**A report on**

# BIOGAS INSTALLATION AND TRAINING

**(October 30 to November 14, 2003)**

***Alam, Myitkyina, Myanmar***

**Organized by**

***METTA Development Foundation***
***The Burma Sustainable Development Project (BSEP)***
***Grassroots Leadership Training (GLT)***

**Submitted by**


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The assistance received during the course from all the concerned, METTA Development Foundation and its staff and institutions who provided facilities for manufacturing biogas appliances are also acknowledged.

Last but not the least; I would like to thank all the participants for their interest and enthusiasm, which made the programme a success.

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November 2003.

## Executive Summary

Training course was conducted from $3^{rd}$ to $1^{3th}$ November 2003 as per the schedule. On the first day of the program, course began with the introduction of the participants as well as technology with basic information and design of the course. On the same day, site selection was made and after layout of the plant, the pit was dug. On the second day, floor soling of the digester was completed which was followed by making round wall and two compost pits. On the same day the drawing of the template was prepared and ordered to fabricate at the local workshop. On the next day, digester wall was plastered after back filling and inlet pit was made. Lectured were also delivered on factors affecting biogas and on uses of biogas and slurry.

On the fifth day of the course, mud mould was made and dome as well as slabs were casted and lectures were delivered on plant feeding. On the sixth day, turret and outlet were constructed. Similarly on the seventh day, lectures were delivered on construction process and operation and maintenance of the plant and reading drawings. On the next day mud from the dome were removed, cleaned and plastered. On the same day pipe fittings were made with water drain pit construction.

On the ninth day dome was painted. On the same day evaluation of the participants were made. On the next day the plant was fed with dung and water. Finally the plant was ready for operation.

The last day was devoted for overall discussion regarding biogas construction and final evaluation of the participants.

## Note from Director of BSEP

*Much of this report is based on material developed for the Nepal context and as an aid in training the thousands of masons that have built over 100,000 biogas digestors in Nepal. Because of similarities between rural hill area Nepal and rural Burma in climate, local economic structure, and locally available skills and materials, small-farm-scale biogas as practiced in Nepal is a very promising technology for Burma. Sections 10 and the accompanying annexes summarize details specific to the training in Alam, Myitkyina.*

*– Chris Greacen, Director BSEP*

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# 1. INTRODUCTION

Biogas technology is one of the most trusted and popular alternative energy sources used for cooking and lighting in Nepal. By the end of this fiscal year, (2002/2003) a total of more than 123,000 biogas plants are installed in the country The development and dissemination of biogas technology in Nepal is started mainly after the establishment of Gobar Gas tatha Krishi Yantra Vikash Company Pvt. Ltd. Gobar Gas Company in short.

As more and more companies are entering in the field of biogas there is competition between companies to find and develop their own market segments and promotion strategies to commercialize biogas technology in the country. Promotion activities are also being done by other non-governmental organizations.

**Basic Information on Biogas**

Biogas is a mixture of different gases such as methane (50-65%), $CO_2$ (30-40%), hydrogen sulfide (less than 1%) and other gases such as nitrogen, hydrogen, carbon monoxide in traces. Biogas consists of water vapour, which needs to be removed through a device known as water drain.

Biogas is flammable gas produced by microbes when organic materials are fermented in a certain range of temperature and moisture contents. It acidifies under airtight conditions. The main component of biogas is methane, which is represented as $CH_4$ symbolically. It is colourless, odourless and tasteless but due to the presence of other gases, it has slight smell of garlic or rotten eggs. The specific gravity of biogas is 0.86.

The production of biogas occurs in two stages:

i. Bacteria breakdown complex organic materials
ii. Organic materials and $CO_2$ are either oxidized or reduced to $CH_4$ by methanogenic microorganism.

In this way methane is formed from fermentation of animal wastes or any cellulose organic materials. For fermentation several conditions such as air tightness, suitable temperature, necessary nutrients, water contents, maintaining a suitable pH balance should be met.

There are three types of fermentation:

i. Continuous process
ii. Batch process
iii. Plug flow process

In the continuous process, the substrate or feed should be continuously added and at the same time slurry will come from the other end continuously. In the batch process one can predict the behaviour of a continuous culture. It has three stages such as: exponential, stationary and death phase. The plug flow process is the same as tunnel type where dung is plugged.

In the aerobic decomposition of organic matter, the main gas evolved is $CO_2$. At low oxygen tension, appreciable methane is released in the degradation of cellulose, proteins, organic acids and alcohol. $CH_4$ producing bacteria are as a source of energy for growth. Methane formation is also influenced by acidity. The maximum rate occurs in environments of near neutral pH as there is little acidity below pH 6.

Methane forming bacteria have many physiological properties in common, but they are heterogeneous in cellular morphology. Some are rods, some cocci while others occur in clusters of cocci known as sarcinae. All methane forming bacteria are grouped into a single family Methanobacteriaceae with three species as Methano coccus, Methano sarcina and methano spirillum.

Most of the population of Nepal resides in the semi-tropical region and the energy needs of rural population are for cooking and lighting. The need is met mostly by firewood and dung cakes. Use of firewood results in deforestation and use of dung burns valuable fertilizer. These problems can be overcome by installing a biogas plant. But in order to find wider acceptance of the technology, the speed of digestion must be increased and the type of bacteria enabling this must be developed to attack cellular materials in the cattle dung. The methanogenic bacteria are more effective at temperature about 30 - 35 degree Celsius.

# 2. COURSE DESIGN

## *2.1 Course Concept*

The course concept was basically practical oriented as the masons or technicians were less educated. Hence biogas experts were consulted and courses have been designed taking their views.

The masons or technicians were familiar with the uses of biogas, factors affecting biogas basic principle for the installation and operation of the plant in general and construction of the plant in particular. Hence this course is basically designed for those who had already acquired the skill of a mason.

## *2.2 Course Objectives*

The purpose of the training is to make participants able to install and operate the plant smoothly with the applied and common knowledge of biogas equipment. The main objectives are:

- Impart adequate knowledge and skill for the installation of biogas plant.
- Make them familiar with the principles of biogas technology.

### *2.3 Course Contents*

The training course is more practicals oriented however some theory classes were also conducted to impart basic knowledge in process of biogas installation. The main contents are provided in the training schedule.

### *2.4 Course Methodology*

The methodologies of the courses were based on the resource person, the participants and the training environment. However it was assessed the understanding level of the participants, interest creation and curiosity development. The Methodology of this training consists of lecture on the related topic by the resource person, illustration and demonstration of the practical work by the resource persons and technical assistants, question answer method, recitation method, learning by doing, teamwork, manufacturing companies visits, discussion and evaluation.

**Selection of participants**

The course was executed for the local prospective technicians in the vicinity of MITTA. MITTA officers nominated the participants. There were ten participants from the nearby location of the country

**Course Duration**

The duration of course was 14 days comprising of theory and practical classes.

***Training venues***

All training classes were held in The Training Wing of MITTA. Some practical classes were conducted at the site.

## 3. USES OF BIOGAS AND BIOSLURRY

### *3.1 Uses of Biogas*

As explained earlier, biogas is a mixture of different gases such as methane (50-60%), Carbon dioxide (30-40%), hydrogen sulfide (less than 1%) and other gases such as nitrogen, hydrogen, carbon monoxide in tresses. Biogas is a wet gas because it picks up water vapor from the slurry.

Biogas is a flammable gas produced by microbes when organic materials are fermented in a certain range of temperature, moisture contents under anaerobic conditions. The main component of biogas is methane, which is colorless, odorless and tasteless, but due to the presence of other gases it gives slight smell of garlic or rotten eggs.

Methane is formed from the fermentation of animal waste or any other cellulose organic materials such as decaying vegetables, straw and so on. However, for this to work certain conditions such as air tightness, suitable temperature, necessary nutrients, water contents, and maintaining suitable pH balance must be maintained.

Since biogas is a high quality fuel, it can be used for many purposes besides cooking and lighting, such as fuel for running dual fuel engine, for agro-processing, pumping water and for generating electricity. A brief description of each use is given below:

**a. Cooking**

The main use of biogas, at present, is for domestic purposes, such as cooking and lighting. Biogas can be used with suitably designed burners to give a clean, smokeless, blue flame, which is ideal for cooking. More than 87 percent of the people in Nepal use firewood for cooking. If the trend continues all forest will disappear in less than 25 years. It is believed that biogas will help in reducing deforestation as majority of the biogas owners use the gas for cooking.

**b. Lighting**

Most of the Nepalese people in rural settlements use kerosene for lighting lamps. Nepal has no indigenous sources of kerosene. As such the country has to spend scarce foreign exchange and supplies are often unpredictable. Biogas owners especially in the hills where there is no electricity prefer the use of biogas facilities for lighting.

**c. Operating dual fuel engines**

Biogas is a high-grade fuel, which means that it can be used in internal combustion engines. It is more usual to use it in dual-fuel engines which are adopted diesel engines that still use 20-30 percent diesel along with 70-80 percent biogas to provide ignition.

About 70% of diesel requirement can be replaced by biogas for running dual fuel engines such as Kirloskar, Usha etc. These engines can be used as follows:

- For running agro-processing equipment
- For pumping water for irrigation
- For generating electricity

**d. Running boilers, refrigerators as well as vehicles**

The dual-fuel engines can also be used for boilers, refrigerators, and milk chilling plants and running vehicles.

### *3.2 Uses of Bio-slurry*

The various uses of slurry can be summarised as follows:

**a. Fertiliser**

Fertilizer is an essential input for any crop. The slurry is rich in various plant nutrients such as nitrogen, phosphorous and potash. Well-fermented biogas slurry improves the physical, chemical and biological properties of the soil resulting qualitative as well as quantitative yield of food crops. Nitrogen remains in the effluent of biofertilizer from the slurry, while some escapes as ammonia gas. When the effluent is dried, most of the nitrogen is lost.

Slurry from the biogas plant is more than a soil conditioner, which builds good soil texture, provides and releases plant nutrients.

It was found that the slurry from anaerobic fermentation of a biogas digester improves the physical and chemical properties of the soil. Since there are no more parasites and pathogens in the slurry, it is highly recommended for use in farming. The economic value of the slurry shows that investment can be gained back in three to four year's time if slurry is properly used.

**b. Feeding fish and animals**

Other uses of the slurry include putting it into ponds as feed for algae, water hyacinth, fish or ducks; using it in hydroponics, where plants are grown in a nutrient rich solution on a gravel bed or even using it as feed supplement for pigs and chickens. The author conducted an experiment in feeding slurry (about 15%) to the fishpond and about 200 fishes were harvested at the end of the experiment.

**c. Mushroom cultivation**

The slurry coming from the plants can also be used for mushroom cultivation. The slurry mixed with powder of rice straw or wheat straw, water, lime, urea, calcium super phosphate, powder of maize when put in a plastic bag with some seeds of mushroom and keeping in a room temperature of about 22-25 degree Celsius will be ready for cultivation within about six weeks. The author conducted this experiment in Butwal.

**d. Earthworm cultivation**

The byproduct received from mushroom cultivation can be used for feeding animals as well as for earthworm cultivation used for feeding chickens. This was observed at Sichuan Province of China.

**e. Other advantages**

- Environmental pollution control
- Environmental sanitation
- Drudgery reduction

# 4. FACTORS AFFECTING BIOGAS PLANT

There are several factors affecting biogas plants of which the major factors are summarized as follows:

**a. Temperature**

The optimum temperature for methane producing bacteria is about 35 degree Celsius. When the slurry temperature is low gas production is greatly reduced. At 10 degree (slurry temperature) the production of biogas more or less stops. In dome plants, the temperature can be increased with composting whereas in drum plant it can be increased by solar radiation and in both by using the heat exchanger if the gas is used for running engines. At various digester temperatures, the gas production was found as follows:

Table 1: Gas production at various digester temperatures

| Digester temperature | 25 degree | 30 degree | 35 degree |
|---|---|---|---|
| Gas production (cum) / kg total solid | 0.26 | 0.30 | 0.45 |

**b. Retention time**

It is temperature dependent. The higher the temperature, the faster the bacteria use the food from the slurry and sooner it needs replacing. Retention time can be calculated as follows:

$$R = \frac{V}{F}$$ where, R= Retention time, V = Volume of the digester, F = Feeding

In Nepal, drum plants are designed especially for Terai regions where temperature is higher and transportation of the drum is not a major problem. So in these plants the retention time is 52 - 60 days. But in case of dome plants, the retention time was 73- 83 days for the plants built before 1990 as they were designed for hilly regions where the temperature is comparatively lower. However, as there are no more drum plants built in the country the retention time is calculated 55 days for the plants installed in Terai and 70 days for the plants installed in the hills and higher mountainous areas.

**c. Air**

Methane producing bacteria are anaerobic. So air should be excluded in the plant interior.

**d. Bacteria**

It is greatly affected with methanogenic bacteria. If they are less in number, gas production is greatly reduced.

The fermentation process involves in two stages. Firstly bacteria breakdown complex organic materials and secondly the breakdown of organic materials to produce methane by a kind of bacteria known as methanogenic microorganism. If this type of bacteria is not developed to attack cellular materials in the dung, methane cannot be formed.

**e. Carbon nitrogen ratio (C: N ratio)**

The elements of carbon and nitrogen are the main nutrients for anaerobic bacteria. Carbon is utilized for energy and nitrogen for the building of cell structures. Bacteria use carbon 25-30 times faster than they use nitrogen. So the ratio seems 25-30:1. If the carbon nitrogen ratio is not appropriate, we can increase or decrease the ratio by adding certain amount of urea or gypsum. But how much should be added can be determined as follows.

Here is given the C: N ratio of various feeding materials.

Table 2: C: N ratio of various feeding materials

| Materials | Gobar | Straw | Pig manure | Poultry droppings | Night soil |
|---|---|---|---|---|---|
| C:N ratio | 25 | 87 | 14 | 8 | 8 |

**f. pH**

pH for bacteria is usually 7-8, but can go up or down further by 0.5. pH can be checked either with universal indicator or pH paper or pH meter. It is quite easy to find out the pH with the help of pH paper. If it is with pH meter, the following procedure should be done.

**g. Gobar water ratio**

The ratio is dependent upon the feeding materials (DM%). However, there should not be any stratification in the digester. In other words, mixing of gobar should be properly done, which can be easily observed by calculating the DM%. If there is a great change in DM% of the top as well as bottom, there will be stratification. Generally, gobar water ratio should be 1:1. If the amount of water is more the gas production is less.

The slurry should be neither too thick (more than 14%) nor too thin (less than 6%) but should be 8-10 % of total solids. If pig or poultry droppings are used, the total solid contents should be 6%.

**h. Volatile acids**

Volatile compounds are acetic acid, propionic acid, butyric acid etc. Volatile acids are more important than pH as they give the actual situation inside a plant. They are not easily measured and this has to be left to researchers.

**i. Solid contents**

Fresh cattle dung normally has solid contents of 15-24%. The solid contents of the slurry should be 8-10%.

**j. Toxic substances**

This does not apply to village situations. Some animals are given special foods and medicines. For practical purpose these can be ignored, as they will not very much affect the gas production. However, the night soil plants used in the hospitals may contain toxic substances such as phenol, herpic, sulphate, soap, fats and antibiotics.

Viewed from microbiological perspective, gas production from grass feed gobar or straw feed gobar might be different due to the nutrient contents in the feeding materials.

# 5. BIOGAS APPLIANCES

The following tools and devices are regarded as biogas appliances and most of them are manufactured in sixteen recognized workshops. These workshop consist of lathe machines, welding machines, drilling machines, sheet rolling machine, angle rolling machine, sharing machines, abrasive cutter, hydraulic press, grinding machines, pipe bending machine. Several staff working in the workshop manufactures the following appliances. Most of the biogas appliances are manufactured in the workshop of Biogas Companies, which are equipped with all necessary machines, manpower and materials. The following is a list of key appliances:

**a. Mixer Machine**

Some of the workshops have developed two types of mixing machines; horizontal and vertical. The performance of the horizontal mixing machine is good. The reported lifetime of the non-galvanized device ranges between 2-10 years. The horizontal mixture machine is expensive and due to this reason, GGC developed vertical mixing machine. It was decided in July 1990 to take the non-galvanized mixer out of production.

**b. Gas pipe**

The quality of the gas pipe is reported well. These gas pipes were of 1/2 inch to 4 inches inside diameter. Ultimately R&D of GGC approved the two inches GI gas pipe of light quality.

In order to facilitate and improve the work of mason, it was proposed to fix the reduction elbow gas tight to the gas pipe before supplying to the field offices.

**c. Stove**

These workshops have manufactured both square as well as deluxe flat type stoves. The performance of both stoves is good. They were of 16-cf. capacity and the efficiency of these stoves is 52-60 percent. However, it should be considered that the distance from the flame ports to the surface of the cooking vessel should be accurate (30-35 mm). It is better to have single row of burning ports. The ratio of burning port area to orifice area should be 200 to

300. Similarly, the ratio of primary air opening to diameter of orifice should be about 6. Rubber hosepipe is used to connect the stove with gas tap.

**d. Main Gas Valve**

The main gas valve purchased from the Netherlands is good. Similarly Italian valves are also widely used in the country. Other valves used in the past were not as good as that of the Netherlands one. Due to this reason, GGC had developed different varieties of main gas valve. They are mostly on the research phase.

**e. Gas tap**

The performance of the gas tap is mixed. It was the experience that the gas taps were replaced within 3-12 months after installation. As a result, GGC, Rastriya Gobar Gas, Nilkamal, Public Gobar Gas Companies developed a new type of gas tap and supplied it to the field and R&D monitored the performance of these gas taps. Similarly such gas taps are manufactured by other workshops in Nepal and some are imported from India. All gas taps supplied to the field offices were to be tested at the workshop for leakage at a pressure of 300-cm water column before sending to the field office.

**f. Lamp**

Initially most of the lamps used were purchased from Varanasi, India. However, Nepali lamps were also developed in the workshop but were found to be less efficient in comparison to the Indian Santosh lamps and were unable to manufacture commercially. Nowadays, the company under BSP support is also manufacturing Ujeli lamps.

**g. Water drain**

Several manufactures have developed several types of water drain. For drum type it was of about one meter long buried under the ground level. However, for dome plants it was of only about 6 inches long. These water drains are manufactured by recognized workshops. The performance of these water outlets is good.

**h. Templates**

GGC had developed and made compulsory to use the dome template while casting the dome. The performance of the templates was good. However, masons were sometimes reluctant to carry these templates and some masons folded the template while carrying to the field. As a result, the shape of the domes was damaged. So GGC had developed these templates of 10-mm rod instead of 6 mm for all sizes of the dome plants. These templates are manufactured by several recognized workshops.

**i. HDEP pipe**

HDEP or asbestos pipes are normally used as inlet slurry pipes.

# 6. DESIGNS OF BIOGAS PLANTS

## *6.1 Floating Steel Drum Design*

The floating steel drum design biogas plant was developed in India. The Khadi and Village Industries Commission (KVIC) approved a design made by Jashabhai Patel for biogas extension programme in India. The floating steel drum design adopted by GGC was based on the KVIC design with some modifications; which include taper digester design and gas outlet through the central guide pipe.

Drum or gasholder is welded steel fabrication with a steel frame at the open end. The gasholder is located at the center of the digester by a central inner guide pipe. Scum breaker bars or mixing arms are welded between top plate and the stiffeners. As biogas slurry is fairly corrosive, the gasholder and other accessories rust within 8-10 years. So the drum should be sand blasted or cleaned with sand paper or wire brush and painted with high build black (HBB) paint each year. GGC made available of 100, 200, 350, 500, 750 and 1000 cf. drum plants. The drum plants are named on the basis of gas production per day from the plant.

The digester of the drum plants was built underground. The inlet pipe was either of asbestos cement or PVC having 4-inch internal diameter. In bigger plants there is partition wall at the centre. The central guide pipe is placed at the center of two 'spiders' made of steel rod and fixed 300 mm apart into the brick wall. For mixing dung properly a mixing machine is fixed in the inlet pit. Similarly the water outlet device is placed at the lowest level to trap moisture present in biogas.

## *6.2 Fixed Dome Design*

The fixed dome design biogas plant consists of an underground digester pit with a concrete dome shaped cover for collecting gas from the slurry. It is an adoption of a design developed originally in China. The modifications are: there is no manhole on top of the dome, the digester is connected with slurry reservoir chamber instead of AC pipe.

In fixed dome design, the concrete dome is casted over a mud mould. The gas pipe is placed at the center of the dome and fixed with anchors and supported with turret. The digester wall, inlet and outlet wall is made with first class quality bricks or stone. These plants were for the first time designed in Gobar Gas tatha Krishi Yantra Vikash P. Ltd., Research Unit at Butwal on 1979. Several air ceiling materials such as wax, coal tar and acrylic plastic emulsion paints were applied under the dome as ceiling materials while conducting research. Ultimately it was proved that acrylic plastic emulsion paint is the best ceiling material. Eleven such plants were installed in Pokhara in the same year and a follow up survey was made on 1981 by the author. This survey showed that all the plants were functioning well.

Initially plastering made the digesters of these plants simply on the mud wall. However, nowadays the digesters of these plants are made with brick or stone wall plaster from inside. Similarly the curvature of the bottom floor is modified to flat bottom. Dome plants of 4, 6, 8, 10, 15, 20, 35, and 50 cum capacities were designed by GGC. Their volume named these plants. The following table shows the size, input and output of the fixed dome plant.

Table 3: Size, volume and gas production of fixed dome plant

| Size (cum) | Digester vol.(Cum) | Gas storage vol. (Cum) | Daily dung feeding (kg) | Retention time (Day) | Gas production/ day (Cum) |
|---|---|---|---|---|---|
| 4 | 2.8 | 1.2 | 25 | 80 | 1.4 |
| 6 | 4.4 | 1.7 | 40 | 75 | 1.8 |
| 8 | 5.8 | 2.2 | 48 | 83 | 2.2 |

The dome plant is more appropriate for feeding any alternative feedstock such as crop residue, kitchen waste, vegetable waste and industrial wastes. feeding both in batch and continuous.

### *6.3 Tunnel Design*

Tunnel type or plug flow type digester incorporates some of the best features with slurry displacement gas storage system. The gas pressure is variable as in dome plants. Some plastic sheet and glue are used underneath the tunnel as ceiling material for collecting gas inside the tunnel. Tunnel plants are of the size 10, and 15 cum in volume. About 100 of such plants were installed by GGC in Nepal.

## 7. BASIC PRINCIPALS FOR INSTALLATION OF FIXED DOME DESIGN BIOGAS PLANTS

The fixed dome design biogas plant is the most popular design and as a result more than 123,000 of such model plants have been installed until the middle of 2003 in Nepal. In order to install such a plant the following construction materials are needed.

Bricks - burnt with No.1 quality.
Stones - clean and strong.
Sand - free from mud.
Cement - ordinary Portland
Gravel or pebbles - free from vegetable matter and soil.

Some important guiding factors are outlined below:

**Site selection**

- The plant should be close to where the gas is used - gas pipes are expensive.
- It should be close to the supply of input materials (dung, water etc)- it saves time and labour.
- It should be close to the place where effluent can be stored.
- It should be 10-15 m far from any shallow wells (drinking water sources).
- It should be free from any intrusion of bamboo or big tree roots.
- It should be in the sun.
- There should be suitable foundation conditions.

**Lay out**

The positions of the digester pit, inlet, toilet attachment and reservoir are defined. The centre of the dome is located and circle of diameter (depending upon the size) is marked on the ground using string, lime powder and sticks.

**Digging pit**

A hole is dug within the circle to the required depth to make the digester.

**Brick/ stone soling**

Soling must be done on unmoved, levelled and compacted earth. Stone or bricks to be laid uniformly and concrete should be poured in between.

**Brick wall around the pit including inlet pipe fixing**

While making brick wall, a piece of 1/2 inch GI pipe or MS rod should be placed vertically and with the given radius, 4" brick wall to be made up to the given height. The inlet pipe is to be placed accordingly.

**Plaster on the brick wall**

Brick wall to be plastered about 10 mm with 1:3 cement sand ratio. Back filling must be done after making brick wall.

**Mud mould and casting concrete dome**

Fill with mud inside the digester up to the height of the dome, which is marked at the central pipe, which is buried in the mud. Using template make the shape of the dome. Put some thin layer of sand on top of the dome. 1/2-inch central pipe to be replaced with main gas pipe. Cast the dome with 1:3:3 ratio of cement, sand and gravel. The thickness of the dome at the centre must be 7 cm for the plant up to 10-cum. capacity. The anchor of the main gas pipe should be placed properly.

**Turret construction**

Make turret of about 50-cm height on top of the dome next day.

**Inlet construction**

Inlet pit must be constructed in a way that gobar-mixing machine should exactly fit inside the inlet pit. The floor level of the inlet pit must be 5 cm whereas the toilet pan 15 cm. above the over flow of the outlet reservoir tank. The height of the inlet tank should be 50 cm. above ground level. There should not be more than 2-cm gap in between the wall and the edge of the mixing arm of the machine.

**Outlet construction**

The length, breadth and the height of the outlet must be as given in the drawing. It should be above ground level and is made of 4" brick wall masonry and plaster with 1:3 cement sand mortar.

**Casting concrete slabs**

The outlet reservoir should be covered with 3" reinforced concrete slabs.

**Pipe fittings**

Teflon tape must be used in order to avoid leakage from pipefitting. There should not be any unnecessary fittings and unions. There should not be any fittings in between the main gas valve and main gas pipe. The fittings should be about 1' below ground level. The main gas valve must be closed when the gas is not used. Water drain must be made at the lowest level of the fittings. Water drain pit must be of the size 40X40 cm and depth 50 cm. and the cover of 66X66 cm.

**Plastering and painting dome**

After removing all mud from the digester, the dome must be cleaned with wire brush and water. Put cement water solution on the dome. Plaster the dome with 1:3 cement sand mortar of 10-mm thickness. Next day plaster with 1:2 cement sand mortar of 5 mm thickness. Apply acrylic plastic emulsion paint mixed with double of cement. Top filling of the dome should be 50 cm.

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**Leak testing**

Once the plant is completed fill the plant with water and do the leak testing if it is applicable.

**Feeding the plant**

When there is no leakage, feed the plant with the mixture of gobar and water at the ratio of 1:1. Make at least two compost pit equal to or bigger than the volume of the plant. Properly store, and use the slurry in the field to various crops as and when needed.

**Operation of the plant**

Remove the first gas collected inside the dome, it may not burn. Now the plant is ready for cooking or lighting.

## *7.1. UNDERSTANDING BIOGAS DRAWING AND ITS MEASUREMENTS*

Size, volume and gas production of fixed dome plant are as given in the following table.

Table 4: Measurements of the plant

| Size (cum) | Digester vol.(Cum) | Gas storage vol. (Cum) | Daily dung feeding (kg) | Retention time (Day) | Gas production/ day (Cum) |
|---|---|---|---|---|---|
| 4 | 2.8 | 1.2 | 25 | 80 | 1.4 |
| 6 | 4.4 | 1.7 | 40 | 75 | 1.8 |
| 8 | 5.8 | 2.2 | 48 | 83 | 2.2 |
| 10 | 7.5 | 2.8 | 60 | 83 | 3.1 |
| 15 | 11.4 | 3.9 | 90 | 83 | 4.2 |
| 20 | 14.2 | 5.8 | 120 | 83 | 6.4 |
| 35 | 27.4 | 8.9 | 210 | 83 | 10.5 |
| 50 | 39.1 | 14.9 | 300 | 83 | 15.0 |

The dome plant is more appropriate for feeding any alternative feedstock such as crop residue, kitchen waste, vegetable waste and industrial wastes. feeding both in batch and continuous.

The design calculation of the existing 4, 6, 8, 10, 15 and 20 cum fixed dome design biogas plants are given in the following table 5

Table 5: Design calculation of existing plants

| **Capacity** | **4 cum** | **6 cum** | **8 cum** | **10 cum** | **15 cum** | **20 cum** |
|---|---|---|---|---|---|---|
| A | 1.40 | 1.50 | 1.70 | 1.80 | 2.48 | 2.64 |
| B | 1.20 | 1.20 | 1.30 | 1.52 | 1.25 | 1.76 |
| C | 1.35 | 1.51 | 1.70 | 1.83 | 2.05 | 2.33 |
| D | 0.50 | 0.60 | 0.65 | 0.68 | 0.84 | 0.86 |
| E | 1.54 | 1.55 | 1.72 | 1.68 | 1.80 | 2.03 |
| F | 1.02 | 1.22 | 1.35 | 1.54 | 1.75 | 1.99 |
| G | 1.85 | 2.08 | 2.21 | 2.40 | 2.61 | 2.88 |
| H | 0.86 | 0.92 | 1.05 | 0.94 | 1.15 | 1.15 |
| I | 1.12 | 1.16 | 1.27 | 1.24 | 1.32 | 1.37 |
| J | 1.51 | 1.60 | 1.75 | 1.71 | 1.93 | 2.03 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Template curvature (R) | 1.13 | 1.44 | 1.67 | 1.93 | 2.36 | 3.03 |
| No. of bricks | 1200 | 1400 | 1700 | 2000 | 2400 | 2800 |
| Cement bags | 11 | 13 | 16 | 19 | 27 | 34 |
| Sand bags | 60 | 70 | 80 | 90 | 110 | 120 |
| Aggregate bags | 30 | 35 | 40 | 50 | 60 | 70 |
| MS rod Kg | 11 | 11 | 14 | 14 | 18 | 44 |
| Initial dung required | | | | | | |
| Hills (kg) | 1450 | 2200 | 2900 | 3500 | 5500 | 7200 |
| Terai (kg) | 1450 | 2200 | 2900 | 3500 | 5500 | 7200 |
| Initial water required | | | | | | |
| Hills (lit.) | 1450 | 2200 | 2900 | 3500 | 5500 | 7200 |
| Terai (lit.) | 1450 | 2200 | 2900 | 3500 | 5500 | 7200 |
| Daily dung feeding | | | | | | |
| Hills (kg) | 24 | 36 | 48 | 60 | 90 | 120 |
| Terai (kg) | 30 | 45 | 60 | 75 | 110 | 150 |
| Daily water mixed | | | | | | |
| Hills (lit.) | 24 | 36 | 48 | 60 | 90 | 120 |
| Terai (lit.) | 30 | 45 | 60 | 75 | 110 | 150 |
| Use of stove in hours | | | | | | |
| Hills | 2.5 | 3.5 | 5 | 6 | 10 | 12.5 |
| Terai | 3.0 | 4.0 | 5.5 | 7 | 12 | 14.5 |

## 7.2. CONSTRUCTION MATERIALS

- Bricks/stone, rod, paint, sand, cement, pebbles
- Mixture machine, inlet pipe, dome gas pipe, GI pipe and fittings, gas valve, water drain, gas tap, rubber hosepipe, gas stove, lamp, teflon tape.
- Measuring tape, pipe wrenches, slide wrench, bamboo piece and rope

For 6 cum Biogas Plant (1.7 cum gas per day) the following local construction materials are needed:

No. of Bricks : 1500 Nos.
Cement bag : 15 bag
Sand : 70 bag
Aggregates : 35 bags
MS Rods : 8 mm dia 15 Kg
Rubberhose pipe : 2 m
Acrylic plastic emulsion paint : 2 lit.
GI Pipe and fittings : depends on distance
Initial dung required : 2200 Kg
Daily Feeding : 40 Kg of Dung
Equipment to be purchased from Yangon:
Gas Valve : 1 PC
Gas Pipe : 1 PC

Gas Tap : 2 PC
Stove : 1 or 2 PC
Water Drain : 1 PC
Template : 1 PC
Mixture Machine : 1 PC

**Cost**

The cost of the plant varies from size to size. However, the quotation issued by NBPG, which applies to most of the companies for the fiscal year 2002/03 is as follows:

Table 5: Cost of various sizes of fixed dome plants

| **Particulars** | **4 cum** | **6 cum** | **8 cum** | **10 cum** |
|---|---|---|---|---|
| Biogas appliances and their fittings | 4842 | 5399 | 6251 | 6601 |
| Construction charge | 4100 | 4800 | 5200 | 5800 |
| 3 Years guarantee | 600 | 600 | 600 | 600 |
| Promotion fee | 525 | 525 | 525 | 525 |
| Sub-total | 10167 | 11424 | 12676 | 13626 |
| Materials cost at hills | 10194 | 11944 | 14705 | 17135 |
| Material cost at Terai | 9874 | 11624 | 14065 | 16495 |
| **Total cost at hills** | **20,361** | **23,368** | **27,381** | **30,761** |
| **Total cost at Terai** | **20,041** | **23,048** | **26,741** | **30,121** |

It is assumed that life of a biogas plant is 25 years and present value of firewood and kerosene is Rs 1.5 per kg and Rs 17 per lit. respectively. Plant nutrient present in the dung is assumed to be N = 0.5%, P= 0.25% and K= 0.5%.

Similarly the maintenance cost of the plant is assumed to be Rs 400/year and it produces 2.2 cum. of gas per day. Government has been providing a subsidy of Rs 9000 for 8 cum plant installed in the hills.

## *7.3. PLANT FEEDING*

Feeding rate and the number of cattle needed for fixed dome design biogas plants are as shown in the following table 6.

Table 6: Plant feeding

| SN | Capacity in cum. | Initial gobar required (Kg) | Daily feeding (kg) | | Daily water required (Lit.) | | Required cattle head |
|---|---|---|---|---|---|---|---|
| | | | Hills | Terai | Hills | Terai | |
| 1 | 4 | 1450 | 24 | 30 | 24 | 30 | 2-3 |
| 2 | 6 | 2200 | 36 | 45 | 36 | 45 | 3-4 |
| 3 | 8 | 2900 | 48 | 60 | 48 | 60 | 4-6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | 10 | 3500 | 60 | 75 | 60 | 75 | 6-9 |
| 5 | 15 | 5550 | 90 | 110 | 90 | 110 | 9-14 |
| 6 | 20 | 7200 | 120 | 150 | 120 | 150 | Above 14 |

# 8. OPERATION AND MAINTENANCE OF THE PLANT

**Some possible problems and their solutions**

Here are given some possible problems of biogas plants with their solutions.

Table 8: Some possible problems of biogas plants and their solutions

| Problems | Reasons | Solutions |
|---|---|---|
| Gas does not burn | The first gas coming from the plant may not burn | Remove the gas from the dome once or twice. It will start burning. |
| There is plenty of gas inside the dome but won't come in the stove or lamp | Main valve may be closed | Open the main gas valve. |
| | Gas tap or gas jet may be blocked | Clean the gas tap and gas jet. |
| | May be blocked in the pipe line | Open main gas valve and water drain. Remove the water or slurry through the water outlet. |
| Less gas production | May be there is no daily and adequate feeding | Feed the digester as recommended. |
| | May be cold | Insulate the plant with composting. |
| | More water inside the digester | Put less water in the toilet and add water as recommended. |
| | May be due to toxic substance while cleaning toilet | Clean the toilet only with brush and water. |
| | Leakage from the pipe line | Check the joints and fittings with the help of soap water. If bubbles occur repair the leakage. |
| Flame is very weak and red | There may be impurities in the gas tap and stove | Clean the gas tap and stove weekly. |
| | Less gas inside the plant | Close the main gas valve and collect the gas. |
| Gas burns with long flame | There may be blockage in the air regulating hole and ring | Clean the hole and the ring. |
| Slurry comes through the pipe line | Inadequate feeding | Feed the plant adequately. |
| | Gas using frequently | Close the valve for about 10 hrs. |

| | | |
|---|---|---|
| | Gas leakage | Check the main gas valve and other fittings with soap water and repair the leakage. If the problem is not solved contact the concerned company. |

Over the last thirty years, the development of biogas technology has gained great momentum in comparison with other renewable energy technologies despite some problems occurring in technical or financial nature concerning policy level and institutional field. Low gas yield especially in the winter seasons, underfeeding of the plants, no commercial use of gas as well as slurry, no choice of other design, size and feeding materials are some of the technical problems. Single quotation, lengthy loan process is some of the financial problems. Similarly, irregular and inconsistent policies in the past and in few cases misuse of subsidy are some of the policy level and institutional problems.

Besides these problems, the owners are advised to visit the company from where they have installed their plant to understand more about the operation of the plants effectively.

## QUALITY BIOGAS PLANT

This programme is deemed successful for the following reasons.

- Introduction of well proven design and appliances after several years of research and development.
- Promotional and awareness activities have been carried out at different levels.
- Financial studies have been made and as a result subsidies are being provided continuously through the local banks if the plant is installed on loan and through BSP if the plant is installed on cash.payment
- Technical capabilities have been properly examined and local masons have been trained.
- Several companies were recognised for the installation as well as supply of biogas plants and accessories. Quality control visits are being made with a view to maintain the standards of the plant. BSP has developed 73 parameters for this purpose.
- A good organisational networking has been achieved through biogas co-ordination committee and slurry co-ordination committee.
- By the attachment and use of toilet to the biogas plants and through saving on firewood and kerosene, a significant improvement in health and environment has been noticed.
- Slurry Extension Programme (SEP II) have been introduced to increase the effective market for biogas plants by maximising the benefits of the operating biogas plants through improved use of slurry in crop production. It has also indirectly contributed in reducing the workload, especially of rural women and girls.

- An association of all biogas companies named NBPG has been formed for the promotion and extension of biogas plants. Similarly, AEPC has been established in the governmental level.
- Quality management of the plants has been introduced.
- Generation of employment in the rural areas has been enhanced.

Because of these reasons, national biogas programme in Nepal is considered as one of the most successful programmes in Asia. It has also been supported with the clear responsibility of each and every organization involved in this technology. Some of other factors that made important impact to ensure the success of this programme are:

- Availability of both loan and subsidy funds for certain period of time,
- Privatisation of biogas companies and banks,
- Awareness of activities conducted timely basis, and
- Proper assessment of technical capacities.

# 9. METHODS OF INCREASING GAS PRODUCTION IN WINTER MONTHS

There are various methods of increasing gas production, especially in winter months. Some of them are described below.

## *9.1 Compost for Heat Generation*

One of the most important factors affecting biogas is the temperature. The optimum temperature for methane producing bacteria is about 35 degree Celsius. When the slurry temperature is low, the gas production is greatly reduced. At 10 degree, the production of biogas more or less stops. Insulation of dome with compost is one of the best methods for heat generation for smaller dome type biogas plants.

A compost pile can generate significant amount of heat from decomposition of organic materials such as agricultural residue, straw, grasses etc. Decomposition can be accelerated by the addition of water with effluent from the plant. The effect of compost for heat generation greatly varies with the height of the compost pile and the time it takes to decompose. The height should be not less than a meter or so. The compost should pile on the top of the plant for insulation.

This experiment was done in GGC office at Butwal in Oct. 1982, in a 10 cum dome plant. The plant was daily fed with 60 kg of dung. Daily gas production, temperature of the slurry as well as compost was measured.

A similar 10 cum plant at Kalikanagar, near Butwal was used as control measuring daily gas production as well as temperature. It was also fed with equal amount of gobar daily with that of the first plant. The slurry temperature inside the digester was 2.03 degree Celsius more in the plant with compost. Similarly the gas production was increased by about 22.3%. Similar experiment was conducted in Kathmandu, and the gas production was increased by about

51%. This shows that the effect of composting is more in cooler place (Kathmandu) than in warmer place (Butwal).

Thus compost is more than a fertilizer and more than a soil conditioner. Compost generates heat for the plants, but also builds good soil texture and structure, provides and releases plant nutrients, protects against drought and stops nutrient loss through leaching but also stimulates the growth of the plants.

### *9.2 Utilization of Waste heat from biogas power generation*

A heat exchanger was applied in a 500 cf. steel drum plant at Bhutaha of Nawalparasi, the gas of which was used in 7 HP engine for agro-processing on experimental basis. The gas production was increased by about 37% in winter, assuming that only 50% gas is produced in a similar plant of the same capacity without having heat exchanger. Similar experiment was also conducted in R&D office of GGC at Butwal.

The engine installed was of water cooling system. One heat exchanger assembly is made up of concentric GI pipes connecting between the engine and heat exhaust silencer and uses waste heat from the exhaust gas to heat water. The other part of the heat exchanger was placed one foot above the digester base and heats the slurry in the digester. A valve can adjust the amount of cooling water flowing through the engine. Maximum heat was generated when the water is flowing at the rate of 2 lit. /min. as the flow rate increased the temperature decreased and vice versa.

Thus using gas heat from an engine is one of the best ways to maximize biogas production in winter in large size plants, by increasing the temperature of the slurry.

### *9.3 Solar radiation*

In this process the influent (gobar mixed with water) in the inlet can be warmed under the sun by covering with a plastic sheet and let the influent enter inside the digester at about 2-3 p.m. This experiment was conducted at GGC R&D Unit at Butwal by the author. GGC experiences showed that this process could increase about 5-8% of the gas production.

### *9.4 Insulation with rice straw*

Insulation can also be done with rice straw, rice husk and so on. Their thermal conductivity is 23 times lower than that of soil and condenses to run off leaving the insulation dry.

Similarly plastic sheets like polyethylene can be used as a cover over insulating materials to reduce the amount of materials required. As light penetrates the plastic, it is transformed into the longer heat waves. The heat enhances evaporation of moisture from the insulating material and ground below. This experiment was conducted in a 10 cum plant of Kunda Dixit's house at Patan Dhoka.

The gas can further be increased when gobar was mixed with other feeding materials such as poultry dropping, piggery and night soil.

# 10. EVALUATION OF THE PARTICIPANTS

About four percent of the scheduled session was given for the evaluation & feedback. Participants were evaluated through their practical exercises, written tests and oral tests. Feedbacks from the participants were collected about the lectures and practical classes and the program was run in accordance with it.

Based on their performance, their attitude & their effort in this training, participants have been categorized into 4 different groups with the grading as follows:

Very good (A) with qualities: Very sincere, Enthusiastic, Industrious, Good interpreter, Good listener, Capable of solving the occurrences and practice in work.

Good (B) with qualities: Sincere, Enthusiastic, Industrious, Interpreter, Good listener and practice in work.

Satisfactory (C) with qualities: Sincere, Industrious, Listener and practice in work.

Weak (D) with qualities: Weak in all.

**VERY GOOD (A)**

Jung Ting, Ze Ying, Myin Thwin, Tu Awng.

**GOOD (B)**

**NAW SAM, SENG NAW, LA AWNG, TANG GUN, HKA LI, LA JA, GUM SANG**

**SATISFACTORY (C)**

**SENG AWNG, LA SENG, SAU YING, NAWNG LAT DUM, AWNG MAI, LA NU, SUT AWNG DAW HKA NAN, BAWM HKAW.**

**WEAK (D)**
Zan Shan, Tang Ji, Ya Li Ta, La Seng, Nawng Lat, Gaw Lu Tu, Zahkung Yaw.

## Observation and Comments

IT IS BELIEVED THAT PARTICIPANTS HAVE ENHANCED THEIR KNOWLEDGE, ATTITUDE AND SKILLS THROUGH THIS BIOGAS-TRAINING COURSE. REGARDING THEIR KNOWLEDGE ENHANCEMENT THE PARTICIPANTS WERE ABLE TO IDENTIFY, LABEL, DEFINE, CLASSIFY AND

DESCRIBE THE EQUIPMENT, PROCESS OR EVENTS. SIMILARLY, THAY WERE ALSO ABLE TO EXPLAIN, GIVE EXAMPLES, REASONS, ESTIMATE AND LIST DOWN THE EQUIPMENTS OR PROCESS. REGARDING ATTITUDE THEY WERE ABLE TO ADOPT APPROPRIATE METHOD AND ENHANCED CURIOSITY OR INTEREST. AS FAR AS THE SKILLS ARE CONCERNED THEY WERE ABLE TO SKETCH, MAINTENANCE, INSTALL, DEMONSTRATE AND OPERATE THE SYSTEM.

1. NAME OF PARTICIPANT: Seng Awng

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | SATISFACTORY |
| SINCERETY | GOOD |
| INTERACTION | NOT VERY INTERACTIVE |
| PERFORMANCE | SATISFACTORY |
| UNDERSTANDING LEVEL | SATISFACTORY |
| FINAL GRADING | C |

2. NAME OF PARTICIPANT: Zau Shan

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | SATISFACTORY |
| UNDERSTANDING LEVEL | SATISFACTORY |
| FINAL GRADING | C |

3. NAME OF PARTICIPANT: La Seng

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | APPRECIABLE |
| SINCERETY | GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | B |

4. NAME OF PARTICIPANT: Galawng Saw Ying

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | VERY GOOD |
| FINAL GRADING | A |

5. NAME OF PARTICIPANT: Naw Lat

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | B |

6. NAME OF PARTICIPANT: La Ma Awng Mai

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | APPRECIABLE |
| SINCERETY | GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | B |

7. NAME OF PARTICIPANT: Naw Sam

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | VERY INTERACTIVE |
| PERFORMANCE | VERY GOOD |
| UNDERSTANDING LEVEL | VERY GOOD |
| FINAL GRADING | A |

8. NAME OF PARTICIPANT: SENG NAW

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | VERY GOOD |
| UNDERSTANDING LEVEL | VERY GOOD |
| FINAL GRADING | B |

9. NAME OF PARTICIPANT: SHADAN LA RING

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | B |

10. NAME OF PARTICIPANT: GAW LU TANG GUN

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | APPRECIABLE |
| SINCERETY | GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | B |

11. NAME OF PARTICIPANT: Zung Ting

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | C |

12. NAME OF PARTICIPANT: Nhka Tan Gun

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | APPRECIABLE |
| SINCERETY | GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | B |

13. NAME OF PARTICIPANT: NHKUM HKA LI

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | VERY GOOD |
| UNDERSTANDING LEVEL | VERY GOOD |
| FINAL GRADING | A |

14. NAME OF PARTICIPANT: Za Yinth

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | VERY GOOD |
| UNDERSTANDING LEVEL | VERY GOOD |
| FINAL GRADING | A |

15. NAME OF PARTICIPANT: Myint Thun

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | VERY GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | A |

16. NAME OF PARTICIPANT: Kepare La Nu

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | B |

17. NAME OF PARTICIPANT: Hpau Wung La Ja

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | VERY INTERACTIVE |
| PERFORMANCE | VERY GOOD |
| UNDERSTANDING LEVEL | VERY GOOD |
| FINAL GRADING | A |

18. NAME OF PARTICIPANT: YA LI TA

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | B |

19. NAME OF PARTICIPANT: SUT AWNG

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | B |

20. NAME OF PARTICIPANT: LA SENG

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | B |

21. NAME OF PARTICIPANT: NAWNG LAT

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | VERY GOOD |
| UNDERSTANDING LEVEL | VERY GOOD |
| FINAL GRADING | A |

22. NAME OF PARTICIPANT: Gaw Lu Tu

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | VERY GOOD |
| UNDERSTANDING LEVEL | VERY GOOD |
| FINAL GRADING | A |

23. NAME OF PARTICIPANT: Hka Nan

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | APPRECIABLE |
| SINCERETY | GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | C |

24. NAME OF PARTICIPANT: Bawm Hkaw

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | GOOD |
| UNDERSTANDING LEVEL | GOOD |
| FINAL GRADING | B |

25. NAME OF PARTICIPANT: Za Hkung Yaw

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | APPRECIABLE |
| SINCERETY | SATISFACTORY |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | SATISFACTORY |
| UNDERSTANDING LEVEL | SATISFACTORY |
| FINAL GRADING | C |

26. NAME OF PARTICIPANT: TU AWNG

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | VERY GOOD |
| UNDERSTANDING LEVEL | VERY GOOD |
| FINAL GRADING | A |

27. NAME OF PARTICIPANT: GUM SAN

| ASPECT | REMARKS |
|---|---|
| WILLINGNESS/ENTHUSIASM | HIGHLY APPRECIABLE |
| SINCERETY | VERY GOOD |
| INTERACTION | INTERACTIVE |
| PERFORMANCE | VERY GOOD |
| UNDERSTANDING LEVEL | VERY GOOD |
| FINAL GRADING | A |

# 11. ANNEXES

## *ANNEX 11.1: LIST OF PARTICIPANTS*

| No | Name | Identity card | Organisation | Address |
|---|---|---|---|---|
| 1 | Seng Awng | 1/MNYN(Nain) 073201 | Anglican Church | 2/46, Awng Tapye, Monyin |
| 2 | Zau Shan | 1/MKN(Nain) 078349 | " | 99, Tatkone TsanPya, Myitkyina. |
| 3 | La Seng | 1/MKN(Nain) 099099 | " | 147, Takhin Net Hpre Lan, Tita quarter, Myitkyina |
| 4 | Sau Ying | 1/WMN (Nain) 016099 | Railway Unit (Metta) | 1/370, Awng Tapye, Myonyin. |
| 5 | Nawng Lat | 13/NHKT (Nain) 054442 | KBC | Kawa Yang Village |
| 6 | Awng Mai | 1/MKN (Nain) 125188 | NDA(K) | Wuyan, Waimaw Myo |
| 7 | Naw Sam | 1/MKN (Nain) 046653 | KBC | SNN 145, Shata Pru, Myitkyina |
| 8 | Seng Naw | 1/MKN (Nain) 107420 | " | 155, Tatkone Tsan Pya, Myitkyina |
| 9 | La Awng | - | Goat project | Lung Ga Zup Village |
| 10 | Tang Ji | 1/MKN (Nain) 100620 | " | Tang Hpre Village |
| 11 | Zung Ting | 1/MNYN (Nain) 108441 | Baffalo bank project | Kachin Tsu, Namawn Village |
| 12 | Tang Gun | 1/BMN (Nain) | Bhamo Unit (Metta) | 2 miles, Awng Taya Quarter, Bhamo |
| 13 | Hka Li | 1/MHKN (Nain) 026823 | Diocese | Kai Thik Village, Mansi |
| 14 | Ze Ying | 1/MKN (Nain) 079090 | Nam Sheng Village | Tsi Dung Village, Namsheng |
| 15 | Myin Thwin | 14/PTN (Nain) 147596 | Railway Unit (Metta) | Mya Kan Ta, Myo Nyin |
| 16 | La Nu | 1/MKN (Nain) 118111 | Diocese | 11, Janmai Kawng, Myitkyina |
| 17 | La Ja | 1/MKN (Nain) 030764 | KBC | Nye Mye-2, Lekone, Myitkyina |

| | | | | |
|---|---|---|---|---|
| 18 | Ya Li Ta | - | Goat project | Alam Village, |
| 19 | Sut Awng | - | Diocese | Myitkyina |
| 20 | La Seng | - | Diocese | Awng Nan, Myitkyina. |
| 21 | Nawng Lat | - | Diocese | Awng Nan, Myitkyina |
| 22 | Gaw Lu Tu | 1/MTSN (Nain) 020239 | Diocese | Mansi Village |
| 23 | Daw Hka Nan | 1/MKT (Nain) 0188759 | KBC | Hopin Myo |
| 24 | Bawm Hkaw | 1/WMN (Nain) 002178 | KBC | Hka Kum Village, Waimaw |
| 25 | Zahkung Yaw | 1/MTS N (Nain) 010389 | Diocese | Shewgu Myo |
| 26 | Tu Awng | 1/YKN (Nain) | Diocese | Shewgu Myo |
| 27 | Gam Seng | 1/MKT (Nain) 068830 | KBC | Mugawng Myo |

## *ANNEX 11.2: PROGRAMME SCHEDULE*

**1st Day**

Introduction of participants and programme
Design of Biogas, site selection, lay out
Digging pit

**2nd Day**

Soling digester pit
Basic information on biogas and course design

**3rd Day**

Round wall making
Back filling
Compost pit making

**4 th Day**
Plaster round wall
Back filling
Inlet making
Factors affecting biogas
Biogas appliances
Uses of biogas and bio slurry

**5 th Day**

Mould making and casting dome as well as out let slab

**6 th Day**

Turret construction
Inlet and outlet construction

**7 th Day**

Theory on construction process, construction materials, operation and maintenance and drawing reading

**8 th Day**

Removing mud from dome
Cleaning and plastering
Pipe fittings
Water drain pit construction
Top filling

**9 th Day**

Painting dome
Evaluation of the participants

**10 th Day**

Feeding dung in the plant
Discussion
Interaction

**11 th Day**

Operation of the plant

**12 th Day**

MYT to Yangon

**13th Day**

Yangon to Bangkok

**14 th Day**

Discussion with Mr. Chris on
Finance
Report

**15 th Day**

Bangkok to Kathmandu

## *ANNEX 11.3: EVALUATION SHEET*

| SN | NAME | PRACT | FINAL | REMARKS |
|---|---|---|---|---|
| 1 | Seng Awng | D | C | |
| 2 | Zau Shan | D | E | |
| 3 | La Seng | D | B | |
| 4 | Sau Ying | C | C | |
| 5 | Nawng Lat | D | C | |
| 6 | Awng Mai | C | C | |
| 7 | Naw Sam | A | C | |
| 8 | Seng Naw | A | C | |
| 9 | La Awng | B | B | |
| 10 | Tang Ji | D | | ABSENT |
| 11 | Zung Ting | A | B | |
| 12 | Tang Gun | B | B | |
| 13 | Hka Li | A | D | |
| 14 | Ze Ying | B | B | |
| 15 | Myin Thwin | A | A | |
| 16 | La Nu | C | C | |
| 17 | La Ja | B | A | |
| 18 | Ya Li Ta | D | E | |
| 19 | Sut Awng | C | C | |
| 20 | La Seng | D | | ABSENT |
| 21 | Nawng Lat | D | D | |
| 22 | Gaw Lu Tu | D | D | |
| 23 | Daw Hka Nan | D | B | |
| 24 | Bawm Hkaw | D | B | |
| 25 | Zahkung Yaw | D | | ABSENT |
| 26 | Tu Awng | A | A | |
| 27 | Gam Seng | B | B | |

Note: A Excellent
B very Good
C Good
D Satisfactory
E Weak

## ANNEX 11.4: FEED BACK ABOUT TRAINING COURSE

1. Opinion about subject matter of the course (in percentage)

| Description | Days | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Very good | 36 | 20 | 32 | 36 | 36 | 48 | 44 | 40 | 44 | | | | |
| Good | 40 | 60 | 52 | 52 | 52 | 44 | 48 | 52 | 44 | | | | |
| Satisfactory | 16 | 20 | 12 | 12 | 12 | 8 | 8 | 8 | 8 | | | | |
| Not understood | 8 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |

2. Opinion about allocated time for the course (in percentage)

| Description | Days | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Too long | 12 | 28 | 16 | 28 | 24 | 16 | 24 | 20 | 28 | | | | |
| Good & balance | 76 | 60 | 72 | 68 | 64 | 64 | 68 | 68 | 64 | | | | |
| Short | 12 | 12 | 12 | 4 | 12 | 20 | 8 | 12 | 8 | | | | |

3. Opinion about understanding of course matter (in percentage)

| Description | Days | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Very well learned | 12 | 20 | 20 | 28 | 40 | 28 | 20 | 28 | 36 | | | | |
| Confidence for practical | 72 | 56 | 72 | 52 | 56 | 64 | 72 | 68 | 48 | | | | |
| Did not understand | 16 | 24 | 8 | 20 | 4 | 8 | 8 | 4 | 16 | | | | |

4. Opinion about training methodology (in percentage)

| Description | Days | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Very good | 28 | 24 | 36 | 32 | 44 | 40 | 36 | 36 | 40 | | | | |
| Good | 36 | 40 | 32 | 44 | 36 | 32 | 44 | 36 | 40 | | | | |
| Satisfactory | 28 | 32 | 28 | 24 | 20 | 20 | 20 | 28 | 20 | | | | |
| Not so good | 8 | 4 | 4 | 0 | 0 | 8 | 0 | 0 | 0 | | | | |

## *ANNEX 11.6: EVALUATION BY THE PARTICIPANTS*

1. Opinion about subject matter of the course (in percentage)

a. Very good b. Good
c. Satisfactory d. Not understood

2. Opinion about allocated time for the course (in percentage)

a. Too long b. Good and balanced
c. Short

3. Opinion about understanding of course matter (in percentage)

a. Very well learned b. Confidence for practical
c. Satisfactory d. Did not understand

4. Opinion about training methodology (in percentage)

a. Very good b. Good
c. Satisfactory d. Not so good

| Description | Days | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Subject matter | | | | | | | | | | | | | |
| Allocated time | | | | | | | | | | | | | |
| Understanding of the course | | | | | | | | | | | | | |
| Training methodology | | | | | | | | | | | | | |

## *ANNEX 11.7: EVALUATION OF THE PARTICIPANTS*

Name:

1. What is the use of biogas?
a. run engine b. cooking food c. lighting lamp d. all

2. How much is the ratio of dung and water in the mixture?

a. 1:1 b. 1:1.5 c. 1:3 d. 1:2

3. How much dung is fed in a 6 cum plant?

a. 30 kg b. 45 kg c. 60 d. 100 kg

4. What should be the quality of cement used?

a. with lumps b. moistured c. portland d. all of the above

5. What place is appropriate for installing biogas?
a. in a shadow b. far from cattle shed c. Sunny place d. None of the above

6. What instrument is used for maintaining the height and shape of the dome?

a. gas pipe b. water drain c. template d. Non of the above

7. Why should we close the main gas valve while not using gas?

a. to use less gas b. to stop slurry entering in the kitchen c. to stop leakage d. all of the above

8. Why the dome is filled with mud on top?

a. to stop from upliftment b. to stop from cold c. to increase gas production d. all

9. Where should we place water drain?

a. at the lowest level of the pipe line b. at the highest level of the pipe line c. at the same level d. Non of the above

10. How big is the size of the compost pit?

a. Smaller than the volume of the plant b. bigger than the volume of the plant c. equal to the volume plant of the d. Non of the above

11. What are the advantages of composting?

a. no loss of nutrients b. high yielding c. land more fertile d. all

12. Which paint is normally used while painting dome?

a. acrylic plastic emulsion paint b. Enamel paint c. Black Japan d. all

13. What is the ratio of cement and sand for brick masonry work?

a. 1:1 b.1:2 c. 1:3 d. 1:4

14. What is the ratio of cement, sand and pebbles for casting dome?

a. 1:1:1 b. 1:2:3 c. 1:3:3 d. 2:2:3

15. What kind of plant is called quality biogas plant?

a. Plant running without any problem b. Plant constructed with specified measurements c. Plants with good quality appliances d. all