Formulation of Programme Implementation Document for Domestic Biogas Programme in Kenya

Mission Report on Selection of Biogas Plant Design and Formulation of Quality Control Framework and Certification Procedures for Biogas Constructors

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April 2009

Table of Contents

ABBREVIATION

ABCK	:	Association of Biogas Constructors of Kenya
ABP	:	Asia Biogas Programme
ABPP	:	Africa Biogas Partnership Programme
CBO	:	Community Based Organisation
CAMARTEC	:	Centre for Agricultural Mechanisation and Rural Technology
DGIS	:	Directorate General for International Cooperation (The Netherlands)
DRE	:	Department of Renewable Energy
GGC	:	Gobar Gas (Biogas) Company (Nepal)
GHG	:	Green House Gases
GTZ	:	German Agency for Technical Cooperation
HRT	:	Hydraulic Retention Time
M&E	:	Monitoring and Evaluation
MFI	:	Micro-finance Institutes
MOE	:	Ministry of Energy
NBIC	:	National Biogas Initiative Committee
NGO	:	Non Governmental Organisation
O&M	:	Operation and Maintenence
PID	:	Programme Implementation Document
QC	:	Quality Control
R&D	:	Research and Development
SACCOS	:	Saving and Credit Cooperatives
SNV	:	Netherlands Development Organisation
KSh	:	Kenyan Shilling
ToR	:	Terms of Reference
USD	:	United States Dollar

ACKNOWLEDGEMENT

During the course of this mission, I have received help and advices from a large number of people and professionals, without which successful completion of the assignment would have been difficult. First of all, I would like to extend my appreciation to all, the names of whose do not appear in the list of acknowledgement.

My special thanks to Mr. Wanga Moses, Senior Advisor, Northern Rift Portfolio, SNV-Kenya for his continued unfailing supports as well as suggestions and feedbacks during the whole process of the mission. I acknowledge the support of Eng. Njeri Waruingi-Kahiu, Mr. John Maina and Mr. John Masai who accompanied me during the field study and provided me with very useful information which were instrumental in consolidating the study findings.

I cordially extend my thanks and gratitude to all the biogas company personnel and respondent plant users who provided their valuable time to answer our questions and share their experiences. The views, problems and perceptions of these people have helped me in carrying out my assignment in various ways.

In closing, I would like to extend my sincere thanks to SNV Kenya team, especaiily the central and northern portfolio offices in Nairobi and Eldoret for helping me during my mission in Kenya.

Prakash C. Ghimire

1. Introduction and background

Under the framework of the Biogas for Africa Initiative, ETC UK - after having completed a desk review[1] - executed a study commissioned by Shell Foundation on the feasibility of promoting biogas technology in Kenya[2]. The final report of this study provided information on the history of domestic biogas and the technology applied so far in the country, different organisations involved in promotion of domestic biogas technology as well as dissemination approaches/models used by these organisations. To better understand the (prospective) customers, focus group discussions were held with 106 people and semi-structured interviews with 40 people in five districts who were already applying zero-grazing of cattle and with 15 people who already owned a biogas digester. The outcome of such discussions revealed that the monthly expenditures on energy (excluding electricity) ranged from €10 to €20 per month per household ranging in size from 4 to 8 persons. A very rough calculation of the theoretical market potential arrived at more than 172,000 biogas units, much lower compared to another rough estimate (more than 1.2 million) conducted for the Biogas for Africa Initiative[3]. Based on a marketing and financial analysis, ETC UK recommended the implementation of a market-oriented programme starting in five regional hubs (Kiambu, Nyandarua, Nakuru, Kakamega and Kisii) and to expand on the basis of actual commercial practices of the private sector. A production target of 6,000 units over a period of 4 years (preceded by one year inception) was considered feasible.

In May 2007, the Biogas for Africa Initiative was formally launched in Nairobi, Kenya. The Kenyan participants to this event decided to assume ownership of the principles advocated by the Initiative and formed a Task Force in June 2007, chaired by the Department of Renewable Energy (DRE) of the Ministry of Energy (MOE). As one of its beginning activities, the Task Force compiled and submitted comment on the draft version of the feasibility study report[4]. In 2008, the Task Force in Kenya was transformed into a National Biogas Initiative Committee (NBIC). This Committee has eleven members, being Association of Biogas Contractors in Kenya (ABCK) (represented by SCODE), banks (represented by Equity Bank), Energy Regulatory Commission, Jomo Kenyatta University of Agriculture & Technology, Kenya Renewable Energy Association, Micro-finance institutions (represented by Kenya Women Finance Trust), Ministry of Livestock Development, Ministry of Energy, NGOs (represented by SCODE and Practical Action-EA), project developers (represented by IT Power), and, Saving and Credit Cooperatives (SACCOS) (represented by Kenyan Union of Savings and Credit Organisations). The MOE is chairing the Committee. The main responsibility of the Committee was identified to develop a Programme Implementation Document (PID) for a national programme on domestic biogas in Kenya and to present it to a wider group of stakeholders for adoption. The Committee established three sub-committees which all convened meetings a couple of times, but did not manage to deliver a presentable document, mainly due to lack of clarity of the possibilities for co-funding of the programme by the Biogas for Africa Initiative.

In December 2008, the Directorate General for International Cooperation (DGIS) under the Netherlands Ministry of Foreign Affairs approved a proposal for the Africa Biogas Partnership Programme (ABPP). In this Programme, DGIS in collaboration with two Dutch development NGOs, HIVOS and SNV Netherlands Development Organisation, aim at supporting the implementation of national biogas programmes in six Afcian countries. HIVOS will be responsible for fund management and overall coordination and the responsibility of capacity building services & knowledge management will be taken care of by SNV. Kenya is among the six targeted countries. HIVOS and SNV undertook a joint mission to Kenya from 12-16 January 2009 to furhter speed up the process. During this mission, a consultative stakeholders' meeting was conducted on 15 January at Silver Springs Hotel in Nairobi. In this meeting, decision was taken to carry out additional works on the selection of the most appropriate technology for dissemination under the framework of the national biogas programme in Kenya.

[1] Leanne Wilson, Phil O'Keefe and Fred Muchena, *The potential for biogas in Kenya.* ETC UK and East Africa, undated
[2] ETC UK, *Promoting biogas systems in Kenya. A feasibility study.* Final Draft, 18 October 2007
[3] Felix ter Heegde and Kai Sonder, *Domestic biogas in Africa: a first assessment of the potential and need (Draft/ Discussion Paper)*. Biogas for Better Life: An African Initiative, May 2007
[4] Task Force, *Comments on feasibility Study on promoting biogas in Kenya.* undated

A Terms of Reference (TOR) was developed by Africa Biogas Partnership Programme (ABPP) with the objective to prepare a detailed PID for the proposed national programme on domestic biogas in Kenya. The execution of this TOR was proposed to be done in two stages, the first team of technical experts to initiate with the finalisation of various technological aspects such as selection of best suited standard model of biogas plant for Kenya context and its characteristics, quality control mechanisms and private constructors certification process which are integral part of the PID and the second team of experts with the responsibility to finalise the institutional set-ups and other key issues related to programme management and to carry out the writing exercise of the PID.

SNV Kenya is coordinating the formulation of the PID by making available the services of the in-house personnel who have been working in biogas programmes in different Asian countries under the framework of Aisa Biogas Programme (ABP). This brief report summarises the activities and outcomes of the mission of first team in Kenya during the period March 13 to April 02, 2009.

2. Objectives of the proposed biogas programme

The anticipated overall objective of proposed national programme on domestic biogas is to further develop and disseminate domestic biogas technology in Kenya with the ultimate goal to establish a sustainable and commercial biogas sector in the country.

The tentative specific objectives contributing to its overall objectives are:

- To develop a commercially viable, market oriented biogas industry in Kenya,
- To increase the number of quality biogas plants by 8,000 in a period of four years;
- To ensure the continued operation of all biogas plants installed under the programme;
- To further strengthen involved institutions for sustainable development of the biogas sector,
- To provide low cost, clean and environmental friendly energy for cooking and lighting and reduce smoke-borne and smoke-induced diseases inherent to traditional cooking,
- To enhance household as well as environmental sanitation conditions,
- To reduce workload of the people, especially that of women and encourage the use of time saved to productive agriculture and family care as well as welfare activities,
- To facilitate employment generation by creating jobs at the local level in the form of construction masons, supervisors and biogas entrepreneurs,
- To improve the productivity of agricultural fields with the effective use of nutrient bioslurry and minimise the adverse effects of chemical fertilizers, and,
- To ensure environmental benefits through forest conservation as the results of reduced use of firewood and charcoal and reduced Green House Gas emissions (GHG),

3. Rationale of the Mission

It is well understood that the success of biogas programme depends heavily upon the workable and effective implementation plan that is based upon the grassroots reality of the sector. These include, among others, information on physical status and functioning of existing biogas plants, users' perception on the technology, impact of biogas plants on the users, and capacity of the grassroots communities to adopt and internalise the technology. Information on these issues would help in deciding best suitable implementation modality for the program. This technical mission has been considered to be instrumental in colleting first hand primary data and information on these issues from the users' level so that the findings are reflected in the implementation plan.

Non-functioning and poorly functioning biogas plants cause not only capital waste but also do a lot of harms and damages to the reputation of biogas technology and eventually to the desired future expansion biogas program. The satisfied biogas users are the main and effective extension media for the promotion of the technology and vice-versa. And hence, to safeguard the interest of the users, it is important that the biogas plants functions to the desired level; which is only possible when the plants are constructed and operated as

per the set quality standards. To ensure the quality of biogas plants, it is important that effective quality control mechanisms are formulated and enforced effectively. Quality management, therefore, should be a vital component of the PID.

Private sector, especially the constructors of biogas plants and manufacturers of biogas appliances, are means to develop a more productive biogas sector and to increase the economic participation of the population in the sector. Participation of the private sector helps in checks and balances between countervailing powers, and minimises the role of the government sector from the need to intervene. Keeping this in mind, biogas programme is anticipated to aim at letting the biogas sector develop by using the internal forces of demand and supply and by reducing external driving forces such as centrally planned production targets and subsidization in the long run, though the immediate or short term driving force should be external, like subsidy. Effective mobilization of private sector is very important for the sustainability of the proposed biogas programme. The proposed PID should, therefore, address the issue of private sector mobilisation in an effective and efficient manner.

4. Objective of the Mission

The main objective of the mission was to assist in the formulation of PID for the National Domestic Biogas Programme in Kenya by:

a. Selecting best suitable design/model of biogas plants for wide-scale dissemination of the technology in Kenya under the framework of Africa Biogas Partnership Programme
b. Formulating basic framework for quality management mechanism in general and quality control in particular, within the Biogas Programme
c. Preparing general accreditation/certification modality for the participation of private sector constructors/manufacturers in Biogas Programme

5. Activities

The following activities were carried out during the mission:

- Study the feasibility report prepared by ETC and other relevant documents to collect secondary data and information,
- Linking with and incorporating initial lessons from ongoing domestic biogas initiatives in line of the Africa Biogas Partnership Programme,
- Propose the criteria for selection of the most appropriate technologies (performance factors);
- Identify in consultation with NBIC, ABCK, GTZ/PSDA and other stakeholders the models to be included in the selection process;
- Conduct a quick survey to get acquainted with the practice on the ground and to identify prices of needed materials, agree on performance factors and match different potential biogas plant designs (all 8 m3) with the performance factors as preparation for the constructors' workshop.

- Produce a score card, scoring the different models to the selected criteria
- Facilitate the workshop to select the most appropriate design and sizes with related investment costs based on agreed criteria/performance factors; to propose a certification process for constructors; and to propose quality control mechanisms to ensure quality construction and after sales service.
- Prepare an overview of the findings and present to a workshop which groups all identified biogas constructors both of the public, private or development institutions.
- Facilitate the workshop to select;

- a standard appropriate design, size(s) and investment costs for household based on agreed criteria and performance factors.
- quality control mechanisms
- certification process for private sector constructors/manufacturers

o Prepare report on outcome of the workshop

6. Outcome of Field Investigation

The field investigation works consisted of the following activities (Detail itinerary has been provided in Annex-1):

- Review of existing data and information available in Kenya and elsewhere
- Preparation of semi-structured questionnaries for data collection
- Consultation with experts and professionals involved in the sector
- Observations of biogas plants of different models/designs installed in different parts of Kenya to assess physical status and functioning as well as quality of workmanship
- Consultations with the users to know the effects/impacts of biogas plants on them
- Consult with the entrepreneurs involved in the sector

A field visit was carried out from 17th to 21st of March 2009 covering Kiambu, Nyeri, Nakuru, Eldoret, Kapsabet areas. The filed survey team also visited one supplier and interviewed some biogas contractors in the process. The following types of biogas plants were considered during the study:

- Floating dome digester,
- Fixed dome digester-Carmatec and Akut designs
- Tubular Digester/Balloon type
- Puxin Design
- Ambita Model

The main instrument of the study was the semi-structured questionnaires and open-ended unstructured interviews with the respective plant user. Additional investigation tools included observations, especially of different components of biogas plants, cattle-sheds, household kitchen and slurry pits in the sampled households and informal discussions with people in the survey clusters. The semi-structured questionnaires were discussed among experts from various organizations involved in biogas promotion and extension in Kenya prior to the field-testing. During the field survey process, the study team adopted an interactive approach rather than a 'question and answer session' with the respondents to enhance the quality of data and information collected.

The following tables show the details of biogas plants visited during the field investigation:

Type of digester	Location	Size	Number of digester	Operational	Not operational
Floating Dome	Tigoni Wambugu farm Kaptumo Kapchumba	8M3 16M3 16M3 16M3	4	3	1
Akut	Tinganga	30M3	1	1	
Tubular digester	Mukurweini Mogotio Ridgeways	4.7M3 4.7M3 4.7M3	3	3	
Ambita Model	Warazo Jet	-	2	1	1(under construction)
Puxin Design	Karishen,Narumoru	6M3	1	1	
Carmatech	Lanet	25M3	7	6	1(abandoned)

design	Lanet Lanet Kaptumo Musobejo Lelmokwo Mweiga	16M3 10M3 50M3 16M3 50M3 16M3			

Likewise, the following table shows the constructors and suppliers consulated:

Name of Company	**Number of Digesters installed**	**Type of digester installed**	**Location and address**	**Area of operation**
Equater Fuel wood energy saving	App. 120 (Since 2004)	Akut design	Nanyuki	Around Nyeri, Laikipia,Meru, Thika,Githunguri
SCODE	Over 500 plants (Since 2000)	Carmatech design	Lanet, Nakuru	Whole country
Puxin Kenya	Supplier			Whole country

The outcome of the field investigation revealed the following facts:

- Most of the biogas plants have been installed in relatively well off households.
- Most of the users were satisfied with the performance of their biogas plants.
- Users were not aware of the required size and anticipated gas production from their plants.
- The constructors were responsible to decide the size of plants.
- Biogas plants were over-sized in relation to the need and most of them were under-fed.
- The plants in general were too costly - there is need to assess cost reduction methodologies without compromising the quality.
- Biogas plants were built without any defined quality standards.
- Quality of construction and workmanship in general have been satisfactory; however there were lot of rooms for further improvement.

- Efficiency of biogas plants based upon actual feeding is satisfactory, however, the overall efficiency based upon the size is very low
- There are lots of rooms for improvements in fitting pipes and appliances.
- There is need to install water drain properly.
- Location of plants in most of the cases were not proper leading in less gas pressure in the point of application.
- O&M training to users needs to be emphasized.
- Handling of slurry is not done properly – slurry pits need to be constructed.
- Quality of feeding has to be improved to avoid/minimize the scum formation.
- Water dung ratio in most of the plants was proper.
- Urine collection system has not been integrated in most of the cases.
- The orientation of inlet pipe and the digester centre line is not proper in most of the cases.
- In most of the cases firewood is also being used for cooking purpose even after the installation of biogas plants.

In conclusion,

- Production of biogas is far more than the consumption leading in escaping of biogas in atmosphere – not good from environmental point of view.
- There is high need to diversify gas use and optimize the efficiency of appliances.
- The cost of biogas plants ranged from KSh. 34,000 (for tubular) to KSh.300,000 (for Akut model of 30 cum).
- The financial saving from the installation was reported to be ranging from KSh 2000 to 8000 per month.
- The main problems reported were less gas pressure, gas leakage, and non-functioning of water drains.

7. Constructors' Workshop

Field investigation exercise was followed by a 3-day workshop of the constructors' of biogas plants in Kenya to select a standard appropriate design, size(s) and investment costs for household based on agreed criteria and performance factors; quality control mechanisms and certification process for private sector constructors. The workshop was attended by participants from private and public constructors as well as experts in the sector. The workshop schedule and the details of participants have been given in Annex-2 and 3. The main issues presented and discussed in the workshop were:

- SNV supported biogas programmes in Asia and Africa
- Outcome of the field investigation
- Technical assessment of models under consideration
- Criteria to select biogas plant model
- Ranking exercises
- Quality management under the framework of biogas programme
- Role of private sector in biogas programme
- Criteria for private sector accreditation

The following sections highlight the events and outcome of this workshop.

7.1 Events and Outcomes

7.1.1 Welcome and Opening

The workshop formally started with the welcome of participants, opening remarks and agenda introduction from Mr. Paul Mbuthi, representative from Ministry of Energy. He highlighted the objectives of the workshop and requested the participants to contribute their time and efforts to make this workshop a success. The participants then introduced themselves and expressed their interests to participate constructively in the workshop. He emphasised the need for the large scale dissemination of biogas technology in Kenya and urged the participants to come up with the consensus on the best model of biogas plant to be promoted in the country. Expressing best wishes for the success of the workshop, and urging the participants for their valuable contributions, he expressed his belief that active participation of the participants in the whole process of the workshop would be instrumental in achieving the workshop objectives which ultimately would ensure effective dissemination of biogas technology in the country and minimise negative consequences of the conventional fuel sources.

7.1.2 Presentation on SNV supported Biogas Programmes

The informal opening ceremony was followed by the presentations from the facilitator, Prakash C. Ghimire, Senior Advisor, Asia Biogas Programme of SNV; plenary discussions, group works and group presentations on different models of biogas plants being used under the frameworks of biogas programmes in Asia and Africa including their general characteristics, associated strengths, weaknesses and suitability in Kenyan context. The facilitaor stated his presentation with highlights on successful biogas programmes supported by SNV in different countries in Asia and Afcia. According to him, with nearly two decades of involvement in domestic biogas SNV,

- has demonstrated with its approach that dissemination of biogas is not a technology driven affair. The integrated, sectoral approach modelled for many current development initiatives;
- learned that more “abstract” development objectives (capacity building, governance, integrated development) can be served in a tangible way through product dissemination;
- learned that involvement in activities with tangible results is crucial, both for internal as well as external justification, and;
- learned that establishing commercially viable biogas sectors in developing countries is not a “short-term” activity but rather has a time horizon of 10 years or more.

7.1.3 Presentation on Field Findings

Following the presentation on SNV's experience and achevements in biogas technology dissemination, Eng. Njeri Waruingi-Kahiu presented the summary of the outcome of field investigation. Accoding to her, 21 digesters of various designs such as floating drum, tubular, fixed dome under various trademarks of Camartec, Puxin and Akut of various capacity ranging from $5m^3$ to 50 m^3 were visited in Central, Rift Valley and Nairobi.

She presented the following to be the main outcomes:

- The biogas industry is vibrant and growing in Kenya; however, such growth is mainly inhibited by inability of potential farmers to raise the initial capital investment for building zero grazing units; buying materials for digester construction; and insufficient numbers of animals to generate sufficient feedstock.
- Biogas digesters were installed in middle and upper class households. Customers expressed satisfaction with the performance of their biogas plants but indicated that after sales support was virtually non-existent. The users depended on the contractors to decide the size of plants and were familiar with how much gas was produced from their plants per day.
- Most farmers reported reduced purchases of wood, paraffin, liquefied petroleum gas and charcoals. Reduced indoor air pollution, ease of use and availability of more time for other income generating activities were aslo mentioned as perceived benefits.
- Over fifty percent of the installations visited were funded through farmers’ savings. The remaining units were funded though cooperative loans and grants from development agencies. The cost of biogas plants ranged from thirty four thousand shillings (Ksh. 34,000) for tubular digester to three hundred thousand (Ksh. 300,000) for a thirty cubic metre fixed dome.
- Of the 21 digesters visited, sixteen were operational, one was abandoned, and one was under maintenance. Three tubular digesters were not operational. The main problems reported were low gas pressure, gas leakage and non-functioning of water trap. The wrong location of the water trap affected the gas output in some installations. More attention needs to be given to fitting of piping and appliances.

7.1.4 Presentation on Selection of Biogas Plant Model

Prakash C. Ghimire then facilitaed the session on selection of biogas plant model. He descried different models of biogas plants being disseminated in various parts of the world and highlighted that some major criteria for the selection of biogas plants for a particular context.

He emphsised that to successfully achieve anticipated objectives of biogas programme, it is imperative that the best suited model/design of biogas plant is selected for the wide-scale dissemination. Varieties of models/designs of biogas plants are being used in different countries in the world with successful track records. As reported earlier, there are different models being installed in Kenya-the fixed dome models, floating gas holder type, plastic tunnel model etc. Based upon the performance of the existing biogas plants and experiences from other biogas countries, attempts should me made to select the best model for the wide-scale dissemination of the biogas technology in the country.

According to him, a biogas plant should be:

- Strong
- Reliable/robust
- Water tight
- Gas-tight
- Built of local materials
- Cheap to build
- Easy to build
- Cost effective to supervise the construction
- User-friendly (Easy to operate and maintain)
- Easy to insulate (in cold areas).

To ensure that a biogas plant fulfils the above mentioned parameters, the following factors need to be considered to evaluate the suitability of biogas plant assuming that the adaptability of any biogas plant in a given context depends mainly upon these factors.

a. Climatic and geo-physical parameters
   - Ambient temperature
   - Geo-physical conditions of the soil
   - Condition of ground water-table
   - Sunshine and humidity

b. Technological Parameters
   - Structural strength against different load conditions (structural durability)
   - Methods of construction/supervision
   - Time and effort in quality control
   - Methods of operation and maintenance
   - Applicability/adoptability of the design in different geographical context for mass dissemination
   - Prospects for sharing of technical information and know-how

c. Affordability of potential farmers to install biogas plant
   - Availability of construction materials
   - Availability of human resources (skilled and unskilled) at the local level
   - Cost of installation, operation and maintenance
   - Transportation facilities

d. Purpose of the use of the products from biogas plant
   - Use of gas for cooking, lighting and/or operating a duel-fuel engine
   - Use of slurry as organic fertiliser
   - Gas use pattern/cooking habits of people (type of food, time for cooking, cooking style etc.)

e. Performance of existing models, if any, in the local and/or regional conditions
   - Existing physical status and functioning
   - User's level of satisfaction

f. Quality and quantity of available feeding materials
   - Type of feeding materials (cattle dung, pig manure, human excreta etc.)
   - Availability of water for mixing
   - No. of cattle/pig per household

The following factors were considered to select the types of biogas design for detailed analysis:

- Models presently in use at the local level
- Models not in use at the local level but are being widely used in other countries with similar socio-economic and climatic conditions
- Models with proven track records of successful operation

7.1.5 Ranking Exercise

The suitability of different models of biogas plant potential to be disseminated in Kenya were ranked based upon the criteria shown in the following evaluation matrix.

Biogas Plant Model Score Sheet

SN	Evaluation Criteria	Model 1	Model 2	……..
1	**Climatic and Geological Conditions**			
1.1	Ambient Temperature			
1.2	Type of Soil			
1.3	Condition of Ground Water Table			
1.4	Sunshine and humidity			
2	**Technological Parameters**			
2.1	***Structural Durability and functioning***			
2.1.1	Inlet Chamber and Inlet Pipe			
2.1.2	Digester			
2.1.3	Gas Holder			
2.1.4	Outlet Tank/hydraulic chamber			
2.2	***Methods of Construction/ supervision***			
2.2.1	Requirement of area for construction			
2.2.2	Digging of Pit			
2.2.3	Construction of Base (foundation)			
2.2.4	Construction of Digester			
2.2.5	Construction of Gas Holder			
2.2.6	Inlet and Outlet Tanks			
2.2.7	Time and Efforts in Quality Control			
2.3	***Operation and Maintenance***			
2.3.1	Operational Activities			
2.3.2	Maintenance Activities			
2.3.3	Top-filling and protection of plant			
2.4	***Applicability/Adoptability in different Geographical context (including suitability with locally available construction materials)***			
2.5	***Prospects for sharing of Technical Information and Know-how***			
3	**Affordability of Farmers to install biogas plants**			
3.1	Availability and accessibility of construction materials at the local level			
3.2	Availability of human resources			
3.3	Cost of Installation			
3.4	Operation and maintenance cost			
3.5	Transportation facilities			
4	**Purpose of the use of Products from biogas**			
4.1	Use of Gas			
4.2	Use of Bio-slurry			
4.3	Gas use pattern/Cooking habits			
5	**Performance of Existing biogas plants in local/regional context**			
5.1	Existing physical status and functioning			

5.2	Level of Satisfaction of Users			
6	**Quality and Quantity of available feeding materials**			
6.1	Number of cattle/grazing pattern			
6.2	Type of feeding materials (cattle dung, pig manure, human excreta etc.)			
6.3	Availability of water for mixing			
7.	**Other Criteria**			
7.1				
7.2				
7.3				
	Total Marks obtained			
	Ranking **Final Decision**			

Ranking of different models as per the criteria given above was done in two stages. At first the participants ranked the following three types of biogas plants using the score board:

- Steel floating gas holder model
- Fixed dome model
- Plastic tunnel (tublar model)

The following table summarises the score given by the the 21 participants for these three different models of biogas plants:

Evaluation Results

SN	Floating drum	Fixed Dome	Tubular	Preference
1	138	142	133	Fixed
2	127	151		Fixed
3	110	126	88	Fixed
4	121	117		Floating
5	152	93		Floating
6	45	51	42	Fixed
7	118	169	60	Fixed
8	108	99	93	Floating
9	59	64	50	Fixed
10	139	166	136	Fixed
11	84	128	68	Fixed
12	59	99		Fixed
13	57	86		Fixed
14	61	122	46	Fixed
15	140	106		Floating
16	46	78		Fixed
17	139	137	122	Floating
18	125	230		Fixed
19	102	147		Fixed
20	109		102	Floating
21	116	114	110	Floating
Total	**2155**	**2425**	**212**	
			Fixed	**14**
			Floating	**7**

As shown in the above table, out of 21 participants who took part in scoring, 14 favoured the fixed dome model and seven favoured floating drum model biogas plants. It was therefore decided to concentrate furhter discussion on different designs of fixed dome biogas plants. The faciliator then discussed the following

models of fixed dome biogas designs to assist the participants in selecting three best suitable model from among them for further discussion:

- The Cambodian Farmer's Friend Model
- The Modified GGC Model from Nepal being used in Ethiopia and Rwanda in Africa
- The modified CAMARTEC Model being used in Tanzania
- The AKUT model developed by GTZ for EU-PSDA biogas programme in Kenya
- The Chinese Puxin model being introduced in Kenya
- The SNV/IDCOL Model being used in Bangladesh

Drawings of some of these designs have been given in Annex-6.

The participants were than requested to evaluate these models based upon the criteria as discussed. Majority of the participants expressed their views that only two models, viz. Modified CAMARTEC and AKUT, be considered given their popularity in the country. For final evaluation, therefore, Modified CAMARTEC and AKUT models were considered.

As a consequence of the outcome of the evaluation and characteristics of the designs, it was agreed to follow a technology resulting of a development of a combination of these two designs and also to incorporate recent technological achievements of other countries, for mass dissemination of biogas digesters in Kenya. Keeping in view the outcome of the evaluation, the facilitator then proposed a new design that incoroporates the strengths of both Modified CAMARTEC and AKUT designs.

7.1.6 Characteristics of the New Model

Combination of Modified CAMARTEC and AKUT Model of Biogas Plants is selected with the following proposed modifications:

- The new design will have conical floor for areas having weak soil conditions and flat floor for relatively strong areas.
- There will not be manhole on the top of the gas holder. It will have manhole from the expansion chamber.
- The shape of expansion chamber will be rectangular. A RCC slab will be constructed to cover the it.
- The outlet passage will be design in such a way that it facilitates easy entrance of people inside the digester (at least 60 cm square). The step in the passage will be removed.
- The gas holder will be designed to store at least 60% of the daily gas production
- The overflow level in the expansion chamber will be arranged in such a way that gravity flow of slurry from inlet to slurry pit is possible
- 5 different sizes (4, 6, 8, 10 and 12 cum) of biogas plant will be designed. The minimum pressure to be considered while designing will be 70 cm of water column.
- HTR of 50 days will be considered while preparing the modified design
- The design will incorporate options for direct feeding of dung from the cattle shed as well as separate mixing tank depending upon the site condition and user's demand/need
- The other design parameters will be as per the standard norms and practices

The participants unanimously approved the modification provisions. Prakash C. Ghimire on behalf of Biogas Programme was given the responsibility to prepare the new design. The final design as well as costs and quantity estimation of the new design have been given in Annex-4 and 5.

7.1.7 Presentation and Discussion on Quality Control Framework

As per the agenda for the second day, the facilitator started the sessions with the presentation on importance of quality management in biogas programme. He emphasised the fact that non-functioning and poorly functioning biogas plants cause not only capital wastes but also harm the reputation of biogas

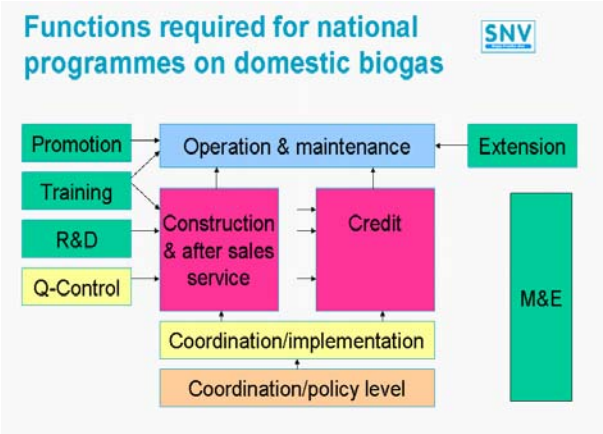
technology and eventually to the desired establishment of permanent biogas sector. Therefore, 'quality' should be the prime concern of the future biogas programme. The quality should basically relate to the following aspects of biogas programme implementation:

- **Quality of the design of biogas plant**: The biogas plant should be cost-effective; users' friendly; easy to construct, operate and maintain.
- **Quality of training and capacity building activities**: Correct training need assessment; proper selection of training participants, proper selection of facilitators, suitable training contents, session plans and scheduling; appropriate training methods; effective practical sessions; effective evaluation of training; timely follow-up of the evaluation findings.
- **Quality of promotion and extension works**: Potential customers should fully be aware and understand all the benefits and costs. They should be provided with factual data and information and should be aware of their roles and responsibilities for quality control.
- **Quality of the construction** (including selection of construction materials and appliances): Strict adherence of set quality standards on site selection, selection of construction materials and appliances and construction.
- **Quality of the operation and maintenance** by the users and technical backstopping from the installer: Effective training to users', timely follow-up visits by the installer.
- **Quality of after-sale-services** on behalf of the installers: Strict adherence of terms and condition of after-sale-service provisions including timely actions to the complaints from users, routine visits and problem-solving.
- **Quality of financial and administrative procedures and practices**: Proper utilisation of fund, timely disbursement of subsidy amount, proper book-keeping, less-lengthy procedures, fast, friendly and useful customer services.

The facilitator told if the biogas plant does what is anticipated by the programme personnel and what the user wants it to do, then it is a quality plant. That's meeting the anticipated requirements. Hence, quality is the performance excellence of biogas plant as viewed by all stakeholders. Thus, if the installed biogas plant:

- has the right dimensions, configuration and features,
- does what it's supposed to do,
- is reliable and durable,
- is delivered on-time, and
- is well-supported; then

It is quality biogas plant.



Describing various functions under a biogas programme as shown in the following figure, the facilitator stressed the need to integrate quality aspects in all these functions. The basic objective of quality control in any biogas programme is to ensure that the installed biogas plants meet the set quality standards and they function optimally without any major problems for the anticipated duration of time. Quality should be the prime concern of the programme. Effective quality control not only helps in ensuring the compliance of quality standards but also provides learning opportunity for the programme personnel.

The facilitator than explained the importance of structured QC system as follows:

- To maximize performance, reliability and lifetime of every biogas plant
- To maximize the value for money for biogas customers, biogas programme, donors and Government of Kenya

- To maximize the potential livelihood benefits to customers and communities
- To minimize the risk of accidents or damage to users or property
- To maintain the reputation, credibility and value of the Biogas Program in Kenya

Emphasising that the quality control refers to the operational techniques and the activities used to fulfil and verify requirements of quality and it is the planned process of identifying established technical specifications for the project and exercising influence through the collection of specific (usually highly technical and standardized) data, he pointed out the need to formulate quality standards related to various aspects of biogas programme implementation.

In biogas programme, quality control is involved in developing systems to ensure biogas plants are designed and constructed to meet or exceed users' requirements. As with cost control, the most important decisions regarding the quality of a biogas plant are made during the design and planning stages rather than during construction. It is during these preliminary stages that component configurations, material specifications and functional performance are decided. Quality control during construction consists largely of insuring conformance to this original design and planning decisions.

After the presentation, the participants were divided in four different groups to work out on the best model of quality control system during construction and installation of biogas plant. The participants were requested to focus their discussions on the following three key questions:

- What should be the general process of Quality Control under the framework of national biogas programme in Kenya?
- What are the potential roles and responsibilities of different stakeholders in quality control?
- What quality standards are necessary?

Outcome of Discussion on Quality Control

Summarising the presentation from the three working groups, the facilitator presented the following major points as the outcome of the discussion:

The Biogas Programme in consultation with ABCK and national implementing partner will formulate quality standards on the following aspects based upon the agreed deign of biogas plant to be disseminated:

- household selection
- plant size and site selection
- construction materials & appliances
- workmanship of construction (plant) and installation (pipeline & appliances)
- user instruction (verbally & provision of user manual)
- after-sales service

The Biogas Programme shall formulate in consultation with stakeholders the methods and procedures to be used for the quality control process. The process should incorporate procedures on:

- How and when the installer submits the details on the digesters under construction.
- Random sampling method to select digesters.
- Expected time of field visit after commencement of work.

- Formats for site verifications.
- Time for site verification.
- Standard forms to be signed by all parties concerned e.g. contractor, user, financier and quality controller from the program.
- Creation of a computer database for the information.
- Feedback mechanism to the contractor .
- Follow up mechanism to ensure that the contractor implements recommended measure in the next installation.

In general the following Quality Control Process was agreed:

- The National Implementing Agency will have the mandate of coordinating the activities related to quality control. A National Biogas Programme unit will be established under the jurisdiction of this agency.
- The National Biogas Programme as the operational entity will be responsible to implement the quality control activities. It will house a quality management unit to manage activities related to quality control.
- The task of quality control could be outsourced to specialized consulting firm which will be selected on competitive bidding process
- The National Biogas Programme will be responsible for the bidding process. The final decision on the selection of consultant to act as the external arm of the Programme will be taken by the National Implementing Agency.
- The biogas companies will be responsible for carrying out the internal quality control of the activities. The biogas programme will ensure the required capacity building of the accredited companies to effectively carry out the quality management activities. Companies will be responsible for:
    - On site quality control (e.g. distance from house etc.)
    - Give feedback on quality control standards.
    - Ensure that contractors conform to the quality standards.
    - Support the other contractors to build necessary capacity to conform and adhere to the standards.
    - Develop disciplinary procedures (code of conduct).
- Biogas users will be provided with pre-construction training in which their roles on quality control will be discussed. They will be also involved in quality control.
- The biogas programme in consultation with ABCK and biogas companies will finalise the sampling methods and process of external quality control mechanisms including number of visits
- The timeline in general will be as follows:

SN	Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	…	20	….	47	48	49
1	Site survey by contractor and verification by programme	▨	▨	▨																	
2	Under construction inspection of 10-25% of the total no. of plants by the programme				▨	▨	▨	▨	▨	▨	▨										
3	Pre-filling final acceptance inspection for all of the digesters by programme, Warranty Issued											▨	▨	▨	▨						
4	First gas and flame testing by contractor															▨	▨				
5	General inspection after one and a half month of operation by programme/contractor																	▨	▨	▨	▨

7.1.8 Presentation and Discussion on Certification Process for Private Sector

The third and final day of the workshop commenced with the recapitulation of the previous day. The facilitator initiated the session on certification process for private sector constructors and manufacturers to participate in biogas programme. He underlined the importance of private sector involvement in an effective

and efficient manner for effective promotion and extension of biogas technology and to ensure sustainability of the sector. Central in the concept of any biogas programme should be the inclusion of the private sector constructors and manufacturers in the primary process leading to sector growth.

The presentation from the facilitator included the following important roles that the private sectors can play effectively based upon past experience in previous biogas programmes:

- Promotion and marketing of the technology
- Demand collection
- Construction and quality control
- After-sales-services
- Users training
- Manufacturing of appliances
- Marketing of appliances
- Ensuring availability of spare parts
- Research and development (user's satisfaction surveys)

The presentation also highlighted the following basic pre-requisites for the private sector to participate in biogas programme:

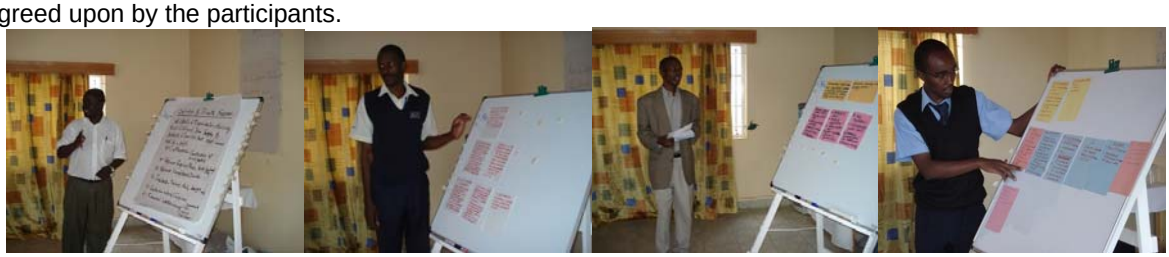
- Commitment to comply with the approved standard design and sizes of biogas plants;
- Commitment to employ trained, certified and registered masons for the construction of biogas plants;
- Commitment to construct biogas plants on the basis of detailed quality standards;
- Commitment to participate in production and marketing of quality biogas appliances (pipes, valve, stove, water trap, lamp) approved by the programme
- Commitment to provide proper user training and provision of a user instruction manual;
- Commitment to provide at least one year guarantee on appliances and two years guarantee on the civil structure of the biogas plant, including an annual maintenance visit during guarantee period;
- Commitment to ensure timely visit of a technician to the biogas household in case of a complaint from the user;
- Proper financial and administrative management system in place

Following the presentation on importance and roles of private sector, the participants were divided into three groups for discussion on the following two key questions:

- What are the potential roles of private sector companies in the biogas programme?
- What should be the certification/accreditation criteria for the involvement of private sector companies in biogas programme?

Outcome of Discussion on Private Sector Involvement

Based upon the presentations from the three working groups, the following outcome was summarised and agreed upon by the participants.



Definition of Private Sector

1. Institutions and organizations deriving their livelihood from supply of products and services that meets consumers need at a profit.
2. Institutions, organizations and individuals involved in providing quality goods and services for sustainability while ensuring economic viability in the biogas sector.
3. Non governmental, non-NGO, business oriented, sector services on its own
4. A profit making/driven entity not affiliated to government in its operation

The following entities should be termed as private sector:

- Contractors
- Appliance Manufacturers/suppliers
- Consulting firms/individuals
- Construction materials suppliers
- Financing Institutes (Commercial banks, MFIs, SACCO, Self-help group)
- Carbon Offset companies
- Local Artisans
- Training Institutes (Universities, polytechnics)

Roles of Private Sector

- Product Development
- Contribute towards helathy competitiveness/ level field
- Sustaining the market
- Ensure customer's satisfaction
- Ensure Market regulation
- Ensure social/moral responsibilities
- Job creation
- Promotion and dissemination through construction and stimulation the training needs for artisans and users
- Provide users manuals and guidelines
- Act as link between users and R&D institutions; users and financers (banks, credit associations); manufacturers and consumers; users and policy makers
- Conduct R&D activities in situ
- Enforce quality control mechanisms
- Ensure the sustainability of the technology (self propelling)
- Awareness creation for the product
- Capacity building and resource generation –Human and other resources
- Dissemination of technology
- Quality improvements and control
- After sales services
- Establish linkages with other stakeholders. e.g. R&D
- To pay taxes
- Lobby and advocacy through unions and associations
- Compliance with set standards
- Received training of biogas business management
- Household selection
- Construction (site selection/plan)
- Fabrication of appliances
- Training of users and provisions of users manual

- After-sales services and guarantee
- Self regulation
- Financing and credit management
- Insurance for installed plants
- Managing 'sinking fund' for association
- Managing subsidy

Accreditation/Certification Criteria

- Legal Business Unit/Registered
- Qualified staffing/technicians
- Physical office/Premises to work (well established office)
- Adhere to code of conduct
- Adhere to ethical compliances
- Abided by common interests and practices
- Well established financing procedures/Standard financing/ accounting system or management in place
- Tax compliances (free from any liabilities)
- Field experience/reputation in the sector
- Sound background (proven track records)
- Having clear organizational structure
- Data handling and communication facility
- Professional in the technology
- Reliability and trustworthiness
- Financially capable
- Adequate Tools and equipment
- Business plan with clear vision, mission and objectives

7.2 Informal Closing of Workshop

The 3-day workshop came to an end with the closing remarks from MOE representative, some selected participants and SNV staff members. They expressed their deep satisfactions on the outcome of the workshop and thanked all the participants and the facilitator for their active participation, constructive suggestions and effective facilitation. An informal evaluation of the workshop from the participants indicated that the process has been effective and outcomes have been beneficial for the future of biogas programme in the country.

8. Conclusion

The mission has successfully been completed in the stipulated time frame. It has been effective and successful in selecting best appropriate model of biogas plant to be disseminated under the framework of the proposed national biogas programme; formulating workable quality control framework; and preparing accreditation/certification mechanisms for effective participation of private sector companies in the programme. The workshop provided a common platform to share ideas, information, problems and potential solution on biogas plant construction in Kenya. The outcome of the general evaluation of the training program supports the effectiveness and success of the workshop in particular and the mission as a whole. To formulate practical PID for effective promotion and extension of biogas technology in the country, outcomes of this mission is expected to be instrumental and highly beneficial.

Annex-1: Itinerary

Dates	Agenda
March 16, 2009	Arrival in Nairobi Meeting in SNV Portfolio Office
March 17, 2009	Finalisation of Field study modalities including checklists Field investigation works started. Visited some plants around Nairobi, Kiambu
March 18, 2009	Field investigation in Nyeri
March 19, 2009	Field investigation in Nakuru
March 20, 2009	Field investigation in Eldoret, Nandi, Kapsabet, Kaptomo
March 21, 2009	Meeting in the office of Pioneer Techology and visits to demonstration site
March 22, 2009	Preparing report on field investigation
March 23-28, 2009	PCIA Biannual meeting in Kampala, Uganda
March 29, 2009	Preparations for Biogas Constructor's Workshop
March 30, 2009	Workshop on Selection of Best Biogas Plant Model
March 31, 2009	Workshop on Quality Control Framework
April 01, 2009	Workshop on Certification Procedures for Biogas Constructors
April 02-03, 2009	Travel back to Phnom Penh via Addis Ababa and Bangkok

Annex-2
Constructor' Workshop on Selection of Best Model of Biogas Plant; Quality Control Mechanisms and Accreditation of Private Companies

Session No.	Time Schedule	Session Topic	Facilitation
Day-1: March 30, 2009			
	08:30-09:00	Registration and Opening	
	09:00-09:30	Introduction, Objectives, Expected Outputs and Detailed-Schedule	
1	09:30-10:30	SNV and Energy Interventions	SNV
	10:30-10:45	Tea break	
2	10:45-11:30	Presentation on outcome of field investigation	Kahiu/Maina
3	11:30-12:15	Presentation and discussions on models of biogas plants under scrutiny	SNV
	12:15-13:30	Lunch	
4	13:30-14:15	Criteria for the selection of best suitable model of biogas plant	Study Team
5	14:15-15:15	Group discussions to evaluate the biogas models under consideration based upon the selected criteria	Participants
	15:15-15:45	Tea break	
6	15:45-16:30	Presentation of the outcome of the group discussion	Participants
	16:30-17:00	Recapitulation and closing of the first day	SNV
Day-2: March 31, 2009			
7	08:30-09:30	Presentation and discussions on potential changes, if any, in the selected design for the Kenyan context	All
8	09:30:10:30	Presentation on importance of quality management in biogas programme	SNV
	10:30-11:00	Tea break	
9	11:00-12:15	Group discussion on quality management process, quality control and role of different stakeholders on quality control	Participants
	12:15-13:30	Lunch	
9a	13:30-14:15	Presentation on the outcome of group discussions	Participants
10	14:15-15:15	Group discussion on Quality standards	Participants
	15:15-15:45	Tea Break	
11	15:45-16:30	Group presentation on Quality standards	Participants
	16:30-17:00	Recapitulation and closing of the first day	SNV
Day-3: April 01, 2009			
12	08:30-09:30	Presentation on the role of different stakeholders on biogas programme	SNV
13	09:30-10:30	Discussion and presentation on potential role of private sector on biogas programme	Participants
	10:30-11:00	Tea break	
14	11:45-12:15	Discussions and presentation on basic minimum criteria to be fulfilled by the private companies for the accreditation	Participants
	12:15-12:30	Recapitulation and closing of the workshop	SNV
	12:30-13:30	Lunch and Departure	

Annex-3 : Name of Participants, Day One

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Annex-4
Design of Kenyan Model Biogas Plant (4, 6, 8, 10 & 12 m^3 Sizes)

Annex-5a
Quantity and Cost Estimation of Kenyan Model Biogas Plant (Flat Bottom)

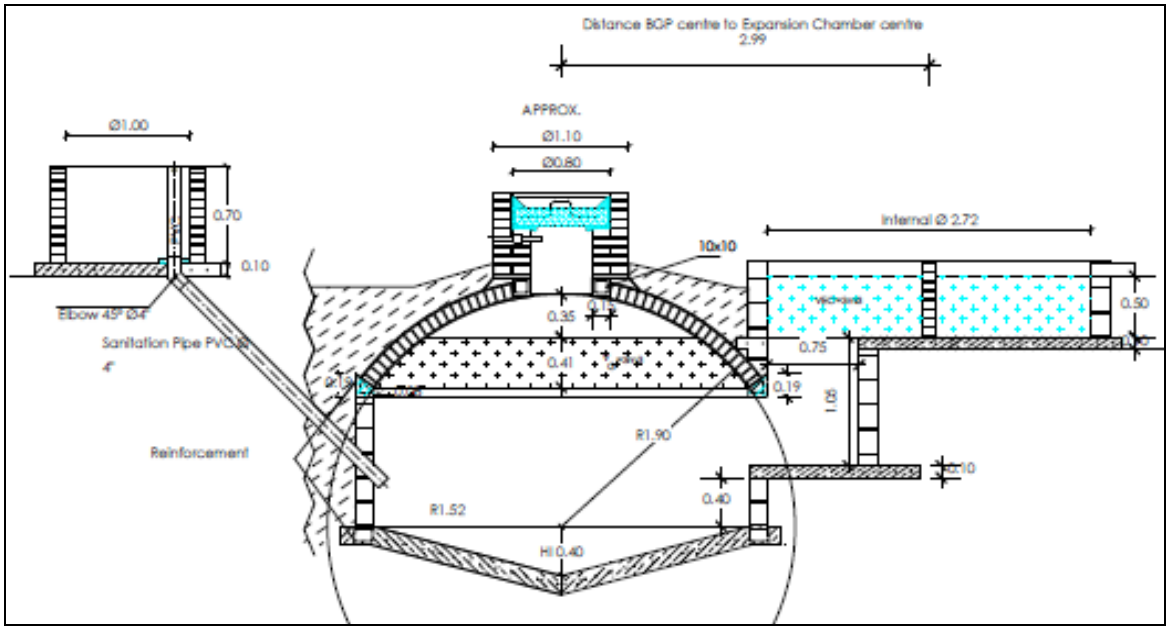
SN	Item	Unit	Unit Cost	6m³		8m³		10m³		12m³	
				Quantity	Total Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
			Tsh		Tsh		Tsh		Tsh		Tsh
I	**Construction Materials**										
1	Bricks/Concrete blocks	No.									
2	Cement – 50 kg bag	bag									
3	Gravel 1x2	m^3									
4	Coarse sand	m^3									
5	Fine sand	m^3									
6	Inlet pipe 10cm dia, length 2m	piece									
7	Iron bars ø 8 mm	Kg									
8	Binding wire	kg									
9	Water proofing compound	kg									
10	Acrylic emulsion paint	Lit									
	Subtotal 1										
II	**Accessories**										
11	G.I Gas outlet pipe Ø 0.5", 0.6m long	pcs									
12	GI nipple, Ø 0.5" for connecting main gas pipe and main gas valve	pcs									
13	Main gas valve (Ballvalve Ø 0.5")	pcs									
14	Male-female socket Ø 0.5", G.I. with aluminum thread, for connecting main gas valve and gas pipeline (G.I.)	pcs									
15	G.I. 90◦ elbow	pcs									
16	T-socket Ø0.5" for water trap (aluminum thread inside)	pcs									
17	Water drain	pcs									
18	Gas tap	pcs									
19	Teflon tape	pcs									
21	Gas pipe, G.I. or PVC pipe Ø 0.5”	m									
22	Gas rubber hose pipe Ø 0.5” and 2 clamps	m									
23	Stoves – single burner	pcs									
24	Lamp	pcs									
25	Pressure meter/Manometer	pcs									
26	Miscellaneous										
	Subtotal-II										
III	**Labours**										
26	Skilled Labour	No.									
27	Unskilled Labour	No.									
	Subtotal III										
	Total										
	Overhead, Guarantee and After-sales Services(20%)										
	Total Cost of Installation										

Annex-5b
Quantity and Cost Estimation of Kenyan Model Biogas Plant (Conical Bottom)

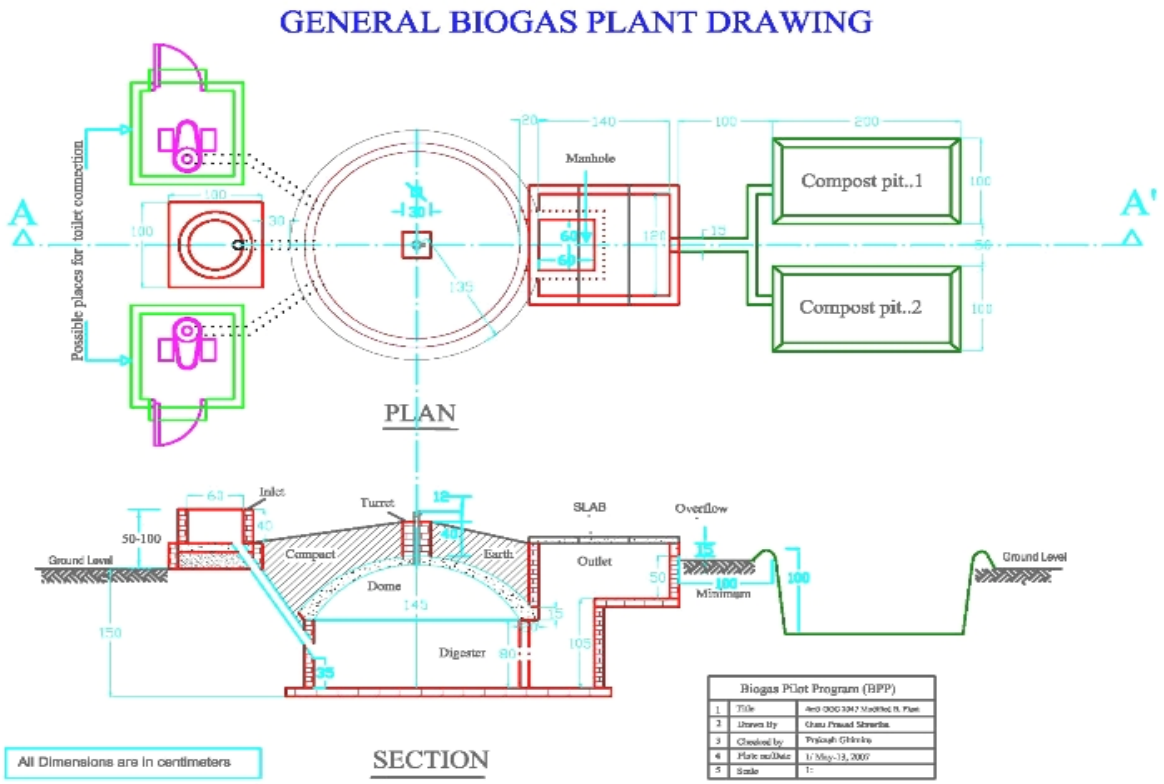
SN	Item	Unit	Unit Cost Tsh	$6m^3$ Quantity	$6m^3$ Cost Tsh	$8m^3$ Quantity	$8m^3$ Cost Tsh	$10m^3$ Quantity	$10m^3$ Cost Tsh	$12m^3$ Quantity	$12m^3$ Cost Tsh
I	**Construction Materials**										
1	Bricks/Concrete blocks	No.									
2	Cement – 50 kg bag	bag									
3	Gravel 1x2	m^3									
4	Coarse sand	m^3									
5	Fine sand	m^3									
6	Inlet pipe 10cm dia, length 2m	piece									
7	Iron bars ø 8 mm	Kg									
8	Binding wire	kg									
9	Water proofing compound	kg									
10	Acrylic emulsion paint	Lit									
	Subtotal 1										
II	**Accessories**										
11	G.I Gas outlet pipe Ø 0.5", 0.6m long	pcs									
12	GI nipple, Ø 0.5" for connecting main gas pipe and main gas valve	pcs									
13	Main gas valve (Ballvalve Ø 0.5")	pcs									
14	Male-female socket Ø 0.5", G.I. with aluminum thread, for connecting main gas valve and gas pipeline (G.I.)	pcs									
15	G.I. 90◦ elbow	pcs									
16	T-socket Ø0.5" for water trap (aluminum thread inside)	pcs									
17	Water drain	pcs									
18	Gas tap	pcs									
19	Teflon tape	pcs									
21	Gas pipe, G.I. or PVC pipe Ø 0.5”	m									
22	Gas rubber hose pipe Ø 0.5” and 2 clamps	m									
23	Stoves – single burner	pcs									
24	Lamp	pcs									
25	Pressure meter/Manometer	pcs									
26	Miscellaneous										
	Subtotal-II										
III	**Labours**										
26	Skilled Labour	No.									
27	Unskilled Labour	No.									
	Subtotal III										
	Total										
	Overhead, Guarantee and After-sales Services(20%)										
	Total Cost of Installation										

Annex-6: Different Models of Biogas Plants

AKUT Biogas Plant



GGC Biogas Plant



Modified CAMARTEC Biogas Plant