PROJECT PROPOSAL TO NORAD

CONSTRUCTION OF 4 BIO-GAS PLANTS TO SUPPLY ENERGY FOR HOSPITALS IN ERITREA

DRAFT

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ON BEHALF OF THE ERITREAN RELIEF ASSOCIATION

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Introduction

Eritrea, like many countries of the third world, has energy problems. It depends totally on imported oil and gas. Although the Eritreans during their long struggle to get rid of foreign occupation have made remarkable achievments in relying on their own resources, notably in the military and social aspect, nothing has been done in the field of energy. The rural communities have always and still continue to depend on firewood and charcoal for energy. The consequence being vast deforestation of the landscape, erosion of the soil, shortage of rainfall etc.

The concept of enhancing the self-reliant development of rural communities by the implementation of appropriate biotechnologies is one worthy of serious examination. Energy, it is expensive. It is precious. It is essential. Agriculture, in its widest context, is a renewable source of energy. So agriculture may become not only a source of food but also a source of energy from its waste products.

Anaerobic digestion is a well developed method by which a gas, a biogas, which is rich in energy can be produced from animal dung. This supply have the advantage of being locally produced. Most organic matter can be digested to produce biogas, which contains about 70% methane. As a highgrade source of energy, biogas may be compared with natural gas and can contribute to the energy supplies of a farm, workshop, school or community specially in isolated places where supplies of electricity and conventional fuels may be costly and unreliable.

Animal wastes and human sewage are readily digestible organic matter that can offer digesters a suitable and constant supply. Biogas is essentially a local fuel which can contribute to the self-reliance of energy. It is however difficult and expensive to store large quantities of biogas and as much as possible the rate of daily production should be matched by gas use. Biogas may be produced from a wide range of agricultural and industrial materials. The quantities of biogas produced will vary with the nature and organic content of the material, the operating temperature and the time the waste material is retained in the digester.

Rural farms provide large amounts of organic waste, particularly in the form of animal manure, and by processing it through a digester it is a readily available source of energy for farmers. Considering today's cost and unreliability of fuel supply, whenever organic waste is available, biogas can be produced and utilised with simple equipment as in China and India.

Biogas has been in use in Asia particularly in China and India for several decades. Hundreds of thousands of biogas plants provide the rural communities in these countries with heating burners, electricity and engine power.

The gas plant can digest not only the cattle dung but also the urine of the cattle and the human excreta. After these materials pass through the gas plant the manure is not only rich in its nutrients but is also innocucos and odourless, free from flies and other sources of infection. The gas which is produced will burn with a non-luminous blue hot flame without a trace of smell. Unlike untreated cow dung and other fuels the use of methane will prevent smoke. Utensils will remain bright.

Project aim

The aim of this project is to build and to operate pilot biogas plants in order to develop a good technical concept for large scale, medium scale and small scale operations. It will furthur involve carrying out a study for the development of the concept among the farmers. Under the project 4 biogas plants, 2 large size, one medium size and one small size are to be built at selected locations providing energy to hospitals in remote places. While the short term objective is to enable these hospitals to produce sufficient gas for their own use from their own resources, the long term objective is for these plants to serve as a model for the rural farm communities to benefit from the development of the technique.

A community utilizing its indigenous energy production, mostly via biological processes, is becoming potentially a more independent community. Since the operation of biogas plants creates the cycle of events: cows in a field discharge dung which is transfered to biogas generator, thereby evolving methane gas for cooking and light, and an effluent sludge which can act as a nitrogen fertilizer, which is then applied to the pasture to be grazed by cows, the user can benefit from every phase of the process. Therefore this project can be called comprehensive and multi-beneficial.

In the long run, as a result of farmers switching from firewood to the use of biogas, the forests could be spared, soil erosion could be protected and climatic effects of deforestation could be controlled. There is no doubt that a successful completion of this project will pave the way for self-reliance in the field of energy. Besides the production of biogas and fertilizer, the presence of the cows in the vicinity of the hospitals will ensure the supply of the neccesary diet of milk and milk products to the patients.

To conduct a full-scale experimental project to recover energy, detailed information is required on the availability of wastes and residues, geographical distribution, seasonal variation etc. For the efficient use, easy operation and maintenance, simple technical method and because of its proven application, it is suggested that the so-called Gobar Gas Plant of India be used as a model for the building of the digesters under this project. Application of these designs and certificate of their appliances and equipments is available from the official commission that supervises thousands of plants in the country. The similarity of climate in the two regions which are more or less in the same latitude will ensure the function of the equipment and makes it easy to determine the retention time in the digesters.

System description

Anaerobic digestion is the process by which organic material is fermented by bacteria in the absence of air. The results or benefits of the process are that the organic material is stabilized and that energy is produced in the form of digester gas, whose main constituent is methane. It is preferable to regard the process as a treatment process which produces energy as a by-product, rather than primarily as an energy producer. Here is the system description:

Waste collection systems

Collection systems usually consist of pipes or channels for transporting waste (dung + urine) to a collection tank. To achieve uninterrupted daily supply of waste, the animals assigned for this purpose have to be stable bound. Regular and constant inputs are made to the digester from the collection tank. Some systems will require a pumped input while others may rely on gravity.

Pre-treatment systems

Pre-treatment of the waste may make it easier to digest. Separation, screening or maceration will remove or breakdown large fibres. The efficiency of gas production from the remaining smaller, more uniform particles is increased and scum formation in the digester and blockages in pipes and valves reduced.

The digestion process

The digester tank or well maintains anaerobic conditions for optimum digestion. Retention time will usually vary between 3 and 20 days, digester being continuously or regularly fed, so that incoming raw waste displaces an equivalent amount of digested liquor. The shape and construction of digesters is very variable depending on the number of cattle, temperature and other environmental factors. But for all practical reasons, we would select the concrete structures built below ground level.

Stirring mechanisms

Regular stirring prevents scum formation and enhances the rate of digestion by ensuring uniformity of the contents. A mechanical stirring device manually or with the help of the cattle is a possible option. In addition, the stirring would increase production of methane in a plant.

Gas storage

Gas production has to be balanced against actual demand. This is done by constructing a gas store in which up to one day's production can be kept. Storage in excess of this requires very large and therefore expensive storage tanks. Gas storage is needed to allow for discontinuous gas consumption.

Further treatment and final disposal

Sludge treatment technology has been well advanced in some countries in Europe, especially in the United Kingdom, and although different sludges have varying characteristics, suitable treatments are available depending upon the end use and disposal of the digested waste. Equipment is available for the disposal to land of digested sludges or solid wastes by irrigation or mechanical spreaders, for separating the solids from the waste before or after digestion, and for further purification of liquid effluents.

Safety

Provided that a digester receives the waste for which it was designed within acceptable limits of variation, digestion is problem free. However safety considerations are essential in the design of digester systems. Methane is potentially explosive and care must be taken to minimize the risk of gas leaks and to remove sources of ignition. By observing minimal safety precautions there is neither the danger of explosion of the gas plant nor any problem of foul odour or fly breeding. Therefore there is no objection to locating the gas plant near a residence.

Equipment

A gas plant comprises of a digester of adequate size to ferment in an efficient manner the cattle waste, urine and night soil. The gas holder covers this digester to collect and divert the gas produced through fermentation into the gas pipe at correct pressure. The gas pipe will convey the gas from the gas holder to the points of use i.e. kitchen stoves, gas lamps and gas engines without undue loss of pressure.

The fermentation tank or digester of the Indian and Chinese type is made of bricks and cement morter or other locally available building materials. The gas holder is normally fabricated from mild steel sheets. Mild steel gas holders will have to be scrubbed and painted before use. In addition they will have to be protected periodically from corrosion. Pipe for carrying gas should either be of galvanised iron or black polythene or HPD with an internal diameter of not less than 1" or 25mm and wall thickness of 4.7mm. Inside the house 1/4" or 1/2" G.I. pipe should be used.

Stoves, gas lamps, engines and pipes specially designed for this purpose, tested for efficiency and approved by the Khadi & V.I. Commission of India are available for purchase from the commission. Biogas production with simple equipment as in India and China where small units utilise the dung of a few animal and provide gas for a rural family is considered ideal in the Eritrean case at present rather than the more developed pilot or fullscale plants in Europe which are suitable for large farm areas or supplied by urban sewers. Such plants require heavy pumps, compressors and gas boilers. These plants, besides being big in size are built above ground floor and they can be easy target for enemy aircraft.

Construction of gas plant

The two major components of a gas plant are:

The Digester

This is a sort of well, of masonry work, dug and built below ground level. Depth and diameter of the well varies depending upon the quantity of materials to be fed in. This well has a partition wall in the middle dividing it into two semi circular compartments. Two slanting cement pipes reach the bottom of the well on either side of the partition wall and have their opening on the surface of the ground by the side of the top of the well. One pipe serves as inlet and the other as outlet. Cattle dung is mixed with water in the proportion of 4 : 5. This mixture is led down in the inlet pipe and as the well gets filled up equal quantity of dung slurry flows out through the outlet pipe, outlet opening being lower than inlet. The partition wall stops short of the top of the well and thus it remains submerged in the dung slurry. It may be noted that the well is so designed that it can hold 30 to 50 days material. Initially it is filled up, so that whenever any material is put in from one side an equal quantity goes out from the other. Depending on the variation in atmospheric temperature, the retention period of the digesters can be maintained at 30 days as the ambient temperature in Sahel varies from 20°c to 40°c.

The gas holder

This is a drum like structure constructed of mild steel sheets. It fits like a cap in the mouth of digester where it dips in the slurry and rests on a ledge constructed inside the digester for this purpose. The drum collects gas which bubbles out from the cattle dung slurry put in the digester. The drum rises as as the gas is collected in the gas holder. The gas so accumulated flows out through the pipe. This gas can be led to the kitchen or can be used for gas lamps whenever required. In its up and down movement, the drum is guided by a central guide pipe. Gas formed is otherwise sealed from all sides except at the bottom. The gas which accumulates inside the drum is under pressure equivalent to the weight of the drum. The pressure is no doubt very small 7.5 to 10 cm. water column, but it is adequate to press the gas into the kitchen stove or gas lamp.

Pre-requisites for setting up a gas plant

The individual or the institution must have sufficient number of animals. The animals should be stable bound. If they are free grazing type their dung would be lost in the pasture and it would be difficult to ascertain the actual quantity produced every day. It is not economic to establish even the smallest size gas plant unless fresh dung of a minimum weight of 40 kg is available every day.

On an average the daily droppings expected from a stable bound large size cow/oxen can be taken up to 20 kg per day. Medium size would drop up to 10 kg. If the animals are very small, the quantity may be much smaller. Though no definite figure can be mentioned because of a number of variables, roughly about two animals are essential for establishing a 2 cubic meter gas plant. The larger the number the bigger will be the gas plant.

Sufficient space must be available for constructing the gas plant and for location of pits for outlet slurry. This space again must be very near the stable on one hand and close to the place where gas is to be used. It is not advisable to transport the dung over long distances for use. Normally the distance should be within 20 meters.

Sufficient quantity of water must be available. Normally the cattle dung is mixed with a more or less equal quantity of water before feeding into the gas plant. Unless sufficient water is available it is not possible to think of setting up a gas plant.

Operation and maintenance

The gas plant is easy to operate. All that is necessary is to collect cattle dung and urine, or vegetable wastes, dump it into the mixing tank, add water, mix properly and then feed it into the inlet pipe. In these digesters air is excluded. The slurry, upon entering the plant discharges an equal quantity of pipe slurry from the outlet pipe. After fermentation the waste turns into two useful products. One is fuel gas which is piped to cookers and lamps. The other is nitrogen rich and inoffensive manure for farmland. The slurry from the outlet pipe should immediately be led to the compost pit and covered.

This is a continuous operation. Therefore the raw material must be fed into the digester on a regular interval once or twice a day depending on the gas requirement. The digester retention time is determined according to the speed at which the material is digested and, more important, the time taken for the bacteria washed out with the displaced material to be reproduced. Controlled digestion takes place at an elevated temperature, normally in the mesophilic range (around 35 c). Digestion is accelerated as the temperature rises.

Digester mixing is required for two reasons - to ensure a homogeneous mixture of digesting material and to assist the mechanical throughput. The degree of mixing varies greatly with different digester designs. However, it is known that successful digestion is possible with little or no mixing. The net energy production will also increase with increasing size and improved insulation of the digester, especially in cold weather conditions.

Occasionally the gas holder will have to be rotated to break the scum that forms in the digester. Similarly, condensed water in the gas pipe will have to be removed once a month. The gas holder should be repainted once or twice a year as the situation demands.

Benefits of biogas

Product benefit

The two main products of a gas plant are gas and manure. The gas can be used as fuel for heating or lighting or for motive power. The gas consists of approximately 55% methane and 45% carbondioxide. Since the compostition of this gas is different from coal gas or buthane gas, appliances such as stoves or lamps to be used have also to be of special design. These appliances are available from British and Indian manufacturers. The gas can also be used for running oil engines. For this, the quantity of gas available must be sufficient. On an average 425 litres of gas is required per horse power per hour. If a 5 H.P engine is to be used for say 8 hours, at least I8 cubic meters of gas would be required per day. The manure can be used as a ready made fertilizer to the farms around the gas plant. The outlet slurry as it comes out is quite rich both in nitrogen and humus. It is fully digested and is in a finely divided condition. It can most profitably be applied to the farm directly by mixing with irrigation water. This way maximum benefit is derived because the nitrogen content of fresh slurry is over 2% and it is in a condition that mixes with soil very easily.

Subsequential benefits

The development of biogas in rural farm communities, in addition to its direct products, has subsequential benefits affecting the overall environment and the living standard of the community, these are:

-- positive impact on deforestation, relieves a portion of the labour force from having to collect wood and transport coal, helps conserve local energy resources.

-- inexpensive solution to problem of rural fuel shortage, improvements in the living and health standards of rural and village communities.

-- effective destruction of intestinal pathogens and parasites, end products non-polluting, odours non-offensive.

-- system pays for itself and apt example of self-reliance and self-sufficiency.

-- residual sludge is applied as top-dressing, good soil conditioner, inorganic residue useful for land reclamation.

Planned digester location & capacity

Biogas plant	location	digester size	animal numbers	daily prod. of gas	use for gas
No. I		$25m^3$	25	30-40	
No. 2		$25m^3$	25	30-40	
No. 3		$15m^3$	15	16-26	
No. 4		$10m^3$	10	12-15	

source : British Anaerobic and Biomass Association Ltd.

Biogas plant	location	number of residents	livestock area	average temperature	average rainfall
No. I					
No. 2					
No. 3					
No. 4					

source : Eritrea Research and Information Center.

Useful data

No firm figures can be given as to how much dung (green) is available per animal. It depends on the size of the animal, type of feed and whether or not the animal is stablebound or freely grazing. Nevertheless the following figures can be taken as broad averages for stable-bound grown up animals of medium size.

Buffalo	about	I5kg.	per day
cow / oxen	"	I0kg	"
calves	"	5kg	"

Gas per kg of wet dung 0.037 Cum (I.3 cft)
In case of attached latrine, gas produced per person using the latrine is 0.028 Cum (Icft.)

Gas consumption

for cooking	: 0.227 Cum (8cft) per day per person
for light	: 0.127 Cum (4.5cft/hr) per lamp of I00 candle power
for motive power	: 0.425 Cum (I5cft) per H.P. per hour.

Size of gas plant

The size of gas plant at any place will be determined by actual number of animals or persons. Smallest gas plant is of 2 cu.m size which requires 2 or 3 animals.

source : Khadi and Village Industries Commission

Finance

The cost of the project will consist mainly of:

a) Purchase of animals, equipment and building materials

b) Design of digesters and other specialist consultation fees

c) Operating cost for a year. Cattle food and spare equipment

Cost breakdown of biogas plant No. 1	cost estimate
cost of 25 cows to be assigned for this purpose	____________
cost of feeding the cattle for one year experimental period	____________
cement and bricks for building the digester 25m^3	____________
tank gas holder (specify dimension and material type)	____________
inlet pipe and outlet pipe (diameter x length)	____________
gas pipes (diameter x length)	____________
kitchen stoves, gas lamps, gas engines (specify quantity)	____________
cattle ranch with cement floor (specify dimension)	____________
total	____________

Cost breakdown of biogas plant No. 2	cost estimate
the same as in plant No. 1	____________
total	____________

Cost breakdown of biogas plant No. 3	cost estimate
cost of 15 cows to be assigned for this purpose	______
cost of feeding the cattle for one year experimental period	______
cement and bricks for building the digester $15m^3$	______
tank gas holder (specify dimension and material type)	______
inlet pipe and outlet pipe (diameter x length)	______
gas pipes (diameter x length)	______
kitchen stoves, gas lamps, gas engines (specify quantity)	______
cattle ranch with cement floor (specify dimension)	______
total	______

Cost breakdown of biogas plant No. 4	cost estimate
cost of 10 cows to be assigned for this purpose	______
cost of feeding the cattle for one year experimental period	______
cement and brixks for building the digester $10m^3$	______
tank gas holder (specify dimension and material type)	______
inlet pipe and outlet pipe (diameter x length)	______
gas pipes (diameter x length)	______
kitchen stoves, gas lamps, gas engines (specify quantity)	______
cattle ranch with cement floor (specify dimension)	______
total	______
grand total	______

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Then there is the need for the services of an expert in biogas operation system to:

a) make a study of the proposed sights

b) provide appropriate design of the digesters

c) select and purchase equipment

d) prepare operation and maintenance manual

e) train personnel who will run the plants and in turn provide technical guidance to farmers to use the system.

Conclusion

The Eritrean Relief Association hereby presents its project proposal to NORAD and applies for the necessary finance to cover the initial cost of the project. The project, from our side, is seen as feasible and will mark the first milestone in enabling our rural communities to use their own resources to become self-sufficient in the field of energy. A successful completion of this project will not only provide the farm communities in Eritrea with the techniques of gas production by means of digestion, but will have far-reaching consequences in preserving the environment and improving the health conditions and overall standard of living. It should also be noted the eye sickness caused by firewood smoke which is suffered by many of our people, specially the women, can be avoided by switching to biogas.

We are confident that NORAD will give utmost consideration to our application for assistance in undertaking this project.

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REPLACEMENT VALUES OF DIFFERENT FUELS

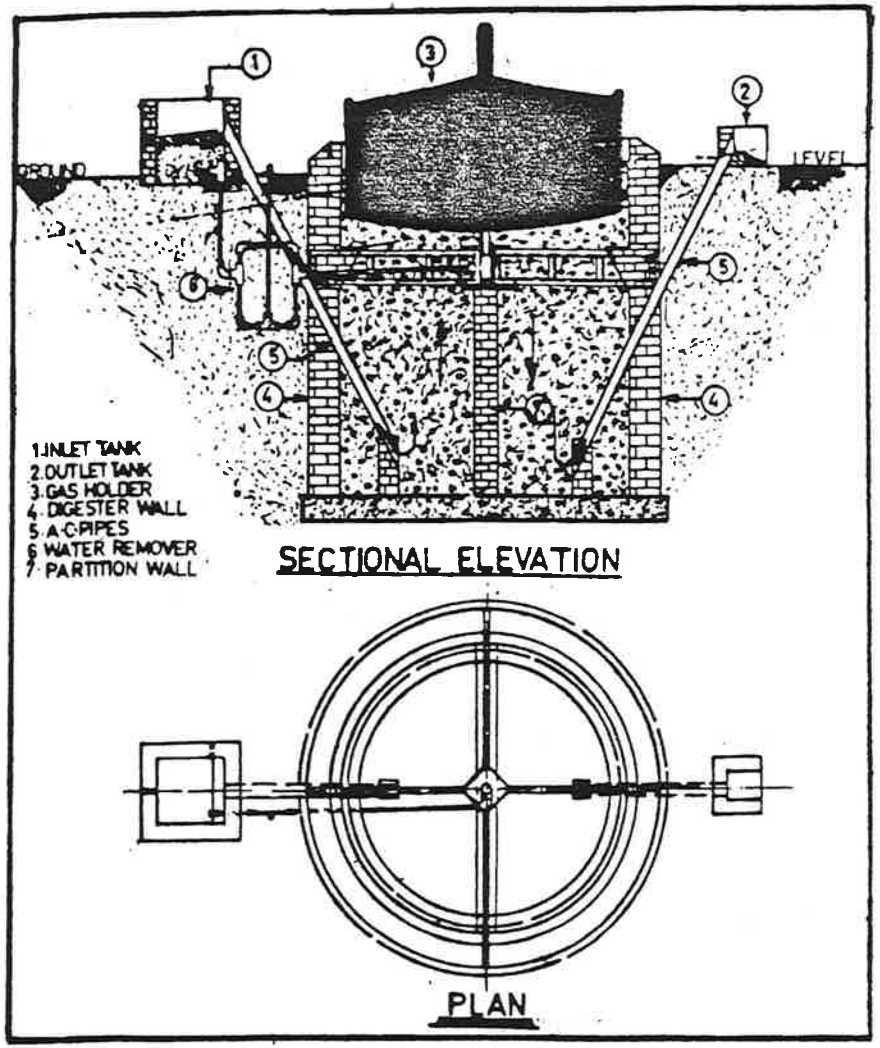
Name of fuel	Unit	Bio-gas 1M³	Kero-sene 1 Litre	Fire wood 1 Kg.	Cowdung cakes 1 Kg.	Char-coal 1 Kg.	Soft coke 1 Kg.	Butane 1 Kg.	Furnace oil 1 Litre	Coal gas 1M³	Electri-city 1 Kwh.
Bio-Gas	M³	1.0	1.613	0.288	0.081	0.686	0.623	2.309	2.398	0.849	0.213
Kerosene	Litre	0.620	1.0	0.178	0.050	0.425	0.386	1.431	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	0.310
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	M³	1.177	1.899	0.339	0.096	0.808	0.734	2.788	[illegible].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

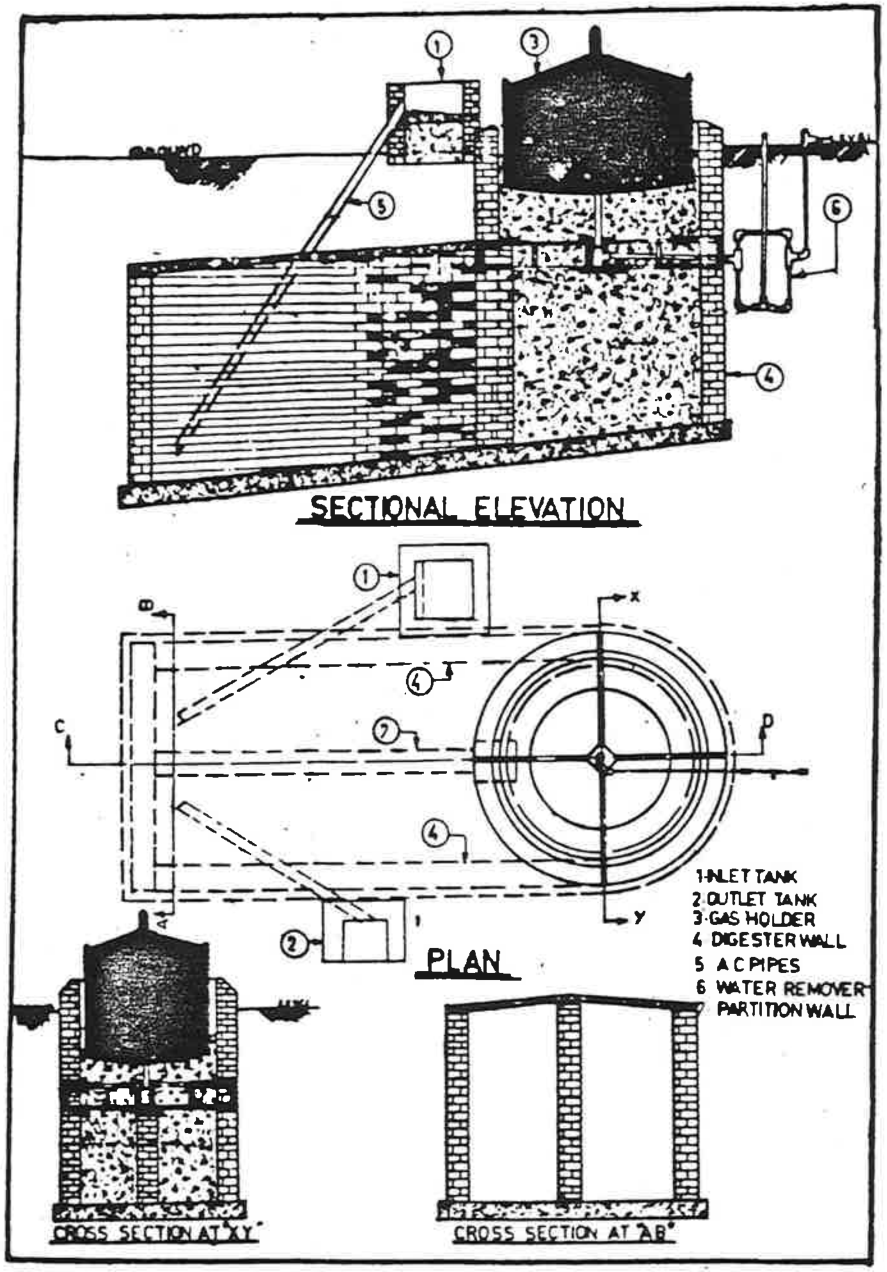
For equivalents read vertical columns.
1 M^3 (Cubic Meter) = 35.315 Cubic Feet

COMPARISON OF VARIOUS FUELS

	Name of fuel	Calorific value Kilo-Calories	Mode of burning	Thermal efficiency %	Effective heat Kilo-calories
1.	Bio-Gas (M³)	4713	In standard burner	60	2828
2.	Kerosine (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 cake (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

source : Khadi and Village Industries Commission, India





source : Khadi and Village Industries Commission, India