Itoleka Girls
Secondary School

ENVIRONMENTAL PLANT

Itoleka Girls Secondary School
Kitui in Kenya

PROJECT PLAN

Helge Underland

September12 v1109

WASTE BECOMES ENERGY -IMPORTANT FOR THE ENVIRONMENT – A PUSH FOR THE WOMAN – HEALTH BENEFITS FOR THE FAMILIES

Content

Illustration 1: The kitchen block at Kalimani SS

Reason for the project

The Norwegian non governmental organization (NGO) Help to self-help in Africa (HSA) are doing environmental projects in Kenya and Tanzania. We have just finished a similar project at Katulani Secondary School in Kitui. This has been a successful project in many ways. We have gain experience which will benefit this new project.

Itoleka Secondary School is situated in the eastern part of Kenya appr 10 km sout-west of Kitui town.
The school was started in 1988 and sponsored by Anglican Church of Kenya (ACK). It is a two streamed school with 255 students, out of which 155 board in the school. The school stands on 18 acres and is endowed with power from the NATIONAL GRID. Water is an issue here since it comes from MASINGA which is erratic.
The school has science lab, an empty computer lab and a small administration block.
It has a spacious field that is not levelled, is well fenced and is endowed with a lot of trees.
The school has 8 (eight) classrooms, a small smoky kitchen and a MULTIPURPOSE HALL.
The school has a principal's house and one extra house for the boarding master.
The school has 11 teachers and 10 support staff. It has a large cement water tank and two plastic tanks @ 10,000 litres.
The school is located 10 km from Kitui and is a mixed day and boarding school.
The school Principal is

In co-operation with the board at the school we have decided to build a pig house, a biogas plant, drill for water and (optional) install a electrical generator run on biogas. This will be the main project, and there will be some minor projects not mentioned in this prospect.

Pig breeding in addition with a biogas plant is a multifunctional and they are depending on each other. Pig breeding makes jobs and income. Biogas makes green environment.

The principle of "help to self-help" is to arrange the way so people can make their own living and take the responsibility of their own development. We prepare for involvement from the locals in the development of this project.

The pig-house will enable work for one person, income for the school by selling pigs and pig manure for the biogas plant for production of biogas for use in the kitchen and for the generator. Production of pigs need a lot of clean water. We will therefore drill a well for water at the school. This will give water for the pig house, the school and it will be possible to sell water to the inhabitants in the local community. At least (optional) we will install a electrical generator run on biogas.

We have decided to construct a big pig house, and the plan is to produce 120 pigs pro year after tree years. The biogas plant will be constructed in 2013.

Biogas is a very environmental and sustainable power source, that will contribute in reducing the deforestation and pollution. We have just started to introduce the biogas in Africa.

In East-Africa, many biogas plants have been constructed. It is our consideration to increase the know-how to build biogas plants through learning by doing. We want our workers to become skilled, so that they can build their own biogas plants.

The prevention of deforestation is a main issue for the western countries to reduce the CO_2 emissions.
A biogas plant is one out of many initiatives, which can reduce the CO_2 emissions, because it uses waste as an energy resource instead of trees. We will also point at an African initiative, “Biogas for better life”. They have an ambition to construct 2 million biogas plants in Africa within 2020. You can read more about this at www.biogasafrica.org .

Conclusion

As far as I can see, we have a good basis for the construction of a successful environmental plant at Itoleka Secondary School. Some of the advantages will be:

- Conservation of the nitrogen and phosphorus from pig manure. When it passes through a biogas plant, it will increase its value as fertilizer.
- One achieves gas for cooking, and prevents deforestation.
- Less hard work (for women) in connection to collection of firewood.
- The construction of the pig house and biogas plants will be done by local craftsmen and hence contributes to the field of industry and business, by spreading the knowledge within this trade.
- Benefits from the pig breeding.
- Clean water will be good for the students health and welfare.

The estimated cost for a biogas-plant like this example in the study, will be app. NOK 80.000. For The pig-farm we have estimated the cost of the building, pigs and food for one year to app. NOK 120 000. We have made some estimates for the number of man-hours and material needed. In order to have prices that are more exact, one needs to contact local industry. From a Norwegian point of view, the biogas is not very expensive.

Illustrasjon 2:

From the kitchen at Kalimani Secondary School

Scope of work

According to Help to Self-help in Africa`s (HSA) cooperation with Itoleka Secondary School (ISS) we need to specify our support of economic and practical kind.

I VISION

HSA will contribute to the construction of a pig house, biogas plant, borehole for water and (optional) a biogas generator at ISS, then the pig manure can be used in a biogas digester for production of biogas for cooking in the kitchen and for producing electricity for the water pump.

By doing this we will assume that ISS will save money for buying firewood and charcoal for cooking, and make profit from pig farming and from water sale. The profit shall be used for developing of the school.

II FINANCING

The financing of the project will be through:

- money from HSA
- non-interest bearing loan from HSA
- money from ISS
- labour from the school

HSA will have no economic or material benefits from the project.

We use the term «contribution from the school». This is contribution from the pupils and the parents
trough construction work or other activities which gives income to the project. In Norwegian we name this form of contribution for «dugnad» and this is one way the Norwegian nation is founded. We assume that the same term among you in Swahili is named unpaid “Ushirika“. «Dugnad» does not give any person any economic or material benefit for themselves, but everyone contribute in what ever they are capable of, and all the contributors will benefit from the common labour.

III PIG HOUSE

The first task is to build a pig house.

1. HSA will contribute in the design of the pig house in cooperation with ISS.
2. ISS will contribute to do the digging for the foundation, production of bricks, sand, ballast and do the construction work.
3. HSA will pay for the timber, cement and the roof sheets.
4. HSA will be at the site with a construction supervisor.
5. HSA will pay for 10 piglets.
6. HSA will pay for a course for two skilled and interested people in pig farming and maintenance of a biogas plant.

IV BIOGAS

The second task is to construct the biogas plant. In this plant the pig manure is digested to methane gas which will be used in the kitchen for cooking. This is a more advanced construction work than building the pigstery.

1. HSA will contribute to the design of the biogas digester

2. ISS must do the digging for the plant
3. HSA will pay for the cement, pipes and other necessary equipment.
4. HSA will pay for the project supervisor, the "fundi" and skilled bricklayers.

V WATER

The third task will be to drill a water well.

1. HSA will contribute to the water drilling
2. ISS must do the unskilled labour
3. HSA will pay for the drilling, pump, electrical installations pipes and other necessary equipment.
4. HSA will pay for the project supervisor, the "fundi" and skilled labour.

VI GENERATOR

The final task (optional) will be to install a generator run on biogas.

1. HSA will contribute to the generator installations
2. ISS must do the unskilled labour
3. HSA will pay for the generator, electrical installations and other necessary equipment.

VII PROGRESS

To achieve the goal, we need a binding plan of progress. When the scope of work for the different tasks is calculated, ISS have to make a plan of progress. At first for the pig house, which HSA expect to be finished through 2012. The biogas plant HSA assume to be constructed in 2013, water well in 2013 and the generator in 2014

VIII MILESTONES

According to HSA`s visits to the ISS we assume the following milestones:

1 .	HSA will visit the ISS and start the evaluations of school for this project
2	HSA will be at the school for making agreement for this project
3 .	HSA will visit the school to inspect the construction work of the pig house
4	Project start for the biogas digester
5	Completion of the biogas digester
6	Water drilling
7	Generator project (optional)

Basics

With this project in mind, I wish to emphasize the importance of training local people to design and construct this equipment on a local basis. One good solution/ the best solution is to train local people, and give the necessary education locally. In Kenya, and in Tanzania, we know that the expertise for biogas already exists. There also is some commercial activity linked to the field. By installing biogas plants, one will reduce the need for cutting the forest for combustion and provide floating fertilizer for agriculture. This is fertilizer of high quality (phosphorus and nitrogen) utilized by plant life, and will additionally reduce the water consumption.

The toilets can be connected to the biogas digester for production of biogas from the human manure. In fact this will become a very small part of the total amount of manure, and it will add a lot of water in the digester. We have noticed skepticism in using the slurry containing human manure as fertilizer.

In connection to using the slurry containing human manure as fertilizer, there are actually no problems concerning the transmition of bacterial disasters as cholera, typhoid, salmonella, and koliforme. These bacteria will all die in the biogas digester during processing. There is a problem connected to parasites, e. g giardia and different internal worm, (tapeworm, hookworm etc). These worms are tougher than the bacteria. Viruses (norovirus an other which causes gastroenteritis). We are a little unsure, but human pathogen viruses are vulnerable to sunlight and other environments outside the human body.

You have to be careful when the slurry is being spread when removed from the tank. Some precautions must be taken in order to assure that all parasites and bacteria are dead. Therefore, do not use the slurry directly on plants that are to be used shortly after. In addition, if the plants are being sprayed, one has to use a type of equipment which does not spread eggs from parasites with e.g aerosol and its like. Practical and good routines should be sufficient to take care of this.

One idea may be to arrange the toilettes to separate the urine and handle it properly in tanks and make it clean for use as fertilizer. We acknowledge that the use of urine may be taboo in some cultures. However, the urine is surprisingly clean and the only problem may be rests of medicine.

The grey water from the showers and sinks, etc. must be separated and lead to a pool outside of the house. Due to the high temperatures, the process of decomposing the pollution will make the water good enough for reuse. The outcome of this process may not be water with quality as drinking water. We will recommend that the water be used for watering the fields. Alternatively, it will be filtered trough the soil, and lead into the wells.

One important premise for a successful plant is not only linked to the construction and installation of the plant. It is very important that the maintenance and the daily running of the plant are fully acceptable. There must be a frequent supply of pig manure. The emptying of the fertilizer is also important.

To get fresh water to the pig house, we need gutters to collect the rainwater from the roof, and store it in tanks. We recommend over ground tanks in plastic or in plastered masonry.
For the light in the pig house, we will install a PV system with LED lamps.

The biogas plant

In a biogas plant the supply comes from black water from the toilets, waste from animals and other organic waste. In the anaerobic process (Process with no oxygen), the bacteria will start its process to produce methane gas and carbon dioxide (CH_4 and CO_2) The principle sketch for the plant is shown below.

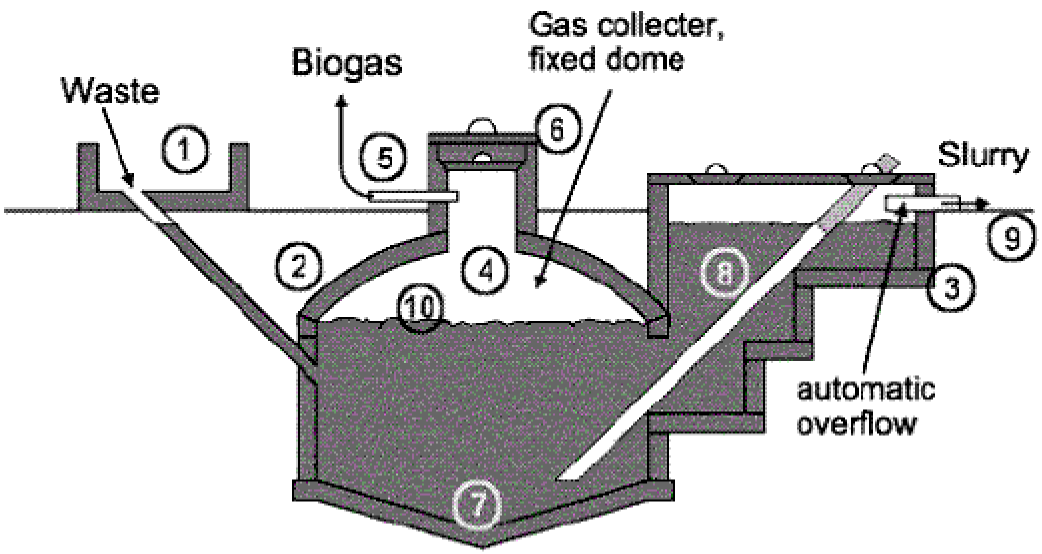

Figure 1: Fixed dome plant Nicarao design: 1. Mixing tank with inlet pipe and sand trap. 2. Digester. 3. Compensation and removal tank. 4. Gasholder. 5. Gaspipe. 6. Entry hatch, with gastight seal. 7. Accumulation of thick sludge. 8. Outlet pipe. 9. Reference level. 10. Supernatant scum, broken up by varying level.
Source: TBW

During the production of gas, the pressure will increase, the level inside the tank will sink and the mud will flow from the tank as fertilizing substance.
By use of gas, the pressure will go down.

We will construct a biogas digester of chine's model, with a "fixed dome". That means no movable parts in the system. This is a well-proven model and has a wide range.

The biomass added in the digester will contain there for app. 20 days. It is important to use the gas every day, and biomass (pig manure) has to be added daily.

At Itoleka Girls Secondary School there will be 100 students in the dormitories. The pig house will be designed for app. 60 pigs and piglets. With this information, we have calculated with building a 45 m^3 biogas digester. The plant will produce 6 – 8 m^3 biogas pr day.

Selection of "Fundi"

A "Fundi" is the common title of a skilled worker who is trained in supervision, and in taking the responsibility for and guaranteeing that the work is being performed in the correct manner, with the expected quality.
Together with Itoleka Secondary School we have to find a polite and skilled fundi for the work. We have to ensure he really is a fundi, and we already have one in mind.

Has has educated one mason to be a certified biogas mason. He is skilled and partcipated in the construction of the biogas digester at Katulani Secondary School.

Construction method

We anticipate that the plant will be constructed from local material and local craftsmen.
We will require locally produced concrete bricks of god quality because the size of the biogas digester. This is the same construction method we uses at the biogas digester at Katulani Secondary School.

The pig house is made from ordinary red bricks with cement plastering.

Illustrasjon 3: The biogas digester build from concrete bricks

Illustrasjon 4: The biogas digester is almost complete

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Illustrasjon 5: The tank must be waterproof at the bottom and gas proof at the top. This requires skilled masons to perform proper work.

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Construction Details of Biogas Plants

This section provides detailed information on materials and devices used in the construction of biogas plants:

- Checklist for construction
- Agitation
- Heating
- Piping systems
- Plasters and Coats
- Pumps
- Slurry equipement
- Underground water

Checklist for building a biogas plant

1. **Finishing the planning**, i.e. site evaluation, determination of energy demand and biomass supply / biogas yield, plant sizing, selection of plant design, how and where to use the biogas, etc., in accordance with the planning guide
2. **Stipulate the plant's location and elaborate a site plan**, including all buildings, gas pipes, gas appliances and fields to be fertilized with digested slurry
3. **Draft a technical drawing showing all plant components**, i.e. mixing pit, connection to stabling, inlet / outlet, digester, gas-holder, gas pipes, slurry storage
4. **Preparation of material / personnel requirements list and procurement of materials needed for the chosen plant**:
   - bricks / stones / blocks for walls and foundation
   - sand, gravel
   - inlet / outlet pipes
   - metal parts (sheet metal, angle irons, etc.)
   - gas pipes and fittings
   - paint and sealants
   - gas appliances
   - tools
   - mason and helper
   - unskilled labor
   - workshop for metal (gas-holder) and pipe installation
5. **Material / personnel assignment planning**, i.e. procedural planning and execution of:
   - excavation
   - foundation slab
   - digester masonry
   - gasholder
   - rendering and sealing the masonry
   - mixing pit - slurry storage pit
   - drying out the plant
   - installing the gas pipe
   - acceptance inspection
6. **Regular building supervision**

7. **Commissioning**
   - functional inspection of the biogas plant and its components
   - starting the plant
8. **Filling the plant**
9. **Training the user**

Recipe for a water- and gas proof surface

Cement plaster with special additives

Good results in water- and gas-tightness have been achieved by adding 'water-proofer' to the cement plaster. For gas-tightness, double the amount of water-proofer is required as compared to the amount necessary for water-tightness. The time between the applications of the layers of plaster should not exceed one day, as the plaster becomes water-tight after one day and the new plaster cannot adhere to the old plaster. The following 'recipe' from Tanzania guarantees gas-tightness, provided the masonry structure has no cracks:

1. layer: cement-water brushing;
2. layer: 1 cm cement : sand plaster 1 : 2.5;
3. layer: cement-water brushing;
4. layer: cement : lime : sand plaster 1 : 0.25 : 2.5;
5. layer: cement-water brushing with water-proofer;
6. layer: cement : lime : sand plaster with water proofer and fine, sieved sand 1 : 0.25 : 2.5;
7. layer: cement screed (cement-water paste) with water-proofer.

The seven courses of plaster should be applied within 24 hours.

A disadvantage of cement plaster is their inability to bridge small cracks in the masonry structure as, for example, bituminous coats can do.

Gas installation

Accordance to how the plant and the kitchen are situated, we have to use ½" gas pipe made of PVR.
We also need drainage for the condensation of water. Water vapour will condensate in the pipe. We recommend an automatic condensation drain, and the level gas pipes outside should tilt toward the direction of condensation about 3-5%.

In the kitchen we need two or three gas burners for the cooking. Gas burners are sold in Nairobi and they need to be modified for biogas.

Table 3: Appropriate pipe diameter for different pipe lengths and flow-rate (maximum pressure loss < 5 mbar)

	Galvanized steel pipe			PVC pipe		
Length [m]:	20	60	100	20	60	100
Flow-rate [m^3/h]						
0.1	1/2"	1/2"	1/2"	1/2"	1/2"	1/2"
0.2	1/2"	1/2"	1/2"	1/2"	1/2"	1/2"
0.3	1/2"	1/2"	1/2"	1/2"	1/2"	1/2"
0.4	1/2"	1/2"	1/2"	1/2"	1/2"	1/2"
0.5	1/2"	1/2"	3/4"	1/2"	1/2"	1/2"
1.0	3/4"	3/4"	3/4"	1/2"	3/4"	3/4"
1.5	3/4"	3/4"	1"	1/2"	3/4"	3/4"
2.0	3/4"	1"	1"	3/4"	3/4"	1"

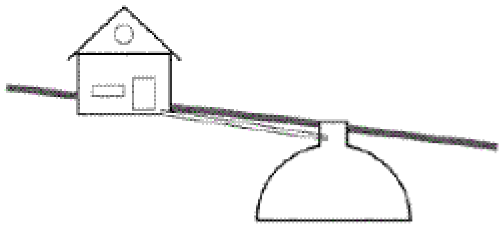


Figure 27: Piping system with straight slope from kitchen to digester. No water trap required as condensation water drains into the digester
Source: TBW

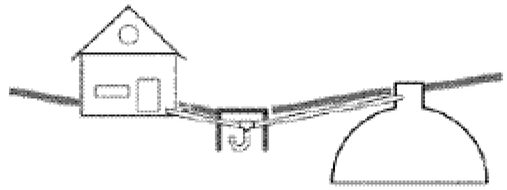


Figure 28: Wherever condensation water cannot drain back into the digester, a water trap becomes necessary
Source: TBW

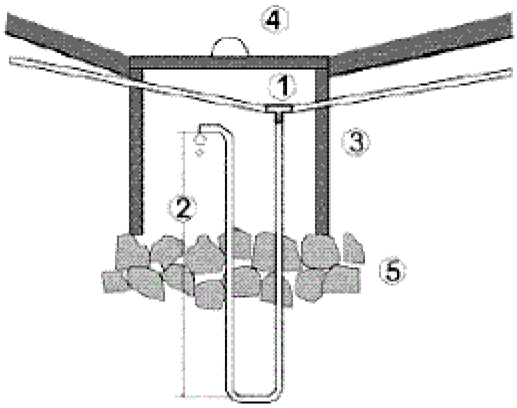


Figure 29: Automatic water trap: (1) T-joint in the piping system, (2) water column, equal to max. gas pressure + 30% security, (3) solid brick or concrete casing, (4) concrete lid, (5) drainage
Source: TBW

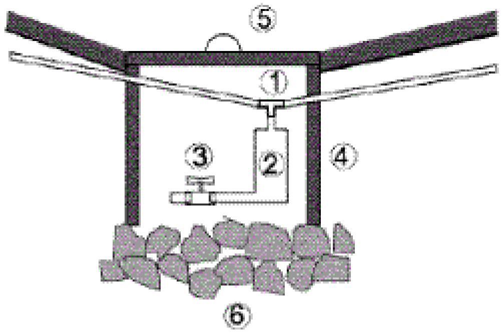


Figure 30: Manual water trap: (1) T-joint, (2) buffer storage for condensated water, (3) manual tap, (4) casing, (5) concrete lid, (6) drainage
Source: TBW

Different ways to remove the condensed water

It is important that there is no leakage in the gas pipes, as it can create explosions.
The methane gas has no smell or colour. The buildings are usually well ventilated, so the risk of an explosive mixture of air and gas is very low.

There are many different gas burners on the market, and these have to be selected according to the amount of gas and cooking pans.

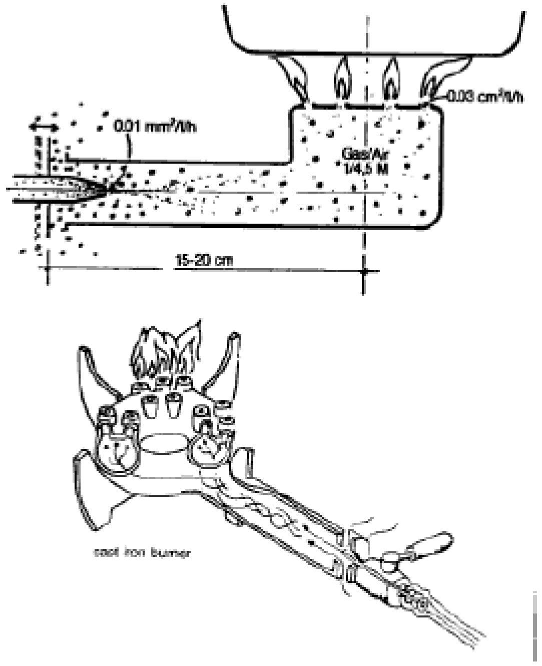


Figure 45: Schematic diagram of a gas burner
Source: Production and Utilization of Biogas in Rural Areas of Industrialized and Developing Countries, Schriftenreihe der gtz No. 97, pg.185

Illustrasjon 6: Different sizes of gas burners
©Muasa 2007

Illustrasjon 7: Boiling water with biogas.
Kiabakari Bible School, Mara; Tanzania
©Muasa 2008

Animal dung

The production of biogas is dependant upon large amounts of animal dung. Some of the dung may be collected from the cattle, which is normally used. However, for having sufficient amount of droppings we propose to establish a pig farm by building a house for the purpose, which is large enough for about 60-80 pigs, both grown ups and piglets. The pig droppings are very suitable for the production of biogas. By keeping the pigs inside, it will, providing correct feeding, be easy to use the droppings as material for the gas reactor. The cattle dung is also suitable, and by keeping them in house during night time, half the dung may be collected from the cattle.

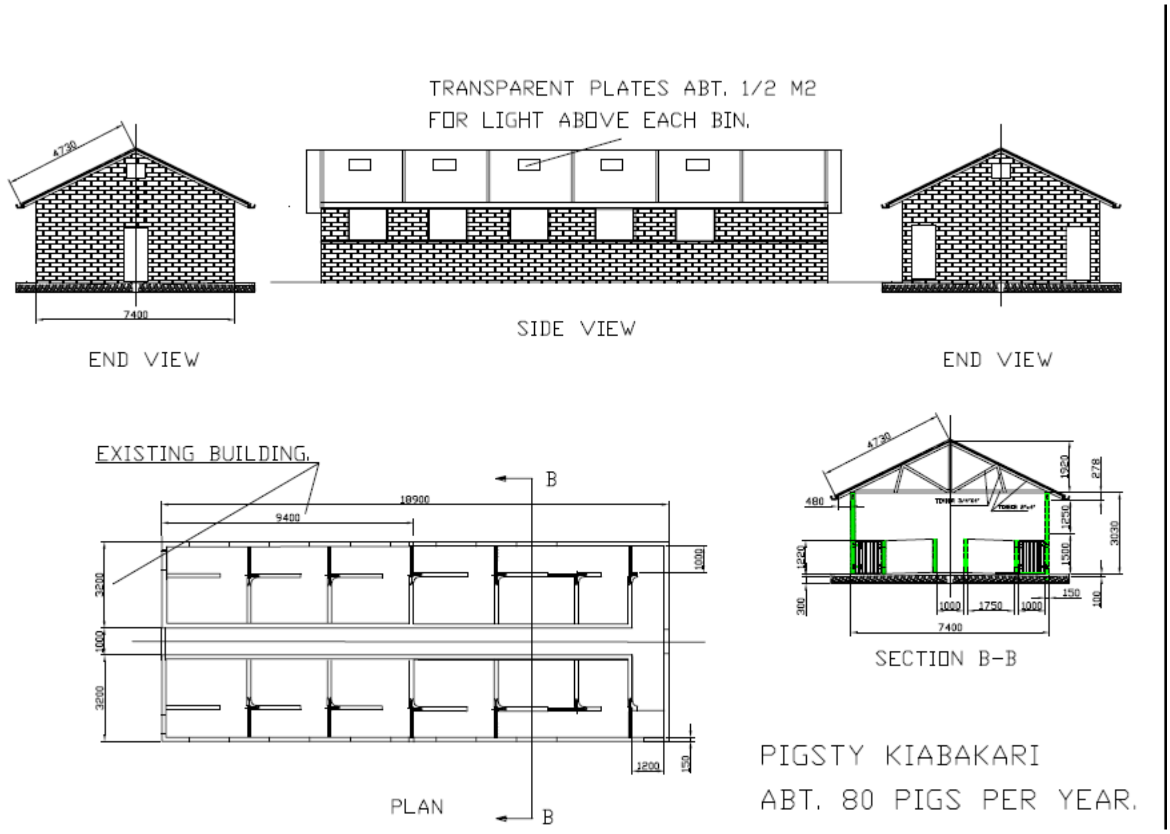
For feeding the pigs, all sorts of leftovers from biological material can be used. However, normally the leftovers from the kitchen must have some additional pig food as e. g maize and soy. We assume that the provision of such food should not be difficult. The question of price must be settled.

The planning of the pig farming is essential in order to have the full effect of it. If this is made properly, it will give good pig meat for the school, it can be sold on the market and the piglets may be sold to other farmers. From what we have heard, pork is a valuable type of meat in Kenya. The market price is high.

The pig is a modest animal, which can eat almost all kinds of food. However, he has a weak point, the stomach. He can take almost every burden of external strain, but is very vulnerable against stomach trouble. It is important to hinder stomach trouble to occur by giving additions to the food of e. g iron sulphate or some formic acid in the water. The right mixture of food is very important and will have great influence of the weight. As said before, the pig can eat what ever you offer, but the food energy differs for all kinds of food, and hence must be calculated exactly.

Description of the pigsty

We propose the pigsty to be built by brick stone on a foundation of reinforced concrete, with the size of about 4,5 x 13,5 metres. This should be sufficient for a herd of 30 to 40 pigs of various growths. The floor must be plastered. Through the midst of the house, we have made a gutter, which is 40 cm. deep and 60 cm. wide. The space between the inner walls must be min. 70 cm. in order to have space for a wheelbarrow. The rooms must have sloped floor, (about 2%) towards the middle. By placing the food bins at the dividing walls, we think that the droppings will emit into the gutter.



Example of pigsty

The walkway consists of a grating floor, which is hinged toward the walls when the dung is being removed from the gutter towards the ends of the house. The external walls have openings in it, about 60 x 70 cm. This will allow the mother pigs to be outside on the ground and to enter the house for hiding from the sun. The intention of the outside gardens is of great value for the pig's well-being.

The pigsty will have a plated roof with gutters for collection of rainwater. The water will be stored in two 5m^3 tanks, preferably built by stone at the ends of the house. This water shall be solely for use of the pigs.
Finally, we will install a solar panel to light the house, and the outside of it. These light fixtures will be by LED and have very limited consumption of power.

Illustrasjon 8: From the pigstery at Katulani Secondary School
© Muasa 2010

Cost

The cost of the projects is difficult to estimate. The local prices of materials and wages differ. We have made an estimate of materials and man-hours. For the biogas reactor the costs are based on the materials and man-hours used at the existing reactor at Katulani Secondary School.

For the estimate of the pigsty, we have calculated the materials and received prices from the vendors of the most important materials. From experience we can see heavy variations in the prices.

The man-hour estimate is based on time previously spent at Katulani Secondary School. We have estimated one fundi and 8 workers in 3 months for the erection of the reactor and the pigsty. On top of the erection cost we need one construction manager and a combined driver and interpreter during the construction time. Those two must have lodging and food available and the local interpreter and driver must be paid in accordance with local wages. Cost of car must also be included. Local transport of manager is included, as well as the provision of local purchase.
Travel for manager from Norway to Itoleka in Kenya is also included.

The total estimate in accordance with the above should be KES. 3.000.000. However, calculation that is more exact is necessary when the local prices are being settled. Reference is made to the attached budget sheet.

Water drilling

We will start the preparations for the water drilling by contact the Ministry of Water and Irrigation in Kitui and check were we can have a bore hole for water nearby the school. Probably they have been doing some surveillance on this issue in the area. There will be necessary to do agreements with the Ministry and landowners in the area.

Probably we have to drill for 180 – 220 m and install an submersible pump in the borehole. I addition we will need a house for technical installations and for the sale of water.

Illustrasjon 9: Sale of water at Katulani Secondary School

Electrical generator

As an option we want to install an generator for producing electricity. This generator has to run on biogas. We do some considerations for an generator installation at Katulani Secondary School, but it is difficult to find generators for biogas, and it is not common to convert from gasoline or diesel to biogas, or to have an interchangeable generator for different fuels.

Further development.

We would like to think that we could start education of biogas entrepreneurs and develop the grey water handling procedures. Prior to start of the biogas plant at Kiabakari Bible School we had an introductory course for the students. The students were very interested in the project and wished to build similar plants at home when they could see the gas burning. The gas is much better than charcoal and fire wood.

Illustrasjon 10: Lectures in biogas at Kiabakari Bible School

Finish

There are some questions/issues that have to be solved locally. This is the attitude of the authorities regarding the handling of grey water, and in particular on the subject of biogas. Furthermore, it must be made clear of what the attitude of the authorities is regarding the use of human droppings. We know that this is prohibited in some cultures, and without problems in others.

**Itoleka Girls
Secondary School**

www.selvhjelpiafrika.org