Popularization & Set up Biogas Plants in Bangladesh

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Abstract

Bangladesh, being situated in a hot, humid, sunny region and the landmass being crisscrossed by innumerable rivers and streams, is endowed with a plentiful supply of renewable sources of energy. Out of the various renewable (i) solar, (ii) biomass, (iii) wind and (iv) hydro power are being used in Bangladesh. These sources have already been in use in the primitive way. Bangladesh is in a favorable position in respect of the climatic conditions and availability of the raw materials for biogas production. As biomass fuels are consumed beyond their renewable limits (unsustainable), it has become mandatory to promote efficient burning devices and conversion technologies. As huge quantity of biomass fuel is wasted due to inefficient way of burning, biogas technology can play a vital role in the conservation of biomass resources. Biogas technology, as it uses animals, Industrial, Municipalities solid waste and agriculture wastes and returns the wastes as fertilizer, supplies energy as bonus. Besides fuel and fertilizer, this technology provides better hygienic conditions in the rural and urban areas with reduction of GHG as a further benefit. Because of the booming growth of poultry farms, a boom in biogas plant installation is expected. This project is mainly concerned with the above issues and The overall goal of the project is to develop and established biogas plants in Dhaka, Gazipur and Barisal district through Sewage Sludge , Agricultural and crops wastes , Industrial Wastes , Animal By-products ,fish wastes, Municipal Solid Wastes , Dry Continuous Digestion of Source Separated Waste, Practically any kind of watery organic substance, households wastes, with the ultimate goal to establish a sustainable and commercial biogas plant and technology in Bangladesh to improve socio-economic health and sanitary conditions of the rural and urban people, and to reduce GHG emissions. It is expected that this project would certainly contribute to the improvement of the living standard of the people of Bangladesh and provide income generation and also contribute to poverty reduction and country's GDP.

Key word: Biogas, Biomass, Waste, Sustainable, Renewable sources

1.1 Introduction

As biomass fuels are consumed beyond their regenerative limits (unsustainable), it has become mandatory to promote efficient burning devices and conversion technologies. As huge quantity of biomass fuel is wasted due to inefficient way of burning, biogas technology can play a vital role in the conservation of biomass resources. Biogas technology, as it uses Animals, Industrial, Municipalities solid waste and agriculture wastes and returns the wastes as fertilizer, supplies energy as bonus. Besides fuel and fertilizer, this technology provides better hygienic conditions in the rural and urban areas with reduction of GHG as a further benefit. Because of the booming growth of poultry farms, a boom in biogas plant installation is expected.

This project is mainly concerned with the above issues and The overall goal of the project is to develop and established biogas plants in Dhaka, Gazipur and Barisal district through Sewage Sludge , Agricultural and crops wastes , Industrial Wastes , Animal By-products ,fish wastes, Municipal Solid Wastes , Dry Continuous Digestion of Source Separated Waste, Practically any kind of watery organic substance, households wastes, with the ultimate goal to establish a sustainable and commercial biogas plant and technology in Bangladesh to improve socio-economic health and sanitary conditions of the rural and urban people, and to reduce GHG emissions. It is expected that this project would certainly contribute to the improvement of the living standard of the people of Bangladesh and provide income generation and also contribute to poverty reduction and country's GDP.

1.2 Justification of the Project:

With the implementation of the project, the following benefits will be achieved to a great extent: (1) Greenhouse gas (GHG) emissions will be reduced significantly. (2) Production of biogas will facilitate cooking, lighting, vehicle fuel as natural gas and generation of electricity for rural, Urban and commercial applications. (3) Facilitate production of organic fertilizer to increase crop production, thus improving economic conditions.(4) Biogas digested manure improves micro-flora of the soil and building the soil structure and texture, conserves natural resources, which would gradually lead (5) Improve sanitary and health conditions of rural and urban people. (6) By checking deforestation, ecological equilibrium will be maintained (7) Turning Natural Waste into Safe, Affordable Fuel (8) Green employment generation

1.3 Energy Situation and Government Policy

Since energy is used in domestic cooking, food processing and lighting, industries, transport, agriculture and other economic activities, energy related problems now facing the country must be identified. The current pressing problems are (1)Consumption of huge amount of biomass about 80 million tons per year (GOB, 2008) leading to large GHG emissions to the atmosphere and shortage of organic matter needed for productivity of soil, feed for cattle, raw material for industries, and fuel for domestic and industrial use.(2) Consumption of crop residues and cattle-dung as fuel in increasing amounts, about 80% of total biomass , leading to deficiency of organic matter and micro-nutrients in the soil(3.) Rapid deforestation tends to erosion and change in climatic patterns leading to less sequestration. (4) Inadequate availability of energy is affecting growth and even maintenance of industries leading to unemployment

National Energy Policy 2008 has been updated recently. The final updated version is awaiting GOB approval. The Power Cell will articulate and co-ordinate in implementing the RE projects and will assist the Board of Investment (BOI) to promote and facilitate foreign and local investment in this sector. The Cell would represent the government interest in RE projects. The Power Cell/Energy Regulatory Commission (ERC) will undertake the following functions.

(i) Assist in issuance of licenses for RE projects sponsored by private entrepreneurs in a localized area.

(ii) Identify and assess the potential for establishment of RE projects, which could make a significant contribution to energy needs in both the short and long term.

(iii) Recommend financing and delivery mechanisms to increase the affordability of RE systems for the rural poor.

(iv) Encourage NGOs and private sector organizations in the development of RE and suggest strengthening the institutional requirements for successful implementation of these projects.

(v) Recommend required training facilities for technology transfer needed to support commercialization of RETs.

(vi) Identify the type and extent of support needed from international organizations.

(vii) Consider existing infrastructure and future plans of different utilities before issuance of licenses for establishment of RE projects.

TABLE-1: ENERGY BLANCE 1990

In Peta Joules (1015 Joules)

	Oil	Natural Gas	Coal	Hydro Power	Electricity	Total Comm. Energy	Non Comm. Wood Fuel	Wood Fuel	Total Biomass	TOTAL ENERGY
SUPPLY										
Indigenous Production	0.36	3.76	0.06	169.40	0.50	174.48	313.80	84.00	488.30	888.40
Imports	53.82	85.20	0.00	0.00	0.00	139.02	0.00	0.00	0.00	139.02
Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stock Change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bunkers*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Primary Energy Supply	54.18	88.96	0.06	169.40	0.50	313.50	313.80	84.00	488.30	1027.42
Power Stations (Thermal Generation)	17.80	37.60	13.00	169.40	0.00	237.80	0.00	0.00	0.00	237.80
Auto Producers	0.00	4.80	1.00	21.40	0.00	27.20	0.00	0.00	0.00	27.20
Refinery Fuel	4.10	0.00	0.00	0.00	0.00	4.10	0.00	0.00	0.00	4.10
Losses & Unaccounted for	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Commercial Energy Demand	32.28	46.56	0.06	0.00	0.50	79.40	313.80	84.00	488.30	567.70
Household & Cottage Industry	0.00	0.00	0.00	0.00	0.00	0.00	313.80	84.00	488.30	488.30
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industry	32.28	46.56	0.06	0.00	0.50	79.40	0.00	0.00	0.00	79.40
Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commerce & Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumption	32.28	46.56	0.06	0.00	0.50	79.40	313.80	84.00	488.30	567.70

Source: National Energy Policy January 15, 1998

TABLE- 2: ENERGY BLANCE 2000

In Peta Joules (1015 Joules)

	Crude oil	Petroleu m Product	Coal/Coa l	Natural Gas	Hydro Electricity	LPG	Total Comm. Energy	Non Comm. Wood Fuel	Wood Fuel	Other Crop Residues	Total Biomass
SUPPLY											
Indigenous Production	0.00	0.00	18.82	365.8	0.00	0.0	374.58	323.1	531	884.01	14.47	1043.
Imports	84.00	82.68	0.00	0.00	0.00	0.0	166.68	0.00	0.0	0.00	0.00	166.6
Exports	0.00	13.93	0.00	0.00	0.00	0.0	13.93	0.00	0.0	0.00	0.00	13.93
Total Primary Energy Supply	84.70	96.59	18.82	365.8	0.00	0.0	676.39	323.1	531	884.01	14.47	1197.
Power Stations (Thermal Generation)	8.84	0.00	1.60	81.01	0.00	0.0	91.74	39.18	65.2	97.00	1.06	140.3
AMADOR GAS CONS.	45.70	82.68	0.00	0.00	0.00	0.0	1.31	0.00	0.0	0.00	0.00	1.31
Refinery Fuel	5.00	4.18	0.50	0.00	0.00	87.84	0.0	198.50	0.00	0.0	0.00	0.00
Losses & Unaccounted for	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Commercial Energy Demand	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Household & Cottage Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commerce & Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Planning Commission (2002), adapted.

TABLE-3: 2009 Energy Balance for Bangladesh

In thousand tonnes of oil equivalent (ktoe) on a net calorific value basis

Supply and Consumption	Coal	Oil Shale and Peat	Oil	Oil Products	Natural Gas	Nuclear	Hydro	Geothermal, Solar, Wind, etc.	Biofuels and Waste	Electricity	Heat	Total
Production	800	75	0	1532	0	0	133	0	5813	0	0	8353
Imports	422	86	3859	0	0	0	0	0	0	0	0	4367
Exports	0	0	0	-1	0	0	0	0	0	0	0	-1
International Marine Bunkers*	0	0	0	-38	0	0	0	0	0	0	0	-38
International Aviation Bunkers*	0	0	0	-192	0	0	0	0	0	0	0	-192
Stock Changes	-271	140	141	0	0	0	0	0	0	0	0	10
TPES	929	1277	3828	1802	0	0	133	0	5813	0	0	12933
Transfers	0	0	0	0	0	0	0	0	0	0	0	0
Statistical Differences	0	0	0	19	0	0	0	0	0	100	0	119
Electricity Plants	-219	0	-656	-6226	0	0	-133	0	0	3258	0	-3976
CHP Plants	0	0	0	0	0	0	0	0	0	0	0	0
Heat Plants	0	0	0	0	0	0	0	0	0	0	0	0
Gas Works	0	0	0	0	0	0	0	0	0	0	0	0
Oil Refineries	0	0	3972	-3972	0	0	0	0	0	0	0	0
Coal Transformation	0	0	0	0	0	0	0	0	0	0	0	0
Liquefaction Plants	0	0	0	0	0	0	0	0	0	0	0	0
Other Transformation	0	0	0	0	0	0	0	0	0	0	0	0
Own Use	0	0	-83	0	0	0	0	0	0	-183	0	-274
Distribution Losses	0	0	0	-203	0	0	0	0	0	-74	0	-328
TFC	403	0	3976	9443	0	0	0	0	5813	3099	0	23135
Industry Sector	403	0	3976	3443	0	0	0	0	0	1742	0	9563
Transport Sector	0	0	0	4000	0	0	0	0	0	0	0	4000
Other Sectors	0	0	0	1999	0	0	0	0	5813	1357	0	9169
Residential	0	0	0	1429	0	0	0	0	5813	1357	0	8599
Commercial and Public Services	0	0	0	570	0	0	0	0	0	0	0	570
Agriculture / Forestry	0	0	1049	18	0	0	0	0	0	113	0	1179
Fishing	0	0	0	0	0	0	0	0	0	0	0	0
Non-Specified	0	0	0	0	0	0	0	0	0	0	0	0
Non-Energy Use	0	0	2927	0	0	0	0	0	0	0	0	2927

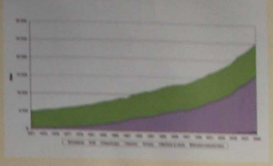
TABLE-4: Renewables and Waste in Bangladesh in 2009

	Municipal Waste*	Industrial Waste	Primary Solid Biofuels	Biogas	Liquid Biofuels	Geoth ermal	Solar Thermal	Hy dro	Solar Photo voltaic	Tide, Wave, Ocean	Wind
Unit	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GW	GWh	GWh	GWh
Gross Elec. Generation	0	0	0	0	0	0	0	188	0	0	0
Gross Heat Production	0	0	0	0	0	0	0	0	0	0	0
Unit	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ			
Gross Heat Production	0	0	0	0	0	0	0	0			
Unit	TJ	TJ	TJ	TJ	1000 Tonnes	TJ	TJ				
Production	0	0	369048	0	0	0	0				
Imports	0	0	0	0	0	0	0				
Exports	0	0	0	0	0	0	0				
Stock Changes	0	0	0	0	0	0	0				
Domestic Supply	0	0	369048	0	0	0	0				
Transfers	0	0	0	0	0	0	0				
Statistical Differences	0	0	0	0	0	0	0				
Electricity Plants	0	0	0	0	0	0	0				
CHP Plants	0	0	0	0	0	0	0				
Heat Plants	0	0	0	0	0	0	0				
Gas Works	0	0	0	0	0	0	0				
Oil Refineries	0	0	0	0	0	0	0				
Coal Transformation	0	0	0	0	0	0	0				
Liquefaction Plants	0	0	0	0	0	0	0				
Other Transformation	0	0	0	0	0	0	0				
Own Use	0	0	0	0	0	0	0				
Distribution Losses	0	0	0	0	0	0	0				
TFC	0	0	369048	0	0	0	0				
Industry Sector	0	0	369048	0	0	0	0				
Transport Sector	0	0	0	0	0	0	0				
Other Sectors	0	0	0	0	0	0	0				
Residential	0	0	0	0	0	0	0				
Commercial and Public Services	0	0	0	0	0	0	0				
Agriculture / Forestry	0	0	0	0	0	0	0				
Fishing	0	0	0	0	0	0	0				
Non-Specified	0	0	0	0	0	0	0				
Non-Energy Use	0	0	0	0	0	0	0				

Total Primary Energy Supply
Bangladesh

Share of total primary energy supply in 2009
Bangladesh

Energy Production
Bangladesh



1.4 Biogas Potential in Bangladesh

Bangladesh, being situated in a hot, humid, sunny region and the landmass being crisscrossed by innumerable rivers and streams, is endowed with a plentiful supply of renewable sources of energy. Out of the various renewable (i) solar, (ii) biomass, (iii) wind and (iv) hydro power are being used in Bangladesh. These sources have already been in use in the primitive way.

Bangladesh is in a favorable position in respect of the climatic conditions and availability of the raw materials for biogas production. Biogas is a kind of fuel gas obtained by anaerobic decomposition of organic matter such as cattle dung, poultry droppings, human excreta, agricultural residues, water hyacinth, garbage etc. In Bangladesh from over 22 x 108 cattle heads, assuming 80% collection of cow-dung (According to BEPP (1987, 34% of the raw dung is dried for burning as fuel. With the introduction of biogas plants, drying of dung for use as cooking fuel will not be necessary, the total gas obtainable is 2.377 x 106 m3 (0.037 m3 per kg fresh dung) per year. Processing of human excreta will yield biogas to the tune of 1200 x 106 m3 per year. 24% of the total population i.e. 0.24 x 130 = 31.2 million people live in urban areas producing some 31.2 x 106 x 0.3 x 365 = 3.42 x 109 kg of household wastes annually. This has a potential of producing 3.42 x 109 x 0.048 = 157.3 x 106 m3 of biogas. Moreover, water hyacinth, which is available in plenty in Bangladesh in beels, haors, ponds and rivers, is a good source of biogas. It grows very rapidly and is capable of rapid multiplication in any place where water exists. It is a nuisance in agriculture, fisheries and navigation. Yield varies from 10 to 20 tons per year per acre. Excluding water hyacinth, total potential of biogas from cow-dung, human excreta and urban wastes stand at 3675 x 106 m3 (ADB, 2003), which is equivalent to 1.98 million tons of oil (1 m3 biogas = 22.31 x 106 Joules). It is rather difficult to obtain up-to-date data about the number of farmers keeping sufficient heads of cattle in Bangladesh as the latest census was conducted in 1998. By then, 8.17 million holdings (45.8% of the then total holdings) were reported to keep 21.37 million of cattle (an average of 2.64 cattle per holding), while 0.27 million households (1.5% of all holdings) were reported to keep 0.72 million buffaloes (an average of 2.67 buffaloes per holding). The numbers of cattle in the agricultural census of 1983-84 (21.48 million) and 1977 (20.80 million) were slightly lower. It is not clear from the 1996 census data to which extent holdings with cattle also kept buffaloes. There was a positive correlation between the average number of cattle and buffaloes per holding and the size (acreage) of the holdings.

Over 850,000 holdings in 1998 kept five or more heads of cattle and could be regarded as the potential biogas owners. If all dung produced by a minimum five heads of cattle could be collected, this amount would be sufficient to feed a biogas plant with a gas output of 2m3 per day. 2.1 million holdings keeping three or four cattle heads could be regarded as a bigger market segment, but as the amount of dung is limited to 30–40 kg per day, they would need to be supplied with smaller sized biogas plants, e.g. with a gas output of about 1.5 m3. Most of the information regarding cattle population reveals that the cattle population is rather stagnant. In other words, the number of cattle nowadays will be more or less the same as in 1998. The number of holdings however has increased over this period by about 20% which means that the average number of cattle heads per holding has decreased. Rough estimates by experts from BBS and BRAC on the present number of households with three or more cattle heads range from 875,000 to 1,825,000

1.5 Technology Options

The following three basic biogas designs have been tried in Bangladesh. These are (i) floating dome digester, (ii) fixed dome digester, and (iii) plastic dome digester.

Floating dome digester: It works on the principle of constant pressure, changing volume.

The digester and cylindrical wall, commonly made from brick and cement, is covered with a gas tight MS cylinder which moves up when gas production is higher than consumption and comes down under the reverse condition.

Fixed dome digester: It works according to the principle of constant volume, changing pressure.

When the rate of gas production is higher than that of gas consumption, pressure inside the digester rises and expels some digester contents into the outlet compartment. When the consumption is higher than production, pressure inside the digester falls and the expelled materials in the outlet compartment run back to digester.

Plastic dome digester:

A long cylindrical polythene/PVC bag, half-buried longitudinally in the ground, is fed with fresh cow dung slurry at one end and discharged at the other. With the formation of gas, the bag swells like a balloon and the gas is led out to the point of use through a pipe by putting pressure on the balloon from outside.

1.6 Dissemination of Biogas Technology

Dissemination of biogas technology is gaining momentum. A good number of institutions are already involved in planning, research, development and dissemination of this technology. The Institute for Fuel Research and Development (IFRD) of Bangladesh Council of Scientific Industrial Research (BCSIR) has been the main actor for the dissemination of domestic biogas plants in Bangladesh to date. Other organizations involved at different stages have been BRAC, Local Government Engineering Department (LGED), Department of Environment (DOE), Grameen Shakti (GS), Bangladesh Agricultural University (BAU),

Bangladesh Small & Cottage Industries Corporation (BSCIC), Danish International Development Agency (DANIDA) and Department of Livestock Service (DLS). Due to termination of projects, progress of installation of biogas plants is at present very slow.

1.7 Project Description

1.7.1 Project Goal: The ultimate goal of the project is to establish a sustainable and commercial biogas plant and technology in Bangladesh to improve socio-economic, health and sanitary conditions of the rural and urban people, and to reduce GHG emissions. It is expected that this project would certainly contribute to the improvement of the living standard of the people of Bangladesh and provide income generation and also contribute to poverty reduction and country's GDP.

1.7.2 Project Objectives: Objectives of the project are:

1) To disseminate biogas technology and set up 3(three) mega biogas plants in Dhaka, Gazipur and Barisal District.
(i) To attract and strengthen the project for sustainable development of the power sector.
(ii) To generating electricity from a renewable source and to reduce greenhouse gas (GHG) emissions.
(iv) To reduce consumption of traditional biomass fuel and kerosene and provide alternative sources of energy to the rural people of Bangladesh through biogas technology for cooking, lighting, irrigation and the generation of electricity.
(v) To popularize biogas technology, make the people aware of the benefits of the technology and motivate them to use it.
(v 1) To provide organic fertilizer, containing NPK (Nitrogen, Phosphorous, and Potassium) and micronutrients to soil through organic recycling.
(vii) To improve hygienic and sanitary conditions in rural and urban areas and create pollution-free healthy environments by anaerobic processing of garbage, wastes, dung, droppings, night soil and organic matters which causes a filthy and obnoxious environment and act as a source of stink and diseases.
(viii) To alleviate poverty and generate self-employment through enhancement of production oriented activities by Integrated Farming System (IFS) including irrigation, dairy farming, poultry farming, pisciculture, vegetables, horticulture, nursery etc.
(ix) To develop human resources and enhance adult education.
(x) To improve rural quality of life through providing gas and electricity and check the migration towards city.
(xi) To provide rural households with smokeless, comfortable, healthy, timesaving cooking devices and enable them to engage in extra earning activities.
(xii) To establish micro-level decentralized electricity generating units in farms, growth centers, bazaars, cluster-houses, co-operatives, commercial enterprises, private holdings etc. based on right soil, dung, poultry droppings, garbage, agricultural wastes etc. and provide electricity in inaccessible areas.
(viii) To save hard earned foreign currency by replacing the use of commercial fuel by a clean gaseous fuel.

1.7.3 Project Outputs: Under this project, it is planned to build 3 mega biogas plant (i) Dhaka City Solid Waste to Electric Energy Project in Dhaka District (ii) The Integrated Biogas Agro-Ecological Farming on Barisal District (iii) Biogas Production and Utilization from Anaerobic digestion (AD) On Gazipur District. The project is envisaged to continue for 25 years. Net reduction of carbon dioxide will increase from year to year because of the progressive increase of the number of plants in operation. During the project period, the cumulative savings will be equivalent to 2 million tons of carbon dioxide emissions and CO2. With the use of credits for reduction of CO2 emissions, the project appears to be financially viable. The value of the credits for carbon dioxide reduction outweighs the cost of the project resulting in higher IRR. Moreover, this project will enhance a forestation and agricultural production in the country.

1.8 Financial analysis

Financial analysis will be done in accordance with the project Guidelines by the project authority for Preparation and Presentation of Financial Analysis. The analysis will be carried out to examine the financial viability of the project through calculation of the financial rate of return (FIRR). All Constituent costs and benefits of the project will be included in the analysis. The FIRR is based on the investment costs and the streams of costs and benefits spread over the life of the project (25years). Estimated project costs will be define by the viability of project through the project investors.

1.9 Economic Analysis

Economic analysis will be done in accordance with the project Guidelines for the Economic Analysis of Projects. The economic analysis will be carried out to reassess the economic viability of the project through calculation of the economic rate of return (ERR). All constituent costs and benefits of the project are included in the analysis. The ERR is based on the investment costs and the streams of costs and benefits spread over the life of the project. In the analysis, all costs and benefits are expressed in constant 2009- Taka (Tk) in the domestic price numeraire. A conversion factor (CF) of 0.88 will be used adjust salaries and wages to economic values. A zero residual value has been assumed for project machinery and equipment. An exchange rate of Taka=200 = $1.00 will be use to convert the dollar values in their local currency equivalent. A 25 years economic life has been used, though actual life could be in the range between 30-35 years. The loan term is assumed 25 years with less nominal rate of interest. Working capital is equity financed. Description of machineries and equipment and the basis of cost estimates will be flung up before the project.

Quarterly cash flow after the project period:

Loan repayments to the bank are completed during the project period. Cash flow will, therefore, include receipts from service charges and fertilizer sales, and expenditure on variable and fixed costs. The project will, therefore, remain sustainable after the project period.

Market push and pull:

Biogas industry will grow in the country with a market push and pull for machinery, spare parts and backup service. With the facilities available in the locality and the knowledge of biogas technology and its benefits, the pace of replication is bound to increase.

1.10 Other Biogas Environmental Benefits

Economic analysis includes health and environmental benefits of the project which occur in the following manners.

- Local air quality will be improved because of the reduction of CO2, and smoke leading to an improved environment.
- Kitchens will have much less of the above gases and smoke leading to fewer occurrences of eye and lungs diseases of women and children.
- Kitchen will remain cleaner because of less production of smoke.
- House courtyard will remain free of bad odor and germ bearing insects giving an improved aesthetic appearance and hygienic environment. A random sample will be used to calculate Environment and Health benefit of the Project

1.11 Recommendations

A. The project should be implemented

(i) To improve the financial, social and environmental benefits.
(ii) To realize its positive impact on domestic, commercial, environmental issues.

B. The implementation strategies for implementation should be

(i) To have a structure for installation and continued post-installation services.
(ii) To demonstrate sustainability of a COM-able project.

C. Since the project is COM-able. The investors may come forward with a soft loan to be recovered directly from the DOI revenue streams.