Biogas: Alternative Energy at Work

While the cost of carbon-based fuel is rising, people in rural areas across the world are experiencing financial hardships due to the price and inaccesibility of energy. People in rural Costa Rica are no exception. Before implementing the **biogas project** (what is biogas?), the majority of the people in Santa Fe de Guatuso purchased gas to power its gas ranges. As a result of the town's remote location, the price of a tank of gas had cost over $15 USD. Although this is a cost that many people in the developed world could afford, a family in Santa Fe that used more than one tank per month could not likely pay for the fuel to cook its food. Consequently, many families were forced to supplement their gas with firewood. Although this fuel source had no perceived monetary cost to the family, the practice of cutting trees for firewood was a long-term liability for the region of Guatuso as a whole. Such a practice was also harmful in the short-term, as the firewood was burned in the kitchen and often ignited with plastics and rubbers, which when burned give off carcinogenic dioxins. As a result, the people in Santa Fe were torn between financial, environmental, and health concerns.

While faced with this dilemma, the Santa Fe Women's Group decided to seize an opportunity that conquered this threat to their financial, environmental, and physical well-being. The group chose to use the animal waste from their cattle to make **biogas for cooking**. Not only would the project take care of the environmental threat from the burning of firewood, but it would also solve the problem of animal waste management in the dairy-producing town.

In order to utilize cow manure for this alternative cooking fuel, the group needed to build biodigesters, which are tanks that process the manure to produce a biogas that is mostly comprised of methane. (Learn about biodigester design and construction) The **biogas is produced** in the tank through the anaerobic (which means 'in the absence of oxygen') digestion of the manure by bacteria. These bacteria, which thrive in underwater, oxygen-free environments, consume the animal waste, reproduce, and give off a methane-rich waste. This biogas bubbles up from the depths of the manure/water mixture and escapes through the surface above. the biogas is then trapped by a large plastic balloon that hovers over the tank. Then, in the middle of the plastic, PCV tubing connects the biogas source to the kitchen, where the gas range (see picture at top of page) is ready to supply the alternative energy for cooking.

With the aid of a donation from the UN Women's Group in Vienna, Austria and the technical assistance of the Agriculture Ministry office in Guatuso, the Santa Fe Women's Group was able to build 16 biodigesters in 2006. The women of Santa Fe, however, are not finished with this important biogas project. They are still dedicated to increasing energy independence through biogas by extending the privilege of a biodigester to other deserving families in Santa Fe and the greater Guatuso area. To know more about biogas and biodigesters, explore the following links:

- Learn about biodigester construction - See the biodigester design that the women's group used for its biogas project that was featured in the Summer 2007 issue of the Permaculture Activist.
- Biogas and Biodigester FAQ's - Learn the basics about biogas and get some of your specific biogas questions answered
- Video on how to make an anaerobic methane digester - Transcription of the English translation with link to the video
- Video on biogas in Pune, India - See how biogas works in this Indian city where they use leftover food, instead of manure, for their biogas energy needs
- Video on biogas digesters in Tamil Nadu, India - See how this rural Indian state utilize its abundant raw materials to create energy independence through biogas.
- Video of the UC Davis Biogas Plant - Interesting large-scale biogas plant that processes solid organic wastes with minimal preparation
- Read our collection of online biogas articles - Learn about biogas in other parts of the world from a newly-updated compilation of online biogas articles
- Learn how to make your own homemade biodigester - This book offers an easy-to-use, step-by-step illustrated manual on how to make your own homemade biodigester to create biogas

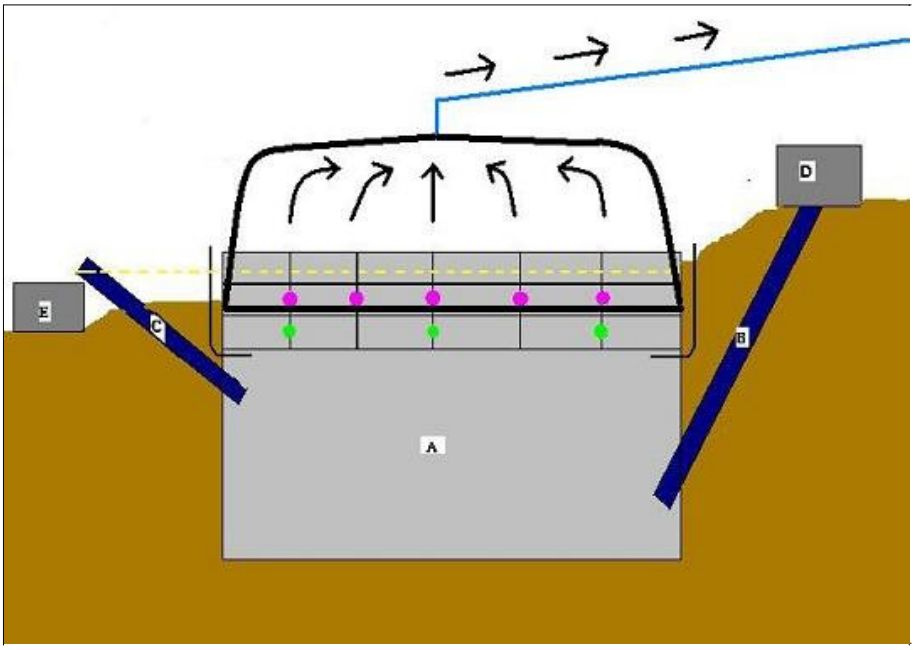
step-by-step illustrated manual on how to make your own homemade biodigester to create biogas in your very own backyard.
- Cow Power - This is a short video that speaks to the importance of biogas production.
- What is Anaerobic Digestion? - A video introduction to the biogas production through anaerobic digestion.

External Biogas Links:

- Paul Harris's Introduction to Biogas
- Biogas by Wikipedia
- Biogas on WikiSpaces

Biodigester Design & Construction

Understanding the Basics of a Biodigester



Above is a sketch of the profile of a biodigester to better visualize the concept. In the picture, A represents the biodigester tank where the water and manure mixture is digested by the bacteria. When working with cow manure in a biodigester of this size (1.9 meters deep X 1.5 meters wide X 3 meters long), every day you need to add 10 gallons of water and 5 gallons of manure. When working with pig manure you work with a 1:1 ratio, or rather, 5 gallons of water for the same 5 gallons of manure. In Costa Rica they use twice as much water for the cow manure because the cattle grazes on grasses, making the manure more fibrous than that of pigs. So, keep in mind that grain-fed cattle may produce less-fibrous and easily-digested manure. In the picture B and C represent the entrance and exit tubes respectively. The entrance tube should enter the tank near the bottom and the exit tube should enter the tank just beneath the first row of cement block. D and E represent the mixing tub and the collection tub respectively. The mixing tub will ideally be more than 15 gallons in volume in order to mix the water and manure thoroughly. The mixture should have a uniform consistency to facilitate optimal digestion throughout the tank. Also, in the picture, the green circles represent the bottom support pins that catch the frame of the plastic in case the water level decreases drastically. The purple circles represent the top hangers against which the frame of the plastic rests as it tries to float up to the water surface. The curved tubes that enter the tank on each end are to hold the mixing rope. The mixing rope is to have 3-5 gallon jugs half-full with sand attached. When two people tug back-and-forth on this mixing rope for a few minutes daily, the partially submerged gallon jugs break up any thick film that may gather at the surface, suffocating the bacteria in the tank below. The dotted yellow line represents the liquid level. Notice that the level comes right up to the rim of the exit tube. This parity is important, as every day that you put in 15 gallons of mixture, the exit tube, in theory, will discard the same volume into the collection tub to be used for fertilizer. The black dome that hovers over the tank is the plastic frame that fits just under the top hangers (purple circles) and holds the plastic that balloons up when the biogas, represented by the upward arrows, bubbles up from the surface of the water/manure mixture. The biogas then escapes through the PVC tubing represented by the blue line that extends above the middle of the plastic.

Through this tubing the biogas is transported to the kitchen to be burned for cooking.

Biodigester Materials

The biodigester design that the Santa Fe Women's Group used is a fairly simple and inexpensive one. A few of the tasks, like digging the hole, may be quite labor-intensive, and some of the tasks require certain skills, like creating cement walls and laying cement block, but the cost of the materials is relatively modest at around $300 US in Costa Rica, and the construction time is fairly short at about one week. Below is a list of the most essential materials that the Santa Fe Women's Group used for its biodigesters. In order to facilitate a good understanding of the instructions later on, all of the materials in the list include a brief description of their roles in a functioning biodigester. Some of the materials not included in the list are not as essential and can be replaced by other parts that are more convenient for your particular situation. These options will be explained as we go along.

Quantity	Description
2	Cubic meters of sand to mix with the cement to make the walls of the biodigester and to fill the cement block
1	Cubic meter of rock to mix with the cement and the aforementioned sand
5.5	Meters of a strong, yet flexible, plastic sheet with at least 2.8 meters in width. This plastic will be used to contain the biogas that is produced in the biodigester tank
4	Meters of 3" PVC tubing to use for the entrance and exit tubes for the biodigester tank
9	50-kilogram sacks of cement to make the walls and the floor of the tank, as well as to fill the three rows of cement block. You may also use the cement to mount the mixing tube on the entrance tube.
60	Blocks of cement measuring 12 cm X 20 cm X 40 cm to make the three rows into which the bottom pins and the top hangers are placed.
1	1/2" PVC tubing sufficient enough to make a rectangular frame with a circumference of 16.6 meters **and** to carry the biogas from the biodigester to the kitchen where it will be burned
*	Enough rebar to lay down the three rows of cement block along the edge of the tank
2	Tubes with a rounded elbow to put at each end of the biodigester like shown above in the picture. The mixing rope is to be threaded through these tubes.
5	Meters of thin rope to thread through through aforementioned curved tubes to mix the water and manure inside the tank
3-5	Gallon jugs half-filled with sand to be attached to the mixing rope, partially submerged in the water/manure mixture to break up any thick film accumulated at the top of the tank
20	Curved tubes for the top hangers. See the pictures below of the hangers in place to get a good idea of what these are like.
12	Straight tubes for the bottom pins. Again, see the pictures and you

12	should be able to find something similar at a hardware store.

There are other materials that you will possibly need, like wood, nails, and sheets of tin for making the roof for the biodigester, but I won't include these materials, simply because some people will use other materials or different quanitities of the same materials. Also, the connection of the the tubing to your gas range in the kitchen will require materials as your situation demands, not simply the materials put on some list that I make. I also understand that I may not be the best at explaining all of the materials and construction steps, especially considering the limited explanatory scope of this web page, so if you have any questions or suggestions, please contact me.

Biodigester Construction

Now that you know a bit about how a biodigester works (you may have already known much more than I) and the basic materials needed, you'll have any easier time making sense of the following construction directions. To build the biodigester, first you need to dig the hole. The hole should be 1.5 meters wide by 3 meters long (or longer if you're capable of greater production, but the measurements of the plastic indicated here are for a biodigester of 3 meters in length) by 1.3 meters deep (the three rows of cement block around the edges should make an overall depth of 1.9 meters). Once the hole is fixed to the proper dimensions, you need to dig the two ditches—one for the entrance tube, and one for the exit tube. (See the picture below to see the entrance ditch in the forefront with the 3" PVC tube placed within) The entrance ditch should be dug at about a 45° ang le, entering the tank as close to the bottom as possible, leaving no more than 30 centimeters between the point of entrance and the biodigester's floor. The exit tube should be dug at roughly a 30° angle with the ditch entering the tan k no more than 40 centimeters from the top of what should at this point be a 1.3 meters-deep hole. The entrance and exit tubes can be placed in now or after creating the cement walls, making sure that they are sealed firmly within the cement walls and do not stick out too far into the tank. Also, you need to make sure that the exit tube is exposed above ground level by at least 40 centimeters. (This is roughly where you will accomodate the water/manure level when you fill the tank) The top of the entrance tube should be at least 70 centimeters above the top of the top of the tank at this point.

Then you need to create the cement walls. The amount of materials used may vary in this step, as different people may use different measurements when mixing cement. The Women's Group used roughly a cubic meter of rock and two meters of sand to mix with nine 50-kilogram sacks of cement to pour the cement walls and to fill the rows of cement block.

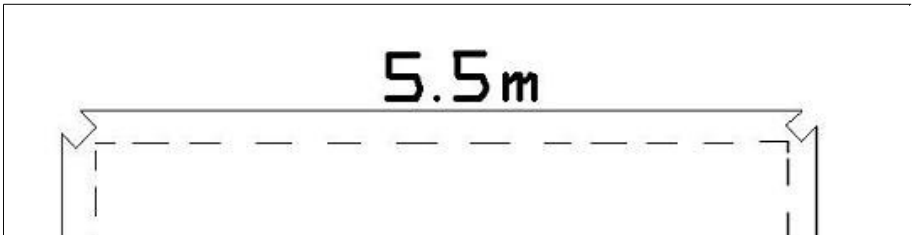
Once the cement walls are ready, you can lay the cement block around the rim of the tank. In the first row place one plastic peg in every other space between the blocks about halfway up the height of the block. The plastic pegs should stick out at least a few inches, for they will support the plastic frame if the water/manure level in the tank recedes. As you are placing the first row, make sure to place the tube for the shaking rope on each of the short ends of the tank, exactly in the middle. (See picture below to see the placement of the tube that holds the rope) Then, in the second row of block, the PCV hooks are to be placed in every space between each block. At least half of

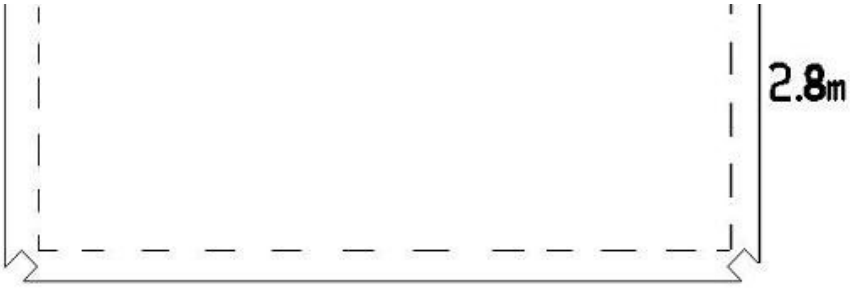
the hook needs to jut out into the interior of the tank, for these hooks are important to maintain the plastic frame submerged below the water/manure level within the tank. Then, you can place the third row, whose purpose is to allow room between the top hooks and the top of the last row of cement block in order to ensure that the water/manure level remains higher than the plastic frame that creates the water seal, trapping the biogas within the biodigester. At this point, your work on the tank is just about done. All that remains is the cement floor, which will prevent the water/manure mixture from seeping through the bottom of the tank. The floor can be made with a cement mixture with sand and/or rock, requiring about one full sack of cement.

Now that you're done with the tank, you can build the roof that protects the biodigester from the elements. I am not going to explain how to build shelter for your biodigester, as there are a number of different ways of doing it with several combinations of a vast array of materials. However, I will tell you that it is important to cover the biodigester tank entirely, and perhaps a little bit more, because direct contact with intense sunshine can deteriorate the plastic cover. Also, a lot of rainfall seeping in between the cement block and the floating plastic frame will dilute the manure/water mixture.

Another part that you can make at this point is the loading tank. This is also a part that can be made with whatever you have available. Put in general terms, though, the loading tank should be big enough to mix the 15 gallons of manure/water added daily. The container is to be mounted on the entrance tube. The Women's Group hollowed out the bottoms of barrels to then mount them on the entrance tubes using cement. Since you need to mix the water and the manure well to get a consistent liquid mixture, it is important to be able to cover the hole of the entrance tube. In order to do this, you can use some sort of plug that fits a 3" PVC tube, and then employ a chain to be able to pull the plug without reaching into the manure mixture every time you load. Another way to plug the hole, and perhaps a better one, is to fit a valve to the entrance tube that you can easily open and close. When not loading, the the entrance tube should be closed at all times. This will prevent rainfall from entering the biodigester tank and diluting the manure/water mixture inside.

Now you can prepare the plastic cover for the tank. First you need to place the plastic flat on a clean floor. (Rocks and other debris may damage the plastic) Once the plastic is placed flat on the ground and cut to the dimensions of 5.5 meters X 2.8 meters (the plastic that the Women's Group comes in rolls 2.8 meters wide, so trimming the sides was not necessary), you can use a permanent marker to draw a inscribed rectangle 20 centimeters inside the edge of the plastic. (See picture below) Then, you can cut a pentagonal shape out of the plastic on each of the four corners of the plastic. The pentagon is to have each side 10 centimeters long. (Save the plastic pentagons to be used later) These cuts will help you pass the PVC tubing through the plastic slits that you will make. To make these slits for the PVC frame, you need to apply PVC rubber cement just outside the rectangle that you already inscribed 20 centimeters inside the plastic. Start applying the glue on one side as you then fold the edge of the plastic to stick right where you made your mark 20 centimeters in. Once done with the first side, do the other three the same way, and your end result should be a rectangular plastic with four slender pockets around the edges with the corners exposed through which you will pass the PVC tubing frame.





Then, you need to make the hole in the middle of the plastic. To do this, fold the plastic like you would a blanket, doing two folds (the stack is then 4 sheets thick). Then, find the corner of the stacked plastic that is equivalent to the very center of the plastic sheet and take a very small snip at the very tip with a scissors. Unfold the plastic and you will see a small square hole of roughly one square centimeter. Then, use two of the plastic pentagons that you cut from the plastic and cut them into squares with 10 centimeters on each side. Then, cut a hole in the center of the plastic squares equivalent to the hole in the middle of the large plastic sheet. Then, use your glue to paste the square patches on each side of the plastic with the holes lined up. Then, you need to insert a valve that allows the flow of the biogas from the plastic bag to the 1/2" PVC tubing. To do this you can use a setup with both male and female valves and washers on each side of the plastic, the outside of which is shown in the picture here. Make sure that everything fits nicely and that you do not puncture any part of the plastic during this stage.

Then, you can prepare the PVC tubing frame that fits the plastic within the biodigester tank. To do this you can cut your 1/2" PVC tubing into pieces barely shorter than the measure of the inside of the rows of the cement block. The rest of the length (only a centimeter or two for each side) will be made up by the elbow connectors that connect the four pieces of tubing. Once the tubing is cut you can gently guide the tubing through the pockets made around the edges of the plastic. Once in place you can join the pieces of tube with the elbow connectors. Then, you can acoomodate the plastic underneath the top hangers in the tank (the water level in the tank is preferably up near the top hangers at this point). Now you are ready to connect the rest of the PVC tubing to the valve made in the middle of the plastic. For this you will need to utilize another elbow to direct the tubing towards the kitchen. Then, slightly away from the biodigester, but still within the confines of the shelter that you built, you will need to create the safety water seal, the gas switch, and the biogas filter. In order to do this you will need a 2-liter Coke bottle, into which you insert a tube that will be submerged at least 2" under water. This water seal allows the biogas to escape if too much pressure is built up within the plastic. Then, you can fit a switch to the PVC tubing to shut off the flow of gas to the kitchen when not in use. Then, in a 1" tube that you can fit to the 1/2" PVC tubing with the correct adapters as shown in the picture, you can stuff a few pieces of steel wool into the tubing in order to filter out some of the impurities in the biogas. Putting in the steel wool, and replacing it every few months, will prevent chemically-induced marks on the bottoms of pots and pans. Then, you can place the rest of the tubing necessary to carry the biogas to the kitchen.

The connection of the tubing to your gas range (now biogas range) is not necessarily difficult, but the methods will vary, depending on the gas range that you have and the other materials you are using. I trust that you will be able to make the connection in the kitchen based on your own possiblities and preferences. Once the the connection is made in the kitchen (or perhaps before if you were very anxious), you can raise the water level in the tank about 10 centimeters above the top hangers and start putting in the manure/water mixture. You can start by putting in the 15 gallons every day of a 2:1 water-to-manure ratio for grazing livestock, or the 10 gallons of mixture of a 1:1 ratio for grain-fed livestock. Bit by bit, the tank will attain the proper proportion of water and manure, and within roughly 3 weeks you will have an inflated plastic cover and you can start cooking with your new biodigester.

If you have any questions about the construction or maintenance of this style of biodigester, visit our Biogas and Biodigester FAQ's page. If you want to know more about the Santa Fe Women's Group's biogas project, visit our biogas page. If you have any specific questions about the construction of this biodigester style contact us. If you want to explore other recommended online resources consider the following:

The following is a translation of the transcription of the biogas (methane) digester instructional video made by the EARTH University in Guápiles, Costa Rica. The video is currently hosted on YouTube in two segments, Part 1 and Part 2. If you'd like to know about how the Santa Fe Women's Group uses biogas in rural Costa Rica, visit the main biogas page or see the digester design they used.

Anaerobic Biogas (Methane) Digester Video

The Agriculture School of the Humid Tropical Region (EARTH University)...
presents

How to install a biogas (methane) digester at low cost

The poor usage of natural resources is taking us to the destruction of the planet. Deforestation, high levels of carbon dioxide generated by forest fires, pollution caused by vehicle, industries, and other factors, are causing a global warming effect at an accelerated pace. In this sense, high poverty rates contribute to this phenomenon. Currently, many options have come about to substitute wood as a source of fuel, as gas and electricity have increasingly higher costs. Solar cooker have requirements in their usage and don't work on rainy days. An alternative that is being used more and more often is the anaerobic methane digester.

What is an anaerobic biogas (methane) digester?

An anaerobic biogas (methane) digester is an aparratus formed by a double polyethylene bag, an exit valve, and a safety valve. Inside the bag excrements are fermented, giving as a result the production of a natural gas called biogas. This biogas can be used to heat and cook food, to create light, to heat farm animals, and generally, as an extra energy source. The fermented excrements that exit the biogas (methane) digester can be used as an organic fertilizer. In the production of biogas, you can use manure from cows, pigs, horses, goats, or even human feces. Installing a homemade anaerobic biogas (methane) digester is not very costly. Nevertheless, you will have to invest at least $120 in the cost of materials and installation. The amount of materials is directly related to the size of the anaerobic methane digester, whose length can vary from 5 meters to 50 meters. To install a methane digester with 13 meters in length, you should get:

- 34 meters of 8-caliber transparent tubular polyethylene plastic with 4 meters of circumference
- 8 plastic 10-liter buckets
- 2 meters of a 1 1/4-inch plastic transparent hose
- A PVC "T" 1" thick
- A male PVC adapter, 1"
- A female PVC adapter, 1"
- 2 PVC elbows (90°), 1"
- 1 meter of PVC tubing, 1"
- A PVC plug to fit 1" PVC tubing
- Two rigid plastic washers with a hole in the center equal to 1"
- A two-liter bottle of soda or other equivalent container
- 3 car tire inner tubes, cut into two pieces equal in shape and size to the plastic washer, and the rest to set aside as tying materials are needed later in construction

- 8 empty fertilizer sacks
- A 1/2" metal tube
- A used garden hose
- A tube of PVC cement

The first step in the installation of an anaerobic biogas (methane) digester is the preparation of the bag. To do this you should extend the tubular plastic over a dry, sturdy floor without any rocks that may break the plastic. Then, fold the plastic bag in half and cut it, leaving two bags, each of them 17 meters long. Extend one of the bags over the floor and have someone crawl inside while holding an end of the other bag. The person should not wear shoes or carry objects that can make holes in the bag. Once the two bags are lined up, forming one bag, eliminate the wrinkles that formed during the process.

The second step is the preparation of the main digester ditch. This ditch is a thermal isolator and protector of the materials. It is recommended to dig the ditch close to where you keep the livestock that supply the digester. The size of the methane digester varies with respect to your biogas and fertilizer needs, as well as the amount of manure available. For this reason, the ditch measurments will vary as well. For the example of the materials already described, the ditch should be of a 1.2-meter width on the top and a 1-meter width on the bottom of the ditch. The ditch should also be 1 meter deep and 13 meters long. The walls for the ditch should have a light coating of plastic to support them structurally from erosion. On the ends of the ditch you should dig two inclined ditches that reach the bottom of the main ditch. These two ditches should be the same width as the buckets you will be using.

The third step consists of preparing the safety valve for the biogas. For this you must make a circular cut in the top of the double bag that permits the tight entry of the male PVC adapter. This cut is to be made 3 meters from the end of the bag to be placed closest to the place where you'll use the biogas.

How do you creat the exit valve?

We take the rigid washer and we place it over the male PVC adapter. We then place the tire inner tube seal over the washer so that the washer does not do harm to the polyethylene bag of the anaerobic methane digester. Then you introduce the male PVC adapter into the hole cut in the digester's bag. On the outside you then place the other inner tube seal, the other rigid washer, and the female PVC adapter that was previously attached to the PVC tubing and the PVC elbow of 1". Once the exit valve is placed, you can put the bag into the ditch and pass the ends of the bag through the buckets at each end of the ditch.

The next step is to set up the safety valve. To do this you must place a post to support it.

How do you set up the safety valve?

To set up the safety valve you must take the 1" T and insert inside a small piece of 1" PVC between 20 and 25 centimeters. This piece does not get glued within because it needs to be removed to replace the steel wool that goes inside every six months to a year. On the ends of the T we place the small pieces of PVC that are between 8 and 10 centimeters. These are glued into the T with PVC cement. We then place the larger PVC piece into the mouth of the 2-liter soda bottle with the T and the other PVC pieces attached. Here it is clear that the PVC tubing will maintain submerged in water up to these holes that create a seal of water about 5 centimeters deep.

This safety valve connects to the exit valve by means of the transparent plastic hose. Once the bag is installed in the ditch, and the ends are placed on the buckets, and the exit and safety valves are connected, the next step is to inflate the bag with the exhaust of a car, tractor, or motorcycle. To do this you need to tie up one end of the bag with the rest of the tire inner tube scraps, avoiding the escape of any smoke. At the other end, tie the mouth of the bag around a garden hose that will funnel the smoke into the bag. The other end of the hose is then place over the exhaust pipe of the automobile. Once this connection is then sealed with the tying of more inner tube scraps, you turn on the engine until you completely fill the digester's bag. Once this is complete, the safety valve should start bubbling, signaling the reaching of the digester's maximum biogas capacity. Now take the garden hose to introduce water into the bag to the point where no gas can escape, creating a water seal. Then, when no gas can escape, you open up the ends of the bag to be mounted in the buckets. On the end that corresponds to the anaerobic anaerobic methane digester's exit, you dig a hole through which to channel the material that has been digested for fifty days, after which this material can be used as organic fertilizer. From then on, you will feed the anaerobic methane digester every day with manure dissolved in water. Every bucket of manure should be mixed with four buckets of water, being completely dissolved before pouring the mixture into the digester.

[Image]

Following this recommendation, an anaerobic methane digester with 13 meters in length and four meters in circumference, and that is fed with 50 kilos of fresh manure dissolved in 200 liters of water daily can produce up to 16 hours of burn time every day.

[Eliseo Arias, Guácimo, Costa Rica]

Being able to have it, who isn't going to have this gift that is so cheap? I recommend this to everyone who asks me about it.

[Credits]

A production of *The Agriculture School of the Humid Tropical Region (EARTH University)*

If you'd like to know about how the Santa Fe Women's Group uses biogas in rural Costa Rica, visit the main biogas page or see the digester design they used.

1 Part 1
2 http://www.ruralcostarica.com/digester-video.html
3
4 Part2
5 http://www.ruralcostarica.com/digester-video-2.html

Biogas and Biodigester FAQ's

What is biogas?

Biogas is a gas produced by anaerobic digestion (in the absence of oxygen) of organic material, largely comprised of methane (about two-thirds). Biogas is often called "marsh gas" or "swamp gas" because it is produced by the same anaerobic processes that occur during the underwater decomposition of organic material in wetlands.

What is a biodigester?

A biodigester is a tank that processes the organic material that produces biogas. A biodigester can come in different shapes and sizes, depending on the needs of the people using it and the local possibilities in building materials. Come see the biodigester design that the Santa Fe Women's Group used.

What material can I use to feed a biodigester?

In theory, any organic material can be decomposed anaerobically to produce biogas, but some materials work better than others. In general, materials need to be rich in energy and easily digestible. Manure works very well, coming from cows, pigs, or horses. Biodigesters can be fashioned from septic tanks, but the waste production is often not enough to produce enough biogas, and cleaning agents (bleach etc.) kill the anaerobic bacteria necessary for digestion. Plant material can be used, but acidic matter should be avoided, for they disturb the anaerobic processes. Plant matter is also often low-energy and slow to digest, creating a number of difficulties for digesters relying solely on such material.

What is the production capacity of a biodigester?

This is probably THE MOST frequently asked question, and is the most difficult to answer for the following reasons:

- Biogas production is best measured by scientific processes not common in rural Costa Rica and with tools not available in rural Costa Rica (sorry)
- Biogas production varies with the type of material you use to feed the biodigester
- Biogas production varies with the temperature of the mixture inside the tank
- Biogas production varies with the acidity or alkalinity of the mixture inside the tank
- Other factors, such as defects in construction, can make true measurements of biogas production very difficult

To give an answer, though, the best estimate I can give is what I've measured in cooking time for the biodigesters that we have here in Santa Fe. Biodigesters here that measure 1.9 meters X 1.5 meters X 3 meters, that work well, will produce about six hours of cooking time daily. This should be sufficient for all the cooking for a large family.

Are there different styles of biodigesters?

Yes. There are many different styles of biodigesters. The Santa Fe Women's Group used a style that in Costa Rica is known as "media bolsa," consisting of a large underground tank that is covered by a large, inflatable plastic sheet. Another style used in Costa Rica is called "salchicha" ('sausage' in English), consisting of a plastic bag spread out in a ditch with tubes attached at each end to put in and take out the organic material. I am very interested in this style

end to put in and take out the organic material. I am very interested in this style and will make a page describing the instructions if I get the chance to build this type of biodigester.

How does climate affect biogas production?

Tropical climes generally have no problems with temperature because the anaerobic bacteria thrive in higher temperatures. If you live in a more temperate climate, you may need to heat the tank during colder months. If temperatures within the tank reach temperatures below 20℃, the biogas production slows down. Under freezing conditions, you will not have digestion—only a big poopsicle.

What is the most cost-efficient way to create a biodigester?

This will depend largely on the supply of certain materials that you have in your area. If you have access to affordable cement, I would recommend that you make a tank with cement. However, if you have very clay-like soil, you can maintain a biodigester tank in pure dirt with minimal draining. In April of 2006, this biodigester that the Santa Fe Women's Group built costed 161.000 colones, around $310 US at the time.

My biogas production has dropped quite a bit. How do I figure out what's wrong with my biodigester?

There are a number of things that can affect the biogas production in a biodigester.

Biogas leaks

If there is very little biogas, there may be a leak somewhere. If you are using water to seal the tank, make sure that water levels are sufficient enough to make a strong seal. In a biodigester like the ones the Santa Fe Women's Group made, if there are no problems with the water levels, you should check the plastic to see if there is a hole. With two or three people, you can remove the PVC frame from the plastic and hold the plastic up to sunlight to spot any holes that may have formed. If you don't find any holes, you can then check the PVC tubing that carries the biogas to the kitchen. To do this you can fill the tubing completely with water to see where, if anywhere, water is leaking through.

Temperature problems

As stated before, if temperatures reach below 20℃, you will experience a drastic decrease in biogas production. If this is the case, look to adapt a heating system to your biodigester.

Problems with the biodigester's pH

The pH in the biodigester tank should be as close to neutral (7) as possible. Since the anaerobic processes in a biodigester produce acids, the most common pH problem is one of acidity. If you do a simple litmus test on the biodigester's contents and the result is below 7, you should add a small amount of lime to normalize the tank's pH. Since excessive amounts of lime will not be soluble in the mixture and may harm the bacteria, you should never exceed a lime concentration of 500mg for every liter of mixture in the biodigester tank.

Other problems

There are a number of other problems that can arise during the life of a biodigester. To investigate problems, it is best to think back to the basics of what makes a biodigester work (organic material, strong water seal, warmth) and eliminate anything else that could possibly harm its functioning. For

example be careful not to introduce unnecessary chemicals into the tank, and try not to use livestock that has recently been given antibiotics or other medications, for these chemicals present in the manure may cause damage to the bacteria in the biodigester tank. Also, make sure to use non-corrosive materials for the structure of the tank. Cement and plastic cause no harm to the mixture in the tank, but metals should be avoided for use in the tank, or any of the tubing through which the biogas travels.

Why does the gas not escape from the biodigester tank?

In the biodigesters that the Santa Fe Women's Group made, there are small openings for the entrance and exit of waste material through which small amounts of biogas can escape. However, a vast majority of the biogas escapes through the surface of the mixture inside the confines of the plastic that covers the tank. Any biogas that escapes is negligible.

Why put steel wool in the biodigester tubing?

Steel wool (about three pieces) is placed in the tubing that carries the biogas to the kitchen in order to filter out impurities in the biogas. Biogas often contains elements that can stain the bottoms of pots and pans. Steel wool is not necessary, but is recommended.

How do you remove the digested material from the biodigester?

If the mixture in the tank is at the same level of the exit tube, anything introduced through the entrance tube will force the same volume out the exit tube on the other end. Ureka!

What can I use the digested waste for?

The digested material that comes out the exit tube of the biodigester is a liquid material that accumulates near the surface of the tank and is eventually forced out as more undigested material enters the tank. This liquid can be used as a convenient growth stimulant for nearby plants. In rural Costa Rica people often plant banana trees or vegetable gardens around their biodigesters, taking advantage of this great organic material.

Do you have any more information on biogas and biodigesters?

Well, we do have our own pages on biogas and biodigesters, but if you want further information, you can visit these online resources:

- Biogas news articles
- Beginners Guide to Biogas
- Biogas by Wikipedia