"FREQUENTLY ASKED QUESTIONS"
on
BIOGAS TECHNOLOGY

DR. DEEPAK SHARMA
ER. KAPIL SAMAR

Sponsored by :
Ministry of New and Renewable Energy, Govt. of India, New Delhi

BIOGAS DEVELOPMENT AND TRAINING CENTRE
Department of Renewable Energy Engineering
College of Technology and Engineering
Maharana Pratap University of Agriculture & Technology, Udaipur (Raj.)
Ph. : 0294-2471068, +91-9414160221 ; E-mail : deepshar@rediffmail.com

FREQUENTLY ASKED QUESTIONS

FAQ's

ON

BIOGAS TECHNOLOGY

DR. DEEPAK SHARMA

ER. KAPIL SAMAR

BIOGAS DEVELOPMENT AND TRAINING CENTRE, UDAIPUR

COLLEGE OF TECHNOLOGY AND ENGINEERING

(MINISTRY OF NEW AND RENEWABLE ENRGY, NEW DELHI)

(2016)

Foreword

In the recent years our mother, earth has come under the severe threat due to the environmental stresses caused by ever increasing use of fossil fuels based energy. This has attracted the attention of scientists, environmentalists, governments and civil societies as well as common people all over the world. India has taken a bold decision to supply electricity from renewable sources to 18,000 villages, which cannot be connected to gridpower supply.

During the recent years, biogas generation and biogas plant slurry management as bio-manure systems have attracted considerable attraction, not only as an alternative source of energy, but also as a promising source of decentralized sustainable rural development through its entrepreneurial scope at local level and environment protection capabilities. The Ministry of New and Renewable Energy, Government of India,has been makingcontinuous progress in promotion of biogas technology for domestic, industrial and agricultural application, and also energy recovery from Waste to Energyfrom urban & municipal wastes. Biogas Technology is a promising one for meeting the sustainable development goals and social cause.

I convey my best wishes to Dr. Deepak Sharma and his team for bringing out a Book on “Frequently Asked Questions” on Biogas Technology and hope that it would play a ready-reckoner for all the users of biogas plants including potential and new stakeholders in biogas sector, a prominent sub-sector of the Bio-energy.

Ms. Varsha Joshi
Joint Secretary
Ministry of New and Renewable Energy
Govt. of India

Introduction

Traditionally, biomass had been utilized through direct combustion. Cow dung cake is one of the most important and widely used biomass for the production of daily energy needs. It has been estimated that 2.5 billion people around the world are not being able to access the modern fuels. They are highly dependable on locally available wood and cow dung cakes.

About nine-tenth of the rural households in India uses traditional biomass-wood and dung-as a household fuel annually. Burning of biomass or cow dung cakes through direct combustion creates indoor air pollution and ultimately contributing to serious health problems, particularly cancer and respiratory infections. Approximately half a million premature deaths and nearly 500 million cases of illness are estimated to occur annually as a result of exposure to smoke emissions from biomass use by households in India, making indoor pollution the third leading health risk factor.

Biogas represents renewable source of energy that derives mainly from decomposition of organic wastes in the absence of oxygen. In India, biogas mainly produced from cattle dung. The biogas technology is being promoted by Ministry of New and Renewable Energy, Govt. of India since 1981-82.

Usually it is difficult to understand about biogas technology at once. Here some questions and answers are listed that are commonly asked by a new user in the field of biogas technology. This book also includes method of economics evaluation, address of Biogas Development and Training Centres and list of state nodal agency that makes users easy to approach for getting more information about biogas technology.

FAQ'S ON BIOGAS TECHNOLOGY

1. What is biogas?

Biogas is a combustible gaseous fuel that is collected from the microbial degradation of organic matter in anaerobic conditions. Biogas is principally a mixture of methane (CH_4) and carbon dioxide (CO_2) along with other trace gases. Biogas can be collected from landfills, covered lagoons, or enclosed tanks called anaerobic digesters. The biogas typically has 60% methane and 35% carbon di oxide. There is also some percentage of hydrogen, nitrogen, oxygen, ammonia, moisture etc

2. What is organic material?

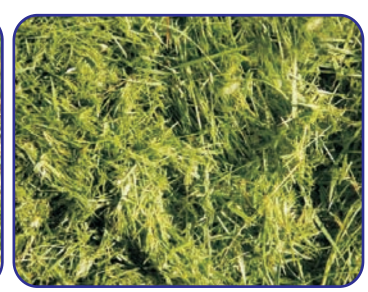
Organic material is something that was living and can decay. Wasted or spoiled food, plant clippings, animal manure, meat trimmings and sewage are common types of organic material used with anaerobic digestion. In contrast, inorganic material includes things like rocks, dirt, plastic, metal and glass.

3. What are the sources of biogas generation?

Biogas is commonly made from animal slurry, sludge settled from wastewater and at landfills containing organic wastes. However, biogas can also be made from almost any organic waste has the ability to produce biogas: human excreta, slurry, animal slurry, fruit and vegetable waste, slaughterhouse waste, meat packing waste, dairy factory waste, brewery and distillery waste, etc. Fiber rich wastes like wood, leaves, etc. make poor feed stocks for digesters as they are difficult to digest. Many wastewaters contain organic compounds that may be converted to biogas including municipal wastewater, food processing wastewater and many industrial wastewaters. Solid and semi-solid materials that include plant or animal matter can be converted to biogas.

Cattle Dung

Kitchen Waste



Agritulture Waste

4. **How is organic matter decomposed?**

Organic matter anarobically decomposed in the presence of bacteria. The bacterial decomposition of organic matter takes place in three phases namely hydrolysis, acid phase and methane phase.

5. **What happens in all these three phases?**

In the hydrolysis phase, heavier hydrocarbons are broken into smaller molecules, which are then converted to organic acids by acid forming bacteria. In the methane phase, fermentation of acids, hydrogen and CO_2 produces methane.

6. **What are the major applications of biogas plant?**

Biogas plant produces biogas and bio manure. Biogas can be used for thermal application like cooking, lighting and power generation through diesel/petrol gensets. Bio manure can be used as fertilizer in agriculture. Bio manure increases annual grain yield.



7. **What are the salient benefits of biogas technology?**

It provides clean gaseous fuel for cooking and lighting.

a. Digested slurry from biogas plants is used as enriched bio-manure to supplement the use of chemical fertilizers.

b. It improves sanitation in villages and semi -urban areas by linking sanitary toilets with biogas plants.

c. Biogas plants help in reducing the causes of climate change.

8. **How electricity could be produced by using biogas?**

Biogas operated gensets are available for generation of electricity. One cubic biogas can produce 4-5 kWh electricity depends on efficiency of genset and average methane content in raw biogas.

9. In which conditions biogas can be produced?

Biogas production is obtained by anaerobic decomposition (absence of oxygen) of biomass in the presence of bacteria. The bacterial decomposition of biomass takes place in three phases, namely hydrolysis phase, acid phase and methane phase.

10. Can biogas be used in place of fossil fuels? How?

Methane is the principal gas in biogas. Methane is also the main component in natural gas, a fossil fuel. Biogas can be used to replace natural gas in many applications including: cooking, heating, steam production, electrical generation, vehicular fuel, and as a pipeline gas.

11. What is the potential of implementation of biogas plant in India?

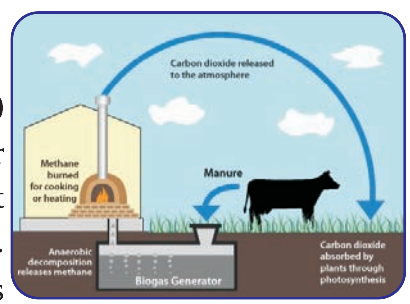
According to statistical data of availability of cattle dung, there is a potential of construction of 12 million family size biogas plants in India.

12. What are the environmental impacts of producing/using biogas?

One of the gases produced by the decomposition of slurry is methane gas, which is estimated to trap 20 to 30 times as much atmospheric heat as carbon dioxide and reducing methane releases into the air is a crucial element of fight to limit the global warming.

The important substance for plant growth is nitrogen, which remains in place after extraction of biogas. This leads to further environmental advantages. By reducing the weight and volume of fertilizer and increasing the amount of fertilizer available from composted waste reduces the need for chemical fertilizers, which release the extremely powerful greenhouse gas nitrous oxide.

13. Does biogas contribute to climate change?



During combustion of biogas, carbon dioxide (CO_2) is released that is reabsorbed by plant matters for their growth. Carbon in biogas comes from plant matter that fixed this carbon from atmospheric CO_2. Thus, biogas production is carbon-neutral and does not add to greenhouse gas emissions. Further, any consumption of fossil fuels replaced by biogas will lower CO_2 emissions.

14. How much energy is contained by biogas?

One cubic meter biogas is equivalent to about 4700 kCal energy.

15. How can we compare the quality of biogas equivalent to other hydrocarbon fuels?

Quantities of various hydrocarbon fuels that will have energy equivalent to $1m^3$ of biogas are given in as under-

Name of the fuel	Kerosene	Firewood	Cow dung	Charcoal	Furnace oil	Electricity	LPG
Equivalent quantity to $1m^3$ of biogas	0.60 lit.	3.50 kg	12.3kg	1.50 kg	0.40 lit.	4.70kWh	0.43 kg

16. What are the quantities of biogas consumption for its different applications?

Consumption of biogas is mentioned as under

S.N.	Application	Consumption
1	Cooking	$0.25m^3$/person/day
2	Lighting	0.13 m^3/hour/lamp
3	Engine operation	0.5 m^3/hour/horse power

17. For an 8 members family, what will be the capacity of the biogas plant to meet their daily energy requirements ?

Approximately 0.24 cum biogas is consumed by a person daily for completing his cooking needs. According to this, a total of 1.92 cum biogas is required for complete daily cooking needs. 2 cum biogas plant is the standard design next after the 1.92 cum biogas, so the appropriate size of the biogas plant would be 2cum.

18. What are the standard designs of biogas plant available?

Under the family size biogas plant 1, 2, 3, 4, and 6 CUM plants are considered as standard design.

19. Does the biogas plant smell bed?

In case of appropriate operation, a biogas plant does not release any bad odour into the environment. Hydrogen sulphide produced in the course of decomposition is converted to odourless elementary sulphur biologically or chemically in a closed space. Only incoming substrates (like manure, organic waste, etc.) can be a source of bad smell. In the course of biogas production, microorganisms use the components of manure for their vital processes, which are responsible for bad smell, so fermentation effluent is practically odourless, and it is a good-quality fertilizer for the vegetation.

20. How much cattle dung is required daily for feeding of different sizes of biogas plant?

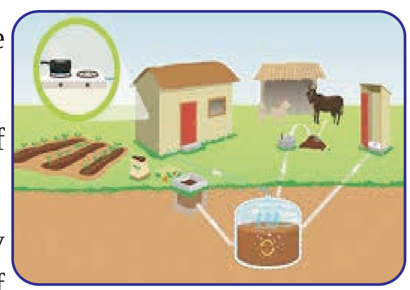
Size of biogas plant (m^3)/day	Amount of wet dung required daily (kg)	Approximate numbers of adult cattle heads	
		Local	Cross breed
1	25	2-3	1-2
2	50	4-5	2-3
3	75	6-7	3-4
4	100	8-10	4-5
6	150	12-14	6-8

21. How much area is required for installing a biogas plant?

It depends on the size of the biogas plant. Generally 2 cum biogas plant requires 15 feet × 15 feet plane surface. The site must be open to receive sun radiation for most part of the day that keep the plant warm.

22. Are there any criteria for selection of best site for installation of biogas plant?

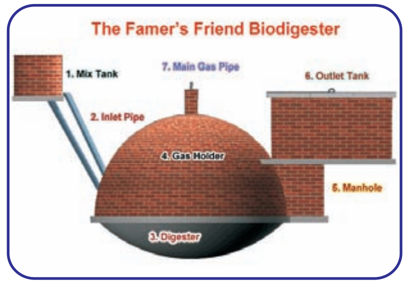
Following points should be considered while selecting a site for installation of biogas plant-



- It should be close to the kitchen to minimise cost on gas pipeline
- It should be near to cattle shed to minimise the distance for carrying cattle dung.
- There should be enough space for storage of digested slurry or construction of compost pit.
- It should be 10-15 meters away from any drinking water well to prevent contamination of water.
- The area should be free from roots of tree which are likely to creep into the digester and cause damage.
- It should be open to receive the sun radiation for most part of the day to keep the digester warm.
- It should be on an elevated area so that plant does not get submerged during normal rains.

23. What are the components of a biogas plant?

A biogas plant consist of the following parts-



a. Mixing tank and inlet

b. Digester

c. Gas holder or gas storage dome

d. Outlet and compost pit

e. Gas main outlet valve, pipeline, gas stove

24. Why methane produced better in the absence of air (anaerobically)?

Most bacteria grow more rapidly when they have a source of oxygen. When they run out of "free oxygen" in the air, some can obtain it from other compounds. Bacteria which use these compounds produce methane gas (CH_4) as a waste product.

25. Biogas production from both traditional and newly pre fabricated type biogas plants are same. Which should be preferred & Why?

Life of brick masonry constructed biogas plants are around 20 years while life of prefabricated biogas plants are 10 years only. But the prefabricated biogas plants can be shifted as per the requirement. According to suitable condition, beneficiary can make his choice.



26. By which Ministry, this programme is initiated?

Ministry of New and Renewable Energy (MNRE) Govt. of India is implementing 'National Biogas and Manure Management Programme' (NBMMP) for installation of family size biogas plant since 1981-82.

27. Please mention the details about NBMMP?

National Biogas and Manure Management Programme is a Central Sector Scheme, which provides for setting up of family type biogas plants mainly for rural and semi-urban/households. A family type biogas plant generates biogas from organic substances such as cattle –dung, and other bio-degradable materials such as biomass from farms, gardens, kitchens and night soil wastes etc.

28. What are the main objectives of NBMMP scheme?

The objectives of the scheme are as follows:

- To provide clean gaseous fuel mainly for cooking purposes and organic manure to rural and semi urban households through family type biogas plants.
- To mitigate drudgery of rural women, reduce pressure on forests and accentuate social benefits.
- To improve sanitation in villages by linking sanitary toilets with biogas plants.
- To provide bio-digested slurry (liquid / semi-solid and dried) as an upgraded source of enrichment for manure to reduce and / or supplement use of chemical fertilizers; by linking biogas digested slurry with enrichment units such as wormy-composting plants and other organic enrichment facilities of slurry.
- To meet 'lifeline energy' needs for cooking as envisaged in “Integrated Energy Policy” report of the Planning Commission.
- To help in combating and reduction in causes of climate change by preventing emissions of carbon dioxide and methane into the atmosphere.

29. What is the physical target of biogas plant in this scheme?

The programme will be implemented with a physical target of 6.50 lakh biogas plants for the 12th plan period.

30. Is there any financial support by Govt.of India?

Sl. No	Particulars of Central Financial Assistance (CFA) & States / Regions and Categories	Family Type Biogas Plants under NBMMP (1 to 6 cubic metre capacity per day)	
A.	**Central Subsidy Rates Applicable (In Rs.)**	**1 Cubic Metre**	**2- 6 Cubic Metre**
1.	NER States, Sikkim (except plain areas of Assam) and including SC and ST Categories of NE Region States.	15,000	17,000
2.	Plain areas of Assam.	10,000	11,000
3.	Jammu & Kashmir, Himachal Pradesh, Uttrakhand, Niligiri of Tamil Nadu, Sadar Kurseong & Kalimpong Sub-Divisions of Dar jeeling, Sunderbans (W.B.) and Andaman & Nicobar Islands.	7,000	11,000
4.	Scheduled castes / Scheduled Tribes of other than NE Region States including Sikkim & other Hilly States / regions as given in Sl.no.3 above.	7,000	11,000
5.	All Others	5,500	9,000

31. Is there any financial support by Govt. of Rajasthan?

Please visit website of Govt. of Rajasthan for updates.

32. Is there any condition for claiming CFA on biogas plant?

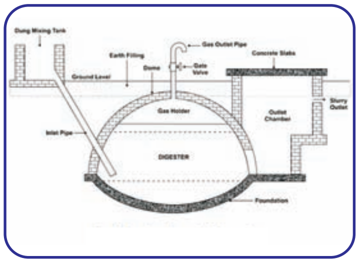
First farmer intimate the respective State Nodal Agency for construction of biogas plant. Technical staff from SNA once verifies the biogas plant constructional site, than he/she can construct biogas and claim for subsidy. Beneficiary may be male or female, businessman or serviceman, private employee or Govt. employee or student. It should be ensured that user has a bank account and an identity proof. If user belongs to SC and ST category, he must have caste certificate to avail the additional grant.

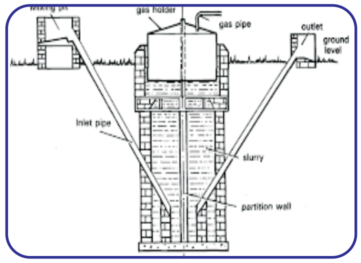
33. Which family size biogas models are approved for claiming CFA?

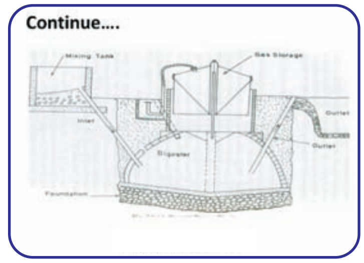
The list of MNRE approved models of Biogas Plants (Family Size) capacity 1 m³ to 6 m³ per day is as given below:

S.No.	Biogas Plant Models*	Specifications/ Ministry's letter No. and date of approval.
1.	**Fixed Dome Biogas Plants:** (i) Deenbandhu fixed dome model with Brick masonry construction. (ii) Deenbandhu ferro -cement model with in-situ technique. (iii)Prefabricated RCC fixed dome model.	Ministry's letter No.13 -10/96-BG dated 10-1-2002 Code of Practices (Second Revision), IS 9478:1989 of the BIS, New Delhi. Ministry's letter No.13 -11/99-BG dated 5 -3-1999
2.	**Floating Dome Design Biogas Plants:** (i) KVIC floating steel metal dome with brick masonry digester. (ii) KVIC floating type plant with Ferro - Cement digester and FRP gas holder. (iii)Pragati Model Biogas Plants.	Code of Practices (Second Revision), IS 9478:1989 of the BIS, New Delhi. Code of practice IS -12986:1990 of BIS, New Delhi. Code of Practices (Second Revision), IS 9478:1989 of the BIS, New Delhi.
3.	**Prefabricated model Biogas Plants:** (i) Prefabricated Reinforced Cement Concrete (RCC) digester with KVIC floating drum.	Ministry's letter No.13 -1/2007-BE, dated 29.02.2008.
4.	**Bag Type Biogas Plants (Flexi model)**	Ministry's letter No.7 -39/89-BG dated 14.7.95

*New innovative and cost effective models of plants may be added depending upon the technology development and their field worthiness.



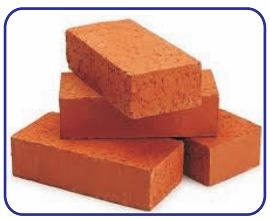




34. What are the materials required for construction of a biogas plant?

Bricks, cement, sand, concrete, is required for construction of a biogas plant. PVC or asbestos pipe is used for inlet and outlet as required. For KVIC biogas plant, additional GI sheets are needed for fabrication of gas holder. (Table 2 & Table 5.)

Recently, HDPI material based readymade biogas products are available in market. They could be used for biomethanation.



35. From the above said approved models, which one is best for the state of Rajasthan?

Deenbandhu biogas plant is one of the most suitable biogas plants according to geographical conditions. Cost wise it is also cheaper than all others.

36. How would I ensure that biogas plant constructed meets all technical condition as desired by MNRE?

Beneficiary must check the dimensions of biogas plant at constructional stages and cross check it with standard designed dimensions. After construction, the gas portion should be painted with di-epoxy. Initially the plant would be fed with 1:1 dilution of cattle dung and water. ISI marked (BIS code IS - 8749: 1988) burners having a minimum thermal efficiency of 55% biogas stoves / chullhas should be used for safety. Use HDPI pipes for biogas distribution is technically and economically best.

37. Why the gas holder portion is painted with di-epoxy paint?

The conventional method of repairing is either with applying oil paint or tar coat over plastering. The inner surface has not proved to be result oriented as a film of oil paint is too thin and tar does not have good bonding with any cemented surface and even new plaster also develops cracks and peels off due to change in compressive strength between the old and new plaster.

Epoxy paint has two part- a Hardener and Resin. Both are mixed in equal ratio for application. After application, it becomes a thin harder surface that enables gas to escapes from cracks.

38. Is it possible to construct a biogas plant on hilly region?

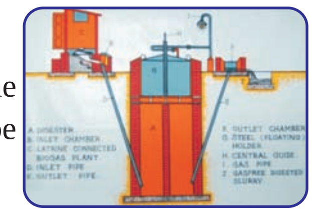
In the hilly region, there are two major issues-

A. Loss in temperature from digester during night which downs the rate of gas production.

B. Digging of pit for deep construction due to stones.

In such situation, KVIC biogas plants are not suitable for optimum production. Fixed dome biogas plants could be functioning well. Deenbandhu biogas plant would be economically sounds better due to its less excavation work.

39. Can a sanitary toilet be linked with the biogas plant?



Yes sanitary toilets can also be linked with biogas plant. The additional CFA of Rs.1,200/- per plant as subsidy can be granted to biogas users.

40. Can I burn biogas in a common LPG burner?

LPG stoves can be modified to fit the properties of biogas but the efficiency will often not be as good as with a genuine biogas stove. It is also a risky task. It is advised to buy a new biogas stove for better use.

41. The above said biogas burners are not commonly available in the retail market. From where it can be purchased? Are there any Govt. approved vender?

Presently there are no government approved vendors but there is a list of manufactures that are certified by ISI and KVIC. They may address their dealers nearer to beneficiary's location. Beneficiary must visit to MNRE website, respective state nodal agency or BDTC's for the list.

42. How the excess biogas can be utilized?

Excess biogas can be stored in balloons for use in near future. But while using stored biogas, calculated amount of dead weight such as scraped tyre, gunny bags filled with sand etc. could be used to create pressure.

43. Such a big target cannot be completed without the help of those entrepreneurs who are working in rural areas like NGOs, Gram panchayat etc. Is there any financial benefit to NGO for taking such projects?

The Turn-key job fee is linked with five years warranty for trouble-free functioning of biogas plants set up on **Turn-Key Work basis**. Turn-key job fee of Rs. 1500/- is payable for biogas plants involving part construction work either for digester or dome. Only MNRE approved family type biogas plants are eligible for this assistance**.** This is subject to the condition that the Turn-Key Worker would visit the plant at least twice in a year during the warranty period. The fee is paid to turn key worker as per MNRE norms.

44. As mentioned, a biogas plant can be constructed by a skilled and trained labour. How we can contact with those trained biogas masons?

Every year MNRE approved training centres organise trainings to create a cadre of masons and technicians skilled in the construction and maintenance of approved models of biogas palnt. List of those training centre is given in Annexure-1 with contact details. It is better for beneficiary to contact once at these training centres before planning for construction of biogas plant.

45. Why aren't we doing more with biogas? What are the barriers to increasing biogas production and use?

Biogas is being collected and used to generate electricity or steam at many landfills, wastewater plants. However, many opportunities for biogas production are yet to be implemented. Until recently, the low cost of fossil fuels has hindered implementation of biogas production. There is a limited awareness of the potential and advantages of biogas production by citizens, government officials, and in the business sector that has limited interest in biogas production. More education, demonstration and investment in biogas technology would help overcome these barriers.

46. Feed stock for cattle is varying from season to season. In respect to this, dung quality varies. By this factor, is there any effect on production of biogas?

Yes, but this effect is avoidable. There will be no much difference in gas production.

47. Biogas is a prominent fuel for cooking in rural areas. But villagers are not aware with this technology. The Ministry must promote this technology to the rural people. Is there any provision to conduct such camps for promoting this technology?

The training centres (as mentioned in **Annexure 1**) conduct one day camp for raising awareness about the benefits of biogas plants among users specially women beneficiaries, and for imparting awareness on operation and maintenance and day to day upkeep of biogas plants. Villages having about 1-5 biogas plants in operation will be selected as venue and 40-60 household of the selected village will be contacted and invited for attending User's Course. Efforts should be made for involving in all such courses.

48. A biogas plant is fed with cattle dung and water in 1:1 ratio for getting biogas. In this situation, the technology couldn't be used in water scare areas.

Design of biogas plant on only fresh cattle dung has been developed approved by MNRE, GoI. In such plants, fresh cattle dung (16-18% solid content) is directly fed to biogas plant without mixing of water. This design is gaining popularity in desert districts of Rajasthan.

49. Is there any role of earth condition in laying foundation for biogas plant?

Of course, if the earth is sandy, hard brick ballast is laid by an ordinary procedure using cement, sand and brick ballast (1:4:8) or cement, sand and gravel mortar (1:2:4) without reinforced.

If during wet earth is observed, there is a possibility of water seepage through the ordinary laid foundation in rainy season. Therefore under these circumstances, a 75 mm thick layer of dry brick ballast (without cement) is spread and is well compacted. Above this a 150 mm thick layer of cement, sand and brick ballast at a ratio of 1:4:8 is laid. In this layer a net of steel rods of 15 mm diameter (tied by binding wire) bound at a distance of 10.5cm each is also used as reinforcement.

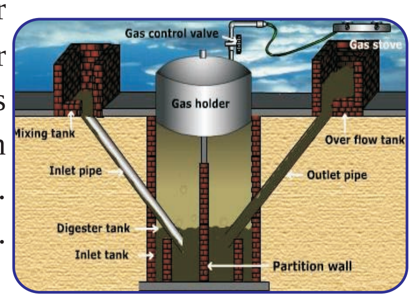
50. What would be the mortar ratio maintain at different constructional stages?

The mortar ratio to be maintained at different constructional stages of a biogas plant is mentioned as under

Constructional stage	Material	Ratio
Laying foundation (in dry earth condition)	Cement : Sand : Brick Ballast Cement : Sand : Gravel	1:4:8 1:2:4
Laying foundation (in dry earth condition)	Cement : Sand : Brick Ballast And reinforcement	1:4:8 15 mm diameter
Construction of digester (wall thickness 115mm) (wall thickness 230mm)	Cement : Sand	1:4 1:6
Construction of dome	Cement : fine sand : Coarse sand	1:1:2
Outer Plaster I (12 mm thick)	Cement : fine sand : Coarse sand	1:2:3
Outer Plaster II (12 mm thick)	Cement : fine sand : Coarse sand	1:1:2
Inner Plaster at dome ceiling (12 mm thick)	Cement : fine sand	1:2
Inner plaster at digester (12mm thick)	Cement : fine sand : Coarse sand	1:1:3
Coating	Cement : water	1:2

51. In many cases, partition wall collapsed in KVIC biogas plant. Why?

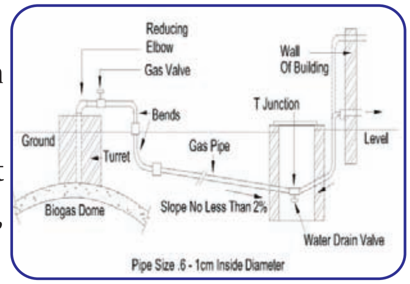
Partition wall is constructed to divide the circular well into two equal halves in biogas plant of $4m^3$ or above. It controls the flow of slurry. It is recommended to feed slurry on both side of partition wall with equal quantity at the time of initial feeding. It maintains equal pressure on partition wall. Pressure difference causes collapse situation.



52. Fabrication of steel drum for gas holder in floating drum biogas plant at beneficiary level is a tough task. The holder may be fabricated with improper dimensions. Which is the easiest point to purchase it as readymade?

The gas holder and guide frame can be purchased from a nearby approved workshop of a State Agro Industries Corporation, a fabricator recognised by a State Government/KVIC Board or State Nodal Agency.

53. What are the components in gas distribution pipeline?



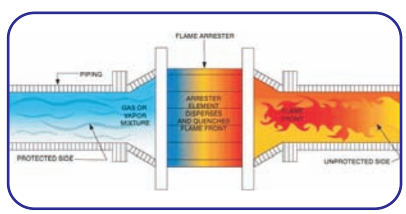
The gas distribution pipeline includes the gas vent pipe, gate valve, hose pipe, moisture trap, pipe, bends, joints, stop cock, pressure tube clips etc.

54. What would be the appropriate size of pipe in gas distribution line?

The size of the pipe depends upon the distance between the plant and the kitchen. The greater the distance, the larger should be the diameter of the pipe. With the pressure of approximately 8 cm water column, one cubic meter biogas can be transported in one hour in a 12mm pipe over about 20m, in a 19mm pipe over about 150m and in a 25mm pipe over 500m.

Diameter of pipe (mm)	Distance between plant to kitchen (meter)
12	30
19	50
25	100

55. Is it possible to flow back of fire from the burner? If this happens, the biogas plant may causes fire accident.



Flow back of fire might be possible. In order to stop accidental flow back of fire from burner to gas holder, a flame arrester must be incorporated in the pipe line as a safety device.

56. Where should fire arrester be placed?

Fire arrester is placed just after the main gas valve near the digester or just before the gas stove. It is safer to have one at both place.

57. What would be the size of the fire arrester with respect to pipe line?

For a 12mm main gas pipe use a 19mm arrester and for a 25mm pipe use a 32mm arrester.

58. If a biogas plant stops generation of gas, how a farmer can detect the reason?

There are a number of things that can affect the biogas production in a biodigester.

A. Biogas leaks

If there is very little biogas, there may be a leak somewhere. The biogas gas holder and biogas pipeline should be checked for leakage. A simple soap solution can be used to detect the leakage

B. Temperature problems

If ambient temperatures reach below 20^0C, you will experience a drastic decrease in biogas production. If this is the case, look to adapt a heating system to your biodigester

C. Problems with the biodigester's pH

The pH in the biodigester tank should be as close to neutral as possible. Since the anaerobic processes in a biodigester produce acids. The most common pH problem is one of acidity. Beneficiary can do a simple litmus test on the biodigesters content. If the results are below 7, beneficiary must add a small amount of lime or grounded lime stone to normalize the digester's pH. Since excessive amounts of lime will not be soluble in the mixture and may harm the bacteria, beneficiary should never exceed a lime concentration of 500mg for every litre of mixture in the biodigester tank.

D. Other problems

There are a number of other problems that can arise during the life of a biodigester. To investigate problems, it is best to think back to the basics of what makes a biodigester work (organic material, strong seals, warmth) and eliminate anything else that could possibly harm its functioning. For example be careful not to introduce unnecessary chemicals into the tank, and try not to use livestock that has recently been given antibiotics or other medications, for these chemicals present in the manure may cause damage to the bacteria in the biodigester tank. Also, make sure to use non-corrosive materials for handling the gas and water. Cement and plastic cause no harm to the mixture in the tank, but metals should be avoided for use in the tank, or any of the tubing through which the biogas travels.

59. How can we examine KVIC gas holder for gas leak?

The steel gas holder should be tested for gas leaks by keeping water in it overnight. It can be put to a smoke test by burning a cloth dipped in kerosene inside the holder and watching for the smoke coming out of any joints. Only the tested and painted gas holder should be placed on the digester.

60. How can we examine Deenbandhu gas dome for leak?

Its a slight tough task than KVIC gas holder. The gas storage dome can be examined by fixing a U shaped safety valve made of glass tube at the gas outlet pipe and then filling the digester with water or inflating with air using a manually operated air pump to make the column of water in safety valve rise to at least 90 cm. After 24 hours, the water column should be checked for a drop in level. If water column drops or gas escapes, the leak must be located by pouring soap water on all suspected locations outside the gas chamber and around the gas vent pipe joints.

61. Is there any general procedure for initially feed the biogas plant?

Fill the plant with a correct mixture of dung slurry (dung and water in ratio 1:1) through the inlet chamber. The gas pipe should be disconnected. The digester should not be filled to more than 75 – 80% of its volume, under any circumstances thus allowing some volume for storage of gas. The quantity of slurry recommended for the particular size of plant should be added daily.

62. Is the first gas is flammable?

The production of gas after filling of the gas chamber would take about 7 – 20 days. The initial gas stored may not be combustible and should be allowed to escape. Purge air from all delivery lines by allowing gas to flow out prior to first use. Ensure that condensed water is able to flow out from the pipeline through the water trap.

63. **Can biogas be fed just after the initial feeding? Is it the right way?**

The slurry should be added only after the production of inflammable gas has started, i.e. after about 20 days from initial filling of the plant up to the recommended level. The stirring can be done in a fixed dome plant by moving a bamboo pole up and down in the inlet and outlet openings. This will help in breaking of scum if done at least once a day.

64. **Are digesters cold or hot?**

The optimum temperature for bacteria to remain alive and multiply is above 30 to 38 degrees Celsius. Digesters can also work at temperatures that are both lower and higher than this. Because the bacteria working in the digester are very sensitive to temperature, cooler digesters take more time to break down the biodegradable feedstock, while hotter ones may not break down the biodegradable feedstock due to bacteria remaining in dormant stage.

65. **In the winter season, with a drop in temperature, production of biogas also drops. In such situation what would we do for optimum production?**

Following tips may be useful-

i.) Warm water from solar water heaters can be used for dilution of dung.

ii.) Diluted dung slurry can be prepared in the mixing tank and kept all day to warm up. Than the digester may be loaded in the evening.

iii.) Addition of organic matter containing high percentage of nitrogen like urine, nightsoil etc.

iv.) The gas holder should be covered with plastic sheets in day so the digester temperature can be increased. During night time, the same will be covered with gunny bags that remains insulated and heat loss can be minimised.

v.) The digester should be recycled along with fresh slurry in order to increase the bacterial population in the digester.

66. **As the biogas plant is charge with fresh slurry, a black liquid is discharge from opposite side. What is that liquid?**

That liquid is digested slurry. This slurry is a natural substance used for enriching the soil. It is a by-product obtained from the biogas plant after the digestion of dung or other organic matter.

67. **How is biogas slurry beneficial?**

Biogas slurry is free from weed seeds, foul smell and pathogen. It contents major plant nutrients which nourish the soil to accelerate the growth of plants, especially for root growth which enhances crop yield in a sustainable manner. It enhances the aeration and water holding capacity of soil for root penetration resulting in better growth.

68. Generally it is saying that application of biogas slurry is good. What are the scientific points behind this statement?

The application of biogas slurry enhances the fertility of the soil to optimize quality production. Secondary, its dark colour, absorbs more sunlight which results warming up of soil.

69. Is it best to apply liquid slurry to crop?

Yes, application of liquid slurry to crop is one of the best methods for increasing overall yield. Some advantages are mentioned as under-

a. It has better nitrogen component compared to dry and semi dry slurry.

b. It acts as a soil conditioner. Aggregated soil communicates the absorption of the slurry. Moreover the bacteria and fungi growth is enhanced on application of biogas slurry, which is crucial for plant crop yield.

c. Good for acidic soils.

d. Reduces harmful elements like aluminium and minimizes toxicity.

e. Supplies nutrients to beneficial microbes.

f. Changes membrane permeability of root hairs and enhances nutrient uptake.

g. The water holding capacity of the soil increases.

70. Handling of liquid slurry is not more convenient. Are there any machines available for handling?

Liquid biogas slurry can be handled with equipments or manually. The equipment becomes necessary for community biogas plant, which yield large quantity of slurry. It is therefore necessary to develop suitable equipment for handling the slurry and for field application. A few equipments which are in use at different places are as follows:

- Low cost wheel barrow
- Slurry injector
- Slurry cart
- Slurry tanker

For the effective use of slurry, a beneficiary must use the liquid slurry as far as possible. After the application of liquid slurry, excess slurry can be dried in open sun condition. The dried slurry can be converted in to powder form by hitting wooden bamboos. The dried powder can be used in the next sowing period.



71. Is there any other method for storing and transporting the biogas liquid slurry?

From the outlet of the tank, a channel leads Biogas slurry to a filter bed with opening at both ends. A compact layer of green or dry leaves is made in the filter bed. Biogas slurry flows down and gets filtered allowing the preparing fresh slurry. The semi solid residue left on top of the bed can be transported and stored in a pit use when required.

72. Is there any harm in handling the slurry manually?

No. there is no harm in handling the slurry manually as it is free from pathogens which otherwise causes diseases. Most of the harmful organisms like eggs of hookworms are killed in the process of anaerobic digestion. Moreover, the pathogen, which pollutes the ground water gets eliminated.

73. What are different types of Biogas slurry?

Liquid biogas slurry: It has a solid content about 6%, pH value of about 8 to 9 and nitrogen 1.8% along with other nutrients. This is the best form for use.

Semi Dried biogas slurry: It is with solids varying from 15 to 20%, pH value varies from 7 to 9%.This is the next best form for use.

Dry biogas slurry: The slurry coming out from the plant remains in drying pit for some period without application. The solids vary from 50 to 70% and the pH value from 7 to 8. Dry slurry micronutrients but very less as it lost if sun dried.

74. When dung and other fertilizers are available than why biogas slurry alone is preferred?

Fermentation reduces the C/N ratio by removing some of the carbon, which has the advantage of increasing the fertilizing effect. Another favourable effect is that nitrogen and other plant nutrients become mineralizes and hence more readily available to plants. Moreover, well digested slurry is practically odourless, easier to spread and does not attract weeds and insects flies. The following table indicates how biogas slurry is more effective than other organic slurries in relation to NPK.

SI.NO.	Slurry	% content N_2	% content P_2O_5	% content K_2O
1.	Fresh cattle dung	0.3-0.4	0.1-0.2	0.1-0.3
2.	Farmyard slurry	0.4-1.5	0.3-0.9	0.3-1.9
3.	Compost	0.5-1.5	0.3-0.9	08.-1.2
4.	**Biogas slurry**	**1.5-2.5**	**1.0-1.5**	**0.8-1.2**
5.	Poultry slurry	1.0-1.8	1.4-1.8	0.8-0.9
6.	Cattle urine	0.9-1.2	Trace	0.5-1.0
7.	Paddy straw	0.3-0.4	0.8-1.0	0.7-0.9

75. What are the differences in the uses of biogas slurry and urea in general?

The differences are as under:

S.NO.	Biogas slurry	Urea
1.	Balances Nourishment	Imbalanced Nourishment
2.	Pollution free	Causes pollution of water, air etc.
3.	Eco Friendly	Damage to the Ecology
4.	Defense against pests	Vulnerable to pests
5.	Can be made at home	To be bought from outside only
6.	Cost effective	Fluctuating cost
7.	Needs less water	Needs more water
8.	Maintains soil fertility	Spoils the soil strength
9.	No side effect	Many adverse effects
10.	Quality food	Less healthy food
11.	Better health	Poor health
12.	Wholesome	One-sided
13.	Less yield but sustainable returns	More yield and quick returns
14.	Increasing returns	Diminishing returns

76. Chemical fertilizers are easily available in market. Why do we choose a hard way for biogas slurry?

The inorganic chemical fertilizers are harmful in the long run as they do not provide balanced diet to plants, severely affecting the physical, chemical and microbial properties of the soil. The impact of extensive use of inorganic fertilizer is shown as under-

i.) Destroys soil micro flora, especially the nitrogen-fixing bacteria.

ii.) Causes pollution of fresh water reserves.

iii.) Reduces soil porosity, aggregation and ultimately leads to infertility

iv.) Erodes top soil due wind because of missing organic matter in the soil.

v.) It is not cost effective on long term basis.

77. What is the difference between composting & biogas slurry?

S. No.	Composting	Biogas slurry
1.	Unselective degradation by both aerobic and anaerobic microbes causing more weight loss without proportional enrichment of fertilizer value. Both carbon and nit rogen are consumed during degradation.	Selection anaerobic digestion. Weight loss is less. Mainly carbon is consumed for producing methane.
2.	Proper degradation time is 90 to 120 days.	Proper degradation time is 30-40 days.
3.	About 30 -40 % Nitrogen is lost due to evaporation of Ammonia	Loss by evaporation is negligible.
4.	Compost has bad odour.	Odour is minimized.
5.	Some quantity is blown off by wind.	No such loss.
6.	N is less	N, P, K is comparatively more.
7.	Compost has limited macro and micro nutrients.	Biogas slurry has more macro and micro nutrients.

78. Is it possible to replace inorganic fertilizers totally?

It is not possible as to totally replace inorganic fertilizers by biogas slurry use alone. We cannot meet the food needs of billion Indian people. However, to increase the quantity of food, we need to gradually change from inorganic to organic for sustainable returns.

79. Which combination with biogas slurry yields better results?

Biogas slurry along with Gypsum and NPK is showing significant results in the production of crops compared to other combinations.

80. Today, I am switching over to biogas slurry from fertilizers. I think, I will get more yield from today. Is it right?

There will be no instant increase in production due to the switch over. In fact, initially there will be decrease in the yield. But over a period of two to five years, there will be an increase in the quantity and quality of the yield.

81. What are the other uses of biogas slurry?

Biogas slurry is also being used for fish culture, which acts as a supplementary feed. On an average 15-25 litres wet slurry can be applied per day in a 1200 sq. ft. pond. Biogas slurry mixed with oil cake or rice bran in 2:1 ratio increased the fish production remarkably. Biogas slurry can be also used for the production of bio fertilizers like Azolla and aquatic biomass Spirulina.

82. What are the benefits of other nutrients in biogas slurry?

It was noticed from 2 samples of soil collected-one from biogas slurry paddy cultivated land and another from chemically applied land that the bacterial count was 23.3 % more in the slurry applied soils than in the chemical applied soils, resulting in-

- Increase of micronutrients in the soil.
- Improved drainage and better aeration to the root system.
- Improvement in the soil structure.

- Strong Immune system.
- Less number of weeds.
- Less Methane exposure.
- Qualitative improvement in taste, smell, size, colour etc.

83. Why we need to manage the use of Biogas slurry?

The management of slurry is very important in the effective utilization. At present the users just allow biogas slurry to enter lower surface areas resulting in loss of nitrogen. The slurry will be effective if only farmer uses it properly. The farmers are still not aware of the value of biogas slurry and resort to the traditional ways of using the biogas slurry with the agriculture/farm/ cattle waste.

84. Whether biogas slurry can be used daily/fortnightly/ monthly basis?

Yes. It can be used as needed depending on the species grown / compost preparation and its availability.

Daily:

Biogas slurry can be applied daily in kitchen gardens, for vegetables and horticultural plants, this act as a soil conditioner. The biogas slurry can be directly connected to an irrigational channel or applied while watering the plants. However, a study to evolve a proper system to meet the requirement of different crops based on the output and fertility of soil is necessary.

Fortnight/Weekly:

Storage capacity, availability of biomass for compost making and alternate methods for use of biogas slurry through pelletization are to be considered for fortnight/weekly applications.

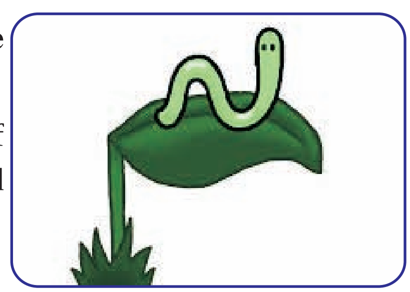
For dry land and cash crops, the slurry can be applied weekly/fortnight.

Monthly:

For paddy and horticultural plants biogas slurry can be used periodically where the application of inorganic fertilizer is less as it is a better substitute without detriment to the yield.

85. How much quantity of digested slurry can be added into fresh slurry?

For about 100 litres of fresh slurry about 2 litres of digested slurry can be added. This will speed up and increase gas production.



86. What are the common operational problems generally encountered with biogas plant?

Defect	Cause	Remedy
No gas after the first filling of the plant.	Lack of time.	It may take 3 – 4 weeks
Slurry level does not rise in inlet and outlet chambers even though gas is being produced.	i. Gas pipe blocked by water condensate. ii. Insufficient pressure. iii. Gas outlet blocked by scum.	a. Add more slurry. b. Check and correct c. Rotate the agitated slurry with a wood pole.
No gas at stove but plenty in the plant.	i. Gas pipe blocked by water condensate. ii. Insufficient pressure. iii. Gas outlet blocked by scum.	a. Remove water condensate from moisture trap. b. Increase weight on gasholder. c. Disconnect the outlet valve from the hosepipe and clean it by pouring water.
Gas does not burn.	Wrong kind of gas	Add properly mixed slurry
Flame far from burner.	Pressure too high or deposition of carbon on the nozzle.	Adjust gas outlet valve and clean nozzle.
Flame dies quickly	Insufficient pressure	Check quantity of gas. Increase pressure by breaking the scum by stirring the slurry.
Unsanitary condition around biogas unit.	- Improper digestion - Improper disposal of slurry	- Add correct quantity of slurry - Use slurry for composting of crop residues

87. What are the maintenances and general care must be taken up after installation of a biogas plant?

Daily

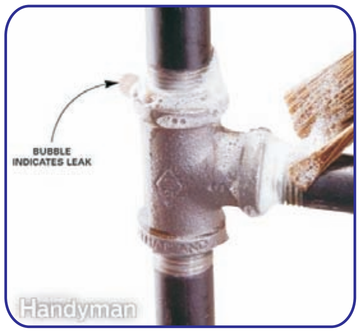
- Add dung slurry to the plant. Keep ratio of dung and water as 1:1.
- Make sure that no stones and sand is getting into the plant during feeding.
- Clean the gas burner.
- The water traps should always contain water otherwise the gas will leak out through the gas trap.

Monthly

Check gas pipeline for leaks with a soap solution.

Annually

- Check for gas and water leaks and repair them.
- Check gas pipelines for leakages.
- At intervals of 5-6 years, check for any solid sediment at the bottom of the digester plant by inserting a long stick in the plant and determining the change in depth. It should be completely emptied to allow for removal of the solids and plastering of the inside portion of the plant. Take the necessary safety precautions when performing this task.



88. What are the safety measures to be taken during the operation of the biogas plant?

Safety measures for floating drum type biogas plant are mentioned as under-

a. It is essential that all the air in the gas holder is released to environment whenever the holder is removed for cleaning, painting and any other purpose.

b. Do not weld the gas holder when it full of gas.

c. Corrosion of the gas holder should be avoided by water jacket seal.

Safety measures for fixed dome type biogas plant the mentioned as under-

a. The main gas outlet valve at the top of the dome must be kept open while feeding dung slurry into the plant for the first time after installation or during the cleaning of the plant.

b. Gas must not be lighted at the main valve on the top of the dome. Otherwise sometimes due to negative pressure or back fire, explosion can take place resulting in damage to the dome and other part of the plant.

c. Inlet and outlet chambers should be covered firmly with stone or concrete slab to prevent children or animals falling in accidently.

89. Are there any other safety measures?

Other safety measures are-

- Check the right position of flame arrester in the pipe line and change it over the period.
- If there is a smell of unburnt gas due to leakage, then the gas must not be lighted and doors and windows should be open to let the gas dissipate.
- Sometimes the upper layer of digested slurry gets dried up but lower remains watery. Nobody should be allowed to walk on the slurry as it may give way and the individual can sink into the plant.

90. Is a biogas facility dangerous?

A biogas plant is a closed system, and the biogas produced therein remains within the system, so if plant operation is done with due care and caution, neither the workers nor the environment are endangered. Even if methane escaped into the atmosphere there would be no serious explosion hazard, since methane is lighter than air. According to its characteristics, biogas mixes easily with air. An air biogas mixture containing 5% methane is explosive, but if a higher air concentration is reached (above 15%), biogas is not flammable anymore. The oxygen concentration in the anaerobic digesters is so low that the content is safe.

91. Is this gas poisonous?

Biogas shouldn't be breath. Due to its methane content (a flammable gas), it should be dealt with in a safe and secure manner. Some of the trace gases that make up about 1% or less of biogas are acidic and can be corrosive to certain kinds of metals and need to be dealt with carefully.

92. Is there any other composition in biogas?

Some properties of naxious gases present in biogas are given in below Table.

Gas	Explosive range		Physiological effect
	Minimum (%)	Maximum (%)	
Ammonia	16	-	Irritant
Carbon di oxide	-	-	Asphyxiate
Hydrogen sulphide	4	46	Poison
Methane	5	15	Asphyxiate

93. Economically wise which biogas plant is better to install?

The cost of installation of the floating drum type biogas plant is about 20-30% higher than of a fixed dome type plant. Maintenance of floating drum biogas plant is also higher than fixed dome biogas plant as the steel drum of the gas holders require painting at least once a year.

94. It is claimed that bio CNG is better than conventional CNG. What does Bio-CNG means?

Bio - CNG means methane gas derived from organic material. It is identical in properties to natural gas, but it is not derived from fossil fuels. Bio - CNG can be produced from biogas which has been cleaned or upgraded to meet natural gas specifications, by the removal of gases such as CO_2 and hydrogen sulphide to leave an almost pure (90 - 98%) methane gas.

95. What will be the major application area for Bio-CNG?

Bio - CNG can be injected into the gas network or compressed for use in natural gas vehicles. Once fed in the gas network, it can provide domestic or commercial cooking and heating, or be used as vehicle fuel in locations remote from the source of the gas.

96. Is Biogas a kind of renewable energy?

Yes, anaerobic digester technology is employed world-wide to create renewable energy. Biogas produced from an anaerobic digester is comprised primarily of methane gas, which can be used instead of fossil fuels to produce energy. This "renewable natural gas" can substitute fossil fuel natural gas for any need including heating, cooking and motive power. Biogas can also be used as fuel to make clean electricity. All of these options provide us with the opportunity to turn organic "waste" and into a valuable renewable energy resource in a sustainable manner.

97. What has been your experience in the niche sector of biogas? Are biogas plants making headway in the states of Rajasthan, Gujarat and Diu-Daman?

There is an ample potential of biogas plant installation in these state. Gujarat has already covered more than 70% of its estimated potential whereas Rajasthan and Diu-Daman have still a lot of scope to work upon. The biogas technology can play an important role in rural and semi urban sectors for fuel and fertilizer production apart from sanitation and environmental benefits in urban areas. Waste recycling through biomethanation is a promising option for electricity generation. The climatic conditions are also favourable in all these three states for biogas generation.

98. How many family type biogas plants has been setup so far in the country?

A total of 4.81 million family type biogas plants have been setup in the country as on Dec, 2015.

99. What steps can be taken for creating better awareness?

Ministry of New and Renewable Energy, GoI, has introduced a unique strategy to ensure mass adoption of biogas plants countrywide. This will require a well developed promotion strategy to activate the sector and incentivize stakeholders.

The University's awareness creation and consumer education programme will take into consideration and address concerns related to the challenges, barriers, risks, constraints and the lessons learned in the biogas sector in India and elsewhere.



100. What is the existing level of awareness among the users?

In India, 4.81 millions of family biogas plants have been built to provide cooking fuel and lighting in rural areas. Over the last 35 years remarkable progress has been made in the development of anaerobic digesters (bioreactors) to increase methane (CH_4) yield and improve its process flow technologies.

Nowadays, thousands of projects around the world, from small dairy farms to large municipal waste water treatment plants, are demonstrating that biogas recovery systems are environmentally and economically sound.

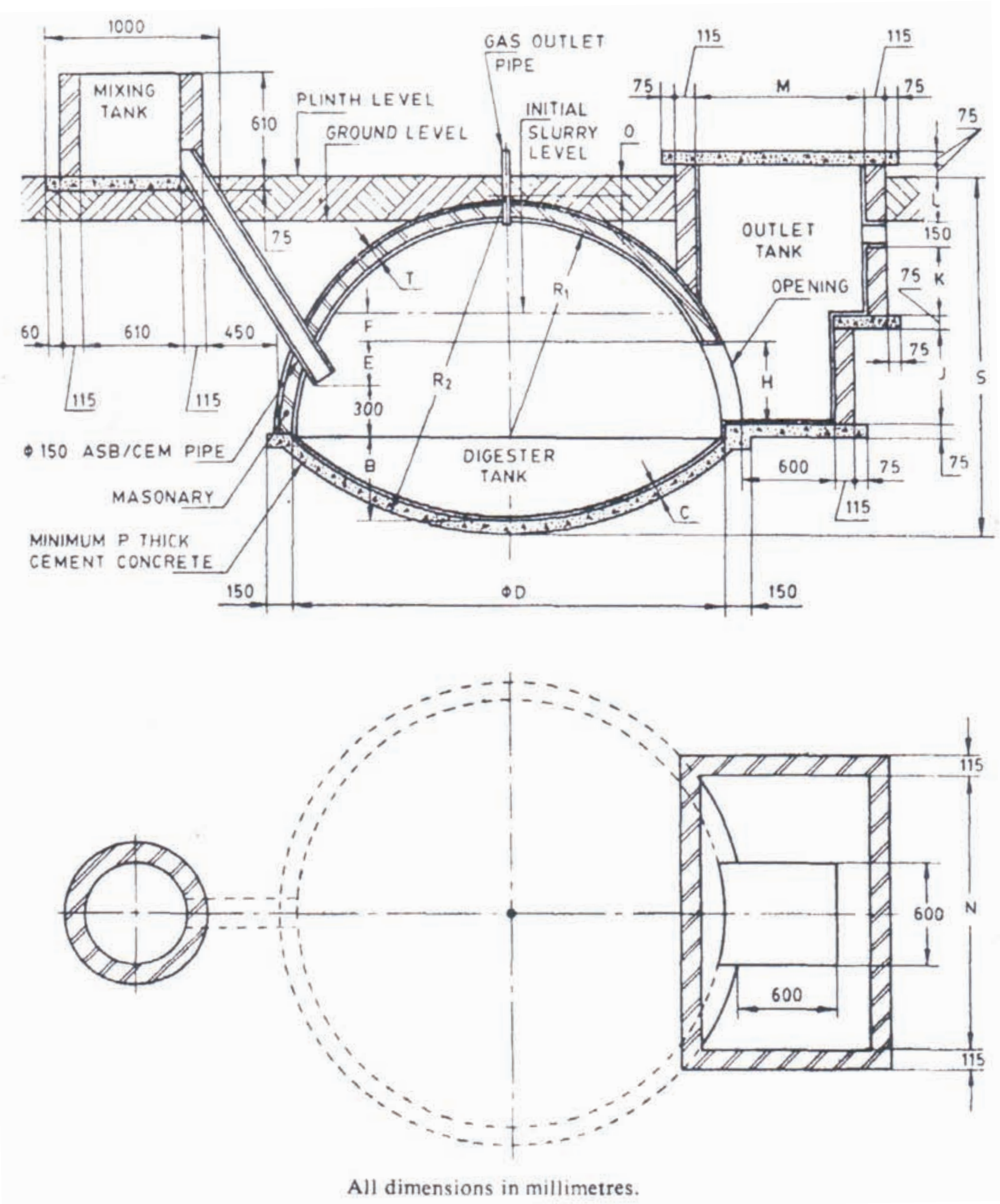


Fig. 1 Layout of Deenbandhu Biogas plant

Table 1. Dimensions of Deenbandhu Biogas Plant

Symbol	Plant Capacity m^3/ day				
	For 40 Days Retention Period All Dimensions are in Centimeter				
	1 m^3	2 m^3	3 m^3	4 m^3	6 m^3
A	105	127.5	145	159	180
B	42	51	58	63.6	72
C	7.5	7.5	7.5	10	10
D	210	255	290	318	360
E	7	24.5	35	42	57
F	18	17.5	20	24	29
G	0	7.5	10	15	20
H	29.5	47.0	57.5	64.5	77
I	50.7	59.7	66.7	74.8	83.2
J	40	57	70	81	96
K	3	40	43	46	46
L	25.7	26.2	27.7	31.7	32.7
M	100	100	100	100	120
N	94	165	232.5	289	362
O	13.8	14.8	18.3	102	26.8
P	7.5	7.5	7.5	10	10
Q	15	15	15	15	20
R_1	105	127.5	145	59	180
R_2	169.5	201.5	228	242	287
S	181.4	212.9	237.4	263.5	292.9
T	7.5	7.5	7.5	11.5	11.5

Table 2 Material Requirements for Deenabandhu Biogas Plants

	40 days Retention Period					55 days Retention Period				
Plant capacity m^3/day	*1*	*2*	*3*	*4*	*6*	*1*	*2*	*3*	*4*	*6*
Bricks (class I) (nos.)	700	1000	1300	1600	2200	800	1100	1500	1900	2500
Cement (Bags)	8	14	16	22	28	9	15	19	25	33
Stone chips (cu. ft)	30	40	50	60	80	35	45	55	70	90
Sand (cu. ft)	30	40	50	60	85	30	40	50	65	90
Coarse Sand (cu. ft)	30	40	50	60	85	35	50	60	65	100
GI pipe 1/2" dia. with socket (inch)	7	7	7	7	7	7	9	9	9	9
AC pipe 6" dia. (ft)	6	6	6	6	6	6	6	6	6	6
Iron bars 6 mm dia. (kg)	5	7	10	12	15	5	7	10	12	15
Paint (Litre)	1	1	1.5	2	3	1	1.5	1.5	2.5	3

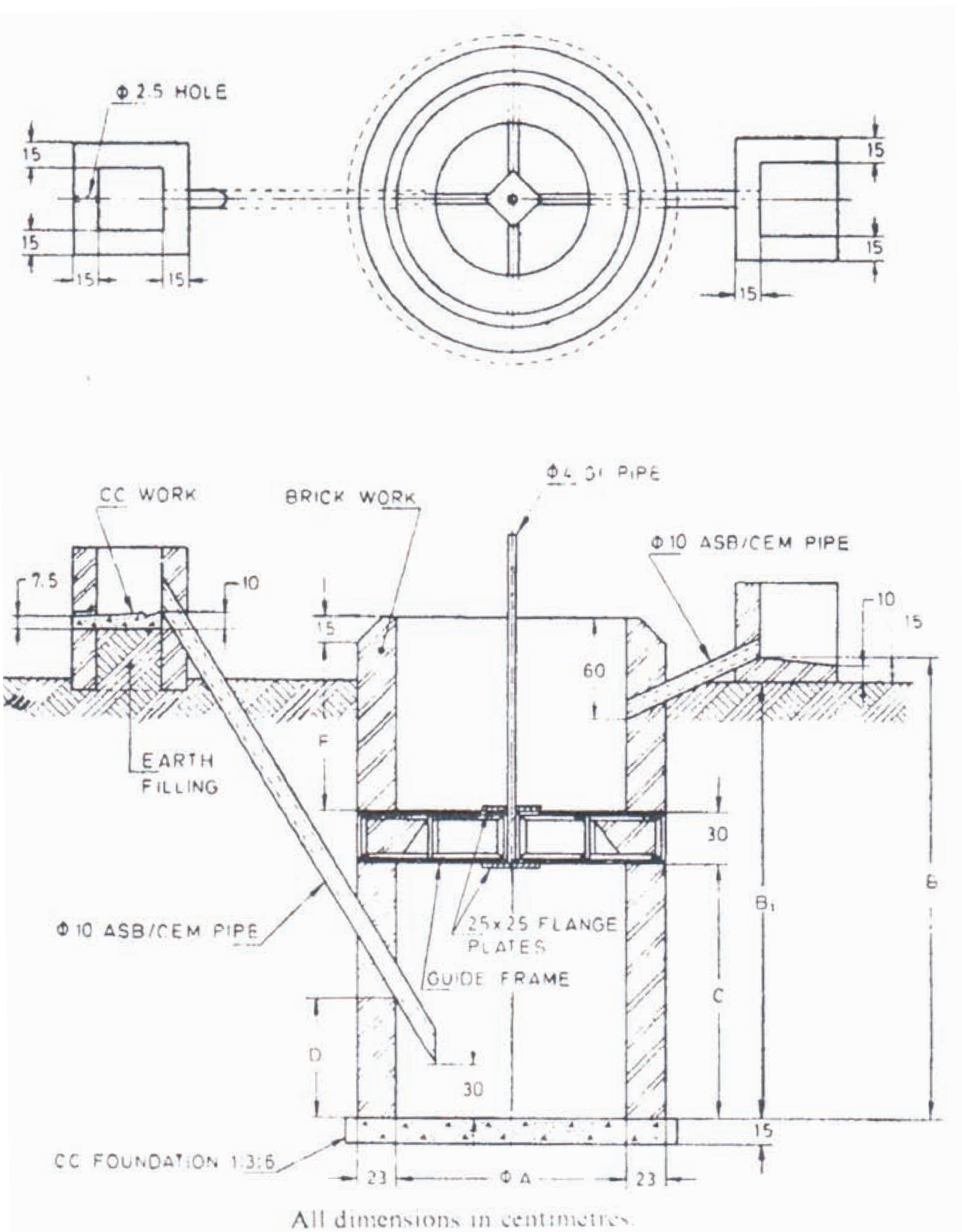


Fig. 2. Layout of KVIC Biogas Plant

Table 3. Dimensions of KVIC Biogas Plant

Code	Bio-Gas Plant Capacity m^3 / day				
	For 40 Days Retention Period All Dimensions are in Centimeter				
	1 m^3	2 m^3	3 m^3	4 m^3	6 m^3
V	2.16	4.32	6.48	8.64	12.96
A	118	128	155	182	220
B	198	336	344	332	341
B_1	175	313	321	209	318
C	108	206	214	202	211
D	60	60	60	60	60
R	2.16	2.16	2.16	2.16	2.16
T	3.92	3.92	3.92	3.92	3.92

V = volume of digester in cubic meter
A = inside diameter of digester in centimeter
B_1 = depth of digester from ground level
B = depth of degester from lower end of outlet in centimeter
C = depth of degester below the central guide frame
D = distance between inlet pipe and bottom of digester
R = ratio of digester and plant capacity
T = ratio of digester and gas holder capacity

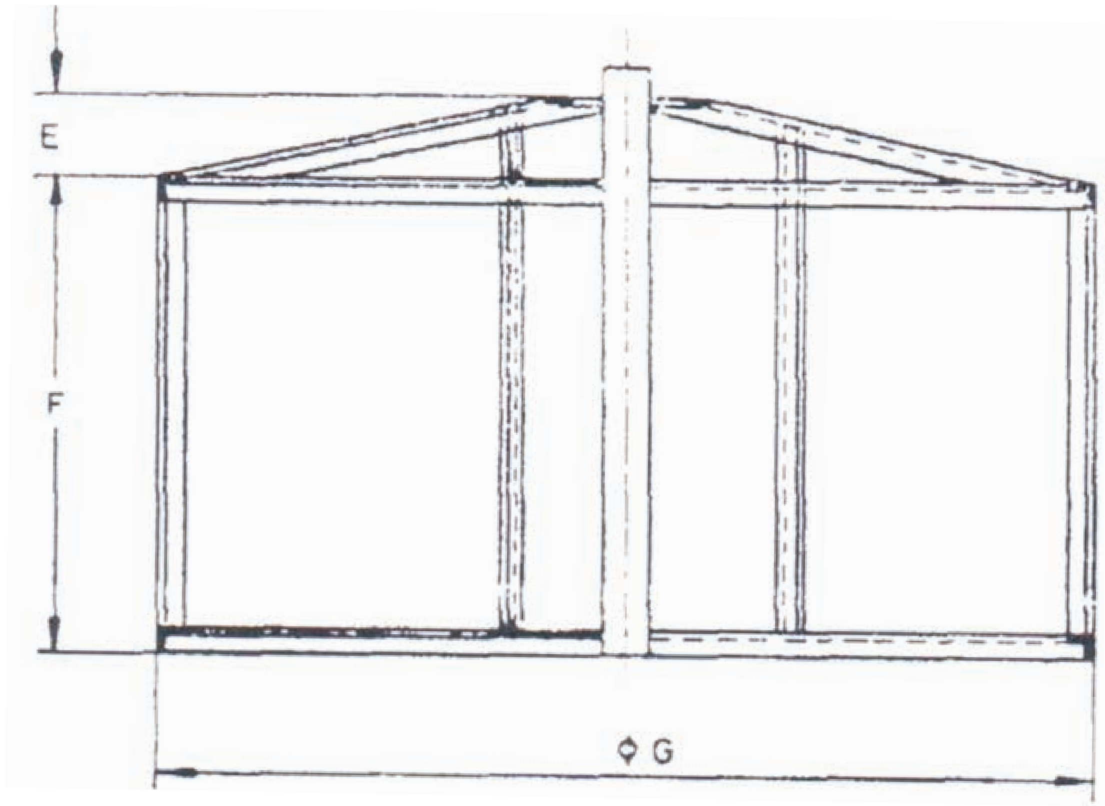
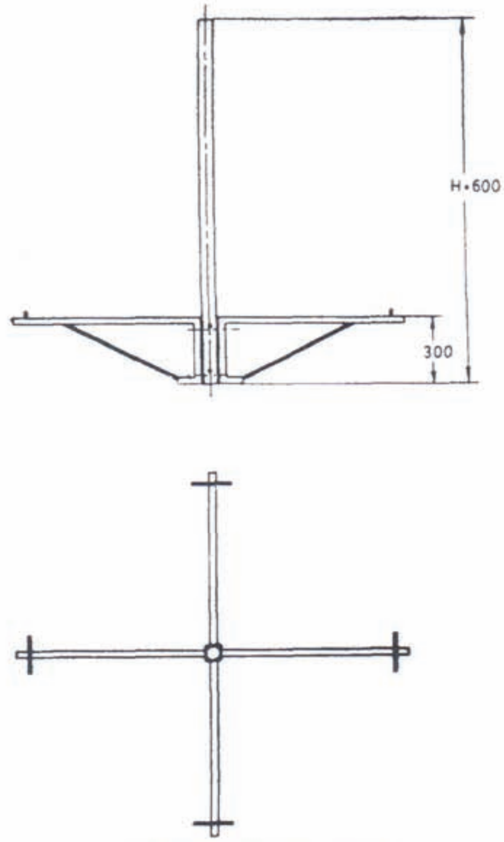


Fig. 3 Design of Gas Holder for KVIC Biogas Plant

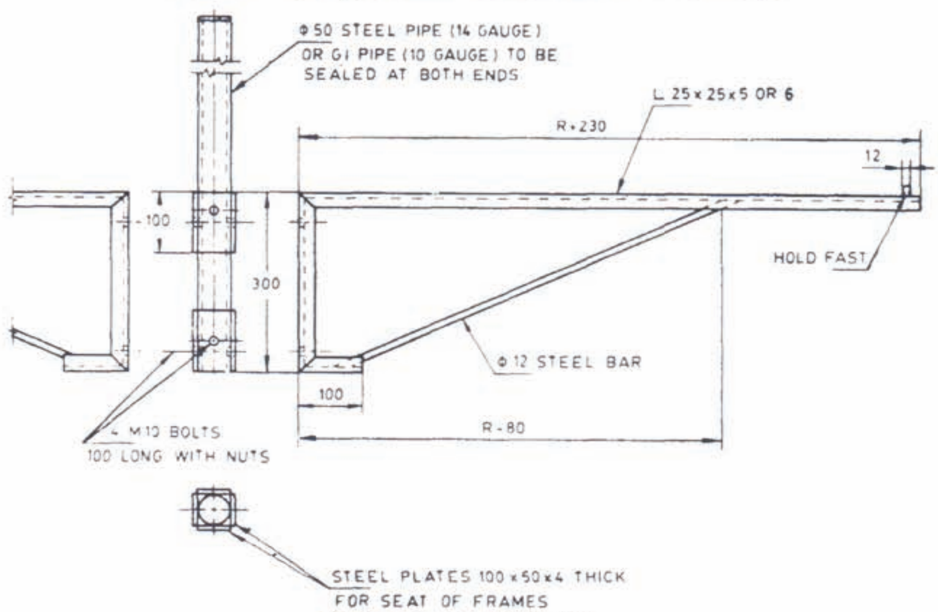
Table 4. Dimensions of gas holder for KVIC Biogas plant

Parameter	Size of the gas plant (m^3)				
	1	2	3	4	6
Volume of the gas holder (m^3)	0.55	1.10	1.65	2.20	3.30
Diameter of the gas holder (G) (in cm)	108.0	118.4	145.0	167.5	205.0
Height of the gas holder (in cm)	60	100	100	100	100
Slope (E) (in cm)	5	5	10	10	15
Thickness of M.S. sheet in SWG	14	14	12	12	12
Size of the MS Angle (in mm)	25×25×4	35×35×5	35×35×5	35×35×5	35×35×5
Size of the MS flat (in mm)	40×6	40×6	40×6	40×6	40×6
Size of the GI pipe (in mm)	50	50	50	80	80



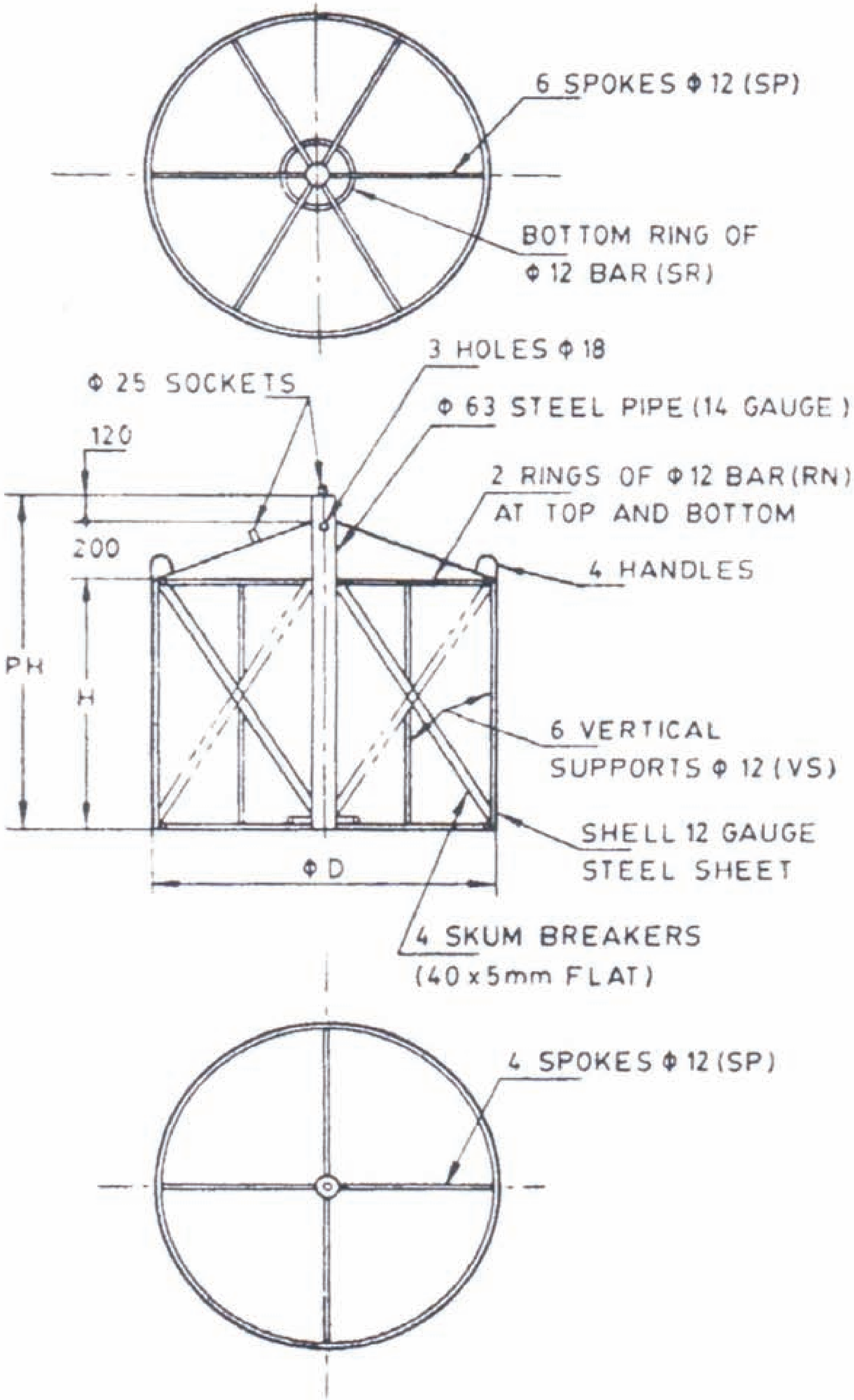
All dimensions in millimetres.

FIG. 7A DETAILS OF GAS HOLDER FOR PRAGATI MODEL



All dimensions in millimetres.

Fig. 4 Details of Gas Holder for KVIC Biogas Plant



All dimensions in millimetres.

Fig. 5 Details of Gas Holder for KVIC Biogas Plant

Table 5. Material Required for KVIC Biogas plant

Size of plant (m3)	*2*	*3*	*4*	*6*	*8*	*10*
1. Material required for construction						
(1) Bricks (no.s)	2460	2770	3210	3730	4430	4650
(2) Sand (m^3)	1.97	2.52	2.90	3.46	4.05	4.18
(3) Stone Chips 1/2" or 3/4" (m^3)	0.60	0.85	0.95	1.25	1.40	1.60
(4) Cement (bags)	13	17	19	23	26	28
(5) A.C. pipe 100 mm internal diameter (R.M.)	3.8	3.6	6.3	6.5	6.6	7.1
II. Material required for central guide frame						
(1) 35 x 35 x 4 or 5 mm angle iron (R.M.)	10.9	11.9	12.7	14.3	15.0	16.5
(2) M.S. Pipe 40/68/80 mm diameter (R.M.)	32 mm	1.85	1.85	2.15	2.15	2.20
(3) Square plate 250 x 250 x 6 mm (nos.)	2	2	2	2	2	2
(4) 14 mm diameter and 32 mm long bolts with nuts (nos.)	16	16	16	16	16	16
III. Materials required for gas holder						
(1) 35 x 35 4 x 5 mm angle iron (R.M.)	16.8	19.4	21.0	30.6	35.3	40.4
(2) M.S. Pipe 50 /80 / 100 mm internal diameter	1.15	1.15	1.25	1.25	1.45	1.50
(3) 250 mm diameter and 6 mm thick flange plate (nos.)	2	2	2	2	2	2
(4) Flats 40 x 6 mm thick (R.M.)	4.2	4.2	4.3	3.5	4.1	4.2
(5) Gas outlet pipe flange 25 mm diameter (nos.)	1	1	1	1	1	1
(6) G.I. bend 25 mm diameter (nos.)	1	1	1	1	1	1
(7) Heavy duty gas value 25 mm diameter (nos.)	1	1	1	1	1	1
(8) M.S. sheet (2.5 m x 1.25 m) (nos.) (12 guage) (2.5 mm)	2.25	3.0	3.25	4.25	4.50	5.5

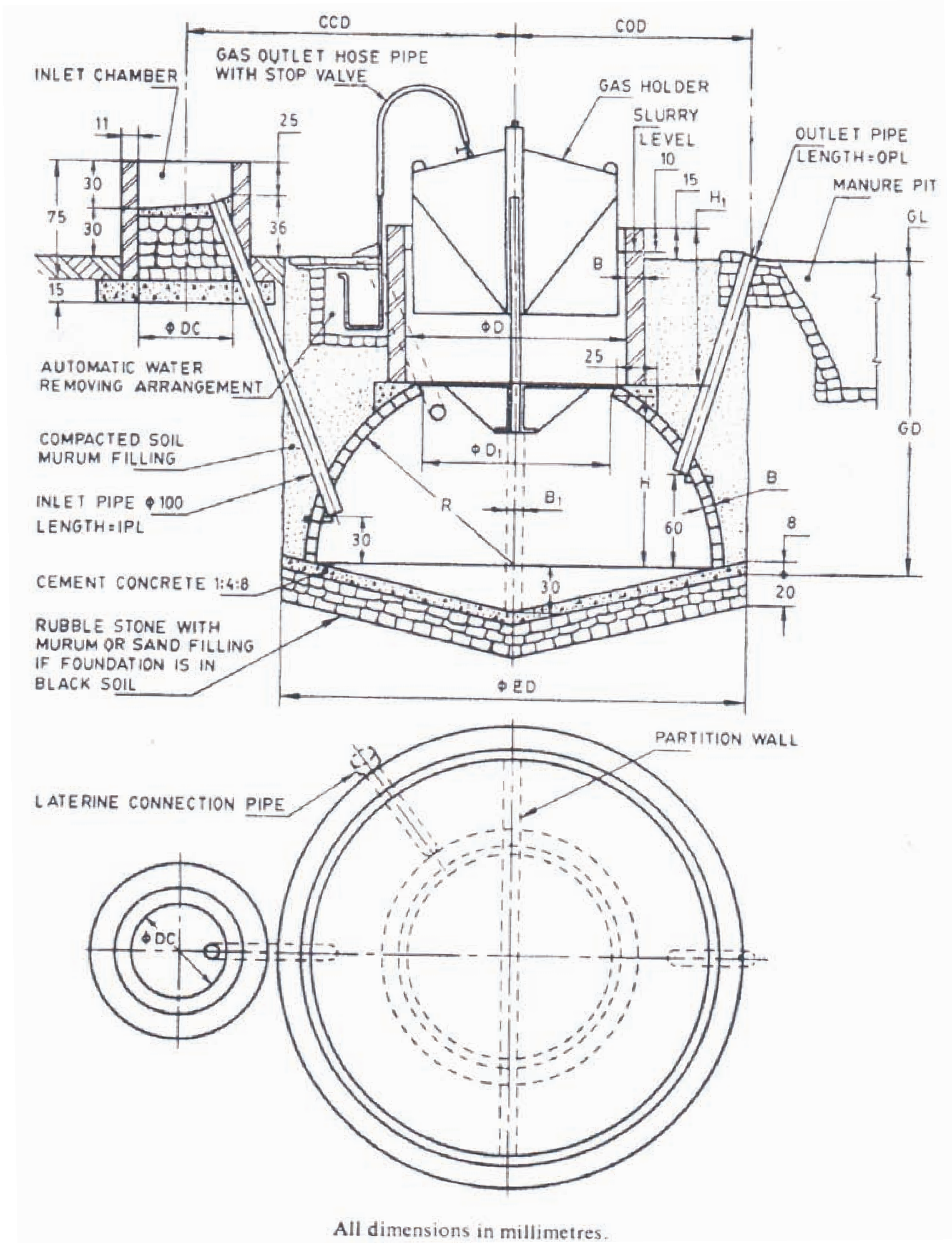


Fig. 6. Layout of Pragati Biogas Plant

Table 6. Dimensions of Pragati Model Bio-Gas Plants and Details for Various Capacities

Description	Code	Plant Capacity m^3 All Dimensions are in Centimeter				
		1 m^3	2 m^3	3 m^3	4 m^3	6 m^3
Digester						
Excavation diameter	ED	255	280	310	330	400
Excavation (excluding conical portion) depth	GD	185	210	220	225	250
Brick Masonry Work						
Hemispherical portion radius	R	120	125	140	150	180
Width (thickness) of shell	B	7	7	7	7	11
Top opening of shell (diameter)	D_1	75	110	140	150	180
Top to toe level height	H	115	125	130	140	165
Top Cylinder portion – Diameter	D	110	135	160	180	215
Top Cylinder portion – Height	H_1	100	110	110	110	110
Top Cylinder portion – Width	B_1	11	11	11	11	11
Inlet Chamber						
Masonry (Inside clear) diameter	DC	50	60	70	80	100
Masonry height		Depending on fundable strata				
Masonry (thickness) width		11	11	11	11	11
Centre to centre distance from digester	CCD	-	190	210	225	265
Centre to centre distance from outlet and digester	COD	-	150	165	175	205
Inlet pipe length	IPL	210	215	220	225	250
Outlet pipe length	OPL	-	136/170	145/180	160/195	180/115
If required latrine connection pipe length		180	180	180	180	180

NOTES
1 Height of gas holder is taken as 100cm. (Depending on the width of M. S. sheets available)
2 Partition wall in the digester not required for 3 m^3 or below.
3 R.C.C. raft in place of bottom concrete is recommended in seismic zone and weaker fundable strata.

Table 7 Details of Gas Holders for Pragati Model Biogas Plants

All Dimensions are in Centimeter

Parameter	Size of the gas plant (m^3)				
	1	2	3	4	6
Diameter	100	120	150	170	200
Radius	50	60	75	85	100
Height	100	100	100	100	100
Skeleton of 12 mm bars Top and bottom rings	315	377.5	472.5	534	628.5
Vertical support	100	100	100	100	100
Nos.	6	6	6	6	6
Horizontal support spoke of 12 mm diameter					
Bars, Top	50	60	75	85	100
Nos.	4	4	4	4	4
Bottom	50	57.5	75.5	82.5	97.5
Nos.	6	6	6	6	6
12mm bar	95	95	95	95	95
Bottom ring scum breaker 4Nos.	111	116	125	131	141
MS. Sheet (2.5m long) Nos.	2	2.5	3	3.5	4.25
M.S. pipe 63 mm diameter	132	132	132	132	132
25 mm Dia B.G. sockets Nos.	2	2	2	2	2
12 mm handles 4 nos. each	90	90	90	90	90
M.S. Sheet cut flaps	To be used out of wastage of M.S. Sheets				

NOTE - Height of gas holder is taken as 100 cm.

Returns from Biogas Plant

(i) For 2 cubic meter biogas plant, daily 50 kg of cattle dung and 50 kg of water is required.

Cattle dung requires throughout the year	=	365 days × 50 kg	=	18250kg
Water required throughout the year	=	365 days × 50 kg	=	18250 kg
Total quantity			=	36500 kg

(ii) If a 2 cubic meter biogas plant is used continuously for a month, it can save 26 kg of L.P.G. that is equivalent to 2 cylinders.

Monthly Saved Cost of 2 LPG cylinders	=	2No. × Rs. 380	=	Rs. 760
(Assume cost of one cylinder is Rs. 380)				
Yearly saving	=	Rs. 760 × 12	=	Rs. 9120

(iii) Approximately 25% of fed slurry is converted into biogas and remaining 75% portion will be back from outlet as digested slurry. This digested slurry is dried upto 25% w.b. moisture content. A total of 10.8 ton dried digested manure can be utilized as fertilizer.

(iv) Total investment

Constructional Cost-	=	Rs. 27860
If cattle dung buy at a cost of Rs. 1 per kg,		
Yearly expenditure incurred for purchasing of 18.25 ton of dung	=	Rs. 18250
Total	**=**	**Rs. 46110**

(v) Returns

First year returns		
Subsidy	=	Rs. 9000
L.P.G. saving	=	Rs. 9120
If digested slurry is sold out at a cost of Rs. 3 per kg		
Yearly income from 10.8 ton slurry	=	Rs. 32400
Total	**=**	**Rs. 50520**

On the basis of above calculation, it can be evaluated that there is no income and no loss in the first year of installation. After the first year, income from the biogas plant is mentioned as under:

Year	Expenditure	Returns	Benefits
Second year	Rs. 18250	Rs. 9120 + Rs. 32400 = Rs. 41520	Rs. 23270
Third year	Rs. 18250	Rs. 41520	Rs. 23270
Fourth year	Rs. 18250	Rs. 41520	Rs. 23270
Fifth year	Rs. 18250	Rs. 41520	Rs. 23270

It can be resulted that a 2 cubic meter biogas plant can save Rs. 23000 approx every year.

Glossary

1. **Acid:** Traditionally considered any chemical compound that, when dissolved in water, gives a solution with a pH less than 7.
2. **Acetic acid-** A carboxylic acid, acetic acid is a relatively weak acid mainly used as a pH buffer (chemical formula CH_3COOH).
3. **Acidogenic Acid-forming**- used to describe microorganisms that break down organic matter to acids during the anaerobic digestion process
4. **Ammonia:** A gaseous compound of hydrogen and nitrogen, NH_3, with a pungent smell and taste.
5. **Anaerobic bacteria**: Micro-organisms that live and reproduce in an environment containing no "free" or dissolved oxygen. Used for anaerobic digestion.
6. **Anaerobic digestion** (Digestion, fermentation): A microbiological process of decomposition of organic matter, in the complete absence of oxygen, carried out by the concerted action of a wide range of micro-organisms. Anaerobic digestion (AD) has two main end products: biogas (a gas consisting of a mixture of methane, carbon dioxide and other gases and trace elements) and digestate (the digested substrate). The AD process is common to many natural environments and it is applied today to produce biogas in airproof reactor tanks, commonly named digesters.
7. **Anaerobic digester** A device for optimizing the anaerobic digestion of biomass and/or animal manure, often used to recover biogas for energy production. Commercial digester types include complete mix, continuous flow (horizontal or vertical plug-flow, multiple-tank, and single tank) and covered lagoon.
8. **Barrel of oil equivalent (BoE):** The amount of energy contained in a barrel of crude oil, i.e. approx. 6,1 GJ, equivalent to 1 700 kWh. A "petroleum barrel" is a liquid measure equal to 42 U.S. gallons (35 Imperial gallons or 159 litters); about 7,2 barrels are equivalent to one tonne of oil (metric).
9. **Base:** Traditionally considered any chemical compound that, when dissolved in water, gives a solution with a pH greater than 7,0.
10. **Batch feed:** A process by which the reactor is filled with feedstock in discrete amounts, rather than continuously. Biochemical conversion: The use of biochemical processes to produce fuels and chemicals from organic sources.
11. **Bioenergy (Syn. Biomass energy):** Conversion of biomass into energy. Organic matter may either be used directly as a fuel or processed into liquids and gases.

12. **Biogas:** A combustible gas derived from decomposing biological waste under anaerobic conditions. Biogas normally consists of 50-60% methane.

13. **Biogas upgrading:** A process whereby a significant portion of the carbon dioxide, water, hydrogen sulfide and other impurities are removed from raw biogas (digester gas) leaving primarily methane.

14. **Biological Oxygen Demand (BOD):** Chemical procedure for determining how fast biological organisms use up oxygen in a body of water.

15. **Biomass feedstock:** Organic matter available on a renewable basis. Biomass includes forest and mill residues, agricultural crops and wastes, wood and wood wastes, animal wastes, livestock operation residues, aquatic plants, fast-growing trees and plants, and municipal and industrial wastes.

16. **Bio-methane:** Biogas which has been upgraded or "sweetened" via a process to remove the bulk of the carbon dioxide, water, hydrogen sulfide and other impurities from raw biogas. The primary purpose of upgrading biogas to biomethane is to use the biomethane as an energy source in applications that require pipeline quality or vehicle-fuel quality gas, such as transportation.

17. **Bioreactor (Syn. Digester):** Device for optimising the anaerobic digestion of biomass and/ or animal manure, and possibly to recover biogas for energy production.

18. **Capacity:** The maximum power that a machine or system can produce or carry safely (The maximum instantaneous output of a resource under specific conditions). The capacity of generating equipment is generally expressed in kilowatts or megawatts.

19. **Cellulose**: A complex carbohydrate, (C6H10O5)n, that is composed of glucose units. Cellulose forms the main constituent of the cell wall in most plants.

20. **Compressed biomethane**: Compressed biomethane (CBM) is basically equivalent to compressed natural gas (CNG). The main difference is that CNG is made by compressing natural gas (a fossil fuel) whereas CBM is made by compressing biomethane (a renewable fuel).

21. **Compressed natural gas**: CNG is natural gas that has been compressed to 3,000 to 3,600 pounds per square inch, gauge (psig), usually for purposes of onboard fuel storage for natural gas vehicles.

22. **Conventional pollutants:** As specified under the Clean Water Act, conventional pollutants include suspended solids, coliform bacteria, biochemical oxygen demand, pH, and oil and grease.

23. **Centralised Anaerobic digestion (CAD):** Supplying slurry from several animal farms to a centrally located biogas plant, to be co-digested with other suitable feedstock.

24. **Combined heat and power generation (CHP) (Syn. Co-generation):** The sequential production of electricity and useful thermal energy from a common fuel source. Reject heat from industrial processes can be used to power an electric generator (bottoming cycle). Conversely, surplus heat from an electric generating plant can be used for industrial processes, or space and water heating purposes (topping cycle).

25. **Desulfurization:** Any process or process step that results in removal of sulfur from organic molecules.

26. **Dew point:** The temperature at which vapor in a gas-vapor mixture starts to condense.

27. **Digester gas:** Biogas that originates from an anaerobic digester.

28. **Digestate:** The treated/ digested effluent from the AD process.

29. **Digester gas:** Biogas that originates from an anaerobic digester. The term is often used, and used in this report, to represent only biogas from a wastewater treatment plant.

30. **Economy of scale:** The principle that higher volume production operations have lower unit costs than smaller volume operations.

31. **Effluent:** The liquid or gas discharged from a process or chemical reactor, usually containing digestate from that process.

32. **Emissions:** Fumes or gases that come out of smokestacks and tailpipes, seep from inside factories or enter the atmosphere directly from oil well flares, garbage dumps, rotting vegetation and decaying trees and other sources. They include carbon dioxide, methane and nitrous oxide, which cause most of the global greenhouse effect.

33. **Endothermic:** A process or reaction that absorbs heat. For example, ice melting is an example of an endothermic process because it absorbs heat from its surroundings.

34. **Energy balance:** Quantify the energy used and produced by the process.

35. **Enteric fermentation:** A digestive process by which carbohydrates are broken down by microorganisms in the rumen to simple molecules for absorption into the bloodstream of a ruminant animal, such as a cow.

36. **Exothermic:** A process or reaction that releases heat. For example, wood burning in the presence of oxygen is an example of an exothermic reaction.

37. **Feedstock:** Any material which is converted to another form or product.

38. **Fossil fuel:** Solid, liquid, or gaseous fuels formed in the ground after millions of years by chemical and physical changes in plant and animal residues under high temperature and pressure. Crude oil, natural gas, and coal are fossil fuels.

39. **Gigawatt (GW):** A measure of electric capacity equal to 1 billion watts or 1 million kilowatts.

40. **Global warming:** A gradual warming of the Earth's atmosphere reportedly caused by the burning of fossil fuels and industrial pollutants.

41. **Greenhouse effect:** The effect of certain gases in the Earth's atmosphere in trapping heat from the sun.

42. **Greenhouse gas (GHG):** Gases that trap the heat of the sun in the Earth's atmosphere, producing the greenhouse effect. The two major greenhouse gases are water vapor and carbon dioxide. Other greenhouse gases include methane, ozone, chlorofluorocarbons, and nitrous oxide.

43. **Grid system:** An arrangement of power lines connecting power plants and consumers over a large area.

44. **Heat exchanger:** Device built for efficient heat transfer from one fluid to another, whether the fluids are separated by a solid wall so that they never mix, or the fluids are directly contacted.

45. **Heat transfer efficiency:** Useful heat output released/ actual heat produced in the firebox.

46. **Heating value:** The maximum amount of energy that is available from burning a substance.

47. **Hemi-cellulose:** A carbohydrate polysaccharide that is similar to cellulose and is found in the cell walls of many plants

48. **Hydraulic retention time (HRT):** HRT is the average time a 'volume element' of fluid resides in a reactor. It is computed from liquid-filled volume of an anaerobic digester divided by the volumetric flow rate of liquid medium.

49. **Joule (J):** Metric unit of energy, equivalent to the work done by a force of one Newton applied over a distance of one meter. 1 joule (J) = 0.239 calories; 1 calorie (cal) = 4.187 J.

50. **Kilovolt (kV):** 1 000 volts. The amount of electric force carried through a high-voltage transmission line is measured in kilovolts.

51. Kilowatt (kW): A measure of electrical power equal to 1 000 watts. 1 kW = 3,413 Btu/hr = 1,341 horsepower.

52. Liquefied biomethane: Liquefied biomethane (LBM) is basically equivalent to LNG (liquid natural gas). The main difference is that LNG is made using natural gas (a fossil fuel) as a feedstock whereas liquefied biomethane is made using biomethane (a renewable fuel) as a feedstock.

53. Landfill gas: Biogas produced as a result of natural, anaerobic decomposition of material in landfills. Landfill gas (LFG) is typically composed of approximately 55% methane and 45% CO2, with variable air content due to air introduced during the LFG collection process. Small amounts of H2S, siloxanes, other sulfur compounds, various trace hydrocarbons and other impurities can be present which provide a significant challenge in LFG handling and upgrading.

54. Liquefied natural gas: A natural gas in its liquid phase. Liquefied natural gas (LNG) is a cryogenic liquid formed by cooling natural gas to approximately - 260º F at atmospheric pressure. In practice, LNG is typically stored at somewhat elevated pressures (e.g., 50 to 75 psig) to reduce cooling requirements and allow for pressure increases due to LNG vapor "boil off." LNG is stored in doubleinsulated, vacuum-jacketed cryogenic tanks (pressure vessels) to minimize warming from the external environment. LNG is typically greater than 99% methane.

55. Kilowatt-hour (kWh): The most commonly-used unit of measure telling the amount of electricity consumed over time. It means one kilowatt of electricity supplied for one hour.

56. Mesophilic digestion: Takes place optimally around 37°-41°C or at ambient temperatures between 20°-45°C where mesophiles are the primary micro-organism present.

57. Methane (CH_4): A flammable, explosive, colourless, odourless, tasteless gas that is slightly soluble in water and soluble in alcohol and ether; boils at – 161,6ºC and freezes at –182,5ºC. It is formed in marshes and swamps from decaying organic matter, and is a major explosion hazard underground. Methane is a major constituent (up to 97%) of natural gas, and is used as a source of petrochemicals and as a fuel.

58. Municipal solid waste (MSW): All types of solid waste generated by a community (households and commercial establishments), usually collected by local government bodies.

59. Nitrogen or nitric oxides: NOx is a regulated criteria air pollutant, primarily NO (nitric oxide) and NO_2 (nitrogen dioxide). Nitrogen oxides are precursors to photochemical smog and contribute to the formation of acid rain, haze and particulate matter.

60. **Nitrous oxide:** N_2O, a greenhouse gas with 310 times the global warming potential of carbon dioxide.

61. **Nonconventional pollutants:** Pollutants not classified as conventional or toxic but which may require regulation. They include nutrients such as nitrogen and phosphorus.

62. **Oil equivalent:** The tonne of oil equivalent (toe) is a unit of energy: the amount of energy released by burning one tonne of crude oil, approx. 42 GJ.

63. **Power:** The amount of work done or energy transferred per unit of time.

64. **Process heat:** Heat used in an industrial process

65. **pH:** An expression of the intensity of the alkaline or acidic strength of water. Values range from 0-14, where 0 is the most acidic, 14 is the most alkaline and 7 is neutral.

66. **Plant:** A facility containing prime movers, electric generators, and other equipment for producing electric energy.

67. **Renewable resources:** Naturally replenishable, but flow-limited energy resources. They are virtually inexhaustible in duration, but limited in the amount of energy that is available per unit of time. Renewable energy resources include: biomass, hydro, geothermal, solar and wind. In the future they could also include the use of ocean thermal, wave, and tidal action technologies. Utility renewable resource applications include bulk electricity generation, onsite electricity generation, distributed electricity generation, non-grid connected generation, and demand-reduction (energy efficiency) technologies.

68. **Sludge:** Bio-solids separated from liquids during processing. Sludge may contain up to 97% water by volume.

69. **Sustainable:** An ecosystem condition in which biodiversity, renewability and resource productivity are maintained over time.

70. **Thermophilic digestion:** Anaerobic digestion which takes place optimally around 50°C-52°C but also at elevated temperatures up to 70°C, where thermophiles are the primary micro-organisms (bacteria) present.

71. **Total Solids:** Total solids (TS) means the dry matter content, usually expressed as % of total weight, of the prepared feedstock. By definition, TS = 100% – moisture content % of a sample.

72. **Volatile organic compounds:** VOCs are non-methane, non-ethane, photo reactive hydrocarbon gases that vaporize at room temperature (methane and ethane are not photo reactive).

73. **Volatile Solids:** Volatile Solids (VS) are the organic (carbon containing) portion of the feedstock. It is usually expressed as a fraction of total solids, but sometimes expressed as a fraction of total sample (wet) weight. The amount of VS in a sample is determined by an analytical method called "loss on ignition."

74. **Volatile fatty acids (VFA):** These are acids that are produced by microbes in the silage from sugars and other carbohydrate sources. By definition they are volatile, which means that they will volatilise in air, depending on temperature. These are the first degradation product of anaerobic digestion prior to methane creation.

75. **Volts:** A unit of electrical pressure. It measures the force or push of electricity. Volts represent pressure, correspondent to the pressure of water in a pipe. A volt is the unit of electromotive force or electric pressure analogous to water pressure in pounds per square inch. It is the electromotive force which, if steadily applied to a circuit having a resistance of one ohm, will produce a current one ampere.

76. **Watt (W):** A standard unit of measure (SI System) for the rate at which energy is consumed by equipment or the rate at which energy moves from one location to another. It is also the standard unit of measure for electrical power. The term 'kW' stands for "kilowatt" or 1 000 watts. The term 'MW' stands for "Megawatt" or 1000000 watts.

Conversion units

Kilowatt (kW) = 1 000 Watts

Megawatt (MW) = 1 000 kW

Gigawatt (GW) = 10^9 Watt

Terawatt (TW) = 1 thousand million kW

1 Joule (J) = 1 Watt second = 278 x 10^{-6} Wh 1Wh = 3 600 J 1 cal = 4,18 J

1 British Thermal Unit (BTU) = 1 055 J

1 cubic meter (m^3) = 1 000 liter (L)

1 bar = 100 000 pascal (Pa)

1 millibar = 100 Pa

1 psi = 689476 Pa

1 torr = 13332 Pa

1 millimeter mercury (0°C) = 13332 Pa

1 hectopascal (hPa) = 100 Pa

POSITIVE EFFECTS OF BIOGAS PLANTS

A Survey Report by BDTC, Udaipur

1. Reduction in bad smell of raw materials presently fed to the biogas plant mentioned by 96% of the owners
2. Produced biogas was used for cooking by 97% of the owners and for lighting by 12% of the owners.
3. Most of the female users (94%) mentioned that the amount of gas was sufficient to meet the cooking needs.
4. Approximately 90% of female users mentioned Biogas plant is a time saving product. Now these users spending their time especially on education of children (mentioned by 50% of all female users), household works (mentioned by 33% of all female users) and gardening (mentioned by 27% of all female users).
5. Biogas plants save time of cooking (mentioned by 97% of all female users)
6. No smoke during use of biogas stoves (mentioned by 98% of all female users)
7. Cooking utensils do not become dirty (mentioned by 89% of all female users)
8. Use of biogas for cooking is safe (mentioned by 95% of all female users)
9. Bio-slurry used by 79% of all biogas plant owners, mostly as fertiliser (74%), but also as fish feed (5%).
10. Remaining owners drained the slurry (12%), sold it (2%) or gave it to others (6%).
11. Increased crop production through use of bio-slurry was reported by 60% of the owners.
12. Increased fish production through use of bio-slurry was reported by the owners.
13. Application of biogas for cooking can save approximately Rs. 6000 per annum per household.
14. Biogas helps to keep the environment hazard free and hygienic
15. Use of biogas helps to keep kitchen and clothes clean
16. Use of biogas does not irritate eyes
17. Biogas plants have encouraged people to rear more cattle heads
18. Bio-slurry is used in sericulture
19. Biogas plants save forests and trees

Annexure - 1

S.No	Locations	Name of Institution	States Covered
1.	**Guwahati**	Dr. Pinakeswar Mahanta, Assistant Professor & Head, Department of Mechanical Engineering, Indian Institute of Technology, Guwahati, North Guwahati, Guwahati- 781039 Ph: 0361-258-2651/2662 (O), Fax: 0361- 2690762 Mob:- 09435734561 E_mail: pinak@iitg.ernet.in	All North-Eastern Region States including Sikkim and West Bengal
2.	**Bangalore**	Dr. V. Kumar Gouda, Biogas Development and Training Center, Department of Agricultural Engineering, University of Agricultural Sciences, GKVK, Bangalore- 560065 Ph: 080- 23330153/335, 080- 23640206 ® M-9901069131 E-mail: vkgouda@rediffmail.com	Goa and Karnataka
3.	**Indore**	Prof. S.P. Singh Director, Biogas Development and Training Centre, Centre of Energy Studies and Research (CESR), Devi Ahilya Vishwavidyalaya, Khandwa Road, Indore- 452017. Ph: 0731- 2460309, Fax: 0731- 2467378/2462366 ® 0731- 2446803 Mob: 09424009418 Email: spsanjali@yahoo.co.in	Chhattisgarh, Madhya Pradesh and Maharashtra
4.	**Ludhiana**	Dr. Sarabjit Singh Sooch, (PI) Research Engg & Incharge BDTC Dept. of Civil Engg. Punjab Agricultural University, Ludhiana141004, Punjab Ph: 9872084513 (M), 09501034513 (M), 0161-2401655(F) sssooch@rediffmail.com	Punjab, Himachal Pradesh, Uttrakhand and Jammu & Kashmir

5.	**Udaipur**	Dr. Deepak Sharma Head, Deptt. of Renewable Energy Engineering Coordinator, Biogas Development and Training Centre, College of Technology & Agricultural Engineering, Maharana Pratap University of Agriculture & Technology, Udaipur-313001 (Rajasthan) Ph: 0294-2471068 (O), 0294-2414021(R) Mob.: 9414160221 Email: deepshar@rediffmail.com Web.: www.ctae.ac.in	Gujarat, Rajasthan and Daman & Diu
6.	**Coimbatore, Tamil Nadu**	Prof. (Dr.) S. Kamaraj 094439-34139 Coordinator, Biogas Development and Training Centre, Agricultural Engineering and Research Institute, Tamilnadu Agricultural University, Coimbatore - 641003. Ph: 0422- 6611526, 527, 545 Fax: 0422- 6611454 Email., bioenergy@tnau.ac.in , kamarajs@hotmail.com Mob.: 9442961793	Tamil Nadu, Pondicherry, Kerala, Andaman & Nicobar and Lakshadweep
7.	**Delhi**	Prof. V.K. Vijay Programme Coordinator, Biogas Development and Training Centre, Center for Rural Development & Technology (CRDT), IIT Hauz Khas, New Delhi- 110016 M- 9871366611 Ph: 011- 26596351, 26596311, Fax: 011- 26591121, 26596351 Email: vkvijay@rdat.iitd.ernet.in bdtciitd@gmail.com	Haryana, Uttar Pradesh and NCR Delhi
8.	**Odisha**	Dr. Snehasish Mishra, Associate Professor (PI-BDTC), School of Biotechnology, Kalinga Institute of Industrial Technology (KiiT), **Bhubaneswar 751024. Odisha,** Email: smishra@kiitbiotech.ac.in, snehasish.mishra@gmail.com Mob.: 9437110305, 9438669414 Fax No. 0674-2725732	Andhra Pradesh, Odisha, Bihar and Jharkhand

List of officers

Ministry of New & Renewable Energy
Block No. 14, CGO Complex, Lodhi Road, New-Delhi

S.no.	Name and Designation	Contact Details
1	Sh. Upendra Tripathy Secretary	Off:+91-11-24360359 Fax:+91-11-24367861 Res:+91-11-23388368 Email: tarun.kapoor@nic.in
2	Ms. Varsha Joshi Joint Secretary	Off:+91-11-24361027 Fax:+91-11-24367413 Res:+91-11-28052890 Email: varsha.joshi@nic.in
3	Sh. G.L. Meena Advisor, Bio Energy Head NBMMP & BDTC	**Off: +91-11-**24368904 Email: gl.meena@nic.in
4	Dr. B.S. Negi Director, R&D Coordination and Biogas Power (Off Grid Programme)	**Off: +91-11-** 24368581 Email: negi.nic.in
5	Sh. Sita Ram Meena Biogas R&D	**Email: meena.sr@nic.in**

Maharana Pratap University of Agriculture & Technology, Udaipur

S.no.	Name and Designation	Contact Details
1	Dr. P. K. Dashora Vice Chancellor	0294-2471101
2	Dr. B. P. Nandwana Dean, CTAE	09414472732
3	Dr. Deepak Sharma Coordinator-BDTC & Head, Deptt.of REE	09414160221 Email: deepshar@rediffmail.com

INTERVIEW

Dr. Deepak Sharma
Professor & Head Department of Renewable Energy Engineering. College of Technology & Engineering, Maharana Pratap University of Agriculture & Technology

"There is an ample potential of biogas plant installation in Gujarat and Rajasthan"

Dr.Deepak Sharma in discussion with Energetica India opens a new subject on industry and academic collaboration in India's renewable energy industry and the research work being done at educational institutes.

Energetica India: Please introduce us to your work in the field of renewable energy?

Dr. Deepak Sharma: I have been engaged in research, teaching and extension activities in the field of renewable energy for the last 33 years, actively involved in designing the course curriculum for Ph.D. and M.Tech. courses in Renewable Energy Engineering. The activities of Biogas Development and Training Centre at national level have been coordinated by me since long. Publications of text book chapter, booklets, technical bulletins, research paper in national and international journals, participation in International and national conferences/Seminars/Workshops etc. as convenor/expert/delegate and development of technologies for energy efficiency are key areas of my work. I have been associated with many Universities/Colleges as examiner and expert.

Energetica India: What has been your experience in the niche sector of biogas? Are biogas plants making headway in the states of Rajasthan, Gujarat and Diu-Daman?

Dr. Deepak Sharma: There is an ample potential of biogas plant installation in these state. Gujarat has already covered more than 70% of its estimated potential whereas Rajasthan and Diu-Daman have still a lot of scope to work upon. The biogas technology can play an important role in rural and semi urban sectors for fuel and fertilizer production apart from sanitation and environmental benefits in urban areas. Waste recycling through biomethanation is a promising option for electricity generation. The climatic conditions are also favourable in all these three states for biogas generation.

Energetica India: What kind of progress is education in renewable energy engineering making in India?

Dr. Deepak Sharma: There are sincere efforts being put in by the government and private sector to harness the energy sources which are renewable and eco-friendly through various technological innovations. The renewable energy engineering education in India is making headway in bridging the gap between technology seekers, financial institutions, government and industrial sector through promoting efficient utilization of natural resources and waste management systems. This, on the one hand, secures energy availability (the demand of which is growing rapidly) and reduce the production cost, on the other side.

Energetica India: How many students easily manage to find opportunities after completing their education in renewable energy?

Dr. Deepak Sharma: The students after completing their higher education in renewable energy from MPUAT are absorbed in industries promoting establishment of power generation plants. Few students also prefer to get jobs in R&D/academic institutions for solving need based regional waste management issues. The trend of inter disciplinary work on smart grid through wind and solar energy, renewable energy certificates, renewable purchase obligations, green buildings, PV efficiency, etc. have attracted students of mechanical, electrical, electronics, civil, agricultural engineering background to work on various development issues after obtaining M.Tech/Ph.D. in Renewable Energy Engineering.

Energetica India: Is the industry collaborating with educational institutes to provide internship and on-field training?

Dr. Deepak Sharma: Yes, the industries are readily collaborating with educational institutes to provide internship and on-field training for the students pursuing degree course in renewable energy sector. The industries are particularly interested in ensuring power supply at decentralized level as these projects enjoy favourable regulations policies.

Energetica India: What kind of technical innovations can we see from your department and students?

Dr. Deepak Sharma: The Department of Renewable Energy Engineering, CTAE, Udaipur through the faculty and students have set future goals to work on following areas mainly for technical innovation:

- Development of thermo-electric generator based biomass cook stoves for community use with higher thermal efficiency which could be fulfilled by technological intervention only from young technocrats.
- Utilization of biogas as transport fuel (bio-CNG) on commercial basis to support large scale charitable live stock farms for income generation and processing of waste.
- R&D on cold storage facilities for rural/semi urban areas based on renewable energy sources to minimise post harvest storage losses.
- Combined Heat and Power system development for meeting industrial sector energy demand through own resources.
- Entrepreneurship model development for solar, biomass and improved cook stoves popularization.

Activity at a Glance