BIOGAS FOR OVERSEAS VOLUNTEERS

The Oil Drum Digester
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More pictures: Mombasa Project

Connections					
Carbon Trading	Climate effects	Research & Speculation	Economics	Musingu Kenya	Hyacinth
Climate Problem	Nigeria	Kenya	Kendu, Kenya	Hyacinth Project, Lake Victoria	Mombasa Project

The Oil Drum Digester

This apparatus was originally built in Nigeria at Government College, Bida and operated for several years, providing gas for cooking.

The volunteer in tropical countries can make a bio-gas digester using the following components:
oil drum
tar drum (if available)
3/4 inch water pipe
1/2 inch gate valve
various other water pipe fittings, including elbows, nipples, T-junction
2 inch gate valve
2 inch nipple
1/2 inch hard polythene plastic pipe or steel water pipe

These parts, especially fittings for plastic pipe connections, may not be available in every country.

Parts which should be brought from Britain
gas tap for attaching cooker to gas supply
fittings for plastic pipes
2 inch fittings (rather heavy but much more expensive in Africa)
spirit level (for laying out pipes)
large adjustable spanner
gas lamp
burner

Getting Oil Drums

In Nigeria I found the Public Works Department to be a source of suitable oil drums. These were drums which were no longer suitable for transporting oil products because of being bashed or having small holes. If the holes are not too large you may be able to fill them in or cover them with paint or welding or other method. A tank used for bio-gas does not move about and so holes are less dangerous. If the holes are only in the blank end the drum is quite suitable because you are going to remove that end. However, try to obtain the least damaged drums. Inspect the threaded holes carefully to make sure you can screw a pipe into them. You may well be able to get drums of these kinds for nothing or a small present to someone (or even pay for them legally).

In Nigeria tar barrels were used in large numbers by the PWD for carrying tar for the roads. Many of these drums seemed to make only one trip so were available in large numbers. The useful feature of these drums is that they have a smaller diameter than the oil drum so that they will fit inside and can be used as gas holders. These drums have only one hole at one end. If they are not available you will need to find a suitable alternative.

Construction Method

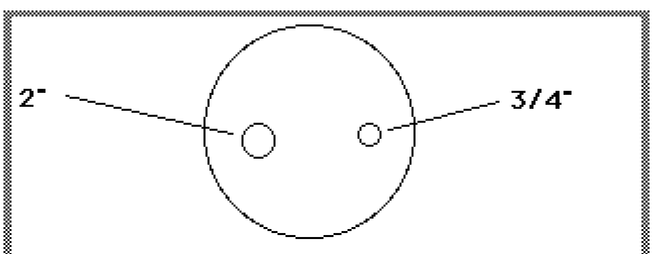
1. The Oil Drum

Knock the plain end out of the oil drum using a chisel. This is a job like opening a food can with a can opener. Don't knock out the end with two threaded holes.

Now you can knock out any dents by bashing with a mallet from the inside.

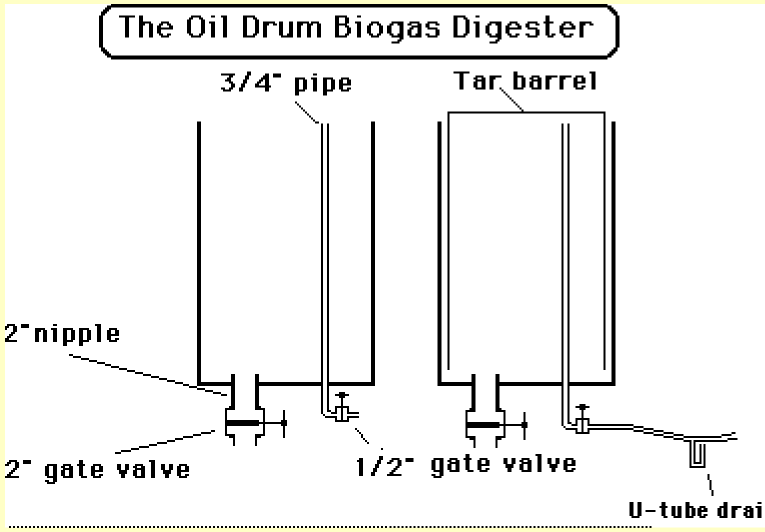
Cut a piece of 3/4 inch pipe about the length of the oil drum. On one end cut a thread. In most towns there will be a plumber who can do this. The thread has to be suitable for screwing into the small hole of the oil drum, with a protruding amount of thread suitable for attaching the 3/4 inch elbow or reducing elbow (3/4-1/2) to which you will attach the gate valve.

This pipe should stand straight inside the drum to just below the top of the open end. (When the gas plant is operating the pressure of the gas will force the water level below the rim of the drum). The 3/4 " pipe carries away the gas and also helps to hold the gasholder in place.



One end has two threaded openings.

If you can get some black bituminous paint it is helpful to cover the inside of the drum with a good thick coat to prevent corrosion. However, this type of paint is difficult to find in most countries. If no paint is used the drum will last about two years. The metal is in the most danger when the drum is empty and exposed to the air.



2. The Tar Barrel

Knock out the end which has the filling hole in it. This barrel needs no other treatment. The tar remaining on its side will protect it, but you can paint the outside if you wish.

3. The Outlet Valve

Take the 2 inch nipple and screw it into the 2 inch hole of the oil drum. Attach the 2 inch gate valve to this. To prevent leakage you can apply paint along with the fibres from sisal twine to the threads before insertion.

When these have been done the digester is complete. Mount the oil drum on blocks so that any contents can be caught in a bucket placed under the 2 inch valve.

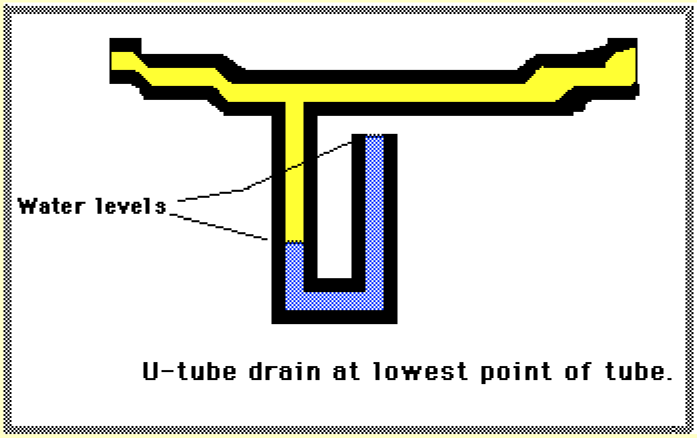
4. Gas Pipes

Gas can be transported through 1/2 inch pipe, either steel or plastic. Plastic pipe is easier to handle. It can be cut with a saw very easily and can usually be put into the appropriate fittings without special tools. Get a 3/4 inch to 1/2 inch reducing nipple, or elbow. Connect together more than one digester by using T-junctions. You will need a gas tap to receive a rubber or plastic tube connecting to the cooker. The fittings for plastic pipes are not always available. Try your local farm suppliers in Britain. Water fittings will do. If the distances are very extended you may need larger bore pipe.

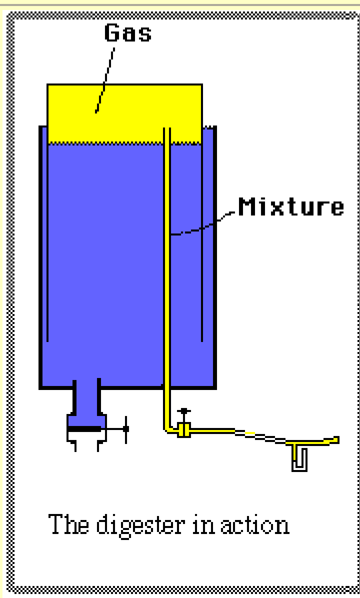
5. Drain

Water will condense in the gas pipe. At the lowest point of the gas pipe there must be a drain to let out the condensed water. This can consist of a U-tube made with two 1/2 inch elbows, two 9 inch lengths of pipe and a T-junction. One of these will be needed at every low point, but usually you can arrange that there is only one low point. Use the spirit level to check the gradients of pipes.

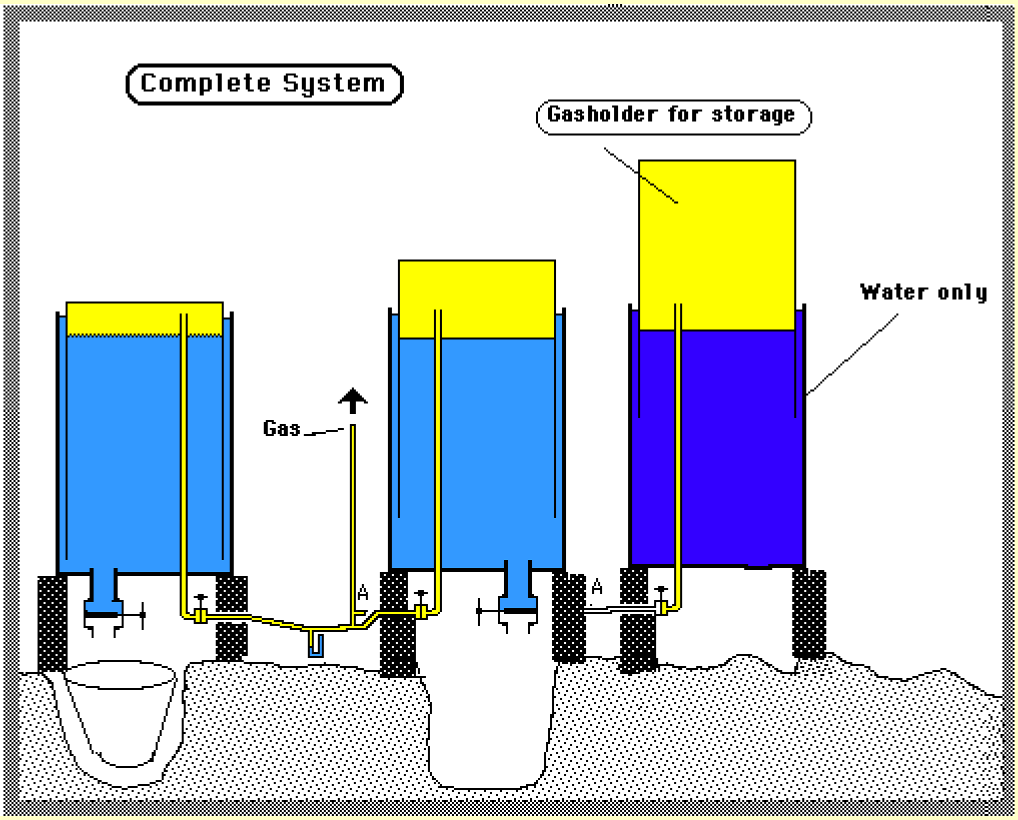
The U-tube must be full of water when the gas plant is operating. In very dry countries, or in the dry season, it may need topping up due to evaporation into the atmosphere. Probably the longer the pipe feeding the drain the less likely it is to dry out. Normally water will drain out through the open end of the U-tube as it comes down the pipe. Gas will not get through the water seal (though carbon-dioxide will, which is a useful feature). It is the same principle which is used on all lavatories and bath and sink drains.



The length of the U-tube depends on the pressure of gas you wish to maintain. It should not be less than 9 inches (23 cm) which will be suitable for a pressure of from 3 to 6 inches (8 to 16 cm) of water. This is a suitable pressure range for most purposes.



How many of these oil drum digesters will you need?
One person cooking with no other fuel needs at least two of these digesters. It is useful to build another, without a 2" gate valve, to be used as a gas holder alone. Three full gasholders contain enough gas to bake bread or roast a chicken in an ordinary small gas oven.



The only surviving photo. Note the stones on the lid to control the gas pressure.

Materials for Making Gas

Dung from animals can make gas without any vegetable material. Cows, horses, sheep and pigs are all useful sources of waste. Chicken and pig are best because

most concentrated.
The main disadvantage of chicken manure is that it produces a proportion of hydrogen-sulphide which, even when present in only small proportions, corrodes metal fittings. (It is also poisonous, but not in the quantities produced so there is never likely to be enough to be a danger). When it burns it oxidises to sulphur-dioxide. Cowdung produces almost no hydrogen-sulphide but needs larger quantities than chicken to produce the same amount of gas. If you have plenty of cow dung build more digesters. Probably three oil drum digesters will be needed to supply as much gas as two filled with chicken manure. Don't despise horse manure. Cow dung must be fresh. Dried cow manure won't reabsorb water and so will float on top of the mixture.

Mix the dung with water: half fill a bucket with dung and fill with water and stir it all together until it is a slurry. The water can be dirty though you should avoid detergent which might kill the bacteria.

On a large scale it is best to make gas from animal wastes mixed with vegetable wastes such as dried grass, straw, banana stalks, coffee factory wastes and other vegetable throw-outs. This needs a fixed tank which is not suitable to be made from oil drums. **(See below)**

Human Waste

What about human waste? Most sewage works make bio-gas. However, you should avoid this in the oil-drum digester. Although most disease-causing bacteria and parasites would be killed, you can't be sure all of them would die because the drum is not designed to hold the mixture for a long period. Some fresh material will always come out of the valve when new material is added. (This is the chief inefficiency of the oil-drum digester). Moreover, the mixture is not isolated from the air or from contact with people.

The World Health Organisation advises that human wastes should be held in the absence of oxygen for two months at least, or heated to a high temperature, or both# . This means you should not experiment with human wastes. Piss on the compost heap by all means.

In China human wastes are an important source for gas digesters and hence of fertiliser which contributes to the productivity of the soil. But the digesters are larger and must be designed to minimise health problems, in particular by preventing new material mixing with older and emerging from the fertiliser output.

Possibly if the outlet liquid is passed through a vegetable digester, the pathogens will be killed. This needs research.

Gotaas **Composting** (see Book list)

OPERATION

A. Starting

Starting the bio-gas process is the most difficult part. If you can start, you can continue.

1. Look for the bacteria.

The best source of bacteria is to use the output from an existing gas plant. However, if there isn't one, any swamp or deep puddle may contain the anaerobic (oxygen-hating) bacteria. In Nigeria I found the bacteria at the town's slaughterhouse where the paunch-manure - undigested food from the stomachs - and dung were dumped in a swamp which heaved and bubbled with gas. Scoop some of the mud and put it in a tin with the lid on.

2. Get some cow dung.

Put two buckets of fresh cow dung and water in the oil drum. Add the mixture from the swamp. Put the tar barrel on and close the half-inch gate valve. Next day add another bucket of cowdung and water (half and half stirred up).

Don't try to start with chicken manure. If you do it will go sour and stink badly.

The bacteria should soon take over and start producing gas. The tar barrel will act as a gasholder and start to rise. When it does, open the valve and let the gas out. For the first day or two the gas will be mostly carbon-dioxide. Don't try to light it in case there is a mixture of air and bio-gas. After two or three days you can test the gas with a match.

Keep adding a bucket of fresh cowdung and water every day until the drum is half full. If there are no cows, as in the rainforest area, use horse, donkey, sheep or goat.

3. Add Chicken manure

Then you can start adding a bucket of chicken manure and water every two days. This procedure should prevent sourness and bad smells arising.

As soon as the gasholder is rising regularly you can start using the gas.

Alternative starting method.

If there is another digester, then you can start much faster. Put some of the output from the other digester in the new one. Fill it to about half full and then add a bucket of fresh material every day.

Things which can go wrong.

1. Sourness.

Signs: Bad smell. The gas produced, if any, will be very thin and burn with difficulty.

The cause is adding fresh chicken manure too fast. Chicken manure is acidic and kills the right bacteria when too much fresh material is present. Then the process will probably go wrong. In this case you have no choice but to empty the tank and start again. Cow and horse manure are alkaline, which is why it is wise to start with those.

2. Gas holder doesn't rise.

Check for bubbles in the mixture. If there are bubbles and the gasholder still doesn't rise you must check for leaks in the pipes and gasholder. Close the small gate valve.

Since there should be some Hydrogen Sulphide in the gas there will be enough smell to detect the leak. Check the gasholder (tar barrel) for leaks too. Turn it up and fill it with water. It is of course unwise to use a match. Soapy water will detect large leaks but because you are dealing with small quantities of gas even a microscopic leak can drain it all away. Check all joints and the gate valve itself.

B. Running the gas digester.

When the gas is coming off regularly you should add a fresh bucket every two days. Once the tank is full you will need to draw off a bucket of material from the bottom before adding a fresh bucket at the top.

Put this used material straight on to the garden. Although fresh chicken manure will damage your plants, digested manure will benefit them at once. Alternatively you can put the material in another tank with vegetable wastes to produce more gas. The bacteria will live on the nitrogen and other minerals and consume the cellulose in vegetable wastes.

You can keep up this procedure for a long time. The only bad thing that may happen is that sand and dirt may build up in the bottom of the oil drum and a scum may form on the top of the mixture. It is wise therefore to empty it out completely at least once a year to inspect it. If you have more than one digester it will be easy to restart it. If you have only one, fill a Nido tin with mixture and put the lid on, to preserve the bacteria from the poisonous effects of oxygen.

If you are going away for a day or two, stop adding new material a few days before you leave. Then the gas production will fall while you are away. Excess gas will bubble away into the air harmlessly (except for slightly adding to the Greenhouse warming of the atmosphere). Adding new material on your return will revive the process within minutes.

You will find that gas builds up overnight. You can use some for breakfast and then let it build up again for lunch. Then you can empty out the gas for the evening meal and let the gasholders rise again through the night.

Temperature

At 35^{o}C the material should be processed in about 30 days. If the ambient temperature is less the material will be processed more slowly. At 30^{o} the rate is halved and you will add a bucket every four days but you should then have twice as many tanks to process the same amount as at 35^{o}. At 25^{o} you will add a bucket every six days. At 20^{o} the rate is halved again and it can take six months to obtain all the energy from the mixture. At 15^{o} it will take a year, which is not practicable as the daily rate of production will be tiny. If you are in a highland location where the temperature frequently drops below 20^{o} you may need to arrange for the tanks to be in a sheltered location with plenty of sunlight. The rate of gas production will also be less. This means that at lower temperatures you will need more tanks to produce the same amount of gas. A greenhouse or similar collector of solar heat would be useful, especially in the high tropics such as Kenya or Ethiopia.

Outside the tropics, where there is a marked cooler season the apparatus may not function in the winter. In cold weather it will be necessary to heat the mixture to the

optimum temperature 30-35^o. Surrounding it with insulation like a British hot water tank is necessary. In Britain this means that the oil-drum digester is too small. A much larger plant is necessary to allow for the insulation and heating which become needed in a cold climate. (See Book List - Fry.)
According to Gotaas (see Book list) one tonne of manure produces gas at the following rates:

Temperature	**Production Rate**	**Digestion Period**
Degrees C	Cubic metres/day	(months)
15	0.15	12
20	0.3	6
25	0.6	3
30	1	2
35	2	1

Gas Pressure
The pressure of gas is measured in the height of water it will hold up in a tube. For cooking purposes three or four inches (8 cm) is enough. If you want to power a gas lamp, up to six inches (15.24 cm) may be needed. You can adjust the gas pressure by putting weights, such as stones, on the lids of the gasholders. Decide on your gas pressure before designing the U-tube drains.

Using the Gas

Cooking
The gas can be used in an ordinary gas cooker designed for bottled gas. However each burner must have the jet removed. This is a small hole designed to let the high pressure bottled gas through slowly. Biogas is at a much lower pressure. In most cookers these jets are removable in case the cooker is to be used with mains gas which is similar to bio-gas.
You may be able to use a separate burner and make your own cooker. A bunsen burner made for mains gas may do quite well enough. A general purpose burner may be usable in a fridge as well.
Hydrogen Sulphide Damage
If you make gas from chicken manure there will be hydrogen-sulphide in it. This is not dangerous to you but it will damage the brass fittings of the cooker. The most important of these are in the valves (taps) which turn the burners on and off. After a long time on bio-gas they will become stiff and seize up.
The best way of avoiding this is to produce gas without hydrogen-sulphide. Is there

any lubrication which will protect the brass fittings? I don't know.

Avoiding Hydrogen Sulphide

Cow and horse manure produce a lower proportion of hydrogen-sulphide (but also less bio-gas).

Hydrogen sulphide is not produced in digesters which use mainly vegetation. When used material is drained from the oil drum as new material is put in, it can be put straight on to a vegetable garden. However an alternative is to put it into a tank containing vegetation, such as grass, maize stalks, banana trunks, leaves and other soft vegetation (no woody materials). You can also add more fresh animal manure. The vegetation - the cellulose - will break down into methane, carbon-dioxide and a solid remainder which can be used as compost. The liquid drained off when emptying this tank can be led to the garden as liquid manure.

Unless a slurry can be made of vegetable material, the oil drum is not suitable for vegetation digestion. Whereas the animal process is continuous, vegetation has to be digested in batches. A tank is filled with vegetation, the animal manure is added, the tank is filled with water, the lid is put on and gas comes off for 30 days ($35^{o}C$) and the whole tank is then emptied. In this case you will need a larger gasholder than is provided by an oil drum.

Other Uses for the gas.

1. Refrigerator

In many areas without electricity, or with intermittent electricity, a biogas-powered fridge could be a useful device, especially in a health centre for storing vaccines and drugs.

The gas can be used in a fridge designed for kerosene (paraffin). You will need a suitable burner. A bunsen burner may be suitable. The flame is adjusted so that it burns continuously. A special burner was designed in Kenya in the 1960s and more of these could be made if there were a demand. To use bio-gas in a fridge you will probably need more gas than can be made in two oil drums.

2. Lighting

Electricity, especially the fluorescent tube, is by far the most efficient method of lighting, in terms of energy. However, in many places there is either no electricity or it is unreliable. (In Nigeria, I found it tended to go down in voltage at night, because that was when people turned their lights on!) Solar photovoltaic converters with lead acid storage batteries for forklift trucks and low voltage caravan-type lamps (or an inverter to produce mains voltage from battery output) are probably the best choice in these circumstances.

However, gas lamps adjusted to north sea mains gas can burn bio-gas. In locations without electricity bio-gas can provide adequate light for reading, marking books and the like.

The lamps can still be obtained, but you would need to bring one from Britain. Bottled gas lamps may be difficult to adapt.

Gas lamps have three main problems:
i. They use fragile gas mantles which do not last as long as electric bulbs.
ii. They produce a lot of heat which is a nuisance in a hot country.
iii. They attract insects (and the heat makes it necessary to open the windows).
However, the same is true of the various kinds of kerosene and bottled gas lamps. If you are already making your own fuel, a gas lamp makes a lot of sense.

3. Engines

Biogas in large quantities can power suitably adapted internal combustion engines. But an oil drum doesn't make enough. If you want to run an engine build a large scale installation.

Larger Scale Gas

The oil drum digester is easy to make and cheap. However, as the drums do not last long, it is not a good design for a permanent installation. A proper apparatus should be designed to last for generations. It will of course cost more and be made of stone or concrete. Many factors need to be considered before building a permanent gas plant. Among these are: the source of materials, the use of the gas and, most important, the social arrangements for controlling it. In India where gas digesters are owned by the richer farmers, an unfortunate effect is to deprive the poor of their fuel, because all the cowdung goes into the rich farmer's digester, and the dried grass as well.
You can study the design of bigger digesters by taking some of the standard books with you.

Health and Safety

1. Mosquitoes

Perhaps because bio-gas contains carbon-dioxide, mosquito larvae do not breed in the water of gasholders, drains and digesters, even where it is exposed to the air. There is no need therefore to cover the water with a surface of oil.

2. Hygiene

Wash your hands thoroughly after putting material in or taking it out.

3. Danger?

Treat the gas as carefully as you do gas at home. As it is lighter than air it will tend to rise (whereas bottled gas rolls along the floor). Houses in tropical countries usually have enough ventilation to allow bio-gas to escape to the outside.
The gas is only explosive if air or oxygen is mixed with it within a narrow range. This is quite difficult to do inside the tanks. (Of course if you take the lid off and test the bubbling mixture with a lighted match you must not be surprised if you singe your hair, as I did once in Kenya when I was very new to the process.) One safety aspect is that an oil-drum gasholder cannot store much gas. Even if a tap is left open accidentally all the gas will escape in about half an hour. Bottled gas or

kerosene primus stoves are far more dangerous.

The gas is not poisonous.

Reasons for Making Biogas

Fuel Crisis

There is a serious fuel crisis in most countries of the world. Most people in Africa and Asia use firewood or charcoal to cook food. When there were fewer people in the world wood was a quite acceptable fuel. Trees are an excellent renewable fuel - a means of fixing solar energy. But as the number of people using them increases the trees are disappearing because people cut wood faster than it can grow - this even without the destructive felling for short-term profit. And animals, especially goats, also increase and prevent seedlings growing. In densely populated areas, such as parts of Nigeria and Kenya, trees are cut down to make land for cultivation.

Volunteers may see areas of desert or eroded land where there was forest within living memory. Tree cover has many effects, besides providing firewood. A body of trees reduces the temperature of the area surrounding them. Tree roots form a sponge which absorbs rainy season water and lets it out during the dry season, preventing floods and lengthening the period of flow of rivers and streams. The coolness and humidity also lengthen the growing season. Nor should we ignore the wildlife. Thus the disappearance of the forests is a catastrophe.

New Fuels

If we insist on having more people (and Africa has the world's highest rate of population increase) we must have new fuels. Oil-based fuels, such as kerosene and bottled gas are not good substitutes for wood. (You may find yourself in a country where kerosene is absent from shops for weeks on end - even in Nigeria, a major oil producer, this can happen.) Worse, it is unwise for people to become reliant for everyday necessities on products which will become less available in the future. Even now to import oil products is a drain on many countries' resources.

For the foreseeable future electricity will not fill the gap either. In many areas it has not arrived yet. Even where it is available people will often prefer to use charcoal for cooking because they are reluctant to run up electricity bills, whereas charcoal can be paid for in cash and carried away. This is true even though charcoal is actually a more expensive fuel in many countries (for example Kenya) when the amount of heat produced by each fuel is compared. Biogas requires no payments once the apparatus has been acquired.

Few small farmers are likely to be able to afford connection to the electric grid in the near or foreseeable future. Investment in electricity overwhelmingly benefits urban industry and the richer inhabitants of the towns.

You may well find in many places that electricity, even where it generated from water power, is erratic, of variable voltage and often switched off.

Biogas is a fuel which makes you independent of the oil producers. Having a gas-plant feels like having a little oil well in your garden. It also produces fertiliser for your garden. In the long run the fertiliser is more valuable than the gas, which can be thought of as a by-product of making compost.

Theory of Biogas

Biogas is a mixture of methane and carbon-dioxide. Methane is the main constituent of Natural (north sea mains) Gas. Because bio-gas contains about one third carbon-dioxide it doesn't burn in exactly the same way as natural gas. The Flame Speed in air is a little less. This means the burners have to have slightly bigger holes to let more air in.

Natural gas was probably bio-gas once. (*Probably* because there is a hypothesis that some of it may come from deep in the earth and not be of biological origin, or be derived from bacteria deep in the earth's crust.) If it was once bio-gas, the carbon-dioxide has escaped by dissolving in water.

Biogas is formed by bacteria acting on plant and animal remains in the absence of oxygen. This condition is found in the natural world at the bottom of swamps and lakes, and in the guts of animals, especially the ruminants. Biogas bubbles up from marshes where there is vegetable matter on the bottom. If Phosgene, which is self-igniting, is also present, the gas will ignite forming what country people called Will o' the Wisp flames. Hence a digester can be thought of as an artificial swamp.

To obtain the best conditions you need a mixture of animal and plant remains. This is described in detail in the WHO monograph Composting.

Biomass

Fuel produced by living creatures from solar energy is classified as Biomass energy. Biogas is a biomass fuel which can easily be made by ordinary people in tropical countries. Of all the biomass energy sources it is probably the one which has fewest bad effects on the ecology and society. Of the others: alcohol uses land and other resources which would otherwise produce food; charcoal leads to deserts by removing the tree cover; so to a lesser extent does firewood. The materials from which biogas is made are commonly available and also produce compost which will improve the land. For the most part these materials are undervalued and thus have no monetary value at present.

Only the carbon in the materials is used to make fuel. Some of the carbon goes into the methane (CH_4), some of the rest goes into the carbon-dioxide (CO_2). Some remains to form the fertiliser solids found in the liquid. The nitrogen, phosphorous, potassium and other plant nutrients pass into the liquid which is returned to the soil. When wood or leaves are burned, many of these are lost to the atmosphere, especially the nitrogen. This is one reason why areas such as the middle part of Nigeria, where grass is regularly burned, are deficient in nitrogen.

A compost heap made of animal and plant wastes will get hot inside if it is properly made. The methane from the digester contains the energy equivalent of this heat - except that the heat can be used in the kitchen. However, many compost heaps lose nitrogen in the form of Ammonia when the heat drives it off, if too much nitrogenous material has been added (Gotaas Composting).

Raw animal manure, especially chicken, put straight on to the soil can damage plants. If it has rotted well in a compost heap, or been digested in a gas plant the bad effects are avoided. Plant roots seem able to take up nutrients from the liquid coming from the bio-gas tank at once.

Vegetable wastes

Unrotted vegetable matter is also harmful to crops in that while it is rotting the nitrogen in the soil is taken up by the bacteria and fungi as they break it down and is not available to the growing crops.

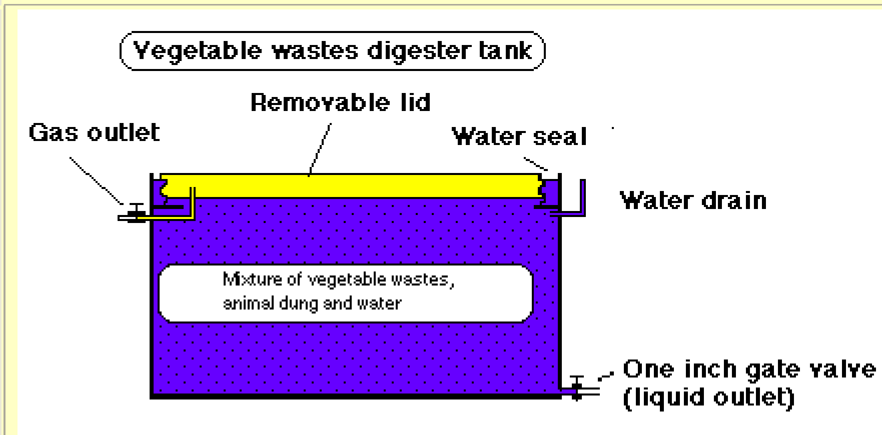
In a well-designed system there should be vegetable digesters as well as animal digesters. The oil-drum digester is the easiest type to build. The output from the oil-drum should be run through a vegetable tank to produce more gas and compost.

The real future for bio-gas lies in the conversion of vegetable wastes from rural industrial processes: such things as straw, maize stalks, grass, leaves, banana stems, coffee pulp, sugar bagasse and floating water weed such as Water Hyacinth. All these are waste products and many are at present being burned, with a resulting loss of nitrogen and humus. Water Hyacinth clogs lakes and rivers (it was introduced by accident from South America).
In the Savannah area of West Africa square miles of grass are burned in the dry season to stimulate a small amount of grass growth for nomadic cattle herders. All the heat from the burning grass is wasted energy. The process of burning impoverishes the soil. If this grass were made into gas vast amounts of energy could be produced from this not very productive area which would become agriculturally more productive. The nomads, however, would be unhappy.

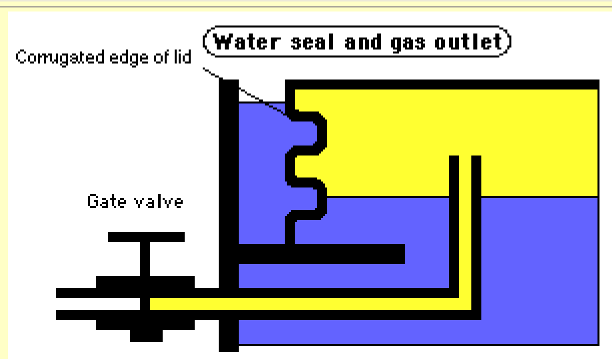
Whereas the oil drum digester using only animal wastes is a continuous process, vegetable wastes must be processed in batches. The tank is filled with material, closed off and the digestion begins. When the gas ceases to come off the gate valve is closed, the liquid run out on to fields, the tank is opened and the solid waste taken out. The liquid is excellent fertiliser, the solid material makes compost. It may be necessary to keep the solid material in a compost pile for a period before spreading on the land.

How long will a batch stay in the tank? That depends on the temperature. I used this system in Kenya at a height of about 5000 feet. There the batches lasted about two months. At higher temperatures, such as 37^{o}C the batch may last only one month.

For smooth rates of production it is suitable to have more than one tank. If there are three tanks, one may be just beginning, a second may be in the middle of its cycle and the third ready to empty.



This drawing is based on a design produced by the Tunnel Company in Kenya.



Economics

The value of the process consists of the value of the fuel produced and the fertiliser. It is difficult to value the gas. In some cases it makes possible things which were not done before. It is difficult to put a monetary value on speed of cooking. The fertiliser is also difficult to value. The long-term effect is better soil and a lower threat to the forests, but these too are hard to value.

The cost of the process is made up of the capital and maintenance of the apparatus and the labour required. The raw materials often have no present value (but as soon as you show interest in thrown away chicken manure you may find the owners wanting money for it). On a farm, if the process uses material which would have to be moved anyway, extra labour is probably negligible. If the gas makes unnecessary the task of searching for firewood there is a reduction of labour.

In many places women spend hours of their day looking for fuel. If fuel comes from a gas plant with much less labour, women can spend their energies on other things - perhaps saleable crafts. (The economic value is likely to be to the benefit of women rather than men, because generally it is women who work the hardest. For the same reason, men may tend to overlook the benefits.)

In general it is only the capital cost which need be considered. Maintenance is small, if the plant has been well-designed to last a long time. The oil-drum digester, of course, is not a long-lasting device and needs to be replaced every two years or so.

OIL

The amount of oil in the world is finite. Some researchers believe we are very close to the point of Peak Production - the point at which production begins to decline. Although demand for oil continues to rise very little new oil is being discovered. The implications are that oil price will considerably rise after the Peak. Tropical countries with biogas capability will find the value of biogas to users will greatly increase. In 2004 the oil price has risen to much higher than it was two years ago (when it was historically very low).

BBC report

Energy Prices (1998)

All Uganda prices in pounds sterling equivalent

	Price	equiv 1 m^2 gas	Value m^2 gas	1 tonne/day £
diesel	£0.62p/litre	0.72 lit	0.4464	13.39
kerosene	£0.50p/litre	0.87 lit	0.435	13.05
petrol	£0.75p/litre	0.8 lit	0.6	18
charcoal	£4.50/30kg	1.45 kg	0.217	6.53
electricity	£0.06p/kwh	2.2	0.132	3.56

Kenya prices 1998

	Price	equiv 1m^2 gas	Value m^2 gas	1 tonne/day £
diesel	£0.32p/litre	0.72 lit	0.2304 p	6.91
petrol	£0.38p/litre	0.87 lit	0.304	9.12
kerosene	£0 .22p/litre	0.8 lit	01.914	5.74
- LPG	£10/15litre	1.45 kg		
- labourer's salary				£25/month

These prices were estimated on an inspection visit to Uganda in 1998. Put the present day prices into the second column to get an idea of what the gas would be worth at the time of your reading this paper. The third column shows that for example 1 cubic metre of biogas is the equivalent of 0.72 litres of diesel oil. Note that in 1998 fuel prices were lower in Kenya.

As the prices of oil products rise, the value of the biogas also increases. However, these values are only a guide to the overall utility of the biogas. Although diesel and petrol are the most expensive sources of energy, biogas is unlikely to be a substitute for road fuel. It might be a substitute for diesel or petrol fuel used to operate an electric generator. It may be a substitute for kerosene as used for cooking and lighting. For cooking it is also a substitute for charcoal, whose negative value is in the damage to forests.

In a village it is the not the monetary value that may be the most important. For people who have to spend time looking for firewood it is time that is saved. That time can be used to do something else, that may be worth money.

The Volunteer and Gas

There are two reasons why it is useful for you to learn to make gas. One is that you will find a source of fuel makes your life easier if you are in a place where fuels are hard to find. The other is that it is necessary to have this technology on show in places where ordinary people can see it. At present bio-gas is likely to be found in research institutes where ordinary people never see it.

If you become interested in it you can go on to design more permanent types of gas plant.

Permanent Plants

A permanent gas digester will cost real money. I have never built one though I have seen them in Kenya. It will need such things as good quality concrete or stone blocks and metal-working skills to make gasholders and lids. Study the books mentioned in the Book List, especially Fry - Methane Digesters.

The key problem is building a large gasholder (for example, 10 cubic metres). This needs the skills of working with corrugated iron. In East Africa the skill of making tanks from this material is widely spread. In a country, such as Nigeria, where water tanks are not made of this material it is difficult to build a proper gasholder.

Cultural Problems

Don't underestimate the cultural problems. Some people don't like handling animal wastes - perhaps non-farming westerners have a big problem here. If you as an educated westerner can be seen to handle these materials you can help to make it respectable. If you are teaching in secondary schools you will find that many of the students and some of your fellow teachers believe that practical work of this kind is degrading - a kind of caricature of the British class system. This is not a useful attitude in countries where agriculture will continue to need the greatest investment of intelligence and money, and is often the most neglected area of the economy.

Book List

Peter-John Meynell Methane: Planning a Digester (Prism Press)

Michael Crook A Chinese Bio-gas Manual (ITDG)

L.John Fry Methane Digesters (L.John Fry)

Christina Freeman & Leo Pyle Methane Generation by Anaerobic Fermentation (ITDG)

Dr. Leo Pyle & Peter Fraenkl Methane: Proceedings of a one-day seminar (ITDG)

All obtainable from the Intermediate Technology Bookshop, 103-105 Southampton Row, London, WC1B 4HH.

Harold B. Gotaas Composting (World Health Organisation) 1956 (Probably out of print but available in some libraries)

See also Ram Bux Singh

Some addresses:
Tunnel Technology Ltd
P.O Box 1
Koru

Kenya

00 254 341 51065

Hamworthy Engineering Ltd. Commercial Biogas apparatus
Fleets Corner,
Poole