Design guide for biodigester treatment plant in cowshed housing

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Introduction

The various environmental impacts generated by dairy cattle farm, is a major worldwide concern. It is estimated that the livestock sector is one of the main causes of soil degradation and water resources, it is also responsible for 18% of emissions of greenhouse gases, including nitrous oxide (65%) of anthropogenic origin that according to FAO (2008) "*... has 296 times the Global Warming Potential of CO2. Most of this gas comes from manure ".* Hence the urgent need for alternatives to mitigate these effects.

In our country agriculture and livestock is an important activity that brings economic benefits, but also causes environmental problems to be addressed. Cervantes et al. (2007) indicate that:

"Milk production in Mexico has increased to over 10 billion liters in 2005; however, in recent periods growth rates have been volatile and with a declining trend. On the other hand, the percentage share of the different production systems is changing; the technified went from 24-51% and familiar decreased from 21 to 9% in the period 1980-2000. "

One of the factors that explain this reduction of "family system" is that very few technological changes have been incorporated.

There are areas with a clear dairy vocation that also complement this productive activity with the cultivation of fodder to produce their own food, in the state of Puebla traditionally a producer of milk and dairy community is Francisco Javier Mina, Chipilo, auxiliary board of San Gregorio Atzompa, located twelve kilometers from the city of Puebla. A recent study (Cervantes et al., 2007) indicates that 45% of households have a dairy farming as an economic activity. This figure clearly shows that environmental problems caused by this activity are important and it is essential to create specific solutions that help minimize them.

The issue concerns many specialists and researchers from different disciplines. From architecture, one of the challenges is to provide an integrated system including an appropriate technological solution for the treatment of waste power generation to the "Cowshed housing", so it contributes in reducing environmental impacts from cattle excreta and features production of renewable energy for various uses (heating, DHW heating, cooking, lighting and power) in communities characterized by the dairy farm.

It is estimated that the potential energy capture from the proper management of manure from cattle, represents an opportunity to provide electricity and biogas at different scales depending on the size of farms. Therefore, in this community is viable the integration of biodigesters in the "*home-Cowshed*", not only to help develop an environmentally sustainable dairy industry, but also to harness the energy potential of livestock waste.

The purpose of this manual is to spread the benefits of the implementation of the biodigester treatment plant as an alternative of treatment of waste for energy use, not only in the community of Chipilo, but in all of those that the "*Cowshed housing"* is a household production system.

It is started from the exhibition of the design features, the necessary calculations and recommendations for the farmer to use from the self-production of the biodigester treatment plant as power generation system.

The material presented here is structured from a synthetic methodology that makes easy to read and understand. Thus four stages are contemplated.

In the first stage, it is obtained the general information on where the biodigester treatment plant will be located, emphasizing the physical-geographical and climatic characteristics; in the second stage the data that determine the capacity and volume required depending on the specific needs of the Cowshed gather is acquired. The third stage is the formal proposal design that part of the calculations generated from the information collected and is presented by means of drawings to facilitate easy understanding of the biodigester factory treatment plant. Finally, in the last stage, the calculation of the production of biogas coupled with the analysis of the energy demand of housing-Cowshed is performed that will determine the potential use of biogas for cooking and its possible use to generate electricity.

Another item to note is the section in which the investment costs will be analyzed, essential aspect to evaluate the feasibility of these actions; emphasizing available public policies that support the financing of these technologies.

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SANTIAGO -AZPIAZU, Gloria Carola

1.What is Biomass?

Biomass is that organic matter of vegetable or animal origin; considered the stored energy of living beings. In the natural cycle, animals and plants take advantage of biomass, appropriating its power to improve their lives. The part that is not utilized is considered residual biomass. This residual iomass becomes a resource to generate energy to help us in every day. Residues of an activity such as livestock produce biomass that can be used to produce fuel and generate electricity.

Sources of Biomass			
Agricultural	Forestry	Industrial	Vegetables
Straw	Pruning	Inert waste (Nonabsorbable by the environment) Hazardous Waste with treatment	Terrestrial
Branches of Pruning	Forest clearing		Aquatic
Manure			

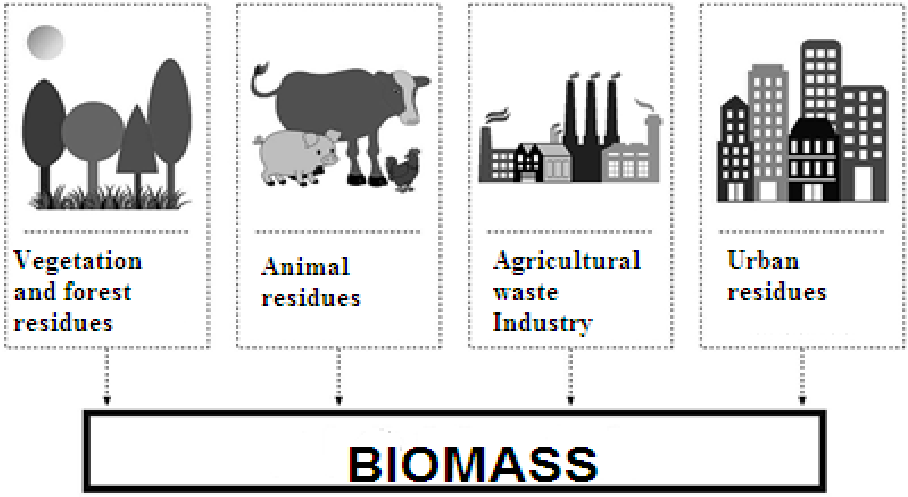
Table 1: Source Biomass based in Article Other Renewable energies. Industrial.IES Technology "Cristóbal de Monroy", Dept. of Technology.

Biomass has two main treatments:

- Thermochemical methods: Use the heat as a source of transforming dry biomass (straw, wood ... etc).
- Biochemical methods: Use the presence of microorganisms such as bacteria for performing the treatment of the biomass.

One of the most important biochemical methods for the treatment of biomass is the anaerobic digestion, which is considered one of the most suitable for treating biomass with a high moisture content and get a gas with low calorific processes, perfect to help in the field work; the use of the gas produced by the anaerobic digestion, can be used as natural gas.

The treatment of biomass has the advantage of decreasing carbon dioxide, a gas that occurs in various activities, including livestock, which affects the quality of the environment.



Scheme 1. Biomass. Web-based image, taken from: Knowing biomass and its benefits (2013, May 19). Recovered from http://comocuidarelmedioambiente.com/conozcamos-la-energia-biomasa-y-sus-beneficios

2. What is Anaerobic Digestion?

It's a simple biochemical process for converting organic matter into gas (methane) and is also an alternative for treating wastewater.

This process is generated by fermenting bacteria that decompose organic waste, which occurs in the absence of oxygen (anaerobic fermentation process), Saved (2006).

It has as products the biogas, which is a fuel with methane (CH4) and carbon dioxide (CO2) and also generates a subscription or natural fertilizer. So that biogas can be used as fuel, must be 50% or more of methane.

Fermentation takes various phases, the two most important are:

1. Acid: Where amino acids, fatty acids and alcohols are formed.

2. Gene Methane: Where methane (gas) is formed, the carbon dioxide and ammonia

To perform anaerobic digestion, an installation called Biodigester (biogas plant) is needed.

It is important to consider that the place where anaerobic digestion is performed must be completely closed; is considered that the digester is an equivalent to the process of digestion that occurs in cows.

Gene methane bacteria (producing biogas) are slow growing and metabolism is one of the most important things in the digester, so it becomes important to consider: the degree of acidity (PH), the temperature and the time required to organic matter is processed within the digester.

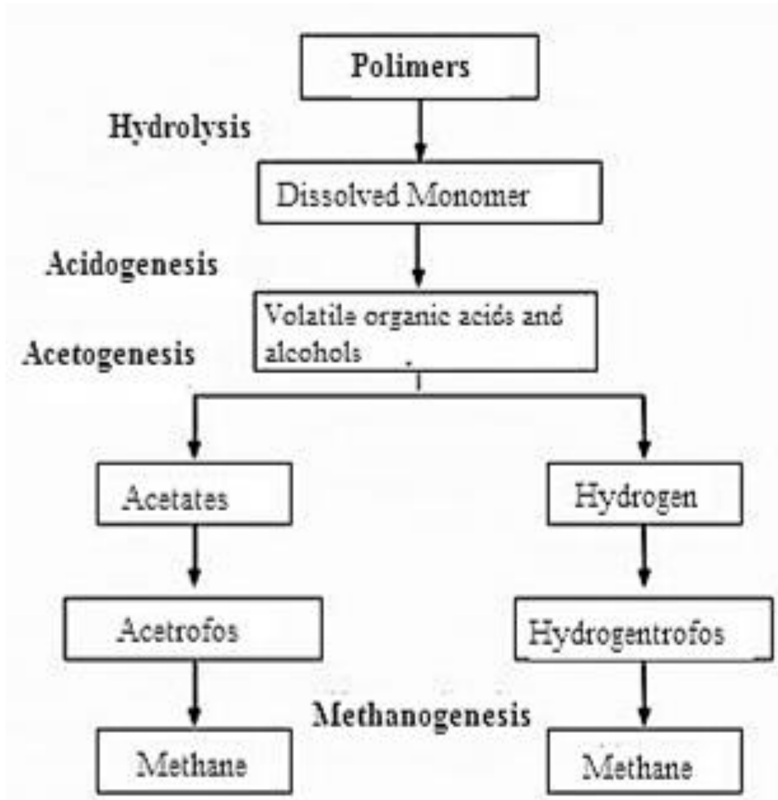


Figure1. Anaerobic Digestion Process. Retaken from Monografías.com. Part of a monograph. Ramos Castillo. Coffee pulp uses. Carballo Abreu, Pérez Díaz [2008]. Monografías.com, Pinar del Rio, Cuba. Scheme 7 simplified metabolic stages of anaerobiosis. Review 11 November 2013. availability http://www.monografias.com/trabajos68/usos-pulpa-cafe/usos-pulpa-cafe2.shtml

3. What is a Biodigester Treatment Plant?

The installation for the production and collection of biogas is called biogas digester plant. The biogas production process is conducted in a vessel known as digester in which the fermentation process is performed (anaerobic digestion) .Chacón (2006).

The digester is a technological alternative for the treatment of wastewater and cattle dung. For the smoothness and efficiency of fermentation material chosen, its combination with water is needed, since it is necessary to generate a mud or silt to methanogen bacteria can make the process easier.

The two main products of the biodigester treatment plant are biogas and fertilizer, called biol, which can be used as a natural nutrient in agriculture.

Biodigesters have a variety of classifications and typologies depending on different parameters, in particular the operational that are: temperature, agitation (mechanical methods) and retention time (Lacueva, 2012). Considering the simple technology, without added active methods for performing anaerobic digestion, retention time extensive adaptation and passive temperature control, there are three main types of digesters:

- Plant ball
- Plant of Fixed Dome
- Floating Bell Plant

3.1 Plant ball

Image 1 : Ground Ball. Web image. Biodigesters PVC. Medellín (2013, February 19). Available in http://medellin.olx.com.co/biodigestores-en-pvc-iid-483988340#

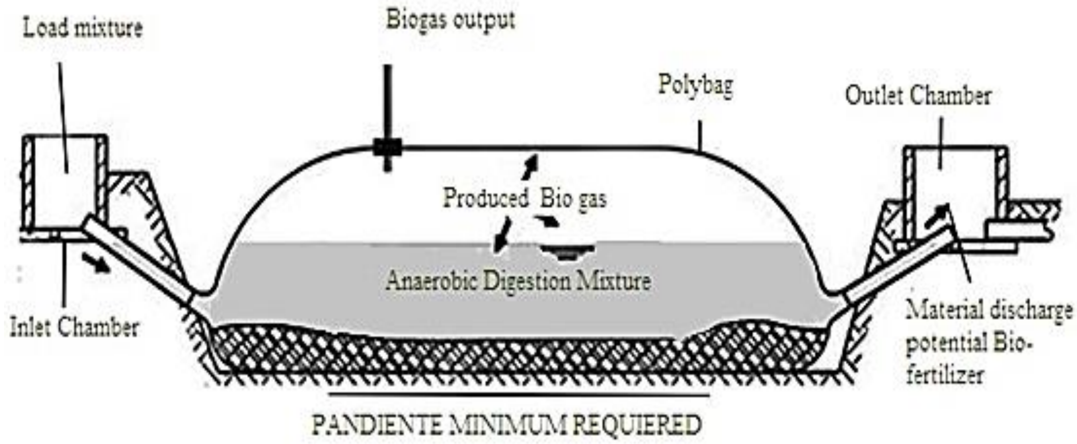


Figure 2. Resumption of Saved (Figure 3, page 14, 2007) Parts of Biodigesters plants. Robles-Gil (2001); Olaya (2006).

3.2 Plant of Fixed Dome

Image 2. Plant Fixed Dome. Web image. F. Cut Problems of Biogas Technology. Cuba, CUBASOLAR (No. 36, December 2006). Available in: http://www.cubasolar.cu/biblioteca/energia/Energia36/HTML/articulo04.htm

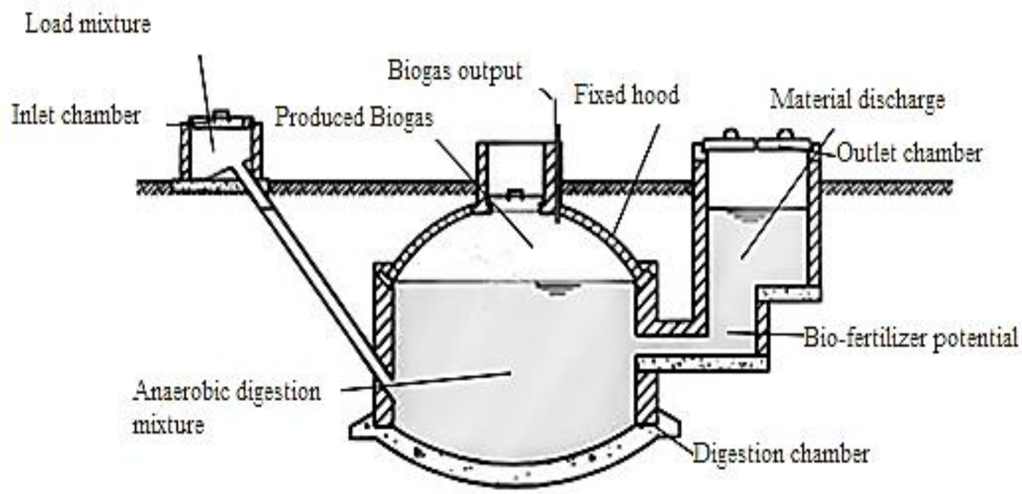


Figure 3. Resumption of Saved (Figure 3, page 14, 2007) Parts of biodigesters plants. Robles-Gil (2001); Olaya (2006).

3.3 Floating Bell Plant

Image 3. Floating Biodigester Bell. Web image, batch Biodigester. (2011, November) Available in http://queremosunmundomejor2012.blogspot.mx/2011/11/biodigestores-de-flujo-discontinuo_7104.html

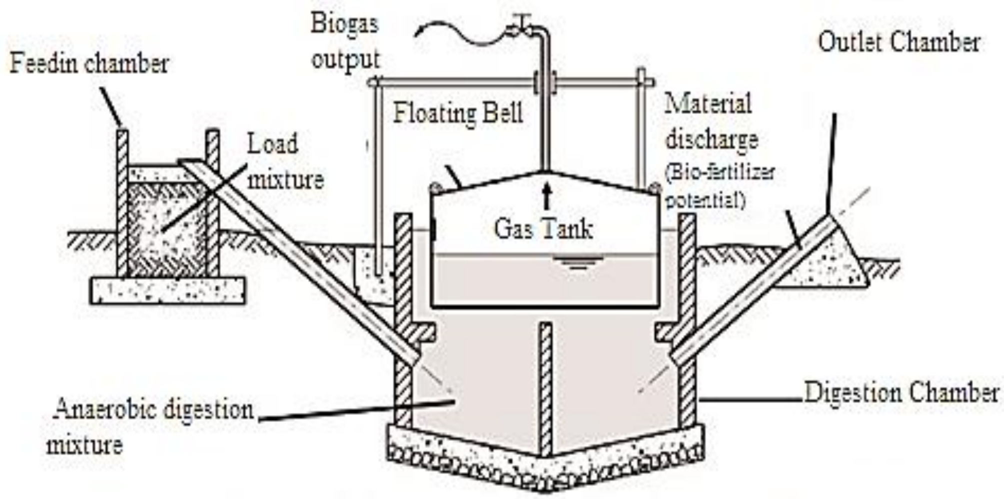


Figure 4. Resumption of Guardado (fig 3, page 14, 2007) Parts of Biodigesteras plants. Robles-Gil (2001); Olaya (2006).

4. How to choose a Treatment Plant?

Each of these plants has its own characteristics, according to the analysis, the choice of the treatment plant the following factors are considered:

1. Objective: What is the purpose?

2. Operating System: The way of filling the biodigester treatment plant, temperature ranges with which operates, capacity.

3. Technical Resources: Training you have to design and build the biodigester.

4. Economic Resources: Funding, heritage to make the investment for the construction of the plant.

5. Materials Zone: Block, Partition, pipes and materials needed for the design and construction of the biodigester treatment plant.

6. Type of organic matter: Excreta, remains of silos or animal feed. Depending on which to be treated is the type of plant that is chosen.

Returning to the above points, it is recommended to perform a table, allowing us an overview of the characteristics of the context of the study:

Objective	Operating System	Technical Resources	Economical Resources	Zone. Materials	Type of Organic Matter
Treating cattle manure. Help for overheads in electricity and gas in the house and barn (according to the conditions and characteristics of each).	Continuous (Loading media on a daily basis). Mesophilic temperature (12-35 °). Capacity according to retention time. (Minimum 45 days of duration).	Durable design of the digester. Capacity building on the site. Manpower Training. Review of a technical or specialist for the design or construction of PTB	Funding by the government to help rural infrastructure. Particular investment. Remuneration of investment products through giving the treatment plant.	Block Partition Red Annealing Cement Wire Rods Sand Clay	Using Dairy cow dung. Design according to the cattle.

Table 2. General Characteristics of the Community of Chipilo for selection of type Treatment Plant. Dueñas (2013)

To design and use the digester is necessary to take into account the characteristics of the place, because as has been seen is necessary to choose the type, capacity and utility that will give the biodigester treatment plant.

Once the analysis for the cause study in Chipilo is concluded Francisco Javier Mina have the biodigester fixed dome treatment plant, based on the changes proposed by Guardado (2007) is the best choice given the characteristics and conditions of the place.

So can be concluded for the case study the following advantages:

- A construction site with a good life, having ongoing maintenance.
- Mixing with water is only slightly water, by one of manure, in proportion (1: 1), allowing water savings.
- The parts of the plant are not prone to corrosion and wear.
- You can have a simplified method of construction that lasts for 10-15 days.
- The interior is sealed to ensure anaerobic digestion.
- Plug inspection, top, for easy cleaning.
- Saving gas under the dome of the digester.
- Construction materials known, manageable technical support.
- High quality biodigester treatment plant.
- A buried digester, which resists temperature changes that occur in the region.
- Easy operation and degradation in one place.
- Removing sludge in one place without disrupting the operation. Guardado (2006).

Also citing the following disadvantages:

- Calculation for design volume and basic geometry
- Construction supervision
- Skilled labor
- Increased cost of initial investment with long-term return.

According to the type of operation, according Vizquez (2010), biodigesters can be divided into Upper and Lower Rate. Given the characteristics of the place and there is no active tools for temperature, stirring sludge and sludge return; Fixed Dome biodigester will be considered within the regime Low Rate, which has the following characteristics:

- Increased volume and low cost of production by variety of materials.
- Use in agricultural farms.
- Extended Period, for the treatment of effluent.
- Retention of sludge in the digester.
- Income Filler and solid concentration of 1% to 8%.
- The mixtures can excreta of animals, combined with the water used for cleaning.

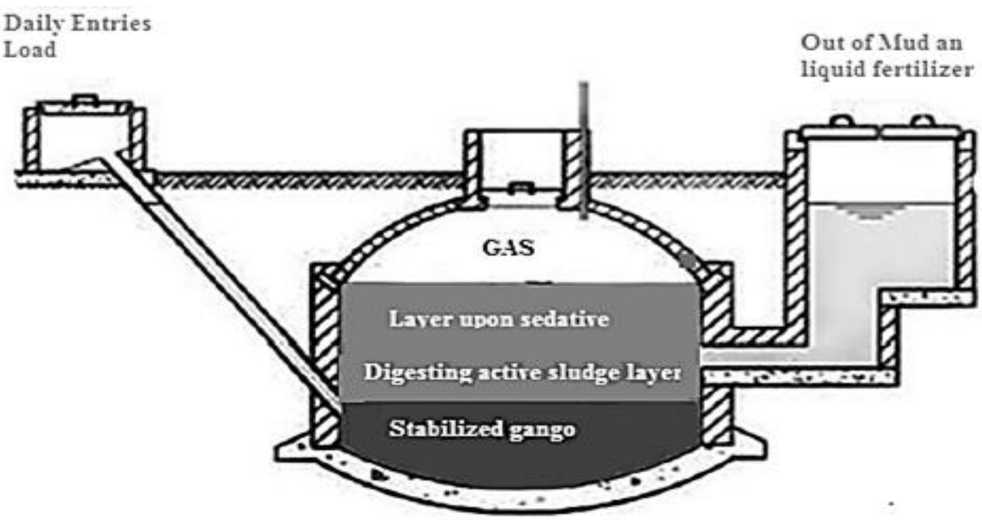


Figure 5. Sludge layers within biodiges- tor. Image Resumption of Guardado (2007), adapted by Dueñas (2013).

4.1. Factors and Design Indicators for a Biodigester Treatment plant

To design this biodigester treatment plant is necessary to consider the following factors:

Factor	Indicator
Ubication	Maximum <0.95 Maximum pressure length. (950m) + 0.5 Reference Level Up Level Land. Pressure of a column of water to 1m = 1000 (kg / m3) Design pressure required.
Retention Time	Ordinary Time: 30 days Retention Time Excreta Vaccine recommended for: 40 days.
	Working temperature: -PsicofIlica- 10 to 25 ° C / Low activity of bacteria. -Mesofílica- 12-35 ° C / Optimum 29 ° -33 ° C. - Thermophilic. 37 ° -65 ° C / 55 ° C Optimo
	Lower temperature (5 ° C biogas production stops). The maximum time is inversely proportional to temperature inside the digester.
P.H.	Optimal range: 6.6 to 7.6 / -6.5 / 7.5 Below 5 / 8- Above Inhibition of Fermentation Process. Stages:
	Acid.PH = 6 Basic.PH = 8 Neutral Value .PH= 7
Load Material	Recommendation 5-10% Dry content 16-17% Water content 83-84% Cattle: -Biodigester tubular.- daily mix ratio 1: 3 -Biodigester Fixed Bell.- daily mix 1: 1.
Biodigester Volume	Liquid Volume = Tiempo * Charge.= m3 Volume Gas= 1/3 V liquid.

Table 3. Factors and indicators for the calculation and design Biodigester, Various Authors. Synthesis, Dueñas (2013).

For the synthesis of Table 4 Bautista manuals (2010: 67) were used:

Guevara (1996: 80), Guardado (2007: 70), Martí (2008: 85), Víquez (2010: 61-64), establishing the factors and indicators to use for calculation and design of the digester in the context of study

One of the vital factors to consider is the location, as this will determine factors such as pressure, volume applicable, use of topography, type of construction, identification of sources of supply of water and organic matter. For location is important to know the characteristics of the land where will be built, keeping in mind also the types of equipment and machinery that biogas will used. The distance of the treatment plant and the place where the supply is found, the pressure also influence the biogas circulating inside the pipes, so it is recommended according Guardado (2006) distances of no more than 950 m of degeneracy point and exit point of the biogas.

Analyzing the factors proposed for the design of a Biodigester treatment plant, it could be concluded as the best option for the case study, design and construction of the plant Fixed Dome low rate.

The biogas generated within the treatment plant, it can be used for cooking in kitchens, lighting, and operation of boilers, internal combustion engines and welds.

Biogas production depends on many aspects, including the composition of manure that varies with power, handling of waste and soil types that are taken into the barn.

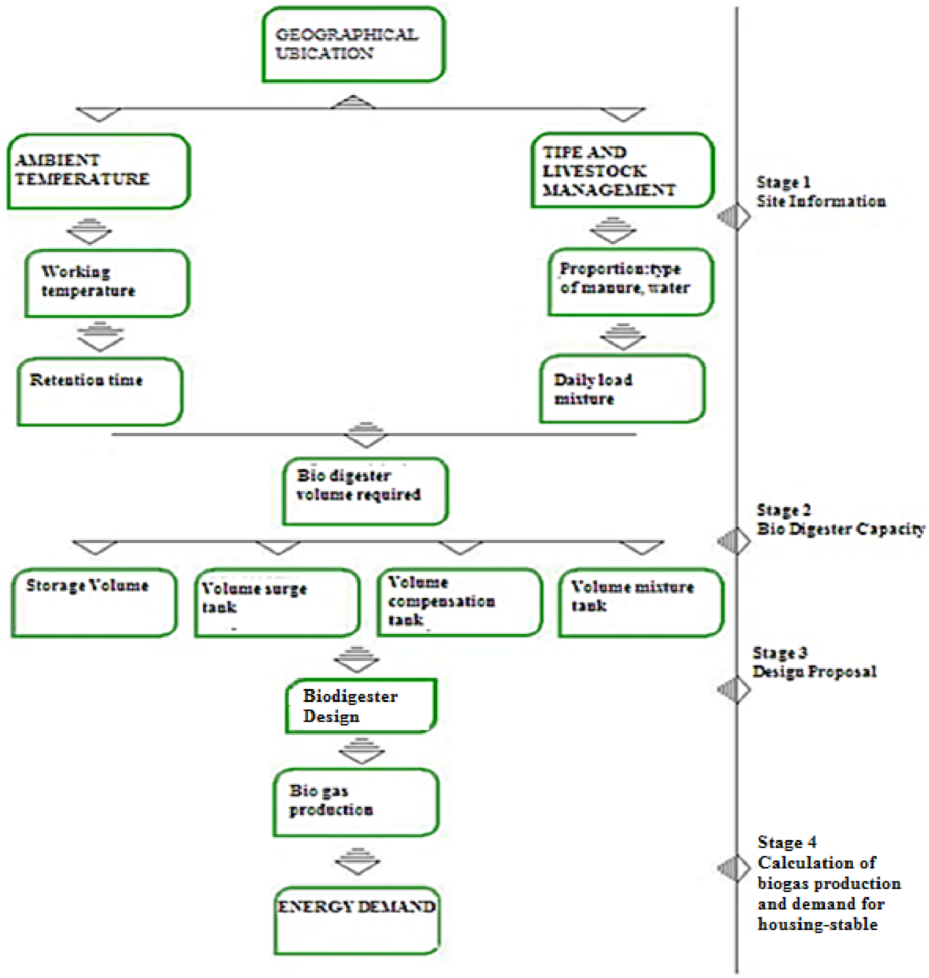
5. Considerations for the Biodigester Treatment Plant Design

For the design of a Biodigester treatment plant of a fixed dome is important to point although in the literature can be identified criteria given by different authors, is due on adaptation to the context where it was built.

An important contribution of this book is the proposal of a biodigester treatment plant in the community of Chipilo, according to the characteristics and needs of the place.

A review and adaptation to be applied in the study site, as is the community of Chipilo is required.

An outline generated by Dueñas is presented (2013) to understand what steps and factors to consider in the design of the biodigester treatment plant.



Scheme 2. Design Biodigester Fixed Dome. Dueñas (2013).

The geographic location affects bio digestion, especially its altitude, in relation to temperatures reached. The village of Chipilo of FranciscoJavier Mina, has an altitude of 2139 meters.

The location and orientation of the treatment plant help the conservation of temperature, although by common sense is known that the south is warmer, should be identified the limitations of land and existing buildings, as they influence the installation site and the rate of radiation of the biodigester treatment plant.

In general it can be said that the average temperature of the village of Chipilo according to the study of climate, through the Köppen-García system by Dueñas (2013) it has a sub humid climate with an average temperature of 17.1 ° C, with high temperature oscillation.

Making necessary to conserve the temperature inside the digester, where is appropriate to buried it, in order to maintain the temperature in the range of 30 ° - 40 ° C, to generate the digest, as is has the psychrophilic temperature range 10 to 25 ° C (room temperature) and it should be kept stable; it is recommended that in the months where the temperature drops more than 5 ° C, hot water will be used, the mixing, to help the process of anaerobic digestion.

Should be considered in the daily mix, the field survey was done in the community, in the stables prefer Dung by shovel and wheelbarrow, having a storage place for it and its removal through trucks; which directly allows the realization of the dung-water mixture in the ratio 1: 1. In order to save water to be used in the mixture and maintain the ratio 1: 1, it can be considered that:

1. The wash water work areas can be recycled and can be used to perform daily mixture; always they do not contain chemicals, disinfectants (chlorine). If it is hot water, it will further help to maintain equilibrium temperature necessary for bio digestion.

2. In the case of using hose a practical method it is necessary to how many liters of water out of the hose in a minute and calculated by the time it takes to perform the task, how much water is used and also knows how much of kg manure it had.

The mixing ratio of daily load is basic because it helps us to determine the size and capacity of the digester, besides affecting digestion.

Retention time (while remaining the mixture within the digester), that determines the quality of products especially biogas, if it has a proportion of less methane at 50% it is no longer flammable, as specified by Guardado (2006). Uniting the type of climate (temperature) with the type of manure (cattle) and by reviewing past experiences of others, is considered ideal a retention period of 56 days to the region where it is proposed, with the least consider a retention period of 40 days.

5.1 Features and Benefits of production

Each author proposes differently, the ability to produce biogas from manure, the proportion of how to mix with the water and the necessary retention time to produce biogas.

Animal	Daily Animal Manure Wet (Kg)	Biogas-(M3/Day)	Manure-Water Ratio
Pig	2.25	0,101	1:1-3
Cow	10	0,360	1:1
Horse	10	0,300	1:1-3
Sheep	5	0,200	1:1

Table 4. Indexes to determine Biogas production from the weight and Characteristics of the biomass. Based Proposed by Guardado (2007) .

In general the daily muck produced by cows it is ranging from 8 to 10 kg per 100 kg by animal body weight. Because chelates power, handling and collection of excreta, marked changes in these numbers for design calculations used in this manual, it is considered that manure production is 10 kg, as is seen in the manual written by Guardado (2007).

By generating the daily mix (water-manure), it is important to balance the mixture entering and exiting, because that is going to determine the product of sludge and fertilizer (biol) we will have, plus they help to correct operation of the digester, allowing the renewal of sludge.

According to their treatment bio digestion, will the wealth of methane (CH_4), calculated from 65-80%, with an average calorific value of 23 MJ / Nm3, which leads to savings in fuel consumption, and reducing greenhouse with an efficiency 20 times the CO_2 generated during combustion, this according to Best Available Techniques Guide Dairy Sector in Spain (2008) .The use of biogas, from a Biodigester treatment plant promotes savings within the range of 6-8 kWh / m3 proposed by the Best Available Techniques Guide Dairy Sector in Spain (2008); always being careful in determining aspects of it such as anaerobic effectiveness of that system and determining the levels of pH and hydrogen sulfide.

Deffis C. (1999), gives a comparative value of the biogas fuel compared to other fuels. This table allows us to perform comparative biogas energy.

Fuel	Kcal/m3	Kcal/Kg	Fuel quantity equivalent to 1000 m3 of biogás (M3)
Biogas	5,335	-	1,000
Natural gas	9,185	-	581
Methane	8,847	-	603
Propane	22,052	-	242
Butane	28,588	-	187
Electricity	860 Kcal/kWh	-	6,203
Coal		6,870	776
Oil		11,357	470
Fuel Oil		10,138	526

Table 5. Comparison of Biogas Energy. Deffis Case (1999) Energía Using Primary Sources ecológica.pp.163.

In more practical terms, for the production and use of biogas according to Martí (2008) we can say that:

Premium Organic Matter	Production	Biogas spending	
Water dung mixture	Biogas	Cooking gas	Generator electricity by burning
80 Lts Daily Mix (proportion 1:1)	700-750 Lts /day biogas	140 – 170 lts / hour	300 lts of biogas/hour for electricity generator

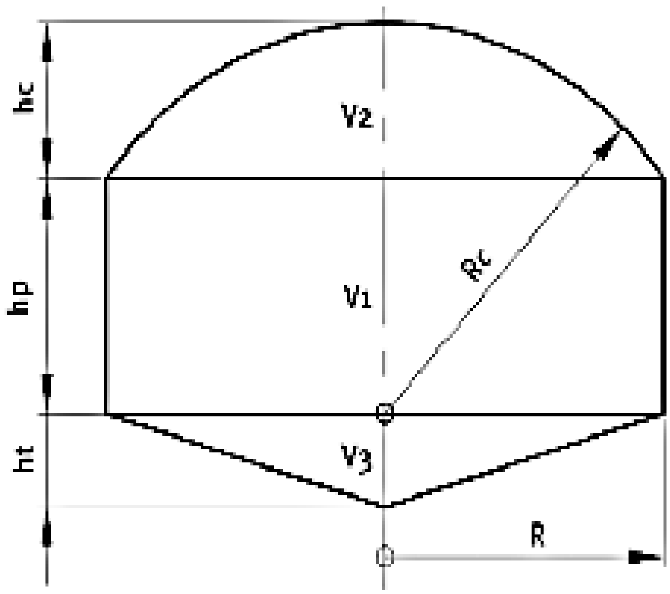
Table 6. Production and use of biogas. Martí (2008).

We have tha 1 m3 biogas (70% methane) is equal to 0.55 liters of diesel, Aguilar and Botero (2006) or 0.80 liters of gasoline, Chacón (2006), also has an equivalence with 1.5 m3 butane gas.

5.2 Technical Design Specifications

For drawing and projection of fixed dome digester, calculations are based on the document "Design and construction of simple biogas plants" Guardado (2007); including due to the adaptation made to the place, changes of some variables and the need for simplified calculations.

Then the calculation formulas presented; where you can appreciate the basic geometry used to establish the basic steps for your design.



U: Unit
hc: Dome height
hp: Wall height
R: Basic radio
Rc: Dome radio
D: Diameter of the cylinder
ht: Cone base height

Proportions
$R_c = 5 . U$
$D = 8 . U$
$hc = 2 . U$
$hp = 3 . U$
$ht = 0,15 . D$

Proportional Unit
$U = R/4$

The constant 1.21 is valid for measuring uidad given by Metre

Digester Volume
$Vtot = V1 + V2 + V3 =$
$= R^2 . \pi . 1,321$

Partial volumes
$V1 = R^2 . hp . \pi$
$V2 = hc^2 . \pi . [Rc . (hc/3)]$
$V3 = R^2 . \pi . (ht/3)$

Basic radio
$R = \sqrt[3]{V_{tot} / (\pi . 1,321)}$

Figure 6. Parties in Which a fixed dome digester and Their formulas are divided. Guardado (2007, pp.24)

The calculation of fixed dome digester for the case study was conducted from the definition by Guardado (2007), and some particular emphasis in changes such as:

1. In the case of surge tank, due to the lack of explanation of the variables, will seek to follow the recommendation to give size having a volume equivalent to the volume of the spherical segment, having a radius equal to the digester and leaving a border of 20cm to consider in overall height.

2. For the volume of the spherical segment, by a lack of mathematical precision to achieve the appropriate total volume of the digester, being limited by the publication of the manual and do not have the privilege to converse with the author, it was decided to change the second mathematical formula to calculate the volume of the spherical segment:

Volume spherical segment. Guardado (2007)	$V = hc^2 . \pi$.[Rc.(hc/3)] hc= Dome height Rc= Dome ratio

(1)

So for purposes of this manual, for calculating the spherical volume, the formula is completely changed by the resumption of vitutor.com (http://www.vitutor.com/geo/esp/v_9.html), where it has that:

Volume of spherical cap (2nd Formula)	V = πh^2/3 (3r-h) h= Height of the spherical segment. r= Spherical ratio

(2)

It have taken the same variables in the spherical volume formula Guardado (2007), which can be seen in Figure 2, but completely changes the formula of volume 3.

Another important factor is the ambient temperature, so as previously recommended above, it is important to consider a retention time of 56 days; taking as basis the proposed by Martí (2008) on "Family Biodigesters. Design Guide and Installation Manual ", which establishes the general climatic characteristics:

Tables T.7.Compilación Marti (2008) .Table 4.1 Retention Time according Temperature (pp.27) and Table 5.1 Identification of Eco-regions according Room Temperature and Height (pp. 47).

Region	Ambient temperature	Work temperature	Height (msnm)	Retention time (days)
Tropic	13 a 38 °C	25-30 °C	0-1800	20
Valley	5 a 30 °C	15-20 °C	1800-2900	30
Plateau	-12 a 20 °C	6- 10 °C	2900-4500	60

Table 7. Compilation of Tables Martí (2008) .Table 4.1 Retention time as temperature (pp.27) and Table 5.1. Identification of Eco-regions according to room temperature and height (pp.47)

For the calculation of retention time it was taken into account the climate in the place, as it was mentioned the oscillation and extreme temperature environment, which implies ranking between valley and plateau, mostly determined the altitude of 2140 meters because the average annual temperature is 17.1 ° C. For what it was made averaged retention times of this classification of eco-regions for the design of biodigesters according to Martí (2008), resulting in 45 days at least to increase the quality of anaerobic digestion and the fertilizer is 25% increase in the retention time, so that the retention time at 56 days.

As taking the specific characteristics of local climate following the construction and operation of the digester is recommended:

1. Seizing the average temperatures of the day, ie leverage filling the digester with the sunlight, so that with the help of sunlight the digestion process is maintained.

2. If the rudeness or construction of the digester occurs in a portion of the land, where no south facing has recommended that construction of this greenhouse is made to have a greater influence on the temperature that must be anaerobic digestion.

5.3 Dimensioning General Biodigester

In this section, only the calculation of the geometry of the digester will be complemented with the general tables, where the results of the formulas used for different parts of which are synthesized the biodigester treatment plant is composed, with a range will be discussed 10- volume of 100 m3.

Variables and constants, for the case study will also be defined; thus having a general guide to determine the capacity of the digester with different volumes, according to the particular needs of the farmer. Finally will be exemplified how should be the design sketch, plan and section, to have a correct construction.

5.3.1. Key Features

To calculate the first thing is to know the number of cattle, as this determines the amount of manure produced per day. For this issue must be considered:

1. Amount of manure produced per kilogram of animal per day, in this case the cow, which will be considered in the animal 10 kg / per day.

2. Time passing cattle in the barn (storage time), considered in 18 hrs / day, thinking about 6 hours lost due to the rest of the animals at night and milking time, as it requires other cleaning inside the parlor.

3. The average live weight (RRP) of each cow is estimated at 400 kg of animal, this because it does not have an exact knowledge of the weight of each animal varies according to your age, type of feeding, breed of cattle.

4. The live weight equivalent of each cow (PVe), which is considered in 350 kg, according to Table 6 Design and Construction of Simple biogas plants Guardado (PP26, 2007).

5. Environment temperature range, the average temperature as mentioned above is 17.1 ° C, clear that it is important to note that the maximum temperatures recorded are an annual range of 26 ° C to 28 ° C and minimum temperatures 2.7 ° C-11.3 ° C according to the National Weather Service (1971-2000).

5.3.2. Calculating day manure

The general formula for calculating manure day takes these concepts and develops as follows:

$$\text{Manure Day} = \text{Cattle (Cow)} \times (PVp/PVe) \times \text{Amount of manure (Cow)} \times \frac{\text{Housing time}}{24\ \text{hrs}} \quad (3)$$

After having the amount of manure generated by day, according to the amount of livestock proceed to calculate the suspended solids produced by that amount of manure:

$$\text{Suspended solids} = \frac{\text{Kg Manure}}{\text{day}} \times 0.2\ (20\%) = \frac{\text{Kg Suspended solids}}{\text{day}} \quad (4)$$

Finally the daily mixture volume is obtained (dung-water) that is required in the case of cattle manure the ratio is 1: 1, i.e., 1 kg of manure per 1 kg of water, for practical reasons it may be performed according to the proportion of buckets, but always taking care that the condition of the ratio is attained.

$$\text{Daily mixture volume} = \frac{\text{Manure}}{\text{day}} + (1\text{xManure day}) = \frac{\text{Kg}}{\text{dairy mixture}} \quad (5)$$

Table 8 shows the results of the above-explained formulas that determine us the volume in m3 digester according to the number of cattle, for practical terms, the following tables show the total volume of the digester that will be considered in approximation closed to the immediate superior, as can be noted in Table 9.

Quantity of Cattle	Manure day [1](kg/day)	Suspended solids day (20%)[2]	Total volume (Kg/Dairy mixture) proportion 1:1	M3 Day	Bio digestor total volume (TR: 56 days)[3]
10	85.50	17.10	171.00	0.171	9.58
15	128.25	25.65	256.50	0.257	14.36
20	171.00	34.20	342.00	0.342	19.15
25	213.75	42.75	427.50	0.428	23.94
30	256.50	51.30	513.00	0.513	28.73
35	299.25	59.85	598.50	0.599	33.52
40	342.00	68.40	684.00	0.684	38.30
45	384.75	76.95	769.50	0.770	43.09
50	427.50	85.50	855.00	0.855	47.88
55	470.25	94.05	940.50	0.941	52.67
60	513.00	102.60	1026.00	1.026	57.46
65	555.75	111.15	1111.50	1.112	62.24
70	598.50	119.70	1197.00	1.197	67.03
75	641.25	128.25	1282.50	1.283	71.82
80	684.00	136.80	1368.00	1.368	76.61
85	726.75	145.35	1453.50	1.454	81.40
90	769.50	153.90	1539.00	1.539	86.18
95	812.25	162.45	1624.50	1.625	90.97
100	855.00	171.00	1710.00	1.710	95.76

Table 8. Calculation of manure day biodigester Fixed Dome, Made by Guardado 2013. Based on calculations Guardado (2007). (2013).

5.3.3. Calculating Total and Volatile Solids Volume

After obtaining the total volume in cubic meters, a closed approximation of cubic meters is necessary to do the calculations and checking the volatile solids becomes.

1 Storage time 18 hrs/24 hrs, giving a factor of 0.75.
2 It is considered with 20 kg/day. Guardado (2007).
3 Bio digester total volumen considering retention days needed for digestion

Volatile solids according to CNA in NMX-AA-034-SCFI- 2001 standard, are defined as the amount of organic matter (including those inorganic) capable of volatilizing the effect of calcination at 550 ° C (+ - 50 ° C) in an estimated 15-20 minutes. In other words they are able to waste combustion and volatilize. To calculate the following formula is used:

Volatile Solids (kg/m3)	=	Suspended solids by day (kg/day)	÷	Biodigester total volume (m3)

(6)

Cattle quantity	Total volume M3	M3 Closed aproximation	Volatile Solids
10	9.58	10	1.71
15	14.36	15	1.71
20	19.15	20	1.71
25	23.94	25	1.71
30	28.73	30	1.71
35	33.52	35	1.71
40	38.30	40	1.71
45	43.09	45	1.71
50	47.88	50	1.71
55	52.67	55	1.71
60	57.46	60	1.71
65	62.24	65	1.71
70	67.03	70	1.71
75	71.82	75	1.71
80	76.61	80	1.71
85	81.40	85	1.71
90	86.18	90	1.71
95	90.97	95	1.71
100	95.76	100	1.71

Table 9. Calculating and Volatile Solids Volume for Fixed Dome Biodigester conducted by Dueñas (2013). Based on Guardado (2007).

5.3.4. Calculate Geometry and Basic Volumes

For the calculation of basic geometry formulas described above according to Design and Construction of Simple Biogas Plants treaters by Guardado (2007) with the main formula of the radio, to help to get the other measures of basic geometry.

Radio basic formula is:

Radio básic $$R = \sqrt[3]{\frac{Vtot}{\Pi(1.121)}} \qquad R = \sqrt[3]{\frac{Vtot}{3.521725}} \tag{7}$$

From this formula the proportional unit is obtained, with dimensions for measures that seek balance in the measures proposed to the geometry of the digester.

$$\text{Proportional unit} = \frac{\text{Radio}}{4} \tag{8}$$

In the following table we have the formulas applied, according to the proposed volumes cubic meters.

Importantly, the measures are not punctual, however are basic measures that serve to build the plant, treat the measures are as close as possible to closed number.

Biodigester total volume M3	Basic radio M	Proportional unit	Dome radio	Cylinder diameter	Dome height	Wall height	Baded cone height
10	1.42	0.36	1.78	2.84	0.71	1.07	0.43
15	1.62	0.41	2.03	3.24	0.81	1.22	0.49
20	1.78	0.45	2.23	3.56	0.89	1.34	0.53
25	1.92	0.48	2.40	3.84	0.96	1.44	0.58
30	2.05	0.51	2.56	4.1	1.03	1.54	0.62
35	2.15	0.54	2.69	4.3	1.08	1.61	0.65
40	2.25	0.56	2.81	4.5	1.13	1.69	0.68
45	2.35	0.59	2.94	4.7	1.18	1.76	0.71
50	2.4	0.60	3.00	4.8	1.20	1.80	0.72
55	2.5	0.63	3.13	5	1.25	1.88	0.75
60	2.6	0.65	3.25	5.2	1.30	1.95	0.78
65	2.65	0.66	3.31	5.3	1.33	1.99	0.80
70	2.7	0.68	3.38	5.4	1.35	2.03	0.81
75	2.8	0.70	3.50	5.6	1.40	2.10	0.84
80	2.85	0.71	3.56	5.7	1.43	2.14	0.86
85	2.9	0.73	3.63	5.8	1.45	2.18	0.87
90	2.95	0.74	3.69	5.9	1.48	2.21	0.89
95	2.99	0.75	3.74	5.98	1.50	2.24	0.90
100	3.05	0.76	3.81	6.10	1.53	2.29	0.92

Table 10.Calculation of basic geometric measures to Biodigester Fixed Dome by owners (2013). Based on Guardado (2007).

Once certain measures are necessary to make the formulas that will help us to determine the volumes needed to form the overall geometry of the digester and Total Volume.

To calculate the volume of the cylinder (V1), the following formula is used:

$$\text{Cylinder Volume} = (\text{Basic radio})^2 \times \text{Wall height} \times \pi \quad (9)$$

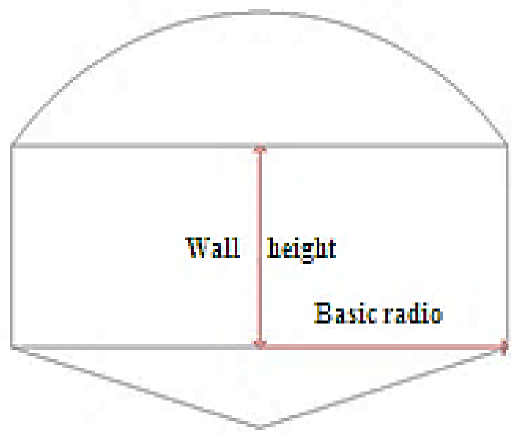


Figure 7. Volume 1, Based on Guardado 2007, author Dueñas (2014)

To calculate the volume Spherical Segment (V2), as explained earlier, it has been changed for better approximation to the m3 required.

$$\text{Sperical Segment Volume} = \pi \times (\text{Height}^2) \times (\text{Radio Sphere}) - \frac{\text{Height}}{3} \quad (10)$$

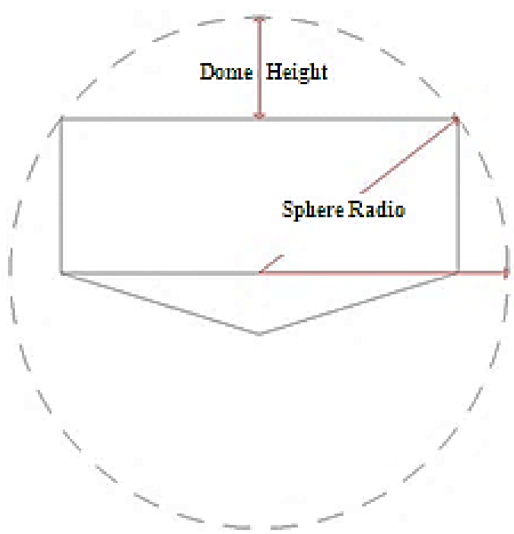


Figure 8. Volume 2, Based on Guardado 2007. Author Dueñas (2014)

Volume three, the cone base in the bottom of the digestion chamber is calculated with the following formula:

$$\text{Volume Cone Base} = \text{Basic Radio} \times \pi \times \frac{\text{Height Cone Base}}{3} \quad (11)$$

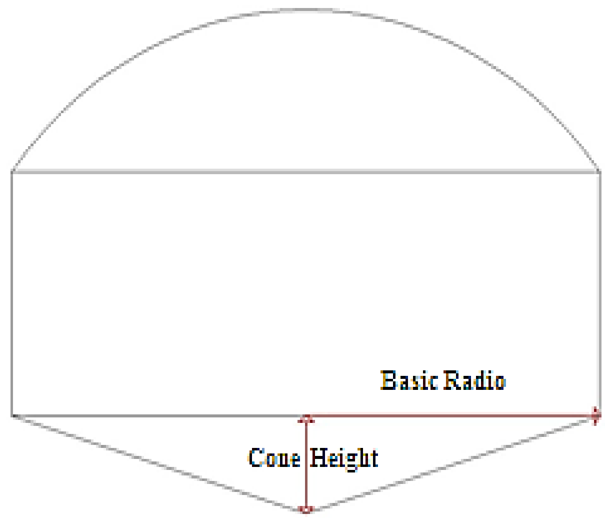


Figure 9. Volume 3, based on Guardado 2007. Author Dueñas (2014)

Checking finally the formula of Total Volume is applied, via radio, this gives an approximate to see if the volumes obtained meet the capacity needed.

$$\text{Checking total volume} = (\text{Basic radio}^2) \times \pi \times 1.121 \quad (12)$$

Certainly by applying this formula was found as can be seen in the following table calculation, with some small variation, but in practical terms the volume condition is met.

Digerter Volume V1+V2+V3	Basic Radio	Cylinder Volume V1	Sphere segmnent volume V2	Based cone volume V3	Cheking total volume
10.08	1.42	6.75	2.44	0.90	10.08
14.06	1.62	10.02	3.62	0.43	14.97
18.65	1.78	13.29	4.80	0.56	19.86
23.41	1.92	16.68	6.02	0.71	24.93
28.49	2.05	20.30	7.33	0.86	30.34
32.87	2.15	23.42	8.46	0.99	35.00
37.67	2.25	26.84	9.69	1.14	40.11
42.92	2.35	30.58	11.04	1.30	45.70
45.72	2.40	32.57	11.76	1.38	48.68
51.67	2.50	36.82	13.29	1.56	55.03
58.12	2.60	41.41	14.95	1.76	61.90
61.54	2.65	43.85	15.83	1.86	40.81
65.09	2.70	46.38	16.75	1.97	69.32
72.60	2.80	51.72	18.68	2.20	77.31
76.56	2.85	54.54	19.70	2.31	81.53
80.66	2.90	57.47	20.75	2.44	85.89
84.90	2.95	60.49	21.84	2.57	90.41
88.48	2.99	62.98	22.82	2.67	94.14
93.91	3.05	66.85	24.22	2.84	99.92

Table 11 Calculating Volumes for Biodigester Dome Fixed by owners (2013). Based on calculations of Guardado (2007).

Given the overall geometry of the Bio digertion chamber for biodigester treatment plant is necessary to consider measures surge tank, and must possess the necessary volume to store the fermenting biomass, Olaya and Gonzales (2009).

Its geometric shape corresponds to the cylinder and since the literature tends not to be as specific technically at this point was chosen for practical terms do the following:

1. The basic shape is a cylinder, so that the basic radius of the digester will resume

2. To determine the height, the view that the dam compensation must equal the volume of the dome in the case of Guardado (2007) retake, however in order to have a clearer idea the formula of Oyala and Gonzales is used (2009), to calculate the gas storage volume:

Gas Volume	$\frac{\pi h}{6}$	X	$(3a^2 + 3b^2 + h^2)$

(13)

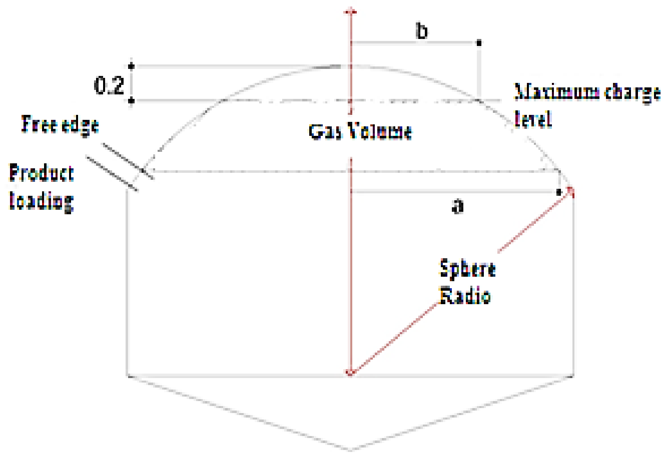


Figure 10. Gas volumen based on Olaya and González (Figure 11, pp 25,2009). Author Dueñas (2014)

Where h = height, b is measures of the dome, which when calculated allow us a better approximation.

The application of this formula will help us to make a check of the volume required in addition to pursuing a proposal of measures necessary to propose the surge tank, since when do the breakdown of this formula according to Olaya and Gonzales (2009), we have the necessary measures, being as follows:

$h = \frac{2(\text{Basic radio})}{5}$ $a = \frac{4(\text{Basic radio})}{5}$ $b = \frac{\text{Basic radio}}{2}$

This guidance will have to propose measures surge tank, of course also we have to take into account the volume of the spherical segment obtained from geometric formulas and formula of volume of gas given above.

Gas Volume				
M3	Gas Volume	a	b	Height
10	1.07	1.14	0.71	0.37
15	1.39	1.30	0.81	0.45
20	1.90	1.42	0.89	0.51
25	2.49	1.54	0.96	0.57
30	3.09	1.64	1.03	0.62
35	3.62	1.72	1.08	0.66
40	4.21	1.80	1.13	0.70
45	4.86	1.88	1.18	0.74
50	5.20	1.92	1.20	0.76
55	5.95	2.00	1.25	0.80
60	6.76	2.08	1.30	0.84
65	7.20	2.12	1.33	0.86
70	7.65	2.16	1.35	0.88
75	10.08	2.24	1.40	0.92
80	10.67	2.28	1.43	0.94
85	11.29	2.32	1.45	0.96
90	11.92	2.36	1.48	0.98
95	12.44	2.39	1.50	1.00
100	13.27	2.44	1.53	1.02

Table 12. Gas Volume Calculation for Fixed Dome Biodigester conducted by Dueñas (2013). Based on Olaya and Gonzales (2009).

So we can conclude with steps to the surge tank is also important to consider the staircase, which is communication between the Bio digestion camera and the surge tank.

M3	Gas Volume	Sphere segmentationn Volume	Radio	Height
10	1.07	2.44	1.42	0.40
15	1.39	3.62	1.62	0.45
20	1.90	4.8	1.78	0.50
25	2.49	6.02	1.92	0.55
30	3.09	7.33	2.05	0.60
35	3.62	8.46	2.15	0.65
40	4.21	9.69	2.25	0.70
45	4.86	11.04	2.35	0.75
50	5.20	11.76	2.40	0.75
55	5.95	13.29	2.50	0.80
60	6.76	14.95	2.60	0.85
65	7.20	15.83	2.65	0.85
70	7.65	16.75	2.70	0.90
75	10.08	18.68	2.80	0.90
80	10.67	19.7	2.85	0.95
85	11.29	20.75	2.90	0.95
90	11.92	21.84	2.95	0.95
95	12.44	22.82	2.99	0.95
100	13.27	24.22	3.05	0.95

Table 13. Surge tank measures according to Gas and spherical Volume segment for Biodigester Fixed Dome. Calculation Made by Dueñas (2013).

The surge tank (Figure 8) must be attached to the biogas camera by a staircase, which depend directly on the height of the wall of the digester, below are a series of recommendations to consider:

- It is considered that should be spaced 30 cm background, considering this measure from the bottom slab of the digester which will determine the end of the second step.

- Must be 20 cm above the finished grade (roughly the same level of the neck of the dome), should not be completely buried, and the side that is not connected to the bio digestion camera, is considered an overflow pipe, if the tank capacity is exceeded.

- The tube must be sloped to facilitate the exit give an earthen ramp permitting its support according to the slope or level of the finished floor is slightly lower to allow the vent pipe. It is considered that this overflow optimal sludge is used or the tube allows drainage connection.

- The criterion can be considered, that the beginning of the first step matches the tank floor and purpose of the match start of the dome (Chain of rudeness), for reasons of structural support.

- Do not have to respondent’s manuals, specification of the size tank access compensation to the Bio digestion chamber, however seeing the designs of another biodigesters, a minimum width of 1 meter for this connection of the staircase is determined.

For the mixing tank, which includes sand trap (Figure 7), it was considered to be calculated, the criterion proposed by Guardado (2007), where the internal volume should be 10-20% more than the daily load considered.

For a better guide to action, it is recommended see Figure 8, wherein the general Biodigester sketch Treatment Plant is located.

Number of heads of cattle day	M3 Day	M3 + 10 %	M3+20%	Proposed Measures	Measures with material	Width
10	0.171	0.19	0.205	Radio	Radio	Interior
15	0.257	0.28	0.308	0.45m	0.60m	0.45 m
20	0.342	0.38	0.410	Height	Height	With walls
25	0.428	0.47	0.513	0.8 m	0.93m	0.60 m
30	0.513	0.56	0.616	Radio	Radio	Interior
35	0.599	0.66	0.718	0.6 m	0.90 m	0.60 m
40	0.684	0.75	0.821	Height	Height	With walls
45	0.770	0.85	0.923	0.8 m	0.93m	0.90 m
50	0.855	0.94	1.026	Radio	Radio	Interior
55	0.941	1.03	1.129	0.65 m	0.95m	0.65m
60	1.026	1.13	1.231	Height	Height	With walls
65	1.112	1.22	1.334	0.95 m	1.10 m	0.95 m
70	1.197	1.32	1.436	Radio	Radio	Interior
75	1.283	1.41	1.539	0.75m	1.05 m	0.75m
80	1.368	1.50	1.642	Height	Height	Con muros
85	1.454	1.60	1.744	0.95 m	1.10 m	0.95m
90	1.539	1.69	1.847	Radio	Radio	Interior
95	1.625	1.79	1.949	0.80 m	1.10 m	0.80 m
100	1.710	1.88	2.052	Height 0.95 m	1.10 m	With walls 0.95 m

* It is considered brick walls of 15 cm thick and a staff of 10 cm thick.

Table 14. Volume Calculation Tank Mix-Desarenador in M3. Dueñas (2014).

The proposed dimensions in the table, trying to give a criterion for adjusting measures according to the material used, it is important to remember that the column proposed measures is based on the calculated volume, taking up 10% of the daily burden and if another material other than partition is chosen, it must calculate its measures for its construction.

As you have noted in the Table, volume calculation tank-mixed sand trap, sand trap width is considered as the proposed radius; which can be considered as valid if there is any modification to the measures proposed in the table.

Within the sand trap, according to Guardado (2007), is considered a clogged drain should be able to perform when filling the bio digestion chamber and serves mainly to remove sediment or undesirable material. The second section is the sand trap that has a sloping portion opposite the loading tube, to prevent the inert material, ie material which cannot be degraded into bio digestion and affecting the production of biogas. Finally, the third section is where the loading tube, usually of PVC with a diameter of 10-15 cm depending on the size of the digester, is proposed if there are one or two tubes of charge.Importantly, the loading tube, on the side that enters the digester is recommended by Guardado (2007), who is of 40-60 cm from the bottom to prevent clogging of the same.

Cattle	Mix tank (Radio)	Basic radio (metros)	Drainage Section (a)	Desarenador Section (b)	Load tuve Section (c)	Desarenador depth (Pending) (d)
10-25	0.45 m	1.42-1.92	0.40	1.00	0.55	0.30
30-45	0.60 m	2.05-2.35	0.50	1.50	0.65	0.35
50-65	0.65m	2.40-2.65	0.60	2.00	0.75	0.40
70-80	0.75 m	2.70-2.90	0.70	2.00	0.85	0.45
90-100	0.80 m	2.95-3.05	0.80	2.50	0.95	0.50

Table 15 Desarenador dimensions of the digester. Dueñas (2014).

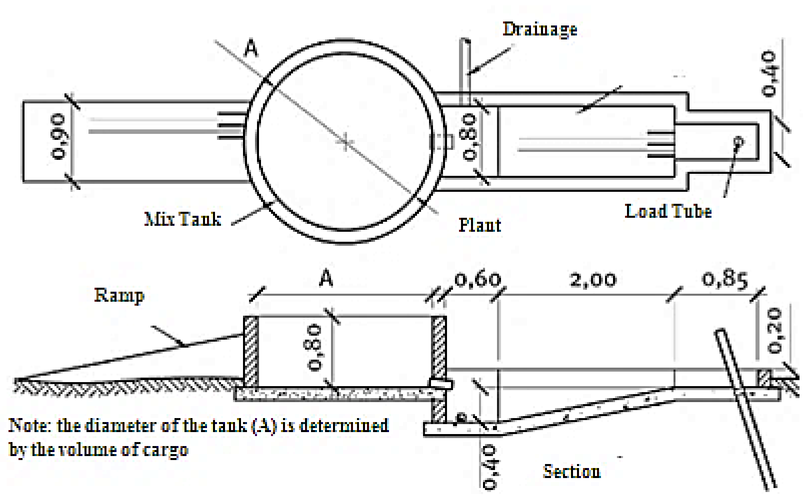


Figure 11. Tank Mixing and sand trap, resumed by Guardado (Figure 12 pp 31,2007).

As the drain section, the height of 0.20 m is kept on ground level, thus giving the slope regularly.

Finally the tube outlet sludge is important to keep a record of at least 0.60 m wide by 1m long; this is recommended, as the output of overflow sludge is not by mechanical means. Should also be noted that this output allows the sludge is stored in a container such as a bucket. The tube diameter will be the same as that used in the loading tube.

Then the general conclusion calculation a sketch of the Biodigester treatment plant of a fixed dome (Figure 8) is shown, where the plant and cut the digester is, to a greater understanding of calculated measures and an approach to how should be the digester at the end of their design.

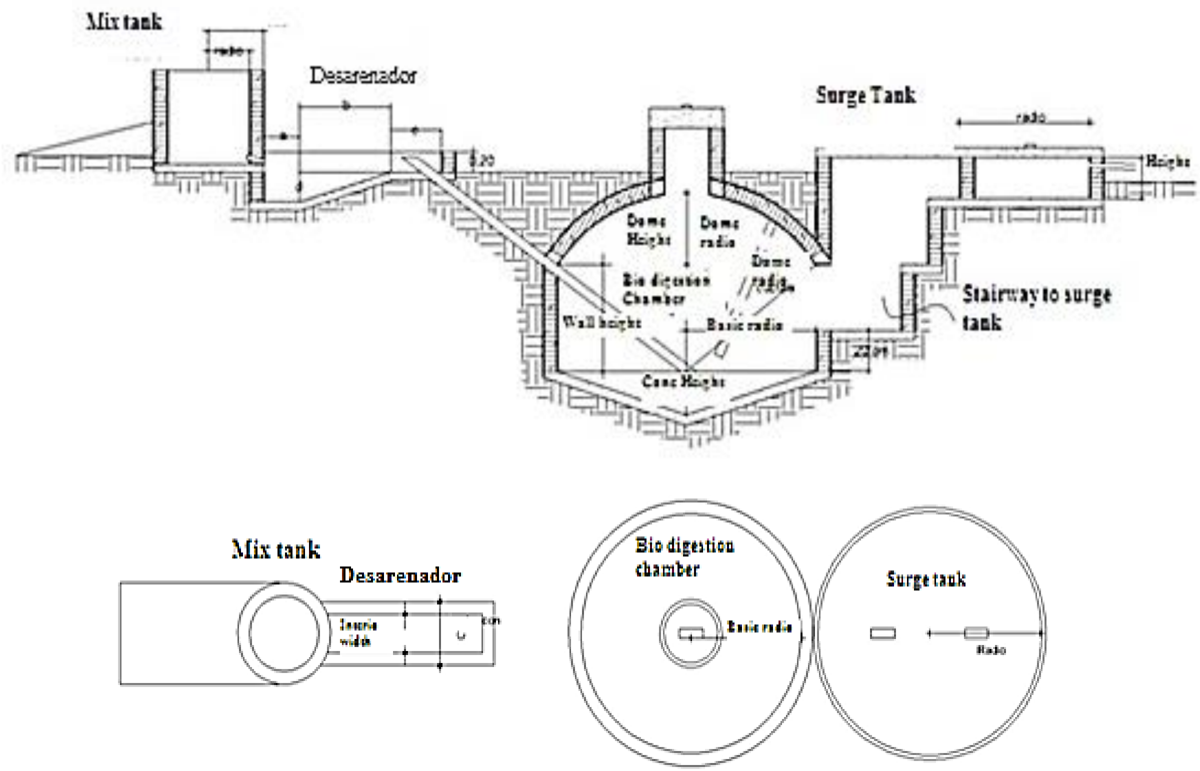


Figure 12 Treater biodigester fixed dome plant (10 m3), Cut and Ground. Adapted and Performed by Dueñas (2014).

5.4 Proposal for Community biodigester Chipilo in the State of Puebla, Mexico.

Example of Dimensioning biodigester

Given the purpose of linking the theoretical to the practical results, then develops a real example, which will enable us to make implementation of the suggestions and applications developed by the authors.

To better understand the sequence given in Scheme 2. Schematic Design for Fixed Dome digester.

Stage 1. Preliminary information from the site.

5.4.1. Location.

The selected context is located in the community of Chipilo of Francisco Javier Mina, in the municipality of San Gregorio.

It has an altitude of 2140m in general, access to main roads and the construction of the house-barn is mostly an orientation to the West and the free area an area used as a dunghill with a general orientation to the east.

Premises.

The site is connected by an easement to a main road. It is a gentle hilly, with little inclination. Where is unplanted construction has a very slight slope towards the drain that overlooks the surrounding area.

Two annexes land that will be considered as one, sharing dependencies have. The two properties have a total area of 2742.96 m2, also has an annex property with wearable device free area of approximately 340 m2; which is currently used as a dunghill of the two stables with a direct connection to the drain that goes to the street.

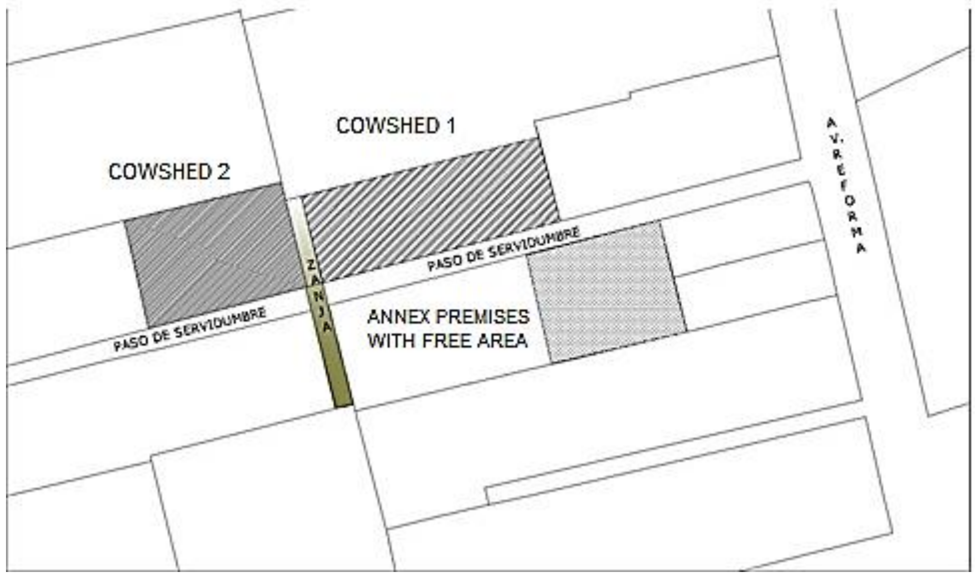


Image 4. Cowshed Housing Premises

The two properties are connected by a bridge crossing a drainage ditch, which is the source of contamination and deterioration of natural resources, especially subsurface layers that with time can contaminate water sources site. This contamination is reinforced by the fact that the lero esterco- is outdoors, without restraint, templates to avoid leaks and excessive burden that affects daily cleaning.

Housing- Cowshed: It has two houses consist ground floor and a floor, spatially distributed in dining room and kitchen on the ground floor, three bedrooms each, and a full bath upstairs apartment.

With regard to drinking water, one has well and the other with public provision, although it is used as a power source for stables well with submersible pump.

The first barn building typology is traditional materials such as bricks, tiles and some modifications foils and steel profiles in functional analysis the main problem is that the patio merges with the easement, the house and the dependencies, which determines difficulties in their productive use. The second barn which is after the trench has only one wing and differs from the courtyard of the house and other outbuildings; Built with materials such as steel profiles and sheets, with concrete floor and storage area. Both sheds stable, have a water cover, with a maximum height of 3.5 m in the barn with steel and 2.7 in the barn built with bricks.

Image 5. Cowshed 1 Community Chipilo of Francisco Javier Mina. Dueñas (2013)

Image 6. Cowshed 2 Community Chipilo of Francisco Javier Mina. Dueñas (2013)
Image 7.

Image 7. The Annex to cover Cowshed property. Community Chipilo of FranciscoJavier Mina. Dueñas (2013).

5.4.2. Sketch-Cowshed Housing

To understand the environment in which it will propose the Biodigester treatment plant, a sketch of the plant ar- quitectónica of Cowshed housing (Figure 11) and the sketch set of the same (Figure 12) are attached. In Figure 13 the facades of the two houses, with the accompanying stable, which gives an idea of the size of the place are. These sketches are as known purpose cer operation and architectural features of the site, we helped to establish the planning and installation location of the digester.

Both houses have similar spaces are ground floor and first floor .As the barn, it was considered the second home as annexed part of it, because it consists of a single shed and uses part of the premises of the first stable; including how the manure was noted. (See Figures 13 and 14).

Once we know according to a general uprising, where are located the different constructs and elements of Cowshed housing, it is necessary to recognize the free space you have in construction, in this case already has identified as the use having this space is reusable for manure treatment within the biodigester treatment plant.

In Figure 14, you can see the analysis made for how to use the free space on the construction of the treatment plant fixed dome.

Basically, the first thing you have to consider is the orientation, knowing how are the cardinal points according to the terrain in which it was decided to design and build the treatment plant; particularly consider the following:

-North: poor performance for biodigester treatment plant.

-Northwest / Northeast: insufficient for biodigester treatment plant operation.

-West and East: usable for treatment plant operation dora biodigester.

-South: optimum performance for biological treatment plant digester.

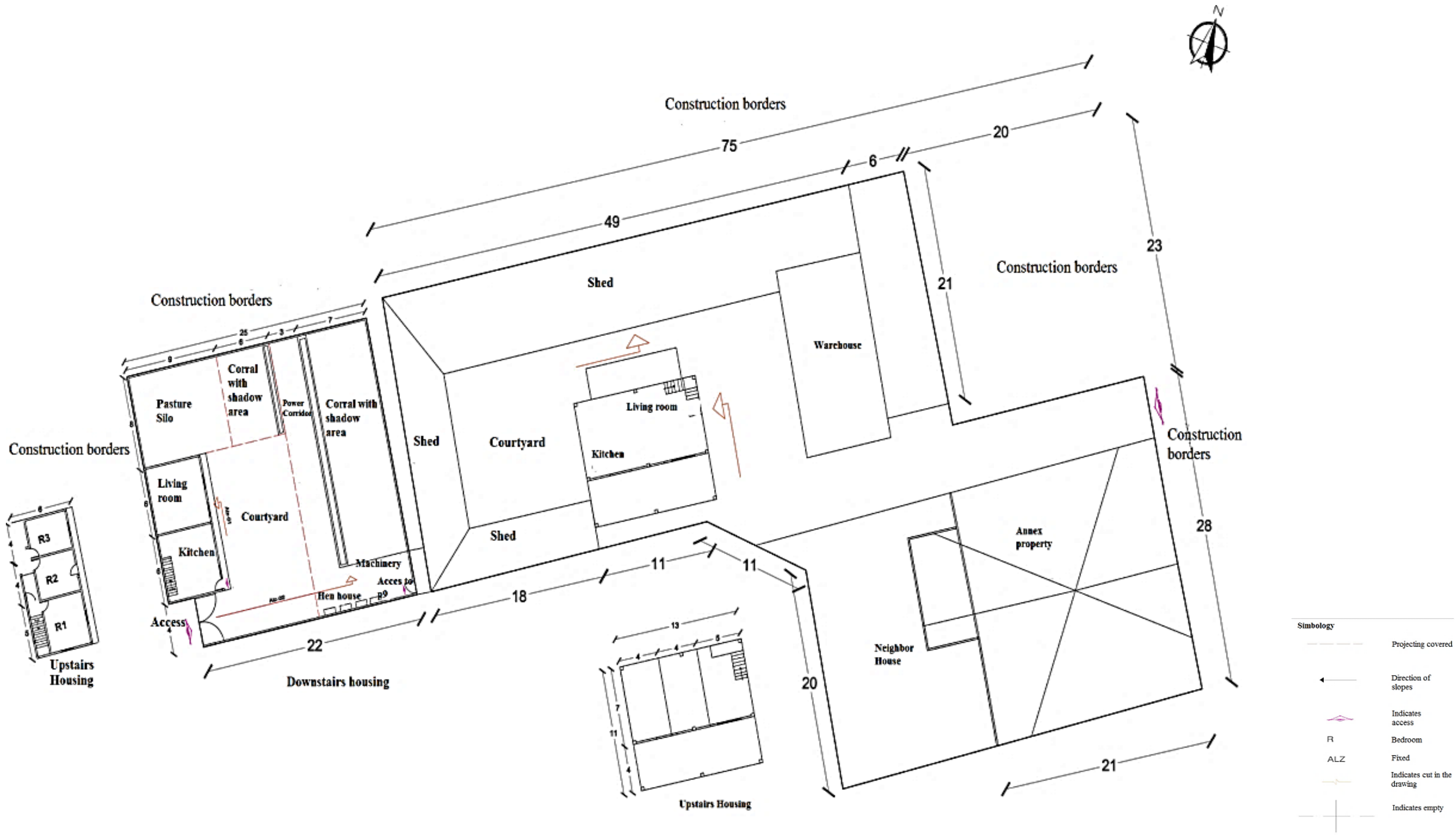


Figure13. Sketch of Architectural Floor Housing-Cowshed, the marked area is the free space considered for the treatment plant. Dueñas (2013).

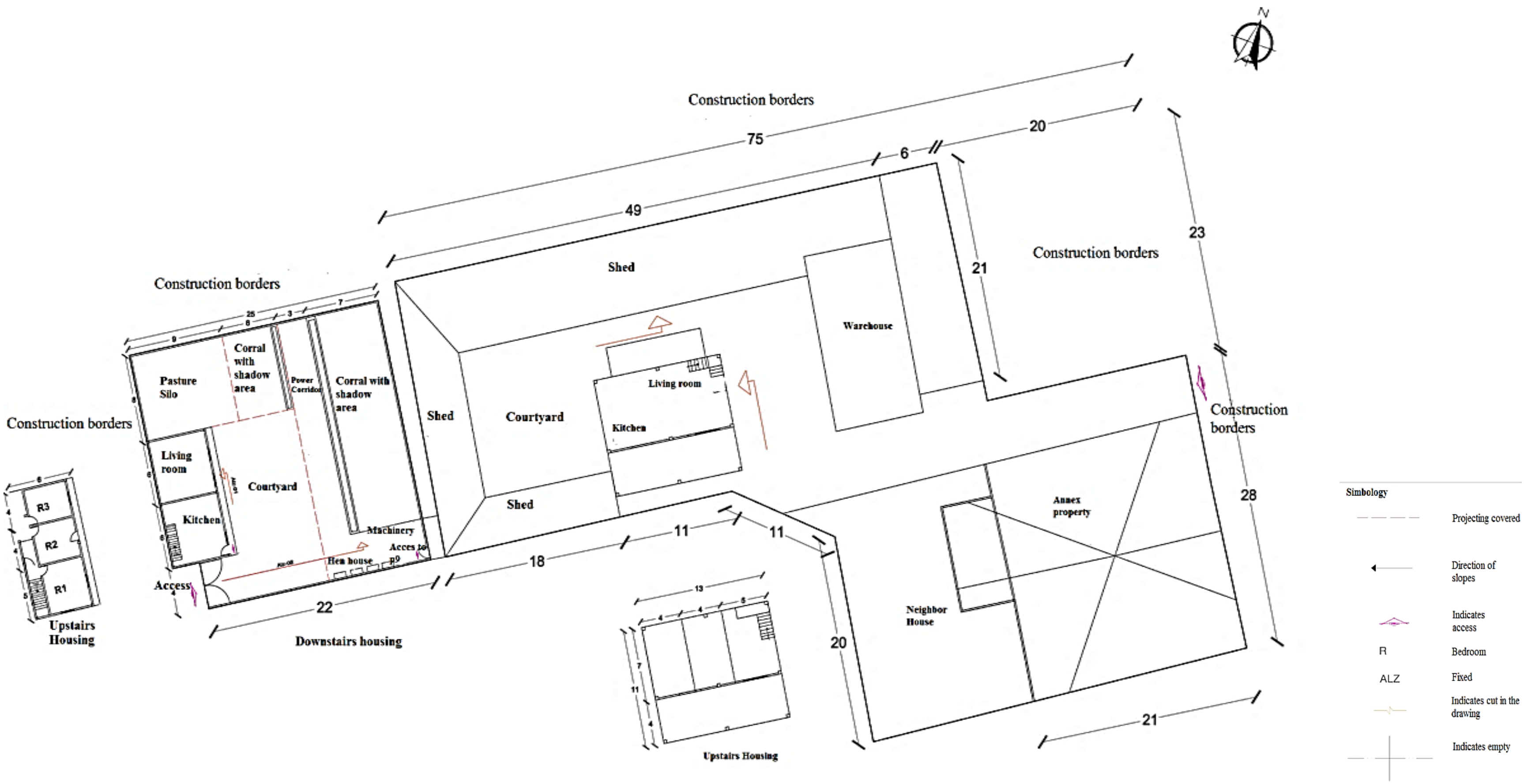


Figure 14. Sketch of Plant Set-Cowshed Housing. Due- cam- (2013).

So in Figure 1, are proposed three possible ubications of the treatment plant within the space, where also is considered factors such as easy access to the mixing tank and power also removing the sludge digestion chamber. No doubt another element that should not be forgotten is the facility that is needed for the gas to generate electricity within the proposal.

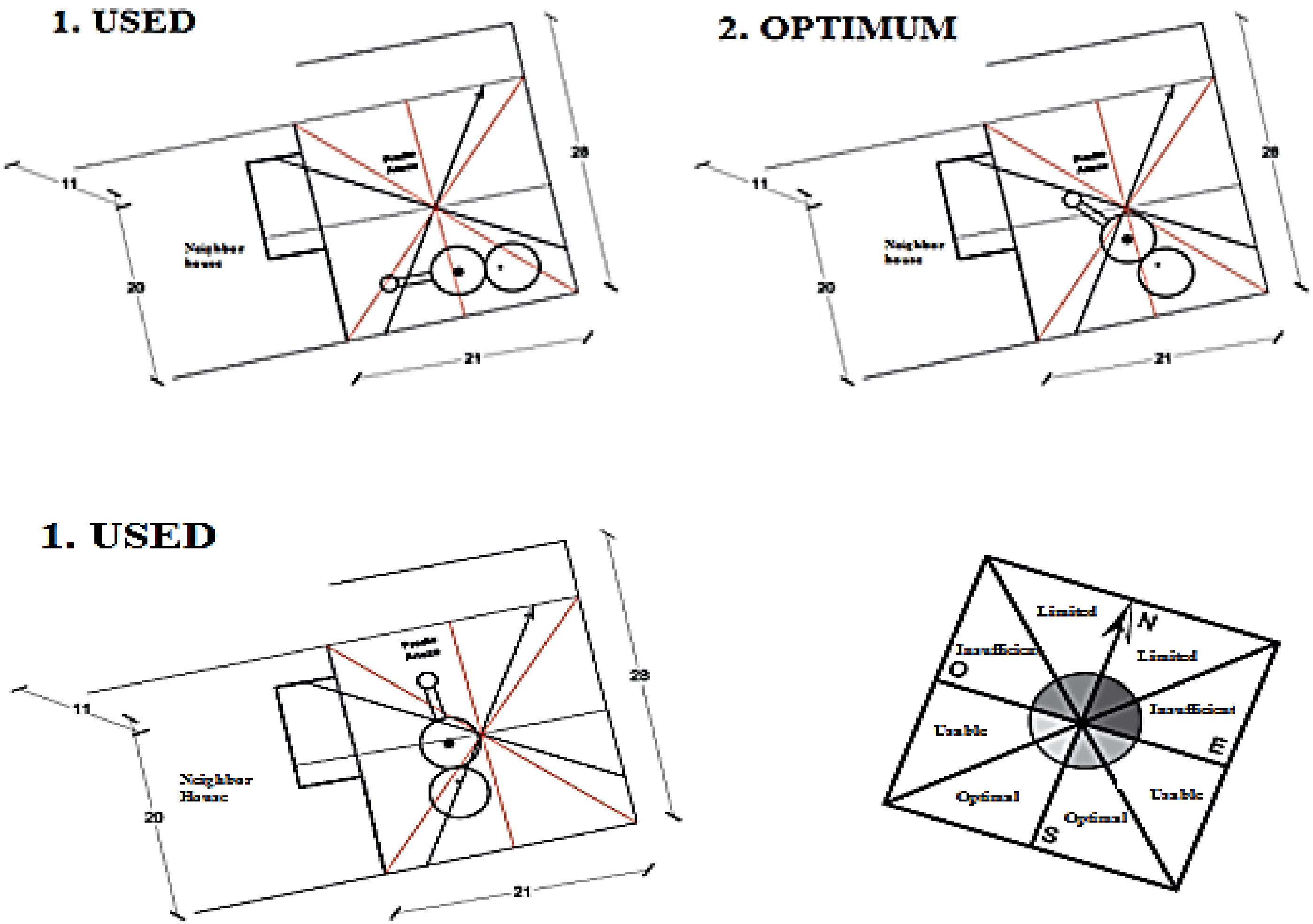


Figure 15. Location of bio- treatment plant manager at State House blog. Dueñas (2013)

5.4.3. Ambient Temperature

In Chipilo of Francisco Javier Mina the average temperature is 17.1 ° C, being able to mention that the maximum temperatures in the annual range of 26 ° C to 28 ° C, and temperatures minimum annual range of 2.7 ° C-3.9 ° C.

5.4.4 Type and Livestock management

Range cattle: 50 cattle.
Amount of manure produced per kg / day: 10 kg / day
Storage time: 18 hrs / day
Cow Average Live Weight: 400 kg
Live Cow Equivalent Weight: 350 kg
Manure Collection: Shovel and truck.

5.4.5 Operating Characteristics

Biodigester.
Working temperature: 30-40 ° C range
Manure-water ratio: 1: 1
Retention time: 56 days
Type Filling: Mix of daily load.

Stage 2. Calculating Capacity of the Biodigester

5.4.6 Biodigester Capacity

For the design of the treatment plant, the explanation will follo two steps in the previous section of General Bio-sizing digester, where considerations are shown.

5.4.6.1 Required volume of Biodigester and storage Biogas

For the amount of manure are reviewed, taking into account in this specific case 55 cattle. Thus obtaining the daily load of 855.00 Kg and the total volume of 47.88 m3

Number of heads of	Manure day	Solid 1	Total Volume (Kg/day mixture)	M3 Day	Biodigester total volume (TR: 56
50	427.50	85.50	855.00	0.855	47.88

According to Table 9 Calculation of Volume and Volatile Solids for Fixed Biodigester Dome page 24 is checked that the proposed m3, do not exceed the limit of volatile solids, the total must not exceed 2kg/ m3.

Number of heads of cattle	Total volume m3	m3 Close approach	Volatile Solids 4
50	47.88	50	1.71

Calculation of basic geometric measures to Biodigester Fixed Dome, from page 23 mind, the main measures of the treatment plant are taken. Importantly, given the measures here would be internal measures without considering the thickness of the material. Within the Manual are considered brick walls of 15 cm and finished to be about 20 cm thick; is very important to remember especially for excavation, to be exact for the rudeness of the digester.

Biodigester total volume	Basic radio	Proportiona	Dom	Cylindric	Dome height	Wall height	Cone base
50	2.4	0.60	3.00	4.8	1.20	1.80	0.72

The next step you considérate the volumen you should have evry one of the geometrical parts, according to Table 11. Calculation volumes for Biodigester Fixed Dome.

Digester Volume V1+V2+	Basic Radio	Cyllinder Volume.	Spherical Segment. Volume	Cone Base	Total Volume
45.71	2.40	32.57	11.76	1.38	48.68

Importantly to check the total volume that is based according to the radius, so it is not accurate and when used only two decimal places, it has a variation in the proposed volume, which was established in square meters closed for ease of handling tables.

5.4.6.2 Tank Volume Compensation and Desarenador Mix Tank

According to the volume and number of livestock, the tables are reviewed to obtain measurements of the other components of the biodigester treatment plant. First the surge tank, together directly at the camera of bio digestion is according to Table 13. Measures Buffer tank according to Gas Volume and Volume spherical segment for Biodigester Fixed Dome. Compensation Tank:

m3	Gas Volumen	Spherical segment	Radio	Height
50	5.20	11.76	2.40	0.75

It is important to remember that these measures are accurate, do not consider the thickness of the material, which must be considered if the construction stage when the excavation to avoid volume change.

After this mixture measurements tank and sand trap, located at ground level are an important part, for the daily burden of the digester are considered primarily by the need for a control ratio mixture.

The material is considered in this table with 15 cm brick cement plaster (Table 14, p. 34). Volume Calculation Tank Mix-Desarenador in M3. As can be seen, the 50 head of the cattle are in this table, in the range of measures ranging from 50- 65 head of cattle, for the mixing tank and the sand trap.

Since within this range have a minimum volume change. We thus have the measures proposed to be considered with a radius of 0.65my Height to 0.95m, for a net total material thickness without; considering in addition the desarenador width of 0.65 m without thickness of material.

Mixture Tank – Desarenador

Number of heads of cattle	m3 day	m3 +105	m3 +20%	Proposed measures	Measures with material	Width desarenador
50	0.855	0.94	1.026	Radio	Radio	Interior
55	0.941	1.03	1.129	0.65m	0.95m	0.65m
60	1.026	1.13	1.231	Height	Height	With walls
65	1.112	1.22	1.334	0.95 m	1.10m	0.95 m

*Considered brick walls of 15m and a staff of 10 cm of thick.

Table 15 Desarenador Dimensions digester consultation, to meet other measures necessary to better understand the sections is recommended guided in Figure 12.

Heads of Cattle	Tank mixture	Radio Basic (meters)	Section Drainage (a)	Desarenador Section (b)	Tube Charge Section	Dept Desarenador Slope (d)
50-65	0.65m	2.40-2.65	0.60	2.00	0.75	0.40

Once consulted all tables are taken measures necessary for sizing the bio digestora treatment plant.

It is important that the considerations given to the use of tables and if you have a variable or greater than the proposed number calculations, it is possible to make the correct sizing of the treatment plant by means of the formulas proposed in this manual are taken into account.

Step 3. Biodigester Proposed Design

5.4.7 Sketch of Treatment Plant

Upon completion of the calculation we have a building of 50 m3, plus 5 m3 approximately grit chamber and necessary records, since it has an area of more than 300 m2; concludes that it is feasible the construction of the treatment plant, within the available space is achieved. Once determined the steps, you can define the geometry of the digester, for which it is suggested to use as a guide in the design and construction of the treatment plant the following sketch.

The sketch appears with the measures previously calculated provide a complete reading, necessary for the rudeness of the biodigester treatment plant.

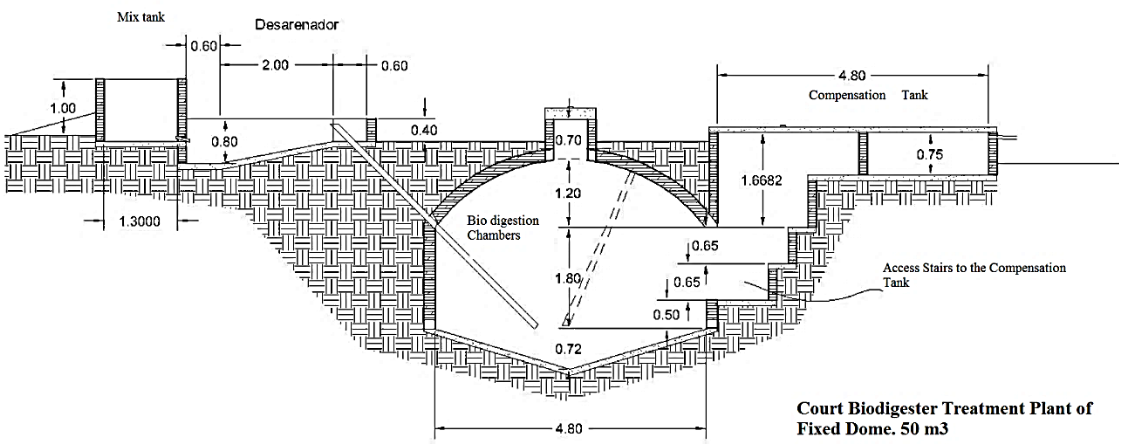


Figure 16. Biodigester treatment plant Type of Nicarao 50 m3, Based on Guardado (2007).Made by Dueñas (2013).

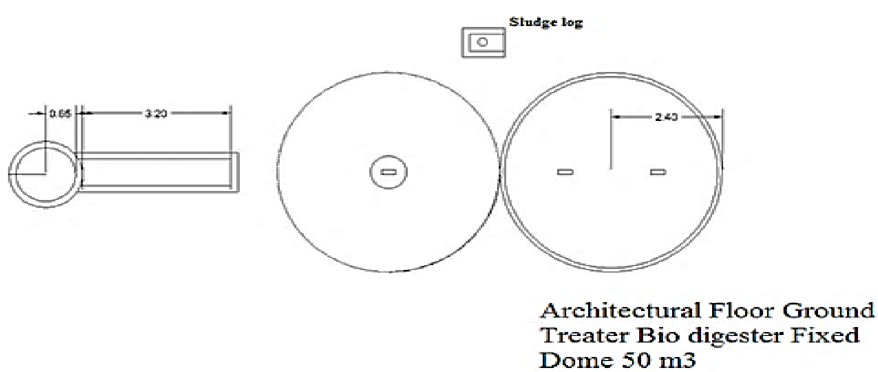


Figure 17. Ground basic AC Biodigester Treatment Plant Type Nica rao based on Guardado (2007). Made by owners (2013).

Stage 4.Calculation of Biogas Production and Housing Demand Stable

5.4.8. Biogas production and energy demand

To calculate the biogas production, there are different ways to do so in this example resumes by Guardado (2007) and Marti (2008), being more attached to the proposal of this manual, in particular because Guardado considers very important the dung-water ratio of 1: 1; calculated as follows:

Author	m3 de Biogas
Guardado (2007)	0.360 m3 Biogas per 10 kg = m3 manure produced.
Marti Herrero (2008)	Amount of manure Magic ° 35.3 N = lts

Another alternative to get biogás production is doing an analysis of manure produced by animals and take loa production according to the volatile solids and composition it has as Olaya and Gonzales (2009) propose, where proposed 0.0871 kg/m3 per kilogram of cattle manure.

We have for this example:

Kg Produced manure	Bio gas Productio	Biogas Produced
427.	0.0360 m3/kg	15.39 M3
427.	35.3 lts/kg	15090.70 Lts

It is important to note that in the production of biogas temperature, water type and quality of manure, are decisive factors in achieving a higher or lower biogas production.

There are also different views about how to equivalence in kWh; this equivalence depends directly on the amount of methane in the biogas and this in turn depends on the quality of biogas according to manure composition, temperature and pressure.

According to the Guide to Best Available Techniques in Spain, Lacteo (2008) Sector proposes a range of 6-8 kWh / m3. Víquez for electricity generation from biogas proposes to consider the conversion of 1 m3 of biogas 6.15 kw, with 65% methane.

However, these two conversions would be without considering the yield of the generating equipment used to produce electricity, because the yield is 35-40%, which is considered as proposed by the BioWorks journal (2013) which sees production of 2.8 kWh of renewable electricity for 1 m3 of biogas.

As a first proposal is the use of biogas as fuel, replacing the LP gas, for use of the stove, either from home or a Milk stove for use of Boiler.

As shown in the diagram E.4, you must have the following items for installation and use of biogas:

1. The digester

2. Pipeline conductive occurs primarily at a compressor (car), to increase the gas pressure to a level functions.

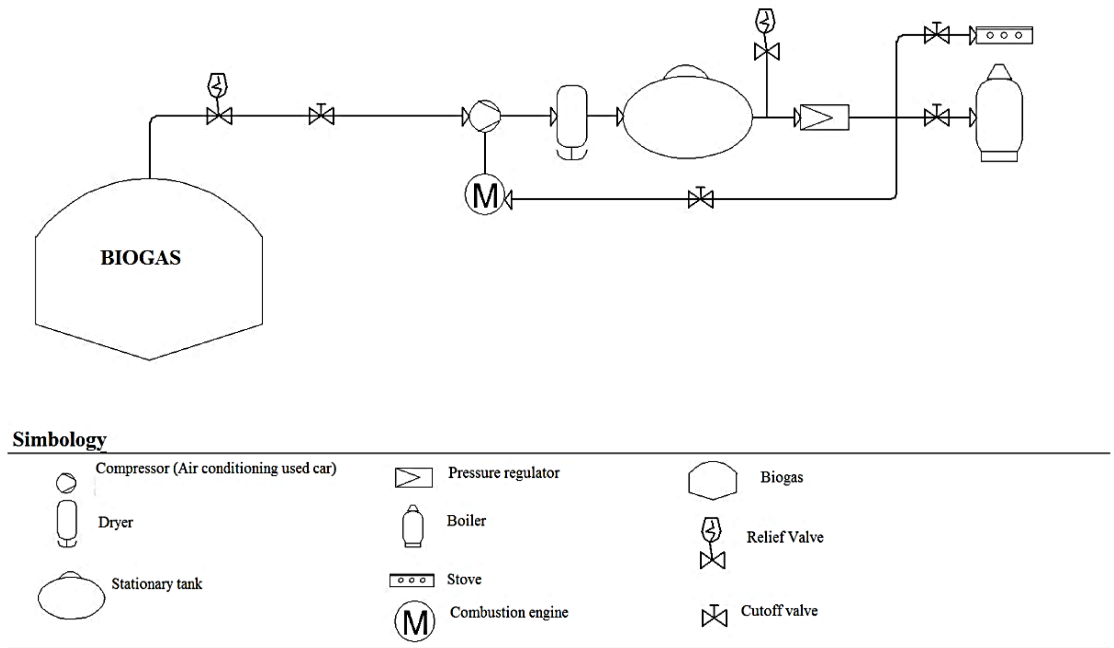
3. Dryer (compressed air) used to remove moisture from the gas and not have problems with water drainage.

4. It is stored in a dirty gas.

5. Go through a pressure regulator to help Mainer energy efficiency, complying with pressure equipment.

6. Finally it is driven by a pipe to the stove, boiler and combustion engine that power the compressor.

This option allows, but more limited, serves as an aid in the production process stable direct practical use for the production of biogas, mitigating the costs of LPG within the Cowshed housing. Taking milk production, this promotes greater savings, when used biogas as fuel in the dairy stove, as might occur in other cases within the community.



Scheme 3. Biogas diagram for use as fuel to produce thermal energy (heat). Hofbauer and Dueñas(2014).

It is important, the dryer, commonly used for compressed air, must be bought with auto drain; ie to be releasing the water as it is being filled. The bottom (purging) can be connected via a hose to a tank for recovering the water, which may be used for the bio- manager, since this water, while clean, odorless gas.

The dryer is part of the call maintenance unit for compressed air, but is neither necessary nor feasible to have the entire unit, if not only the part of the dryer. Given the humidity in the biogas is recommended for 1-3 dryers, according to the amount of water drained resulting thereof, which may be determined in practice.

To consider biogas power generation is important to consider certain factors, which marks Víquez (2010):

1. Technology for the production of biogas. Is the efficiency with which account for biogas production, implementation costs that go according balance looking for a long life.

2. Quantity and Quality of biogas available daily or cumulative. The amount of biogas generated is directly proportional to the amount of energy that may occur. The quality of biogas is related to its composition, particularly the concentration of CH4 and H2S concentration, which needs to be cleaned for proper operation.

3. Power Consumption. Conduct an analysis of power consumption in kWh monthly or daily to determine savings, consumption potential and use for computers.

4. Cost of electricity. Check the average cost of consumption you have and surcharges consume more than the determined in the range of rates

5. Spacing between the source (biogas) and the use of electricity. Respect to consider the voltage drop and the cost of wiring, it is considered feasible to transport more biogas, considering the use of compressor to increase flow and pressure. It can transport natural, but if this is done should be near the reservoir of the generator.

6. Efficiency of the electric generator. You must make a proper dimensioning according to the required power, know well the specifications and consider energy transformations are lost and therefore in reality they cannot be considered a performance 100%, by proposing a good system can be considered a yield of 25-35%.

In order to know the energy consumption, it is recommended to know the specifications of the equipment used inside the barn, especially the type of milking you have and the type of lighting.

If you want to add housing, a practical way to know the energy consumption is through the receipt of Light, which gives the national electricity commission (CFE) in the case of Mexico, because here come the average Kwh consumed.

So according to the example, we have a stable using:

• 2 milking bucket with 1.5 Hp engine with an output of 1000 W, which gives 1.1kW for use of 1 hrs, per milking, with two uses per day, is considered a daily consumption of 4.4 kWh .

- The lighting is stable fluorescent lamps

23 W, with a consumption of 5 hrs and 16 being considered lamps in the two stables, gives us a total of 1.84 Kwh.

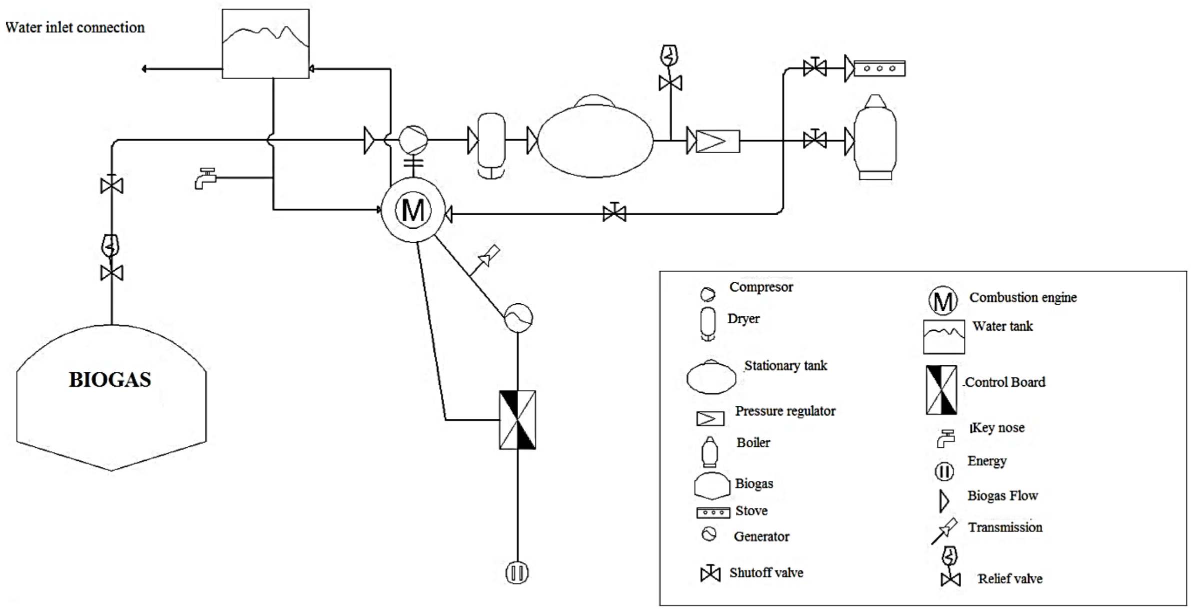
-It also considers the use of submerged water pump gible for the daily supply of water to the res labo-stable. With a capacity of 3 Hp and an expense of 2, 2 kW for an hour and a half gives us 3.3 Kwh.

This gives us a total of 9.54 kWh, about 10 Kwh, tear inside the barn. For each of the dwellings is considered an average of 3 kWh. Considering all the electrical consumption is taken into the barn and two houses, total consumption of example you have is 16 Kwh.

In conclusion, the energy use is proposed:

Barn+ Dwelling = Power required = 16 Kw/h

In the diagram Scheme 4, you can see the basic proposal for the creation of a generator for the generation of electricity in particular the stable. It is important to note that Cowshed housing and different powers are required, as you go from a big requirement Kw stable if one lower in the case of housing; as in this case it exceeds 10 kW to 6 Kw. Assessing the needs of each particular case it is needed in order to have a rationale design that allows us to solve the efficiency and technical requirements. So it is recommended to seek advice and have the help of a specialist, as is the Electronic Ing. Or power generation specialist.



Scheme 4. Diagram of biogás for use as fuel to produce electrical energy through a generator Hofbauer and Dueñas 2014.

To produce electricity with biogas there are several options, being the most feasible:

1. Full Genset, factory purchased through a dealer.

2. Armed Generator Set, comprising combustion engine generator, alternator and Dashboard.

3. Generator.

In the case of this manual and study example, the second option was developed, based on the analysis of needs, cost, efficiency and utility. Basically the aim to establish an armed generator, with the requirements for the case; so you should consider the following:

- It is recommended to retake the diagram E.4. Since here also becomes necessary to maintain pressure in order to have efficiency and the ability to store the produced gas.

- The cooling system or cooling of the engine, it is proposed with water (having a heater) for heating this water to be tapped, so that a tank, which at the same time is proposed, supplied and stored for use. This water will be particularly important to help stabilize the digester temperature, especially in cold weather seasons.

Once these features have mentioned have the main features of the proposed generator:

1. Combustion Engine: It is recommended to use a car engine, preferably from Caribbean Datsun 1.8 liters, for its easy adaptation. The choice of convenience is a 3600 engine rpm, has no computer.

2. Generator: This produces power that can be used directly, with a board regulating throttle. Generator is considered to be 1800 rpm, with capacity of 20 kWh.

3. Dashboard: the task of controlling the throttle, although loses the ability to store energy ago, we should not use batteries. It is used to simplify instead of having rectifier and inverter. Board set to 1800 rpm, 230 V, 6 Hz, three phases.

4. Transmission: Between motor and generator, to increase to 3600 rpm, the engine may have its speed and generator to yours; making use of gearbox provides greater adaptability and flexibility.

As important to consider recommendations can be mentioned that for operation the system must be compressed gas, the first part of this process, wherein the drying gas is compressed and is proposed. The proposal seeks to have the highest efficiency and capacity according to example due to the required power demand is not feasible to put a rectifier and inverter system; although it is possible that increasing demand that can be considered the use or buy a generator corresponds to the calculation of electrical power.

5.4.9 Technical and Cost Proposal

Then investigation costs, which can steam rials due to the advance of time and will change suppliers. Research according to regional suppliers and Puebla became a specialist in automotive mechanics for assembling generator was consulted.

So we can establish a cost comparison between a generator factory and one armed with the fixed dome digester. Which will help determine the resources that are owned and assist the decision making. According to what we have proposed two main proposals:

Biodigestor of fixed dome		
Construction of Biodigester, including Labor, Materials, specializing Monitoring and Assessment.	Materials: Brick, cement, sand, steel. Excavation and fillings. Manpower: Bricklayer and helper. Advisory: Specialist construction.	$73,940.00
Compression system and drying of biogas		
Compression	Car Air-conditioned, running on the combustion engine.	$1000.00
Air Dryer	Only use the dryer, is likely to use at least three. Transparent Automatic purge	$ 320.00 part. $960.00 (3 part)
(System Maintenance Compressed Air)	Used for Gas 1000 lts Second can be used.	$9,649.00
Stationary tank	Better pressure control operation. With regulatory pressure Thread	$ 88.00
Total Compression System and drying Biogas		$2,048.00

Table 16. Table of Costs treatment plant and biogas compression system.

Generator assembly group		
Internal combustion engine. Proposal: Datsun, Caribbean. With transmission.	3600 rpm No computer	$ 15,000.00
Generator (Alternator)	20 kwh 1800 rpm Three Phase 230 V 60 Hz	$ 7,500.00
Transmission Automotive gearbox.	Step 3600 rpm to 1800 rpm.	Included in Combustion Engine.
Dashboard	1800 rpm, 230 V, 60 Hz, three phases.	$6,000.00
Total Armed Generator.		$28,500.00
System Biodigestor in deed and power generation with generator factory.		$162,152.00
System Biodigestor in deed and power generation, generator armed		$ 104,488.00

Table 17. Cost Table Auxiliary Power Generation System biogas.

As can be seen in the table, the generator factory requires less work for implementation in the Biodigester treatment plant of fixed dome, but is more costly, it requires more adjustments for installation and monitoring. This kind of generators are justifiable given when we are talking about large amounts of cattle in barns equipped and high production volumes.

Instead the armed generator, allows us to make the appropriate adjustments to the needs of the home-stable, less expensive, allows reuse elements found to al- regional distance and the ability to perform most of the process of construction.

It is important to say that the generators, if they are distributed in the country, however for a better price, it is more feasible to order it online, because there is a wider range of models, brands and prices. Some are specialized for biogas, however generally have very large capacities; so it can be adapted to work for LP gas, natural gas and propane.

Several companies such as diesel engines (http://www.en-ginesdiesel.com), which have several factory products which may be used or at least are a guide to search.

It is also important to try to manage a subsidy from the government for infrastructure, to amortize the cost of the initial investment. Some of the programs that exist in government, at the federal level are:

- FIRCO / SAGARPA (Shared Risk Trust / Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food). Biofuel Production, bio-fertilizers; efficiency and sustainability of energy in production processes, use of renewable energy. National coverage with specific clauses in bio digestion (50% of the cost), Moto genitor (50% of the cost) and use of biomass for power generation (30% of the project).

- FIRA / SAGARPA (Trust Funds to Agriculture / Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food). Program of sustainability of natural resources component of bioenergy and Alternative Sources.

- CNA (National Water Commission) . Water and Wastewater Program in Urban Areas. (APAPZU) .- Improving and increasing potable water, sewerage and sanitation in urban areas of the country; more than 2500 inhabitants town. It has with economic support and technical advice; having a section for studies and projects, as well as considering the physical efficiency in terms of improved efficiency of motors, pumps and electrical equipment.

Do the project in phases, is also a clear choice, making the construction of the first part using biogas unprocessed only as a means of cooking and heating water for basic functions and then invest in energy production. Since the use of biogas, promote energy savings in Cowshed housing, which can be used as an investment for improving the system and take it to the next level of energy efficiency.

6. Recommendations

In this paragraph, generated from the analysis of the literature, is intended to give general recommendations for the stages, use and maintenance of construction, in order to achieve a better understanding of the related technical aspects; order to have a successful implementation of biodigester treatment plant.

6.1. Construction

For a better understanding it is explained according to the parts that conform to the digester, as can be noted in Figure 12 where are the parts of the digester and Figure 16 where is the sketch example of Biodigester treatment plant of 50 m3.

For technical specifications about the construction of the digester, it is recommended to retake "Design and Construction of Simple Biogas Plants" by Guardado Chacón 2007), in addition to Lacueva (2011).

I. Tank-mixing sand trap

This is where the manure is mixed with water before it enters the digester, to be homogenized, with the help of a stirrer, fulfilling proportion.

It must place a wooden plug, rock or PVC, in the discharge pipe leading into the sand trap, which is easily removable without touching the mixture daily load. The inlet pipe to the digester should also be covered during the mixing process, as appropriate, to control the filling of the digester.

The sand trap is used to prevent inert material such as stone, wood, nails, entering the digester, so it is necessary to have a contrary small inclination, the feed tube, to prevent the entry of these materials.

II. Inlet and outlet pipe

The inlet and outlet valves serve as overpressure for fixed dome digester, being below the level of the dome of gas. They should have a diameter of 10-15 cm, connected to the digester inclined manner, ensuring that the inclination allows the flow of manure, it is necessary that the pipes are submerged in mud without touching the bottom, to prevent escape of gas methane, being to a height of 40-60 cm from it.

They must be easily accessible and straight, to allow the entry of rods that help release the pipe or shake some sludge.

Insertion points to the digestion chamber shall be under construction, be sealed and reinforced mortar. The inlet pipe should terminate in a higher point than the start of the ladder, to promote a daily mixture fluid.

III. Digestion chamber

Must meet sealing requirements to ensure anaerobic environment, to have minimal heat loss during operation of the digester and be resistant to corrosion.

Structural stability to withstand static and dynamic loads is necessary; addition of external forces, which are the earth pressure generating internal forces and compression, which is the voltage generated by the gas.

The dome should have good finishes; ensure that its construction is sturdy and not cracked.

It should be below ground level to counteract the pressure created inside the plant.

The upper recess of the dome lid needs of 100 kg or more reinforced with strengthening braces.

The gas outlet should be 10 cm above the overflow level, to prevent clogging of the pipe.

IV. Surge tank

The accumulated gas displaces the corresponding volume of digested mixture, making it necessary to have a surge tank.

It is an important step to accumulate gas when production peaks exist and this is not consumed immediately. The gas pressure increases, with the volume of gas produced especially because it is not compressed, so it becomes important the existence of the two tanks to control this variation in levels of gas.

It must have an overflow pipe, two inches in diameter, for maintenance and fluid outlet.

V. Register of sludge

It is used for cleaning the sludge accumulated at the bottom of the digester, connected to the digestion chamber through pipe to facilitate maintenance.

The digester sludge must be removed every two years; this pipe is used to remove the sludge and pumping mechanisms.

For driving biogas is important to note the following:

a) Gas pipe, valves and fittings:

You must know the needs of pressure in each case and standardize elements for easy installation.

Because moisture and hydrogen sulfide, pipes should be avoided, little corrosion of ferrous materials resistant.

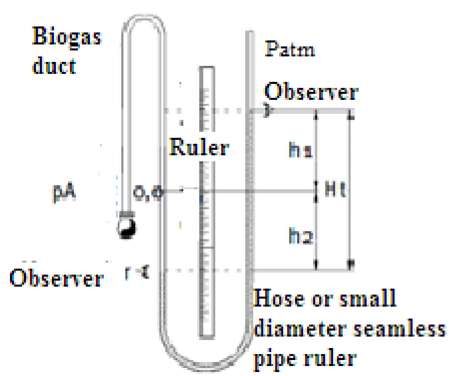
The most suitable materials are galvanized steel pipes, plastic pipes like PVC, remembering that the tubes must be resistant to UV rays.

b) Safety valve:

In most of the manuals, the construction of a safety valve outlet water trap is recommended. However due to changes made to dry and compressed biogas for the proposed system is not viable because it endangers the compressor.So we propose to use a safety valve LP, which are commonly used in gas installations with stationary tank, to help overpressure system and ads meet the same safety function.

c) Gauge:

Used to know the pressure inside the digester, it is proposed that a basic homemade to be lower cost.In practice, one can build a system, for which a thin wooden board 50 * 25 cm, a plastic waste line diameter of 76.2 mm, which is made with an "U", the adjusted is needed without squeezing the timber through staples or wires that are anchored to the timber. One end of the waste anger connected to the pipe with a hose adapter and a connection to "T", the other end free anger.



Left Image.8. Gauge home. Retaken from Lacueva (2011). Right Image 9. Detail gauge. Guardado (2006).

Is installed and the water hose is half filled, when gas is generated, this displace the water, allowing to know the pressure, measured in inches of water column.

It should always be filled with water hose or biogas will leak gauge.

In the case study will help to determine the level of production of biogas. Be used scales mmca 50-0-50 (mm water column), the calculation of the pressure through the known height difference between the inlet of the digester and the atmosphere.

d) H2S filter:

To prevent corrosion of metal components of the system is necessary to have a filter, a tube may be 4 "and 2 meters chips full length oxidized iron in the tube ends to be connected two reductions, the first to 10cm 5 cm and 5 cm another ½ ", a universal joint is positioned to change the chip and connected to the pipe.

Reductions on one side will be attached with glue and on the other must be removable to remove chips, which must be performed every two months.

Chips to be oxidized should be soaked in water and left outdoors for three to four days and is ideal to be small and short to better elimination of the acid.

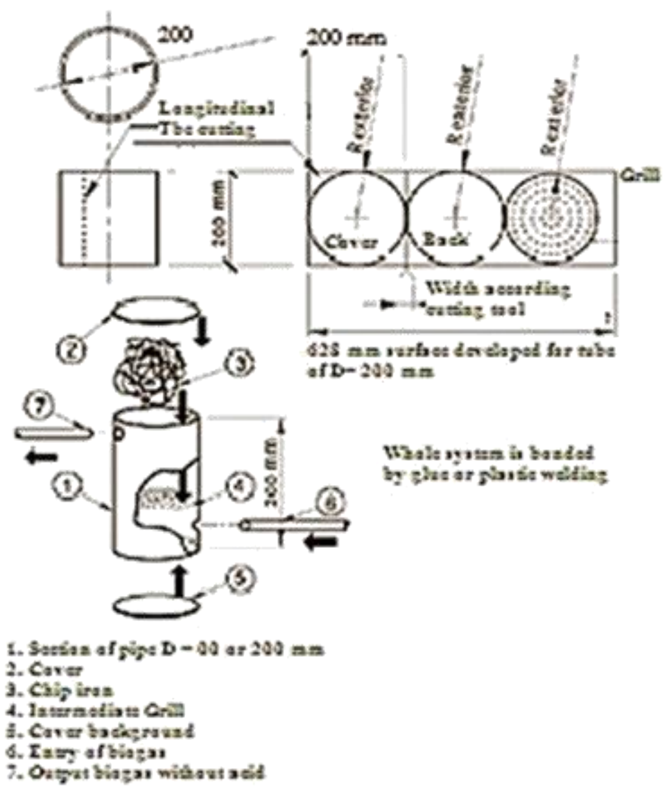


Figure 18.Trap hydrogen acid. Resumption of Guardado (2007, pp.30)

Consideration should be given to installing the valves, which first a safety valve and then a ball valve sets, it is recommended to put this type of valve at the entrance to each team to use biogas.

An outline generated Salmeron Ignasi (2008), where you can see easily, as must be connected to the pipeline shutoff valves, using appliances and electricity generator. To use this as a guide and diagrams explained above in the biodigester treatment plant 50 m3 examples.

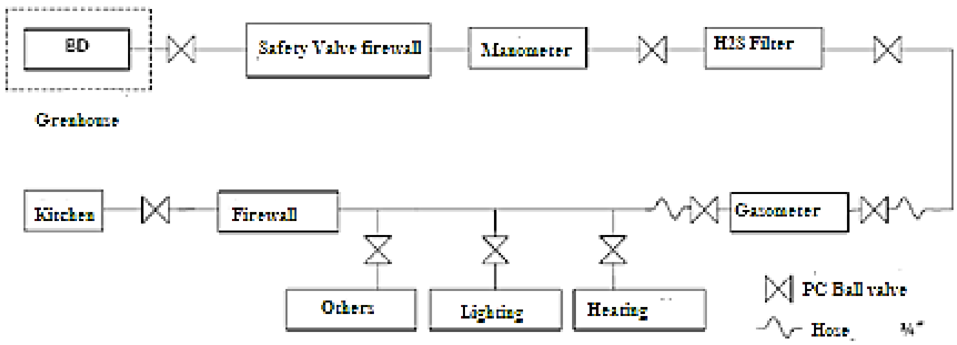


Figure 19 Replacing valves and fittings in the conduct of biogas. Retaken from Lacueva (2011, pp 75).

It is suggested to have a constructive advice for that matter, so within the approximate cost of the digester, is also considered the cost of hiring an architect or engineer to help to build the fixed dome digester.

6.2. Use

Olaya and Gonzales (2009) indicate that the first step in starting and operating the digester is to procure an anaerobic environment, since the gene methane bacteria are very sensitive to oxygen.

You should do a review to ensure sealing of all components is also required a yearly maintenance check and leaks.

According to Lacueva (2011) and Guardado (2007), the operation of the digester starts with a good implementation of the biodigester treatment plant, for which the following is recommended:

-Fill with water the digester, to finish construction for 10 or 12 days. If you have access to water and construction has not been enough oversight and quality, it is recommended to start up with clean water; with the location of a pressure gauge on the gas pipe to measure the air pressure in the dome, displaced by water, while filling the digester until it reaches the maximum pressure, and full 24 hrs left.

1. After the first filling, there is no need to enter mixture to meet waiting time of fifteen days, to allow time for the stages of anaerobic digestion. You must fill the digester to the level of the floor of the surge tank or pressure regulator.

2. It can reduce significantly the time of commissioning, if used as first cargo from another sludge digester operating as it exists in the presence of methanogenic bacteria load.

3. You must leave open the valve of gas during the waiting period to allow air to escape; thus avoiding cracks by the action of shock loads.

4. After the waiting period has elapsed, the outlet valve is closed and waits a few days to build biogas. For vaccines excreta, the valve can be opened to 24 hours.

5. Avoid any flame that cause ignition (lighters, cigars, etc.), during the period in which the output of the initial gas to the environment is sought.

After the initial release of gas, the valve for the pressure is closed to rise again and start using biogas. The initial gas should not be used because it is mixed with air and therefore can be explosive, and even may not be fuel for the content of CO2, so it is recommended to let it escape into the atmosphere without being connected to the stove or the power generation system.

6. The plant is charged regularly when the mixture is displaced and begins to exit the overflow pipe (surge tank).

Some of the points have to be consider for implementation according to Lacueva (2011) and Guardado (2007), are:

- Initial contribution of manure according to the total turnover since the first charge will be to fill the digester; so it is recommended to storing manure from the construction of the treatment plant; accumulating in the form of compost piles.

- The implementation can last from several days to weeks, having as main characteristic the low quality gas with a high content of carbon dioxide, strong odor, low pH and fluctuating production.

- During the filling process, it is recommends that beginning of the level surge tank, the gas valve remains open, so that the air contained therein escape to the extent that water reaches its maximum level, to avoid cracking of the dome by the action of shock loads.

- To stabilize the process at this early stage may cause removal of the sticks by means of mixture introduced into the tube to cause movement. Also you can add a little lime or fresh manure, without adding mixture until biogas production starts.

- Upon completion of gas production according to the proposal capacity will begin to move the liquid manure tank compensation, which has an overflow pipe. Once this happens, you can start feeding the digester on a daily basis.

- The first biogas production should not be used due to its high content of oxygen, which makes the highly explosive gas, which must be removed without being used.

- The user should be familiar with the theoretical and practical operation of the treatment plant, to succeed in their exploitation besides knowing the operation and maintenance of the same.

- The accumulated gas in the dome, will be disposed opening the valve placed at the outlet in the manhole, to be used as trap (H2O), and immediately move away about 20 m in direction against wind (avoid smoking or lighting a flame), after the plant is closed and when the pressure rises again, can start using biogas for cooking food.

- When first started operating a sweep of the pipe with the same gas will occur.

Olaya and Gonzales (2009) marked as special recommendation to start biodigester, it is considered that in the fill, add sludge treated in a digester operating (inoculated), suspending charging for a few days to allow the bacterial population, methanogenic grow and the process be stabilized.

When you already have a digester running, you can use the mud, and bacteria-rich activity, a certain percentage according to the age of digester operation. Inoculator the necessary percentage of the material (activated sludge) is presented in the following table.

Age	Percentage
1	33
2	25
3	20
4	15
5	10
6	5
7	0

Table 18 Age and percentage inoculant ratio material is added, in a starting Biodigester stage Hilbert (2003). Resumed by Olaya and Gonzales (2009)

You must make a daily burden to maintain production of biogas and bio fertilizer; whereas if larger loads to design the retention time are introduced, they may lose the population of bacteria from the digester overflow, also causing acidification problems, odors and loss of production of biogas. (Vargas 1992).

Several authors consider that some residues such as straw or corn fodder, may affect anaerobic digestion in the sense that if they are not degraded, produce creams do not help the digestive process, so that the use of salts is proposed for treatment of these residues (Olaya and Gonzales 2009).Guevara (1996) indicates that to get good gas mileage steadily, you should add raw materials rich in nitrogen to carbon rich materials because they can help stabilize the production process; recognized as acceptable ratio Carbon / Nitrogen 20-30: 1.Given the situation of the Community of Chipilo, where litter is used, it is recommended to have a production control, to know whether this is affected by forage residues that are not extracted. And in practice will determine whether their separation is necessary, which can be done by a chicken wire used as a strainer.As already mentioned, there are inhibitors of the process, which cannot be used either to restrict their use, see Table 18.

Inhibitors	Inhibitory concentration.
S04 (Sulfate)	5000 ppm
NaCl (sodium chloride)	40000 ppm
Nitrate (According Nitrogen content)	0.05 mg./ml
Cu (Copper)	100 mg./l
Cr (chromium)	200 mg./l.
Ni (Nickel)	200-500 mg./l.
CN (cyanide)	25 mg/1 mg./l
synthetic detergent	20-40 mg./l.
Na (Sodium)	3500-5500 mg./l
K (Potassium)	2500-4500 mg./l.
Ca (Calcium)	2500-4500 mg./l.

Table 19. Inhibitory concentration of common inhibitors. Retaken by Guevara (1996)

6.3 Maintenance

The main tasks for the maintenance agreement that Guardado (2007) has are:

- Weekly, control joints, joints and welds with soapy water to prevent leakage.

- Elimination of cream or sobrenadante.- His generation within the digester depends care when entering the digester free excreted from straws, fibers and mixing quality. It will become increasingly it is found that biogas production is affected by the formation of the crust.

- To mitigate the aforementioned problem is advisable to close the valve from the digester, allow it to reach its maximum working pressure and minimally bubbling for 15-20 minutes.

- Should there be traps to remove hydrogen sulf of (H2S). The same should be cleaned every 15 days so as to drain the condensate accumulating there.

- Periodic removal of dried excreta surge tank, which hinders the movement of effluent; if done daily task will be faster, carrying no more than five minutes.

- Check for quarterly attachments and pipe used to supply biogas to the kitchen, heater and generator.

Lacueva (2011) divides maintenance activities three times daily weekly, monthly and yearly, which is summarized in Table 18.

Weekly operation	Weekly and Monthly operation	Annual operation
To measure the amount of water necessary for daily manure mixture, one can use a bucket or a bucket model.	It should collect and store biol, pulling it through cubes or truck, to be used as fertilizer on fields.	Once a year is needed, look inside the digester if floating foam, which must be removed by the same agitator or a practical tool.
You can consider the option of putting marks on the mixing tank to tell us where you should be filled with manure and other brand to where it should be filled with water.	Valves, pipes and storage of biogas will be monitored by visual inspection and leak check.	You should check the permeability to water and gas, check for possible cracks and pressure monitoring biogas. In case of doubt, it is recommended to take the help of a technician in gas for pipes and an engineer or architect for structural review.

Once prepared the mixture, cap the inlet duct for filling, which is recommended to be mixed by a stick inside is removed. After filling the digester, you should clean the mixing tank.	It is recommended to inspect and wash the pipes, valves and stationary tank and if necessary replace parts.	
To check the gas pressure, one can observe the operation of the kitchen and accumulators of biogas.	Every two months rusty iron chips are replaced by the joints of the filter; iron filings should have adequate exposure of water treatment and air three or four days for oxidation.	
Being the biodigester in operation will produce biol, which is an indicator of the proper functioning of the digester, it must be almost odorless and like input mix color. If this condition is not met should measure the pH level of the mixture and check if there are creams that prevent digestion, if so do the above tasks.		

Table 20. Summary of actions necessary for the digester. Based on E SE (2011), by Dueñas (2013).

Also have resumed summary tables made by Lacueva, referring to manuals and research GTZ (Deutsche Gesellschaft für. Technische Zusammenarbeit) German Technical Cooperation., Describing the actions and common problems in the process of anaerobic digestion.

Detection Factor	Cause	Effect on Performance	Remedy
Too high gas pressure.	Lower production consumption, full storage.	Malfunction of the safety valve.	Clean and change the safety valve.
Too Low gas pressure	Higher consumption than production or existence of leaks.	Low gas production.	Detect the leak and seal it.
Low Detection biogas production.	Biological reasons, temperature, substrate, antibiotics, change of pH.	Low production of biogas, cannot supply the required demand gas. Low production of biogas, cannot supply the required demand gas. Poor performance. Clogged pipes.	-Check the quality of biol. -Detect Biological and balance the parameters established causes. -Check pipes and unclog them.
Fertilizer strong odor.	Saturated ground, time less than the required fermentation.	Underperform and discomfort of users.	Reduce the amount of substrate fed.

Table 21. Summary of Actions Maintenance. Resumption of Lacueva (2011).

Problem	Posible Cause	Solution
The digester not has gas,gauge does not indicates pressure	The main key is closed: - Exhaust gas - Bacterium do not working correctly	- Open the tap. - Check with a soap solution and eliminate possible leaks. - The filling time should be greater In case of bad smell, stopping power - Checking PH levels, should be between 6.5 and 8.5

Oscillating gas flame	-Dirty nozzles. -Locked Pipe	-Clean nozzles. -Operate the water trap.
Overconsumption existence or little gas	-Distance between flame and large kitchen. -Wrong diameter nozzles. -Exhaust gas. - There have been fed the plant.	- Adjust the distance - Adapt the diameter nozzles if they had never used on the stove. - Use soap solution. Bubbles indicate a gas leak. Eliminate them. - Attend the plant correctly.
Very small flame	Very small burner nozzle. Pipe diameter for driving small biogas.	- Open the mouthpiece between 2 and 3 mm for domestic hearth. - Check the size of the pipes and fit the needs.
Obstruction of the inlet	Fibrous material	- Use a bar to unlock the pipe.
Stuck gasometer	Floating material	- Turn the gasometer - Open the gas holder and remove the foam..
Low gas production	-Quantity and quality of Substrate. -Determine possible gas leaks in the system. -Disruption of biological process, strong odor, color change of the digested material fall Ph.	-Inspect the quality of the substrate. - Add or healthy livestock manure mixture. Investigate whether pollutants or noxious products (detergents, pesticides, etc.) Entering the plant - Repair leaks, use soapy mixture to detect leaks. - Stabilize the pH by adding an element.
Lowering standards of material digested	-Leak in the plant ·	-Repair.
Bad gas storage..	-Leak in the gasometer	-Repair.
Key stuck gas.	-Corrosión.	-Apply the oil repeatedly.
Leaking gas pipe.	-Corrosión.	-Repair.
Sudden loss of gas.	-Broken gas pipe. -Key to open gas.	-Repair -Close the key
Gas Pressure Pulse.	-Water in the gas line. -Plugging of the gas pipes.	-Eliminate the presence of water. - Unclog with a stick.

Tabla 22. Troubleshooting, causes and possible solutions.

As has been noted in these tables, most of the problems of biogas production are changes Ph.

To measure this, we recommend soaking in mud indicator paper impregnated with a chemical called lackmus; this change color and compared with a reference table to find the Ph.

All this is achieved in a store of chemicals, and is an inexpensive alternative for measuring the Ph.

They have several ways to correct the Ph practical, Guevara (1998), indicates the following:

1. Add a small amount of effluent and adding fresh raw material in the same amount and simultaneously.

2. When the pH is low, you can add ashes, ammonia water (urine), a diluted mixture of both and fermented liquor.

Considering the indications and recommendations contained in the manual, the greater chance you will succeed in implementing this clean technology. Always taking into account any doubt more and problem not solved practically with these recommendations, it is best to consult an expert, as is a Chemical or builder biodigesters Ing.

The literature consulted and presented clarifies us the picture about the diversity of projects implemented biodigesters in the world. Comparison and synthesis allow a better idea about the proposal and implementation of a digester and generate power from the self.

This review also gives us a guide to a better adaptation and application in the case of community of Chipilo, as can be seen in the manual is an economically viable technology adapted to the context of the study

This is intended to disclose in the community, the basis for the design and incorporation into the family production system, hoping the community associations can help in the development and management of the digester.

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