THE DIFFUSION OF FAMILY-SIZE UNIT BIOGAS PLANTS IN SUITABLE AREAS IN TANZANIA - THE DEVELOPMENT OF AN EXTENSION STRATEGY

Christopher Kellner
German Appropriate Technology Exchange,
Biogas Extension Service, c/o CAMARTEC (Centre for Agricultural Mechanisation and Rural Technology), PO Box 764, Arusha, Tanzania

and

Silas Lwakabamba
Energy Analysis Program, Bldg 90 RM 3125,
Lawrence Berkeley Laboratory, University of California,
Berkeley, CA 94720, USA

ABSTRACT

Past efforts to extend biogas technology have not been very successful. The technology is complicated, selection of appropriate sites needs to be carefully planned by experienced specialists, and biogas know-how must be transferred to the villages concerned. The Biogas Extension Strategy described here aims to instruct village artisans in the construction of cheap and appropriate biogas plants.

BIOGAS TECHNOLOGY IN TANZANIA

Since the beginning of 1984 CAMARTEC has been stressing the extension of biogas plants (BGP) in Tanzania. Activities date back to 1974. Many demonstration plants have been set up, technicians trained and much money spent. Unfortunately, a great number of plants are not working.

MISTAKES IDENTIFIED IN FORMER BIOGAS PROGRAMMES

A wide range of mistakes have been identified, which can be divided into three main fields:

1. Selection of locations. Many plants have been set up at places which do not fulfil the criteria for successful operation. Often it was difficult to transport the required amount of dung or it was easier and more logical to use other sources of energy.

2. Technical mistakes. Many plants are not working due to inappropriate design or poor workmanship, especially in the parts that need to be gastight such as the gasholder and the piping.

3. Training of involved persons and follow up supervision. Very often the basic technical knowledge is not clear to the users. Therefore small mistakes in the operation of the plant, the lamp and the burner are very common, the accumulation of which can easily lead to a final failure.

PRECONDITIONS FOR SUCCESSFUL BIOGAS EXTENSION PROGRAMME

In developing a new biogas extension programme, criteria were laid down to overcome past problems.

Criteria of suitability for locating a biogas plant

Among the most important prerequisites for a successful programme for biogas diffusion are the following:

i. High population density which creates pressure on available energy sources.

ii. Sufficient vegetation density to allow cattle rearing in stables without recourse to grazing.

iii. Concentrated animal husbandry - for instance three cattle confined to a stable for 24 hours a day as a minimum.

iv. High intensity of land usage to create a need for fertilisers and systematic disposal of wastes.

v. A sufficient degree of monetarisation of the farming economy so that there is an economic incentive for digester construction and the use of gas and fertiliser.

vi. A technical capability for brick or concrete construction and a level of technical awareness sufficient to operate and maintain a digester.

Digester design

Digesters distributed in Tanzania are either copies of the Indian technology where the gas is stored in a floating drum or a modified Indian Plant. The latter while much cheaper is extremely unreliable, because scrap metal used to make the gasholder corodes quickly. The high costs or unreliability are the main reasons why individuals have not copied demonstration plants.

This first extension trial did not include Chinese fixed dome technology. The advantage of the fixed dome technology is that almost no steelwork is involved. This reduces the costs of materials and makes the setting up and the supervision easier. However, the construction of a fixed dome is difficult and requires trained masons. Thus introduction of such a biogas plant must include training of local artisans in specific building techniques to ensure that the upper part of the fixed dome is crack resistant, gastight and can stand changing pressures. The workmanship must follow precise specifications to function correctly.

Provided appropriate training and supervision were made available, the Chinese fixed dome biogas plant was felt the most suitable to rural Tanzania and this technology forms the basis of the biogas extension project described below.

Sensitive engineering

The practical development of biogas technology requires not only technological know how but also experience of the traditions of the target group, and especially of users reaction to this technology. Appropriate technology evolves through learning from mistakes and drawing conclusions from failures.

Extendable technology cannot be achieved by copying systems that proved successful in other countries or cultures. Instead of instructing farmers how to make a biogas plant by themselves, potential users must have the opportunity to

buy technology appropriate to their situation and culture. Therefore a supply of good quality biogas plants has to be developed in cooperation with the target users. Experienced experts must be available to advise and supervise to ensure the plant is set up properly. And these skills may be transferred to local artisans who will then promote and extend the dissemination of the technology within their communities.

STANDARDISED FAMILY UNITS

For a family size biogas plant to be accepted the engineering input must be reduced. Therefore CAMARTEC developed three standardised fixed dome BGP of different capacities and provides training of technicians and local artisans in their construction. Figure 1 is an example of the design specification for a CAMARTEC fixed dome biogas plant. Tables 1-3 show the requirements and present costs for construction.

BIOGAS PLANT AND STABLE WITH CONCRETE FLOOR FORMING A "UNIT"

To reduce maintenance requirements and daily work input, the family-size BGP is directly connected to a stable with concrete floor. Twice a day the dung is mixed with the urine which has accumulated in a canal in the stable. It has to move down into the digester through a 4" pipe. To make it liquid enough it can be mixed with already digested sludge which is taken from the expansion chamber. Water can also be used, but it has the disadvantage that it has to be carried for a long distance in most cases.

In the case of an existing stable with a dung or soil floor, a concrete floor will have to be constructed even if it increases the costs by about 20%. The concrete floor will ensure a 100% urine and dung collection, an easy filling of the plant and helps to avoid stones and sand from entering the digester.

In general the increase in investment costs is justified, if it helps to reduce the daily work input and increases the reliability of the system.

METHOD OF DIFFUSION

If a technically appropriate solution is found, a method of disseminating the technology is essential. In general there are two methods. The first one is to establish a team of artisans within an organisation that supplies individual customers. This increases the costs and automatically the customers will mainly be big farmers.

The second way is to train artisans who live in areas that comply with all the feasibility criteria. If the supplier lives in the neighbourhood, the demand from surrounding farmers will follow. Most customers will be small-scale farmers with an additional source of income.

The second approach seems to be the more complicated one and will therefore be described in more detail. The aim is to supply as many farmers as possible with BGPs and at the same time to transfer the know how to local artisan.

The programme is carried out in three main steps:

1. A survey is conducted to estimate the potential of farms suited to operate a BGP. A questionnaire is used to determine the energy situation, the

farming system, the availability of digestable material and water and the financial situation.

2. Where a demand for BGPs is identified the technology will be introduced to the village government and interested farmers. This will be done either by setting up a small transportable demonstration unit which supplies a small amount of gas or by organising a site visit to an operating BGP.

3. Selection of a suitable site where the first unit of the particular village is installed. The construction is done by two artisans from the village and supervised by CAMARTEC Biogas Extension Service who will be conducting on the job training. Experience has shown that demand follows initial construction.

Supervision can be reduced as successive plants are constructed. The village artisans are the main suppliers to satisfy the demand.

To ease and accelerate the process for the individual farmer of purchasing the requested building material, CAMARTEC is establishing a material supply store which also supplies lamps and burners. A step in the future will be also to produce these in the country.

The other task of CAMARTEC, within this strategy, is to advise on individual biogas problems, eg planning, construction, feeding, gas production, gas consumption, use of sludge and maintenance.

PRELIMINARY DIFFUSION AREA

In the Arusha region, an area of 200 sq km was identified as satisfying the criteria for introducing biogas technology. There are roughly 7000 farms in this area and 20,000 heads of lifestock of which at least 50% are kept in stables. Ten per cent of the farmers were definitely interested in biogas technology and could afford the technology.

COSTS AND BENEFITS

The investment costs are comparatively high. However converting the amount of gas produced into commercial energies which represent the families newly achieved standard of living, a biogas plant would break even in 3-4 years, including running costs and interest repayments.

However, farmers and especially the farmers' wives have identified shorter-term criteria in support of installing a BGP:

i. The increasing difficulty of getting firewood and kerosene.

ii. Quick and reliable preparation of small things like tea as well as the normal cooking.

iii. Light in the evening.

Farmers interested in obtaining BGPs have tended to be innovative and business oriented. The first four farmers started to convert surplus energy into marketable food products, eg brewing local beer, baking bread or pancakes, or roasting their own coffee in order to sell it.

Figure 2 estimates the preconditions to expect an excessive supply of gas and the capacity of BGP to satisfy the needs of farms of different sizes.

THE FERTILISER

The sludge from BGPs is a very good fertiliser. While not always included among the benefits of the biogas technology and under utilised, its advantages include the following.

i. With zero-grazing and confined to a stable with concrete floors, all wastes from the animals are collected.

ii. The sludge from the digester contains the same amount of nitrogen as the original manure. Traditional ways of storing manure results in major losses of nitrogen.

iii. There is no risk from contamination by chemicals and the fertiliser is easily assimilated by plants.

iv. Slurry fertiliser does not smell or attract flies.

Nevertheless, only a minority of BGP owners utilise this fertiliser. It seems that the disadvantages are major as follows:

i. Transportation of liquid slurry in wheelbarrows or in buckets is difficult.

ii. There is run off and therefore loss of fertiliser.

iii. The fertiliser is most effective when applied to roots, under wet and cloudy conditions, at the stage of intensive plant growth. These pre-conditions occur seasonally while sludge is produced continuously.

The Biogas Extension Programme has to incorporate these findings.

STEPS IN THE FUTURE

The Biogas Extension Programme in the Arumeru District will be extended to other suitable areas. For success, the following aspects need further emphasising:

1. Involvement of private entrepreneurs in plants and construction of accessories. 2.Surveys to estimate the potential number of farms suitable for biogas plant operation.
3. Development of teaching aids and regular training for further training of artisans and technicians.
4. Establishment of a maintenance team.
5. Ensure expert advice on all fields involved in the technology with the help of appropriate booklets and well equipped advisers.
6. Continuous reassessment and improvement of standardised plants.
7. Development of prefabricated building material.
8. Development of methods and instruments for appropriate use of fertiliser.

TABLE 1: List of requisites required for the three CAMARTEC fixed dome standard biogas plants (BGP) (all metric figures). For requirements which are different on each farm see Tables 2 and 3

Item	Unit	Standard digesters								
		Small family BGP (8 m³)			Medium family BGP (12 m³)			Big family BGP (16 m³)		
		amount required	costs	1)	amount required	costs	1)	amount required	costs	1)
Bricks 8 x 11 x 22	pieces	750	2250		1150	3450		1400	4200	
Cement	50 kg bags	10	2000		14	2800		17	3400	
Lime	25 kg bags	4	600		6	900		7	1050	
Sand Stones	kg	2500	1200	2)	4000	1600	2)	5000	2000	2)
Plastic pipe - 4"	6 m	1	500		1	500		1	500	
Hole to be dug	cbm	20	400		26	520		33	660	
Mason	Lump sum	1	1800		1	2500		1	3000	
Helper	Lump sum	1	1400		1	1600		1	2000	
Other Material 3)			400			500			600	
TOTAL			**10,550**	**TSH**		**14,370**	**TSH**		**17,410**	**TSH**

1) All prices relate to 2/85

2) The price for sand can differ extremely

3) Other materials, eg kerosene and wax for gastight sealing, clay for lid sealing, reinforced gas outlet pipe, handles for lid.

TABLE 2: Materials and other requirements including costs per constructing the stable floor

Item	Unit	Type of stable: Cow shed or sheep pen		Pig sty	
		amount/(10m²)	price (TSH)	amount/(10m²)	price (TSH)
Cement	bags	3	600	5	1000
Sand stones	kg	2000	1000	4000	2000
Mason			300		500
Helper			200		300
TOTAL per 10 m²			**2100**		**3800**

TABLE 3: Gas consumption accessories

Item		Purchased through	price (TSH)
Burner		CAMARTEC	700
Lamp		CAMARTEC	500
Pipe 1/2"	1m*	CAMARTEC	80
Pipe 3/4"	1m*	CAMARTEC	110

* Average price, including fittings and one valve and the installation work.

FIGURE 1: CAMARTEC fixed dome biogas plant digester: 8 cbm volume with 1.3 cbm gas storage

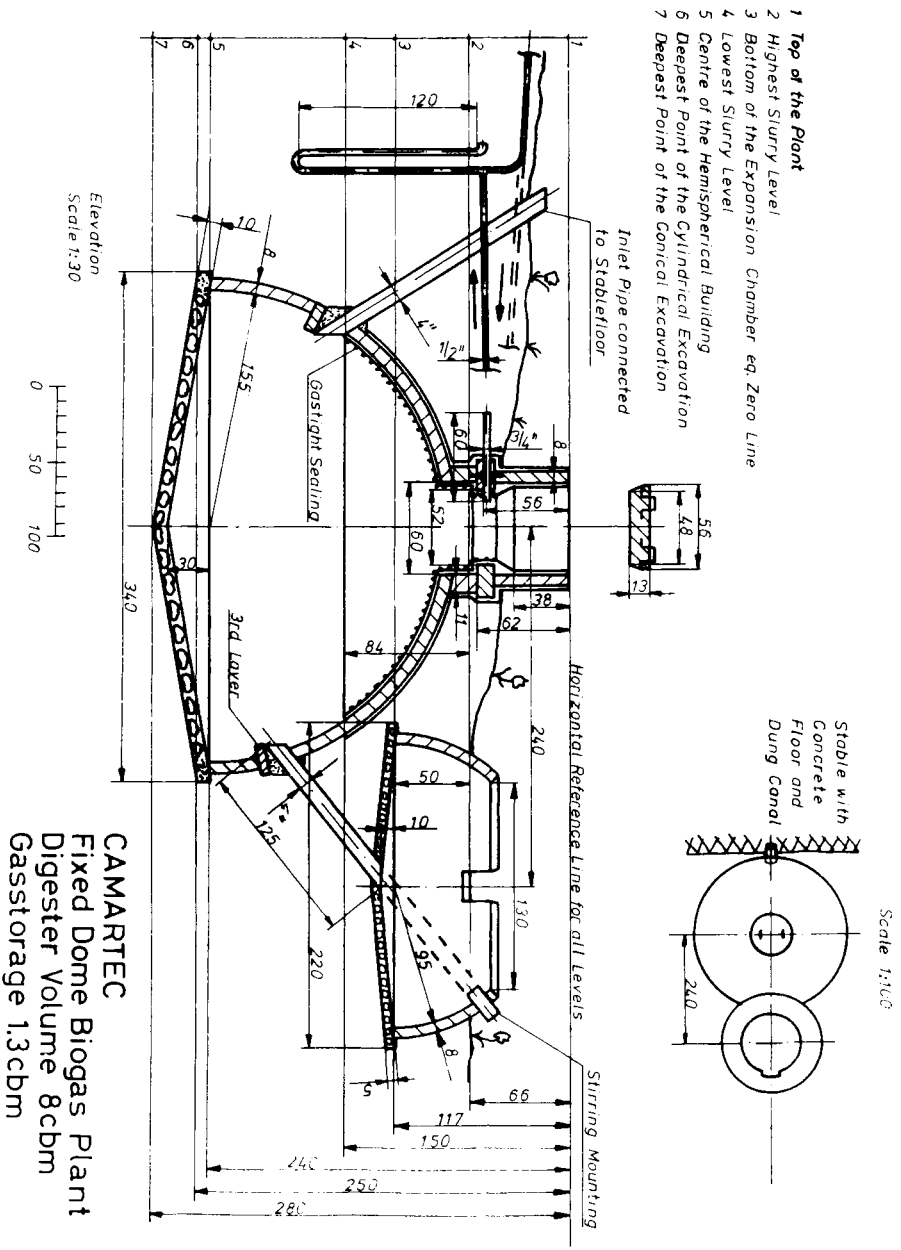

FIGURE 2: Means for first estimating the appropriate standard unit.

All figures are related to the described unit and the cooking habits of the people in Arumeru District of Tanzania.