BCSIR. The poultry feed was prepared and tested by Agro- Organic Food Complex Ltd., Faridpur.

**Table 5.1: Test results of dry biogas produced from poultry litter in a biogas plant at Maona**

| Sl. No. | Specification | Results |
|---|---|---|
| 1 | Methane | 58.72% |
| 2 | Carbon dioxide | 38.25% |
| 3 | Hydrogen Sulfide | 0.35% |
| 4 | Nitrogen | 2.68% |

**Table 5.2: The test results of poultry feed prepared and tested by Agro-organic Food Complex Ltd., Faridpur.**

| Sl. No. | Specification | Results |
|---|---|---|
| 1 | Phosphate | 2.5 % |
| 2 | Potassium | 2.5 % |
| 3 | Nitrogen | 2.5 % |
| 4 | Sulphur | 2.25 % |
| 5 | Magnesium | 1.5% |
| 6 | Zinc | 1.5% |
| 7 | Manganese | 0.5% |
| 8 | Iron | 0.5% |
| 9 | Copper | 0.2% |

| | | |
|---|---|---|
| 10 | Calcium | 1.00% |
| 11 | Organic Matter | 45% |
| 12 | Moisture | 15% |
| 13 | Others | 25.05% |

## 6. Scrubber Technology

Biogas is a mixture of methane and carbon dioxide with small amount of moisture and hydrogen sulfide. Of these gases, methane is the only useful gas. Carbon dioxide does not do any harm except its effect as greenhouse gas and diluent of methane. Some people also opine that the space occupied by carbon dioxide is also disadvantageous. Moisture content causes difficulties during burning. The real problem is, however, hydrogen sulfide. It is a corrosive gas and combines with moisture to form sulphurous/sulphuric acids that can corrode all metal parts that come in its contact.

Scrubbing is the operation that removes unwanted compounds from the biogas before it is used. Scrubbing of biogas is necessary mainly because of the hydrogen sulfide. Sometimes, carbon dioxide that simply 'takes up space' for no useful return is also removed.

The scrubber system needs to allow a fairly free flow of gas to minimize pressure losses in the gas system since the operating pressures are low. Typical system pressures are around 1.15 –1.25 bar. Since appliances usually operate at around 1.15 –1.25 bar, there's not much room to maneuver. Only little reduction can be tolerated, otherwise appliances may not work or the gas flow may even stop. In a system requiring carbon dioxide scrubbing, the low-pressure route will not work well. Instead, a series of pumps or a multi-stage pump/compressor is needed to pressurize the carbon dioxide scrubbing operation and for later methane compression for storage in high-pressure steel bottles. This more expensive storage method is usually only needed for use with vehicles to allow sufficient useful fuel to be stored or carried conveniently.

Scrubbing of hydrogen sulfide

The easiest way to get rid of hydrogen sulfide is to allow it to react with any gas/solution/metal-oxide. Red oxide (in the form of steel wool, for instance) may be used in a wide-necked bottle. It should be of clear glass with the gas inlet pipe running down to the bottom of the container and an outlet pipe coming away near the top. The whole thing must be gas-tight. The steel wool will corrode from the bottom upwards taking up the hydrogen sulfide by conversion to black iron sulfide that can later be reused after being oxidized to rust (ferric oxide) by exposure to air. When the black corrosion reaches about 75% of the height of the container, it's time to change the used steel wool for fresh stuff. It's probably better to run two or more similar bottles or containers connected one after the other to give some flexibility by providing some 'back-up' scrubbing capability.

The chemical reaction of red oxide with hydrogen sulfide is given in the following chemical equation.

$$Fe_2O_3 + 3H_2S \longrightarrow 2FeS + 3H_20 + S$$

The regeneration of red oxide through oxidation in the air takes place according to the reaction below:

$$4FeS + 70_2 \longrightarrow 2Fe_2O_3 + 4SO_2$$

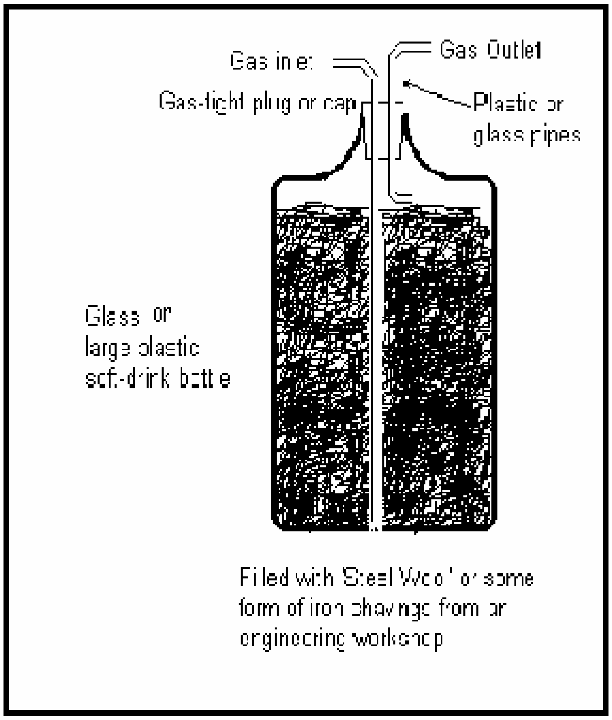


*Figure 6.1: Scrubbing of hydrogen sulphide*

<u>Scrubbing of Moisture</u>

For scrubbing moisture, a simple water trap shows good results. It needs only to drain the water gathered in the trap from time to time.

*Photo 6.1: Biogas power generator with water trap (hanging on the wall)*

<u>Scrubbing of Carbon Dioxide</u>

To remove carbon dioxide ($CO_2$), biogas is passed through a water (or lime-water) spray tower, (Figure. 6.2). $CO_2$ dissolves in the water which is then collected at the bottom of the tower and then sprayed down a second column to release the carbon dioxide gas from the water which is then vented to atmosphere. The water is then recycled back to pick up another load of carbon dioxide.

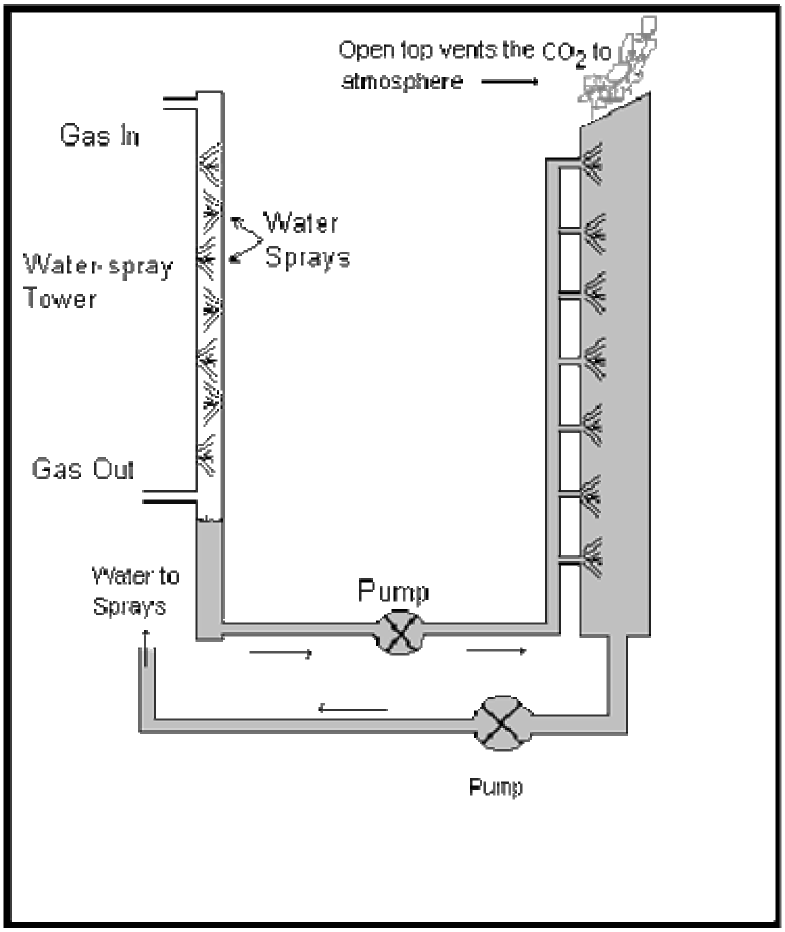


*Figure 6.2: Scrubbing of carbon dioxide*

$CO_2$ has no intrinsic fuel value and can complicate the jet and air settings of user appliances. The reason is that $CO_2$ percentage in biogas can vary from week to week of normal operation, particularly where differing feedstock constituents are used from time to time. In the situation where digester output quality is fairly consistent, $CO_2$ scrubbing may be dispensed with and the appropriate flow settings of user appliances adjusted to suit the overall lower fuel value of the combined $CO_2$/Methane mix.

<u>Combined method of scrubbing</u>

A large number of combined scrubbing technologies are available today. They are popularly called “gas sweetening” and are applied in the processing of natural gas. They are applied at relatively high gas pressures and are able to handle large gas volumes. Both regenerative and non-regenerative processes are available.

The non-regenerative methods are mostly used in the removal of small quantities of acid gases and are considered rather as product treating methods. They are not very economical to operate in the long run. They use caustic soda or lime carbonate as their sweetening agent, which goes to waste as soon as the acid gases removal has been completed. Regenerative methods are very common in the gas industries using sweetening solutions discovered and developed for this purpose by the gas processing industry. Regenerative processes may use liquid or solid sweetening agents.

Liquid sweetening methods are by far the most widely used by the natural gas industry. There are several types of liquid sweetening agents, the most popular of which are the alkanolamines. They use aqueous organic amines as their sweetening agents derived from ammonia ($NH_3$). Ethanol-amines are a series of weak bases having a great affinity for acid gases at low temperatures. The series include the monoethanolamine MEA, diethanolamine DEA and triethanolamine TEA.

The operating cycle and equipment required in a basic aqueous amine process is shown in Fig. 6.3. In this simplified sketch, the sour gas flows upward through a tower contactor countercurrent to an amine solution at approximately atmospheric temperature (25 - 40ºC). This lean amine enters the top of the tower and flows from bubble tray to bubble tray scrubbing the feed stream and picking up the acid gas. Intimate contact of lean amine and sour gas is necessary to absorb as much acid gas as possible and to obtain the sweetened gas overhead. The acid gas reacts with the amine and forms water-soluble salts, which stay in the solution.

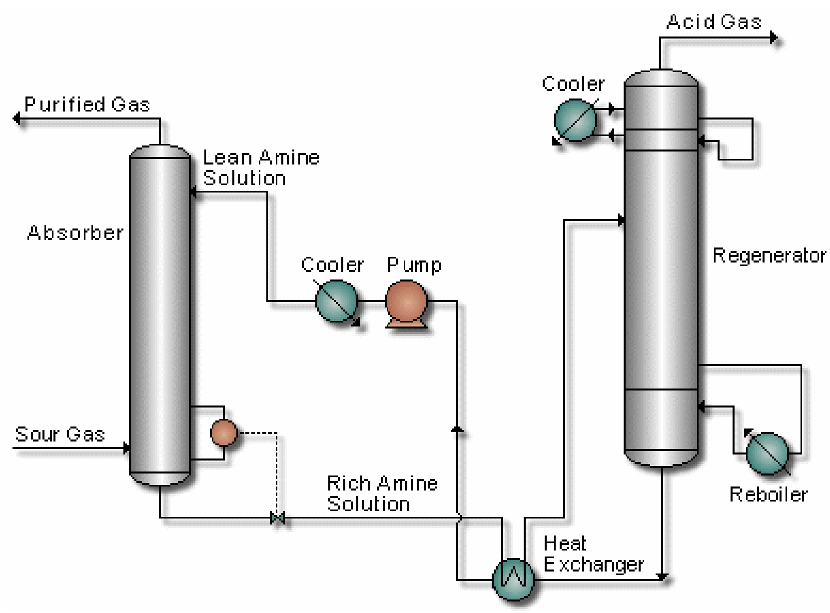


*Figure 6.3: Basic flow diagramme of amine treating process for $CO_2$ and $H_2S$ removal*

## 7. Policies

Bangladesh has no specific biogas policy. However, National Energy Policy 1996, Draft Renewable Energy Policy and Draft National Energy Policy emphasize on harnessing biogas energy. National Energy Policy 1996 urged conservation of energy at end use level to be reached through technological intervention, primarily by dissemination of technologies like improved stoves and biogas digesters. NEP 1996 has also mentioned that the energy needs of rural areas are to be met by a mix of bio-mass fuel and commercial fuels, the composition varying from place to place. NEP 1996 has also emphasized the need of recycling a part of agro-residues into soil. All these indicate the use of biogas technology.

The draft Renewable Energy Policy, which is yet to be finalized and the new National Energy Policy (draft) have mentioned biogas technology more specifically. In the new National Energy Policy, biogas technology has been included as a “new renewable energy” resource and all three types of technologies (floating dome, fixed dome and bag type) have been mentioned without any further detail.

Government has approved Policy Guidelines for Small Power Plants (SPP) in private Sector in 1998 to serve non-grid areas and provide opportunity for sale of excess power from captive generators to consumers in the neighboring areas. Government provides similar fiscal and other incentives to SPP as mentioned in “Private Sector Power Generation Policy of Bangladesh”, which has been approved by the Government in October 1996.

Under the present law, electricity generation for own consumption (captive power) is allowed. It is also allowed to sell the generated electricity to the neighbors. However, it is not clear whether Government would charge any taxes / VAT on such sale. The laws permit import of power generator.

Currently, Captive Power Policy Guidelines are being prepared by the Power Cell. It is expected that this policy will regulate the costs of electricity produced by private sector to be supplied to the grid.

Existing laws do not mention the production of biogas and its sale.

Under Environment Conservation Act 1995, Environmental Clearance Certificate is mandatory for any projects that cause harm to the environment.

The government has declared agro-based industries as a thrust sector and provides specific subsidy for poultry industry. Electricity consumption of poultry farms up to 1000 birds is charged at domestic tariff, whereas larger farms get a subsidy of 20% on electricity bill calculated on industrial tariff rate. Moreover, the interest rate for agro-based industries has been reduced to 8%, where as the usual rate in commercial banks is 12% - 14%. However, only Krishi Bank (Agriculture Bank) provides such loan.

Draft Renewable Energy Policy mentions that the sponsor may use the existing transmission and distribution systems upon payment of a mutually agreed upon wheeling charge. Utilities (BPDB, DESA, DESCO, REB) will buy electricity generated from grid-connected renewable energy projects through mutually agreed “Power Purchase Agreement (PPA)”. It emphasizes the followings:

- GOB will not regulate the price of electricity generated from renewable energy source.
- Renewable energy project sponsors shall be exempt for corporate income tax for a period of 15 years. The sponsors will be allowed to import plant and equipment without payment of customs duties, VAT (Value Added Tax) and any other surcharges as well as import permit fee provided that the equipment is not manufactured or produced locally.

# 8. Technical Potential of Poultry Litter Based Biogas Plants in Bangladesh

Households in rural Bangladesh have always reared birds in their household premises to meet their own protein demand and also for sale. But these are not considered as poultry farms. Poultry farms are defined as establishments that rear poultries in a commercial way in a limited space. Poultry farming began in Bangladesh at the beginning of 1980s. During the last two decades Bangladesh has achieved remarkable progress and poultry has been declared as industry. The annual growth rate has been on average over 20%. However, it is rather difficult to get up-to-date and reliable data on poultry farms. The statistics vary between 100,000 to 200,000 poultry farms. Discussions with poultry sector experts revealed that there are over 100,000 poultry farms of different sizes. A report from Poultry Sector Development Project gives a figure of 112,000 commercial poultry farms, which together produce about 5,900 tons of litter daily (Sinha and Rahman, 2005). Farms with less than 100 birds are not included in this estimation. Of these, 20% farms have a bird population of 1,000 – 50,000. The remaining farms are smaller in size and maintain 100 – 1,000 birds. Dr. Mahbubur Rahman in an interview gave a more detail estimate of the farm sizes, which are given in Table 8.1.

**Table 8.1: Estimated sizes of poultry farms**

| Size (No of birds) | No. of farms (approximate) |
| --- | --- |
| 100 – 249 | 15,000 |
| 250 – 499 | 35,000 |
| 500 – 999 | 45,000 |
| 1,000 – 4,999 | 12,000 |
| 5,000 – 9,999 | 8,000 |
| 10,000 – 50,000 | 1,200 |
| > 50,000 | 50 |
| Total | 116,250 |

A poultry bird (layer) produces about 0.1 kg litter daily; whereas 1kg poultry litter gives by anaerobic digestion during 40 days retention time 0.063 $m^3$ biogas. By longer retention time the gas production increases only insignificantly. If the retention time is shorter, smaller quantity of gas is produced. If the retention time is less than 10 days, the percentage of methane in the produced gas is very small and therefore of no use.

Under optimum conditions, a biogas plant fed with the litter from 100 birds will produce daily

$100 \times 0.1 \times 0.063\ m^3 = 0.63\ m^3$ of biogas

This gas is adequate for a 4-member family to prepare one meal. As such it may be concluded that a 100-bird poultry farm is technically suitable for a biogas plant.

## 9. Observations

- Poultry farms and biogas plants are usually operated by men.
- Most of the biogas produced is being used for cooking purposes; few farms use it for lighting.
- Women are responsible for cooking. The households use traditional three stone stoves for cooking, which cause in-door pollution.
- The users of biogas opine that it is convenient and does not produce any smoke. The kitchen remains clean. They do not need to collect and carry biomass.
- Most of the poultry farms are in electrified areas and they are connected with grid electricity.
- Through use of biogas, households save money.
- In most cases, no water trap is used in the biogas pipe. The cooking devices are working without problems.
- The domes of some biogas plants were exposed to atmosphere. This causes reduced biogas production during low temperature period of November – January.
- There are some incidents of failure of biogas plants caused by leakage/cracking of the dome.

*Photo 9.1: Litter from a poultry farm dumped beside a road spreading bad odour, Maona, Sreepur*

- The majority of the biogas plant owners / operators did not receive any training on biogas technology. Only a few received some sort of orientation.
- In majority of the cases, poultry litter is deposited in a pit adjacent to the farm, which spreads bad smell in the surrounding.

*Photo 9.2: Slurry from a biogas plant*

- The litter (or slurry in case of a biogas plant) is sun dried.

- Very few farms use litter or slurry themselves, rather give after sun drying to any willing person at a small cost or free.

- The sun dried litter / slurry is used as fertilizer or as fish feed by some farmers.

- All biogas plant owners opine that use of slurry as fertilizer increases crop (paddy, vegetables, potato, banana, etc.) production significantly.

- The use of slurry as fertilizer reduces use of chemical fertilizer.

- Most poultry farm owners are aware of the benefits (e.g. reduced smell, high quality cooking fuel, clean kitchen, less insects and flies, improved health, better aesthetic look organic, fertilizer and better for soil) associated with biogas plants.

- No biogas plants use scrubbing technology for removal of hydrogen sulfide or carbon dioxide; only few use water traps.

- The farms which are generating electricity from biogas are facing different types of technical problems, and the generators mostly operate for only short time.

- All operating plants are fixed dome type. They are operating well and as such a proven technology.

- Gas chambers of some plants are undersized resulting in over flow of biogas through the slurry pit.

- Same design is used for both cow dung and poultry litter, although their gas production capacities are different.

- After-sale service is almost absent for biogas plants resulting in non-operation of some plants due to very simple failures.

- Although government declared electricity for all by 2020, but there is no feasible strategy to achieve this.

- There are attempts for power generation using biogas, but any government support is absent.

- At present there is no on-going program or project on biogas technology dissemination, except a small initiative by Grameen Shakti.

- Reliable data on the biogas potential in the country are not available.

- User training is absent. As a result charging rate, timing and water mixing are not according to the design of the plant.

- Slurry processing for improvement of quality in respect of soil nutrients is absent. At present use of slurry as fertilizer is very limited resulting into wastage of huge amount of organic fertilizer.

# 10. Financial Analysis

Net Present Value (NPV)

The value that says how much future and/or past payments and receipts are worth at the present time. A project is financially viable of the NPD is positive.

Internal Rate of Return (IRR)

IRR is the discount rate at which the NPV becomes zero.
A project is financially viable of the IPR is greater than the bank rate.

Benefit / Cost Ratio (BCR)

This is the ratio of discounted total benefits to discounted total costs. A project is financially viable when benefit/cost ratio is greater than one.

BCR = NPV of cash inflows / NPV of cash outflows.

## 10.1 Assumptions and results of analysis

Most of the plants were built in co-operation with BCSIR. Therefore, the data on costs of different components of different sizes of biogas plants found during the study survey were synthesized based on reference costs. Life of this type of plant is assumed to be 20 years.

Operation and maintenance (O & M) cost: O & M cost comprises operation and maintenance costs. The operation cost consists of labor cost and price of poultry litter, whereas expenses relating to the change of gas valves, gas pipe etc. are considered as maintenance.

Maintenance costs occur because of repair works to be undertaken for keeping the plant operational. Maintenance work for biogas plant is usually minor. Usually gas valves and gas pipes are to be replaced after a couple of years. Gas valves and pipes have to be replaced every three years due to leakage.

Labor Cost: To keep the biogas plant operative, poultry litter has to be charged everyday. Even if there is no biogas plant, the poultry litter has to be cleaned and disposed of every day. Thus, the additional work associated with biogas plant is only to mix water with the litter in the inlet tank. During field visits and discussion with the people, it was found that the labor cost was Tk.70 – Tk.100 per 8-hours a day. For mixing 30-kg litter with water, a labor would need 30 minutes. With a labor cost of 100 Taka per day, labor cost for mixing may be estimated at 0.20 Taka/kg, which results to a labor cost of 7.30 Taka per poultry bird per year. For calculation, it will be taken 7.50 Taka.

Cost of poultry litter: Poultry litter is required to be charged everyday. Field visits revealed that poultry owners consider it as a nuisance. Most of the owners were happy, if some one takes this away. For transport reason, it is usually taken in dry condition (about 3 kg of wet and fresh litter makes 1 kg of dry litter) for free or for a very low cost (30-40 kg bag for 20 Taka.) However, the poultry farm owners do not get rid of the nuisance, because the litter remains in the pit for months causing bad smell, bad aesthetic look, and flies, etc. As such, it may be considered that fresh and wet poultry litter is free of cost.

Start-up cost: For start up of a biogas plant for the first time, certain amount of poultry litter has to be charged which increases with the size of the plant. The amount of poultry litter required for a biogas plant with 2 $m^3$, 3 $m^3$, 4 $m^3$ and 6 $m^3$ biogas reservoir volume is 1000 kg, 1500 kg, 2000 kg and 3000 kg respectively. It is assumed that poultry litter is available in adequate quantity free of cost.

Cost of biogas plant: Fixed dome type biogas plant is a proven technology in Bangladesh and at the moment the only type is being constructed. Therefore, for financial analysis, such a biogas plant has been taken as a basis. The cost of a biogas plant depends on the size of the plant and materials to be used. The size of the plant depends on litter to be fed daily, and amount of gas produced and utilization pattern of gas.

A poultry bird (a layer) produces daily 0.1 kg litter on the overage. At a retention time of 40 days by a temperature $30^0$C, 0.063 $m^3$ biogas is produced from 1 kg poultry litter

For plants up to 6.3 $m^3$ biogas production daily, normal brick construction is adequate. But, if the gas production is higher than 20 $m^3$ daily, RCC is necessary, which is much costlier and as such the biogas plant becomes costlier. At the present level of technical know-how available in the country, it is suggested that the plant size is limited to the slurry of 5000 birds. For storing the slurry coming out of biogas plant, a slurry pit is necessary. The pits may be constructed by digging with some safety measures.

On the basis of assumptions made above and current construction costs, the costs of biogas plants are given in, Table 10.1. It is assumed that biogas from 250 birds is supplied to a household against a payment of 300 Taka. Biogas from 100 birds biogas plant is not enough for cooking two meals and is assumed to meet 50% of the demand of a household and will earn 150 Taka per month.

**Table 10.1: Costs for biogas plants and pits for slurry storage**

| **Birds [No.]** | **100** | **250** | **500** | **1000** | **5,000** | **10,000** | **50,000** |
|---|---|---|---|---|---|---|---|
| Biogas produced [$m^3$/day] | 0.63 | 1.57 | 3.15 | 6.30 | 31.50 | 63.00 | 315 |
| Biogas plant cost [Tk] | 10,000 | 15,000 | 18,000 | 30,000 | 200,000 | 200,000 | 200,000 |
| Fertilizer pit cost [Tk] | 1,000 | 2,000 | 3,000 | 4,000 | 20,000 | 20,000 | 20000 |
| No of biogas plants | 1 | 1 | 1 | 1 | 1 | 2 | 10 |
| Total biogas plant cost [Tk] | 11,000 | 17,000 | 21,000 | 34,000 | 220,000 | 440,000 | 2,200,000 |

On the basis of the values in Table 10.1 and assumptions made in Table 10.2 NPV, IRR and BCR have been calculated for various options and for various sized biogas plants, e.g. 100, 250, 500, 1000, 5000, 10000 and 50,000 birds. For biogas plants up to 500 birds, power generation has not been considered, because the plants are small. For bigger farms, power generation is an option. The results are given in Table 10.3 and illustrated in the Figures 10.1 and 10.2.

**Table 10.2: Assumptions for biogas plant operation**

| | |
|---|---|
| Gas supply connection cost | 500 Taka per connection |
| Gas supply to households (No.) | 1 household from litter of 250-bird (In case of 100-bird biogas plant, supplied gas meets only half of the cooking demand of a household and the charge is assumed to be 150 Taka per month.) |
| Generator cost | 20,000 Taka/kW |
| Technical loss of electricity supply | 5% |
| Interest rate | 8% |
| Discount rate | 8% |
| Annual O & M cost | 3% of investment |
| Labor cost | 7.5 Taka per bird per year |
| Income from sale of biogas | 300 Taka per month for connection to a household |
| Electricity sale at a cost (= REB tariff for industries + 15% VAT ) | 4.71 Taka / kWh |
| Power generation | When only power is the option, 100% of produced gas is used for power generation.<br>When both power and gas are sold, it is assumed that 50% of gas is supplied to household and 50% for power production. |
| Fresh litter production | 0.1 kg per bird per day |
| Cost of fresh litter | 0 Taka / kg |
| Fertilizer production | 40% of the litter |
| Fertilizer cost | 0.8 Taka /kg |
| VAT and taxes paid to the GoB | 0% |
| Life time of biogas plant | 20 years |

**Table 10.3: Calculated results of NPV, IRR and BCR**

| Birds | Products for sale | NPV [Taka] | IRR [%] | BCR [-] |
|---|---|---|---|---|
| 100 | Fertilizer | - 9530 | - 2 | 0.52 |
| | Gas | - 3939 | 2 | 0.81 |
| | Gas + Fertilizer | 6533 | 16 | 1.32 |
| 250 | Fertilizer | - 11.308 | - 5 | 0.7 |
| | Gas | - 5294 | 3 | 0.86 |
| | Gas + Fertilizer | 20887 | 23 | 1.55 |
| 500 | Fertilizer | - 6899 | - 3 | 0.88 |
| | Gas | 4993 | 11 | 1.08 |
| | Gas + Fertilizer | 57288 | 39 | 1.95 |
| 1000 | Fertilizer | - 4204 | 6 | 0.96 |
| | Gas | 19575 | 15 | 1.18 |
| | Electricity | 4538 | 9 | 1.03 |
| | Electricity + Fertilizer | 109197 | 29 | 1.77 |
| | Gas + Fertilizer | 124302 | 48 | 2.12 |
| | Gas + Fertilizer +Electricity | 116784 | 36 | 1.92 |
| 5,000 | Fertilizer | - 80976 | 2 | 0.87 |
| | Gas | 37945 | 10 | 1.06 |
| | Electricity | - 37.237 | 6 | 0.95 |
| | Electricity + Fertilizer | 486396 | 25 | 1.63 |
| | Gas + Fertilizer | 561579 | 37 | 1.91 |
| | Gas + Electricity + Fertilizer | 523988 | 30 | 1.76 |

| Birds | Products for sale | NPV [Taka] | IRR [%] | BCR [-] |
|---|---|---|---|---|
| 10,000 | Fertilizer | - 161953 | 2 | 0.87 |
| | Gas | 75890 | 10 | 1.06 |
| | Electricity | - 74475 | 6 | 0.95 |
| | Electricity + Fertilizer | 972793 | 25 | 1.63 |
| | Gas + Fertilizer | 1123159 | 37 | 1.91 |
| | Gas + Electricity + Fertilizer | 1047976 | 30 | 1.76 |
| 50,000 | Fertilizer | - 809768 | 2 | 0.87 |
| | Gas | 379452 | 10 | 1.06 |
| | Electricity | - 372377 | 6 | 0.95 |
| | Electricity + Fertilizer | 4863968 | 25 | 1.63 |
| | Gas + Fertilizer | 5615798 | 37 | 1.91 |
| | Gas + Electricity + Fertilizer | 5239883 | 30 | 1.76 |

Table 10.3 and diagrams show that for option of only fertilizer or only electricity sale, NPV is negative (or near 0) for an interest rate of 8% and IRR is around 8% or less. With 1000 birds, NPV shows a positive value because of proportional much less increase of construction cost with the increase of size. With bigger farms (more than 5000 birds) more than one plant is suggested and as such IRR and BCR remains the same, but NPV increases. As such neither fertilizer sale only nor gas sale only is viable. In case of biogas plants up to 500 birds, the option of both gas and fertilizer sale makes it viable. By bigger plants, sale of any two of the products gas, electricity and fertilizer makes it profitable; however, sale of fertilizer and gas (no power generation) is the most profitable.

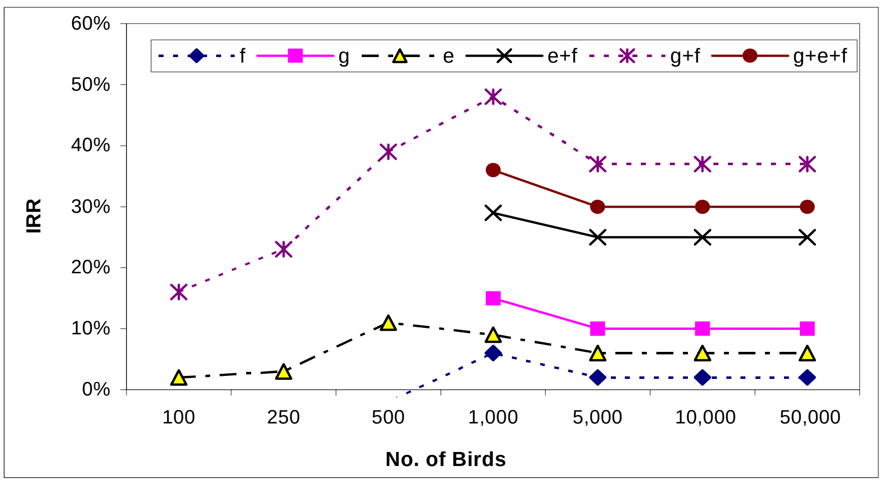


*Figure 10.1: IRR at different plant sizes and sale of products*
*(e = 4.70 Tk/kWh, g = 300 Tk/connection, f = 0.80 Tk/kg)*

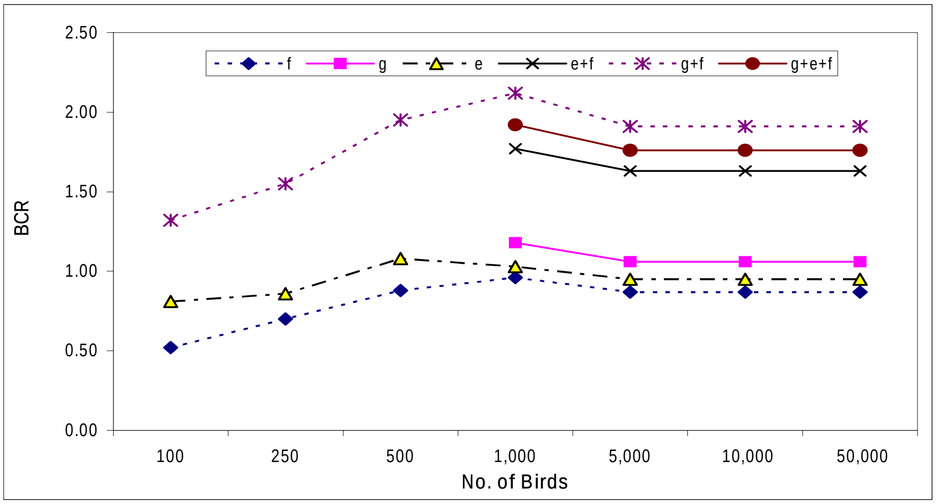


*Figure 10.2: BCR at different biogas plant sizes and sale of products*
*(e = 4.71 Tk/kWh, g = 300 Tk/connection, f = 0.80 Tk/kg)*

## 10.2 Sensitivity Analysis

In this section sensitivity analysis has been carried out to determine how the financial data react to market price variations. Since the viability may be concluded from IRR, only IRR has been shown.

### 10.2.1 Effect of varied expenditures and income

The prices of different construction materials may vary over the period of time. Also the running costs (labor cost, cost of maintenance) may vary. As such sensitivity analysis has been done by variation (-20%, 0% and 20%) in the price of investment, maintenance and labor cost (shown as Ex in the figures), as well as in the sale of gas, electricity and fertilizer (shown as in the figures). The results are illustrated in Figures 10.3, 10.4, 10.5, 10.6 and 10.7 for 100, 250, 500, 1000 and 5,000-bird biogas plants respectively, where only gas and fertilizer sale has been considered.

It is obvious that with higher expenditure, IRR goes down and with higher selling price (in terms of income) IRR goes up. It is evident from the figures that the biogas plants are profitable in all cases of 20% expenditure hike and income decrease by 20%, except the 100-bird plant when income decreases by 20% and expenditure rises at the same time by 20%. With expenditure decrease by 20% and income rise by 20%, IRR increases with plant size.

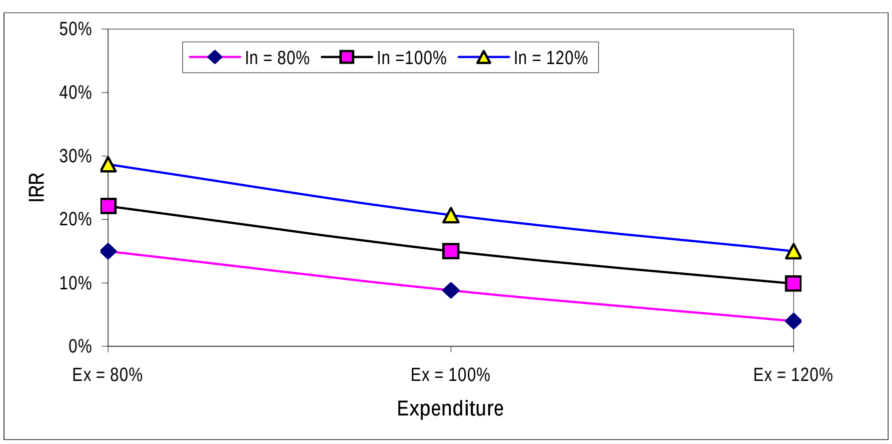


*Figure 10.3: IRR at different incomes (In) and expenditures (Ex)*
*(100-bird biogas plant) for gas and fertilizer sale (g = 300 Tk/connection, f = 0.80 Tk/kg)*

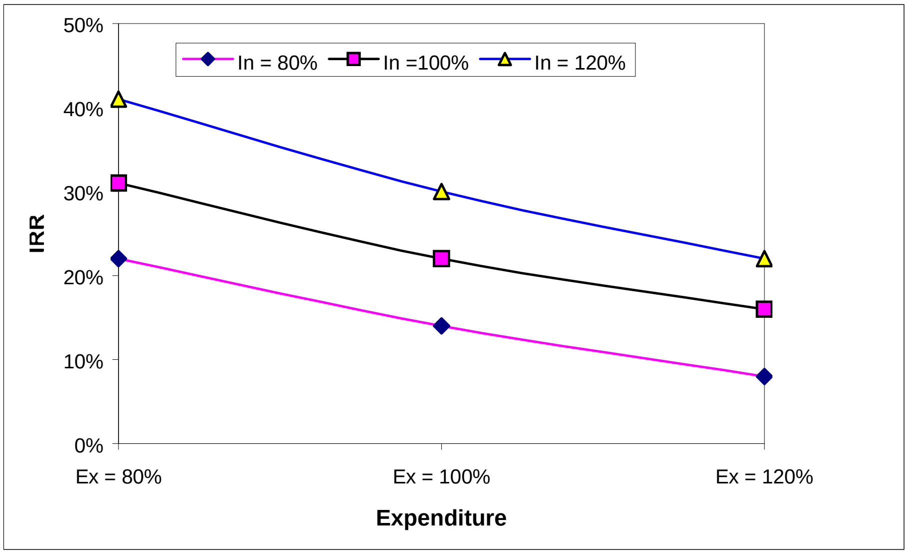


*Figure 10.4: IRR at different incomes (In) and expenditures (Ex)*
*(250-bird biogas plant) for gas and fertilizer sale (g = 300 Tk/connection, f = 0.80 Tk/kg)*

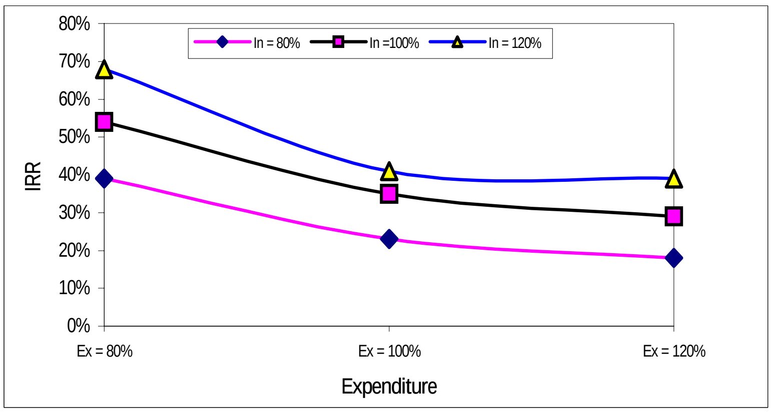


*Figure 10.5: IRR at different incomes (In) and expenditures (Ex)*
*(500-bird biogas plant) for gas and fertilizer sale (g = 300 Tk/connection, f = 0.80 Tk/kg)*

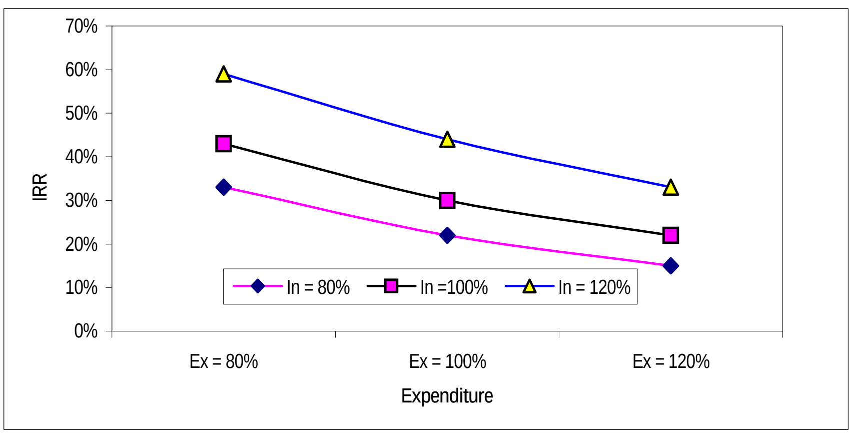


*Figure 10.6: IRR at different incomes (In) and expenditures (Ex)*
*(1,000-bird-plant) (g = 300 Tk/connection, f = 0.80 Tk/kg)*

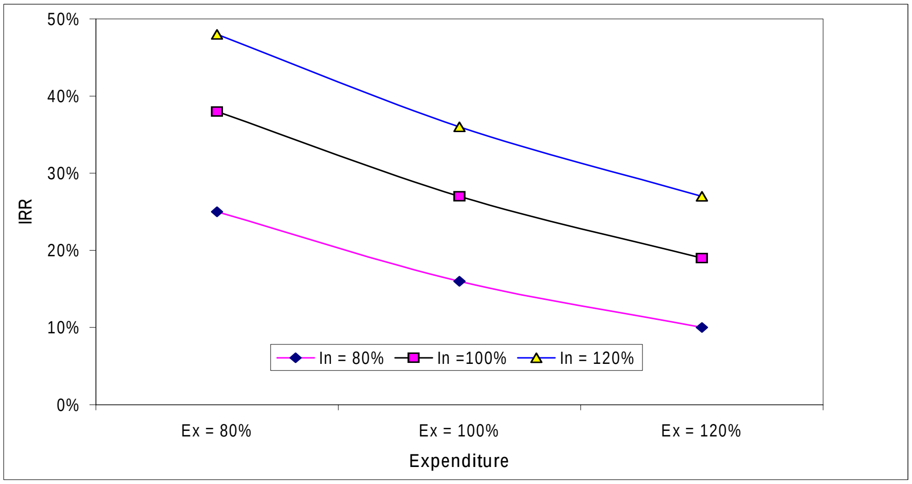


*Figure 10.7: IRR at different incomes (In) and expenditures (Ex)*
*(5,000-bird-plant) (g = 300 Tk/connection, f = 0.80 Tk/kg)*

### 10.2.2 Effect of varied capacity utilization

The output of the biogas plant depends on the availability of raw material slurry, which is dependent on the birds of the farm. In poultry farms, the number of birds may vary with time, which affects the profitability of the plant. For this reason, IRR has been calculated for various capacity utilizations (utilization factor 40% - 100%). Figure 10.8 shows the IRR for 100, 250 and 500 birds, and Figure 10.9 shows IRR for 1000 and 5000 birds for two different modes of business (sale of gas, electricity and fertilizer and sale of gas and fertilizer only).

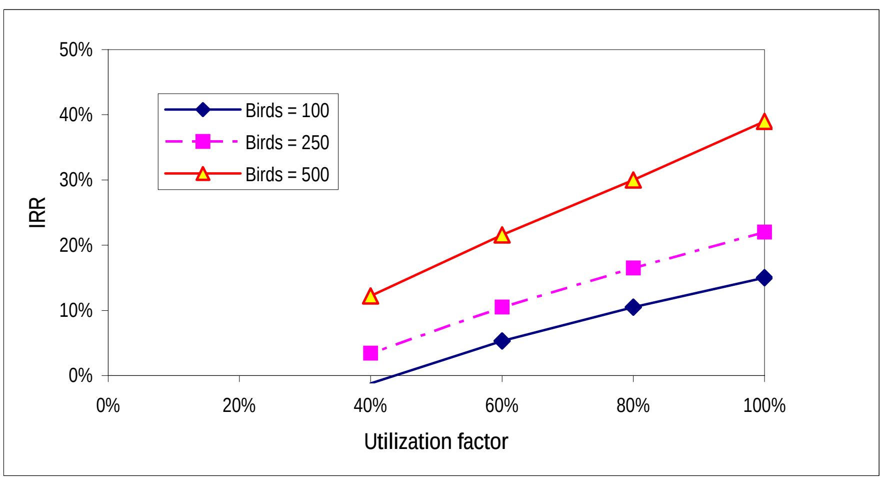


*Figure 10.8: IRR at different Capacity Utilization*
*(g = 300 Tk/connection, f = 0.80 Tk/kg)*

The electricity cost has been assumed as 3.77 Tk/kWh with all other prices remaining the same as given in table 10.2. For the understanding of this assumption please see sub-section 10.2.3 below.

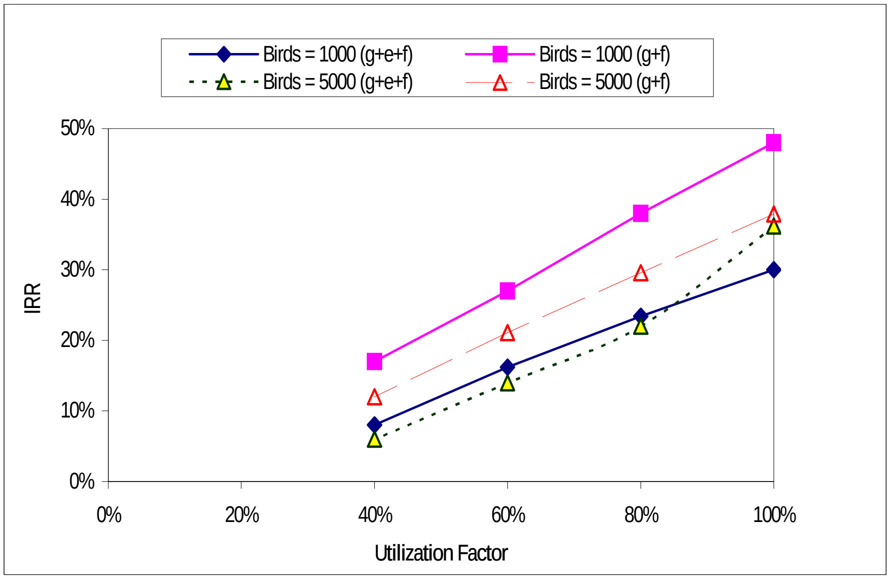


*Figure 10.9: IRR at different capacity utilization*
*(e = 3.77 Tk/kWh, g = 300 Tk/connection, f = 0.80 Tk/kg)*

The figures show that with decreasing capacity utilization, IRR decreases significantly. In all cases, IRR is around or less than 8% by a utilization factor of 40%, except for 500- and 1000-bird plant in case of gas and fertilizer sale. In case of 100-bird biogas plant, the plant is viable only if over 80% capacity is utilized. For 250 birds plant, the capacity utilization need to be over 60%.

It is interesting to note that the biogas plants of more than 250 birds are viable if both gas and fertilizer are sold even at 60% capacity utilization. In is significant, because if a farmer goes for a poultry farm, he may install a biogas plant bigger in size than the birds his farm at the moment has.

### 10.2.3 Effect of electricity price variation

The electricity price is important for the viability of power generation in a poultry farm. The tariff for power in the industrial sector is 4.01 – 4.10 Taka/kWh in REB area with 15% VAT on top of it, which makes the actual price 4.71 Taka/kWh. The poultry farms of up to 1000 birds pay however the domestic tariff, which is 2.85 – 2.95 Taka/kWh with the VAT on top of it. The farms with more than 1000 birds receive 20% discount. The payable (tariff + VAT) price for farms bigger than 1000 birds is 3.77 Taka /kWh. If one consumes electricity for oneself, one may save the mentioned amount of money as is applicable. However, if one wants to sell the electricity to the neighbours, who are most probably domestic consumers, the maximum applicable tariff will be the domestic tariff. There may be another option that the power generated is sold to the grid. Although there is, at the moment, no regulation for power from private producer, it should first be settled. It is apprehended that power utility will not pay more than 2 Taka /kWh, because the reference cost may be around 2.8 US cent as is the case of big private sector producer. Moreover, the supply to grid is associated with a number of technical needs like synchronization. However, a calculation has been made for a 10,000-bird biogas plant with different prices and given in Figure 10.10.

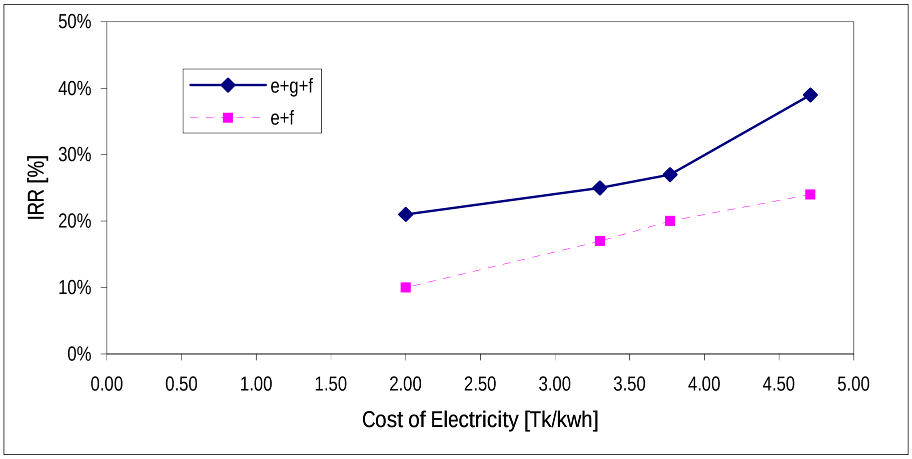


*Figure 10.10: IRR at different electricity tariff (10,000-bird-plant)*
*(e+f: 100% gas for electricity production, e+g+f: 50% of gas for electricity and 50% for gas sale; g = 300 Tk/connection, f = 0.80 Tk/kg)*

It is evident from the Figure 10.10 that power generation is viable even at Tk. 2.00/kWh, if power and fertilizer are sold.

### 10.2.4 Effect of different equities

The profit of a plant depends on the equity and credit available. Calculations have been made for a 5000-bird biogas plant with different equity share and the results are shown in Figure 10.11. It is evident that return on equity increases with decreasing equity. If credit is available, biogas plant is a very profitable business.

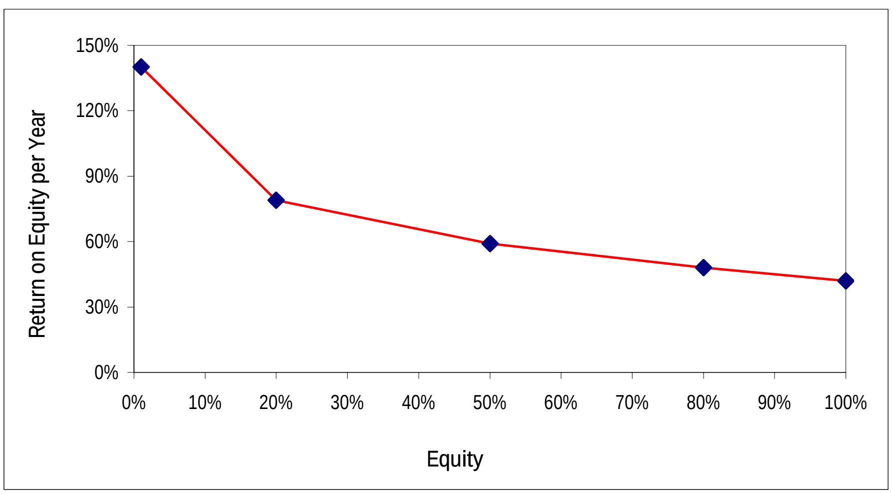


*Figure 10.11: Return on equity per year at different equity ratios*
*5,000-bird biogas plant with only gas and fertilizer sale (g = 300 Tk/connection, f = 0.80 Tk/kg).*

# 11. Major Findings and Recommendations

## 11.1 Major Findings

i) So far, about 25,000 biogas plants, mostly family-size, have been set up in Bangladesh. Most of them are based on cow-dung and poultry droppings. All the plants now in operation are fixed dome plants and their durability is reported to be more then 20 years. Oldest fixed-dome plant in proper operation now in the campus of BCSIR was established in 1990.

ii) BCSIR and LGED have so far trained more than 1,800 engineers, supervisors and masons on the construction, operation and maintenance of fixed-dome biogas plants. This is an important aspect for undertaking a dissemination project as there is sufficient number of expertise available all over the country.

iii) So far, over 2,000 poultry-based biogas plants have been constructed. Plants with birds ranging 100 –5,000 are in operation.

iv) Interviews with the owners and neighbors of poultry farms reveal that construction of biogas plants in each poultry farm is a necessity because of the bad odour that poultry droppings spread in the area. Since poultry industry is booming in Bangladesh, poultry-based biogas plants also should be booming in future.

v) Financial analyses of plants ranging from 100 birds up to 50,000 birds have been done. The results are shown in Figures 10.1 – 10.10. It can be concluded that

  a) With 100 birds using both gas and fertilizer, if sold at a price 300 Taka/connection and 0.8 Taka per kg of fertilizer, the plant is financially viable. However, with either of them alone, the plant is not financially acceptable assuming an interest rate of 8%.

  b) With 500 birds and above, all plants are financially acceptable with gas alone but none of the plants up to 50,000 birds is viable if only electricity or only fertilizer is sold. But electricity and at least any one of other two (gas and fertilizer) makes the project viable, 50% of the gas assumed to be used for electricity generation.

  c) Sensitivity analyses have been done with 20% cost increase in plant construction, operation & maintenance and 20% decrease in revenue received. All plants above 250 birds are viable.

vi) Larger farms may go for electricity production, but selling of gas is more profitable.

vii) Most of the poultry farm owners are capable of financing biogas plants on their own. The small farmers will, however, prefer micro-financing. Most of them will avoid bank loan because of hassles associated with bank loan being approved and received. Micro-financing would be a very good option for them.

viii) Economic benefit derived from biogas plant in terms of fuel and fertilizer saving can have notable impact on national economy. Biogas technology may pave the way for booming poultry industry in the country.

ix) In the case of large biogas plants (more than $3m^3$ gas), owners sell biogas to the neighbor at the rate of TK 300 per connection. This is an encouraging aspect for the commercialization of the technology.

x) However, during the survey, the following drawbacks, which need be reduced/eliminated, have been detected:

  c) Biogas contains moisture and hydrogen sulfide, which should be removed for the better functioning of the cooking burners and electricity generators.

  d) It has been observed that in many plants charging rate and slurry / water ratio are not properly maintained.

## 11.2 Recommendations

9. Since biogas technology is now well established with the availability of expertise in the country, the technology is set to take off provided financial support coupled with appropriate marketing measures is made available.

10. A promotional drive in a selected area, e.g. the upazila with the highest number of poultry farms should be undertaken immediately. The promotional work will be started with a pilot programme with the objective of installing a biogas plant targeting every poultry farm of the upazila. However, before embarking on this, a marketing plan with appropriate strategies should be developed for successful implementation. It should also be followed by monitoring with corrective measures, if necessary

11. (a) For cooking purpose, biogas has proven quite appropriate, even in the presence of small amount of moisture and hydrogen sulfide. It can therefore be safely recommended that a large-scale programme be undertaken for dissemination of poultry-based biogas.

    (b) Field visits have shown that, in almost all cases, initial construction cost is not readily available. For dissemination therefore, some kind of funding will be necessary.

12. In order to solve the problems associated with hydrogen sulfide and moisture, some experiments should be carried out in a suitably sized plant.

13. Setting up of a biogas plant should be made mandatory for poultry farms and should be included in the national policy documents.

14. Measures to popularize fertilizer from biogas plants should be undertaken.

15. Know-how to add value to bio-fertilizer from biogas plant should be acquired and disseminated.

16. For updating the knowledge base of the technicians, training need be provided on a continuous basis.

9\. A dedicated organization for biogas is necessary. This may be a Biogas Foundation. The objective of this organization will be to promote biogas plants all over the country in a concerted manner. It will coordinate all activities related to biogas e.g. policy, research, training, and dissemination. The Foundation will be run by a Board of Directors consisting of representatives from the Govt. and biogas related organizations.

10\. A revolving fund to be administered by the Biogas Foundation will be created for multiplication of biogas plants and administration of biogas related activities. Till the formation of the Biogas Foundation, a suitable organization may volunteer to create and administer the revolving fund.

**Annex – 1**

# Promotion of Biogas Production and Use in Commercial Establishments

# Terms of Reference

## Background

Biogas technology is well known in Bangladesh. Biogas digesters are used by private households as well as in commercial establishments such as poultry and cattle farms, bidi factories. However, it is argued that the potential of biogas generation and use is not sufficiently utilized yet.

The PURE project in cooperation with the *Power Cell/Sustainable Energy Unit* (SEU) intends to support promotion of biogas use in suitable commercial establishments, provided it can be shown that the establishment of biogas infrastructure is financially attractive for such establishments.

The first phase of the activities will be used to develop and test a marketing approach for promotion of biogas use with the focus initially being on suitably sized poultry farms. If biogas use can be promoted successfully in this market segment, subsequent phases may address the potential of other target groups such as cattle farms, abattoirs.

PURE in cooperation with *Power Cell/SEU* will select and engage consultants for the scope of work described below.

## Scope of Work

- Description of the experience with biogas available in Bangladesh
- Assessment of the market potential of biogas use in poultry farms
- Appraisal of the financial feasibility of using biogas in poultry farms (preparation of bankable project documents)
- Preparation of marketing approaches for promotion of biogas use in poultry farms
- Assessment of the need for business development support (BDS) of small and medium enterprises (SMEs) involved in construction and hardware supply of biogas and related equipment
- Launching of marketing drives

## Tasks

The following activities are proposed to cover the above scope of work. The work shall be carried out in three separate steps. The scope of steps 2 and 3 will depend on and adjusted according to the results of the previous step(s).

*Step 1: Technical and financial feasibility of biogas generation in poultry farms*

1.1 Describe in brief the biogas technologies available and applied in the country and summarize the experiences made with biogas utilization with a special focus on biogas use in commercial enterprises; highlight and assess success stories and failures of biogas projects on the basis of already available information; summarize ongoing and planned biogas projects; describe national biogas policies and strategies, if relevant

1.2 Establish the technical potential of biogas use in poultry farms taking into consideration parameters such as the size of farms, type/composition of chicken feed, if relevant; provide a chemical analysis of the typical biogas produced from chicken droppings and, if necessary, describe the technical process and requirements of biogas treatment to render the gas useful for on-farm power generation; describe the most promising technologies for power generation based on biogas; describe the application potential of slurry from biogas digesters and, if applicable, describe production of (organic) fertilizer using biogas slurry as input

1.3 Estimate the costs and benefits of equipping potentially suitable poultry farms with biogas digesters and related facilities for biogas and slurry use (e.g. electric power generators and installations for electricity distribution, distribution of gas for cooking/heating applications, drying/processing/ packaging of slurry for commercial use as fertilizer)

1.4 Prepare bankable project documentation (if necessary, differentiated according to typical poultry farm sizes) on investment in biogas production and use facilities
1.5 Present findings of activities 1.1 to 1.4 for decision making regarding execution of step 2

*Step 2: Market development plan for promotion of biogas generation in poultry farms (tentative tasks)*

2.1 Appraise the situation of the construction and supply industry for hardware of biogas generation and related equipment; if necessary, design concepts to facilitate provision of BDS for SMEs that wish to get involved in setting up and servicing biogas systems
2.2 Develop approaches for marketing of biogas use in poultry farms in conjunction with potentially interested parties such as the 'association of poultry farm owners', NGOs
2.3 Appraise the financing need for financially viable biogas systems and propose financing concepts for farm owners; if necessary, design concepts to facilitate financing for establishment of systems for biogas production and use
2.4 Present a comprehensive marketing concept

*Step 3: Marketing drive to promote biogas generation in poultry farms (tentative tasks)*

3.1 Assist in the marketing drive for promotion of biogas generation in poultry farms
3.2 Evaluate the entire process and describe lessons learnt for possible extension to other target groups (cattle farms, abattoirs, etc.)

**Remarks**

1. The above work will use the information compiled by *Power Cell/SEU* in the context of the ongoing study on development and implementation of a sustainable energy strategy for Bangladesh. Substantial information is already available for steps 1 and 2, which may need to be reviewed and edited
2. Execution of the tasks of step 2 and 3 will depend on the results of activity 1.5 and 2.4, respectively
3. Project monitoring will be done by PURE in cooperation with *Power Cell/SEU*

## Annex – 2

# Findings of the field visit

During the period of the study, the team visited some ongoing activities on biogas technology. A brief on the findings is given below:

**Gorpara, Manikgonj**

- Gorpara is a Union under Sadar Upazila of Manikgonj district. Although the union is located in the rural area, it is densely populated and looks like an urban area.
- BCSIR constructed 97 household-size biogas plants in Gorpara during the period 1999-2004. Of these families, 57 live on business, 30 on service, one on agriculture and the remaining 9 on other professions.
- Out of 97 families, 59 have less than 5 members, 38 have 5-10 members.
- The average monthly income of 34 families is less than Tk.5000/-. Income of the remaining 63 families is between Tk.5,000/- and Tk.10,000/-
- Source of raw materials

| Cow dung | | Poultry litter | |
|---|---|---|---|
| 3-5 cattle: | 41 plants | 100 - 200 birds: | 21 plants |
| 6-10 cattle: | 7 plants | 200 - 400 birds: | 22 plants |
| | 48 plants | 400 - 500 birds: | 2 plants |
| | | | 45 plants |

There are four plants which use both cow dung and poultry litters. These are:

200 birds + 2 cows: 1 No.
200 birds + 4 cows: 1 No.
100 birds + 1 cow: 1 No.
100 birds + 2 cows: 1 No.

- Size and cost of the plants:

  2 $m^3$: 87 Nos. at Tk.12000/- to Tk.13000/-
  3 $m^3$: 9 Nos. at Tk.14000/- to Tk.17000/-
  4 $m^3$: 1 Nos. at Tk.18000/-.

- In the project (BPPP) there was no provision of after-sale service or maintenance. Yet, the agent who was responsible for the implementation of the IFRD project in the area visits the plants frequently and gives necessary advice to the users.

- BCSIR gave Tk.7500/- to the users as subsidy and Tk.5000 to its agents as grant.
- There are some defects in the design and construction, yet the users are happy as the plants are functioning may be with less efficiency.
- Some farmers, who could not avail of the scope given by BCSIR, are now interested to have biogas plants even at their own cost.
- The idea of producing electricity from biogas is known, but is not interesting as there is electricity in the village.
- In the village, although there are a lot of poultry farms, there is no bad smell. The sanitation, health and hygiene condition of the village is very good.
- Socio-economic conditions of the people have improved notably as they are earning good amount of money by rearing cattle and poultry birds.
- Use of gas: All the owners are using the gas for cooking. Two owners are using for lighting also.
- Use of slurry: About 50% of slurry is being wasted. 35 families are using slurry directly in their ponds as fish feed and the rest are using slurry in their paddy fields as fertilizer.
- Present condition of the plants: Out of 97 plants installed in Gorpara Union, 73 are in satisfactory operation, 16 plants working with low efficiency and minor problems. 7 plants were running well when built; but the farms are now closed, because raw material is not available. In the case of 3 plants, residents have left the place. One plant could not be started from the very beginning due to construction fault.
- Although cow dung usually produces 0.037$m^3$ of gas per day per kg and poultry litter produces 0.063 $m^3$ of gas per day per kg, BCSIR used the same design for both cow dung and poultry litter.

### Janna, Manikgonj

- Janna is a village under Dhankura Union Parishad of Saturia upazila under Manikgonj district.
- BCSIR constructed 51 biogas plants in the village. Of these 39 plants are based on cow dung and the remaining 12 plants on poultry litter. All the plants excepting one are in operation.
- Sizes of the dairy farms are between 3 and 8 cows.

- Sizes of the biogas plants are 3 $m^3$ - 5 $m^3$ costing Tk.13000/- to Tk.17000/-, of which BCSIR provided Tk.7500/- to the users as subsidy and Tk.5000 to its agents as grant.
- Farmers, who could not avail of the scope given by BCSIR, are now interested to have biogas plants even at their own cost.
- The idea of producing electricity from biogas is known.
- Socio-economic conditions of the people improved notably.

### Faridpur Muslim Mission

- It is an orphanage with about 600 students and more than 50 staff.
- As a source of income, the mission established a poultry complex with a capacity of more than 20,000 birds, which is expected to rise to 80,000 birds in the near future. However, at present there are 5000 birds.
- One 14$m^3$ (diameter: 4 m) capacity biogas plant at in 2000 and six 42$m^3$ (diameter: 5m and height: 3.2m) capacity biogas plants were installed in 2004; but not all gas produced is utilized.
- A 4.5 kW natural gas generator of Honda has been installed for power generation.
- In order to remove moisture from the gas, there is a moisture filter. But there is no arrangement to remove hydrogen sulfide or carbon dioxide. The generator has starting problems. It runs usually 2 -3 hours daily.
- Use of poultry litter in biogas plant has improved the sanitation condition.
- There is no system to control the rate of charging and maintain water content in the mixture.
- The slurry is being used directly as fertilizer.

### Raj Poultry Farm

- There are 20,000 birds in the farm, to be raised to 100,000 birds.
- Three 42$m^3$ (diameter: 5.4m, Height: 2.8m, bottom: 0.15m CC + soling, wall: 0.25m, round beam-0.3m x 0.3m) capacity biogas plants have been installed at a cost of for Tk.600,000.
- Biogas is being used for cooking and preparation of poultry feeds. Recently, high quality tiles are being produced in modern gas ovens using biogas.
- The farm and poultry litter management is running very satisfactorily.
- The sanitation system of the farm functions very well.
- The gas storage capacity in biogas plants is not adequate for the produced gas and a good quantity of gas escapes through hydraulic chamber.
- There is no system to control rate of litter charging and to maintain litter/water ratio in the mixture.
- The slurry is being used directly as fertilizer and as fish feed.
- The farm is situated by the side of the Barisal-Faridpur highway and is a good place for demonstration of any innovative technology.

### Bogra Farming Complex

- There are 11,000 birds in several sheds.
- There is one biogas plant of capacity 200 cft. constructed at a cost of Tk.25,000/- in 1997 and one biogas plant of capacity 1500 cft. constructed at a cost of Tk.100,000/- in 1999.
- Earlier, there was PDB line for the supply of electricity. Five years ago, one 7.5 kW capacity retrofitted petrol generator was installed, which produces electricity from biogas. About 150 tube lights and 30 ceiling fans are in use. The electricity demand is being met completely by own production. The farm is no more connected with PDB line.
- There is no arrangement for the removal of moisture, hydrogen sulfide or carbon dioxide. The engine is still running with frequent interruption.

- Slurry is being partially dumped and partially used as organic fertilizer.
- As large quantity of litter is not used in the digester, the sanitation condition of the farm is not good.

### Azhar Uddin's Poultry Farm, Savar

- There are some 7,000 poultry birds in several sheds.
- A biogas plant for using litter from 1100 birds was installed under IFRD project.
- The produced gas is used for cooking and the slurry directly for fish cultivation.
- The produced biogas is being used by the owner's household and seven more households.
- The gas is supplied through simple rubber pipe.
- No water trap is in use.
- The biogas consuming households pay monthly 300 Taka/ connection. Thus, from biogas sale, the owner of the plant earns 2100 Taka per month extra.
- The households are preparing their meals using only biogas and no other fuel. They are satisfied with the gas supply.

### Kazi Tea Estate, Tetulia

- The Tea Estate is on about 1200 acres of land with a dairy farm having 1007 cattle.
- 26 biogas plants, each of $28.3m^3$ have been installed at a cost of Tk.5,200,000.
- The biogas is being used for cooking of meals for the staff and preparation of food for commercial purposes.
- The wet slurry is being used directly in the tea garden.

### Kazi Poultry Farm, Tetulia

- There are about 200,000 birds in the farm.
- There is no biogas plant yet.
- The litter is being collected and used directly as fertilizer.

### Maona Poultry Village

- Maona is a union of Sreepur Upazila under Gazipur district.
- There are about 2000 poultry farms in the Upazila.
- In Maona union alone, there are about 300 poultry farms, mostly small size i.e. between 250-1000 birds. There are a few large farms with more than 10,000 birds.
- In the union there was no biogas plant.
- Recently, a farm owner has constructed a biogas plant at his own cost. The technical support was provided by an Ex-Agency holder of BCSIR.
- The owner has spent Tk.20,000/- as construction cost and Tk.8000/- as supervision cost to the agent.
- Inspired by the success of the plant, another farm owner has come forward to construct a plant.
- As most of the litter remains unutilized and deposited in open pits, the sanitary situation in the village is very bad. The odor that is spreading in the villages is unacceptable. The aesthetical look is also bad.

### Mollah Poultry Farm, Konabari

- Owner Azaharul Islam Mollah is an Executive Committee Member of Bangladesh Poultry Industries Association.
- Total number of birds in the farm is about 8000.
- The farm owner knows about the biogas technology, but is not much interested in it as there is natural gas supply in the farm.
- There are 80 Nos. of 60W lights, 40 fans and one 2HP pump. The owner is paying electric bill of Tk. 6000/- per month (with 20% subsidy given by the government to large poultry farms).
- The farm owner is not interested in producing power from poultry litters, as there is national grid line.
- Sun dried poultry litter is being sold at a cost of Tk.10/- per bag (40 kg).
- As there is no biogas plant in the farm and as the litter management system is bad, the health and hygienic conditions of the farm are very bad.

## Domestic biogas plants at Bera Upazila under Pabna

- Out of more than 100 biogas plants constructed by BCSIR in Bera Upazila, 2 non-operational plants were visited as planned.
- Both the plants were based on cow dung.
- One plant was non-operational, because the owner does not rear cattle anymore. As such there is no cow dung available.
- The other became non-functional after two years of operation. There was a leakage in the pipe line, which could not be detected by the owner due to his ignorance. As such the plant has remained nonfunctional since then.
- The plant was constructed under IFRD project, which did not have any provision of after-sale services.

## Baoniaband, Mirpur

- In Baoniaband, government allotted land to 2600 slum families @ one decimal per family. Government constructed sheds including pit latrine at a cost of Tk.7000/ for each family.
- As the soil of the area is clayey, the latrines got filled up within a short time. The owners had to clean the pit every 3 - 4 months.
- In 1994, LGED constructed one biogas digester connecting 96 latrines of these houses.
- The plant could solve the problem of water overflow. At the same time biogas from the plant was supplied to three houses.
- Before construction of the biogas plant, it was assumed that there might be social barriers to using the human excreta based biogas for cooking; but in practice no such problem arose.
- This has created interest among the slum dwellers. LGED constructed 6 more plants in Dhaka following the same design.
- Subsequently, some other stakeholders like ICDDRB, Plan International, Proshika etc came forward and showed interest to replicate the technology. They constructed 19 plants in Baoniaband, one in Singair, four in Ganaktuli and 14 in Agargaon following the same design. All the plants are based on night soil and working satisfactorily.
- All the plants were fully subsidized and there was no cost sharing or cost recovery system.

## BRAC Biogas Power Generation at Dakshmin Kushtia, Shaturia

- Under its research programme, BRAC constructed a biogas plant of size 25 $m^3$ at Dakshmin Kushtia, under Shaturia Upazila of Manikgonj district at Tk. 80,000/- in 2004.
- In order to generate electricity by using biogas, one 750W capacity DC-LPG generator (Sterling Engine) was imported from USA and installed.
- 325 kg of cow dung purchased @ Tk. 0.70/- per kg is fed every day, which produced about 8 $m^3$ of gas per day.
- The generator consumes 25 cft of gas per hour, working 3-4 hours in the evening and supplying electricity to 13 houses.
- It is a cluster village, so the distance from the generation point to the point of use is not more than 150m.
- There is a community committee to manage the whole system. The committee collects Tk.5/- per bulb per day and Tk.6/- for one TV per day.
- There are 5 (12V) batteries to store electricity for supplying at the time of need.
- The generator has also provision of running on LPG.
- The biogas storage capacity in the plant is not adequate so that the much of the gas escapes unused and as such the power generated does not correspond to the gas produced.
- The efficiency of the generator is low.

## Biogas Power Generation in Rural Development Academy (RDA), Bogra

- Rural Development Academy, Bogra is a research institution established in 1974 under the Ministry of Local Government, Rural Development & Cooperatives.
- The institute is has undertaken action research projects on different rural development aspects based on the needs of the rural people.
- RDA initiated an action research project on biogas power generation and constructed two biogas plants in 2001-02, one within the academy compound and the other in a dairy farm within the boundary of the academy. Two generators were installed in June 2004.
- There are 75 big size cows in the farm.

  - Specification of the digester:

    Digester size: 130 $m^3$
    Gas holding capacity: 26.12 $m^3$
    Cow dung charging per day: 1500 kg
    Cost of construction- Tk.406,500/-

  - Specification of the generator:
    Company: Honda-Japan
    Generator type: Natural Gas Generator
    Generator capacity: 4.5 kW and 4 kW
    Voltage: 220 Volt
    Generator cost: Tk.110,000/-
    Cost of moisture filter: Tk.3,000/-
    Starting fuel- Biogas
- The biogas is used mainly for cooking for RDA kitchens.
- Biogas is also used for power generation. The generator cannot run continuously.
- The generator is being used only for demonstration purpose.
- There is no starting problem with the generator.
- There is no arrangement for the removal of hydrogen sulfide carbon dioxide and moisture.

### Problems observed during the field visits

1. Digester/hydraulic chamber/outlet at higher/lower elevation
2. Use of bleaching powder
3. Water content in the raw materials is high/low
4. Leakage in top dome, burner and pipe line
5. Burner and pipe became rusty
6. Water in the pipe
7. Design not proper
8. Faulty workmanship
9. Bad smell, when gas valve is open and burner is not working
10. Digester is above ground level,
11. Burner not appropriate
12. No water trap
13. No pressure meter
14. Plant is far away from the source of raw materials
15. Capacity of gas storage chamber is less/more
16. Back up service is absent
17. The number of cows is decreased/increased
18. Inlet and hydraulic chamber not always at 180 degree apart
19. There is still some hesitation to use night soil biogas for cooking.

## List of the persons interviewed

1. Mr. B. D. Rahmatullah, Director General, Power Cell, Dhaka
2. Mr. Gopal Chandra Sen, Division Chief (Energy), Planning Commission
3. Dr. Fauzul Kabir Khan, Managing Director, IDCOL
4. Mr. M. Emdadul Haque, Deputy Secretary, ERD, Dhaka.
5. Md. Abdur Rouf Miah, Assistant Director, Power Cell, Dhaka.
6. Md. Shah Alam, National Consultant, SEU, Dhaka.
7. Mr. Subir Nathak, Team Leader, UNDP Study Project, Dhaka.
8. Dr.-Engr. Khurshidul Islam, National Consultant, SEU, Dhaka.
9. Mr. Md. Shahjahan, Local Project Coordinator, SEMP, DOE, Dhaka.
10. Mr. Md. Shamsul Hoque, Chief Scientific Officer, BCSIR, Dhaka.
11. Mr. Kazi Akteruzzaman, Director, P&D, BCSIR, Dhaka.
12. Mr. Tajmilur Rahman, Project Manager, SRE, LGED, Dhaka.
13. Mr. Md. Noorul Islam Mia, Livestock Statistical Officer, DLS, Dhaka.
14. Dr. Md. Mahbubur Rahman, Consultant, DLS, Dhaka.
15. Mr. Dipal C Barua, Managing Director, Grameen Shakti, Dhaka.
16. Mr. Abser Kamal, General Manager, Grameen Shakti, Dhaka.
17. Engr. Md. Ruhul Quddus, Deputy General Manager, Grameen Shakti, Dhaka.
18. Md. Ariful Islam, Unit Manager, Grameen Shakti, Maona, Gazipur.
19. Md. Alamgir Hossain, Senior Regional Manager, BRAC, Dhaka.
20. Md. Salim, Staff Researcher, BRAC, Dhaka.
21. Md. Azharul Islam Mollah, EC Member, Bangladesh Poultry Industries Association
22. Sayed Abu Siddique, Secretary General, Bangladesh Poultry Industries Association
23. Prof. Dr.-Engr. Abdur Rashid, BUET

### Summary of the findings from interview

- During the last decade about 25,000 biogas plants of fixed done model have been constructed in Bangladesh by different government and non-government organizations. This is the only model now in use in Bangladesh. These plants have helped grow interest among the common people about biogas. It is now the time for wide dissemination.

- At present, there is no programme for promoting and supporting biogas technology in the country except Biogas Extension Programme of Grameen Shakti.
- Power generation from biogas is being used in many parts of the world. But till today, it is highly neglected in Bangladesh.
- R&D to develop more efficient model for biogas digester, improve biogas burner, processing of biogas for using in a generator or in an engine is necessary.
- National Renewable Energy Policy has been formulated long before and needs immediate approval and implementation.
- Developing, encouraging and supporting entrepreneurship is the best way for promoting biogas technology.
- Subsidy is liked by the people; but it does not help widespread dissemination.
- Marketing mechanism for a new technology developed by IDCOL has proved to be successful and has drawn attention of all for replication.
- Biogas technology has proved to be technically viable, environmentally friendly, economically affordable and socially acceptable.
- There are success stories in the field of biogas technology achieved by both government and non-government organizations, which can be replicated directly with minor improvements.
- Operation, maintenance and after sale service are important for the sustainability of a successful biogas programme; credit support can ensure all these.
- Biogas power generation has high potential, but needs more pilot studies before going for wide dissemination.
- CDM may be linked with biogas technology.
- A package of solar and biogas with credit support for poultry and dairy farms may change the life style of rural people.
- Use of clay, jute and dung as cementing material may be thought to minimize cost of biogas plant.
- Burner may also be made of mud, which is cheaper.

**ANNEX-3**

# Focus Group Discussion at Maona

As a part of the study, the consulting team arranged a Focus Group Discussion (FGD) in Grameen Shakti Unit Office at Maona on 24 June 2005 at 10 am. 27 poultry and dairy farm owners including one biogas user attended the meeting. Chairman along with four members (among them three female members) of the local Union Parishad, one Biogas Agent of BCSIR, Grameen Shakti officials and one poultry medicine businessman also attended the meeting. There were also 3 neighbors of the poultry farms to give their reaction. The meeting was presided over by Dr. M. Eusuf.

At the beginning Dr. Eusuf gave a brief of the objectives of the meeting. He also highlighted the biogas technology, its need, benefit and use. On his request Mr. Gofran and Dr. Khalequzzaman spoke on the status and achievements of the technology. Mr. Kamrul Hoque, Asstt. General Manager of Grameen Shakti gave an outline about the extension programme taken by Grameen Shakti. Local Union Parishad Chairman, Members, farm owners, neighbors and some other participants took part in the discussion. A brief on the outcome of the meeting is given below:

1. About 500 poultry and dairy farms are in operation in the Maona Union where biogas plants can be constructed. The farms are mostly concentrated in the villages of Baratopa, Singdighi, Pathor Para. Recently, one biogas plant has been constructed in a poultry farm by the local agent of BCSIR.

2. Almost all the farm owners know about the biogas technology, but they don't know how much raw material is required for a biogas plant, what investment needed, what the amount of gas production is and how many hours a burner may work.

3. Some of the farm owners knew about the subsidy system of BCSIR and wanted to know whether the system would be introduced again. At this stage, the Biogas Agent of BCSIR informed that there is no possibility of such scope in the near future. Some of the farm owners knew about the credit and recovery system of Grameen Shakti and showed interest to have a plant through GS.

4. The owner of Khandker Poultry Farm, which has about 1000 birds, told that they are facing acute problem with the electricity as very often it goes out and the farm remains in the darkness for 2-3 hours. Poultry farms need heat and light. They also face problem with the litter, which spreads bad smell and pollutes environment. So, if they can have biogas plant with a power generation arrangement, they could overcome the problem.

5. Some of the neighbors of the poultry farms expressed that they do not like bad smell, but they are not giving any objection, because, some of them are also thinking of establishing poultry farms in the near future. They may have gas and light connection from the neighboring farm owners if biogas plants are installed. At present they are spending about Tk. 400/- to Tk.500/- per month against fuel.

6. In the Union, most of the litter is wasted. Some farm owners sell their litter to the local farmers @ Tk.10/- per bag (40 Kg).

**Annex-4**

# Expert Meeting

# on

# Promotion of Biogas Production and Use in Poultry Farms
# – The Way Forward –

You are cordially invited to attend a Meeting of Experts on *Promotion of Biogas Production and Use in Poultry Farms* on

***25 October 2005 from 10.00h to 13.00h.***

The venue is

***REB, Nikunja 2, Khilkhet, Dhaka***
***Training Hall, 9th Floor, Room # 1008.***

The poultry farm sector is a promising market niche for biogas use. There are more than 110000 poultry farms in Bangladesh with more than 100 birds each, and the litter produced daily approaches an estimated 6000 tons. On top of this there is already substantial practical experience with biogas use in poultry farms, which bodes well for further dissemination of this technology in this sector.

BCAS, commissioned by PURE, prepared a report on the feasibility of biogas in this sector. Based on this report and the contributions of experts we like to discuss the next steps, namely the effective promotion of biogas application in poultry farms.

**Programme:**

| | |
|---|---|
| 09.30h | Registration |
| 10.00h | Welcome address |
| 10.05h | Presentation of issues by Dr Khalequzzaman, PURE |
| 10.45h | Discussion – Moderator Dr Eusuf, BCAS |

We are looking forward to your valuable contribution.

E. O. Gomm
Coordinator
PURE

**Annex-5**

# Expert Meeting

**On**

## Promotion of Biogas Production and Use in Poultry Farms

**held at REB, Nikunja 2, Khilkhet, Dhaka**
**Training Hall, 9th Floor, Room # 1008**
**On 25 October 2005 from 10.00h to 13.00h**

As per the programme, the registration was started at 09.30h. A large number of experts (the list is attached) registered themselves and took seats. The workshop began at 10.00 h with the welcome address of Mr. Erich Otto Gomm, Coordinator of GTZ-PURE. Dr. M. Khalequzzaman – Senior Energy Specialist of GTZ-PURE presented the main findings and recommendations of the study. On the basis on the findings and recommendations a discussion took place. The discussion was moderated by Dr. M. Eusuf, Senior Fellow of Bangladesh Centre for Advanced Studies (BCAS). A summary of the discussion has been presented below:

Mr. Gomm welcomed the participants and described the background of the project in connection with the objectives of PURE project in brief and mentioned that PURE project would undertake steps to promote renewable energy technologies in Bangladesh. The emphasis would be laid on the commercialization of technologies, most of which are already available in the country. The tasks are to sort out the prospective technologies, identify the barriers on their commercialization, and undertake measures for their commercialization. Mr. Gomm underscored that the main issue of this meeting was to decide which measures needed to be followed in order to promote biogas plants in Bangladesh.

Dr. M. Khalequzzaman presented the findings and recommendations of the study on behalf of the Study Team. The main points of the presentation are given in the following section:

<u>Findings</u>

(i) Biogas technology is a proven technology in Bangladesh. About 25,000 biogas plants have already been set up in the country, most of which are in operation. Most of them are based on cow-dung and poultry droppings. All the plants now in operation are fixed dome plants.

(ii) So far, over 2,000 poultry-based biogas plants have been constructed. Plants with birds ranging 100 –5,000 are in operation.

(iii) There are a good number of skilled engineers, supervisors and masons spread all over the country, who are available to construct, operate and maintain fixed dome biogas plants.

(iv) Construction of biogas plants in the poultry farms is a necessity because of the bad odour that poultry droppings spread in the area. Since poultry industry is booming in Bangladesh, poultry-based biogas plants also should be booming in future.

(v) Financial analyses of plants ranging from 100 birds up to 50,000 birds have shown that

   a) With 100 birds using both gas and fertilizer, if sold at a price 300 Taka/connection and 0.8 Taka per kg of fertilizer, the plant is financially viable. However, with either of them alone, the plant is not financially acceptable assuming an interest rate of 8%.

   b) With 500 birds and above, all plants are financially acceptable with gas alone but none of the plants up to 50,000 birds is viable if only electricity or only fertilizer is sold. But electricity and at least any one of other two (gas and fertilizer) makes the project viable, 50% of the gas assumed to be used for electricity generation.

   c) Sensitivity analyses have been done with 20% cost increase in plant construction, operation & maintenance and 20% decrease in revenue received. All plants above 250 birds are viable.

   d) Biogas plants are financially viable, even a farm as small as 100 birds.

   e) Larger farms may go for electricity production, but selling of gas is more profitable.

vi) Most of the poultry farm owners are capable of financing biogas plants on their own. The small farmers will, however, prefer micro-financing. Most of them will avoid bank loan because of hassles associated with bank loan being approved and received. Micro-financing would be a very good option for them.

vii) Economic benefit derived from a biogas plant in terms of fuel and fertilizer saving can have notable impact on national economy.

viii) In the case of large biogas plants (more than $3m^3$ gas), owners sell biogas to the neighbour at the rate of TK300 per connection.

ix) Biogas contains moisture and hydrogen sulfide, which should be removed for better functioning of the cooking burners and electricity generators.


*Photo Anx 1: Expert Meeting on "Promotion of Biogas Production and Use in Poultry Farms"25 October 05,REB, Dhaka (Left to Right): S. A Abdullah, Chief Engineer (P&O), REB; A, K Chowdhury, Member, PBS, REB; M. Eusuf, Senior Fellow, BCAS (Meeting Moderator) and E.O. Gomm, Coordinator, GTZ – PURE.*

Recommendations

(i) Since biogas technology is now well established with the availability of expertise in the country, the technology is set to take off provided financial support coupled with appropriate marketing measures is made available.

(ii) A promotional drive in a selected area, e.g. the upazila with the highest number of poultry farms should be undertaken immediately. The promotional work will be started with a pilot program with the objective of installing a biogas plant targeting every poultry farm of the upazila. However, before embarking on this, a marketing plan with appropriate strategies should be developed for successful implementation. It should also be followed by monitoring with corrective measures, if necessary

(iii) In order to solve the above problems associated with hydrogen sulfide and moisture, some experiments should be carried out in a suitably sized plant.

(iv) A dedicated organization for biogas is necessary. This may be a Biogas Foundation. The objective of this organization will be to promote biogas plants all over the country in a concerted manner. It will coordinate all activities related to biogas e.g. policy, research, training, and dissemination. The Foundation will be run by a Board of Directors consisting of representatives from the Govt. and biogas related organizations.

(v) A revolving fund to be administered by the Biogas Foundation will be created for multiplication of biogas plants and administration of biogas related activities. Till the formation of the Biogas Foundation, a suitable organization may volunteer to create and administer the revolving fund.

After the presentation, the floor was open for discussion, which was moderated by Dr. M. Eusuf of BCAS. A large number of participants took part in the discussion and gave their opinions to different issues related to biogas technology promotion in Bangladesh.

Mr. Dipal C. Barua, Managing Director, Grameen Shakti mentioned that Solar PV has proven itself acceptable to the people of Bangladesh and he believes that biogas technology would be much more interesting. At Grameen Shakti there were at the moment 15 Nos. of biogas professionals and they had already installed 80 Nos. of biogas plants in different parts of the country. The target was set to install 20 more plants by the end of the calendar year. He expressed his satisfaction on GTZ's initiative in this regard. He mentioned that a committee under Power Cell might be formed leading to a foundation. He also offered the establishments of Grameen Shakti at Maona of Sreepur for any use aimed at wider dissemination of biogas technology.

Dr. Khurshidul Islam told that poultry farms should also take initiative for selling both gas and fertilizer. Fertilizer is very interesting, because it gives soil natural nutrients. Captive power generation plants might also be established by using biogas. However, R& D is necessary in this regard.

Mr. Shamsul Haque of IFRD mentioned IFRD had already developed technology to remove hydrogen sulfide and moisture from biogas. This should be promoted. He also opined that there should be more designs for biogas plants so that people might have options to choose.

Mr. B.D. Rahmatullah of Power Cell opined that biogas was profitable of course. 80% of the poultry farm owners were interested to install biogas plants; they needed only technical assistance. Program should be undertaken in this regard for the whole country.

Mr. Tazmilur Rahman of LGED expressed his willingness to host this study paper in LGED - REIN - website. He argued that every district should have at least one demonstration biogas plant. For effective promotion, advertisement in the TV was necessary. Mr. Rahman expressed his experience of a visit to a 12 MW biogas plant in UK and hoped that such plants were also possible in Bangladesh. Technical as well as financial support from GTZ would be most welcome.

Mr. Shamsul Haque told that IFRD of BCSIR had the expertise to provide training on construction of the biogas plants. IFRD would provide training if asked for. IFRD would also undertake further R & D if any support became available.

Dr. Eusuf of BCAS mentioned that seed money of about 2 Million of BDT is initially required and hoped that GTZ might provide this monitory support. Mr. Gomm reacted on this positively and told that GTZ would facilitate the promotion of biogas technology. Mr. Gomm further told that GTZ would provide some support at the initial stage. If the initiative proved itself successful, he hoped further support would flow from organizations like KfW, World Bank and ADB.

Dr. Eusuf of BCAS underscored the need of a dedicated organization, which would take the whole biogas technology related activity to a pick. Dr. K. Islam also underscored the need of a pressure group, which might be formed in cooperation with Grameen Shakti and BCAS.

He added that BCAS might work as the Secretariat of the pressure group. Mr. Quamar Munir of IPSU opined that a network might be formed first, then gradually extended to forum and finally to a foundation.

Dr. Eusuf offered the BCAS office for accommodation of the secretariat in respect of pressure group. He also mentioned that BCAS was ready to do the Step 2 of the PURE programme. BCAS would work on awareness building and monitor the progress of the activities.

Mr. B. D. Rahmatullah expressed his dissatisfaction over the renewable energy activities in the country and mentioned that the country had been suffering from the lack of policy for the last 10 years. He hoped, however, that the Renewable Energy Policy would be approved by the Government soon. He had been working for this with all sincerity.

**Decisions**

After elaborate discussion, following decisions were made:

- Intensive activities for biogas technology dissemination would be started in Maona of Sreepur and Savar. These two areas would work as piloting area and demonstrate, hopefully, the success of biogas technology before the whole country so that other areas might follow this.
- Grameen Shakti would work in Maona and LGED in Savar.
- GTZ would provide money in the form of a revolving fund for the activities in Maona.
- At the current stage, no foundation would be formed, but a forum would be created, which would act as a pressure group. BCAS would work as the secretariat.
- BCAS would work on awareness building and monitor the progress.
- IPSU would provide support for 5 demonstration biogas plants in Savar and 5 in Maona, Sreepur.

**Closing Remarks**

Mr. Syed Abu Abdullah, Chief Engineer (P & O) of REB expressed his gratitude to GTZ for the unique meeting of experts. Government has assigned Rural Electrification Board to work with GTZ. Marketing of renewable energy technologies is very important. He invited other actors like Grameen Shakti, BRAC to join REB in its effort to provide rural areas of Bangladesh with affordable and sustainable energy for development. Mr. Abdullah thanked all participants for their active participation in the meeting and wished the renewable energy initiative a success.

**Annex-6**

# List of Participants
# Meeting on Promotion of Biogas Production and Use in Poultry Farms

| | | |
|---|---|---|
| Date | : | 25 October 20005 from 10.00h to 13.00h |
| Venue | : | REB, Nikunja-2, Khilkhet, Dhaka-1229 |
| | | Training Hall, 9th Floor, Room No.1008 |

| Sl. No. | Name | Organization | Designation |
|---|---|---|---|
| 1 | Mr. Erich Otto Gomm | GTZ-PURE | Coordinator |
| 2 | Mr. Anwarul Kabir Chowdhury | REB | Member, PBS |
| 3 | Mr. B.D. Rahmat Ullah | Power Cell | Director General |
| 4 | Dr. M. Eusuf | BCAS | Senior Fellow |
| 5 | Mr. Depal C. Barua | Grameen Shakti | Managing Director |
| 6 | Mr. Iqbal Hasan | World Bank | Energy Specialist |
| 7 | Mr. Syed Abu Abdullah | REB | Chief Engineer (P&O) |
| 8 | Dr. Anwar Hossain | FAO/LGED | Consultant |
| 9 | Dr. M. Khalequzzaman | GTZ-PURE | Senior Energy Specialist |
| 10 | Mr. A Gofran | G. Shakti | Biogas Expert |
| 11 | Mr. Abdur Razzaque | REB | Director (RED) |
| 12 | Mr. Tazmilur Rahman | LGED | Project Manager (SRE) |
| 13 | Mr. Md. Shamsul Haque | BCSIR | Chief Scientific Officer |
| 14 | Prof. Abdur Rashid Sarker | BUET | Deptt. of Mechanical Engineering |
| 15 | Dr. Fouzul Kabir Khan | IDCOL | Managing Director |
| 16 | Mr. Shaikh Ehsanul Habib | Green Power Ltd. | Managing Director |
| 17 | Mr. Abul Kalam Azad | REB | Executive Engineer (RED) |
| 18 | Mr. Abser Kamal | Grameen Shakti | General Manager |
| 19 | Mr. Dilder Ahmed Taufiq | GTZ-PURE | Chief of Operations |
| 20 | Mr. Sundar Bajgain | SNU | Consultant |
| 21 | Mr. Prabash C. Ghimine | SNU | Consultant |
| 22 | Mr. Md. Zahidul Islam | IDCOL | Investment Officer |
| 23 | Mr. Nazmul Hossain Chowdhury | REB | Director (Program & Planning) |
| 24 | Mr. K.M. Hossain | Raj Poultry Complex | Proprietor |
| 25 | Mrs. Shamaresh Ghosh | LGED | Biogas Specialist |
| 26 | Mr. K.M. Hasibul Khalid | Biman Poultry | Farm Manager |
| 27 | Mr. Md. Ali Hussain | Biman Poultry | SAE |
| 28 | Dr. K. Islam | BREMADCO | Energy Specialist |
| 29 | Mr. Qamar Munir | IPSU-MOEF | Energy Specialist |
| 30 | Kazi Danood Hossain | IPSU-MOEF | Energy Specialist |
| 31 | Mr. Md. Mainuddin Ahmed | --- | Poultry Consultant |
| 32 | Mr. M. Mazharul Hoque Patwary | REB | Assistant Engineer (RED) |
| 33 | Dr. Md. Abdur Rouf | BCSIR | Principal Scientific Officer |
| 34 | Mr. Naimul Haque | BCSIR | Principal Scientific Officer |


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