BIOGAS PROMOTION IN KENYA

A review of experiences

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Preface

This publication is a summary of the results of a survey commissioned by the Household Energy Regional (HER) Project of Intermediate Technology - Kenya. The survey was carried out by Penroche Development Services Limited (PDS) between September and December, 1995.

The aim of the book is to help development agencies and those involved in the promotion of biogas systems to make informed decisions. It also gives an insight into the critical factors that influence the adoption of biogas technology in Kenya. The survey covered the main biogas promoters in various parts of Kenya. In addition, it examined the various types of biogas plants, implementation strategies, the factors that affect levels of use and those necessary for successful dissemination and adoption of the technology in Kenya.

By 1995 there were ten organisations actively engaged in the promotion and dissemination of biogas technology in Kenya. Most of them are government or quasi-government agencies; private sector involvement was limited. Key organisations in this sector at the time of the survey included:
Special Energy Programme (SEP) - Kenya; the Ministry of Energy and Regional Development (MOERD); Christian Intermediate Technology Centre (CITC), Kapsabet; and Tunnel Technology Limited (TTL).

Promotion of biogas technology has been widely carried out in the humid and agriculturally rich areas of the country notably the central highlands, western Kenya and parts of the Coast Province.

Opinions and interpretation in this booklet are based on the review of experiences and do not necessarily represent the views of IT Kenya, Penroche Development Services or any other organisation mentioned.

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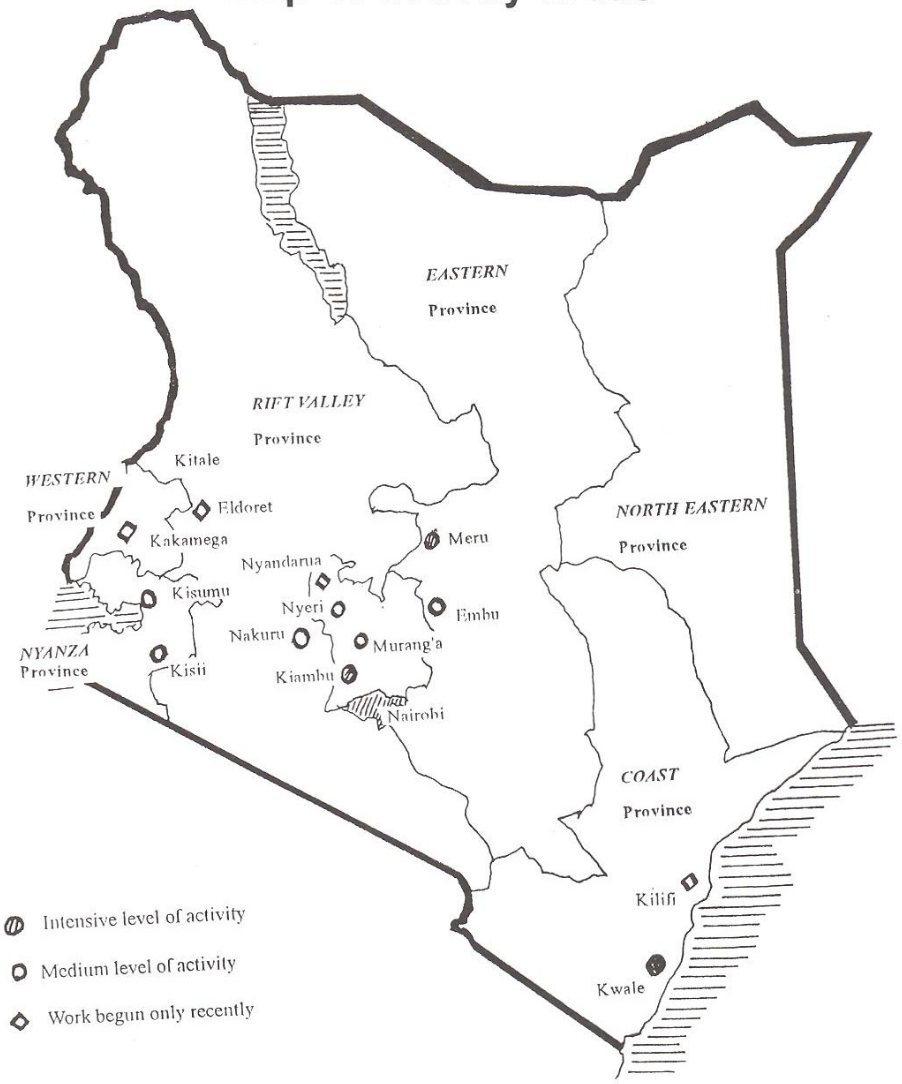
Map of activity areas



Chapter One
INTRODUCTION

Summary of the findings
Biogas is most commonly used for cooking and lighting. Many users appreciate the value of the effluent from the digester and use it as manure on their farms.
In Kenya, the most widely disseminated plant is the Floating Drum type of which there are three different makes, namely:

- the Borda-sasse (or Meru plant) which is promoted by the Special Energy Programme Ministry of Energy and Regional Development (SEP/ MOERD)
- the Hutchinson type designed and disseminated by Tunnel Technology Limited (TTL)
- the Kentainers type developed by Kentainers Limited, a local company.

In addition, there is a Fixed Dome type which is disseminated by the Christian Intermediate Technology Centre (CITC).

Biogas technology is a cost-effective investment if plants are properly constructed, effectively operated and well maintained. It was, however, noticed that there are many abandoned biogas plants in the country. It is estimated that only 25% of the installed units are operational, thus disreputing the technology. Continued use of plants is linked to the dissemination strategy adopted· by the promoting agency. High levels of use were observed in areas where the dissemination was followed with planned monitoring and support to the users. However, in areas where close follow-up activities were lacking, the level of use was low.

The potential for biogas technology is limited to agricultural areas with high population densities. This is further restricted to farmers who can raise capital needed to meet the basic requirements to ensure successful operation of the plant.

Constraints

The main constraints to dissemination ofbiogas technology include:

- Initial high investment cost
- Lack of credit schemes to help farmers to acquire plants
- Disrepute created by the many failed biogas plants
- Limited private sector involvement. There is no profit motive among the main disseminating agencies, hence the lack of driving force resulting in poor penetration of the market
- Lack of financial support for small firms and individuals to set up effective business operations in the sector
- Minimal disposable income among farmers and competing needs for the limited available financial resources.

This review raised the following question: Is biogas technology viable in Kenya? The publication concludes that:

- Biogas technology is a viable source of energy. Factors that determine its viability include high population densities resulting in scarcity of land, which in turn encourages zero-grazing activities that are vital to successful adoption of the technology. These features do not necessarily define the absolute ingredients for viability because resources are needed for the construction of plants and other accessories.
- The scope for dissemination ofbiogas technology is presently limited. Majority of the rural farmers do not meet the basic requirements for successful operation of the plant. Furthermore, most do not have the resources to acquire the technology.
- As land continues to diminish and traditional fuel sources decline, opportunities for wider dissemination of the technology will emerge, provided people have the resources.

Increasing viability It is clearly shown in the cases studied that time and resources should be directed to promoting the technology in areas where there are market potentials. The technology is most appropriate where farmers have the necessary resources. Efforts need to be directed towards specific higher potential and densely populated areas.

The private sector should be involved in all aspects of promotion and dissemination. There are obvious logistical and personnel limitations both at government and development organisations' level in establishing strategies for achieving successful dissemination.

To successfully promote biogas systems, there is need to counter the existing poor image created by the failed technology. One way of achieving this is by promoting proven designs, and providing post-installation support services.

Ways and means of reducing the capital cost of biogas plants need to be explored, operating costs need to be reduced and the systems for operating and maintenance simplified. Opportunities for disseminating the technology in other sectors, such as the large dairy farms, may provide alternative market possibilities.

Small firms and individuals promoting and servicing biogas systems currently face problems accessing credit. There is need to establish and encourage schemes that provide such firms and individuals with credit or working capital and further assist them to operate their enterprises more efficiently.

Organisations promoting the technology should develop the capacity to advise potential users on other available energy options.

Chapter Two
BACKGROUND

Kenya relies on imported petroleum to meet 75% of her commercial energy needs. This is a significantly high level of dependence on an energy source the country has no control over, especially its ever-fluctuating price. The implications and the constraints this situation imposes on national development are many; sometimes having a negative effect on the economy.

Most of the rural households depend on woodfuel to meet their energy needs, yet the commodity is increasingly becoming scarce. About 70% of the total energy consumed in Kenya is derived from wood. Studies carried out by the Beijer Institute in the 1980s predicted an energy crisis in the country by the year 2000. It was estimated that the supply shortfall would have reached 30 million tonnes. Adaptations to woodfuel problems have, however, changed the scenario from woodfuel crisis to biomass energy-related health problems.

It was in response to the impending energy crisis that the government, NGOs and donor agencies initiated various interventions with the general objective of reducing pressure on wood resources. During the same period, new and renewable sources of energy were explored. Projects were initiated in many countries to develop, introduce or test the applicability of solar, wind and hydro power technology.

Biogas technology had been introduced in Kenya in the mid 1950s by European farmers. By 1958, a private company, Tunnel Technology Limited (TTL) was constructing biogas plants in different parts of the country. It is estimated that by the early 1980s, TTL had installed about 150 plants.

Interest in biogas and other Renewable Energy Technologies (RETS) increased tremendously then, and pilot projects involving many plant designs were initiated and demonstration units setup mainly in institutes and colleges.

Most of these projects, however, failed due to poor design, incorrect operation methods and poor maintenance.

There was rapid growth in the field of biogas technology development and dissemination in Kenya between 1980 and 1990. About 300 plants were installed during this period mainly by the Special Energy Programme (SEP) - Kenya and the Ministry of Energy and Regional Development (MOERD).

Despite this, the rate of dissemination has decreased remarkably since the beginning of this decade although several government agencies and a few private companies and individuals have continued to promote the technology.

Chapter Three
DEFINITION OF THE PROBLEM

The survey that preceded the writing of this publication was designed to assess and advise on the viability of biogas technology as a source of energy in rural parts of Kenya. Investigations were carried out to identify:

- organisations promoting and disseminating biogas technology in Kenya
- types of biogas plants disseminated in Kenya
- applications of biogas technology in Kenya
- factors affecting use of biogas technology
- factors affecting acceptability and adoption of the technology.

Information collection

The information in this book was collected from various parts of the country including Meru and Embu in central Kenya; Kericho, Nandi, Kisumu and Kakamega in the Westem and Rift Valley provinces; and the coastal districts of Kilifi and K wale. Sourcing of information was through a variety of methods including:

- arranged discussions with various resource persons in organisations that promote and disseminate biogas technology in the country
- random interviews with 43 users
- review of literature on biogas technology in Kenya
- field visits and observation of installed biogas plants.

The literature review

Several publications and printed literature were reviewed and information that was found appropriate to the survey is incorporated in this book.

Results of a previous assessment on biogas projects

By the time the survey was carried out, only one other study had previously been conducted on biogas. The survey was carried out between November, 1992 and August, 1993. It was to evaluate the performance of some selected biogas plants within the Christian Intermediate Technology Centre project area. The purpose of the survey was to:

- obtain more information relating to gas production and utilisation among households with biogas plants
- determine the benefits, if any, of the biogas plant to the users

- obtain supporting data to provide a basis for advising users on the optimum operational requirements, and potential users on what conditions they should fulfil before investing in the technology.
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Gas metres were installed in five households to monitor gas production and utilization for periods ranging from 88 to 279 days. The results showed that:

- Out of the five plants studied, only four were operational and only two of them were actually beneficial to the users. Therefore users whose plants were operational had:
  - three to five cows so they produced adequate dung to fill the plant
  - maintained an interest in the operation of the plant
  - integrated their working routine on the farm with the activities relating to the plant therefore helping to ease feeding of the biogas plants on a daily basis.
- In households where the users were not benefiting:
  - the biogas plants were not directly connected to the zero-grazing unit, creating difficulty in feeding the plant and transporting the sludge to the farms
  - the zero-grazing unit was only used as a night boma (shed) for the cows, hence only small amounts of cow dung were collected
  - conditions necessary for successful operation of a plant were not initially fulfilled during the planning stages. The number of animals was not adequate so they could not supply the required amount of dung - water was not adequately supplied.

The study concluded that the following factors are critical if a biogas plant is to operate successfully:

a) Before construction takes place conditions for successful operation of the plant must be met
b) The farmer must own at least three zero-grazed cows
c) There must be a reliable supply of water
d) There should be a well-managed farm system into which the biogas plant is integrated
e) The size of the plant constructed should provide enough gas to meet the cooking and lighting requirements of the users
f) The plant owner must be interested in the operation and maintenance of the system.

Chapter Four
WHAT IS BIOGAS?

Biogas is produced by bacteria that break down organic matter in the absence of air. The process is referred to as anaerobic digestion and takes place in a closed tank called a digester. Biogas plants are sealed containers built specifically to create the anaerobic conditions necessary for digestion and controlled production of gas.

Biogas is a mixture of methane (CHJ and carbon dioxide (C02), It is a high grade fuel used for cooking and lighting. The digested residue or sludge is a good quality fertilizer.

Most common biogas plants must be fed daily with feed material or slurry to ensure continuous gas production. The slurry is a mixture of organic material and water, usually in equal proportions. Many types of organic materials such as coffee husks, sisal waste and animal dung can be used.

Products of biogas plants

Biogas

The digestion of organic matter in the biogas plant forms methane commonly referred to as biogas. This is a combustible gas that bums with a hot blue flame. Biogas is neither poisonous nor as flammable as other gases used for cooking or lighting. In Kenya, biogas is mainly used for cooking and lighting.
It is also used, to a limited extent, to run refrigerators, and diesel and petrol engines.

Sludge

The residue or sludge from the fermentation process in the biogas digester is the main product of the plant. It is a fertiliser of better quality than undigested waste because the nitrogen previously unavailable to crops is transformed into water-soluble ammonia which is readily taken up by plants. Experiments conducted locally and elsewhere have proved that sludge is a better fertiliser than commercial, inorganic fertiliser. It improves crop yields when and if properly used, and farmers can save considerable amounts of money that would otherwise be spent on purchasing commercial fertilisers.

Chapter Five
TYPES OF PLANTS PROMOTED IN KENYA

Currently two major categories of biogas plants are being installed and promoted in Kenya. These are the Batch Type and the Continuous Flow plants. The Batch Type plants have been installed mainly on large coffee farms and the number of units installed by 1995 was estimated at thirty countrywide. The Continuous Flow are more popular as they are suitable for use in small households. By the time the survey was carried out it was estimated that about 850 domestic biogas Continuous Flow type of plants had been installed in the country.

Batch Type plants

These are used on large farms where organic matter is available only during certain periods of the year. They are particularly found on large coffee farms and are used to ferment coffee pulp that is available twice a year.

Two operational plants were visited. One is located in Koru and was installed by Tunnel Technology Limited for the Coffee Research Foundation.
The other is at Roma Lime Company Limited.

Feed material or slurry is added in one batch and left to ferment for a period. When it stops producing gas, the slurry is removed from the plant and freshly loaded.

When a Batch plant is used, gas is not continuously available unless a big gas holder is incorporated or several plants are used.

Continuous Flow plant

This type of plant requires the addition of feed material on a daily basis and produces gas at a constant rate. Continuous Flow plants are useful in farms where organic material is available daily. When feed material is added to the plant, an equal amount of sludge is discharged from the unit. It is discharged into a sludge storage tank from where it can be directed to flow by gravity on to the farm. It can also be removed manually. Two types of Continuous Flow plants are commonly disseminated in Kenya. These are the Floating Drum and the Fixed Dome types.

Floating Drum plants

These plants have a large inverted drum which acts as a gas storage tank. They were designed and developed in India but have been widely accepted in the developing world. They are easy to construct, operate and are reliable. The Borda-sasse model is the most widely disseminated plant in Kenya. It has performed very well under local conditions.

The Hutchinson type, built and disseminated by a local company, Tunnel Technology Limited, is another model of the Floating Drum plant which has been available in Kenya since 1970. It has also performed remarkably well.

Fixed Dome plants
Fixed Dome plants were developed in China for processing of human waste. They were introduced in Kenya in the 1970s but are not as widely installed as the Floating Drum types.

Its components are made using stones, bricks or concrete blocks with very few metal parts. They are consequently cheaper to construct than the Floating Drum. The gas produced is stored in an underground space just above the digester called the dome. As gas accumulates in the dome, it displaces the sludge into a compensating tank. Gas pressure is not constant and when the volume is low in the dome, gas supply will not reach the appliances.

Construction of dome-type plants has to be done very carefully otherwise slurry and gas leakages can lead to poor performance.

Chapter Six
EXISTING BIOGAS APPLIANCES

Cookers
The most widely used biogas cooker is the model developed by Kenya Industrial Estates (KIE) - Special Energy Programme (SEP) in 1986. It consists of a metal liner, a ceramic insert and a burner. A version with a double burner is also available.

All the components of the burner can be produced in local workshops and this is the case with a number of workshops in Meru. In Nandi District, CITC produces the burners from the centre's metal workshop. The price ranges between US$ 14 and US$ 18 for the single burner and between US$ 27 and US$ 36 for the double burner version.

Lamps
Various organisations and individuals disseminate a lamp that was developed by KIE in 1987. There is no special mantle for the lamp. It uses the one that is commonly used for the standard kerosene pressure lamps.

Imported lamps are also available from some private companies. Shell Afrigas Company markets a small size and large size biogas lamp imported from Brazil priced at US$ 34 and US$ 48.

The local KIE lamp costs between US$ 14 and US$ 18 depending on where it is purchased. The efficiency of biogas lamps is low, between three and five per cent, although a good lamp can give light equivalent to that produced by a 40-watt incandescent bulb.

Chapter Seven
DISSEMINATION OF BIOGAS TECHNOLOGY IN KENYA

Introduction
Since 1958 when biogas technology was introduced in the country, a number of government agencies, Non-Governmental Organisations (NGOs), private companies and individuals have been involved in the promotion and dissemination of the technology. The number of plants disseminated and installed by 1995 was estimated at 880.

Government Agencies

Special Energy Programme (SEP) - Kenya and collaborating partners

SEP was set up in 1980 as a joint project between the governments of Kenya and Germany, and was implemented by the Ministry of Energy and Regional Development (MOERD).

After a period of planning, biogas activities started in 1983. SEP's role in the dissemination process was advisory, limiting its participation to that of support during the start up period. SEP provided coordination support, promotion, training of local craftsmen, monitoring and evaluation.

Training of local craftsmen formed the basis of the dissemination programme. In 1983, SEP undertook the training of plant builders at a three-week course in Meru. A number of demonstration plants were constructed by trainees under the guidance of a GTZ biogas specialist. The plants were located at educational institutions and it was assumed that they would generate awareness and interest amongst potential users.

This approach was not successful and most of the demonstration units broke down soon after. SEP changed the strategy and instead began to transfer know-how to local craftsmen in the target areas through on-the-job training provided by MOERD instructors.

SEP chose to disseminate a single model to avoid confusing the artisans and the customers. This was the 10m3 Borda-sasse model also referred to as the Meru plant. The technology was selectively introduced in densely populated areas targeting farmers keeping three to five cows in zero-grazing units. The dissemination process was designed to take place on a strictly commercial basis and the user paid the full cost of materials and service provided.

As part of this strategy, the private sector was expected to play a significant role in this process and were indeed involved at all stages. Construction of plants was done by masons and plumbers, while metal workshops fabricated gas holders, guide frames and associated products. Private traders were encouraged to build, stock and market biogas appliances such as cookers and lights.

In fact Kenya Industrial Estates (KIE) was given the role of designing biogas appliances and helping to give interested traders advisory and financial assistance to build these appliances. At field level, the dissemination process was implemented by biogas instructors attached to the MOERD's Agroforestry/Energy centres setup in certain areas.

Promotion was low-key and SEP's strategy was to rely mainly on people already using the system as promoters. A biogas leaflet was produced and widely distributed by the biogas instructors and extension workers. The instructors were expected to train local craftsmen in the construction and supervise the trainees till they were competent. These craftsmen would then go out on their own to build the plant for interested farmers.

The strategy taken by SEP was successful. By 1987, about 150 biogas plants had been constructed in Meru, Kiambu and Nairobi, and interest was steadily growing in other areas. It is estimated that nearly 350 have been built within the SEP framework.

The programme spread to other areas of the country such as Eldoret, Kakamega, K wale, Kilifi, Kitui and Nyeri. Since 1993 there has been a reduction of SEP involvement in activities related to biogas promotion, a factor which has been attributed to reduced direct financial support from GTZ. Promotion and dissemination continues under the biogas section of MOERD.

Ministry of Energy and Regional Development (MOERD)

Since the early 1980s, MOERD has, in collaboration with SEP, been actively involved in the promotion and dissemination of biogas technology. In fact the implementation of SEP' s activities was the responsibility of MOERD' s biogas section. The joint activities of MOERD and SEP have resulted in the installation of about 3 50 plants country wide. Meanwhile dissemination of biogas technology continues under MOERD although SEP is no longer actively involved.

Ministry of Livestock Development (MOLD)

The ministry is involved in helping farmers establish zero-grazing units in various parts of the country. A good working relationship has developed between MOLD, MOERD and SEP, encouraging wider dissemination of biogas technology. In 1995, MOLD began direct promotion of the technology through its extension service. In the Nandi area, the National Dairy Development project is working closely with CITC to promote biogas utilization as part of its extension service.

Kenya Industrial Estates (KIE)

Right from the beginning of the SEP, KIE was assigned a significant role in dissemination. It was mandated to develop a local manufacturing equipment for renewable energy appliances with capability of wide distribution.

KIE has been active in the design of biogas appliances. They also provide advisory and financial assistance to local entrepreneurs wishing to produce such appliances. The idea was to help ensure that biogas users had readily available appliances at affordable prices.

KIE has been involved in designing, testing and distributing biogas cookers and lighting systems. However, it was not possible to assess its impact of technology transfer and provision of financial assistance to local entrepreneurs.

Private Sector Organisations

Tunnel Technology Limited (TTL)

Established in 1958 by Mr. Tim Hutchinson, TTL is based in Koru, Nyanza Province and manufactures and distributes a comprehensive range of Hutchinson biogas plants. They range from small, medium and large scale; with suitability for farms with as few as three to as many as 200 cows. TTL's range of plants include Continuous Flow plants though Batch Types are also offered.

TTL plants have been widely distributed and are found in different parts of the country. Many of these units have been working continuously for over twenty five years with no need for repairs or replacements. Promotion is mainly verbal, spreading from one satisfied user to another. Occasionally, company personnel attend Agricultural Shows to display and promote the plants especially in western Kenya.

Apart from disseminating biogas plants, TTL is involved in designing and producing highly innovative products that use biogas. They include modified kerosene fridges and stationary engines producing electricity for home appliances. The company is also involved in research to improve the quality of existing products as well as innovating new ones. To date, TTL has installed nearly 300 biogas plants in Kenya.

Biogas Africa

Biogas Mrica has been involved in disseminating biogas technology since 1989. The company promotes the Borda-sasse biogas plant and manufactures most of the metallic components at a workshop in Kiserian town of Ngong division in Kajiado district. They target small scale farmers who zero-graze mainly in Ngong and Kiambu.

Kentainers Limited

Kentainers Limited, a local private company based in Nairobi, has developed a Floating Drum plant made from polyethylene (PE).

SEP trainees and individual entrepreneurs

Some of the people originally trained by SEP in 1983 and those trained later by MOERD Agroforestry/Energy Centre as biogas instructors have gone into business building biogas plants especially in their home areas. These people are active mainly in Meru, Nyeri, Eldoret and Kiambu. As a group, they too have contributed significantly to the dissemination of biogas technology. It is estimated that in Meru district alone, this group has installed about 80 plants since 1985. The major drawback to their efforts is inadequate financial resources to set up more effective operations.

The Christian Intermediate Technology Centre (CITC)

CITC Kapsabet is a technical training centre established in 1989 by the Anglican Diocese of Eldoret with help from the German Protestant Church. The centre offers a two year formal course in metal work and has a production unit specialising in the manufacture of appropriate technology equipment.

Biogas activities under CITC began in 1990 when ten masons from the diocese were trained in the construction of biogas plants with help from SEP and MOERD. At the same time, CITC trained its own technicians to fabricate gas holders and biogas appliances. During the initial phase, plants were constructed for those farmers who met the minimum requirements for successful operation of biogas plants. These farmers paid 50% of the cost of the system and the balance was subsidised by the United States Agency for International Development (USAID). About ten plants were built under this arrangement. They were intended to be demonstration units to create awareness and interest among other potential users.

The centre set up a biogas extension service solely responsible for all aspects of promotion, installation and the provision of after-sales customer support. The promotional strategy included participation in Agricultural Shows and distribution of biogas brochures through the extension service.
A manual for biogas users was developed to advise on operation, maintenance and troubleshooting of the system. Occasionally, workshops are held for biogas users and potential users as well as women's groups.

CITC initially promoted the Borda-sasse biogas plant but increase in the price of sheet metal led to a significant escalation in the cost of the plant. The cost of the gas holder doubled between 1990 and 1993, leading CITC to consider alternatives. They conducted a cost analysis which revealed that it was cheaper to build fixed dome plants. The centre now mainly promotes the fixed dome plants in capacities of $10m^3$, 16m3 and 36m3. The Borda-sasse type is currently offered only to those who can afford it.

The $10m^3$ Borda-sasse plant costs between US$ 700 and US$ 800. The CITC project covers the area around Eldoret, Kapsabet, Nandi Hills, Kitale, Kakamega and parts of Nyanza. The project targets small scale farmers practising zero-grazing and have at least three to five cows. By the time of the survey, twenty six biogas plants had been built. The project is operated on a self-sustaining basis; the customer bears the full cost of the system.

Kenya Woodfuel and Agroforestry Programme (KW AP)

KW AP activities in biogas promotion began in the second quarter of 1995. It is a local NGO promoting conservation of wood fuel and agroforestry practices in various areas to help increase woodfuel supplies.

KW AP works closely with the MOERD and MOLD to promote the use of biogas among farmers in Kericho, Nyamira, Kisii and other areas in western Kenya. MOERD staff have been attached to KW AP specifically for this purpose. KW AP has a station in Kericho from where its staff in collaboration with MOERD and MOLD, organise field visits to areas such as Vihiga and Mumias for farmers to observe biogas plants in operation.

Chapter Eight

PERFORMANCE OF BIOGAS PLANTS

Levels of use in households covered by the survey A total of 43 households with biogas plants were visited between September and November, 1995. The number of houses and areas visited are as follows:

- Embu/Meru area (19)
- Nandi (8)
- Kilift/Kwale (8)
- Kakamega(4)
- Kisumu(14)

Table 1: Promoting Agencies

Area	Promoting Agency
Embu/Meru	SEP, MOERD, SEP trainees and other individuals
Nandi	CITC
Kilifi/Kwale	SEP, MOERD, TTL
Kakamega	MOERD,MOLD
Kisumu	TTL

Source: Biogas survey, ITDG/PDS 1995

Table 2: Use of biogas units

Area	**No of households visited**	**BGP in operation**	**% level in use**	**Main reason for non-use**
Embu/Meru	19	8	42	• Breakdown • Size of plant unsuitable • Water • Lack of owner interest
Nandi	8	7	88	• Few cows
Kilifi/Kwale	8	3	38	• Lack of owner interest • Lack of water • Few cows • Breakdown
Kakamega	4	2	50	• Lack of water • Few cows
Kisumu	4	1	33	• Lack of owner interest • Few Cows

From Tables 1 and 2, note the high level of use of biogas plants especially in Nandi area. The level of adoption is mainly attributed to the dissemination strategy adopted by CITC. A biogas extension service has been established to provide advice and post-installation support services to the users. The approach has helped users to properly operate and maintain their biogas plants. On the other hand, areas like Kisumu where customer support is inadequate, levels of use are generally low.

Factors affecting the performance of biogas plants.

The survey identified certain crucial factors which contribute to successful performance of biogas plants. They include:

Technical problems

The most important cause of abandonment of plants after installation is technical in nature and mostly relates to leaking gas holders, digesters and gas delivery pipes.

Water

A significant number of the plants visited in Meru were found to have been abandoned after the water supply the system originally depended on, broke down. The amounts of water the farmers were able to collect from distant rivers or boreholes was only sufficient for domestic use. There is need for adequate supply of water if operation of biogas plants is to be successful. Water is needed for mixing the cow dung to form slurry and for cleaning the zero-grazing unit.

Number of cows

A family of eight in Eldoret with only one cow was struggling to find enough dung to feed the plant. The plant was producing very little gas and the family had to switch to woodfuel to meet their energy needs.

Mode of stock keeping

In another case in Meru, a user was having problems operating his plant despite owning five cows. The problem was related to his mode of keeping his stock. He had not stabled his cows and collection of dung was difficult and tiring. The cows were living on a three-acre farm and collection of dung required that the farm worker move to all corners of the farm collecting dung; a task that he never did satisfactorily. As a result, very small amounts of dung were collected. The dung was then mixed with excessive quantities of water forming a slurry with low organic content which could only produce meagre amounts of gas.

Size of the biogas plant/energy requirements

Twenty five per cent of the plants visited in Meru were not producing enough gas to meet the users' energy needs. By systematically eliminating other factors that could cause low gas production, the problem was traced back to the capacity of the installed plants. Daily gas output was low in relation to the amounts required for cooking and lighting. The situation was observed in all areas except Nandi and Eldoret.

Arrangement of biogas system components

The biogas system comprises the zero-grazing unit, the biogas plant, farm house (where biogas appliances are located) and the farm on which the slurry is applied. To keep the labour input minimal, the system needs to be well-planned. First, the distance between components should be as short as possible. Secondly, the zero-grazing unit should be located on a higher ground than the other components of the system. In situations where the terrain is sloppy, the biogas plant should be located on the higher part of the slope.

In cases where the arrangement of components is not properly done, operational difficulties related to increased labour input were evident. For example, there was irregular feeding of the plant and consequently, suboptimal performance.

Owners' interest
It was only in cases where there has been continuous interest and where strict supervision is provided that successful performance of the plant is usually realized. The reverse was true where owners lacked interest.

Chapter Nine
CONCLUSION AND RECOMMENDATIONS

Factors affecting acceptability of the technology

Basic requirements for a successful operation
Any factor that affects successful performance of a biogas plant has a bearing on the acceptability of the technology. In areas where the first installed plant performed well, word of mouth from satisfied users encouraged other potential users to install their own plants. Where plants failed, the failure created a negative impact on the technology, discouraging potential users in the process.
Social influence created by successfully operated biogas plants is a necessary condition for wider dissemination and acceptability of technology.

Support from promoting agencies
Establishment of a post-installation support service has led to continued interest from users. The operation and maintenance of the plants have been regular and high levels of use registered. A good example is found in areas served by the biogas extension services (BES) of CITC. Officials of BES visit users regularly to ensure proper operation of the plants and provide advice and repair services where necessary.

If plants work well, the users are encouraged to take good care of them so that they can continue to realise the benefits. At the same time, they provide effective 'advertisement' for the promotion of biogas technology.

Indirect competition for financial resources by other technologies
The introduction and promotion of PV technology since the mid 1980s has had a negative effect on the use of biogas technology especially in areas where both technologies are promoted together. PV systems generate electric power that can run small televisions, radios and lighting systems for households. These systems are not in direct competition with biogas systems because each fulfil a different set of user needs. Biogas is mainly used for cooking and lighting and its effluent used as fertiliser, while PV systems are mainly used for lighting and operating small electrical appliances such as radios and televisions. It has been noticed, however, that more often than not, most rural farmers can only afford one of the two technologies and if a decision is made to purchase a PV system, then the farmer will not be able to raise the money to construct a biogas plant.

In many instances in Meru district, many of the potential users of biogas have installed a PV system and consequently, are unable to install biogas plants. PV systems are also associated with financially successful people thus creating social pressure on many people to turn to it.

Cost
The initial investment cost of biogas systems is high, posing a big problem to many potential users who are unable to raise money up front. In addition, there are no mechanisms or schemes through which farmers can borrow money to acquire biogas plants.

The rising costs of components and adverse economic conditions in recent years have reduced disposable incomes in the country. Potential buyers are becoming fewer. Hence cost is a serious constraint to dissemination of biogas technology.

Private sector involvement

Presently, only a few private firms are seriously involved in the promotion of the technology. The profit motive is a necessary ingredient for wider involvement of the private sector. That would provide the basis for its effective dissemination and sustainability.

Labour input

Some users are concerned by the high labour input that the plant requires.
The commitment needed is also high and some who installed the plants had not anticipated such high labour costs. This has discouraged some potential users and occasionally led to loss of interest and eventual abandonment of the plants.

Viability

Is biogas technology viable in Kenya? The authors conclude that there is scope for dissemination of the technology provided the approach used currently is slightly modified. Some modifications are to be done through follow-up and post-installation support. If the current situation continues, the scope of successful dissemination is limited. It is clear that majority of rural farmers in Kenya do not meet the basic requirements for successful operation of biogas plants, but there are areas where community members could afford the technology.

On whether or not the technology is viable, one can say that it is a viable alternative source of energy to specific areas. Such areas are characterised by high population, scarcity of land and zero-grazing activities. The community in the area should, however, support the operations. Resources such as water and cows are a prerequisite for viability of such projects.

The future provides potential and opportunities to disseminate the technology. Land in Kenya is getting scarce while biomass fuel resources are declining. Both provide an, opportunity for biogas technology dissemination.

General recommendations

Generalized opinions can be made targeting specific organisations interested in promoting biogas technology.

1. Market potential should be established before the technology is introduced in any part of the country. This would save resources that may be wasted in promoting the technology where it is not viable, and where in fact the conditions for successful dissemination are absent.
2. Government agencies, NGOs and church organisations promoting the technology should involve the private sector, as it is well placed to effect better marketing strategies and to build grounds for sustainability.
3. In areas with good market potential, and where the technology already exists, there is need to:
    - counter the negative publicity on the technology created by failed biogas plants. Stalled projects could be revived where possible.
    - promote and disseminate biogas plant designs and models of proven performance and durability.
    - offer after-installation support to customers.
4. To encourage more people to use biogas technology, there is need to explore ways of lowering the cost. Examples of cost-lowering initiatives are the Kentainers' and Hutchinson types. They have great potential, and promoting agencies should seek collaboration with agencies or manufacturers interested in exploring such alternatives.
5. Schemes should be established to provide financial support to small firms and individuals promoting the technology so as to enable them operate more efficiently and effectively.

6. Credit schemes should be established to provide loans to potential users who may be unable to raise the initial capital.
7. There is need to acquire information on other energy supply options so as to provide advice on the most appropriate and cost-effective solutions to energy problems based on particular situations.
8. Efforts should be directed at exploring opportunities for promoting the technology in sectors that are currently not exploited, such as dairy farms where the large amounts of cow dung available can produce biogas to power stationary engines. The energy produced can help meet a wide range of energy needs on the farm, thus reducing the energy bill.

Appendix I

Terms of reference of the study

The study reviewed the promotion of biogas in Kenya through a desk and field study. A report was then compiled. The terms of reference of the study are as follows:

A desk study with the following objectives:

1. To determine the scope and results of any previous assessments of investigations of biogas projects in Kenya.
2. To describe the types of biogas units promoted in Kenya.
3. Research on other promotional and printed literature which may have been produced.

Field study with the following tasks:

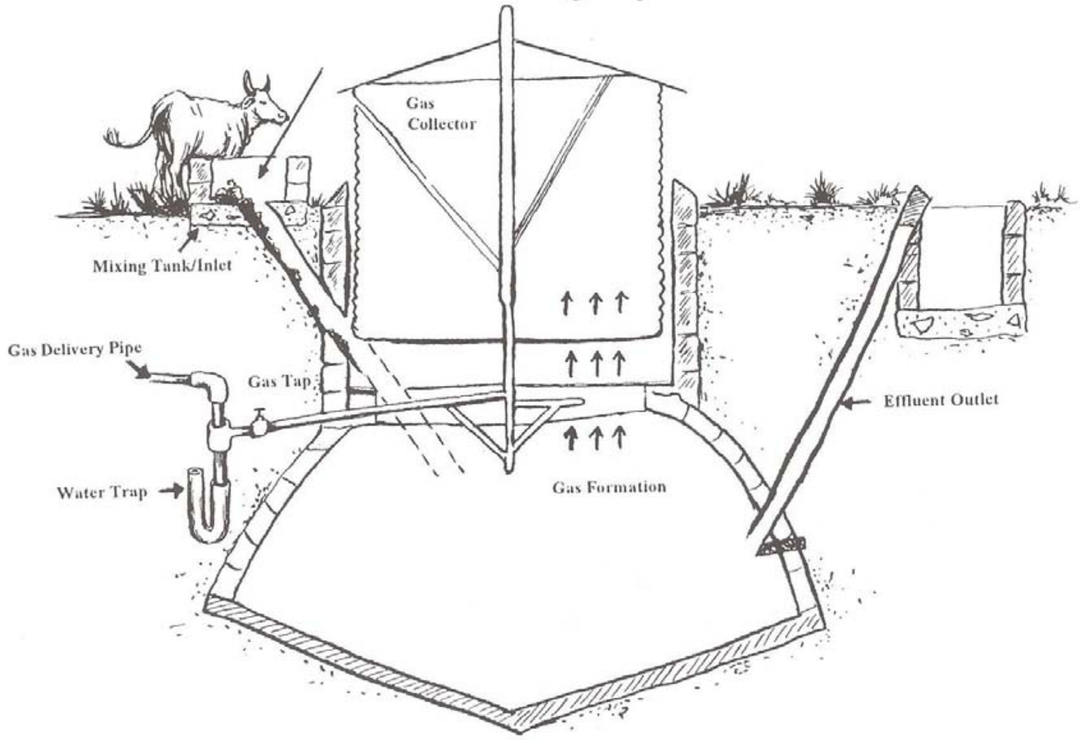
1. To assess the level of activity and success of organisations and private firms currently promoting biogas technology, including:
   - target regions (geographical) · target groups (socio-economic)
   - project periods and support sources · promotion and dissemination methods · level of use where promoted.

Reporting:

1. To present the findings of the desk and field studies
2. On the basis of the above, to summarise options for potential opportunities in the sector.

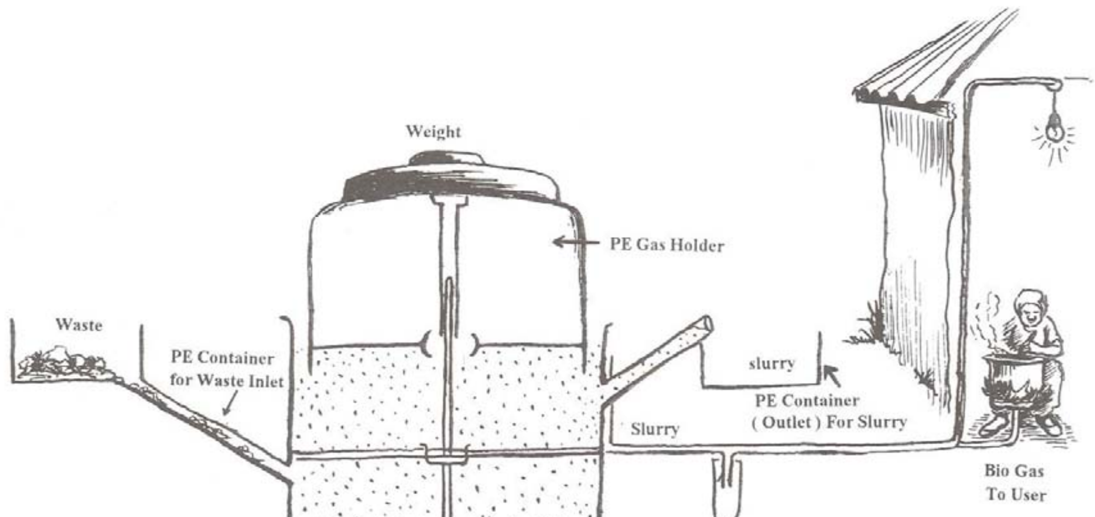
Appendix II

Borda-sasse **biogas plant**



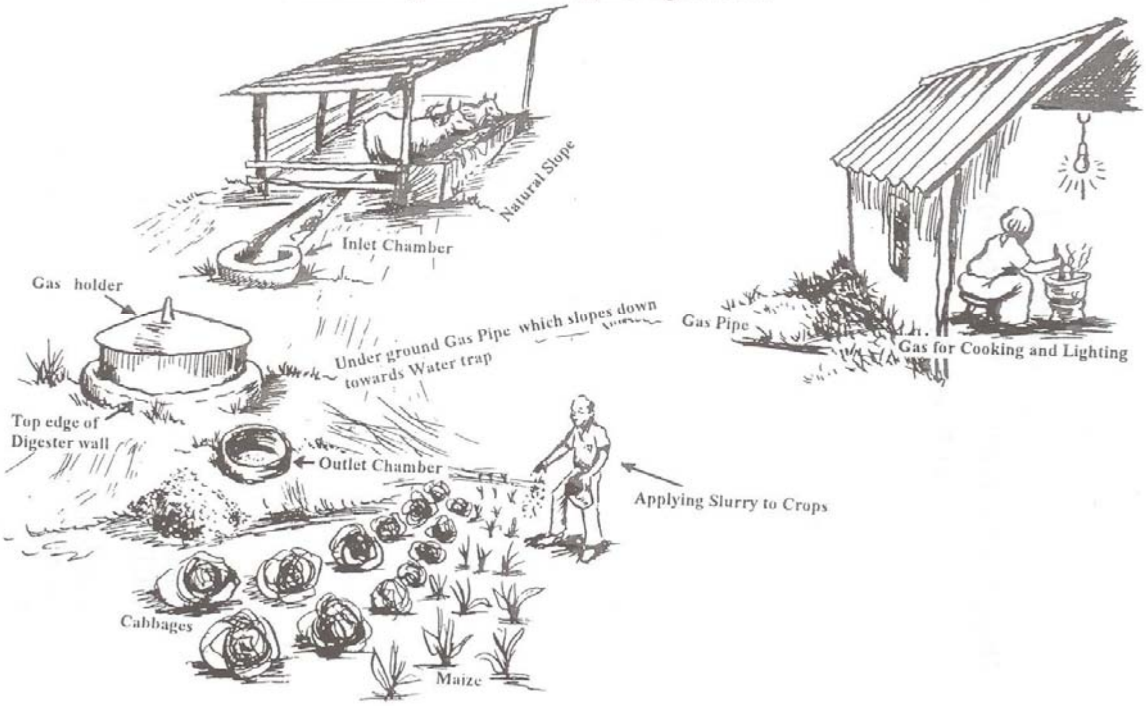
Appendix III

Hutchinson domestic plant



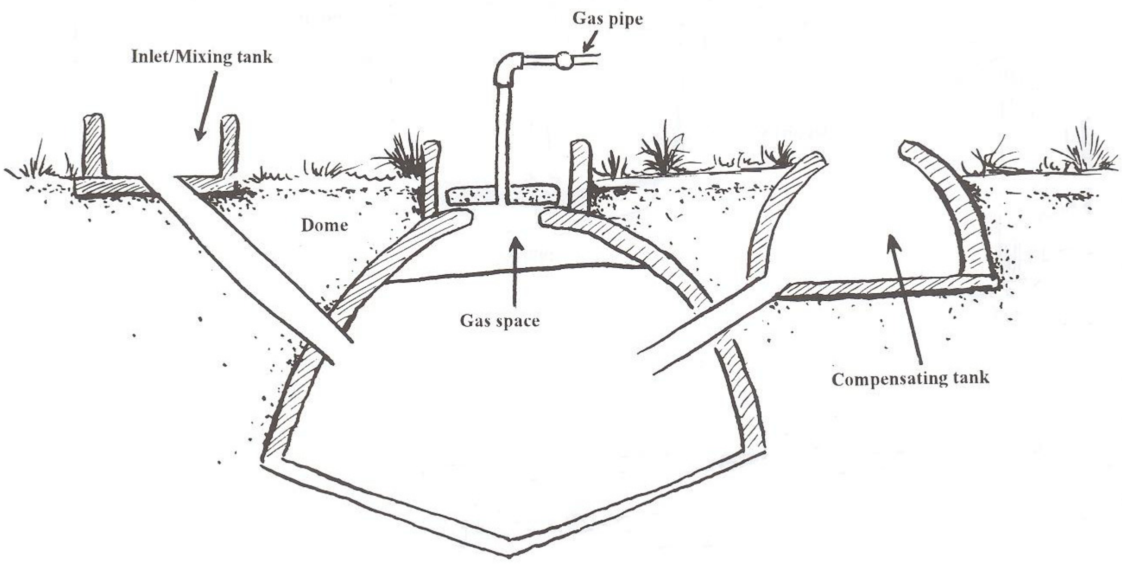
Appendix V

An integrated biogas system



Appendix IV

Fixed dome plant



Glossary

Ammonia	a gas with strong smell that is usually produced when organic compounds decompose
Anaerobic	environment conditions devoid of oxygen
Biogas	gas produced by the anaerobic decomposition of organic materials as a result of a specific bacterial activity
Digester	a closed container which is used to bring about conditions necessary for biogas production
Effluent	residue from the fermentation process in a digester
Flammable	that which can light or catch fire easily
Incandescent	producing or giving light on heating
Organic	that which has life: of or from living things
Sludge	thick liquid material that is discharged from the digester
Slurry	mixture of water and waste material that is fed into the digester
Soluble	that which can dissolve, especially in water
Sub-optimal	less than full capacity
Viable	that which is practised and is sustainable
Zero-grazing	a system where animals are reared in an enclosure. Food and water is brought to them

FURTHER READING

Crook, M; van Buren, A; ITDG; (1981) **A Chinese Biogas Manual**
This publication uses diagrams and pictures to show how the basic design of the biogas pit can be adopted for construction in different soils, from sandstone to sheer rock, which should encourage other developing countries to embark on their own biogas programmes.

Fulford, D.; (1988) **Running a Biogas Programme: A Handbook**
Describes the designs and uses of biogas plants, with technical appendices, for domestic and community plants. Likely economic and social effects of biogas programmes are described from experience, and advice given in the problems of management.

Hislop, D.; ITDG; (1992) **Energy Options: An Introduction to SmallScale Renewable Energy Technologies**
This gives a comprehensive overview of energy options currently available. It is intended for those who need to know where and how they might be used. Energy options has its roots in the series of technical briefs produced for the Technical Enquiries Unit (TEU) by IT Power. It provides a basic understanding of the technology offered and is a springboard to further serious research into the chosen subject.

Bhalla, A. S.; Reddy, A. K. N; (1994) **The Technological Transformation of India** The outcome of a World Employment Programme project, this book consists of eleven chapters and is concerned with the technological transformation of the rural non-farm sector and focuses on the commercialization of rural technologies and the factors hindering this process.

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