BORDER GREEN ENERGY TEAM

Padae Biodigester Installation Report
08/05/2007-18/05/2007

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1. INTRODUCTION

1.1 Background

As part of a United Nations Development Program (UNDP) grant, Border Green Energy Team (BGET) was commissioned to install a biodigester (BD) at the Padae School, in Padae, Tak Province, Thailand. Padae is a Thai-Karen village approximately 20km from Mae Sot, also in Tak province. The function of the BD is to provide methane gas, also known as biogas, to the kitchen of school, used to cook lunch for the approximately 200 students attending the school. It is fuelled by animal manure and other biodegradable material and as a byproduct also produces nitrogen-rich fertilizer.

The parties involved are as follows:

- From BGET, four Staff and one volunteer
- From the Engineering Studies Program (ESP), located at Mae La refugee camp ESP, two teachers and four students
- Paid Burmese-Karen labour, provided by the school
- Various Administrators and teachers of Padae School
- Padae residents

1.2 Scope

The scope of this report deals exclusively with the design and construction of the BD and some preliminary meetings with the administrators of the school. Further BGET trainings given in Padae shall be included in a separate report.

2. PRELIMINARY CONSIDERATIONS AND DESIGN

2.1 Consultations with Padae School

Once UNDP funding was confirmed and Padae School was selected as the benefactor of the BD, in early April 2007, BGET traveled to the school to do a site survey. A 7m by 7m area was chosen next to a boar pen, classroom and about 20m from the kitchen. This site was deemed ideal as it was close to the kitchen, pigs for fuel and possessed a water tap nearby. An unused structure occupied the site at the time and from informal discussions with a teacher, it did not seem to be a problem to tear it down.

Following this first visit, BGET Director Salinee Tavaranan and volunteer Adrian Armorer traveled to Padae with a proposed design. It proposed building two 4m^3 plastic tube biodigesters side by side. An open, covering structure was necessary for this design and was included. At the time, BGET felt uneasy using concrete as an alternative as it could not draw on any experienced masons. The headmaster of the school was unhappy with the prospect of a plastic BD and quietly insisted on concrete, which Salinee and Adrian agreed would be of higher quality and more robust. Also, it was decided to build a structure, regardless of the eventual BD design for aesthetic purposes.

At the follow up meeting, Salinee and Adrian presented a preliminary design to the Padae school administrators for approval. They approved, and it was decided that BGET would fund the construction of an iron and concrete open structure, but not supply the labour. Also, a "rights and responsibilities" document was presented to the administrators for their signature in order to clearly outline the responsibilities of all parties involved.

A few follow up site visits and meetings with the school administrators were conducted in order to straighten out minor details and organize incidentals such as food and material delivery schedules.

2.2 Biodigester Design

Previous BD construction experience was limited to the Polyethylene BD installed at the Agricultural School in Mae La refugee camp in February 2007. After the decision to go with concrete was taken, BGET explored many different designs of this type. Many were rejected based on the fact that the masonry was beyond the skills of anyone present at BGET. BGET also wanted a replicable project that once local inhabitants understand the concept and observe in action, can undertake on their own. A proven design was also desired, to ensure that it would work, so an in-house design was not feasible. Eventually, free of charge plans provided by Geraldo Baron of the Philippines were obtained and were deemed to be a good match for BGET's needs, budget and capacity. The design has won an award, so BGET feels confident it will perform well. A copy of the original plans can be obtained from him by contacting him. Geraldo Baron's website is:

http://www.habmigern2003.info/biogas/Baron-digester/Baron-digester.htm

Some modifications of the design were made by BGET according to our needs, availability of materials and interpretation of the plans. The BGET construction drawings can be seen in figure D.1. The most noteworthy changes are:

- *The addition of a circular inlet mixing tank*. It was felt that this was a simple, yet very useful addition given that it allows easier mixing of manure and water and lesser chance of loss as one would have to pour into the pipe from a bucket without the tank.

- *The resizing of the BD.* This was done because of the fact that the only concrete hollow blocks available in Thailand are 7cm wide, rather than 10cm, available in other countries. This was done to have a more even number of blocks in every row and avoid cutting the blocks when possible.

- *Changing the Inlet Location.* This was done accommodate the mixing tank, which was located in the corner closest to the boar pen.

- *Lowering the wall height of the outlet tank.* This was done in order to avoid having to place blocks over the wood joining the plastic to the concrete wall for easier replacement and aesthetics.

These changes were made constantly considering how it would affect BD performance and what negatives would result, if any. BGET decided that these modifications were acceptable and went ahead with this design.

3. INSTALLATION

3.1 Day 1

The installation started at approximately 8AM with BGET members Adrian, Dtee, Kom and Salinee present. Surat was not present but showed up the following days until completion. Most of the covering structure was complete with the exception of the roof, which had one Padae resident working on it. The location of the main BD tank was laid out and with the help of 4 Burmese-Karen labourers; digging began and reached 1m by the end of the day.

Due to the fact that the structure was incomplete, Dtee and Kom were compelled to help complete it, detracting labour from digging. It was agreed with the school that the structure would be completed *before* the start of the BD, but that did not seem to happen. Also, no local help was provided for the digging as was also agreed upon. The ESP students were not present as the final details of obtaining permission to leave the camp were being resolved.

Figure 3.1. The extent of the digging done on day 1.

3.2 Day 2

Digging continued with the best turnout of Padae inhabitants. About 8 showed up to help. We struck water at about 1m deep and large rocks at about 1.3m deep, considerably slowing down digging. Four ESP students arrived at lunchtime. The roof of the structure was completed by the end of the day.

3.3 Day 3

The final 20cm of digging was completed in the morning by the ESP students. In the meantime, sand and gravel was collected from the quantity we bought located elsewhere at the school. The rebar structure for the slab and wall of the main BD tank (visible in Figure 3.3) was built. This structure, initially intended to be wired together was welded instead by an employee of the school for us, which proved to be of great help. The wood mold for the concrete slab was also built that morning.

Figure 3.2. The final depth of the hole.

After lunch, the gravel, then sand was poured into the hole as a base for the concrete structure. The wood mold, then rebar was positioned and the slab poured, using the school's concrete mixer, also of great help. The concrete was left to dry overnight.

Figure 3.3. Pouring the concrete slab, with the rebar in place

3.4 Day 4

Upon arrival, the concrete slab was under about 5cm of water, but solid. This was the first real notice of water problems. After bailing out the water by hand, work was begun on the concrete block walls. Placing blocks, moving materials and mixing concrete were the bulk of the activity of the day. The inlet and outlet pipes were also placed and set in concrete.

Figure 3.4. Building the CHB walls, with the outlet pipe visible and the hole dug for the inlet pipe on the left.

3.5 Day 5

Day 5 was a Monday, and after the weekend, water had accumulated in the bottom of the BD. More bailing out of the water ensued. Mistakenly, it was decided to fill in the gap between the wall and the hole prematurely. This did not allow for water to go anywhere and therefore forced it towards the BD. The end result was that we had leaks and concrete used to smooth and waterproof the walls would not dry. The solution was to dig a hole deeper than the base of the slab to let water accumulate and we would then pump out. The pump was lent to us by the school. This solution seemed to work, but may be specious as much drier concrete was added and it had rained heavily over the weekend. Whatever the reason for the solution, the lesson learned was to not fill in the gaps between the walls and hole prematurely. The rebar and wood mold for the outlet tank were also built and welded with the help of the school welder. Some gas piping was installed on the structure of the classroom, to take advantage of a school holiday.

Figure 3.5. Digging the extra hole to alleviate water leaking into the BD.

3.6 Day 6

Upon arrival, much less water had accumulated in the bottom of the BD. Regardless, some had still infiltrated, so it was decided to pour another 3cm slab on top of the existing slab, this time with waterproofer. The inlet and outlet tank holes were dug and stabilized with gravel and sand. The slab was poured for the outlet tank along with the bottom two rings of the inlet tank and left to dry overnight. Wall building for the main tank also continued on the three other sides not touching the outlet tank. The gas outlet was installed on the wall closest to the school. Day 6 was also the arrival of the remaining 2 ESP students.

Figure 3.6. The freshly poured outlet tank slab.

3.7 Day 7

The concrete blocks of the outlet tank were completed, along with the waterproofing of the inside of both the main and outlet tank. PVC pipe cut lengthwise was placed on the top of the main tank as shown in figure 3.7 to protect the HDPE from any sharp corners in the concrete. The outlet tube for the outlet tank was also put in place. Wood was cut and drilled to be put around the edge of the plastic in order to achieve a gas-tight seal.

Figure 3.7. The PVC pipe used to protect the HDPE from the concrete.

3.8 Day 8

Final crack filling of all tanks was done early on. The position of anchors in the concrete for the bolts in the wood was marked, drilled and the anchors put in place. The HDPE was then cut to size, cleaned and tested to fit on the BD. The rest of the day was then spent positioning the HDPE, drilling holes in the concrete and taking every precaution for the crucial next step of installing the HDPE permanently.

Figure 3.8. Drilling the anchor holes.

3.9 Day 9

This final day consisted of positioning the wood over the HDPE in order to drill holes though it, using the holes in the wood as a guide. Then, silicone was applied to the concrete surface and the wood was bolted to the concrete, sandwiching the HDPE between them. The last of the gas piping was completed. A small set of stairs was built on the inlet tank to allow for easier mixing. Blue PVC piping was put around the outlet tank for aesthetics. From about 3PM on, students of the school filled the BD with pig, cow and goat manure. All the manure collected resulted in an initial charge of about $3m^3$ of a 50% manure by volume solution. About $1.5m^3$ of only water was added in order to achieve a water seal resulting in the BD reaching about 50% slurry capacity. The site was cleaned of construction garbage, instructions on fuelling were given to 3 teachers and the installation was complete.

Figure 3.9. Applying the silicone and the completed biodigester.

4. DISCUSSION AND CONCLUSIONS

4.1 Positives

To begin, BGET had never built a concrete BD, let alone worked with concrete very much prior to this date. Relying on what was felt as unspecific plans at best; the project was executed on time and within budget. Only time will tell how this BD will perform, but as of this date, few things look to be problematic.

- *Construction Time:* Considering the fact that the plans suggest a 10 day build, this was a definite success. Add to that the fact that BGET helped finish the roof of the structure and that less local labour was provided than expected, and the efficiency of the work becomes only more apparent.

- *Purchasing:* Purchasing also went well, as all material was locally available, except for the HDPE, which was ordered from Bangkok. Bags of cement were lacking and extra 1" PVC pipe was bought but everything else was used.

- *Gas-proofing the HDPE-Concrete interface:* While the product described in the plans was not available, it was decided to use silicone as a substitute. The silicone was not difficult to apply, is designed as a sealant and to adhere to both plastic and concrete and is weatherproof. While likely a more expensive solution than some other products, the seal is such a crucial part for the proper operation of the BD that it was worth it to spend the money on the best solution.

- *ESP Learning Experience:* For students only experienced in Solar-Diesel Hybrid installations, this install was "more hard work, thinking and longer" said Cici, the ESP teacher. There was much more manual labour, but also the engineering side of it was a larger part of this installation. ESP students often volunteered some very good ideas on how to solve problems and learned how to apply their educations.

  Compared to Micro-Hydro installations, the duration was the same and also amount of manual labour, but, the same as above applies. In both cases, the students got to learn how to really work with concrete, beyond the basics of mixing for the foundation of a PV rack or concrete slab of a powerhouse for a turbine. Waterproofing, smoothing, rebar and concrete hollow block construction were all learned. These skills will likely be applied anytime they are outside of the camp due to the prevalence of concrete everywhere.

4.2 Negatives

The negatives involved in this project were few and far between. But like any installation, some aspects can be improved upon.

- *Local Participation:* Relative to other BGET projects, this one is very accessible to locals to build their own, independent of BGET. The materials are accessible and, as long as a few fluid principles are understood, can be built without much expertise. BGET would have liked a local presence helping *every day* and observing construction, but regardless of who is to blame, did not happen. The upcoming training will hopefully correct this and have the local population involved aside from the students that were keen to help out and shall be responsible for fuelling.

- *ESP Permission:* Even though BGET applied for ESP students permission to leave the camp 6 weeks in advance, it wasn't until day 2 that they were able to leave. Also, two students arrived late, and two had to return for 2 days for resettlement interviews. While it may not be possible to reschedule interviews, permission was very slow and required some pressure to be put on Thai authorities. If this is just par for the course, then it might be unavoidable, but if ESP students are to be involved again, then either early application is necessary or to plan for their absence, whether it happens or not.

4.3 Conclusion

The first BGET biodigester installation went off with relatively few problems. With the help of this report and the installation guide, a second BD can surely be built even more efficiently than this first one. No more than 10 days are required for installation if 10 labourers are on site every day; all materials are available in Thailand; and experienced ESP students are available to help.

Upon further consultation with Mr. Baron, some recommendations were made on improving the seal between the HDPE and concrete. Essentially, the HDPE is lowered below the gas pipe. The gas piping would pass *through* rather than under the HDPE and is sealed using rubber and metal washers as shown in figure 4.1 below.

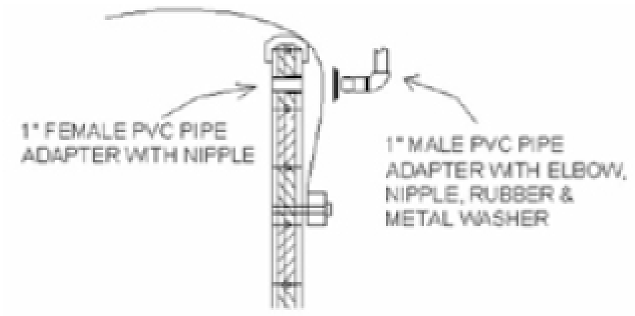


Figure 4.1. Detail of the gas piping outlet from the Biodigester.

The reason the HDPE is lowered and the piping raised is to be able to make a water seal between HDPE and concrete. A small piece of 3” pipe is installed in each wall to allow water to flow into the pocket between the concrete and HDPE.

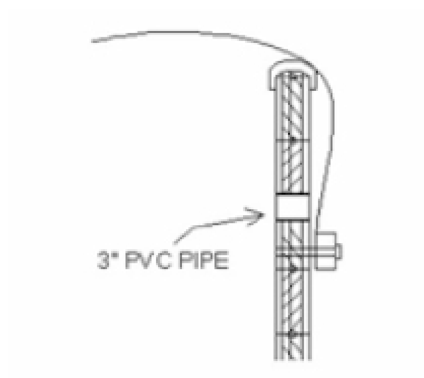


Figure 4.2. Location of the 3” PVC pipe to allow water in between the HDPE and concrete walls.

The fact that water ends up in this space does double duty; first it provides a better seal than just the silicone does, and second, it provides a way to visually check for leaks. A water seal is much more impermeable to the biogas than just the silicone on concrete and HDPE. Also, as soon as the water fills the space, if any leaks are present, water will leak out and the leak can be fixed. Minor leaks will be a trickle of water rather than a loss of biogas and thus not as important a loss to the end user.

On any subsequent BD installations, these simple and cheap modifications should be made as they will improve certainly efficiency.

Since the BD is such an appropriate and attainable technology for locals, it is important to have them involved in the initial construction process and trainings to spread the idea of the BD. This is a perfect project for BGET to continue doing and in that hopefully be copied independently by locals after being introduced to the concepts.

5. FOLLOW UP

BGET went back to check the produced gas a month after the installation. We found the leaks of all the corners where we cut and fold the HDPE. Therefore, the biodigester could not hold any gas. BGET found the practical solution. We used epoxy glue to fill up the holes or leaks at the corner and used aluminum bracket to hold the glue in place, as shown in figure 5.1.

Figure 5.1. Fixed leaks at corners using epoxy glue and aluminum brackets.

APPENDIX A- Anerobic Digestion Basics

From Wikipedia Encyclopedia:
http://en.wikipedia.org/wiki/Anaerobic_digestion

Anaerobic digestion (AD) is the harnessed and contained, naturally occurring process of anaerobic decomposition.[1][2] An **anaerobic digester** is an industrial system that harnesses these natural process to treat waste, produce biogas that can be used to power electricity generators, provide heat and produce soil improving material.[3]Anaerobic digesters have been around for a long time and they are commonly used for sewage treatment or for managing animal waste. Increasing environmental pressures on waste disposal have increased the use of AD as a process for reducing waste volumes and generating useful byproducts. It is a fairly simple process that can greatly reduce the amount of organic matter which might otherwise end up in landfills or waste incinerators.

Almost any organic material can be processed in this manner. This includes biodegradable waste materials such as waste paper, grass clippings, leftover food, sewage and animal waste. Anaerobic digesters can also be fed with specially grown energy crops to boost biodegradable content and hence increase biogas production. After sorting or screening to remove inorganic or hazardous materials such as metals and plastics, the material to be processed is often shredded, minced, or hydrocrushed [4] to increase the surface area available to microbes in the digesters and hence increase the speed of digestion. The material is then fed into an airtight digester where the anaerobic treatment takes place.

There are two conventional operational temperature levels:

- *Mesophilic* which takes place optimally around 37°-41°C or at ambient temperatures between 20°-45°C with mesophile bacteria
- *Thermophilic* which takes place optimally around 50°-52° at elevated temperatures up to 70°C with thermophile bacteria

The residence time in a digester varies with the amount of feed material, type of material and the temperature. In the case of mesophilic digestion, residence time may be between 15 and 30 days. In the case of mesophilic UASB digestion hydraulic residence times (1hour-1day) and solid retention times (<90 days) are separated. In the thermophilic phase the process can be faster, requiring only about two weeks to complete. Thermophilic digestion is more expensive, requires more energy and is less stable than the mesophilic process. Therefore, the mesophilic process is still widely in use.

Many continuous digesters have mechanical or hydraulic devices to mix the contents and to allow excess material to be continuously extracted to maintain a reasonably constant volume.

The digestion of the organic material involves a range of many different species of naturally occurring bacteria, all doing a different job at a different step in the digestion process. Maintaining suitable conditions in the digester is essential in maintaining a healthy bacterial population.

Four stages of anaerobic digestion have been recognised.

1. The first is hydrolysis, where complex organic molecules are broken down into simple sugars, amino acids, and fatty acids with the addition of hydroxyl groups.
2. The second stage is acidogenesis where a further breakdown into simpler molecules, i.e., volatile fatty acids (e.g., acetic, propionic, butyric, valeric) occurs, producing ammonia, carbon dioxide and hydrogen sulfide as byproducts.
3. The third stage is acetogenesis where the simple molecules from acidogenesis are further digested to produce carbon dioxide, hydrogen and mainly acetic acid.
4. The fourth stage is methanogenesis where methane, carbon dioxide and water are produced.

By-products of anaerobic digestion

There are three principal by-products of anaerobic digestion.

- Biogas, a gaseous mixture comprising mostly of methane and carbon dioxide, but also containing a small amount hydrogen and occasionally trace levels of hydrogen sulfide. Biogas can be burned to produce electricity, usually with a reciprocating engine or microturbine. The gas is often used in a cogeneration arrangement, to generate electricity and use waste heat to warm the digesters or to heat buildings. Excess electricity can be sold to electricity suppliers. Electricity produced by anaerobic digesters is considered to be green energy and may attract subsidies such as Renewables Obligation Certificates.

Since the gas is not released directly into the atmosphere and the carbon dioxide comes from an organic source with a short carbon cycle biogas does not contribute to increasing atmospheric carbon dioxide concentrations; because of this, it is considered to be an environmentally friendly energy source. The production of biogas is not a steady stream; it is highest during the middle of the reaction. In the early stages of the reaction, little gas is produced because the number of bacteria is still small. Toward the end of the reaction, only the hardest to digest materials remain, leading to a decrease in the amount of biogas produced.

- The second by-product (acidogenic digestate) is a stable organic material comprised largely of lignin and chitin, but also of a variety of mineral components in a matrix of dead bacterial cells; some plastic may be present. This resembles domestic compost and can be used as compost or to make low grade building products such as fibreboard.

- The third by-product is a liquid (methanogenic digestate) that is rich in nutrients and can be an excellent fertilizer dependent on the quality of the material being digested. If the digested materials include low levels of toxic heavy metals or synthetic organic materials such as pesticides or PCBs, the effect of digestion is to significantly concentrate such materials in the digester liquor. In such cases further treatment will be required in order to dispose of this liquid properly. In extreme cases, the disposal costs and the environmental risks posed by such materials can offset any environmental gains provided by the use of biogas. This is a significant risk when treating sewage from industrialised catchments.

Nearly all digestion plants have ancillary processes to treat and manage all of the by-products. The gas stream is dried and sometimes sweetened before storage and use. The sludge liquor mixture has to be separated by one of a variety of ways, the most common of which is filtration. Excess water is also sometimes treated in sequencing batch reactors (SBR) for discharge into sewers or for irrigation.

Digestion can be either *wet* or *dry*. Dry digestion refers to mixtures which have a solid content of 30% or greater, whereas wet digestion refers to mixtures of 15% or less.

[edit] Reactor types

There is a range of types of anaerobic digesters, however the two main types of operations are batch and continuous.

Batch is the simplest, with the biomass added to the reactor at the beginning and sealed for the duration of the process. Batch reactors can suffer from odor issues which can be a severe problem during emptying cycles.

In the continuous process, which is the more common type, organic matter is constantly added to the reactor and the end products are constantly removed, resulting in a much more constant production of biogas.

APPENDIX B- Biodigester Construction Manual

These are plans based on those graciously provided by Gerardo Baron (http://www.habmigern2003.info/biogas/Baron-digester/Baron-digester.htm) with more detail, visuals, and the modifications made by BGET.

1. Select a location no more than 50m from the end use of the gas. It should also be free of trees, roots and anything else that could damage the BD.
2. Dig a hole 3.0m x 2.6m and 2.0m deep.
3. Keep some earth nearby for filling the gap between the walls and the hole later.
4. Lay down 10cm of gravel and 20cm of sand once the hole is complete.
5. Prepare the rebar for the slab and walls as shown. The connections can be welded or tied with wire.

Figure B.1. The rebar structure.

6. Build the wood frame for the concrete slab.
7. Mix and pour the concrete for the slab, with the rebar in the slab close to the middle.
8. Smooth out the surface of the concrete using trowels or a flat piece of wood or metal.
9. Start building the concrete hollow block (CHB) walls. We decided to offset each block and pass the rebar through the hollow part of each block.

Figure B.2. The inlet and outlet pipes in place, and the pattern of CHB.

10. After the first row of blocks, attach at a right angle some horizontal rebar around the perimeter of the wall. This rebar can be welded or tied with wire.
11. Continue building the CHB wall, repeating step 10 every 3 rows until ground level.
12. Place the inlet and outlet pipes according to their depths on the drawing. They can be moved to adjacent walls according to convenience. This may require digging out the hole a bit further.
13. As you get about 3 rows up, begin the waterproofing of the outside of the wall. Used concrete mixed with fine sand. You will not be able to reach this point later, so it is important to do now.
14. When the wall approaches ground level, dig out a 20cm deep hole for the outlet tank and fill with 5cm of gravel and 5cm of sand.
15. At ground level, stop building the wall, weld or tie the rebar for the outlet compartment and pour the outlet compartment slab.

Figure B.3. Placing and welding the rebar for the outlet tank.

16. While the outlet compartment slab dries, begin waterproofing the inside and the rest of the outside of the tank. Use the same method as in step 13 for the outside of the wall, and for the inside add a second coat of only cement, water and waterproofer.
17. When the slab is dry, continue with the walls of the outlet compartment and main tank in sync, maintaining CHB interlocks. Do not finish the outlet walls higher than where the HDPE will fold over!
18. Don't forget to install the 4" PVC to drain the outlet compartment. Do not glue the elbow, as it must be able to freely rotate for emptying.

Figure B.4. The drain to the outlet compartment.

19. Install the outlet gas PVC pipe as you approach the top of the BD.
20. Waterproof the inside of the outlet compartment.
21. Put PVC piping cut in half over the top edge of the wall to protect the HDPE from sharp concrete. File down any sharp edges.

Figure B.5. The PVC used to protect the HDPE from the concrete.

22. Cut and drill holes in the wood. Place the wood precisely where you want it on the walls, using concrete nails as supports so that it doesn't move. Mark the location of the centre of each hole. Mark on the wood and below it and its exact location. This is important for step 24. Drill the anchor holes and insert the anchors.
23. With the HDPE cut to size, lay it over the BD in its final position.
24. Replace the wood, using the markings from step 22, and sandwich the HDPE between the wood and concrete wall. Gently drill the PVC, being careful not to ruin the anchor. Now the three holes should be all lined up: wood, HDPE and anchors. Put in bolts to test, but do not tighten.

Figure B.6. Positioning the wood to drill through the HDPE.

25. Choose a side to start and remove the bolts and wood. Leave the other 3 sides in place. Have people hold up the HDPE and apply a 15cm strip of silicone or sealer. Put a 2cm strip also just below the PVC pipe at the top of the wall.

Figure B.7. The silicone to gas seal the BD.

26. Repeat the same procedure for the other 3 walls. Touch up corners with silicone or sealant to ensure a gas tight seal.
27. Dig a circular hole 20cm down and 80cm in diameter so that the inlet pipe passes through. Fill the hole with 5cm gravel and 5cm sand.
28. Place two 8cm diameter concrete rings on top of each other, allowing the inlet pipe to come inside and end up flush with the top of the second ring.
29. Place large rocks in the two rings and fill the rest with concrete. Place a third ring on top and secure in place with concrete, but do not fill. Make stairs to ease mixing.

Figure B.8 The mixing tank.

30. Cut a length of 6” pipe to fit inside the pipe in the concrete, but do not glue in place. This will have to be removed to allow slurry to flow in.
31.

Figure B.9. The length of removable pipe in the mixing tank.

32. Complete the outlet piping to the stove. Place a valve as close as possible to the BD and one near the stoves. Try to have a constant slight incline. Condensing water vapour will flow back into the BD.

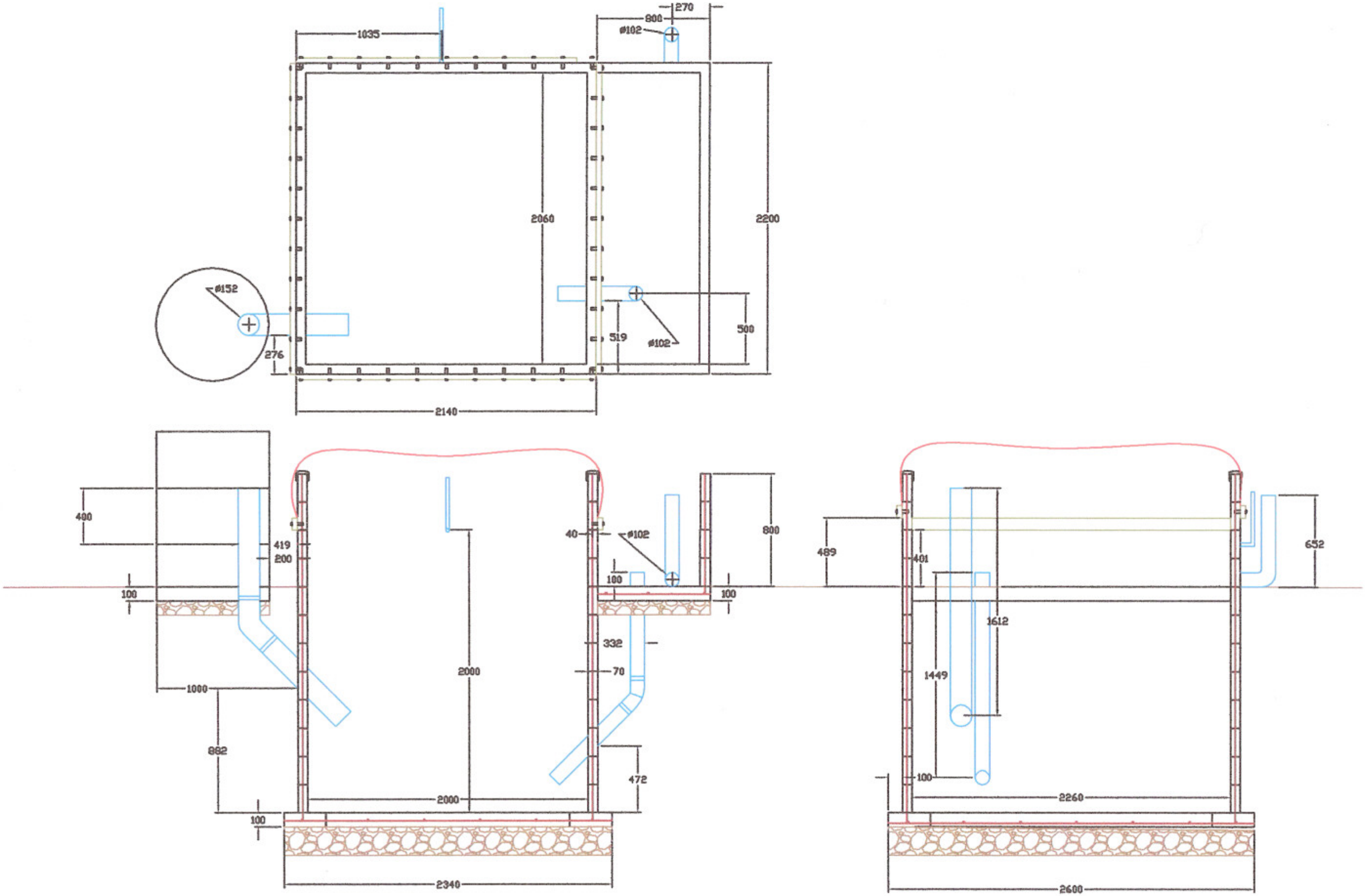
Figure B.10. Gas piping, with valve.

33. Mix pig or cow manure in a 1:1 ratio with water and fill the tank until half full. If not enough manure is available, fill with water until a water seal is obtained. You will have a water seal when the HDPE bulges slightly when fluid is added and does not sink back down afterwards.
34. Feed daily with 20L to 80L of manure mixed with an equal volume of water. In anywhere from 10-40 days, you should have biogas!

APPENDIX C-Materials, Approximate Cost and Construction Drawing

Qty / จำนวน	Item	รายการ	Unit Cost (THB)	Total Cost (THB)
380	4" CHB	อิฐบล็อก	4.25	1,615
10	10mm rebar	เหล็กเส้น 10 มิล ยาว 3 เมตร	97	970
1	dam(=4m3) of Sand	ทราย	1,000	1,000
1	m^3 Gravel	กรวด	700	700
25	Bags of Portland Cement	ซีเมนต์ / ปูนตราเสือ	112	2,800
3	1 gallon containers of Concrete Sealer	น้ำยากันซึม	80	240
3.2	kg Anchor Bolts	สกรูใช้กับคอนกรีต	60	192
50	Anchors	พุกตะกั่ว 3/8	25	1,250
2	Cans of Rubber Glue	กาวที่ทาระหว่างพลาสติกกับคอนกรีตเพื่อกันรั่ว	75	150
4	2x4, 3 meter wood	ไม้ 2 x 4 ยาว 3 เมตร	150	600
6	2x6, 3 meter wood	ไม้ 2 x 6 ยาว 3 เมตร	270	1,620
21	m^3 HDPE tarp 3m x 7m	พลาสติก HDPE	300	6,292
13	pieces of 1" PVC tubing, 4 m long	ท่อพีวีซี 1 นิ้ว	46	598
10	1" PVC elbows	ข้องอ 90 พีวีซี 1 นิ้ว	7	70
5	1" PVC connectors	ข้อต่อ พีวีซี 1 นิ้ว	6	30
2	packs of screws	สกรูโครเมียม	20	40
30	1" PVC pipe brackets	เหล็กตัวยูยึดท่อพีวีซี 1 นิ้ว	10	300
4	1" Gate Valves	บอลวาล์วเปิด ปิด PVC 1”	38	152
1	1” PVC T connectors	สามทางพีวีซี 1”	12	12
1	4 metres length 6" PVC pipe	ท่อพีวีซี 6 นิ้ว	881	881
1	4 metres length 4" PVC pipe	ท่อพีวีซี 4 นิ้ว	416	416
1	45deg elbow, 6"	ข้องอพีวีซี 6 นิ้ว 45 องศา	195	195
1	45deg elbow, 4"	ข้องอพีวีซี 4 นิ้ว 45 องศา	70	70
1	90deg elbow, 4"	ข้องอพีวีซี 4 นิ้ว 90 องศา	70	70
2	cans of PVC cement	กาวใช้กับท่อพีวีซี	115	230
1	stove connection	ตัวต่อเข้าถังแก๊ส	0	0
2	PVC cement brushes	แปรงทากาวท่อพีวีซี	8	16
3	cover piece on the cement block to protect HDPE (PVC 3”)	ชิ้นส่วนที่ครอบบนอิฐบล็อกเพื่อป้องกัน อิฐขูดขีดกับพลาสติก (ท่อพีวีซี 3 นิ้ว)	295	885
3	catchment’s tanks (concrete ring) for mixing tank	วงบ่อ	95	285
35	silicone	ซิลิโคน	105	3,675

3	silicone gun	ปืนยิงซิลิโคน	60	180
	Tools	**เครื่องมือ**		
4	Spade Shovels	พลั่วปลายแหลม / พลั่วปลายตัด	100	400
5	hoes	จอบ	0	0
2	Rock pics	เหล็กใช้เจาะหิน	0	0
1	hand cement mixer	เครื่องผสมปูนด้วยมือ	0	0
1	25/64" drill bit	ดอกสว่าน 25/64	40	40
1	3/4" masonry drill bit	สว่าน และหัวเจาะขนาดเดียวกับสกรูใช้กับคอนกรีต	285	285
2	hacksaws	เลื่อย	0	0
2	hacksaw blades	ใบเลื่อย	5	10
2	hammers	ฆ้อน	0	0
1	pipe wrenches (for anchor bolts)	ปะแจเลื่อน/ปรับได้ (สำหรับสกรูคอนกรีต)	150	150
2	wheelbarrows	รถเข็นปูน	0	0
3	50' extension cords	ปลั๊กต่อสายไฟ 50 ฟุต	0	0
2	various pliers	คีมปากจิ้งจก	45	90
5	buckets for manure collection	ถังใส่มูลสุกร	0	0
3	wheeled carts for manure collection	รถเข็นสำหรับในถังมูลสุกร	0	0
5	scoopers	อุปกรณ์ตักมูลสุกร	0	0
5	concrete trowels	ที่ฉาบปูน โบกปูน	25	125
1	full bget toolbox	กล่องเครื่องมือบีเจด	0	0
1	woodsaw	เลื่อยไม้	0	0
1	ladder	บันได	0	0
1	file	ตะไบ	110	110
7	kg of hose	สายยาง 30 เมตร	58	406
1	Rebar Cutter	กรรไกรตัดเหล็ก	450	450
1	Metal Wire	ลวดมัดเหล็ก	38	38
			Total	27,638



Note: All Dimensions in mm

	01/05/07	Designed by Gerry Baron, Modified by Adrian Armorer	
SCALE	BGET Padae Biodigester		