पेयजल एवं स्वच्छता विभाग
जल शक्ति मंत्रालय
भारत सरकार

DEPARTMENT OF DRINKING WATER AND SANITATION
MINISTRY OF JAL SHAKTI
GOVERNMENT OF INDIA

सत्यमेव जयते

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एक कदम स्वच्छता की ओर

MANUAL FOR GOBAR-Dhan

2022





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ABBREVIATIONS

BCM	:	Billion Cubic Meter
CBG	:	Compressed Biogas
C/N ratio	:	Carbon to Nitrogen Ratio
GP	:	Gram Panchayat
HRT	:	Hydraulic retention time
HDPE	:	High-density polyethylene
ICAR	:	Indian Council of Agricultural Research
KVIC	:	Khadi and Village Industries Commission
LPG	:	Liquefied Petroleum Gas
MoPNG	:	Ministry of Petroleum and Natural Gas
MMT	:	Million Metric Ton
MNRE	:	Ministry of New and Renewable Energy
NNBOMP	:	New National Biogas and Organic Manure Programme
NPK	:	Nitrogen, Potassium and Sodium
ODF	:	Open defecation free
O&M	:	Operation & Maintenance
PAU	:	Punjab Agricultural University
RLBs	:	Rural Local Bodies
SBM (G)	:	Swachh Bharat Mission – Grameen
SLWM	:	Solid and Liquid Waste Management
15^{th} FC	:	15^{th} Finance Commission
TS	:	Total Solids

CHAPTER 1

INTRODUCTION

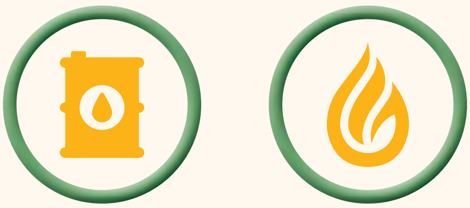
1.1 Background

Swachh Bharat Mission (Grameen) (SBM [G]) was launched on 2nd October 2014 to achieve Open Defecation Free (ODF) India by 2nd October 2019. On achieving the seemingly impossible task by generating a people's movement at the grass-root, SBM (G) Phase II was launched to focus on the sustainability of ODF status and Solid and Liquid Waste Management (SLWM). SBM (G) Phase-II is being implemented on a mission mode from 2020–21 to 2024–25. Under SLWM, Biodegradable Waste Management (BWM) is a major component where organic waste generated in villages is treated by composting, vermicomposting and biomethanation/biogas processes.

In India, the locally generated biomass plays a very important role in meeting the cooking fuel need of the villagers – the biomass is usually collected (in the form of harvested crop stems and crop residues) and stored by the villagers at the time of harvesting of crops for personal use and also give it to landless agricultural laborers. Rural energy demand in many of the developing countries at present is met by renewable natural resources and would continue to play an important role in meeting the energy needs of the rural people, therefore its efficient use has to be looked at very critically.

India is among the fastest-growing economy in the world and its energy consumption is slated to increase rapidly. Energy is an essential factor in the development of the country. According to the estimates provided by the Ministry of Petroleum and Natural Gas (MoPNG), India has a total reserve of 763 Million Metric Ton (MMT) of crude oil and 1,488 Billion Cubic Meter (BCM) of natural gas. The country currently imports nearly 77 per cent of its crude oil requirements and about 50 percent of natural gas requirements. Government of India has set a target of reducing this import by at least 10 per cent by 2022. Further, it has set a target of increasing the contribution of gas in India's energy mix from the existing 6.5 per cent (global average is 23.5 per cent) to 15 per cent by 2022.

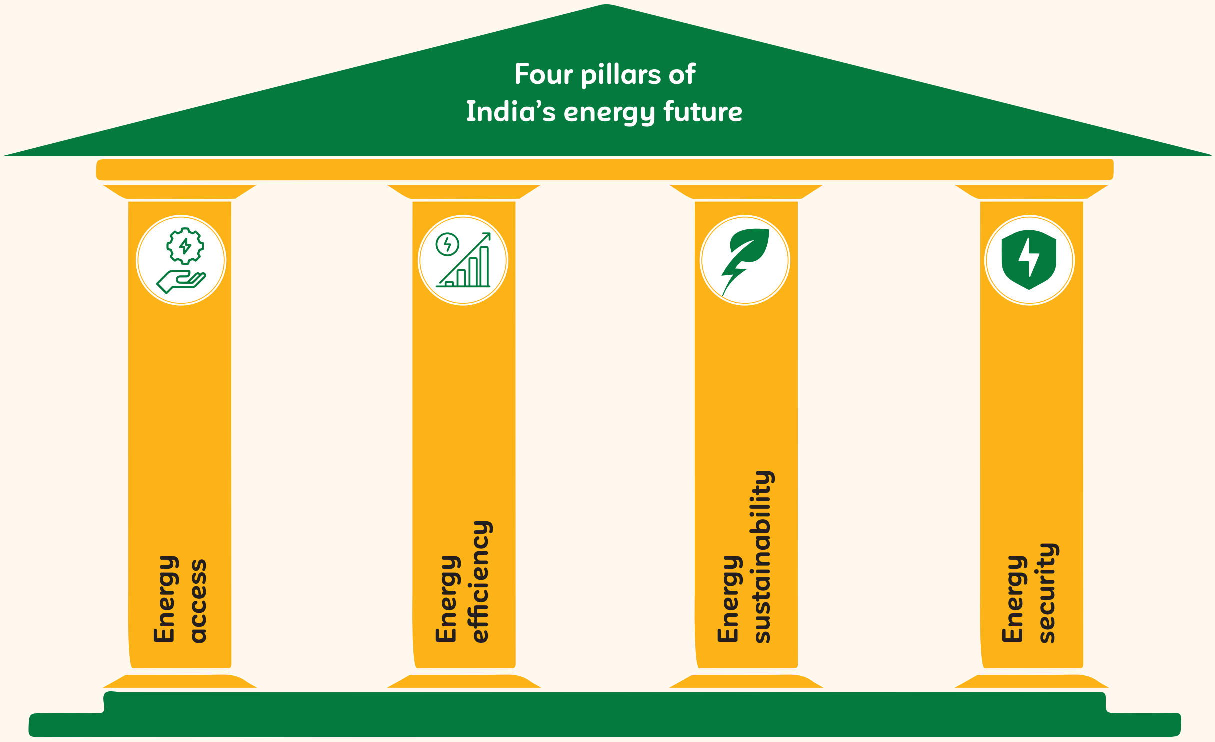
Imports of crude oil and natural gas[4]



About **77%** of crude oil requirement

About **50%** of natural gas requirement

Hon'ble Prime Minister has given the following four pillars of our vision of India's energy future – energy access, energy efficiency, energy sustainability and energy security. The Government of India has also set a target of 'Doubling Farmers Income by 2022'. Rural India generates enormous quantities of bio-waste, which can be harnessed to meet the energy demand.



In India, one of the biggest advantages is that one can produce biogas at home due to the availability of the feedstock in the household itself. This is most beneficial to people in India because it would help ease the strain of delivering reliable energy sources based on fossil fuels and would allow the country to become more energy independent.

1.2 GOBARDHAN

GOBARDHAN was launched by the Government of India in April 2018. It is an integral component of solid waste management for ensuring cleanliness in villages by converting bio-waste including animal waste, kitchen leftovers, crop residue and market waste into biogas and bio-slurry to improve the lives of villagers. This is also useful in providing economic and resource benefits to farmers and households.

Under SBM (G) financial assistance of Rs. 50 lakh per district is available for setting up model GOBARDHAN projects. Cluster and community level biogas plants can be constructed at village/block/district level. But at least one model community-level biogas plant per district is mandatory under the programme. The states and districts can plan more projects in convergence with other schemes like NNBOMP of Ministry of New and Renewable Energy (MNRE) or using 15th Finance Commission (FC). For model GOBARDHAN projects, the districts should preferably take up community-level projects near Gaushalas for an uninterrupted supply of organic wastes to make the projects sustainable in the long run as well as to promote business models.

Additionally, more GOBARDHAN projects may be set up by block at cluster/community levels in the villages with the 15th FC grants to RLBs or other resources of Gram Panchayat (GP)/district/state, as per the financial assistance norms under NNBOMP of MNRE. Appropriate business models to be used for setting up more projects at the village/GP/block/district level. The state/

district may also emulate the model projects for setting up more GOBARDHAN projects at village/ Gram Panchayat/Block/District level, wherever needed and feasible/viable, from their sources or other funds or convergence with other schemes of State or Central Governments.

The details of different models and the funding sources can be seen in the "Framework for implementation of GOBARDHAN" which is available on unified portal of GOBARDHAN. (https://sbm.gov.in/gbdw20/ManualPage.aspx)

CHAPTER 2

BIOGAS PLANTS, PROCESS, BENEFITS

Biogas is a type of biofuel that is naturally produced from the anaerobic decomposition of organic waste. When organic matter, such as food waste and animal waste, breaks down in an anaerobic environment (an environment absent of oxygen), they release a blend of gases, primarily methane and carbon dioxide. Due to the high content of methane in biogas (typically 50–65 % per cent) biogas is flammable, and therefore produces a deep blue flame, and can be used as a fuel source. Biogas is a mixture of gases whose composition is as follows:

Table 1: Composition of biogas

Composition	%
Methane (CH_4)	50–65%
Carbon dioxide (CO_2)	30–40%
Hydrogen (H_2)	1–5%
Nitrogen (N_2)	1%
Hydrogen sulphide (H_2S)	0.1%
Oxygen (O_2)	0.1%
Water vapors (H_2O)	0.1%

Biogas is an excellent and effective means to promote the development of rural and marginalized communities in the country.

2.1 Biogas Equivalents

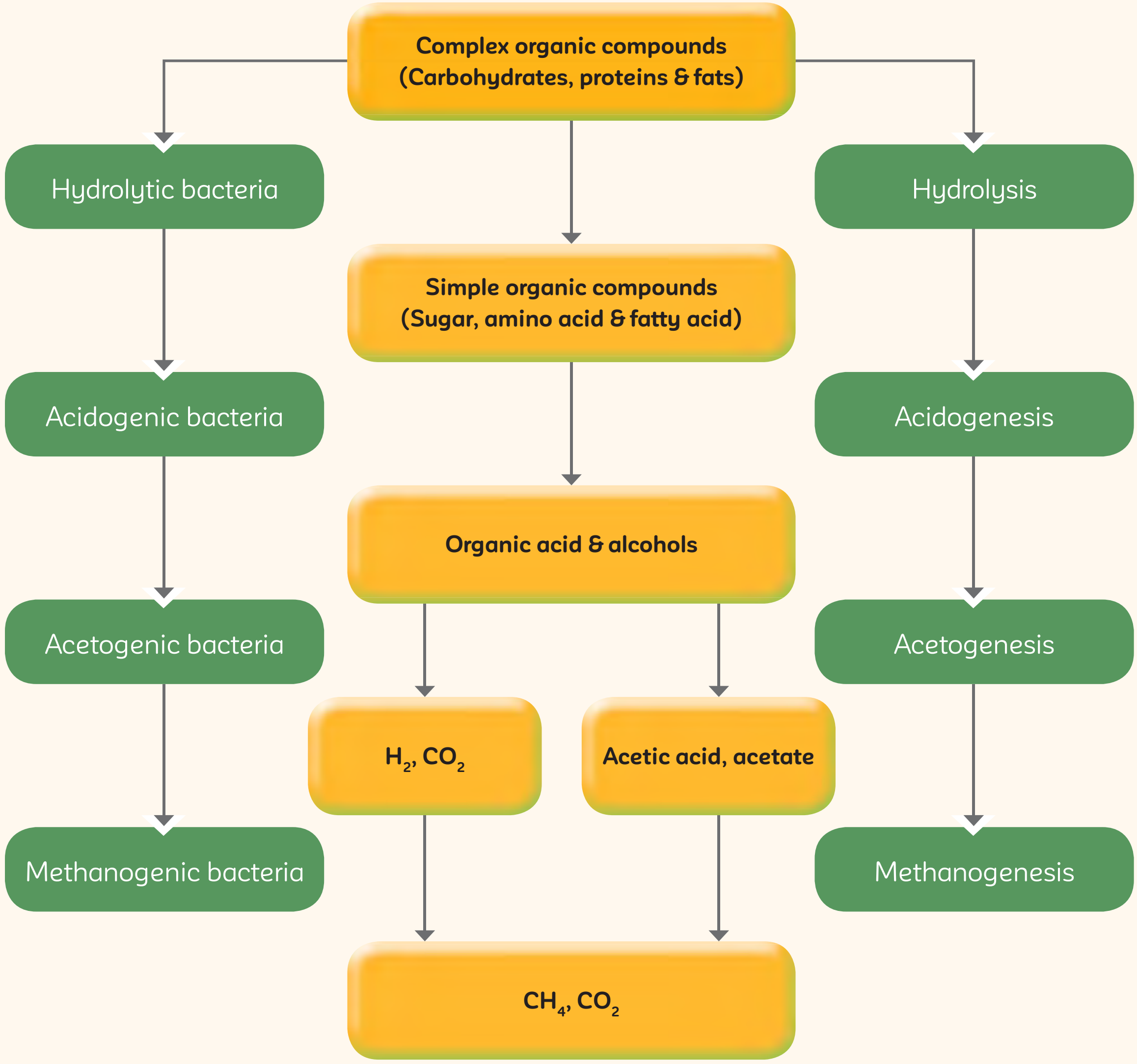
Table 2: Quantities of various hydrocarbon fuels that will have energy equivalent to 1 cum of biogas

Name of the fuel	Kerosene	Firewood	Cattle dung cake	Charcoal	Furnace oil	Electricity	LPG	Diesel	Coal
Equivalent quantity to 1 cum of biogas	0.62 lit.	3.50 kg	12.3 kg	1.46 kg	0.40 lit.	1.25 kW	0.43 kg	0.52 lit.	1.6 kg

2.2 Biogas Plant – Components and Process

A biogas plant consists of a digester, inlet and outlet chamber and a gas holder. The waste is treated inside the digester and biogas generated can be used for cooking, lighting, heating, power generation, etc.

Biogas is produced by anaerobic bacteria, which break down organic material in the absence of oxygen. This process is called "anaerobic digestion". The process that takes place inside the digestor is shown in the next page:



2.3 Different Stages in the Generation of Biogas

i. **Pre-treatment:** Most digestion systems require the pre-treatment of waste to obtain homogeneous feedstock. The pre-processing involves the separation of non-digestible materials either through segregation at the source or through mechanical sorting, the former leads to less contaminated feedstock and hence produces good quality compost. This segregation ensures the removal of undesirable or recyclable materials such as glass, metals, stones, etc. The waste is shredded before it is fed into the digester.

ii. **Waste dilution:** The feed is diluted to achieve desired solids content and remains in the digester for a designated retention time. For dilution, a varying range of water sources can be used such as clean water or re-circulated liquid from the slurry.

iii. **Gas recovery and usage:** The generated biogas can be utilized for cooking, heating & electricity production or purified for use as vehicle fuel (CBG).

iv. **Slurry treatment:** The biogas slurry is dewatered and the liquid recycled for use in the dilution of incoming feed. The solid part is dewatered to 50–55 per cent Total Solids (TS) with a screw press, filter press or other types of dewatering systems and converted to compost.

2.4 Important Operating Parameters

i. **Temperature:** Temperature affects bacterial growth and hence the amount of biogas produced. Treatment of waste in anaerobic reactors is normally carried out within two ranges: around 25–40°C known as the mesophilic range and higher than 45°C known as the thermophilic range. At higher temperatures – the rate of digestion is faster, and thus shorter retention times are required – smaller reactor volumes are required for treating the same amount of waste – higher rate and efficiency of particulate matter hydrolysis – more efficient destruction of pathogens.

ii. **pH:** The anaerobic digestion process is limited to a relatively narrow pH interval from approximately 6.0 to 8.5 pH.

iii. **Moisture:** The moisture content of waste should not be less than 15 per cent as it can prevent the decomposition of waste.

iv. **Toxicity:** Some compounds are toxic to anaerobic microorganisms. Methanogens are commonly considered to be the most sensitive to toxicity.

v. **C/N ratio:** Optimum C/N ratio in anaerobic digesters is between 20–30. A high C/N ratio is an indication of rapid consumption of nitrogen by methanogens and results in lower gas production. On the other hand, a lower C/N ratio causes ammonia accumulation and pH values exceeding 8.5, which is toxic to methanogenic bacteria. Optimum C/N ratios of the digester materials can be achieved by mixing materials of high and low C/N ratios, such as organic solid waste (high in Carbon) and sewage or animal manure (high in nitrogen).

vi. **Organic loading rate:** Organic loading rate is the frequency and speed at which the substrate is added to the digester. For each plant of a particular size, there is an optimal rate at which the substrate should be loaded. Beyond this optimal rate, further increases in the feeding rate will not lead to a higher rate of gas production. Agitation or consistent stirring of the contents in the digester also plays an important role in determining the amount of biogas produced.

vii. **Retention time:** The required retention time for completion of the reactions varies with differing technologies, process temperature, and waste composition. The retention time for wastes treated in a mesophilic digester range from 10 to 40 days. Lower retention times are required in digesters operated in the thermophilic range. A high solids reactor operating in the thermophilic range has a retention time of 14 days.

Hydraulic Retention Time (HRT): Average time required to process the waste

- The design of a biogas plant is directly dependent upon its ‘Hydraulic Retention Time’ (HRT).
- The HRT of any biogas plant is the time for which the mixture of cow dung/any organic material with water stays in the digester to produce biogas.
- HRT of any biogas plant is fixed on the basis that about 80per cent of the biogas is recovered from cow dung during this time at a normal temperature of fermentation (25°C to 35°C).
- HRT of any biogas plant is inversely proportional to temperature.
- This is the main reason due to which HRT for any biogas plant is different for different areas (i.e. plain or semi-hilly or hilly).
- HRT for plain areas is fixed less as compared to hilly areas.

- The cost of any biogas plant is directly related to HRT because the biogas plant where HRT is more, the digester to be constructed for it will be bigger as a large quantity of slurry will be retained in it.

2.4.1 HRT for different regions/states of India

- **Plants based on 30 days HRT:** This is recommended for states of Andhra Pradesh, Goa, Kerala, Karnataka, Maharashtra, Pondicherry and Tamil Nadu.
- **Plants based on 40 days HRT:** This is recommended for states of Bihar, Gujarat, Haryana, Punjab, Jammu area of J&K State, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh and West Bengal.
- **Plants based on 55 days HRT:** This is recommended for states of Himachal Pradesh, North-eastern States, Sikkim, Kashmir area of J&K State, hilly districts of Uttar Pradesh and other hilly areas having long, severe winters.

2.5 Bio-Slurry

The bio-slurry is the semi-liquid effluent from the digester. It is a good fertiliser for crops and improves the soil fertility, soil structure and yields of crops. Research has shown that bio-slurry is even better than regular Farmyard Manure (FYM) and may also reduce the use of chemical fertilisers. The bio-slurry can be used directly or after drying/composting/vermicomposting used as bio/organic manure for improving soil fertility and reducing the use of chemical fertilizers. It is also non-pollutant because it is free from weed seeds, foul smells and pathogens. The slurry is rich in macronutrients such as Nitrogen, Potassium and Sodium (NPK) along with micronutrients – iron and zinc, etc. The slurry/manure of biogas plants is being sold to the farmers and used by them on their crops in liquid/solid form.

2.5.1 Composition and nutrient value of bio-slurry

- Biogas slurry improves the soil's physical, chemical and biological properties marginally.
- The liquid part of slurry has beneficial microbes, folic acid, nitrogen and micronutrients traces in an easily available form for crops.
- The biogas slurry contain considerable amounts of plant nutrients, improve crop production and soil physical properties and prevents adverse environmental impacts of chemical fertilizer use.
- It also improves the content of organic matter, bulk density and porosity of soil matter.
- Biogas slurry contains 20–30 per cent organic matter and macronutrients (N, P, K) & micronutrients (Fe, Mn, Zn, Cu, B etc.) necessary for plant growth.
- It improves the soil properties by increasing the chemical parameters of soil (EC, pH, organic content, available phosphorus and potassium).
- It increases the population of beneficial microbes in the soil.
- On a long term basis, it will help in reducing fertilizer demand and provide an eco-friendly way of maintaining productivity and soil health.
- The digested slurry can be fed directly to the crop through the irrigation channels or it can be stored and used late whenever required.
- To derive maximum benefits from the stored digested slurry, it is essential to prevent its exposure to the sun as any such exposure would result in loss of ammoniac nitrogen content of the slurry.
- It is advisable to dig, two or three manure pits near the biogas plant.
- The nutrient composition of bio-digested slurry is given in the table below:

Table 3: Nutrient composition of the bio-slurry

Sr. No.	Parameter	Amount
1.	Total nitrogen (%)	1.40–1.84
2.	Total phosphorus (%)	1.10–1.72
3.	Total potash (%)	0.84–1.34
4.	Organic carbon (%)	35.0–38.4
5.	Zinc (mg/kg)	103–116
6.	Copper (mg/kg)	51–68
7.	Manganese (mg/kg)	231–295

2.6 Benefits

Biogas plant supplies energy and fertilizer and improves hygiene and protects the environment. A biogas plant lightens the burden on the state budget and improves working conditions for the housewife.

- Promotes environmental protection by reducing methane gas emission and converting it into clean fuel.
- The use of biogas in the kitchen saves other fuels such as cattle dung cakes, kerosene oil, coal, firewood, Liquid Petroleum Gas (LPG).
- The use of pesticides, weedicides can be reduced when the bio-digested slurry is used in agricultural fields as fertilizer.
- The digestion of carbonaceous material in the organic matter anaerobically will make it richer in nitrogen and phosphorus than the compost fertilizer and so is a superior fertilizer.
- The use of biogas controls indoor pollution since it is a smokeless fuel and reduces related problems such as eye infections, respiratory diseases. It also keeps the utensils and kitchens clean.
- Biogas is a more efficient and cleaner fuel than cow dung cakes and firewood.
- Biogas slurry can be applied to the fields along with the irrigation water and reduces the labour required for applying in the fields.
- It helps in the promotion of organic farming.
- Helps in reducing the incidence of vector-borne diseases and promotes public health.

Both solid and liquid part of bio-slurry produced from biogas/CBG plants have been included under fertilizer Control Order (FCO) 1985 as fermented organic manure (FOM) and liquid fermented organic manure. The notification for same can be seen at https://sbm.gov.in/gbdw20/SLRM_Media_content.aspx

CHAPTER 3

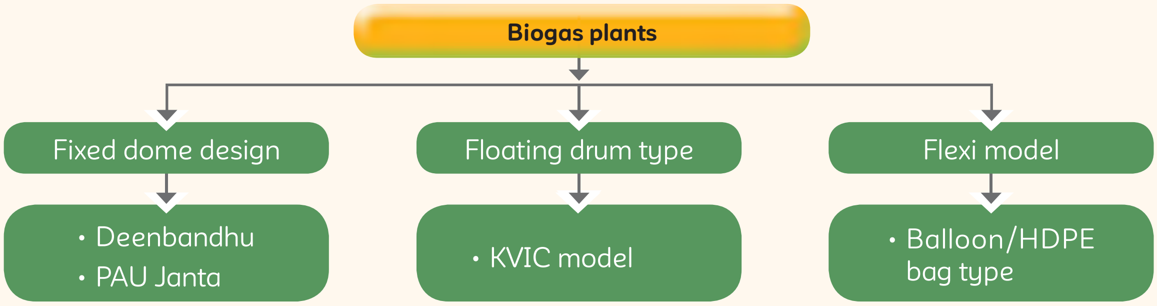
TYPES, TECHNOLOGICAL DESIGNS OPTIONS

Anaerobic digester design has continued to evolve over the years, but systems have generally variations around the theme of the floating-dome and the fixed-dome design; often construction materials vary, or loading positions differ. Some of the most common biogas plants recognized by the MNRE (Ministry of New and Renewable Energy), Government of India is given below:

3.1 Biogas Plant Design Options

Three main types of biogas design options are given below:

- Flexi plants
- Fixed-dome plants
- Floating-drum plants



3.1.1 Flexi plants

Flexi plants consists of a plastic or rubber digester bag, in the upper part of which the gas is stored. The inlet and outlet are attached directly to the skin of the balloon. The fermentation slurry is agitated slightly by the movement of the balloon skin. This is favourable to the digestion process. The balloon material must be UV-resistant.

The flexi plant's design of 2 cum as approved under NNBOMP of MNRE is recommended for installation.

Advantages	Disadvantages
• Low cost • Ease of transportation • Minimal construction (important if the water table is high) • High digester temperatures • Uncomplicated cleaning • Emptying and maintenance	• Short life • Easily damaged • Does not create local employment • Balloon plants are suitable wherever the balloon skin is not likely to be damaged and the temperature is even and high.

3.1.2 Fixed-dome plants

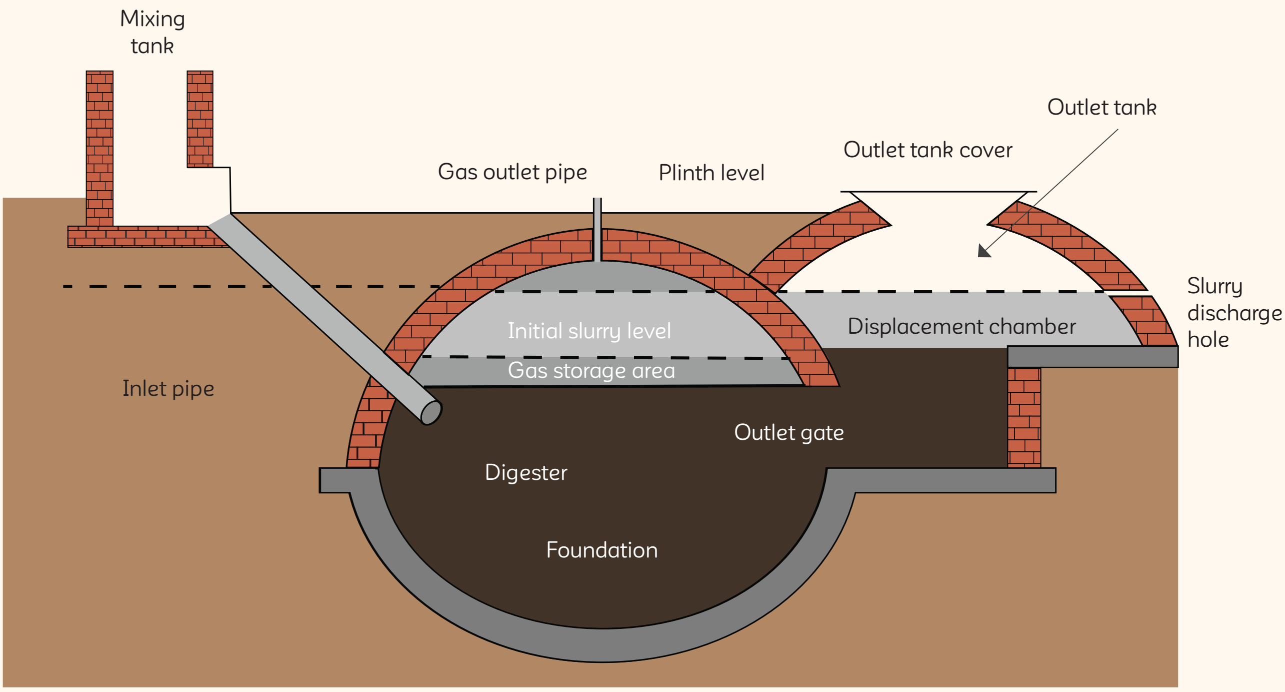
A fixed-dome plant consists of an enclosed digester with a fixed, non-movable gas space. The gas is stored in the upper part of the digester. When gas production commences, the slurry is displaced into the outlet tank. Gas pressure increases with the volume of gas stored.

A. Deenbandhu model

Salient features

- Deenbandhu model biogas plant was developed by AFPRO (Action for Food Production, New Delhi) in 1984. The word 'Deenbandhu' means 'friend of the poor'.
- This plant is designed on the principle that the surface area of biogas plants is reduced (minimized) to reduce their installation cost without sacrificing the efficiency of the plant.
- The design consists of segments of two spheres of different diameters, joined at their bases.
- The structure thus formed, acts as the digester, as a fermentation chamber, as well as the gas storage chamber.
- The higher compressive strength of the brick masonry and concrete makes it preferable to go in for a structure that could always be kept under compression.
- A spherical structure loaded from the convex side will be under compression and therefore, the internal load will not have any residual effect on the structure.
- The digester is connected with the inlet pipe and the outlet tank.
- The upper part above the normal slurry level of the outlet tank is designed to accommodate the slurry to be displaced out of the digester with the generation and accumulation of biogas and is called the outlet displacement chamber.
- This plant is suitable for a digester capacity of 6 cum/day.
- Details of space required for construction of Deenbandhu biogas plants are given at **Annexure-1.**
- The different components of the Deenbandhu model biogas plant are shown in the figure below:

Figure 1: Deenbandhu model biogas plant



Advantages	Disadvantages
• Low construction cost, • No moving parts, • No rusting steel parts, • Long life, • Underground construction affording protection from winter cold and saving space, • Creates employment locally.	• Plants often do not gaslight (porosity and cracks), • Gas pressure fluctuates substantially and is often very high, • Low digester temperatures. Fixed-dome plants are suitable where construction can be supervised by experienced biogas technicians.

B. PAU Janta model biogas plant:

- The Punjab Agricultural University, Ludhiana developed a large capacity fixed dome biogas plant is shown in the figure in the next page.
- The construction of this type of plant is easy.
- The ICAR has approved this design and has recommended the "Transfer of Technology" to the farmers/end-users.
- The MNRE, Government of India has accepted this design for the extensive adoption by end-users for the production of biogas and cogeneration.

Salient design features of large capacity fixed dome modified PAU Janta model biogas plant

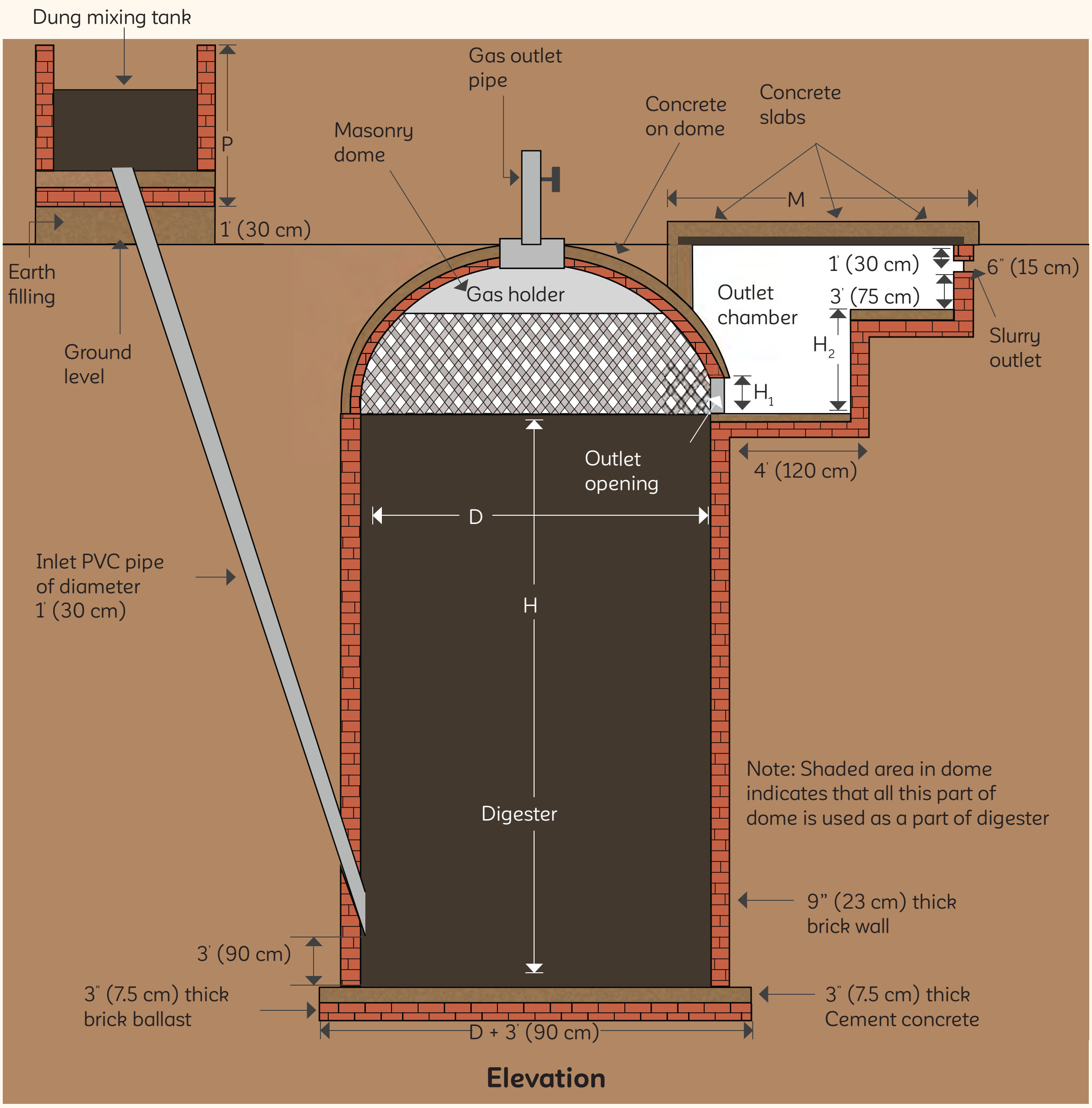
- The biogas plant is an all brick masonry structure. The design is suitable for all regions of the country.

- The plant may be designed for any rated capacity from 20 to 500 m^3/day.
- Maintenance requirements of bricks masonry plants are far lesser than the floating drum biogas plants.
- The cost of this plant is 60–70 per cent as compared to the cost of the floating drum type (KVIC model) biogas plant.
- The payback period of this plant is between 3 to 4 years.
- This plant has been designed for catering to the needs of dairy farmers, poultry farmers, institutes like gaushalas, educational institutions, religious institutions, villages, industries, etc.

Construction details of modified PAU Janta model biogas plant

- The details of the modified PAU Janta model biogas plant are shown in the figure on the next page and the dimensions of different sized biogas plants and other details are given at **Annexure-2.**

Figure 2: Details of modified PAU Janta model biogas plant

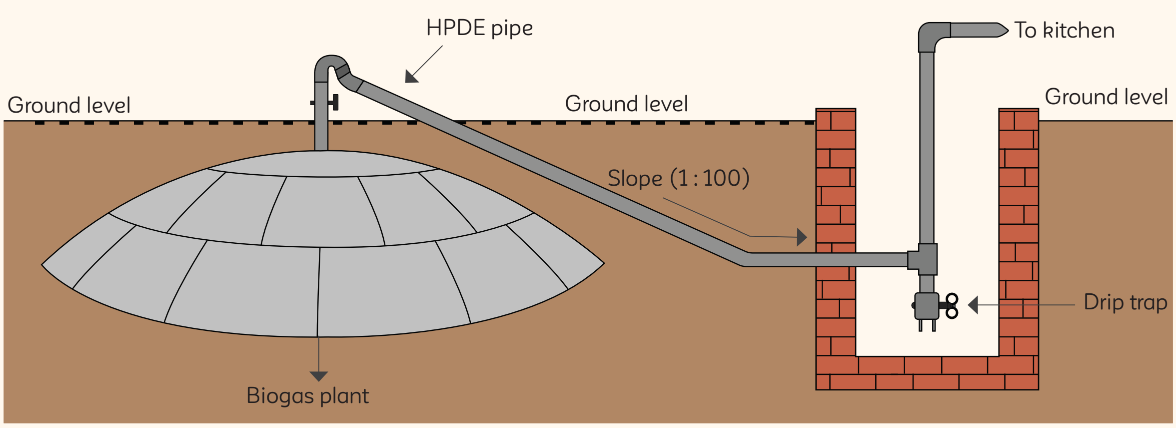


3.1.2.1 Precautions of laying gas pipeline for fixed dome plants

The biogas plant should be installed by trained/skilled workers. The following points should be kept in mind while laying the pipelines:

- The pipes and fittings to be used for laying biogas distribution system, as it is saturated with moisture must be of the best steel or HDPE quality. This is important from a safety point of view, especially for in-the-house connections. Additional emphasis must be given to the selection of valves to be fitted.
- All underground steel pipes should be coated with protective paints to avoid corrosion. It is preferred to use HDPE pipes as they are more efficient and durable. Underground pipes should be about 30 cm (1 ft) below the ground.
- As far as possible, only bends (not elbows) should be used for 90° turns in the pipelines. This reduces pressure drop in the gas pipeline.
- Only gate valves, plug valves or ball valves should be used for the gas pipeline to minimize pressure loss during flow through the valves.
- For connecting burners with gas pipelines, as far as possible, only neoprene rubber tubes should be used.
- Biogas is saturated with water vapours and a slight fall in temperature causes its condensation in the pipeline. Therefore, adequate arrangements to remove the condensate must be made at the time of pipe laying. All the pipes must have a uniform gradient and at the lowest point, a water remover (drip trap) should be installed. Otherwise, water pressure in the pipe results in a drop in pressure which causes a reduction in the flow rate.
- The underground pipe should be laid at a minimum slope of 1:100 (i.e. one cm. in one meter).
- The overground pipe should be laid along the walls and should not be hanging free. It could be hooked with clamps at every 2 m and should not sag at any point. A continuous slope is essential.
- Gas cock in the house should be out of reach of the children.

Figure 3: Laying of gas pipe line



3.1.3 Floating-drum plants

Floating-drum plants are commonly known as KVIC (Khadi Village and Industrial Commission) plants and were standardized in 1962 and are used widely even now.

These plants consist of a digester and a moving gasholder. The gasholder floats either direct on the fermentation slurry or in a water jacket of its own. The gas collects in the gas drum, which thereby rises. If gas is drawn off, it falls again. The gas drum is prevented from tilting by a guide frame.

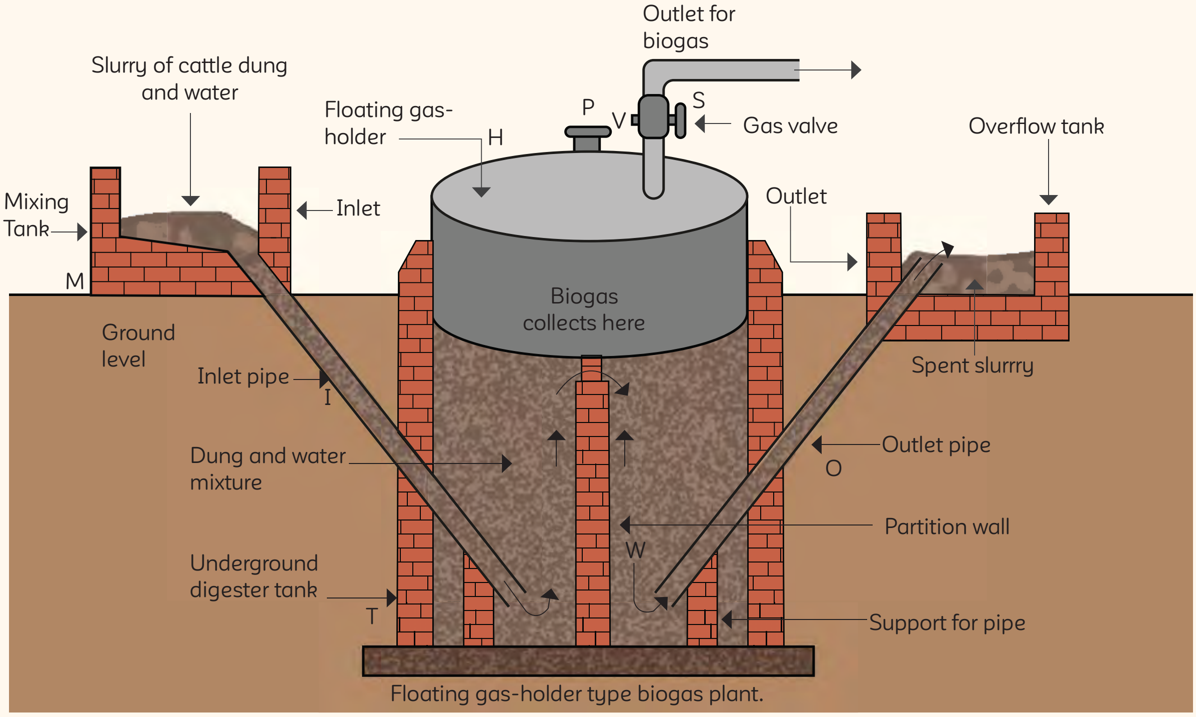
Salient features

- These plants have an underground well-shaped digester having inlet and outlet connections through pipes located at its bottom on either side of a partition wall.
- An inverted drum (gas holder) made of mild steel is placed in the digester which rests on the wedge shaped support and the guide frame at the level of the partition wall and moves up and down along a guide pipe with the accumulation and use of gas.
- The weight of the drum applies pressure on the gas to make it flow through the pipelines to the points of use.
- The gasholder alone is the costliest component which accounts for about 40 per cent of the total installation cost of a biogas plant.
- It also needs to be painted regularly for protecting it against corrosion.
- These plants can be of any size to cater to the needs of the users.
- The dimensions of the different sized biogas plants and material required are given at **Annexure-3.**

Advantages	Disadvantages
• Simple • Easy to operate • Constant gas pressure • The volume of stored gas visible directly • Construction mistakes can be managed while in operation	• High cost of construction for floating drum • The steel parts liable to corrosion • Short life (up to 15 years; in tropical coastal regions about five years for the drum) • Requires regular maintenance.

Despite these disadvantages, floating-drum plants are always to be recommended in case of doubt. Water-jacket plants are universally applicable and especially easy to maintain. The drum won't stick, even if the substrate has a high solids content. Floating drums made of glass-fiber reinforced plastic and high-density polyethylene have been used successfully. Floating drums made of wire-mesh-reinforced concrete are liable to hairline cracking and are intrinsically porous.

Figure 4: The KVIC biogas plant



Floating gas-holder type biogas plant.

3.2 Size of Digester

The size of the digester i.e. the digester volume is determined by the length of the retention time and by the amount of fermentation slurry supplied daily. The amount of fermentation slurry consists of the feed material (e.g., cattle dung) and the mixing water. The formula for calculating the volume of the digester is given below:

Digester volume = Daily feed (liter/day) x Retention time (days)

Example

25 kg of cow dung + 25 liter water = 50 liter slurry (daily feed)

Assuming the Retention time to be 40 days, then the digester volume can be calculated by Digester volume = 50 (l/day) x 40 (days) = 2000 liter or 2 cum.

CHAPTER 4

APPLICATIONS OF BIOGAS

4.1 Electricity Generation

Various technologies to generate electricity from biogas on a household level are available. In principle, the chemical energy of the combustible gases is converted to mechanical energy in a controlled combustion system by a heat engine. This mechanical energy then activates a generator to produce electrical power. In most cases, biogas is used as fuel for combustion engines, which convert it to mechanical energy, powering an electric generator to produce electricity. The most common heat engines used for biogas energy conversion are gas turbines and combustion engines. Combustion engines can be either an internal combustion engine (e.g. reciprocating engine) or an external combustion engine (e.g. stirling engine). The average calorific value of biogas is about 205 MJ/m^3.

Biogas-operated gensets are available for generation of electricity. 1 cum biogas can produce 4–5 kWh electricity depending on the efficiency of genset and average methane content in raw biogas.

For setting up biogas based power generation (off-grid) projects for power generation in the capacity range (3 kW to 250 kW) and thermal energy from the biogas produced from Biogas plants of size greater than 25 cum up to 2500 cum size.

4.2 CBG Generation

Biogas up-gradation to biomethane by removal of contaminants especially H2S and CO2 will significantly improve the quality of the biogas for its further uses. The methane enriched biogas can be used as an alternative to fossil fuels for the production of heat and steam, electricity production and co-generation, vehicle fuel, and feedstock for the production of bio-based chemicals and substrate in fuel cells, starting reactants in chemical processes, substitute for natural gas for domestic and industrial use, gas grid injections (Table 4). Enriched biogas can be compressed and stored in a gas cylinder and transported to the desired location for utilization. Additionally, the use of enriched biogas reduces greenhouse gas emissions. There are innumerable biogas up-gradation technologies to achieve selective separation of gas constituents such as physical or chemical absorption, adsorption on a solid surface, membrane separation, cryogenic separation and chemical hydrogenation. These processes are aimed at enriching the methane content of biogas above 90 per cent and thereby enhancing the calorific value up to 35.3 MJ/m^3. All biogas up-gradation technologies have their own specific merits and demerits and vary according to biogas upgrading sites. The selection of the appropriate technology is based on the specific biogas requirements, site of utilization, and availability of local resources and hence is case sensitive. Hence, the choice of technology should be decided based on the quality and quantity of the raw biogas to be upgraded, the biomethane quality to be achieved, and its utilization.

Novel technologies involving dry reforming (DRM), hydrate separation, biotechnologies (bio-filter/bio-trickling filter and in situ upgrading), cryogenic separation, electrochemical interventions and chemolitotroph-based bioreactors (which can convert CO_2 from the biogas into methane), provide potential options that need to be considered for biogas purification and upgrading.

Table 4: Application-based requirement of purification

Applications	H_2S	CO_2	Moisture
Boiler	Recommended	No	No
CHP engine	Yes	No	No
Vehicle fuel	Yes	Recommended	Yes
Natural gas grid	Yes	Yes	Yes

4.2.1 Bottling of biogas

Biogas comprises of 60–65 per cent methane, 35–40 per cent carbon dioxide, 0.5–1.0 per cent hydrogen sulphide, rests of water vapours, etc. Biogas is a non-toxic, colorless and flammable gas. It has an ignition temperature of 650–750° C. Its density is 1.214 kg/m^3 (assuming about 60 per cent Methane and 40 per cent CO_2). Its calorific value is 20 MJ/m^3 (or 4700 kcal.). It is almost 20 per cent lighter than air. Biogas, like Liquefied Petroleum Gas (LPG), cannot be converted into a liquid state under normal temperature and pressure. It liquefies at a pressure of about 47.4 kg/cm^2 at a critical temperature of 82.10 c. Removing carbon dioxide, hydrogen sulfide, moisture and compressing it into cylinders makes it easily usable for transport applications and also for stationary applications. Already CNG technology has become easily available and therefore, bio-methane (purified biogas) which is nearly the same as CNG, can be used for all applications for which CNG are used. Purified biogas (bio-methane) has a high calorific value in comparison to raw biogas.

The purified biogas is filled in CNG cylinder and supplied to mid-day meal scheme, mess, hotel, industries, etc. for various purposes such as cooking & heating etc. The calorific value of purified biogas is equivalent/similar to CNG. The biogas bottling plants are one of the most potent tools for mitigating climate change by preventing black carbon emission from biomass chulha since biogas is used as a cooking fuel and methane emissions from untreated cattle dung and biomass wastes are also avoided. The purified biogas can be bottled in CNG cylinders and wherever CNG is currently used, compressed biogas (CBG) can be used as an alternative.

In addition to energy production, biogas plants also provide bio-manure and help deal with the problems of waste management, providing a clean environment and mitigating pollution in urban, industrial and rural areas. Biogas is also a prominent alternative to petroleum fuels like LPG, CNG and diesel.

CHAPTER 5

OPERATION & MAINTENANCE

5.1 General

The key to the proper operation of biogas plant is the timely feeding of feedstock in right proportions with water, frequent draining of condensed water in the pipeline through the water outlet, cleaning of overflow outlet, checking of gas leakage through pipe joints and gas valves, and adding of organic materials to slurry pits. As long as these tasks are carried out reliably and carefully the plant will function properly.

The developer/installer or company involved in the installation of the plants should provide the maintenance services and improve their products based on the feedback received from the user community. There should be a provision in the agreement between the implementing agency (GP/district/state) and the developer, so that the developer would not run away after installation of the plant, causing inconvenience to the user later, when any issue relating to Operation & Maintenance (O&M) arises.

The developer/installer or company should make periodic inspections of the plant to solve the problems related to O&M.

5.2 Annual O&M Cost Required to Run the Technology

The O&M cost to operate the biogas technology is very low i.e. almost negligible. Further, it varies according to the design capacity of the plant. The biogas plants are feasible under all soil conditions. No modification is required in most of the soils. However, minor modification (to take care of shrinkage forces) is required to construct a biogas plant digester in the case of black cotton soil. Usually, sand filling around the digester works well for the same. The technology mentioned is feasible under all the terrain conditions.

In the case of very cold regions, the insulation of the plant is required to reduce the heat loss around the biogas plant digester. The temperature of the biogas plant can be suitably maintained by using a solar water heating system coupled with the biogas plant.

In the case of the moderate and hot region, the technology works well without any problem. This technology is feasible under all levels of groundwater conditions. Under the high water table (0–5 m) condition the dimensions of the plants have to be modified to take care of water seepage. There is no issue with other levels of groundwater. The technology is feasible under all rainfall conditions. There is no modification required for different rainfall conditions.

Do's

- Select the size of biogas plant depending on the quantity of dung available with the beneficiaries.
- Install the biogas plant at a place near the kitchen to save the cost of delivery gas pipe.
- Ensure that the plant is installed in an open space, and gets plenty of sunlight for the whole day, all round the year.
- Feed the biogas plant with cattle dung and water mixture in the right proportion (1:1 ratio) to make a homogeneous mixture.
- Ensure that the slurry (mixture of dung and water) is free from soil, straw, etc.
- Cover the top of the inlet and outlet tank opening with wooden, stone or RCC cover, to avoid accidental falling of cattle and children.

Don'ts

- Do not install a bigger size of biogas plant if you don't have sufficient cattle dung or any other feedstock to be used for gas production.
- Do not install the biogas plant at a long distance from the point of gas utilization to save the cost of pipeline.
- Do not install the plant under a tree or under shade.
- Do not fill soil loosely around the plant; otherwise it may get damaged.
- Do not add more than the required quantity of either dung or water. Doing so might affect the efficient production of gas.
- Do not allow soil or sand particles to enter into the digester.
- Do not allow the scum to form in the digester; otherwise the production of gas might stop.
- Do not burn the gas directly, i.e. from the gas outlet pipe even for the testing purpose as it can be dangerous.
- Do not let any water accumulate in the gas pipeline; otherwise the required pressure of gas will not be maintained and the flame will sputter.
- Do not make digested slurry pit more than 1.0 m deep otherwise slurry will not dry fast.
- Do not hurry to get gas after initial loading of slurry, as it may take 10–15 days for gas production in freshly loaded plants.

5.3 Technical Skills Required to Operate and Maintain the Technology

Any person can operate the biogas plant with basic information availed from the skilled workers or the technical staff workers visiting the plants or through users (awareness) camps.

5.4 Type of Operation and Maintenance Required to Run the Technology

Feeding of cattle dung

- Feeding to the plant should be done as per the size of the plant.

(a) Daily feeding

- Feed the plant daily.
- Fill the plant with cow dung and water in the ratio of 1:1.
- Care should be taken that no sand, gravel, and straw is allowed to enter into the gas plant.

(b) Underfeeding

- Feeding less than the recommended quantity of dung is termed underfeeding.
- Gas production will decrease gradually, because of scum formation and a quicker sedimentation process.
- Scum formation depends upon the climate and the feeding pattern.
- Scum formation takes place faster if the slurry does not come out from the outlet tank, because of insufficient gas pressure.

(c) Precautionary measures

- Do not use old or dried cow dung for feeding the plant.
- It is advisable to feed the new plant with the slurry of a nearby working biogas plant.
- Check whether an equal amount of input comes from the outlet tank.
- After the complete use of gas, the slurry level should come up to the first step.
- However, it may not happen due to improper feeding in the biogas plant.
- If the liquid content is more in the slurry, then it can be tested by using a stick.
- Dip the stick in the outlet tank slurry.
- If the solid content of the mixture does not stick to the stick properly, then it can be concluded that water is more and the dung is less.

5.5 General Checks

Several things can affect the biogas production in a bio-digester:

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 leakage. In case of cracks in the dome, there will be the formation of bubbles indicating the leakage of biogas.

B. Temperature problems

If ambient temperatures reach below 20^{0}C, you will experience a drastic decrease in biogas production. The temperature should be in the range of 35 to 38 °C with the input slurry pH of 6.5 to 7.5. In the low-temperature regions either hot water can be added to the input slurry or the digester can be insulated with a hot water jacket.

C. Problems with the bio-digester's pH

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

D. Other issues

There are a number of other problems that can arise during the life of a bio-digester. To investigate problems, it is best to think back to the basics of what makes a bio-digester work (organic material, strong seals, warmth) and eliminate anything else that could 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 bio-digester 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.

5.6 Gas Leakage Problem from Gas Dome/ Holder

5.6.1 KVIC/ Floating dome type biogas plants

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.

5.6.2 Deenbandhu type biogas plants

It's a slightly tough task than a KVIC gas holder. The gas storage dome can be examined by fixing a U-shaped safety valve made of a 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 the 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.

5.7 Common Operational Problems and their Remedy

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.	i. Add more slurry. ii. Check and correct. iii. Rotate the agitated slurry with a wood pole.
• No gas at the stove but plenty in the plant.	i. Gas pipe blocked by water condensate. ii. Insufficient pressure. iii Gas outlet blocked by scum.	i. Remove water condensate from the moisture trap. ii. Increase weight on gasholder. iii. 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 the 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

5.8 Maintenances and General Care to be Taken Up after Installation of a Biogas Plant

A. Daily

- Add dung slurry to the plant. Keep the ratio of dung and water as 1:1.
- Make sure that no stones and sand are 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.

B. Monthly

- Check the gas pipeline for leaks with a soap solution.

C. 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.

5.9 Safety Measures to be Taken during the Operation of the Biogas Plant

A. Safety measures for KVIC/floating drum type biogas plant

- All the air in the gas holder must be released to the environment whenever the holder is removed for cleaning, painting and any other purpose.
- Do not weld the gasholder when it is full of gas.
- Corrosion of the gasholder should be avoided by water jacket seal.

B. Safety measures for fixed dome type biogas plant

- 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.
- Gas must not be lighted at the main valve on the top of the dome. Otherwise sometimes due to negative pressure or backfire, an explosion can take place resulting in damage to the dome and other parts of the plant.
- Inlet and outlet chambers should be covered firmly with stone or concrete slabs to prevent children or animals from falling in accidentally.

CASE STUDY

1. Community Biogas Plant in Bahadurpur, Rupnagar District, Punjab

1.1 Introduction

Bahadurpur is a Gram Panchayat located in the Rupnagar block of the District Rupnagar. It has a total population of 425,102 households (Census 2011). Ram Singh Farm is a dairy farm maintaining a herd of 160 cows in Bahadurpur. The next step was to put up a biogas plant to produce free cooking gas by using cow dung from 160 cows present in the dairy farm. The project aims to manage cow dung and subsequently, manage to supply cooking gas to many families of the village and provide several farmers with a sustainable supply of organic fertilizer.

1.2 Plant operation and maintenance

Ram Singh Farm got the plan and design of the biogas plant from a professor at Punjab Agricultural University, Ludhiana. The capital cost for the installation of the plant was 6 lakh. The biogas plant is 130 cubic meters in size installed in a 60*40 ft. area. Operation and maintenance of the plant are done by farmworkers. Produced biogas is supplied to 90 homes in the village through overhead pipelines. The plant runs 24/7, hence, the gas is supplied free of cost throughout the year to all 90 households in the village, except for four months during winters when the supply is restricted to 6 hours per day.

The biogas is supplied through 1 inch HDPE pipes running at an overhead level and connected directly to households. Maintenance of distribution system and gas connection is taken care of by a plumber provided by the entity, who also maintains the water supply and drainage network in the village. The plumber is paid Rs 100 every month by each of the 90 families.

1.3 Slurry generation and use

Nearly 10,000 liters of slurry are generated every day which is stored in a slurry tank with a capacity of 75,000 litres. To discourage farmers from using chemicals in farming, neighbouring farms are encouraged to pick up the slurry generated from the plant for free. The entity provides a slurry-holding tank of 5000 litre capacity to transport slurry to the farm; however, transportation of the slurry tank to the field is arranged by the farmer himself. If the slurry is delivered to farms, conveyance charges are to be borne by the farmer. In one day, nearly 3 to 4 tanks of slurry are being utilized by the farmers as manure.

Table 5: Facts about Deenbandhu plant

Quick facts		
Sr. No.	Particulars	Details
1.	Process technology	Deenbandhu type biogas system
2.	Design capacity of the plant	130 cum
3.	Total project cost	6 lakh
4.	Commission of the plant	April 2011
5.	Gas generated	Equivalent to 10–12 cylinders/day
6.	Input	Cow dung + urine
7.	Cow dung & other organic waste available	2500 kg/day
8.	Biogas utilization	Cooking
9.	Organic manure	10000 litre of bio-slurry/day

1.4 Technology adopted

The model adopted by the dairy plant is based on the Deenbandhu model. The floor of the dairy plant has a cemented channel that is used to divert the dung and urine to prevent it from mixing with the dirt of the plant. The facility has two biodigesters of 70 cum capacity each, taking the total gas production capacity per day to 140 cum.

Due to the presence of the Rupnagar wetlands nearby, it has been noted that the water table in the district of Rupnagar is very high. Owing to the high water table, the main digester tank of the biogas system has been placed approximately 15 feet below the surface. Since Rupnagar is located in the Northern part of India, the temperatures tend to drop to near zero. Due to this, the digestion process tends to slow down since it requires a temperature of approximately 37°C for optimal functioning. To overcome this obstacle, hot water is injected into the digester via heating coils to increase the temperature of the slurry inside the biodigester. The plant produces approximately 130 cum of gas equivalent to 10–12 cylinders per day which is supplied to 90 households in the village.

2. Community Biogas Plant at Bancharouda, Raipur, Chhattisgarh

The community biogas plant with capacity ranging from 25 m^3 has been constructed at Bancharouda Village of Raipur District in Chhattisgarh under SBM (G). The plant is located in the Bancharouda Gothan campus within the village. Cowdung is purchased from individual households at Rs. 2/kg under the state scheme Godhan Nyay Yojana. Biogas generated from the plant is provided to households/institutions located in the vicinity of the Gothan. The biogas generated is converted to electricity for lighting the Gothan campus. Slurry is used as manure or sold to farmers at Rs. 10 per kg.

Table 6: Overview of community biogas plant at Bancharouda

Sr. No.	Particulars	Details
1.	Plant capacity	25 cum/day (biogas)
2.	Feedstock capacity	500 kg/day
3.	Feedstock type	Cattle dung from households collected under the Godhan Nyay Yojana
4.	Cost	Rs. 10.0 lakhs (approx.)
5.	Biogas utilization	Electricity generation for lighting in Gothan compound and cooking
6.	Slurry production	1000 liters/day
7.	Slurry utilization	Sold to farmers at Rs. 10 per kg after drying

3. Community Biogas Plant at Nayagaon, Hisar, Haryana

The community biogas plant at Nayagaon, Hisar, Haryana has been constructed under SBM(G). It is being operated and managed by the GP. Cattle dung for the plant is collected from the village and transported to the plant using a tractor. The villagers will be paid at 10 paisa per kg for cattle dung. The gas is distributed to households of the villages through a network of overhead pipelines. The slurry is being sold to the local farmers at Rs. 1000/tanker and at Rs. 1500/tanker to farmers of other villages. The biogas plant is designed to cater to the needs of 150 households in the village

Table 7: Overview of community biogas plant at Nayagaon

Sr. No.	Particulars	Details
1.	Plant capacity (feedstock)	10,000 kg/day
2.	Biogas generation	400 cum/day
3.	Feedstock type	Cattle dung
4.	Capital cost	Rs. 75.00 lakhs (approx.)
5.	O&M cost	Rs. 30,000 per month
6.	Feedstock collection	Cattle dung is collected from households and transported to the plant by a tractor-trolley.
7.	Source of funding	➢ SBM (G) ➢ GP fund ➢ MGNREGA ➢ MPLAD fund ➢ State Govt. fund

ANNEXURES

Annexure 1: Deenbandhu Model Biogas Plants (Indicative Figures)

Table 8: Details of space required for construction of Deenbandhu biogas plants of small size

Sr. No.	Capacity of biogas plant (cum)	Space required for construction of biogas plant		
		Length (m)	Width (m)	Area Sq. m.
1	1	6.70	4.26	28.61
2	2	7.62	4.57	34.82
3	3	8.22	4.87	40.13
4	4	9.14	5.48	50.16
5	5	9.44	5.79	54.71
6	6	9.75	6.06	59.45

Table 9: Dimensions of different sized large biogas plants of Deenbandhu model

Sr. No.	Dimensions (ft-inch)	Capacity of biogas plants (cum)				
		1	2	3	4	6
I	**Dimesions of digestor**					
1.	Diameter of digester (E)	7'–0"	8'–6"	9'–6"	10'–6"	12'–0"
2.	Diameter of pit	9'–0"	10'–6"	11'–6"	12'–6"	14'–0"
3.	Depth of digester (A)	3'–6"	4'–3"	4'–9"	5'–3"	6'–0"
4.	Inner radius of digester (D)	3'–6"	4'–3"	4'–9"	5'–3"	6'–0"
5.	Height of outlet gate (H)	1'–6"	2'–0"	2'–0"	2'–0"	2'–0"
6.	Inner depth of foundation (F)	1'–9"	2'–0"	2'–3"	2'–6"	2'–9"
7.	Outer depth of foundation (B)	2'–0"	2'–3"	2'–6"	2'–9"	3'–0"
II	**Dimesions of outlet chamber**					
1.	Height of smaller portion (J)	1'–6"	2'–0"	2'–3"	2'–9"	3'–3"
2.	Height of bigger portion (K)	1'–0"	1'–3"	1'–6"	1'–6"	1'–9"
3.	Width of bigger portion (M)	3'–0"	3'–6"	3'–6"	4'–0"	4'–0"
4.	Length of bigger portion (N)	4'–0"	5'–3"	6'–9"	7'–9"	10'–0"
III	**Dimesions of mixing tank**					
1.	Diameter (P)	1'–6"	2'–0"	2'–0"	2'–0"	2'–6"
2.	Height (R)	1'–0"	1'–0"	1'–6"	2'–0"	2'–0"

(i) The detailed sketch of the Deenbandhu model biogas plant is shown in the below figure.

Figure 5: Deenbandhu model biogas plant

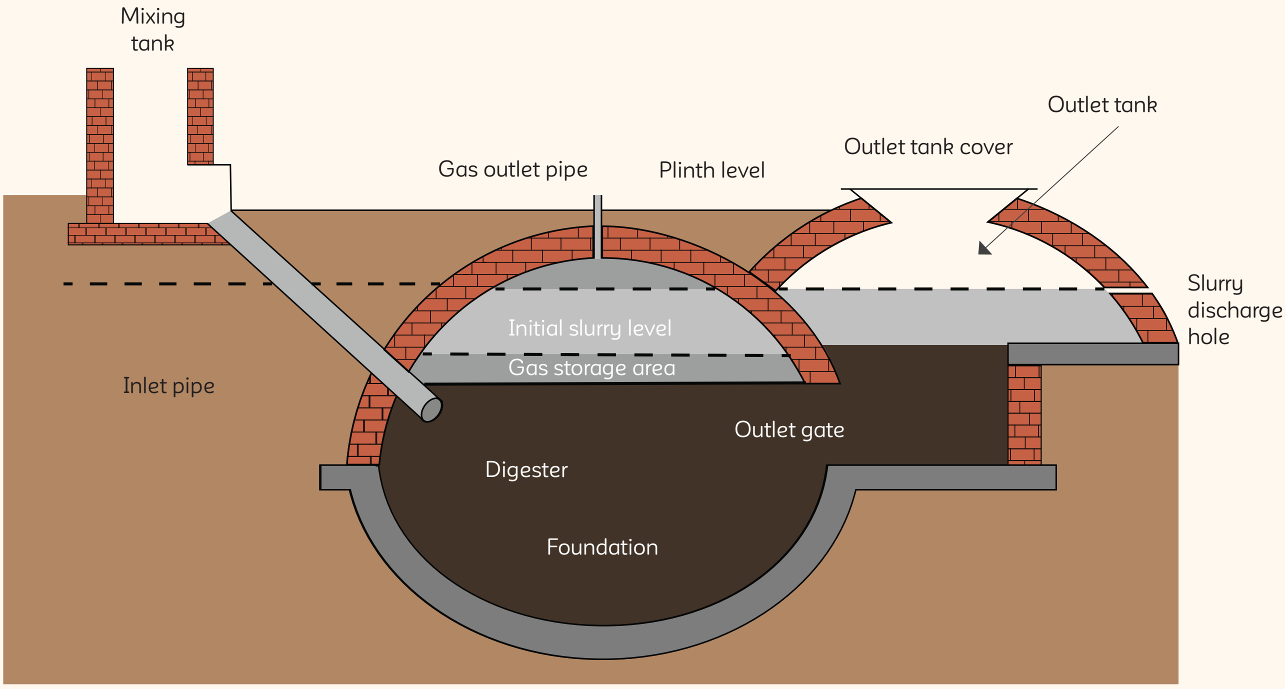
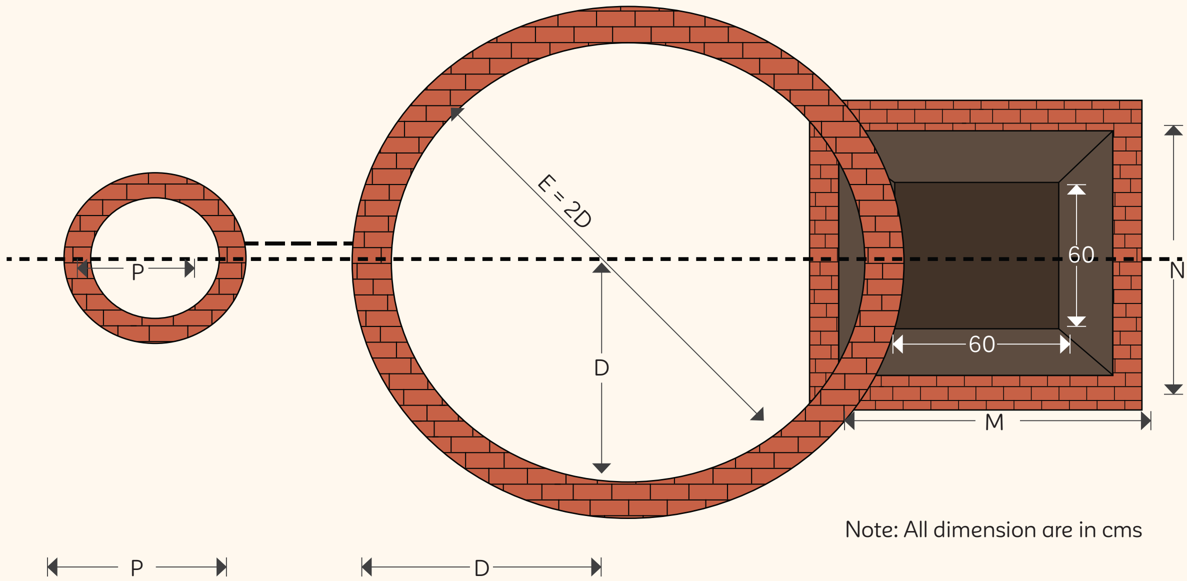


Figure 6: Dimensions of Deenbandhu model biogas plant



Plan

Annexure 2: PAU Janta Model (Indicative Figures)

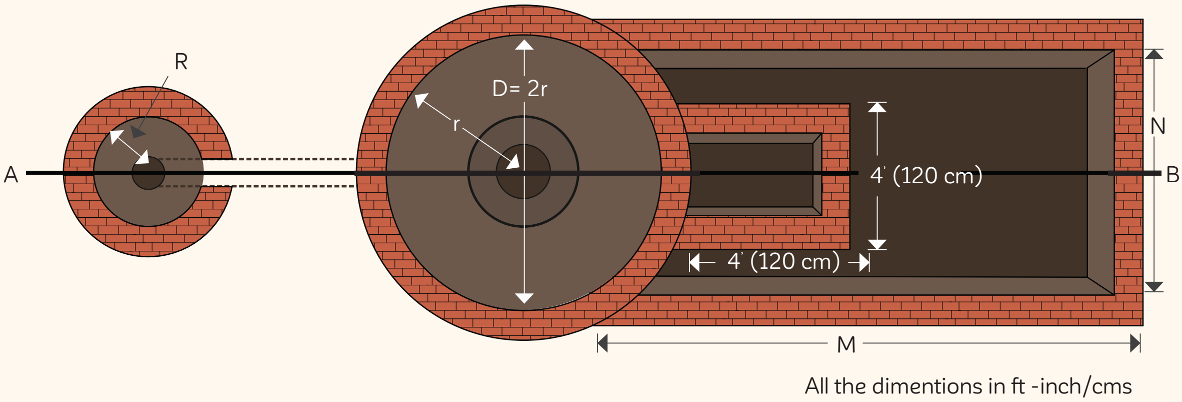
Table 10: Dimensions of different sized modifi ed PAU Janta model biogas plants (All the values are in ft – inches. The figures in parentheses give the equivalent dimensions in cm.)

Dimensions (mm)	Symbol	Capacity of biogas plant (m³/day)				
		25	50	75	100	125
Diameter of digester	D	13.5 (337.5)	15.5 (387.5)	19 (475)	20.5 (512.5)	23.5 (587.5)
Inner radius of digester	R	6.75 (168.75)	7.75 (193.75)	9.5 (237.5)	10.25 (256.25)	11.75 (293.75)
Depth of digester	H	11.5 (287.5)	14.5 (362.5)	14.5 (362.5)	14.5 (362.5)	14 (350)
Depth of digester up to smaller portion of outlet chamber	H_1	5.75 (143.75)	7.25 (181.25)	7.25 (181.25)	7.75 (193.75)	7 (175)
Height of smaller portion of outlet chamber	H_2	9.5 (237.5)	12 (300)	13.75 (343.75)	15 (375)	15.75 (393.75)
Length of bigger portion of outlet chamber (M)	M	14 (350)	18 (450)	22 (550)	25 (625)	31 (775)
Width of bigger portion of outlet chamber	N	10 (250)	13 (325)	17 (425)	19 (475)	20 (500)
Diameter of mixing tank	R	5 (125)	8 (200)	8 (200)	8 (200)	8 (200)
Height of mixing tank	P	2 (50)	2 (50)	3 (75)	3 (75)	3 (75)

Dimensions (mm)	Symbol	Capacity of biogas plant (m³/day)				
		150	175	200	225	250
Diameter of digester	D	24 (600)	26 (650)	28 (700)	29.50 (737.5)	30.50 (762.5)
Inner radius of digester	R	12 (300)	13 (325)	14 (350)	14.75 (368.75)	15.25 (381.25)
Depth of digester	H	16.25 (406.25)	15 (375)	14 (350)	14.50 (362.5)	14.50 (362.5)
Depth of digester up to smaller portion of outlet chamber	H_1	8.25 (206.25)	7.5 (187.5)	7 (175)	7.25 (181.25)	7.25 (181.25)
Height of smaller portion of outlet chamber	H_2	17.25 (431.25)	17.50 (437.5)	18 (450)	19 (475)	19.50 (487.5)

Dimensions (mm)	Symbol	Capacity of biogas plant (m^3/day)				
		150	175	200	225	250
Length of bigger portion of outlet chamber (M)	M	31 (775)	32 (800)	34 (850)	36 (900)	37 (925)
Width of bigger portion of outlet chamber	N	23 (575)	25 (625)	28 (700)	30.50 (762.5)	32 (800)
Diameter of mixing tank	R	8 (200)	8 (200)	8 (200)	8 (200)	8 (200)
Height of mixing tank	P	3 (75)	3 (75)	3 (75)	3 (75)	3 (75)

Figure 7: Dimensions of modified PAU Janta model biogas plant



Plan

Annexure 3: KVIC Model Biogas Plants (Indicative Figures)

Table 11: Dimensions of KVIC model biogas plants of different sizes

Sr. No.	Dimensions (ft-inch)	Capacity of biogas plants (cum)						
		1	2	3	4	6	8	10
DIGESTER								
1.	Excavation width (A)	181	196	221	241	281	301	336
2.	Excavation depth (B)	172	272	292	307	307	347	332
3.	Foundation width (C)	181	196	221	241	281	301	336
4.	Height of digester (D)	180	280	300	315	315	355	340
5.	Height of digester below guide the frame (D_1)	90	150	170	185	185	185	185
6.	Height of digester above guide the frame (D_2)	60	100	100	100	100	125	125
7.	Digester dia (inner) (E)	120	135	160	180	220	240	275
8.	Digester dia (Outer) (F)	166	181	206	226	266	286	321
GAS HOLDER								
9.	Gas holder dia (G)	105	125	150	165	200	225	260
10.	Gas holder height (H)	60	100	100	100	100	125	125
INLET TANK								
11.	Inlet tank length (L)	38	40	75	75	90	90	90
12.	Inlet tank width (W)	38	40	75	75	90	90	90
13.	Inlet tank height (J)	38	40	45	45	45	52	60
14.	Length of inlet pipe (K)	200	300	350	330	350	400	370
15.	Length of outlet pipe (M)	70	90	110	300	300	340	370
16.	G.I. pipe for guide pipe having 40 mm dia (O)	130	195	20	205	205	235	240
17.	M.S. pipe for gas holder (P)	70	115	115	125	125	145	150

Table 12: Material required for the construction of KVIC model biogas plants including labour

Sr. No.	Details of material	Capacity of biogas plant (m^3)						
		1	2	3	4	6	8	10
1.	Bricks (nos.)	2460	2765	3200	3730	4200	4800	5500
2.	Cement (bags)	13	17	19	23	27	32	40
3.	Sand (m^3)	2.00	2.55	2.90	3.40	4.00	4.25	5.00
4.	Brick ballast (m^3)	0.60	0.90	0.95	1.25	1.50	1.75	2.00
5.	A.C. pipe having 10 cm diameter	3.90	4.60	6.30	6.50	7.10	7.70	8.50
6.	Steel drum (gas holder)	1	1	1	1	1	1	1
7.	Steel guide frame along with guide pipe	1	1	1	1	1	1	1
8.	Paint (litre)	2.0	2.5	2.5	3.0	3.0	3.5	4.0
9.	Labour for digging the pit (no. of days)	8	8	10	12	15	18	21
10.	Masons (no. of days)	12	15	20	25	30	34	40
11.	Labour for the plant construction (no. of days)	24	30	40	50	60	65	70

(iii) The detailed sketch of the biogas collecting steel drum (gasholder) & dimensions of the gasholder are given in the next page:

Figure 8: Details of KVIC model biogas plant

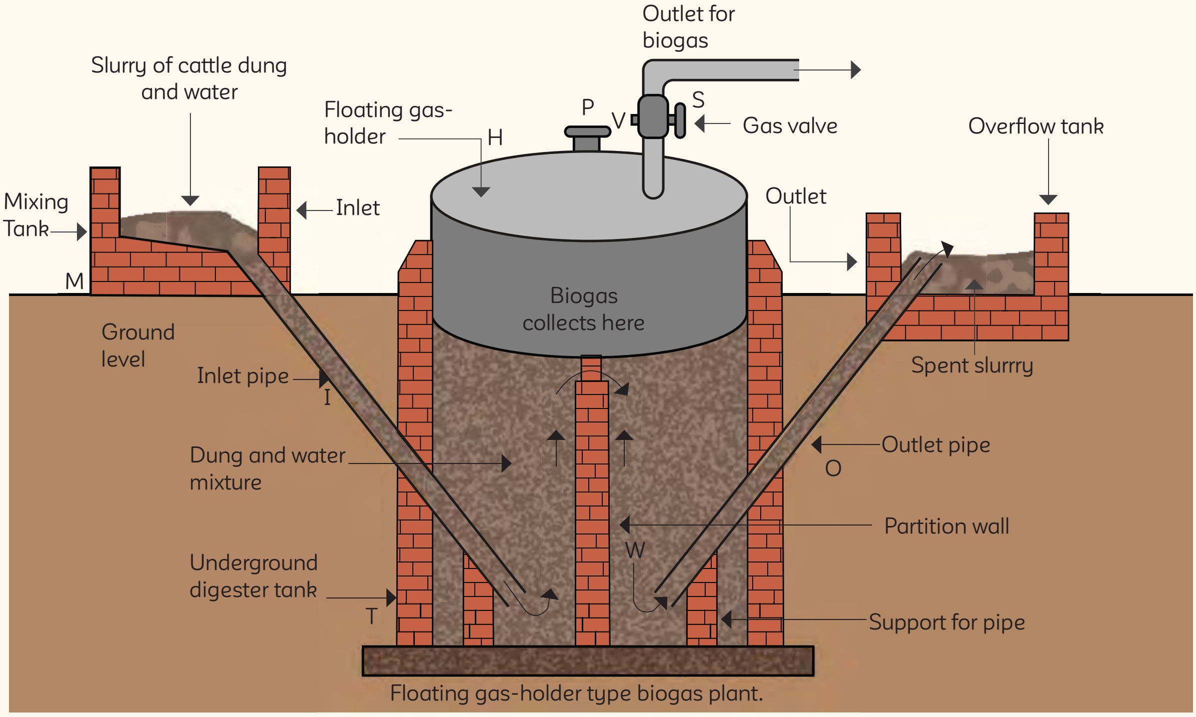


Figure 9: Dimensions of KVIC model biogas plant

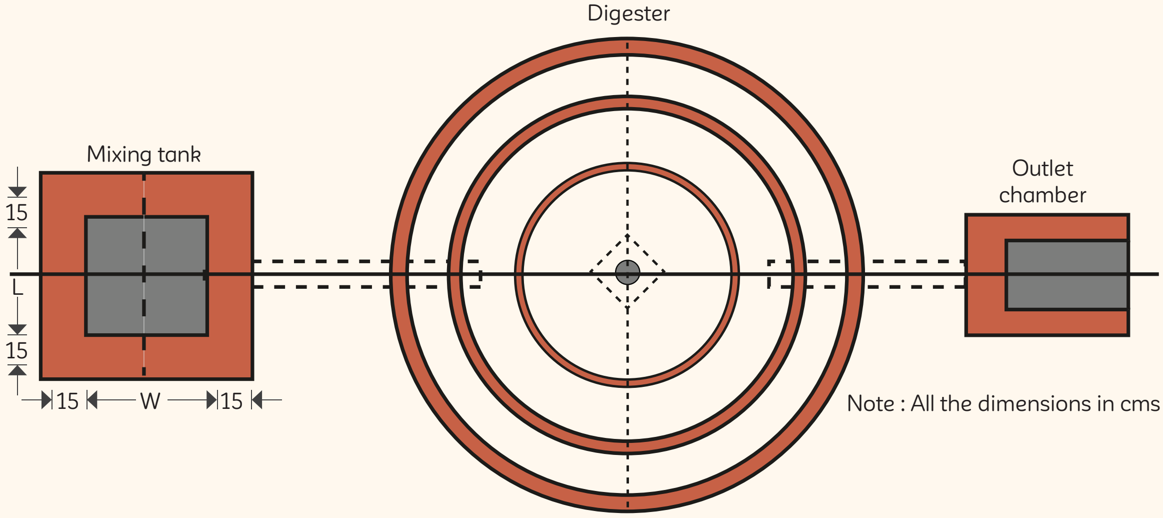


Figure 10: Dimesnions of steel gas holder for KVIC model biogas plant

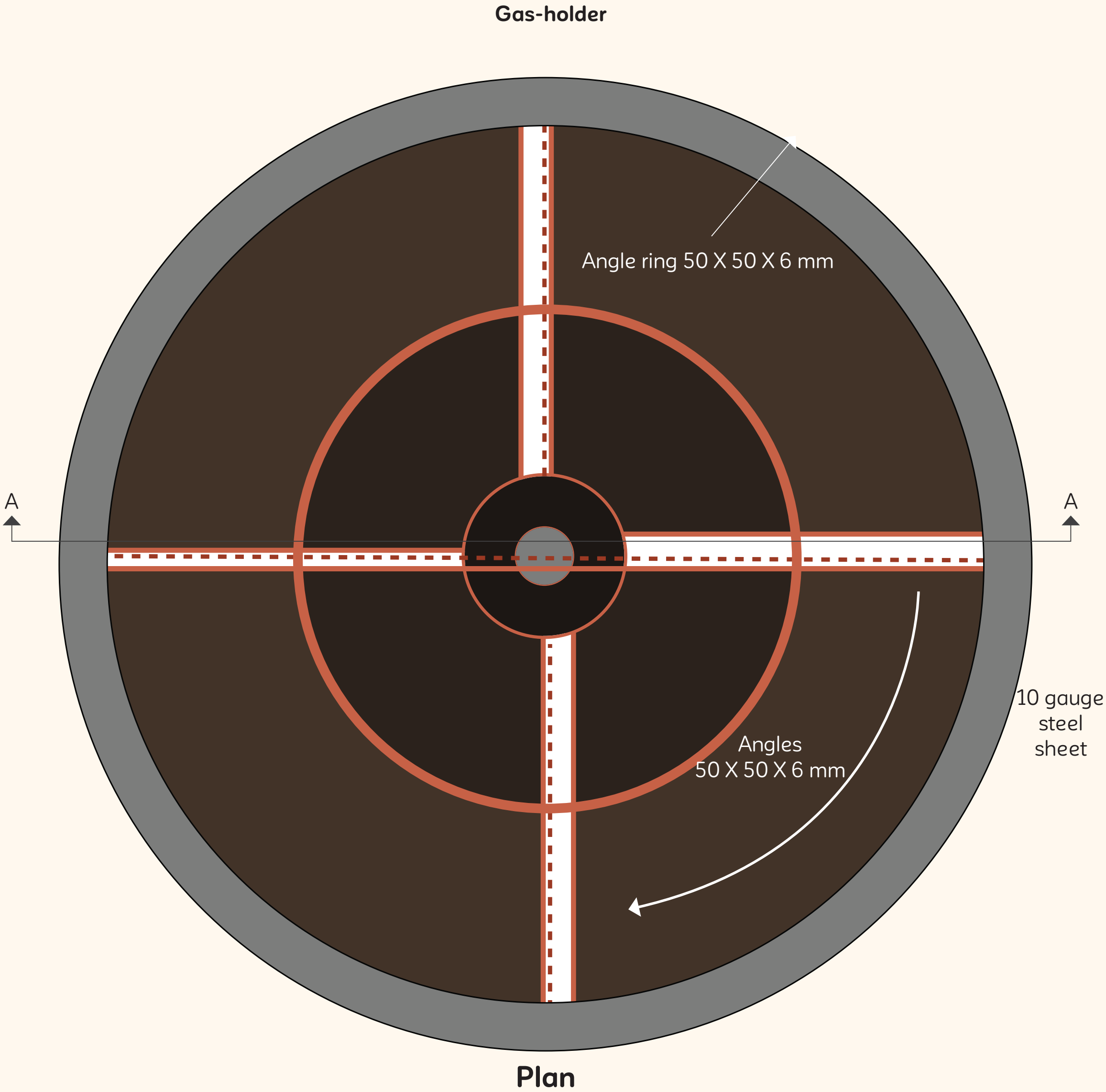
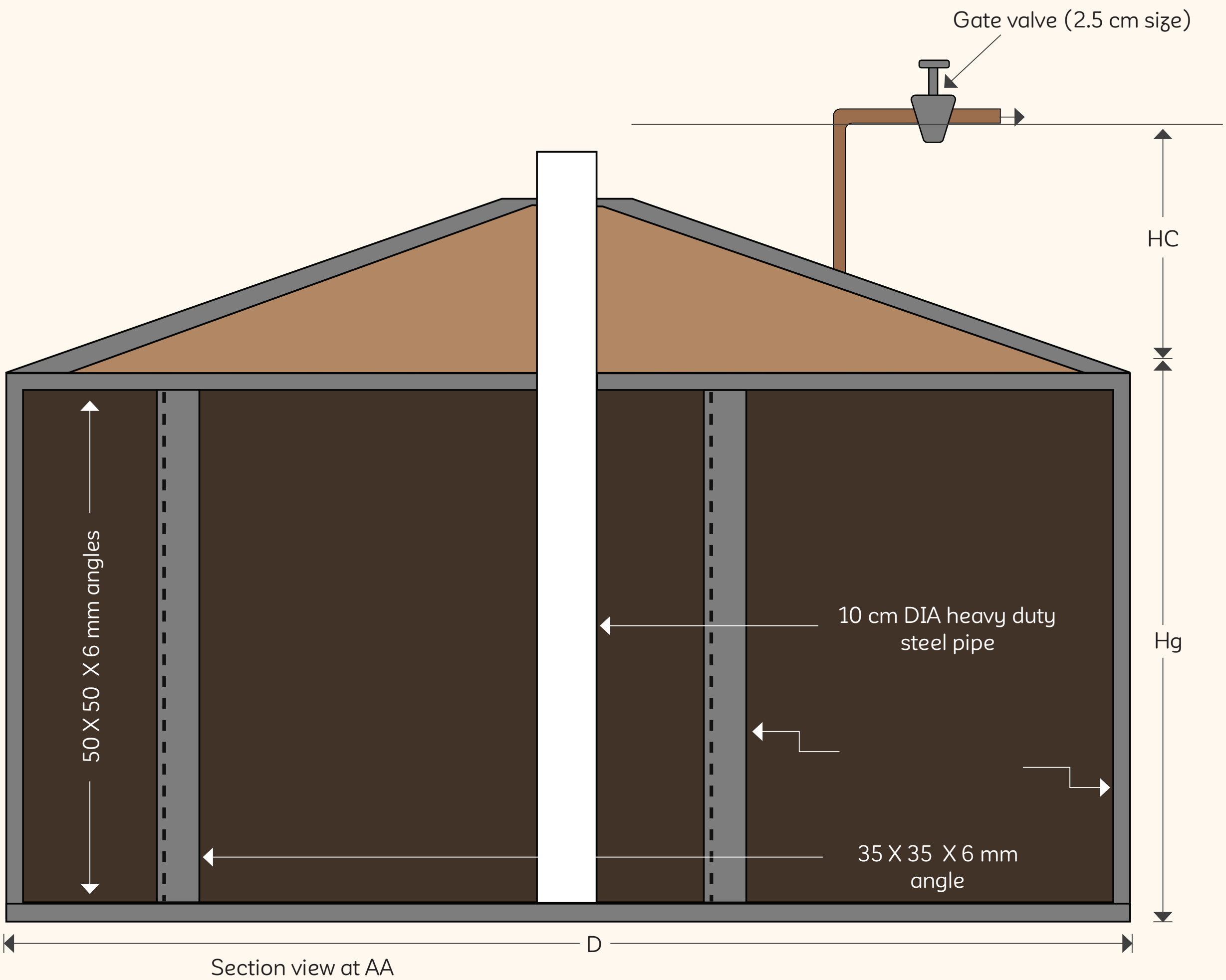


Figure 11: Steel gas holder for KVIC model biogas plant



Front view

Table 14: Dimensions of steel gasholder for KVIC Model biogas plants

Sr. No.	Capacity of biogas plants (cum)	All dimensions in metres		
		Diameter (Dg)	Height (Hg)	Rise of gas holder (Hc)
1	2.84	1.53	0.92	0.80
2	4.25	1.83	0.92	0.080
3	7.09	1.99	1.22	0.080
4	9.92	2.60	1.07	0.080
5	14.17	3.05	1.07	0.080

Table 13: Thickness of G.I. sheet required for manufacturing the steel gasholder

Sr. No.	Size of biogas plant (m^3)	Thickness of G.I. sheet (SWG)
1.	1–3	14
2.	4–10	12
3.	11–85	10
4.	>85	8

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Notes

Notes

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सत्यमेव जयते

स्वच्छ भारत
एक कदम स्वच्छता की ओर