PROTOTYPE BIOGAS PLANT FOR RESIDENTIAL USE

KAZI MAHAMUDUL HASAN
MD. AZAD HOSSAIN
MD. TAUSIK HASAN
MD. MONIRUZZAMAN
MD. ROBIUL ISLAM

DEPARTMENT OF MECHANICAL ENGINEERING
SONARGAON UNIVERSITY (SU)
DHAKA, BANGLADESH

FEBRUARY 2022

PROTOTYPE BIOGAS PLANT FOR RESIDENTIAL USE

KAZI MAHAMUDUL HASAN
ID: BME1802015271
MD. TAUSIK HASAN
ID: BME1802015110

MD. AZAD HOSSAIN
ID: BME1802015112
MD. MONIRUZZAMAN
ID: BME1802015284

MD. ROBIUL ISLAM
ID: BME1802015111

SESSION 2018/2019

A Graduation Exercise Submitted to the Department of Mechanical Engineering in Partial Fulfillment of the Requirements for the Degree of Bachelor of Mechanical Engineering

DEPARTMENT OF MECHANICAL ENGINEERING
SONARGAON UNIVERSITY (SU)
DHAKA, BANGLADESH

FEBRUARY 2022

DECLARATION

We declare that the work in this thesis titled " PROTOTYPE BIOGAS PLANT FOR RESIDENTIAL USE " has been carried out by us (Department of Mechanical Engineering Student). The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this Thesis was previously presented by another thesis or Presentation.

Kazi Mahamudul Hasan   Md. Azad Hossain   Date: 02.02.2022

Md Tausik Hasan   Md. Moniruzzaman

Md. Robiul Islam

ACKNOWLEDGEMENT

All praise is due to Almighty Allah who created us.

First of all, we would like to pay our respects and special thanks to our Honorable sir Md. Mostafa Hossain Sir, He is the Head of our Mechanical Engineering Department and our Thesis Co-Ordinator. Sir helped us with the direction of writing this thesis.

Also, we would like to thank our classmates for their hard work and time in helping us with this thesis. While collecting information and data for this thesis we have received help and advice from many people and professionals and have collected information from many books which are mentioned in the reference. Without all this help, it would have been difficult to complete this thesis successfully.

In addition, we have received help from many people whose name is this not on the acknowledgement, we are forever grateful to them.

ABSTRACT

Currently the evolution of industry and the growing population use a lot of energy. So, we have been using fossil fuels as the primary source of the energy but it is declining very fast and its badly affect environment. So, it is very important to build a new sustainable energy source from renewable energy. This is why it is important, that we need to get an environmentally friendly energy source .in addition, we can supply natural gas to remote villages at very low cost and low maintenance. We can ensure maximum use of cattle dung. Data has been collected from various places for the construction of this biogas plant which is mentioned in the form of reference. We have selected cow dung for this project as it is very readily available and available in large quantities. We have done this project in a short range so that we can easily understand its activities and we are able to produce gas from this. This project produces 2:32 liters gas daily with using 8 kg cow dung & 24 kg water in 1:3 ratios. To increase gas production in the future this project requires more advanced technology to maintain the temperature and humidity. At the same time, small appliances have to be invented instead of big digester and the government must come forward for the development of biogas. then we will get a beautiful environment and a source of sustainable energy.

TABLE OF CONTENTS

Chapter *4*

Chapter *5*

Chapter *6*

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

IFRD	Fuel Research & Development
BCSIR	Bangladesh Council of Scientific and Industrial Research
GS	Grameen Shakti
SED	Sustainable Energy for Development
IDCOL	Infrastructure Development Company Limited
NDBMP	National Domestic Biogas and Manure Programmed
NGOs	Nongovernment Organizations
BCSIR	Bangladesh Council of Scientific & Industrial Research
LGED	Local Government & Engineering Department
EPCD	Environment & Pollution Control Department
DANIDA	Danish International Development Assistance
BSCIC	Bangladesh Small & Cottage Industries Corporation
IDCOL	Infrastructure Development Company Limited
GOB	Government of Bangladesh
NG	Natural gas
KW	kitchen waste
CM	Cow manure
OF	Organic fraction
RMP	Red mud plastic
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
BRAC	Bangladesh Rural Advancement Committee
BUET	Bangladesh University of Engineering and Technology

Chapter *1*

INTRODUCTION

1.1 Introduction:

Due to the population growth and the industrial development, world energy consumption considerably increases in the last decades. The use of fossil fuels is still the main energy sources. However, fossil fuels are not renewable energies, further, they are highly polluting, and their production tends to decrease during the next few decades *[1]*. Yet, the increased energy consumption based on fossil fuels affects our environment through the greater amounts of greenhouse gas emissions, the environmental pollution of water, air and soil, and the climate changes, which dramatically influence the quality of life and the health of people. Therefore, it is important to develop new sustainable energy supply systems that cover the increasing energy demand from renewable sources. Reducing greenhouse gas emissions through renewable energy production is of rising importance.*[2]*

Biogas, produced by anaerobic digestion of wastewater, organic waste, agricultural waste, industrial waste, and animal by-products is a potential source of renewable energy.*[3]*

Anaerobic digestion is a series of biological process in which microorganism breaks down biodegradable material in the absence of oxygen. It is a step-by-step process where the organic carbon is mainly converted to carbon dioxide and methane. Figure *1* shows the process of producing biogas divided into hydrolysis, acidogenesis, acetogenesis and methanogenesis.*[4]*

Biogas is mainly methane and carbon dioxide and small amounts of hydrogen sulfide. The gases methane, hydrogen, and carbon monoxide can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel *[5]*. It can also be used in a gas engine to convert the energy in the gas into electricity and heat and even for internal combustion engines. Biogas can be compressed; the same way natural gas is compressed. When it becomes bio-methane, biogas can be upgraded to natural gas standards.[***6***]

The rate of biogas production depends greatly on the temperature for digesters. Anaerobic digestion process generally occurs at three temperature ranges. These ranges are defined as psychrophilic *(15˚C - 20˚C),* mesophilic *(30˚C - 40˚C)* and thermophilic *(50˚C - 60˚C).[7]*

During biological decomposition and conversion processes, the rate of chemical reaction increases with the increase in the surrounding temperature. However, there should not be rapid temperature fluctuations during the digestion process, due to that methanogenic bacteria are sensitive to temperature conditions. A sudden change in temperature will hamper the methanogenic bacteria resulting in decreased biogas production. The optimum temperature for anaerobic digestion and methanogenic bacteria is found to be between *30˚C to 40˚C.[8]*

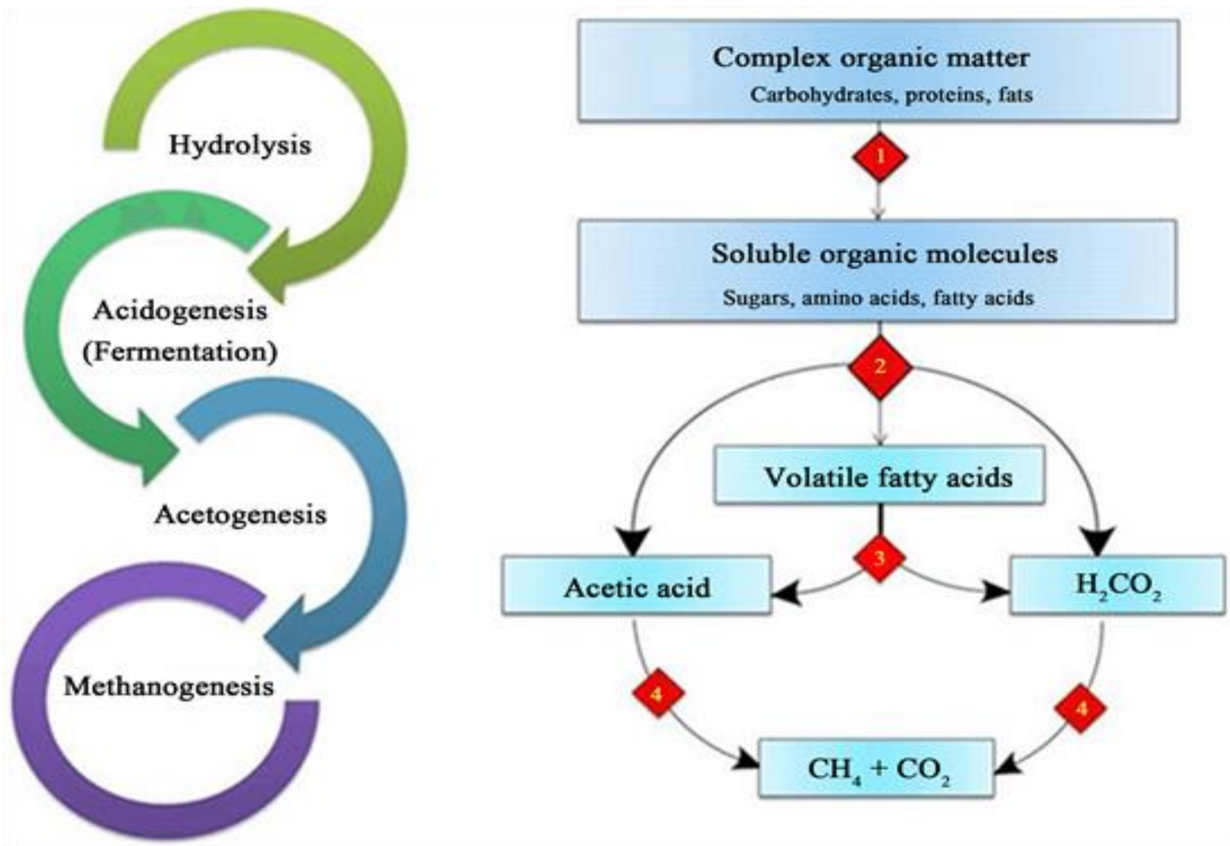

Figure 1. Flow chart of anaerobic digestion process.

1.2 STATEMENT OF PROBLEMS FOR BIOGAS AND THEIR POSSIBLE SOLUTIONS:

The rural population of Bangladesh is dependent on the use of biomass consisting of firewood, straw, crop residues and animal dung as a source of fuel. This is responsible for serious environmental degradation due to deforestation, poor health of household particularly women and children heavy work burden. Therefore, the urgent need to provide economical and sustainable alternative source of energy to minimize deforestation, improve living standard and literacy of rural masses. Biogas, which consists of methane as a major component, is considered to be one such alternative renewable source of fuel. The biogas can be produced on small scale by household using cow dung, human excreta and kitchen waste using suitable digester. That will be a best alternative for energy problem. To make a suitable biogas production system with less cost will be a part of economic growth. Considering the problems associated with global warming and climate change, many countries are moving towards increased renewable energy adoption in their energy systems. Bangladesh is also taking steps to increase the share of renewable energy in energy supply. Biogas plants in general were reported to have positive impacts on the users. The findings of the study revealed that a family saved an average of *1* hour *21* minutes per day as a result of biogas plant. The average annual saving of conventional fuel sources accounted to be: firewood- *1877 kg/hh/yr*, LPG - *7 kg/hh/yr*, dried dug cake - *512 kg/hh/yr* and agricultural residues - *636 kg/hh/yr*, the monetary value of which was calculated to be BDT *4947.10* per year/household, which a significant amount. *84.5%* of the biogas households are experiencing financial benefit from biogas plant.

1.3 GOALS AND OBJECTIVES OF THE THESIS:

1.3.1 Goals:

The main objectives of this thesis work is to design and develop a prototype biogas plant and produce of biogas production by decomposition cow dung. Within this framework, a research work is done to promote the sustainable production of renewable energy from the biogas that obtained from cow dung in small scale concept.

1.3.2 Objectives:

1. To design & develop of a Eco friendly Biogas plant

2. To produce natural gas to serve the village's people**.**

3. To optimize the use of Cow dung to increase the biogas production**.**

4. To make the gas available in rural area for household use**.**

1.4 SCOPE AND LIMITATION OF THE BIOGAS PLANT:

1.4.1 Scope of Biogas:

- Advance technology for reduce temperature and humidity effect on biogas production rate.
- Advance recycling process of methane can ensure the environmental safety.
- Technological improvement must need for optimum output.
- Structural new model should be added and improved.
- Should come up with new processing of fertilizer with modern technology.
- Need to innovate smaller equipment for biogas plant unlike big digester.
- Government should make policies and strategies to promote the development of biogas.

1.4.2 Limitation of Biogas:

Critical Situation: Due to pandemic situation there have a travelling and communication gap with the actual plant owner to visit the place, though we have visited four.

Collecting data issues: It would be better to get the more data regarding project if our team could visit more biogas plant.

Insufficient resource: Due to lacking of proper measuring instruments and materials some property was unmeasured. For example: we didn't measure temperature and humidity.

Rainy season: we have faced a rainy weather on our retention period. That has a significant effect on our gas production. Because lower ambient temperature makes gas production slower.

Insufficient Lab Facility: Due to insufficiency of proper lab we didn't measure exact amount of particular gas on our production.

Result analysis: As we could not get the university laboratory facilities, we have faced huge obstacles on result analysis part to get the actual result.

1.5 METHODOLOGY OF THE THESIS:

In this thesis work, design and development of a prototype biogas plant and the various shot of renewable energy will be discussed. For the better understanding and discussion of thesis activity, the work has been divided into following chapters as:

- LITERATURE REVIEW
- RESEARCH/EXPERIMENTAL DESIGN
- DATA GENERATION/COLLECTION
- ANALYSIS AND DISCUSSION
- CONCLUSION
- RECOMMENDATION

Chapter *2*

LITERATURE REVIEW

2.1 INTRODUCTION:

World will fall in a huge power crisis due to the decreasing of fossil foil. Renewable energy will be a perfect alternative for that problem. Due to availability of Biomass material, it's become a popular way to produce power. Biomass is defined as biological material from either alive or recently alive organisms. Biomass includes byproducts and residues of crop farming and processing industries such as straw, husk, cobs, stalks, leaves, bark, fruits, cutting vines, in addition to animal refuses and plant products used in agro-industrial processing such as grains, bean, flower. It is a clean renewable energy source which can substitute fossil fuels which are used for various purposes. It is considered carbon neutral as there is no net gain of carbon into the atmosphere when it is burned or when used in other ways.

Low production cost, availability of raw material and easy production process make it most popular in household use only.

2.2 CURRENT ENERGY STATUS OF BANGLADESH:

Bangladesh has limited proven natural gas reserve but for its energy need it hugely depends on imported fossil fuel. With the increase in the fuel price in the international market and reduction of gas reserve in the country, Bangladesh is forced to look for alternative sources of energy i.e., renewable energy resources. At present the main energy production in Bangladesh is based on natural gas *(85%)* and major power stations here are run by natural gas. Electricity production is only about *272 kWh* per capita. As the demand is increasing and the gas reserve has fallen to such an alarming level that if no new reserves are discovered then it is assumed that after *2016* the supply of the natural gas will start to decline. Bangladesh as a country of low GDP is contemplating more on the renewable energy sources which are relatively cheap to extract. About *75 million* people of our country have no access to the national power grid & most of them *(87%)* live in rural areas. Only *53%* of the area is connected to the natural grid.*[8]* Majority of rural people depend on inefficient, primitive sources of energy such as fuel wood, agricultural residues, cow dung and kerosene. About *90%* households use biomass for cooking. The rest *10%* use natural gas, LPG and biogas. Only *3%* of the people enjoy natural gas facilities connected to their home through pipelines mostly in eastern part of the country in big cities. Lack of energy is the main hindering force for poverty alleviation. To make the energy system of the country sustainable, generation of energy from the alternative sources has become the crying need for Bangladesh *[9]*. In view of above vulnerable situations Bangladesh needs to adopt renewable energy technologies to protect its environment from further degradation, pollution and man-made and natural disasters.

2.3 **CURRENT STATUS OF BIOGAS PLANT IN BANGLADESH:**

Although biogas plants were initiated by individual supports during *1970s*, development of biogas technology in Bangladesh has received serious attention since 2000. Biogas pilot plant

project has been implemented by the Institute of Fuel Research & Development (IFRD) since *1995*. Under the project up to *2004*, *17,200* biogas plants were constructed. According to an assessment report it has been seen that *99%* of the plants installed under the project are in operation and *91%* of the owners could meet their household fuel demand from the plants. To date, biogas plant has been one of the fast-growing renewable energy technologies in the country. The total number of biogas plants installed in the country by various organizations by *2009* has reached nearly *45,000[10]*. Among them, about *30,000* plants have been constructed by the public agencies with the BCSIR (Bangladesh Council of Scientific and Industrial Research) having made the most significant contribution (*22,000* plants) in the development and dissemination of the technology. Besides, Bangladesh Rural Advancement Committee has installed about 1200 and Department of Environment has installed about *260* biogas plants in the country.

However, the number of biogas plants in the poultry sector is not significant. Out of the total number of biogas plants, in the poultry sector BCSIR has installed about *3000* to *3500* biogas plants, whereas the number of biogas plants installed in poultry sector by LGED and Grameen Shakti (GS) are *2014* and *15015* respectively.[*11*]

The Dhaka City Zoo has also installed one large and three smaller biogas plants that use the animal dung and slaughterhouse waste produced in the zoo. However, the Sustainable Energy for Development (SED) Program, working with several partner organizations, has been working to promote the use of larger (gas production of more than *4.8 cubic meters* per day) biogas plants by dairy and layer poultry farms. As a result, about *1500* biogas plants in Bangladesh today use cow dung or poultry litter to produce biogas on a commercial scale. This is peanut compared to about *1900* million cubic feet of gas commercially produced per day from gas fields of the country during this time. As on *31 December 2012,* a total of around *65,317* biogas plants have already been installed in Bangladesh *[12]*. Figure *2* shows cumulative number of biogas plants from *1985* to December *2012* in Bangladesh.

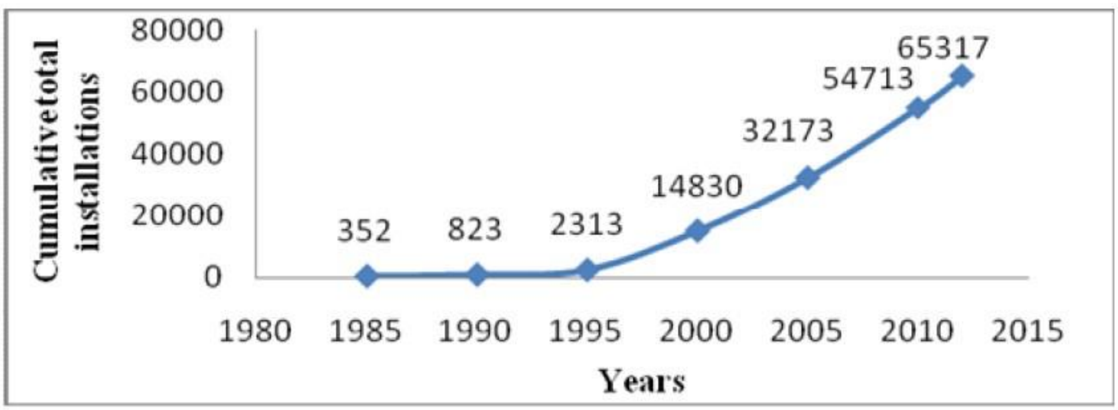

Fig.*2*: Cumulative number of biogas plants installed in Bangladesh

2.3.1 Biogas energy:

Biogas is a renewable gas fuel which can be produced by the anaerobic digestion process of Biodegradable material that takes place in the digester by anaerobic organism in absence of oxygen. In its pure state it is odorless, tasteless, and colorless and burns with a clear blue flame without Smoke. Therefore, biogas is a type of bio-fuel. The main elements of biogas are *40-70%* methane *(CH4)*, *30-60%* carbon dioxide *(CO_2)* and other gases *1-5%[24]*. It also contains several trace gases. Figure *5* shows a biogas-based electricity generation system consists of a digester, a biogas collection tank, a generator as well as the piping and controls required for successful operation. Grameen Shakti is one of the well renowned NGOs which is a major player in the field of biogas generation in Bangladesh. They have completed *35,000* biogas plants. *[25]* At present, Seed Bangla Foundation has proposed a *25 kW* biogas based power plant in Rajshahi *[26]*. Infrastructure Development Company Limited (IDCOL), a government owned investment company, stated a goal to set a target of installing *25%* of the total biogas plants to be erected in the northern region of the country. Till June *2021*, IDCOL has financed construction of over *58,900* biogas plants all over the country *[27]*. Some organizations have constructed domestic biogas plants with their own funds.

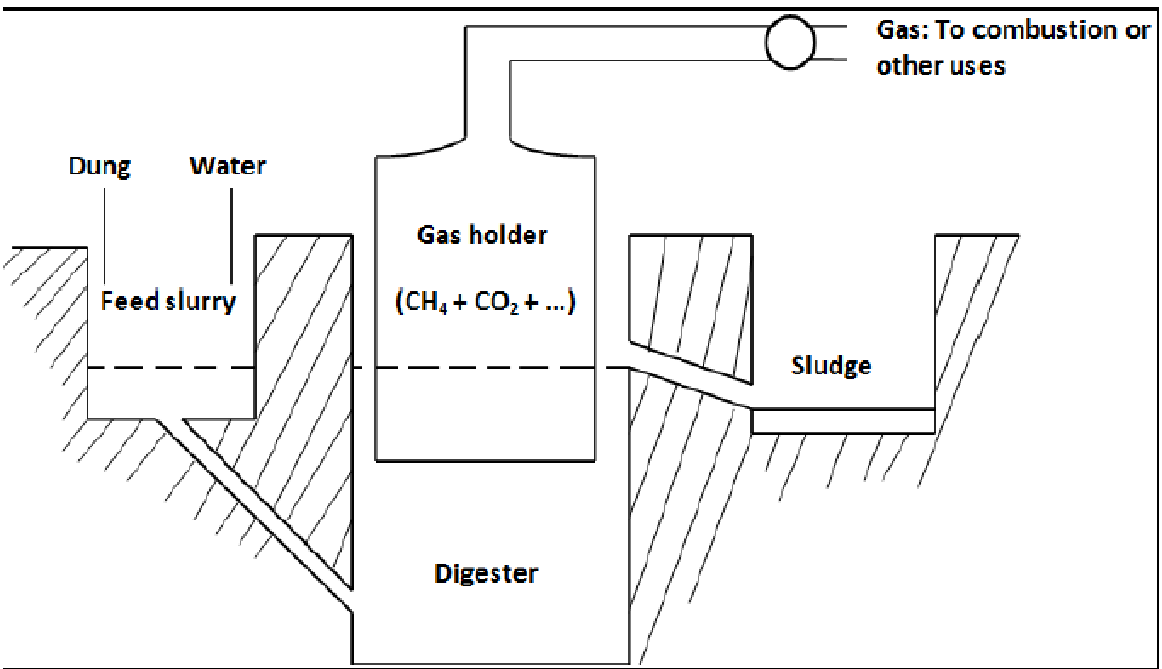

Figure *03*: Construction of a Typical Biogas Plant

Bangladesh has a wonderful climate for biogas production. The ideal temperature for biogas is around *35°C*. The temperature in Bangladesh usually varies from *6°C to 40°C*. But the inside temperature of a biogas digester remains

At *22°C-30°C*, which is very near to the optimum requirement [*28*]. The biogas plant is assumed to have a reciprocating engine efficiency of *50%* and capacity of *10,000 kWh/btu.*

An estimate of the total biogas potential in the country is presented below *[29]*

A. Cattle Dung

1) Total cattle population of Bangladesh = *23 million*

2) Dung available = *230 million Kg/day*

3) Gas that may be obtained = *3106 million* m^3 *(*Mm^3*)/year*

4) (1 kg of dung yields = *0.037* m^3 gas, each cow yields= *10 Kg dung/day)*

B. Poultry Litter

1) Total poultry population (Chickens+ Ducks) of Bangladesh, *(234+44) =278 million*

2) Total poultry litter that may be obtained = *27.8 million Kg/day*

3) Gas that may be obtained = *750* Mm^3*/year*

4) (1 kg litter yields = *0.074* m^3 gas, each bird yields = *0.1 Kg litter/day)*

C. Human Excreta

1) Total human population of Bangladesh = *140* million

2) Excreta available = *56 million Kg/day*

3) Gas that may be obtained = *1512* Mm^3*/year*

4) (1 kg excreta yield = *0.074* m^3 gas, Excreta per person = *0.4 Kg per day*)

Therefore, total biogas potential in the country = *5368* Mm^3*/year*.

Biogas Plants Construction in Bangladesh under National Domestic Biogas and Manure Programmed (NDBMP)

In *2006*- Total biogas plants installed = *206*

In *2007*- Total biogas plants installed = *2116*

In *2008*- Total biogas plants installed = *2648*

In *2009*- Total biogas plants installed = *4459*

In *2010*- Total biogas plants installed = *4800*

In *2011*- Total biogas plants installed = *5049*

In 2012- Total biogas plants installed = 5555

2.4 PIONEERING ORGANIZATIONS IN PROMOTING RENEWABLE ENERGY SECTOR OF BANGLADESH:

Different government, semi-government and nongovernment organizations (NGOs) such as Bangladesh Council of Scientific & Industrial Research (BCSIR); Local Government & Engineering Department (LGED); Environment & Pollution Control Department (EPCD); Danish International Development Assistance(DANIDA); Bangladesh Small & Cottage Industries Corporation (BSCIC); BRAC; BUET; Grameen Shakti (GS); Infrastructure Development Company Limited (IDCOL); some NGOs; department of Youth & Sports etc. are involved in disseminating the biogas technology throughout the country .*[13]*

2.5 INFRASTRUCTURE DEVELOPMENT COMPANY LIMITED (IDCOL):

Infrastructure Development Company Limited (IDCOL) was established on *14* May *1997* by the Government of Bangladesh (GOB) is playing the central role for dissemination of biogas plants in Bangladesh. The objective of IDCOL is to develop and disseminate domestic biogas plants in rural areas with the ultimate goal to establish a sustainable and commercial biogas sector in Bangladesh. In 2006, IDCOL launched a large-scale extension program on domestic biogas plant through 30 partner organizations. The target of IDCOL up to *2012* was to install *60,000* biogas plants in our country with total capacity of *48 MW*, under its National Domestic Biogas and Manure Program (NDBMP). It has also set a target of *25%* of the total target of biogas plants in the northern region which is yet to be brought under the national gas grid. IDCOL is promoting biogas plants of sizes $1.2\ m^3$, $1.6\ m^3$, $2\ m^3$, $2.4\ m^3$, $3.2\ m^3$ and $4.8\ m^3$ both for cattle and poultry owners. Biogas plants of size $2.4\ m^3$ are most common. Approximately *1 MW* biogas-based electricity plant has been installed in our country. IDCOL is financing setting up of three biogas-based electricity generation plants, one in Mymensingh and two in Gazipur, and one organic fertilizer plant in Gazipur by Paragon Agro Ltd. Electricity generated from these plants will be supplied to the adjacent poultry farms of Paragon Poultry Ltd. (PPL) at BDT *4 / kWh*, while organic fertilizer will be sold in the market at *BDT 15* per *1 Kg* packet and *BDT 400 per 40 Kg* packet. Total project cost is *BDT 149.40 million*. At present *38* NGO/MFIs/private firms are working under the program & IDCOL provides grant and refinancing facility and technical assistance to its partner organizations. A total of *1,00,000* biogas plants will be financed by *2016.[14]* Moreover, since *April 2012*, IDCOL along with its partner organizations; has installed *22,549* biogas plants in different parts of Bangladesh*[15]*. *Figure 4* shows year-wise number of installed biogas plants under IDCOL program. It shows a continuous rise in the number of installations marking the success of this current drive. However, a slight drop in number is observed in *2011*. This is due to the prolonged rainy season in *2011* which restricted the construction of biogas plants.

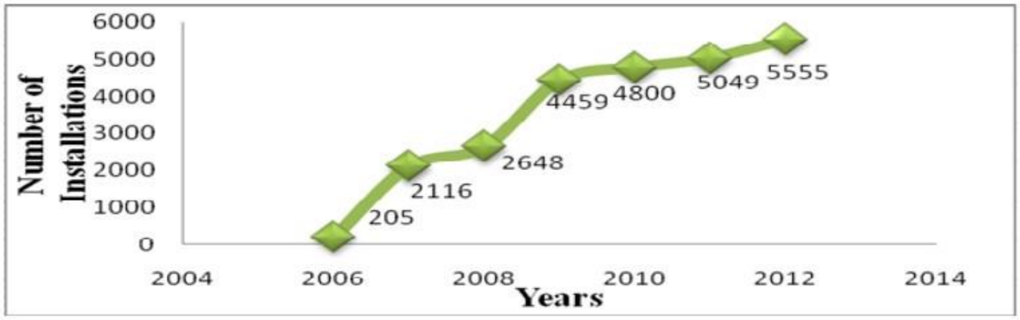

Fig.4: Year-wise installations by IDCOL

2.6 GRAMEEN SHAKTI (GS):

Grameen Shakti (shakti meaning "energy" in Bengali) was created in *1996* as a not-for-profit company under the Grameen Bank. The goal of Grameen Shakti is to promote and supply renewable energy technology at an affordable rate to rural households of Bangladesh. Recently, GS also works as a partner organization of IDCOL for construction of small family size biogas plants. *1.6 - 4.8* m^3 of gas production per day. They have constructed over *13,000* biogas plants as partner organization under IDCOL's program. GS has constructed *26,298* biogas plants up to *31* August, *2013*. Grameen Shakti future plan is to install *6,000* biogas plants in *2013; 8,000 in 2014 & 12,000* in *2015[16].* At present there are about *200* biogas-based generators in the country of size *1KW to 1MW* and among them Grameen Shakti alone has about *100* biogas-based generators. As a pilot project Grameen Shakti imported *10* fiberglass digesters from China and installed them in different customers' households *[8]*. Figure *5* shows year-wise number of installed biogas plants under Grameen Shakti.

Fig.5: Year-wise installations by Grameen Shakti

2.7 OVERALL PROGRESS IN DISSEMINATION

As on *31* December *2012*, a total of around *65,317* biogas plants have already been installed in Bangladesh. Table *1* shows the number of domestic biogas plants installed by major organizations in Bangladesh as of December *2012*.

Organization	Number
IDCOL	26,311
BCSIR	22,334*
GS(outside of IDCOL)	7,000**
NGOs and Others	9,672
Total	65,317

Table 1. Organization-wise Installations

Chapter 3

RESEARCH & EXPERIMENTLE DESIGN

3.1 INTRODUCTION:

3.1.1 Principle of biogas

The principle of a biogas plant is, the anaerobic fermentation of the biomass (organic matter) in presence of water. The working of a biogas plant is, the biomass is mixed with water and then is decomposed by the anaerobic bacteria into the products like gasses (methane, hydrogen, carbon dioxide) and the other side products (manure, fertilizers).

3.1.2 Composition of Biogas

Biogas is a renewable gas fuel which can be produced by the anaerobic digestion process of biodegradable material that takes place in the digester by anaerobic organism in absence of oxygen.

In its pure state it is odorless, tasteless, and colorless and burns with a clear blue flame without smoke. It has very high-octane number approximately *130.* It has combustion properties like natural gas (NG) and it burns at about *800°C*.It is about *20%* lighter than air. Its calorific value is *20* mega Joules *(MJ)/m3* and it usually burns with *60%* efficiency in a conventional biogas stove.

The composition of biogas is about *50 to 75%* methane and *25 to 50%* CO_2 with insignificant to trace nitrogen, oxygen, hydrogen sulfide and hydrogen. The production of biogas is influenced by various factors such as temperature, pH condition of the input charges, nutrient concentration, loading rate, toxic compound etc.

Temperature: The temperature range required for anaerobic digestion is *3°C- 70°C.* Temperature between *35°C-38°C* is considered optimal. Three temperature ranges are common, the psychrophilic *(below 20°C),* the mesophilic *(between 20°C and 40°C)* and the thermophilic *(above 40°C)* ranges. pH value: To provide the better existence of methane producing bacteria, the optimal range is 6 to 7 [18] Table *2* shown the typical composition of biogas *[19]*

Table *2*: Typical Composition of biogas

Compound	Formula	Percentage by volume
Methane	CH_4	*50–75*
Carbon dioxide	CO_2	*25–50*
Nitrogen	N_2	*0–10*
Hydrogen	H_2	*0–1*
Hydrogen sulfide	H_2S	*0.1 –0.5*
Oxygen	O_2	*0–0.5*

3.1.3 Potential of Biogas in Bangladesh

Biogas mainly from animal and MSW may be one of the promising renewable energy resources for Bangladesh. MSW contains an easily biodegradable organic fraction (OF) of up to *40%*. It is a potential source to harness basic biogas technology for cooking, rural and peri-urban electrification to provide electricity during periods of power shortfalls. On feasibility study prepared for the Danish investors about the market potential of Bangladesh it has been indicated up to *800 MW* of electricity could be produced in Bangladesh using organic city waste and poultry litter. *12* gasification-based biogas plants equivalent to *5 MW* capacities are now being considered by donor-financed IDCOL. As on *2012*, only a fraction of the total of *15,000* tons of waste is being recycled annually. About *80%* of produced waste is organic which have a high potential for biogas production. The amount is expected to rise up to *47,000* tons in *2025[30]*. Bangladesh is predominantly an agrarian economy. Agricultural sector still dominates the economy accommodating major rural labor force. As an agricultural country, Bangladesh has embedded with plenty of renewable sources of energy and has huge potentials for utilizing biogas technologies. During winter seasons, huge amounts of vegetables are cultivated in our country which will be a potential source of kitchen waste *(KW)*. Due to lack of efficient transportation and preservation, huge amounts of vegetables are wasted, which may be a source of biogas *[31]* Cow manure *(CM)* is the undigested residue of plant matter which has passed through the animal's gut. CM is used to produce biogas to generate electricity and heat. The gas is rich in methane and is used in rural areas of Bangladesh to provide a renewable and stable source of electricity. According to FAOSTAT *(2011)*, it is estimated that there are *23* million cattle in Bangladesh which produce *230* million Kg of cow dung each day *[32]*. According to the IFRD, there is potential of about *4 million* biogas plants in our country, which can produce *105* billion cubic feet of biogas per year (at a rate of *1.3* cubic feet of gas per kg of dung) which is equivalent to *1.5-million-ton* kerosene or *3.08 million tons* of coal. It has been estimated that about *20%* of the total number of families can be supplied with enough biogas for their household cooking and lightings by the above *[33]*. According to FAOSTAT *(2011)*, the country has a population of approximately *234.7* million chickens and *44.12* million ducks respectively *[32]*. Poultry waste has the highest per ton energy potential of electricity

per ton but livestock have the greatest potential for energy generation in the agricultural sector. It has been estimated that *10%* of the larger dairy and poultry farms alone could produce about *50 MW* of electric power with biogas technology. Implementation plan *2010-2012* of National Domestic Biogas and Manure Program of IDCOL mentioned that total technical potential of domestic biogas plants is *3 million*. "Mobilizing market for the biogas technology" of GIZ study and other studies explained that the large potential market for the biogas digester in *100,000* poultry farms could benefit from the technology through the savings of traditional cooking fuel as well as prevention of disease and pathogen free fertilizer and also meet the energy crisis. Therefore, Bangladesh has a wonderful climate for biogas production. The ideal temperature for biogas is around *35°C*. The temperature in Bangladesh usually varies from *6°C to 40°C*. But the inside temperature of a biogas digester remains at *22°C-30°C*, which is very near to the optimum requirement *[34]*.

An estimate of the total biogas potential in the country is presented below *[32]*.

A. Cattle Dung

1) Total cattle population of Bangladesh = *23 million*

2) Dung available = *230 million Kg/day*

3) Gas that may be obtained = *3106 million m3 (Mm3)/year*

4) (1 kg of dung yields = *0.037 m3* gas, each cow yields= *10 Kg dung/day)*

B. Poultry Litter

1) Total poultry population (Chickens+ Ducks) of Bangladesh, *(234+44) =278 million*

2) Total poultry litter that may be obtained = *27.8 million Kg/day*

3) Gas that may be obtained = *750 Mm3/year*

4) (*1* kg litter yields = *0.074 m3* gas, each bird yields = *0.1 Kg litter/day)*

C. Human Excreta

1) Total human population of Bangladesh = *140 million*

2) Excreta available = *56 million Kg/day*

3) Gas that may be obtained = *1512 Mm3/year*

4) (1 kg excreta yields = *0.074 m3* gas, Excreta per person = *0.4 Kg per day)*

Therefore, total biogas potential in the country = *5368 Mm3/year*.

3.2 TYPE'S BIOGAS PLANT

Mainly classified as

1. Batch type
2. Continuous type
    a. Floating drum (constant pressure) type,
    b. Fixed dome (constant volume) type

3.2.1 Batch type

This type of plant requires feeding in every *50 to 60* days gap. After feeding *8 to 10* days are required to supply the gas and continuously for *40 to 50* days till the process of digestion is completed and after sometimes it is emptied and recharged. The Battery of digesters is charged and emptied one by one to maintain a regular supply of gas through a common gas holder. The installation and operation of these types of plants are capital and labor intensive. They are non-economical unless operated on the large scale. These types of plants are mainly installed in European countries as they do not suit the condition in Indian rural areas *[21]*.

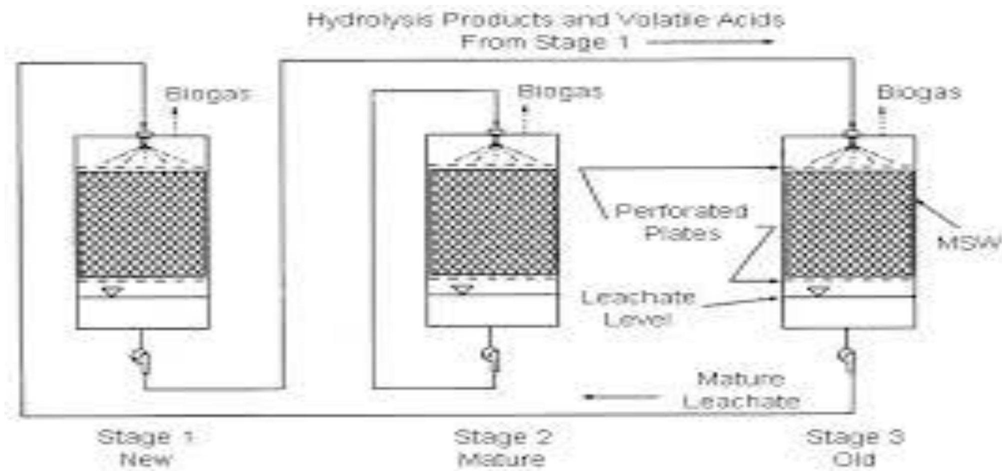

Fig. 6 Batch type biogas plant [20]

3.2.2. Continuous type

This type of plant requires daily feeding with a certain quantity of biomass. The gas is stored in a plant or the separate gas holder and is available for further use. The biomass when slowly passed through digester gets completely digested, and digested slurry is given out through an outlet. The period in which the biomass remains in the digester is known as retention period. This period mainly depends on the type of biomass and operating temperature. The plant is continuously operated and stops only for removal of sludge i.e. undigested biomass residue. The thin dry layer formed at the top of the slurry is known as scum. The function of scum is to prevent the escape of gas from the slurry. The breaking down of layer takes place when the slurry is slowly stirred, and it also helps in digestion process due to better mixing. The feeding pattern of such plants matches with daily waste generation and does not require its storage; therefore, they are convenient for individual owners. These types of plants are mainly popular in India and China *[21]*.

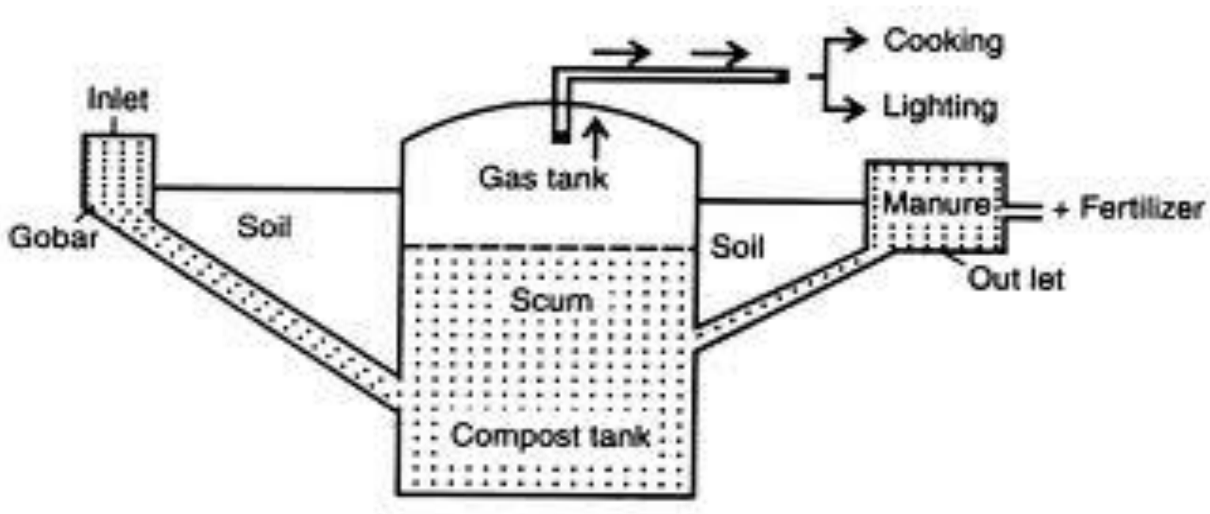

Figure .*7* Continuous type biogas plant *[21]*

3.2.2.1 Floating drum types biogas plant

Khadi Village Industries Commission India develops a domestic biogas plant. In this plant, a mild steel drum is used as a gas holder. This drum is most expensive component in this plant and covered by masonry construction with a partitioning wall that creates a required condition for the growth of acid formers and methane formers. This plant produces a good biogas yield *[21]*.

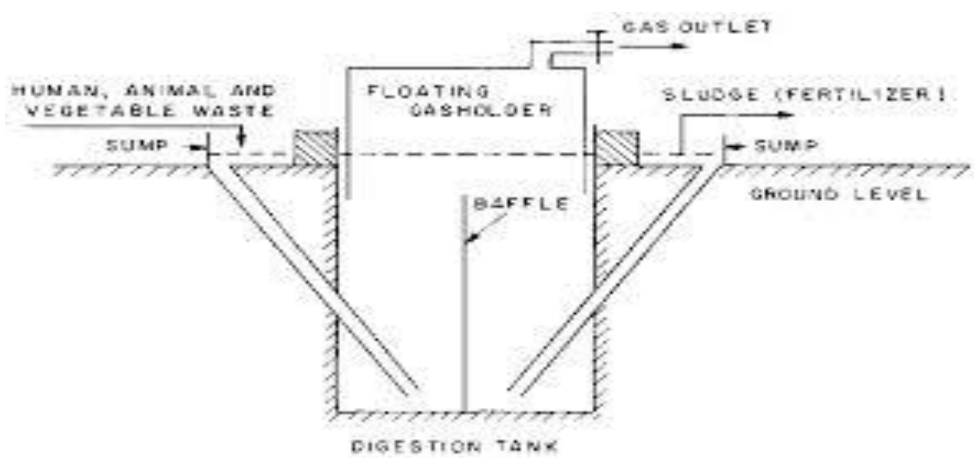

Fig. *8* Floating drum type biogas plan *[21]*.

3.2.2.2 Fixed dome types biogas plant

This type of plant requires only masonry work that's why it's economical in construction. Pressure in gas varies depending on the production and consumption rate. A dome structure is very strong for outside pressure but weaker for inside pressure. A skilled masonry is required for construction of dome as gas exerts pressure from inside out, the dome structure may be failed. The slurry enters from the inlet, and the digested slurry is collected in displacement tank. If the raw material is crop residue than stirring is required. As there is no bifurcation in digester chamber, therefore the gas production is somewhat very low as compared to floating point design. The gas stored in the dome is stored in the dome and displaces liquid in inlets and outlet, sometimes leading gas pressure as high as *100 cm* of water. The gas occupies about *10%* of the volume of the digester. The complete plant is constructed underground therefore temperature tends to remain constant and is often higher than in winter. Many variations in basic models are developed keeping in view the portability, ease of installation and maintenance, local availability of material and cost *[21]*.

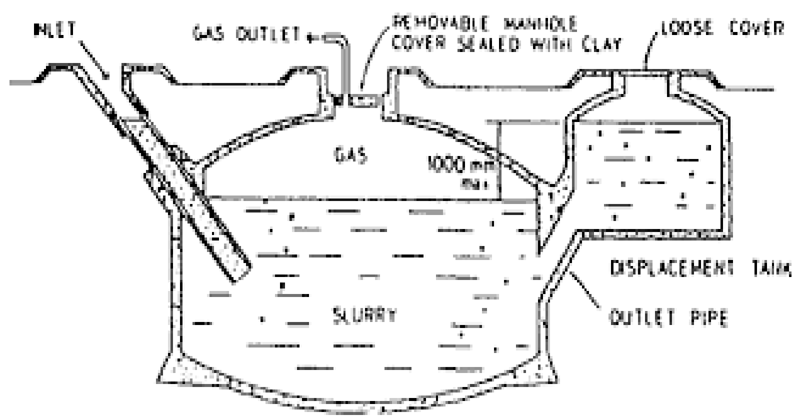

Fig.9 Fixed dome type biogas plant [21]

3.2.3 Balloon Plants

A balloon plant consists of a heat-sealed plastic or rubber bag (balloon), combining digester and gas-holder. The gas is stored in the upper part of the balloon. The inlet and outlet are attached directly to the skin of the balloon. Gas pressure can be increased by placing weights on the balloon. If the gas pressure exceeds a limit that the balloon can withstand, it may damage the skin. Therefore, safety valves are required. If higher gas pressures are needed, a gas pump is required. Since the material has to be weather- and UV resistant, specially stabilized, reinforced plastic or synthetic caoutchouc is given preference. Other materials which have been used successfully include RMP (red mud plastic), Trevira and butyl. The useful life-span does usually not exceed *2-5 years* ***[22]***

3.3 FACTORS AFFECTING THE BIOGAS DIGESTION PROCESS

3.3.1 Temperature

Methane forming bacteria works best in temperature ranges *20 to 55˚C*. Digestions at higher temperature proceed more rapidly than at lower temperature, with gas yield in rates doubling at about every *5˚C* increase in temperature. The gas production decreases sharply below *20˚C* and almost stops at *10˚C.* Raising temperature accelerates the gas production; however, its methane content gets relatively reduced *[35]*.

3.3.2 Pressure

A minimum pressure of *6 to 10* cm of water column i.e,*1.2* bar is considered ideal for proper functioning of the plant, of the plant, and it should never exceed *40 to 50* cm of the water column. Excess pressure leads to masonry through microscopes and inhibits gas to release from the slurry.

3.3.3 Solid to moisture ratio in biomass

The Presence of water is essential for hydrolysis process and activity of extra cellular Enzymes. That helps in better mixing of various constituent of biomass, movement of Bacteria and faster digestion rate. At higher water level, gas production drops but if the water level is too low, more acid accumulation takes place, and it stops the fermentation process. Raw cow dung contains *80%* by weight, and it is mixed with equal amount of water to minimize solid content up to *10%*.

3.3.4 pH Value

The value of pH during acid forming stage is up to *6* or less than *6*. But during methane formation stage pH value goes up to *6.5 to 7.5 [35]*.

3.3.5 Feeding Rate

In the excessive feeding of raw material at a time, an acid will accumulate, and digestion Process stops. A uniform feeding rate in the proper interval of *50* days, amount equal *0.02* of the volume of the digester should be maintained.

The methane content depends on the feed material. Some typical values are as follows *[34]:*

Cattle manure *65%*	Poultry manure *60%*
Pig manure *67%*	Farmyard manure *55%*
Straw *59%*	Grass *70%*
Leaves *58%*	Kitchen waste *50%*
Algae *63%*	Water hyacinths *52%*

3.3.6 Carbon to nitrogen ratio

Carbon and nitrogen are the main requirements for anaerobic bacteria. For good Microbiological activity, ratio required of *C: N = 30:1 [35].*

The fluctuation of this ratio slows the digestion process.

3.4 BIOGAS TECHNOLOGY IN BANGLADESH

Biogas technology programs based on adaptive design and demonstration of family size biogas digesters were initiated at Bangladesh agricultural university, Mymensingh, and Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka, in the early seventies. The first family size design of biogas digester of capacity of *3 cu m* was installed at BCSIR in *1976*. And was of the floating dome type.

The typical floating dome digester is a brick-lined cylinder sunk in the earth, with a wall dividing the cylinder into two, and with inlet and outlet ports leading to the bottom of the tank. The price of such a biogas digester was Taka *12,000*. Subsequently, a lower cost design of the floating dome digester of capacity of *3 cu m* was installed at BCSIR in *1981*. The price of this came down to Tk *3,000* only.

Another biogas production technology program to meet the fuel crisis for cooking was subsequently undertaken and *214* floating dome type biogas digesters were installed under the supervision of the Institute of Fuel Research and Development at BCSIR. Unfortunately, the operating life of these digesters was *3-5* years because of leakage in the gas-holder of the digester. Because of this leakage problem, a fixed dome type family size biogas digester with a capacity of *3 cu m* was installed at BCSIR in *1991*.

A digester of this type varies somewhat in shape, but, unlike the floating type, everything is below the ground. Because it has a gas reservoir of fixed volume, the gas pressure varies. The digester pit is dug into the ground and then lined with bricks. ***[23]***

3.5 CONSTRUCTION, OPERATION AND MAINTENANCE OF BIOGAS PLANT

3.5.1 Construction

3.5.1.1 Plant Location:

The biogas households sampled for the study represented eight districts from all the six divisions in Bangladesh. All the plants were located in easily accessible areas, where basic infrastructure services existed. Easily accessible approach roads to and electricity grid connections in all the sampled households indicated that these plants were installed in relatively developed areas.

3.5.1.2 Reason and Year of Installation

The respondents were asked to give most important reasons/motivating factors for the installation of biogas plants. As per them, the most popular motivating factors were the economic benefits including saving of time and money *(35hhs)*, environmental benefits *(30hhs)*,

availability of subsidy *(17hhs)* and health benefits including the reduction in smoke-borne diseases *(12hhs)*. In other countries like Nepal and India where biogas plants

have been disseminated to a significant extent, the benefit of biogas to replace the conventional fuel sources is the main motivating factor to install biogas plants. However, only *13%* of the respondents told this to be the main motivating factor in Bangladesh. Interestingly, environmental benefits of biogas plants like saving of forest, clean surrounding, proper use of waste materials etc. were valued much more in Bangladesh than in other developing countries.

3.5.1.3 **Decision Making for the Installation:**

When asked the respondents on who made the final decision to install biogas plant, *57%* of them told that the decision was taken after discussions in the family, followed by the household head – the males in *35%* and the females in *5%* of the cases; and the younger members – son or daughters in the family in *3%* of the cases.

The respondents told that they knew about the technology through service providers *(33%)*, biogas users *(23%)*, friends and relatives *(20.5%)*, government officials *(7.5%)* and the publicity media *(4%)*. The remaining *12%* knew about it through more than one of the above-mentioned mediums.

3.5.1.4 **Type and Size of Plant:**

User choose their own model

3.5.1.5 **Construction Management**

LGED implemented biogas project from October *1998* to June *2003*. The organization did not recruit any new staff for the implementation of the project. Construction works were mainly *23* carried out by the trained technicians produced by LGED itself. LGED headquarters initially engaged only one NGO to implement the whole project. Subsequently the number of NGOs was increased to 7 in the later stages. These NGOs contacted the farmers to motivate them to install biogas plants and provided service once the farmer was ready to do so. LGED engineers at grass root level supervised the construction works and the Executive Engineers of the concerned districts made payments. In order to attract the farmers, a subsidy of BDT *5000.00* per plant was

provided to the farmers and additional BDT *5000.00* was provided to the NGOs as grant. BCSIR implemented the project in two phases. At the initial stage they appointed *128* Sub-Assistant Engineers, provided training to them and mobilized them to install biogas plants. They were assigned responsibilities for motivation, installation and after-sales-service throughout the country during the first phase of Biogas Pilot Plant Project (July *1995 to June 2000*). In addition,*898* youths were trained to support the project. The biogas farmers received an investment subsidy of BDT *5,000* under the project. MoUs were signed between BCSIR and several other institutes like BRAC, LGED and DLS for research, training and dissemination of the biogas technology. The investment subsidy for the owner was increased to BDT *7,500* per plant in the second phase of the project that started in July *2000* and ended in June *2004.* In addition to the employment of diploma civil engineers, an agency system was introduced on incentive basis. About *50* agencies were recognized at the district level where the program was to be launched and provided with a lump sum fee of BDT *5,000* per plant as overhead costs. About *1,000* masons and youths were trained under the project as well. At headquarters level, a Project Director and a few staff members were responsible for the coordination, monitoring and supervision of the project. To give incentive to the engineers, there was also provision of BDT *1000.00* as bonus. Grameen Shakti is implementing the project through its appointed staff members. There is no provision of subsidy or grant to the farmers to install biogas plants. The organization is implementing the project with its own internal resources. Plants are constructed with the farmer's cash contribution and a service/supervision charge of *10%* of the cost is collected from the owners. The organization also provides *75%* of the cost as loan, which is recoverable in two

years with *8%* interest. The study findings revealed that biogas plants were constructed by skilled masons with good knowledge on biogas plant in *68%* of the cases, followed by skilled mason without knowledge on biogas plant in *29%* cases and unskilled masons in *3%* of the cases. Though *67%* of the plant owners felt that some technical standards were set by the service providers as regards the quality of construction materials and construction methods, *75%* of them did not know about those standards. *59%* of them expressed that there was set technical standard on the plant design. The rest of the respondents believed that no such standards were set.

3.5.1.6 Financing for Construction:

Biogas plants in Bangladesh, in majority of the cases, are financed in two ways – a flat rate

subsidy from the government on the investment cost and cash contribution from respective plant owners to fill gap. The subsidy provided by the government is insufficient to meet the total cost of installation and a gap exists which the farmers must bridge. This gap is either filled by cash of *24* their own or by credit received from financing institutions on some pre-defined terms and conditions. Total investment cost of biogas plants ranged from BDT *11,800* for biogas plant of capacity *100cft* gas production per day to BDT *30,500* for plant of capacity *300cft* cum gas

production per day

3.6 OPERATION

The key to proper operation of biogas plant is the daily feeding with mix of right proportions of dung and water, frequent draining of condensed water in the pipeline through the water outlet, cleaning of stoves and lamps, oiling of gas valves and gas taps, cleaning of overflow outlet, checking of gas leakage through pipe joints and gas valves and adding of organic materials to slurry pits. As long as these tasks are carried out reliably and carefully the plant will function properly. The subsequent sections describe the finding of the study as regards the operation of the biogas plants.

3.6.1 Plant Feeding

a. Feeding Materials

The amount of gas production in biogas digester depends upon the quantity of feeding added to it daily provided the plant is technically all right. Cattle dung and poultry droppings were the two major feeding materials used. Besides these, kitchen and household wastes, human excreta, urine of animals, water hyacinth and urea were also used to feed biogas plants.

b. Water-Dung Ratio

The outcome of the study revealed that the water-dung ratio was higher than *1 in 56*% of the plants. The ratio varied from *2:1 to 3:1* in these cases. Likewise, *41%* of the plants received equal volume of dung and water. The remaining *3%* of the plants received less water than dung. One of the significant facts noted during this study was that the users tend to increase the volume of water to compensate the feeding materials. In other words, when less dung than needed is available, more water is used and when enough/more dung is produced, users tend to use lesser quantity of water. Higher water-dung ratio was clearly visible in the slurry coming out of the outlet chamber in majority of the plants, being the slurry very thin and diluted.

3.7 TRAINING AND ORIENTATION TO USERS

In fact, the functioning of biogas plant is basically determined not only by the quality of construction and workmanship involved but also by the quality of operation and maintenance efforts from the users. The users should be provided with basic orientation on various aspects of operation and maintenance such as proper feeding of the plant, optimal use of biogas, effective application of slurry, timely maintenance of plant components and improving cooking environment. The following table illustrates the responses of the users when being asked if they have received any training on operation and maintenance of biogas plants from the service providers.

3.8 MAINTENANCE

Effective and timely management of routine repair and maintenance works are key to the sustainability of biogas plants. As long as operational activities are carried out efficiently and routine maintenance works are carried out in time, biogas plants function properly. During the field study, when respondent were asked if they could carry out repair and maintenance works by their own, only one respondent replied in positive. All the respondents expressed urgent need of training on minor repair and maintenance works to effectively manage their biogas plants.

3.9. PHYSICAL STATUS AND FUNCTIONING OF BIOGAS PLANT

The study attempted to evaluate the overall performance of biogas plant on the basis of:

(a)existing physical status and functioning of its different components,

(b) present level of benefits being achieved (the gas being produced),

(c) response of respective plant users whether their expectation prior to the installation of biogas came true after the plants are operational (evaluated in terms of gas demand and supply),

(d) level of users' satisfaction on the impacts of biogas plants on them.

3.9.1 Design

Figure shows Isometric diagram of Bio gas plant

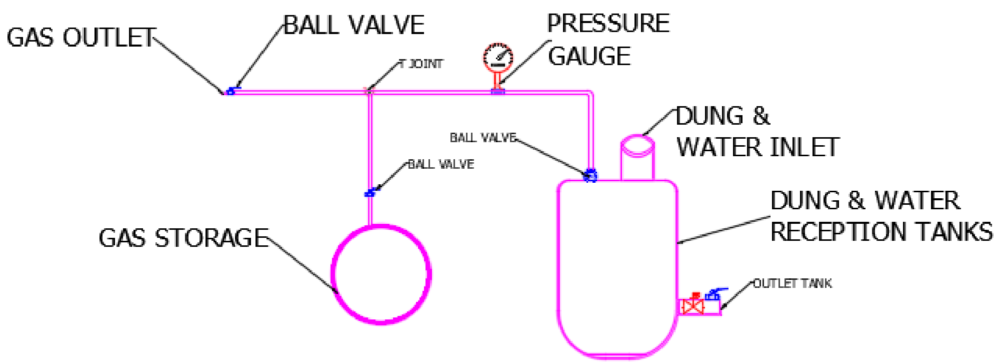

Figure *10:* Isometric diagram of Bio gas plant

3.9.2 Equipment's and Raw materials

The bio digester used for this research is a 40 L capacity Plastic prototype digester (Fig *11)* and the study was carried out between December *21* and January *2022*. [In this study period is winter session and very difficult to produce biogas] We chose Cow dung is the waste used for this study because of its availability. Cow dung is available all over Bangladesh and it's very easy to collect. We chose cow dung for another reason its gas production rate higher than other waste materials such as kitchen west. Fresh cow dung was collected from the Cow firm from Adorshanagor, Badda, Dhaka. Other materials such as hose pipe, gauge meter was collected from Badda that were used. A minimum and maximum ambient temperature of $17^{o}C$ and $27^{o}C$ respectively and a minimum and maximum slurry temperature of $19^{o}C$ and $30^{o}C$ respectively were recorded.

1. **Digester**
2. **Gas discharge line**
3. **Inlet line**
4. **Pressure gauge meter**
5. **T joint**
6. **Ball valve**
7. **Storage tube**
8. **Outlet valve**
9. **Drain line**

Figure *11:* Bio gas plant

3.9.3 Equipment

1. Plastic Drum *(40 litter)*
2. ¾ hose pipe *(10feet)*
3. Pressure gauge meter
4. Balancing Valve *(01 Nos)*
5. Drum connector *2" (01 Nos)*
6. Drum connector *½" (01 Nos)*
7. Ball valve *½" (03 Nos)*
8. Gate valve *2" (01Nos)*
9. PVC pipe *4" (4 feet)*
10. End cap *4" (1 Nos)*
11. *½ * ¼* "Copper nozzle (*10 Nos)*
12. Threat tape *(8 Nos)*
13. M-seal *(05 Nos)*
14. Storage Tube *155/80R13*.

3.9.4 Raw material

1. Cow Dung *8 kg*
2. Water *24 kg*

3.9.5 Procedure and timeline

08 kg of cow dung was charged into the digester fig-*13 & 14* with *24 kg* of water in the ratio of *1:3* of waste to water and the slurry was properly stirred. Here mixture should be proper ration and mixing well. During mixing the cow dung and water we use safety materials for avoid biological hazard in fig 15. The daily ambient and slurry temperatures were measured using thermometer *(-10 to 110^{0}C)*,_The pH Values were monitored to determine the action of methanogens, which utilize the acids, carbon dioxide and hydrogen produced by non-methane producing bacterial using a digital pH meter *(PHS-3c pH meter*). The volume biogas produced was measured by a downward displacement method. The composition of the flammable biogas produced from the waste was determined through the use of Orsat apparatus. For checking the flammability of the gas, a locally fabricated biogas burner was used. A bottom loading balance (*50kg* capacity,) was used in the measurement

Fig: 13 , Weight Cow dung

Fig : 14 , Cow dung

of the water and cow dung volumes. The plant consists of the Dung & water reception tank, the inlet and outlet pipe, the gas pipe and the stirrer. The digester was charged and its performance monitored for *10 days*. The organic wastes were allowed to stabilize, anaerobic fermentation involving the degrading of the wastes by the action of various microbes of different sizes and functions, leading to the production of biogas in the absence of oxygen was achieved.

Figure: 15 Use Safety Materials

3.9.6 Plant Components:

The design of biogas plant generally consists of the different components for effective operation and trouble-free functioning. General findings of the field investigation on these components are briefly described here after:

3.9.6.1 Inlet Tank with Mixing Device and Inlet Pipe:

Here is a *40* litter plastic drum as a Inlet tank cum Digester. as show in fig *11* SL no *1*. Cow dung and water put in through inlet pipe *SL-3* and mix-up it. It is totally airtight.

3.9.6.2 Gas Holder:

We used a Rubber tube as a gas holder. Its collect from Automobile shop.

3.9.6.3 Main Gas Pipe:

Main gas pipe connected from Digester *SL-2*

3.9.6.4 Outlet (Displacement Chamber) System:

Here outlet system we install a outlet line lower portion on Digester tank *SL-9*

3.9.6.5 Pipeline and Fittings:

Here we use ¾ hose pipe for gas carried digester to gas holder and output, we also use various kind of PVC and fittings in this project.

The main functions of this plant are:

1. To collect the gas for processing and storage

2. To regularly stir and mix the charge.

3. To accept new quantities of charge

4. To keep the charge at operating temperature

Chapter 4

ANALYSIS AND DISCUSSION

4.1 DATA TABLE AND GRAPH

Table *3*: mixed mass of charge stock and water ratio

WASTES	MASS OF WASTE (kg)	MASS OF WATER (kg)	Mix Ratio
Cow dung	*8*	*24*	*1:3*

Table *4*: Biogas Composition by % Volume

WASTE STOCK	CARBONDIOXIDE	HYDROGEN SULPHIDE	CARBON MONOXIDE	METHANE
Cow dung	*27.2*	*0.1*	*4.7*	*67.9*

Table *5*: Summary of Results

Items	Cow Dung
Mass of Waste Used(kg)	*8*
Mass of Water Used (kg)	*24*
Total Mass of slurry(kg)	*32*
No of Days of Digestion	*10*
Total Volume of Gas Generated (L)	*23.2*
Maximum Ambient Temp. (^{o}C)	*27*
Maximum Slurry Temp. (^{o}C)	*30*
Peak Volume of Gas (L)	*3.6*

Table *6*: Daily Bio Gas production

No of Days	Daily Volume of gas (L)	Cumulative Volume of gas (L)	Daily Average Volume (L)
1	*0*	*0*	*2.32*
2	*1.2*	*1.2*	
3	*2.16*	*3.36*	
4	*2.88*	*6.24*	
5	*2.72*	*8.96*	
6	*3.6*	*12.56*	
7	*3.2*	*15.76*	
8	*2.8*	*18.56*	
9	*1.6*	*20.16*	
10	*3.04*	*23.2*	

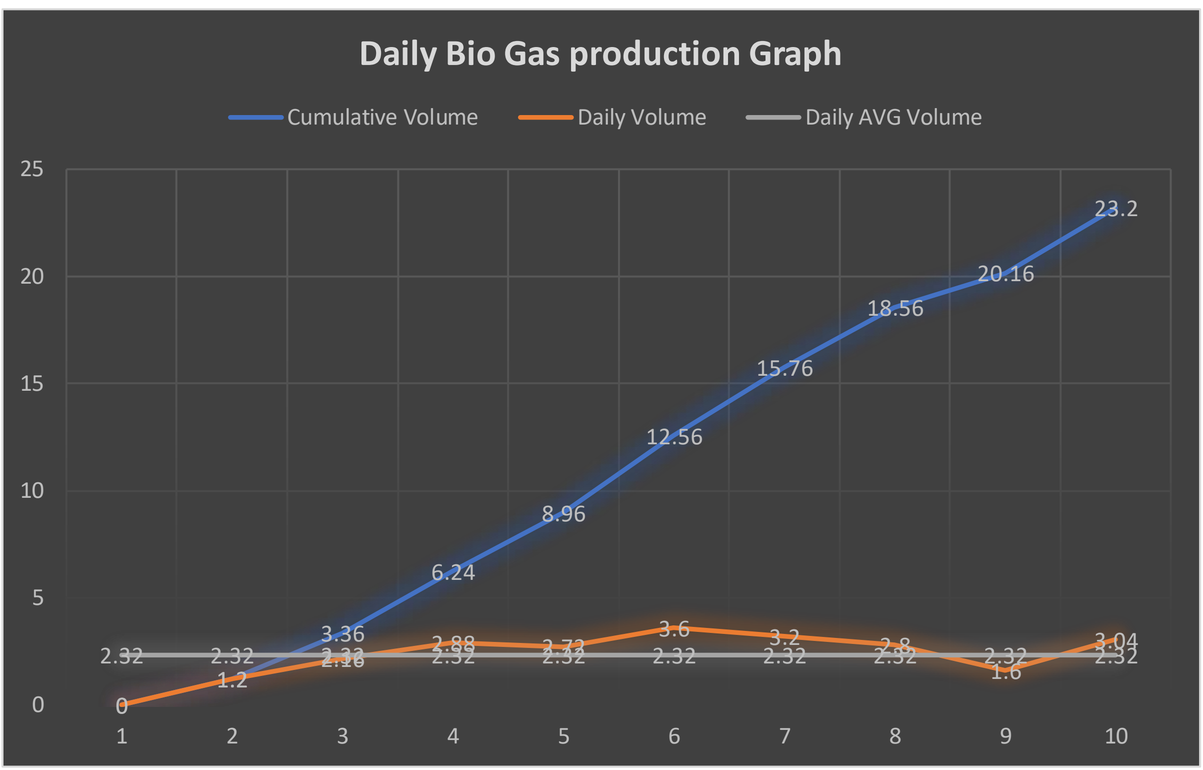

Figure *12:* Daily biogas production graph

4.2 RESULT ANALYSIS

Table *3* shows the mixed mass of charge stock and water ratio. A close examination of table *4,* (Biogas composition by *%* volume) shows that cow dung has the carbon dioxide content of *27.2%,* And methane content of *67.9%.*

Table *5* shows the summary of the result for the waste for the *10* days retention period. From the table, cow dung generated total gas volume of *23.2 L*. Table *15* shows the *10* days daily and volume of biogas production. A close observation shows

That cow dung started daily production on the second day, reaching peak on the 5th day and yielding *3.6 L* of biogas. A cumulative of *23.2 L* of biogas was produced at the end of the *10* days retention period from the cow dung waste. That figure shows the average daily production also that was *2.32 L* per day.

The results show that factors like temperature, pH, concentration of total solids, etc. affect the production of the biogas. The ambient and slurry temperature values were monitored in determining the rate of digestion and Retention of the process, since temperature is very important. The ambient temperature affects the rate of digestion due to the outside walls of the digester surface make direct contact with the atmosphere, hence the digester walls absorb or loose heat depending on the temperature gradient between the digester and its immediate environment. This implies that seasons affect the rate of heat loss or gain from the digester which in turn affects the microbial activities in the slurry at each stage. The bacterial involved may not play its role completely.

Ambient temperature Fluctuated due to climatic conditions. The mesophilic *(20^0C - 45^0C)* is the temperature range that was identified for the slurry temperature (Ts). In the mesophilic temperature, the reaction of the slurry is slower, long retention time and moderate gas production. With experiment carried out during the season showed that slurry temperature up to 30^0C can at times be recorded whereas ambient temperature varied between 18^0C and 27^0C.

The experiment was carried out during winter season which affected greatly the production of biogas, increase in temperature increases the rate of biogas production. The results of the evaluation of the production of biogas from the organic waste are presented in the tables and figures.

Chapter 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

The result of this research on the production of biogas from cow dung, has shown that flammable biogas can be produced from this waste through anaerobic digestion for biogas generation. This waste is always available in our environment and can be used as a source of fuel if managed properly. The study revealed further that cow dung as animal waste has great potentials for generation of biogas and its use should be encourage due to its early retention time and high volume of biogas yields. Also in this study, it has been found that temperature variation, PH and Concentration of Total solid etc., are some of the factors that affected the volume yield of biogas production.

5.2 BARRIERS TO DISSEMINATION OF BIOGAS TECHNOLOGY IN BANGLADESH

Key barriers of biogas technology dissemination included high installation cost of plant, uncertainties about post-warranty services, lack of sufficient funds, technical difficulties, lack of trained manpower, lack of public awareness & social prejudices, lack of policy for dissemination, lack of proper application of standardized technology, scarcity of feedstock and the general reduction in the number of domestic animals, particularly cows. Inadequate gas production was one of the most common problems facing biogas users. As a result of inadequate gas supply, household's often resorted to use traditional cook stoves to meet their cooking needs. Therefore, a large part of Bangladesh experiences flood almost every year. It is extremely difficult to prevent floodwater entering into the digester in flood prone areas, which will collapse the gas production capacity. Entering of flood water into the digester will break down its operational capacity. Sometimes, the rainy season prolongs in Bangladesh and high water table limits the construction season from six to seven months per year. The idea of attaching the latrine to the biogas plant is not getting social acceptance among the rural people due to unawareness of health and environmental benefits. Bangladesh currently does not have any central database for the primary survey report that will be reviewed on the pre-feasibility study before any new installation on the commercial scale. Nevertheless, the current environmental goals have not clearly considered on the environmental laws and acts of this country, as they were brought into force quiet a long time ago. Currently GOB is only focusing on the quick rental power generation which can only be considered as a short-term solution for the projected energy crisis of the country. Investment on every renewable energy source will be a certain encouragement for the private investors, but the initial investment for those projects with the current economic condition will be a challenging job for the government. However, the implementation of family size biogas plants (currently available system) was not successful in the past two decades in many rural parts of Bangladesh, mainly because of design, construction and maintenance problems, and limited research and development capabilities as well as limited coordination among researchers and implementing authorities *[41]*.

5.3 **FUTURE RECOMMENDATION**

- Advance technology for reduce temperature and humidity effect on biogas production rate.
- Advance recycling process of methane can ensure the environmental safety.
- Technological improvement must need for optimum output.
- Structural new model should be added and improved.
- Should come up with new processing of fertilizer with modern technology.
- Need to innovate smaller equipment for biogas plant unlike big digester.
- Government should make policies and strategies to promote the development of biogas.

5.4 WHY WE SELECT BIOGAS PLANT FOR OUR PROJECT?

As previously described day by day our country's population is growing much more. For fulfill the demand of daily uses we are dependent on fossil fuel most of the time. So that we thought to reduce the dependency of using fossil fuel we select this biogas project that we can deploy it in our daily use

5.5 CONCLUSION

Energy recovery from available biomass materials through biogas production can be a strong alternative option to supplement rural energy demand, which can consequently reduce higher level of deforestation, net greenhouse gas emissions as well as use of fossil fuels. By generating biomass fuel from the abundance sources, Bangladesh can solve a big portion of energy deficiency. Research and dissemination of biomass fuel throughout the country should be given priority in solving our energy crisis. However, the barriers and limitations should be accounted as the encouraging factor for the area of future improvement, as the idea of renewable energy sources is still in the early days in Bangladesh. The ongoing projects could be a motivating factor for the future planning in this area. In spite of having limited natural resources and technological drawbacks, the current initiatives and upcoming opportunities have clearly set up a convenient platform for a better solution the energy crisis. A coordinated effort of the concerned authorities and stakeholders and effective implementation of the action plan may surely improve the adaptation approach to mitigate the challenges of energy crisis in Bangladesh.

Chapter 6
REFERENCE

1. Gazali, T. and Moqsud, M. *(2017)* The Effectiveness of Animal Dungs and Leaf Mold for Bioelectricity Generation Using Microbial Fuel Cell with Soils. Journal of Sustainable Bioenergy Systems, *7, 165-181.* *https://doi.org/10.4236/jsbs.2017.74012*
2. Femi, T., Ahmed, I., Helen, O. and Satyavolu, J. *(2018)* Production of Ethanol from Cassava Peelings Using a Developed Percolation Reactor. Journal of Sustainable Bioenergy Systems, *8, 107-115.* *https://doi.org/10.4236/jsbs.2018.84008*
3. Benali, M., Hamad, T., Hamad, Y. and Belkhair, A. *(2019)* The Hydrogen Energy Potential of Solid Waste: A Case Study of Misrata City. Advances in Biological Chemistry*, 9, 45-53.* *https://doi.org/10.4236/abc.2019.92004*
4. Situmbeko, S. *(2017)* Decentralised Energy Systems and Associated Policy Mechanisms—A Review of Africa. Journal of Sustainable Bioenergy Systems, *7, 98-116.* *https://doi.org/10.4236/jsbs.2017.73008*
5. Benali, M., Hamad, T., Hamad, Y. and Belkhair, A. *(2019)* The Hydrogen Energy Potential of Solid Waste: A Case Study of Misrata City. Advances in Biological Chemistry, *9, 45-53.* *https://doi.org/10.4236/abc.2019.92004*
6. Al Mamun, M.R., Tasnim, A., Bashar, S. and Uddin, M.J. *(2018)* Potentiality of Biomethane Production from Slaughtered Rumen Digesta for Reduction of Environmental Pollution. AIMS Energy, *6, 658-672.* *https://doi.org/10.3934/energy.2018.5.658*
7. Benali, M., Hamad, T., Belkhair, A. and Hamad, Y. (2019) Investigating the Use of Combined Hydrogen, Heat and Power System for Omar Al-Mukhtar University Campus. Advances in Biological Chemistry, 9, 31-44. https://doi.org/10.4236/abc.2019.91003
8. Jardine, J., Sundfeld, E. and Durães, F.M. (2013) Availability of Information about Sustainable Bioenergy Technologies: The Agro-Energy Tree of Knowledge. Journal of Sustainable Bioenergy Systems, 3, 260-264. https://doi.org/10.4236/jsbs.2013.34035
9. http://www.unescap.org/esd/Energy-Security-and-Water-Resources/meetings_energy/meeting5Ps-RTWS/Presentations_PDF/Day2/Session_6_Islam_Bangladesh.pdf (retrieved on October 08, 2013)
10. "Bangladesh: country profile", The Economist Intelligence Unit (EIU), London, 2008
11. M. H. Kabir, and W. Endlicher, " Exploitation of renewable energy in Bangladesh", A.H. development , 2012
12. Monshof Ali, "The Use and Status of Biogas Plants of Pabna District in Bangladesh," M. Sc. Thesis submitted to Partial Fulfillment of the Degree awarded by University of Flensburg, Germany(2005), pp.286.

13. M. R. Hamid, M. N. Haque, M. A. Rouf, M. S. Islam, “International Journal of Scientific & Engineering Research”, Volume 4, Issue 3, March-2013, ISSN 2229-5518
14. “Study on Effects of Biogas in the Households in Biogas Villages with focus on Gender Issues” published by Prokaushali Sangsad Ltd., Annex – 1, p.41, Dec. 2010
15. Islam Sharif, “ conference on renewable energy”, Madrid, Spain(2009), October 19–23
16. http://www.idcol.org/energyProject.php (retrieved on October 04, 2013)
17. http://www.energyforall.info/wp-content/uploads/2013/04/Grameen-Shakti.pdf (retrieved on October 08, 2013)
18. A. D. Obozov, and Asankulova, “Biogas in Kyrgyzstan”, Applied Solar Energy(2007), Vol. 43, No. 4, pp.262–265,
19. Basic Information on Biogas Archived 6 January 2010 at the Wayback Machine, www.kolumbus.fi. Retrieved 2.11.07.
20. P. R. Bhat, H. N. Chanakya and N. H. Ravindranath, J. “Energy Sustainable Dev”. 1:39 – 41, 2001.
21. B.H. Khan, “Non-Conventional Energy Resources”. 2009 by McGraw Hill Education.
22. https://energypedia.info/wiki
23. https://en.banglapedia.org/index.php/Biogas
24. U. Rehling, “Small biogas plants, sustainable energy systems and management (SESAM), University of Flensburg, Germany, 2001.
25. https://www.gshakti.org/what-we-do/keyprograms/biogas
26. Mohammad Hossain. 2015. “Achieving Sustainable Energy Targets in Bangladesh” The Magazine of the United Nations.
27. https://idcol.org/home/dbiogas
28. S. Rafique, “Potential Sources of Energies in Bangladesh: Utilization And Environmental Issues”, WREC VII , 2002
29. http://faostat.fao.org/site/573/DesktopDefault.aspx?PageID=573#ancor (retrieved on October 10 ,2013)
30. N. C. Bhowmik, “Bangladesh: Renewable Energy Report, Asian and Pacific Centre for Transfer of Technology of the United Nations–Economic and Social Commission for Asia and the Pacific”, (2008) http://www.recap.apctt.org/download.php?p=Admin/publications/5.pdf(retrieved on April 8,2013)
31. M. Islam, B. Salam and A. Mohajan , “Generation of biogas from anaerobic digestion of vegetable waste”, Proceeding of the 8th International Conference on Mechanical Engineering (2009),26- 28 December, Dhaka, Bangladesh
32. http://faostat.fao.org/site/573/DesktopDefault.aspx?PageID=573#ancor(retrieved on October 10,2013)
33. Badrul Imam, “Energy resources of Bangladesh”, Second edition (2013), pp.288-292.S. Rafique, “Potential Sources of Energies in Bangladesh: Utilization And EnvironmentalIssues”, WREC VII , 2002
34. K. Kaygusuz and A. Kaygusuz, “Renewable energy and sustainable development in Turkey,” Renewable Energy, Vol. 25, Issue 3, pp. 431-453, March 2002.
35. S. M. Maishanu, M. Musa and A. S. Sambo, “Nigerian Journal of Solar Energy,” vol. 9, 183-194, 1990.

36. DPC Group, Dhaka,Final Report on Evaluation of Biogas Plants Established at the Field Level under The BiogasPilot Plant Projects and Project Activities, submitted to BCSIR, Dhaka, June 2004
37. Dr. Amrit B Karki, Prof. Jagannath Shrestha and Mr. Sundar Bajgain, Biogas-As Renewable Source of Energy in Nepal, Theory and Practices, July 2005 Economic Relation Division, Ministry of Finance, Government of Bangladesh,A National Strategy for Economic Growth, Poverty Reduction and Social Development, March2003
38. Kazi Aktaruzzaman, Operation and Maintenance of Biogas Plants Production of Biogas and Generation of Electricity,presented in the National Training Workshop on RE Education in Bangladesh, August 2003
39. Kazi Aktaruzzaman, Biogas Pilot Plant Project Background, Objective and Achievements, BCSIR, Dhaka, June 2003
40. Monsof Ali,The Use and Status of Biogas Plants of Pabna District in Bangladesh, M. Sc. Thesis submitted to Partial Fulfillment of the Degree awarded by University of Flensburg, Germany, March 2005
41. M. H. Rahman, M. A. Mottalib, M. H. Bhuiyan,“A study on biogas technology in Bangladesh”,22nd WEDC Conference(1996), New Delhi, India.