PN-AAW-868

Training in Alternative Energy Technologies

Fifth Session

Design of a biogas unit for one family

by

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ACKNOWLEDGEMENT

The Authors wish to express their thanks to Dr. E. A. Farber and his team for constructively advising for this project.

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I. Introduction

Biogas production is usually considered as a method of treating animal and vegetable wastes. The choice of the most appropriate raw material will depend on many technical and social factors.

Biogas is a combustible gas that all organic matter produce when they ferment and are decompossed by anaerobic bacteria under conditions of uniform humidity constant temperature and full enclosure in a tank.

The chemical properties of the biogas are that it is very stable, does not dissolve in water and is lighter than air. Biogas is a mixture of gases comprising 60-70% methane, 30-40% a combination of carbon dioxide and a small amount of hydrogen sulfide and others pure methane is a colorless, tasteless and odorless gas.

When the methane and air mixture burns a blue flame is emitted and it produces a large amount of heat energy. It is known that one cubic meter of biogas will generate 5200-5600 keal of heat energy. This is sufficient to bring 130 kg of water from 20°C to a boil or light a biogas lamp with a brightness equivalent to 60-100W per 5-6 hours.

Biogas technology represents one of a number of village-scale technologies that are enjoying a certain vogue among governments and aid agencies that offer the technical possibility of more decentralized approaches to development. In the developed countries like in Sahel, this kind of technology can solve some problems. For example, in Senegal the government made a policy which tends to decrease the consumption of wood like fuel.

II. Needs and Advantages of Biogas Use.

- Using of biogas is the best solution to the problem of fuel shortage because it will relieve a portion of fuel which is used for irrigation, refrigeration, and conditioning.

- Reducing the fuel costs and improving living standard of farmers who may have no electricity for lighting.

- Use of biogas in cooking have two advantages: (a) Help in cutting down the problem of desertification. This will keep down the need of firewood and charcoal. (b) Using of biogas is cheaper than firewood or charcoal.

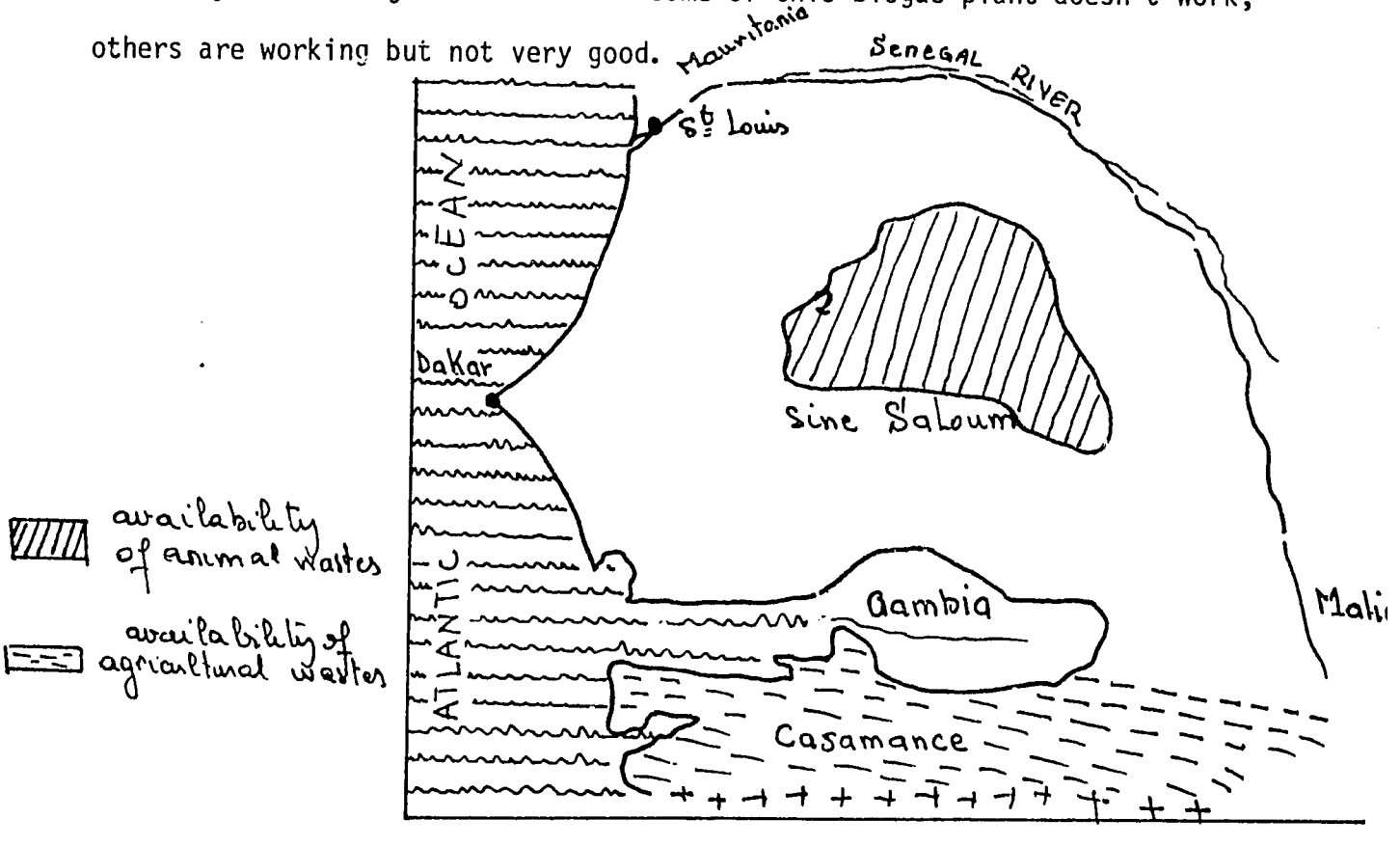
- After fermentation we can obtain fertilizer for their land. Then it solves the problem of fertilizations.

III. Restruction for the point in Senegal/Sudan.

1. Availability and collection of cow manure.

In Senegal we find several parts where people have a lot of cattle. Especially in the sylvo-pastoral zone. These people sometimes don't use the dung from the cattle or they use the dung for cooking in the dry region.

The biomassproject didn't start very well in Senegal. However, we can see some unities in some regions of Senegal particularlyin Casamane (South) at Bombay in the region of Satoum. Some of this biogas plant doesn't work, others are working but not very good.



We have in the capital Dakar a great slaughterhouse where the animal wastes are readily available. For some parts of Senegal the biogas plant can solve the problems of wood. Particularly in rural areas, women use wood for cooking and lighting.

2. Extension Agency

To desseminate this plant in undeveloped countries, we need some organization to help the people to get a biogas plant. In Sahelian countries, for example, the rural people have a lot difficulties to get a biogas plant because they have not enough money and their level of living is very down, so they need help to get this plant. An Extension Agency is necessary to organize the people how they do for getting a biogas plant. Even this Agency can finance the cost for these people. In Senegal exist some Agency like P.H. (Human Promotion) I.S.R.A. (Agricultural Institute) which work directly with the villagers. These Agencies can guide these people doing some training. This training contains different parts of the realization of a biogas plant (how to build a unit a biogas, how to maintain it). Even the rural people can organize themselves in a group and build a great biogas plant for a certain number of families.

3. Technical Points

The single most important rule in operating a digester is to attempt to maintain the operating conditions as steady as possible. The main methods of controlling or balancing the digester are:

(a) Maintaining the bacterial populations.

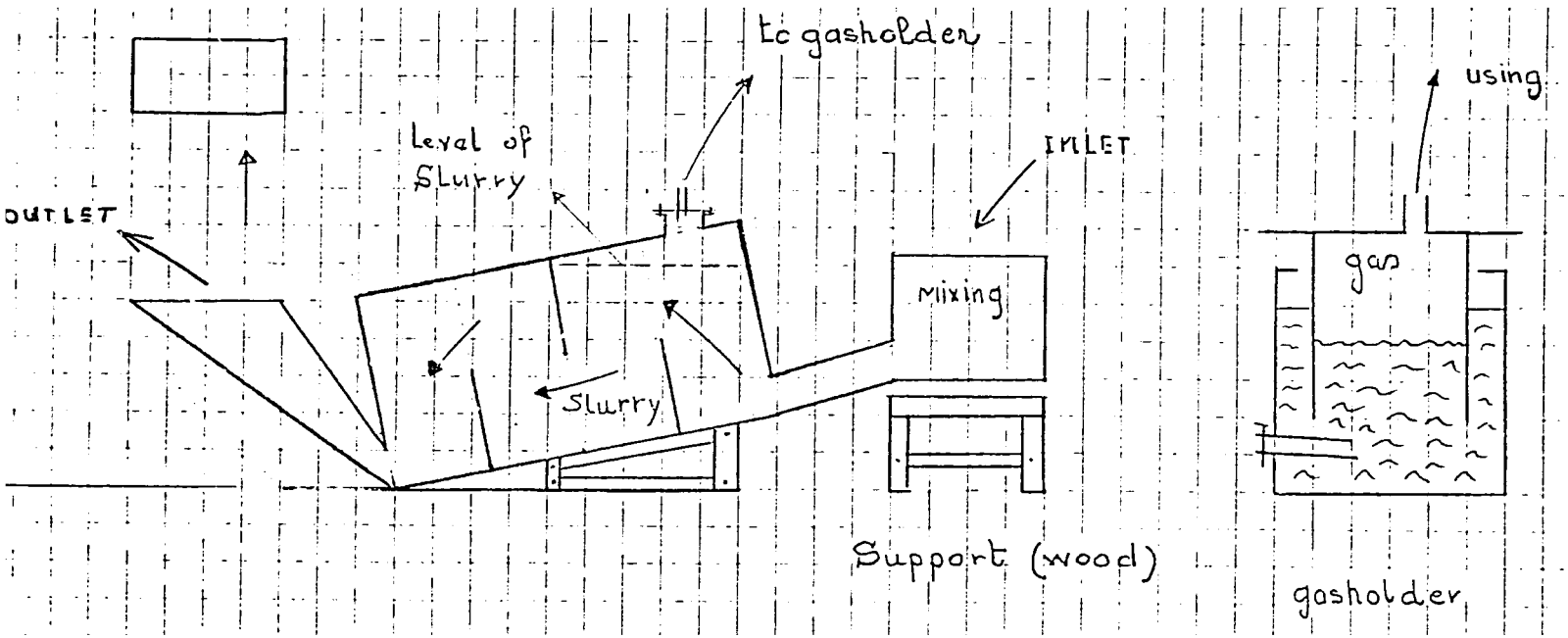
(b) Mixing and time for the digestion

(c) Mixing and time for the digestion

(d) Maintaining uniform and steady temperature

(e) Controlling the pH of the mixture

Sometimes it is necessary to purify the gas. If concern to remove H_2S and CO_2 in the gas. All these technical points may be very difficult for the rural people, that is why it is necessary to have the Extension Agency to help them.



BIOGAS PLANT FOR A SINGLE FAMILY (4-6 persons)

IV. Operation and maintenance of the biogas plant:

Temperature:

The digestor temperature is a key variable in determiing the rate of fermentation. Roughly fermentation starts at about 10°C and increase rapidly with increasing temperature up to the normal operating temperature of 30-35°C. At high temperature, thermophilic bacteria take over. Anaerobic digester are extremely sensitive to fluctuation in temperature.

The process generator is little heat which is sufficient to keep the temperature at the normal (35°C) for colder climate, we need good insulation and some method of heating. We have two solutions for this unit:

(1) To put the digester into the ground for conserving the temperature more or less constant.

2) To paint the body of the digester with black paint and to let the digester outside under the sun. And the night we can put put the digester under lamps to avoid a drop of temperature during the night.

For the rural area, in Senegal for example we can prevent the drop of temperature using a good insulation during the night.

The figure shows the relation between temperature and biogas production.

Collect and Preparation

An important aspect of methane generation in the collection and preparation of the materials to be used in the process. When we consider the feasibility of a methane production system, all of the following components must be considered: collection, preparation, storage of the raw materials, generation, storage of the gas and residue and utilization of the gas.

IV. Sizing of the Prototype and the Model

1. Description of the Project.

As shown at the scheme, the biogas plant is composed by two separated parts:

(a) the digester

(b) the gas storage.

The digester is built with a barrel. Inside this barrel weld some semi-circular plate to have a good circulation of the slurry. The number of barrel we use depend on the size of the biogas plant (family or social).

In this project we use only one barrel like digester.

The gas producted per the digester goes to the gas storage which is made with two barrels (a little one and a big one). The big one is filled with water and we put in the little one in the big barrel. Remarks the digester is painted in black, this for gaining some heat from the sun when the system is outside.

2. Datas of the Design.

The main need of the rural area is to have combustible for cooking. The people use softer dry dung to make cook so they haven't wood.

The cow dung can be used for generation of gas and will allow them to have fertilizer.

We make only two considerations for the design:

- Production of gas methane for cooking.

- Single family composed by 5-6 persons. One person required 12 to 15 c^3 of gas per day. In this design we consider two cases:

1. Size of the prototype
2. Size of the model

3. Size of the prototype

Components of the family 5 persons

Quantity of gas acquired for this family

$$12\ ft^3/day - persons \times 5\ persons = 60\ ft^3/day$$

Quantity of cow dung necessary to produce this volume of gas.

We know one pound of dung gives us 1 ft^3 of gas (approximately).

So for 60 ft^3/day we required 60 lbs. of dung per day. We consider the density of equal to the density of water:

$$63.4\ lb/ft^3$$

Volume of digester

2 (60 lb/day x 30 days): $62.4\ lb/ft^3 = 58\ ft^3$

4. Size of the model

Volume of one barrel $\pi D^2/4 \times h$

$$= \pi\ 22.5''\ 2/4 \times 35'' \times \frac{1'}{12''^3} = 8.05\ ft^3$$

$$8.05\ ft^3 \times 0.70 = 5.64\ ft^3$$

This volume can contain

$$5.64\ ft^3 \times 62.4\ lb/ft^3 = 350.9\ lb.\ roughly$$

$$= 351\ lb.\ of\ slurry$$

This corresponds to 351 lb/2 = 176 lb. of dung for 30 days

Then we have 176 lb/30 days = 6 lb/day of dung

Volume of the gas holder is

$$5.64\ ft^3 \div 2 = 2.82\ ft^3$$

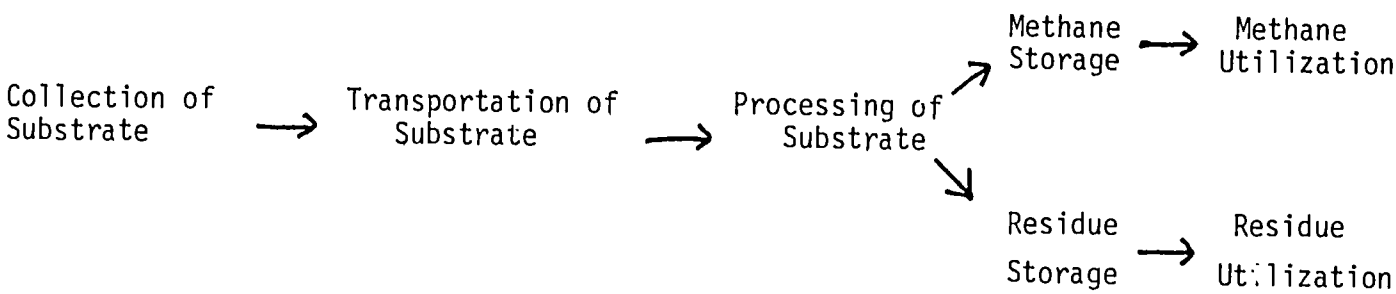
Characteristics of the model

Quantity of gas per day	6 ft^3
Volume of digester	5.64 ft^3
Volume of gas holder	2.82 ft^3
Quantity of Dung per day	6 lb.
Proportion of the mixing in weight	1.1

Characteristics	Prototype	Model
Quantity of gas per day	60 ft^3/day	6 ft^3/day
Volume of digester	58 ft^3	5.64 ft^3
Volume of gasholder	29 ft^3	2.82 ft^3
Quantity of Dung per day	60 lb./day	6 lb./day
Proportion of water and dung	1/1	1/1

V. Economic Evaluation for the family:

Methane production and utilization involves collection, transportation processing, storage of product and residue and utilization processes, as illustrated in the following flow diagram:



A feasibility study for methane production must include the entire production and utilization system involving all these processes; capital and labor requirements and annual costs must be determined for all processes and must be related to local materials, labor and price conditions.

In some countries, if the families had not enough renounce, family digesters will be the best. Community digesters require a larger supply of raw materials. The design in this case may be different.

Managerial and technical skills will be required in most countries to develop a successful methane program. Technical assistance will be required to train local people for the installation, operation and maintenance of methane digesters, and, perhaps, to assure continued use after digesters have been adopted by local people. It is for this we need some extension agencies.

VI. Experimentation:

Two aims should be reached in this experimentation.

- Working of the unity with Dung
- Using of the biogas (analyze components of the gas).

The time delay is not sufficient to have a complete formation of the dung (40 days).

We put one the quantity the model can take (approximately 280 of Dung and water (ratio water: dung = 1).

After we let the unit outside to wait the production of gas start.

The experimentation conditions was not good.

The temperature of system is good during the day, but the night the temperature drop so much. That is the reason we have not production of gas. This system should be work well if the conditions of working are available.

VII. Conclusion

Like we say in the schedule of the project, this unit will be tested in laboratory to study all the parameters, their influency in the system. This unit will be also tested in a family to see the acceptability by the people of the rural area.

The gas from this kind of unit will be used in a motor and we will buy to fire some appliances for the rural area.

This kind of project can be made at big scale in several where there are a lot of annual waste (abation, pastoral area). Extraction of energy from wastes by anaerobic digestion is well known. The use of rural wastes for methane generation, rather than directly as fuel or fertilizer, yields direct benefits.

- Production of an energy resource that can be stored and used more efficiently.
- The creation of a stabilized residue that retains the fertilizer value of the original material.

The need of organic matter in agriculture is well recognized. In the context of fertilizer shortages and increasing prices, the need to use organic wastes has taken on a new dimension and their contribution, certainly cannot be underrated.

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