Biogas the future Sustainable Energy for the Survival of Human nature.

The most commonly available non-conventional sources of energy are Biogas, Solar, Wind, Biomass etc. Though there have been cases of other non-conventional energy sources like recycling of waste, hydel power etc. But they have yet to get the recognition that is due to them. Perhaps in the near future waste recycling may be one of the most commonly used non-conventional energy sources.

Of the various non-conventional energy sources mentioned above, Biogas has been developed and utilised to the maximum extent possible in India has been one of the fore runners in the Biogas technology. The largest cattle population in the world and also the warm climate in major part of the country for most of the year make the simple Biogas technology highly successful in India. India being in the tropical region has bright sunshine round the year. This provides tremendous potential for the solar energy programs in the country. The natural light as a means for solar energy is not only available in plenty at no cost but is also the cleanest from the energy. The other form of energy which has vast potential in the country is wind energy. Here again looking to the topography of the country there are vast tracks of land at high altitude or costal areas which have tremendous potential for tapping wind energy.

Out of the above non-conventional energy sources, the biogas has been the most successful due to various reasons like-

1. Large cattle population in the country side ensuring steady source of supply of the raw material required for running the Biogas plant.
2. Decentralized spread of energy source by having the gas plant with each user.
3. Helps in reducing the denudation of the forest reserves for cutting of trees for fire wood.
4. Helps in maintaining the ecological balance.
5. Helps in rural sanitation by linking of latrines to the gas plants.
6. Lower capital cost in comparison to harnessing Solar or Wind energy.
7. Removing the drudgery of women folk from cooking on pollutant, inefficient, unhygienic cooking methods through use of fire wood, dung cakes.
8. Provides enriched manure which is rich in nitrogen and humus which helps in conditioning of the soil and improving its fertility.

UTILAISATION OF PROUCTS

Gas:

Biogas can be used as fuel in the kitchen or for lighting or for running internal combustion engine. It is also possible to use the gas, if available in sufficient quantity, as a fuel in industry.

So far as domestic kitchen fuel is concerned, at least in villages the major source is fire wood or agricultural residues like tour stalk, sun hemp stalk, cotton stalk etc. The other source is cattle dung cake. The method of burning these is extremely wasteful. Whereas in the case of firewood burning, the conventional method realizes only 17 percent of the potential heat, in respect of cattle dung cakes, it is still lower namely 11 percent. Thus 83 percent of the firewood and 89 percent of the cattle dung cakes are wasted in the conventional Chulas.

Thermal Efficiency

Before we proceed further it is necessary to explain the term thermal efficiency. Every fuel has a quantum of theoretically potential energy. In no case it is possible to fully utilize that energy, and in certain cases, full utilization has to be sacrificed in order to gain certain other conditions. For instance steam engines in the railways have extremely law efficiency but in view of the quickness with which the steam must be generated, efficiency has to be sacrificed. When any fuel is burnt and heat is generated, a part of the potential energy is lost in various ways. If the fuel is not burnt perfectly, that is if there is not enough air, then lot of material passes out in the flue gas as unburnt fuel. The dark smoke which is emitted by some of the motor vehicles is a sign that the petrol or diesel is not being fully used and some of its is being emitted in the form of carbon. Another source of loss is, the heat carried by flue gas. If the gas emerging from the flame and going to chimney or getting dispersed in the atmosphere is very hot, evidently it has carried some heat with it. Yet another source of loss is by radiation that is heat lost to the surroundings without being usefully utilized for the purpose for which it is intended. The warmth we feel near the family chulha represents this heat which is radiated to us instead of the vessel which is put on the fire. Thus the heat that is wasted reduces efficiency of burning and that which becomes useful for the purpose for which it is used, indicates the terminal efficiency. Thus in the domestic fuel the heat that goes to the vessels or in boiler the heat which generates steam, in the lamp heat that creates light and in engine heat that produces power are examples of proper utilization of heat . Thermal efficiency is therefore a measure of actual use we make of a particular fuel.

An example of varying thermal efficiency is the kerosene stove that we use in our houses. Three types of stoves are in common use. Wick stoves, pressure stoves with silent burner. As is commonly observed wick stove gives out a pungent obour which signifies in complete burning of fuel. Naturally the efficiency of the stove is very low, namely 22 percent. In other words, 78 percent of the kerosene that we burn in wick stove is wasted. The pressure stove however has an efficiency of 50 percent and the same with silent burner has an efficiency of 55 percent.

Biogas Stoves

If biogas is to be used in the family as kitchen fuel the maximum of its terminal value must be realized. For this purpose it is necessary to use stoves and lamps that are designed specially for this gas and which can give 55 to 60 percent efficiency. Even when appropriate stoves are used; if aeration is not done the efficiency will again be brought down. It may be borne in mind that for each type of fuel or for each type of gas special appliances have to be designed according to the composition and the character of the gas. That is why biogas cannot be burnt satisfactorily in LPG gas burners. Not that it will not burn at all, the efficiency will be brought down considerably. Not only that more gas will be consumed but the flame temperature will also not be high enough. That means, process of cooking will be slow and will consumer more gas. Properly designed biogas stove, when proper aeration is given, produces a flame temperature of about 800^0 C. In the same stove if the aeration is blocked the flame temperature will go down as low as 400^0 C. In many places where the appropriate quality of stove is used the aspect of aeration is neglected which results in low efficiency.

Biogas stoves are designed for consumption of 0.23 m^3 (225 liters of gas per hour), 0.45 m^3 (450 liters of gas per hour and 1.12 m^3 (1130 liters of gas consumption per hour) of these 0.45 m^3 burner is on a par with Primus stove and is useful for family kitchen., 1.12 M^3 burner is not course for either large families or community kitchen. Biogas lamps consume about 0.13 M^3 or 125 liters of gas per hour and produce light equal to 100 candle power.

Duel fuel Engine

In running diesel engine it is necessary to feed 15 to 20 percent diesel along with gas and in the situation the consumption of gas is about 0.42 to 0.50 M^3 per horse power per hour. In petrol engine however it is not necessary to burn petrol as it can run entirely on biogas. In both cases, the starting must be done either by diesel or petrol. Unless one was very large size gas plant i.e., of a capacity not less than 15 M^3 (525 cft.) it is not advisable to attach an engine.

If adequate gas is available it can also be used for commercial heating process like boiling of water, in laundry or boiling of soap pan in small scale soap factory. Before we decide whether biogas can be used for a particular commercial application it is necessary first to ascertain the amount of other fuel being used and the equivalent of it in terms of biogas. Secondly whether that much gas can be produced with the available cattle dung or other fermentable matter will also have to be considered.

Manure

India is plagued for several decades with the problem of food shortage. This is not due to inadequacy of land but due to poor yield hectare. In fact green revolution appears to have become stagnant. There are many reasons for this. Inadequacy and high cost of chemical fertilizers, inadequate irrigation facilities etc. may have contributed to this stagnation.

However, one of the important cases is insufficient application of organic manure to the soil. While the quick result of addition of chemical fertilizers is easily seen, its harmful effects come to notice rather belatedly. As years pass a stage of diminishing returns sets in. Soil does not respond to the fertilizers unless more and more of them are used. It is feared that as more fertilizers are used year after year, the soil may perhaps be damaged permanently. This is being realized by all thinking people and that is why there is a clamour for more organic manure. The conversation of urban garbage into compost is also being taken up in big cities. Every possible source of organic matter has to be harnessed if green revolution is to be stabilized and has to progress smoothly.

The reasons why organic manures are necessary in addition to fertilizers are many. In the first instance the physical structure of the soil is as important as its nutrient contents, for plant growth. Besides providing nutrients, soil serves two other functions.

1. Providing air to the roots of plants.
2. Supplying water.

In both these functions organic matter has an important role to play. The structure of the soil has to be kept open in order that air may easily percolate the soil. For this propose soil must be composed of small, aggregates and should not be puddle. Organic manure helps in formation of aggregates. As per the work done at Indian Agricultural Research Institute it is observed that addition of fresh biogas slurry helps to form aggregates of more than 0.25 mm size to the extent of over 30 percent.

With dried Biogas manure the percentage comes to about 28 percent and with farm yard manure it is about 23 per cent.

Thus it will be seen that Biogas slurry is the best method of improving the structure of soil.

Then again plant roots absorb water from the soil. If soil is puddle and there is water logging, the plants are not in a position firstly to breath and secondly to effectively absorb the water. Presence of organic matter effectively prevents the condition of pudding and keeps the structure open. The only exception is paddy crop which thrives in puddle soil.

Then again organic matter serves the diametrically opposite function too. In brought condition the soil tends to loose water and become parched. If organic matter is present in soil it resists evaporation of soil moisture and it is common knowledge that during long dry spells it is the soil rich in organic matter that keeps the crops alive. This is because the organic matter has great affinity for water and hence does not allow it to be evaporated.

Besides these two aspects, there are other contributions of the organic matter. Soil is not a dead matter. It is full of life both visible and microscopic. These organisms are extremely active and perform valuable functions in the soil. The earthworm for instance not only helps in opening the soil but also rolls the clay into nodules. Soil bacteria convert organic nitrogen into nitrates which can be absorbed by the roots. So also urea or ammonium soleplate or other nitrogenous fertilizers are likewise converted into suitable forms which can be absorbed by the plants.

Now the soil flora will change according to the chemical composition and the pH of the soil. Excess of chemical fertilizers will promote growth of certain bacteria and kill others. Thus the equilibrium of the soil is destroyed. High pH is bound to destroy the structure of the soil but presence of organic matter serves as a buffer. That means it does not allow injurious effects of soil alkalinity or acidity to effects the crops.
There are other factors too.

For instance, in manuring practice attention is usually given to nitrogen, phosphorus and potash. However there are many other organic elements which are necessary for plant growth in minute quantities. Their absence put a limitation to growth of crops. However organic matter supplies these minor elements and keeps plants growth healthy.

Again it is possible that other ingredients like hormones or enzymes or some other obscure elements are supplied by organic matter.

The sum total effect of organic matter is not, therefore, to be measured merely by the NPK contents of the manure.

FACTORS GOVERNING THE GAS PRODUCTION

Biogas plant is device for conversion of fermentable organic matter, in particular cattle dung, into combustible gas and fully matured organic manure. This is achieved by subjecting the material to anaerobic fermentation.

In biogas plant the whole system is based on continues operation i.e. the matter to be fermented fed in semi-fluid form at one end and the fermented spent slurry is extracted at the other and periodically without distributing the whole system. Now the fermentation, if it is to proceed in the best possible manner has to be arranged under certain specific conditions. Before all these factors are discussed it would be advisable first to see what happens during termination.

Cattle dung, night soil, poultry or piggery droppings and such other fermentable materials when confirmed in a place, out of contact with oxygen, give rise to a large number of bacteria. Broadly these bacteria can be divided into two groups.

1. Acid forming bacteria
2. Gasifying bacteria

The first group converts carbohydrates, proteins, fats into violate acids and in this process produce carbon dioxide. This phase may also be called the phase of liquification. Without these phase the subsequent gasification will not be possible. Liquification is brought about by a set of saprophytic bacteria by means of extracellur enzyme. These bacteria are not very sensitive and thrive in wide range circumstances.

Where first set of bacteria leave the work the second set of bacteria takes over. These are called methane bacteria. They now work upon the material with the help of intracellular enzyme and convert it into methane and carbon dioxide. These bacteria are rather very sensitive to temperature and pH. As matter of fact, the entire process is governed by a set of factors. These factors can be enumerated as under:

1. Temperature of the substrate
2. loading rate
3. Solid concentration.
4. Detention period
5. pH
6. Nutrients concentration
7. Toxic substances, etc

Temperature

It is found that the process of the digestion and gasification proceeds at the highest rate when the temperature is around 35^0 C. When the temperature falls, the process of digestion is retarded and below 15^0 C it is reduced to so much that the gas plant produces very little gas; that is why it is experienced that in winter the gas production is considerably depressed. In the KVIC's design however, because of the depth to which the designer is taken, there is some protection against violent changes in atmospheric temperature.

Loading Rate

Normally, the loading rate which depends upon the capacity of plants and also the retention period retention is correspondidingly decreased i.e. the period of fermentation is curtailed.

Solid Concentration

Ordinarily 7 to 9 percent concentration that is 7 to 9 parts of solid in 100 parts of the slurry is considered ideal. If it is diluted further or if it is concentrated, the fermentation is some what retarded and that is why we recommended 4 parts of the cattle dung to be mixed with 5 parts of water. This brings the concentration to about 8 percent or little higher. The proportion should therefore be maintained fermentation is to progress satisfactorily.

Retention Period

The retention period is the time for which fermentable material resides inside the digester. In KVIC's design this period is ranging from 30 to 55 days depending upon the climatic conditions. Ordinarily it is observed that maximum gas production takes place within the first 4 weeks and then it tapers off gradually. Therefore there is difference of opinion as to what should be the retention period. In major part of the country 30 to 40 days is optimum and there after the production is so small in quantity that it is not worth while making larger investment on a bigger digester. If the size of the digester is made smaller then the outgoing slurry comes out imperfectly digested and is likely to attract files or to give odor. The same may happen if the digester is loaded more than its rated capacity that is to say if a 100 cft digester which is expected to be loaded with about 75 kgs.of cattle dung every day is feed with twice that amount, it would proportionately curtail the retention period.

It may be noted that the retention period could be considerably reduced if the temperature could be agitated or the supply of nutrients in the digester is augmented. The relation period for night soil need not be more than 30 days because of the high nutritional value of the matter. For a very broad idea some figures given by some research workers on the rate of gas production per week may be of interest.

1st week	37	percent
2nd week	26.5	percent
3rd week	17.5	”
4th week	10	”
5th week	5.75	”
6th week	3.25	”

Of course these are only for general purpose and may not be take as in variable phenomenon.

pH

pH is a term which denotes the acidity and alkalinity of the substrate. The gas formation is optimum between pH of 7 and 8. If the pH drops appreciably below this, the gas production may be altogether stopped. When excessive loading is resorted to the acid forming bacteria resulting in lowering the pH. It may be noted that methane formers multiply slowly compared to the acid formers.

Nutrients Concentration

For bacteria nutrients consist of NPK, minor elements and some hormones etc. it is noticed that when sufficient amount of nutrients are available fermentation proceeds very fast that is why initially when the fermentation is to be established addition of oil cake gives stimulus for gas production. The best stimulant in this behalf is the animal urine. Chemical fertilizers for stimulation of gas production can also be used.

Toxic Substances

Toxic Substances like copper which is some feed to pigs may, if found in excess quantity, inhibit gas production but such occurrences are very rare.

Coming to the amount of gas that may be expected per animal, it should be borne in mind that it is a very difficult proposition to exactly mention the amount of gas. In the first instance the amount of animal droppings vary from animal to animal, feed given to the animal, the reason of the year, whether animal is stable bound or free grazing type etc. similarly, the composition of cattle dung or animal dung may vary according to the feed given to it. Nevertheless some board concepts can be given and an attempt is made in the following table. However it must be borne in mind that the figures are likely to vary very widely.

Source (animal)	Availability / day	Gas/Kg.(cft)	Gas per animal per day (cft)
Cattle	10 kgms	1.3	13
Night soil	400 grams	2.5	1
Pig (45 kg. wt)	2.25 kg	2.8	6.3
Poultry	0.18 kg	2.2	0.4
Spent deep litter (from poultry) dry			

The amount of gas available from kitchen waste or flaying waste will depend on the composition and concentration.

The composition of gas produced again varies with the material used for fermentation. On an average from cattle dung we get as which consists of 55 to 66 percent methane and 40 to 45 percent carbon dioxide with negligible amount of H_2S, hydrogen etc. 34 percent H2S, 0.6 percent and other gases 0.4 percent. Here again no firm figures can be given.

Pure night soil gas plant may not work satisfactory always. There are many reasons for this. In the first instance night soil gas plants are likely to have excessive dilation of the fermentation material owning to large volume of water that comes inevitably along with faeces. This upsets the fermentation and also reduces the retention period. This results in imperfectly digested slurry, with offensive odor. Besides this gas produced per person is only is only 1 cft. per day. Naturally even for a small size gas plant of 2 cum at least 60 persons are required, that means, it cannot be a family plant but a sourt of community plant. It is difficult with such a plant to maintain cleanliness of proper attention. However attaching a latrine or two to the biogas plant considerably helps in improving the fermentation by virtue of the nutrients content in the night soil. It not only helps in proper disposal of the night soil but increases the quality of gas and also the manorial value of the outlet slurry.

As mentioned above the gas production depresses during winter. It is necessary to stimulate gas production either by warming up the water used for mixing cattle dung, which provide additional heat to the digester or by putting some nutrients like urine, oil cakes or molasses into the ingoing dung slurry. Yet it must be said that this problem has not yet been satisfactorily solved. Not that scientifically there is no answer to it but considering that our gas plants are small and are installed in villages we cannot afford any sophisticated device for this purpose.

Ferro Cement Precast Digesters:

The biogas digesters of KVIC model are constructed in brick masonary depending on the availability of building material. Thought these materials are well suited and easily available, the time required for installation of gas plant is around 8 to 10 days at times difficulties were also faced due to poor quality of brick and interior quality of masonry work. This leads to development of cracks resulting in the failure of biogas plants. This is particularly more in the case of black cotton soil and sandy soil areas. To overcome this problem effort were made to use reinforced concrete rings which were either pre-cast or cast-in-situ. The reinforced concrete rings digesters consume more cement than conventional brick mansory digesters. Apart from this the order difficulties faced in continuing reinforced concrete digester technology was that the transportation and lowering of digester rings in the pit were difficult due to heavy weight of each ring. In view of this the use of reinforced cement concrete was not pursued.

To overcome these problems mentioned above in building Biogas digesters, efforts were made to use alternate construction techniques. Ferro-cement technology was tried for construction of biogas digesters.

(d) **Moulding**

If it has been decided to use a gel coat, which can be either brushed or sprayed on, care must be taken to see that this layer sets in about 30 minutes. This can be done by suitably adjusting the catalyst/accelerator system. The thickness of the gel coat layer should be about 0.3 to 0.5 mm. The laying up of the fibreglass CF reinforcement must not be started until the gel coat layer has set, and is only slightly tacky.

If it has been decided to use surfacing mat instead of gel coat, a thick layer of resin is brushed over the dried P.V.A. on the mould surface, the Surfacing Mat is laid on to it, additional resin added and all the air removed from the Surfacing Mat with a lamb's wool roller. Use about 280 gms. of resin per square metre.

Whether a gel coat or surfacing mat is used, a layer a resin should always be brushed onto the mould before the fibreglass CF Reinforcement is laid on.

The tailored mat is then placed over the mould area and stipled with a brush. The resin from the mould surface will then dissolve the binder and soak into the glass mat. More resin is applied with a brush and the mat is completely 'wetted out'. The rollers are then applied over the laminate and all the air is removed. It is absolutely essential that no air pockets are left in the layer immediately supporting the gel coat as otherwise 'blisters' will appear after the extraction of the moulding . It is also advisable to use a lower density mat (450 gm/sq.m.) for the first reinforcement layer in order to ensure easy wetting. Whenever the Fibreglass Cf reinforcement has to be applied in sections (e.g. in the case of large surfaces) these should overlap one another by about 2.5 cms so that no area is left unreinforced. Taking care that such joints are staggered, additional reinforcements are laid on, and the moulding is built up to the required thickness. If it is impossible to complete the laminations in one day, additional layers above the first layer of CF reinforcement can be built on the next morning but under no circumstances should the gel coated surface be left without CF reinforcement overnight as its bonding ability will be reduced. To reduce the fibre pattern on the non-contact surface and to improve its smoothness, it is customary to cover this surface with a layer of Surfacing Mat.

The Surfacing Mat can be worked into the laminate using a lamb's wool roller or brush moistened with acetone or resin. The roller or brush should be moist, but not wet. After the whole lay up operation is completed, the moulding is allowed to cure over the mould and then extracted. This can be done by easing the edges of the moulding from the mould and breaking the P.V.A. film. A rubber mallet or compressed air can also be used to help the extraction.

Value of different parameters of FRP gas holder

Sr. No.	Capacity m^3	Diameter m	Ht. of the spherical shell m	Nominal thickness mm	FRP weight approx. kgs.	Weight of the inner M.S. frame approx.kgs.	Addl weight required to be added kgs.
1.	3	1.50	1.0	1.7	29.0	48.0	90.00
2.	4	1.65	1.0	1.7	34.0	52.0	110.00
3.	6	2.00	1.0	2.0	42.00	72.0	185.0

Assembly of Gas Holder

An angles iron skeleton for the standard design (KVIC) of gas holder is fabricated. FRP sheets are bonded together on the outside and to the M.S. angles from inside to form the circumstance of the gas holder. The FRP laminate for the sheets shall consist of 2 layers of gel coat with 2 layers of chopped strand mat (E) glass one each of 300g/m^2 and 450 g/m^2 throughout the length of the sheets.

For the conical top of the gas holder, a one piece FRP top is fabricated using a conical mould. Built in FRP stiffeners are recommended. The area near the conical top in radius 1 mtr. from centre will be supplemented with 3 extra layers of 450 g/m^2. Wherever joints are involved, two additional layers of fibreglass chopped strand mat (E glass) 450 g/m^2 with at least twice by weight of unsaturated isopthalic polyester resin are to be provided to give at least the same thickness at the joints, as in the surface, the overlap should be at least 50 mm on either side of the joint.

Lay-up

1. Proper lay-up shall ensure that inner surface shall consist of the gel coat followed by layers of completely resin imprgnated layers of fibre glass chopped strand mat (E glass) topped with a resin rich surface.

2. All edges of the reinforcement mat shall be lapped and staggered in adjacent layers to obtain maximum possible strength.

3. Sufficient resin shall be used between layers and all subsurfaces roughened enough to ensure complete bond.

4. All cut edges shall be coated with resin so that no glass fibres are exposed and all voids are filed.

Joints

1. Joints shall be made by wrapping with strips of reinforcement mat soaked in resin. The wrap material shall be at least as thick as the thickest FRP section on surface and shall extend to either side of the joint.

2. The inside surface of the joints shall be sealed with the Mild Steel angle framework with two layers of mat 450g/m^2 where accessible.

PRODUCT TESTING
Visual Testing

1. Each holder shall be visually examined for any visible defects in the manufacture the final FRP surface shall be free from wrinkles, blisters, pin-holes, straw cracks and surface crazing.

2. **Overall Dimensions**

The overall dimensions of the holder shall be as per the standard KVIC design.

3. **Text for Leakages**

A circular water tank of 1/2 metre depth with required diameter is put below ground level. A G..I. pipe of 11/2 inch dia and 0.75 metre height is fixed at the centre of this tank The tank is filled with water. The gas holder which is to be tested for leakages is i mmersed in the tank in the same way as is done while housing the gas holder in the digester. Before the gas holder is immersed i the tank the main gas outlet valve on the gas holder is closed. After the bottom of the gas holder touches the surface of the water the gas holder starts floating due to pressure of air in the gas holder. By applying the soap solution on the outer surface of gas holder the leakages if any could be detected. If the gas holder does not show any indication of sinking for about 15 minutes it is ensured that there are no leakages.

Transportation and Erection

1. Enough care shall be taken during the transportation and erection not to cause any damage to outer surface of ten gas holder and any excessive concentrated load is not put on the gas holder.

2. The gas holder shall be transported in an upright position and not by keeping it in a horizontal position.

3. The gas holder should not be dropped on the ground from the vehicle. The gas holder should not also be rolled on the ground.

4. The gas holder is housed in the digester only after a week of curing under normal atmospheric condition.

4. **Tools and Equipments**

The following list is not exhaustive, but it includes most of the more important items that are likely to be required for contact moulding.

Buckets - made out of low polythene are best suited for handling the resins, as polyester does not bind to polythene and the buckets can therefore be cleaned easily. These can be obtained in various sizes ranging from 1 litre to 10 litres capacity. The flexibility and softness for polythene is also an advantage when the cured polyester is being removed, but the same property makes it prone to damage, and these buckets should be handled with care.

Brushes - for the gel coat application 1.25 to 7.5 cms smooth haired brushes should be used. It is important to clean the brushes with acetone as soon as the application is over.

Scissors - A good quality pair of scissors of 22.5 cms size should be used for cutting and preparation of glass mat.

Smooth textured Cloth - This should be used for the application of Wax over the mould.

Rollers for Lamination - are made of mild steel discs. About 15 discs are attached in series and they rotate freely round an axle. The axle itself is held in a suitable bracket, which in turn is attached to a handle. On flat surface ribbed rollers may also be used.

Hand Grinders

Hack Saw Blades for Cutting

Repair of Mouldings

Damage is generally localised and confined to small cracks or fractures. In this case broken material should be removed and the edges feathered. Loose Chopped Strands or Chopped Strand Mat should be laid into the cavity and impregnated with activated resin. Filler may be added to prevent drain on inclined surfaces and a further layer, bonding on to the moulding at least 2.5 cms beyond damage area, is desirable for heavy duty mouldings.

Advantages of FRP

1. FRP produces the green house effect allowing short wave solar radiation to pass into the digester and keeps it inside when once it is converted into heat energy. Thus the FRP gas holder will hence attain higher temperature inside the digester which could accelerate the fermentation process which results in higher yield of gas.

2. FRP has excellent resistence to corrosion.

3. Manufacture of FRP gas holder is labour intensive and energy efficient. The moulding technique be easily followed and thus helps in providing employment to semi-skilled labourers.

4. No power or expensive equipment is required for moulding.

5. Fabrication is easy and can be taken up even at semi urban centres.

SOME RELEVANT DETAILS OF BIOGAS PROGRAMME :

1. SOME USEFUL INFORMATION :

How much dung (green) is available per animal ?

No firm figures can be given. It depends on the size of the animal, feed material and whether the animal is stable- bound or freely grazing. Nevertheless, the following figures can be taken as broad averages for stable- bound grown up animals of medium size.

Buffalo	-	about 15 kg. per day
Bullock or cow	-	about 10 kg. per day
Calves	-	about 5 kg. per day

Gas per kg. of wet dung 0.037 Cum. (1.3 ctf.)

In case of attached latrine, gas produced per person using the latrine is 0.028 Cum. (1cft.)

Size of the Gas Plant

The size of gas plant at any place will be determined by actual number of animals or persons available.

Gas Consumption

For cooking	:	0.227 Cum. (8cft.) per day per person
For light	:	0.127 Cum. (4.5 cft./hr.) per lamp of 100 candle power
For motive power	:	0.425 Cum. (15 cft.) per H.P. per hour

SOME USEFUL DATA

1 Inch	=	25.39998 mm	CALORIFIC DATA		
1 Foot	=	0.3047997 m			
1 Meter	=	3.280833 ft	Methane		
1 Mile	=	5280 ft or 1.6093 km	9212 Kcal/M^3		
1km	=	0.6214 miles	1012 B T U / Cft		
1 Acre	=	0.40468 ha or 43560 sq ft			
1 Hectare	=	2.471 acres	Gobargas		
1 Fluid oz	=	28.412 ml	533 B T U/ Cft		
1 Gallon (imp)	=	4.536 litres			
		10 lb of water			
1 Cft	=	28.317 I	Specific Gravity		
1 Litre	=	0.2205 gallons	CH_4	=	0.558
1 Cubic meter	=	35.314 cft	CO_2	=	1.52
1 Kg	=	2.2046 Ib	Gobar Gas	=	0.92
1 Lb	=	0.4535924 kg			
		453.59 gm	Wt of Biogas	=	36
1 Cwt	=	50.8024 kg	gm. cft		
1 Metric tonne	=	0.9842 British ton			
1 Kg/ Sq cm	=	14.223 Ib/sq inch			
1 Koal	=	3.9657 B T U			

Horse Power :

1 HP	=	75 kg meter/ second
		550 ft Ib/second

One Cubic Meter per day Gas Plant :

Requires :

'NPK' in dry Gobargas Manure

N (N_2)	=	1.4 - 1.8%
P (P_2O_5)	=	1.1 - 2.0%
K (K_2O)	=	0.8 - 1.2%

27.15 kg green dung per day
9.91 tonnes green dung per year

Produces :

10.18 kg air-dry manure per day
3.72 tonnes air-dry manure per day
27 kg Nitrogen per year (N_2)
30 kg Phosphorus per year (P_2O_5)
18 kg Potash per year (K_2O)
365 M^3 gas per year equivalent to
226.3 litres of Kerosene

COMPARISON OF VARIOUS FUELS

Name of fuel	Calorific value Kilo - calories	Mode of burning	Thermal efficiency %	Effective heat Kilo-calories
1. Gobar Gas (M^3)	4713	In standard burner	60	2828
2. Kerosene (litre)	9122	Pressure Stove	50	4561
3. Fire wood (kg.)	4708	In open Chulha	17.3	814
4. Cow-dung cakes (kg.)	2092	- do -	11	230
5. Charcoal (kg.)	6930	- do -	28	1940
6. Soft coke (kg.)	6292	- do -	28	1762
7. Butane* (kg.)	10882	In standard burners	60	6529
8. Furnace Oil (litre)	9041	In water tube boiler	75	6781
9. Coal Gas (M3)	4004	In standard burners	60	2402
10.Electricity(kwh.)	860	Hot plate	70	602

REPLACEMENT VALUES OF DIFFERENT FUELS

Name of Fuel	Unit	Gobar Gas 1 M^3	Kero-sene 1 litre	Fire wood 1 kg.	Dung cakes 1 kg.	Char-coal 1 kg.	Soft coke 1 kg	Butane 1 Kg.	Furnace Oil 1 litre	Coal Gas 1 M^3	Elect-ricity 1 kwh.
Gobar Gas	M^3	1.0	1.613	0.288	0.081	0.686	0.623	2.309	2.398	0.849	0.213
Kerosene	Litre	0.620	1.10	0.178	0.050	0.425	0.386	1.431	1.487	0.527	0.132
Fire Wood	Kg.	3.474	5.603	1.0	0.283	2.383	2.165	8.210	8.330	2.951	0.740
Cow-dung Cakes	Kg	12.296	19.830	3.539	1.0	8.435	7.640	28.387	29.483	10.443	2.617
Charcoal	Kg.	1.458	2.351	0.420	0.119	1.0	0.908	3.365	3.495	1.238	0.210
Soft Coke	Kg.	1.605	2.589	0.462	0.130	1.101	1.0	3.705	3.848	1.363	0.342
Butane*	Kg.	0.433	0.699	0.125	0.035	0.297	0.270	1.0	1.039	0.368	0.092
Furnace Oil	Litre	0.417	0.673	0.120	0.034	0.286	0.260	0.963	1.0	0.354	0.089

Coal Gas	M^2	1.177	1.899	0.339	0.096	0.808	0.734	2.788	2.823	1.0	0.251
Electricity	Kwh.	4.698	7.576	1.352	0.382	3.223	2.927	10,846	11.264	3.990	1.0

For equivalents read vertical columns
1. M 3 (Cubic Meter = 35.315 Cubic deet
* Butane : Bottled domestic cookinng gas sold as Indane, Bharat Gas (Burshane), H.P. (Esso) etc.

LIST OF MATERIALS REQUIRED FOR KVIC TYPE VERTICAL GAS PLANT
30 DAYS DETENTION PERIOD

	2 Cum (70 Cft.)	*3Cum (106Cft.)*	*4 Cum (141 Cft.)*	*6 Cum (212 Cft.)*	*8 Cum (283 Cft.)*	*10 Cum (353 Cft)*
I. Materials required for construction :						
1) Bricks (Nos.)	2,060	2,270	2,510	2,900	3,410	
2) Snad (Cum.)	1.75	2.20	2.40	2.85	3.35	
3) Stone Chips 1/2" or 3/4" (Cum.)	0.60	0.85	0.95	1.25	1.40	
4) Cement (Bags)	11	15	16	19	22	
5) A.C.Pipe 100 mm. Intl.dia. (R.M.)	3.04	3.70	4.90	5.00	5.70	
II. Materials required for central guide frame :						
1) 35 x 35 x 4 or 5 m.m Angle Iron (R.M.)	10.90	11.90	12.70	14.25	15.00	
2) M.S. pipe 40 mm dia. (R.M.)	1.85	2.00	2.05	2.05	2.35	
3) Square plates 250 x 250 x 6 mm. (Nos.)	2	2	2	2	2	
4) 14 mm. dia. and 32 mm. long bolts with nuts (Nos.)	16	16	16	16	16	
III Materials required for Gas holder :						
1) 35 x 35 x 4 or 5 mm.angle Iron (R.M.)	16.80	19.40	21.00	30.60	35.25	
2) M.S. pipe 50 mm Intl. dia (R.M.)	1.15	1.15	1.25	1.25	1.25	
3) 250 mm. dia. and 6 mm. thick flange plate (Nos.)	2	2	2	2	2	
4) Flats 40 x 6 mm. thick (R.M.)	4.20	4.15	4.30	3.50	4.05	
5) Gas outlet pipe flange 25 mm.dia (Nos.)	1	1	1	1	1	
6) G.I.Bend 25 mm. dia. (Nos.)	1	1	1	1	1	
7) Heavy duty gas valve 25 mm. dia. (Nos.)	1	1	1	1	1	
8) Union Joint 25 mm. dia. (N0s.)	2	2	2	2	2	
9) Pipe nipple 25 mm. dia.						

100 mm. long (Nos.)	1	1	1	1	1
10) Pipe nipple 25 mm. dia 150 mm long (Nos.)	2	2	2	2	2
11) Clips (Nos.)	2	2	2	2	2
12) 3 metre polythene or reinforced rubber pipe 25 mm.dia. (Nos.)	1	1	1	1	1
13) 2.50 mm. thick (12 gauge) mild steel sheets (2.5 m x 1.00 m) (Nos.)	2 1/4	3	3 1/4	4 1/4	4 1/2

Notes : 1) Item No.II & III may be entrusted to a local workshop for fabrication of gas holder and central guide frame

2) 10 per cent of the cost of all the items will cover up the gas pipe, the diameter and leng of which depends upon the consumer's distance, no of bends and elbows used, flow of gas in cft. per hour etc.

LIST OF MATERIALS REQUIRED FOR KVIC TYPE VERTICAL GAS PLANT
40 DAYS DETENTION PERIOD

		2 Cum (70 Cft.)	*3Cum (106Cft.)*	*4 Cum (141 Cft.)*	*6 Cum (212 Cft.)*	*8 Cum (283 Cft.)*	*10 Cum (353 Cft)*
I.	**Materials required for construction :**						
	1) Bricks (Nos.)	2,460	2,765	3,205	3,730	4,430	4,650
	2) Snad (Cum.)	2.00	2.55	2.90	3.40	5.00	4.20
	3) Stone Chips 1/2" or 3/4" (Cum.)	0.60	0.90	0.95	1.25	1.40	1.60
	4) Cement (Bags)	13	17	19	23	26	28
	5) A.C.Pipe 100 mm. Intl.dia. (R.M.)	3.90	4.60	6.30	6.50	7.70	7.10
II.	**Materials required for central guide frame :**						
	1) 35 x 35 x 4 or 5 m.m Angle Iron (R.M.)	10.90	11.90	12.70	14.25	15.00	16.50
	2) M.S. pipe 40 mm dia. (R.M.)	1.85	2.00	2.05	2.05	2.35	2.40
	3) Square plates 250 x 250 x 6 mm. (Nos.)	2	2	2	2	2	2
	4) 14 mm. dia. and 32 mm. long bolts with nuts (Nos.)	16	16	16	16	16	16
III	**Materials required for Gas holder :**						
	1) 35 x 35 x 4 or 5 mm.angle Iron (R.M.)	16.80	19.40	21.00	30.60	35.25	43.40

2) M.S. pipe 50 mm Intl. dia (R.M.)	1.15	1.15	1.25	1.25	1.45	1.50
3) 250 mm. dia. and 6 mm. thick flange plate (Nos.)	2	2	2	2	2	2
4) Flats 40 x 6 mm. thick (R.M.)	4.20	4.15	4.30	3.50	4.05	4.20
5) Gas outlet pipe flange 25 mm.dia (Nos.)	1	1	1	1	1	1
6) G.I.Bend 25 mm. dia. (Nos.)	1	1	1	1	1	1
7) Heavy duty gas valve 25 mm. dia. (Nos.)	1	1	1	1	1	1
8) Union Joint 25 mm. dia. (Nos.)	2	2	2	2	2	2
9) Pipe nipple 25 mm. dia. 100 mm. long (Nos.)	1	1	1	1	1	1
10) Pipe nipple 25 mm. dia 150 mm long (Nos.)	2	2	2	2	2	2
11) Clips (Nos.)	2	2	2	2	2	2
12) 3 metre polythene or reinforced rubber pipe 25 mm.dia. (Nos.)	1	1	1	1	1	1
13) 2.50 mm. thick (12 gauge) mild steel sheets (2.5 m x 1.00 m) (Nos.)	2 1/4	3	3 1/4	4 1/4	4 1/2	5 1/2

Notes : 1) Item No.II & III may be entrusted to a local workshop for fabrication of gas holder and central guide frame

2) 10 per cent of the cost of all the items will cover up the gas pipe, the diameter and leng of which depends upon the consumer's distance, no of bends and elbows used, flow of gas in cft. per hour etc.

KVIC TYPE GAS PLANT (1 M^3 to 3 M^3)

BIO- GAS PRODUCTION IN M^3 30 D.R.P. & 40 D.R.P

	DIGESTER	Symbol	Days	1M^3	2M^3	3M^3
1.	Excavation dia	A	30/40	181	196	221
2.	Excavation depth (ht.)	B	30	127	202	217
3.	Excavation depth	B	40	172	272	292
4.	Foundation dia	C	30/40	181	196	221
5.	Height of Gas Plant (Digester)	D	30	135	210	225
6.	Height of Gas Plant (Digester)	D	40	180	280	300
7.	Height of Gas Plant(Digester) Bottom	D1	30	45	80	95
8.	Height of Gas Plant (Digester) Bottom	D1	40	90	150	170
9.	Height of Gas Plant (Digester) Top	D2	30	60	100	100
10.	Height of Gas Plant (Digester) Top	D2	40	60	100	100
11.	Digester dia. (inter)	E	30/40	120	135	160
12.	Digester dia. (outer)	E1	30	166	181	206
13.	Digester dia. (outer)	E1	40	166	181	206
14.	Wall thickness	F	30/40	23	23	23

GAS HOLDER

15.	Gas Holder dia.	G	30/40	105	125	150
16.	Gas Holder height	H	30/40	60	100	100

INLET TANK

17.	Inlet Tank L x W	I	30/40	40 x 40	38 x 38	75 x 75
18.	Inlet Tank height	I1	30/40	40	38	45
19.	Inlet Tank height	I2	30/40	30	355	38
20.	Wall thickness	J	30/40	15	15	15
21.	Lenghth of A.C. pipe (100 mm.dia.)	K	30	150	260	260
	,, ,, ,, ,, ,,		40	200	300	350
22.	Lenghth of A.C. pipe (100 mm.dia.)	K1	30	25	60	65
	,, ,, ,, ,, ,,	K1	40	50	70	60
23.	Lenghth of A.C. pipe (100 mm.dia.)	K2	30	50	20	260
	,, ,, ,, ,, ,,	K2	40	30	50	50

OUTLET TANK

24.	Outlet Tank L x W	L	30/40	-	45 x 45	45 x 45
25.	Outlet Tank height	L1	30/40	-	45	45
26.	Outlet Tank height	L2	30/40	-	50	50
27.	Wall thickness	M	30/40	-	15	15
28.	Length of A.C.pipe (100 mm dia.)	N	30	50	80	110
			40	70	90	110
29.	G.I.pipe (M.S.pipe) for C.G.F.	O	30/40	130	195	200
30.	M.S. pipe for Gas Holder	P	30/40	70	115	115

* All dimensions in cm.

KVIC TYPE GAS PLANT (4 M^3 to 10 M^3)

BIO- GAS PRODUCTION IN M^3 30 D.R.P. & 40 D.R.P

DIGESTER		Symbol	Days	$4M^3$	$6M^3$	$8M^3$	$10M^3$
1.	Excavation dia	A	30/40	241	281	301	336
2.	Excavation depth (ht.)	B	30	227	227	257	247
3.	Excavation depth	B	40	307	307	347	332
4.	Foundation dia	C	30/40	241	281	301	336
5.	Height of Gas Plant (Digester)	D	30	235	235	265	256
6.	Height of Gas Plant (Digester)	D	40	315	315	355	340
7.	Height of Gas Plant(Digester) Bottom	D1	30	105	105	110	100
8.	Height of Gas Plant (Digester) Bottom	D1	40	185	185	200	185
9.	Height of Gas Plant (Digester) Top	D2	30	100	100	125	125
10.	Height of Gas Plant (Digester) Top	D2	40	100	100	125	125
11.	Digester dia. (inter)	E	30/40	180	220	240	275
12.	Digester dia. (outer)	E1	30	226	266	286	321

13.	Digester dia. (outer)	E1	40	226	266	286	321
14.	Wall thickness	F	30/40	23	23	23	23

GAS HOLDER

15.	Gas Holder dia.	G	30/40	165	200	225	260
16.	Gas Holder height	H	30/40	100	100	125	125

INLET TANK

17.	Inlet Tank L x W	I	30/40	75 x 75	90 x 90	90 x 90	70x70
18.	Inlet Tank height	I1	30/40	475	45	525	60
19.	Inlet Tank height	I2	30/40	45	45	40	40
20.	Wall thickness	J	30/40	15	15	15	15
21.	Lenghth of A.C. pipe (100 mm.dia.)	K	30	260	270	300	290
	,, ,, ,, ,, ,,		40	330	350	400	370
22.	Lenghth of A.C. pipe (100 mm.dia.)	K1	30	60	60	70	60
	,, ,, ,, ,, ,,	K1	40	60	60	70	60
23.	Lenghth of A.C. pipe (100 mm.dia.)	K2	30	50	60	40	50
	,, ,, ,, ,, ,,	K2	40	78	75	60	60

OUTLET TANK

24.	Outlet Tank L x W	L	30/40	45 x 45	45 x 45	45x45	45x45
25.	Outlet Tank height	L1	30/40	45	45	40	45
26.	Outlet Tank height	L2	30/40	50	50	50	50
27.	Wall thickness	M	30/40	15	15	15	15
28.	Length of A.C.pipe (100 mm dia.)	N	30	230	230	270	250
			40	300	300	370	340
29.	G.I.pipe (M.S.pipe) for C.G.F.	O	30/40	205	205	235	240
30.	M.S. pipe for Gas Holder	P	30/40	125	125	145	150

* All dimensions in cm.