

HOME BIOGAS

User's Manual: Digester & Stove



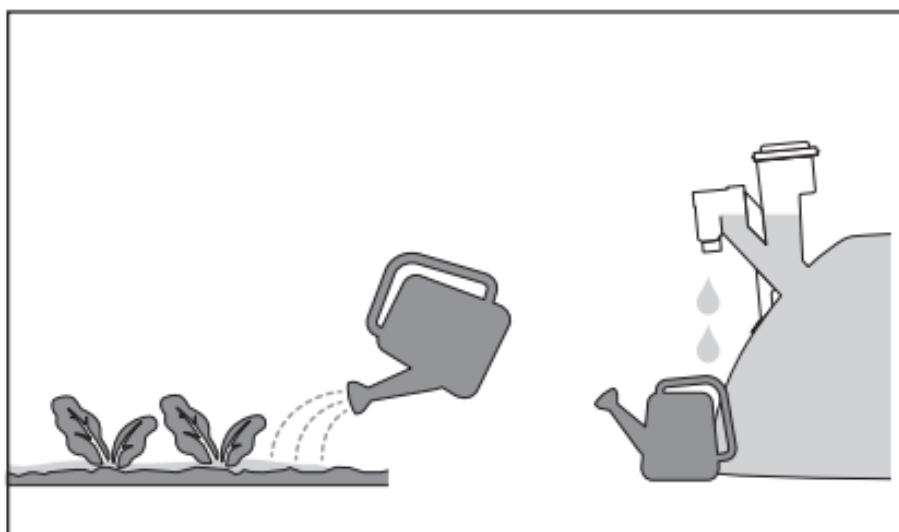
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Disclaimer

This user-friendly manual complements other Home Biogas resources for developing biogas project for Fiji communities. It is designed to be used in combination with Home Household Biogas owner's manual. The user-friendly manual is prepared to improve the successful development, implementation, and operation of the HBG system. While this manual address numerous aspects of the HBG system, it is not possible to cover every component. Therefore, this document should not be considered fully comprehensive, nor should it be used in place of a site-specific installation and O&M manual. Rather, it should be considered a supplement to the owner's manual provided by the supplier. Communities or household in Fiji may utilize this manual to ensure that the operation of the HBG system is optimal. The manual will be updated as the HBG system evolve.

The information on this manual is provided solely on the basis that users will be responsible for making their own assessment of the content present. Therefore, before relying on the content on this manual, users should exercise their own skill and care with the use of this manual and carefully evaluate the accuracy, reliability, currency, completeness, and relevance of the content on this manual.

Using Liquid Fertilizer





BACK

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Preface

Home Biogas systems can be cost-effective mitigation techniques and provide numerous co-benefits to the local communities where they are installed including environmental, energy, financial and social benefits. FNU in collaboration with government and industries promotes the use of HBG system to reduce CH₄ emissions from livestock waste and manage food waste. As an education institute and its outreach program, FNU disseminates information relevant to HBG projects and synthesizes it for stakeholders who implement or procure HBG systems.

Purpose of the User-friendly Home Biogas Manual

The purpose of this user-friendly Home Biogas manual is to help the households in Fiji who have installed the Home Biogas system and biogas system operators improve performance and efficiency. It also helps prevent common difficulties and challenges that can lead to community opposition and system closure. This manual covers, activation, operation and maintenance, trouble shooting, technical specification and safety. It is intended to be a resource that helps operators maximize biogas yield and improve operating uptime while minimizing operations and maintenance expenses.

Acknowledgments

The working group would like to acknowledge the many individuals and organizational contributor who supported the enhancement of the user-friendly Home Biogas manual. Within the working group, work was led Dr. Ravita Prasad, Assistant Professor, School of Sciences at Fiji National University with inputs from Dr. Constantinos Vassiliades, Neapolis University Pafos, Cyprus, Dr. Eric Boachie Yiadom, University of Professional Studies, Accra – Ghana and Dr. Wassim Dbouk, University of Southampton, UK. Special thanks Cagimaiwai Women's Club and UNDP, small grants program for the project and funding of the Home Biogas system, Association of Commonwealth Universities Research to Action Project 2021 for funding one biogas unit and FNU Seed funding for carrying the research work.

The working group also wishes to acknowledge and thank the following individuals who helped towards the development of the user-friendly Home Biogas manual: Cagimaiwai Women's Club and Pacific Grow. The community and industry experts offer Home Biogas system operators best practices guide, and trainings.

This manual was prepared by the working groups which include the following individuals: Naveendra K. Reddy, Jreeta and Ashmit Kumar.

Acronyms

HBG	Home Biogas
FNU	Fiji National University
UNDP	United Nations Development Programme
CO ₂	Carbon dioxide
CH ₄	Methane
O&M	Operation and Maintenance

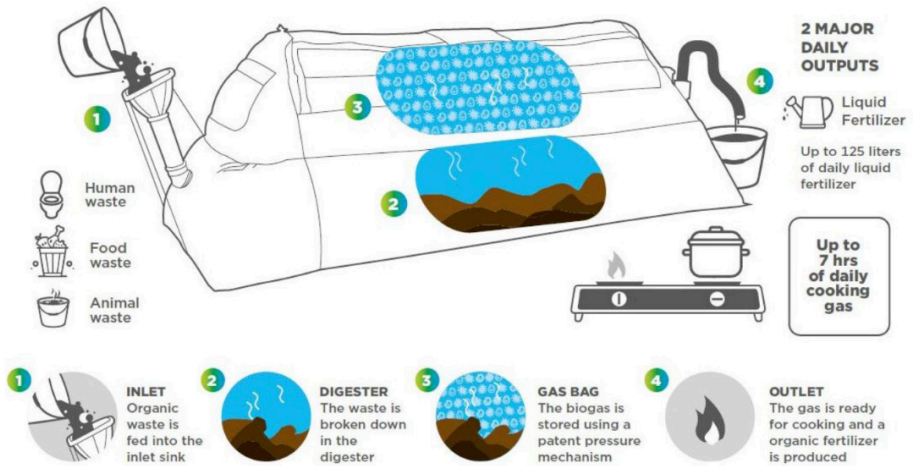
1. Introduction

- Biogas is a byproduct of the breakdown of organic materials, under certain conditions, by anaerobic bacteria.
- The main component of biogas is methane (CH_4); which can be combusted for energy. This energy can be used for cooking purposes.
- When burnt, methane does not release soot or black carbon, which makes it a clean cooking fuel.
- The home biogas system is an efficient, economical, and environmentally friendly system for producing not just clean cooking gas, but also fertilizer rich in organic matter for the garden.

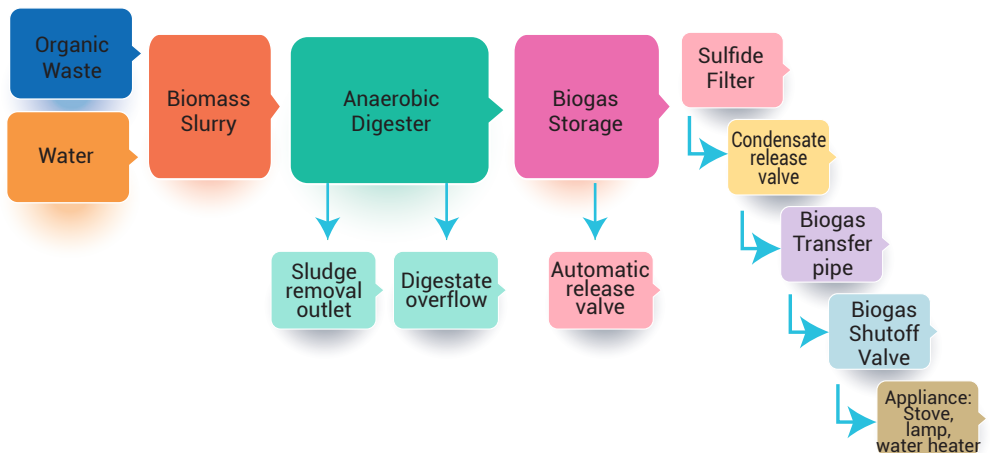


Figure 1: Steps to turn food waste into biogas [2]

2. Parts of the Digester System



Schematic of Household Biogas Systems



3. Activating the System

Activation: is a one-time process, which must be carried out in certain conditions for the right bacteria colony to grow inside the system to ensure gas production.

- Wait a day after assembly and verify there are no leaks before starting activation.
- Activate the system in warm weather (average temperature at least 25°C for the first 4 weeks).
- If the system is fed only with animal manure, there is no need to activate the system so it can continue feeding right away as given below for different system size.

HBG2	15 L manure 30 + L water 45 = L slurry
HBG4	25 L manure 50 + L water 75 = L slurry
HBG7	36 L manure 72 + L water 108 = L slurry

1



To activate ,you will need the required equal amount of water with slurry) Ratio (1:1 as per the system size of animal manure from herbivores ,fresh) wet and up to 2 days old(and clean as possible from straws ,stone, soil ,or sand.

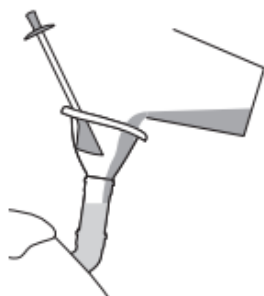
HBG Manure Quantities (Before mixing with water)

2.0	100 L
4.0	200 L
7.0	300 L

The amount of feed can be added over a few days if it is difficult to obtain the full amount at once.

Manure from cows ,sleeps ,goats ,horses, or pigs can be used .Do not use chicken droppings.

2

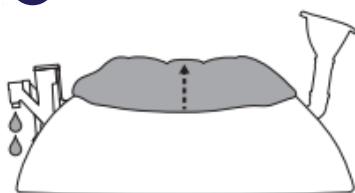


Raise the plunger) rest it on sink's plunger slot (and start filling the sink with slurry.

Equal amount of liquid will pour from the fertilizer outlet that can be reuse to mx more slurry to feed the system.

DO NOT start feeding the system with any food waste until a steady flame can be produced at your stove.

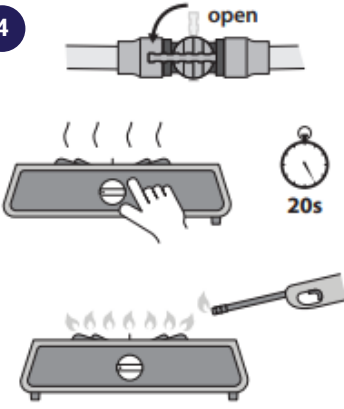
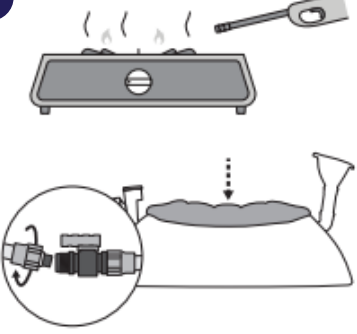
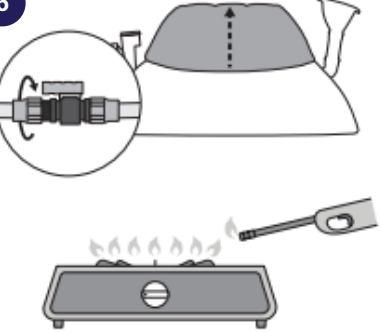
3



**gas tank starts to fill
(1-3 weeks)**

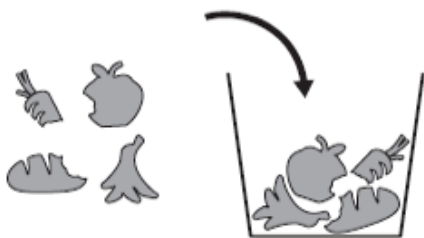
The system will begin to produce gas within 1-3week from the initial feeding depending upon the surrounding temperature and the freshness of the manure.

Once the gas begins to generate ,the liquid will pour out of fertilizer outlet and the gas bag will fill up and expand.

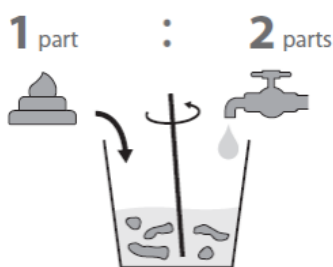
<p>4</p> 	<p>Once you see the gas bag starts to fill visibly ,try lighting the stove(.First open the gas valve at the system)</p> <p>For first time use allow the air in the gas tube to escape for about 20 seconds for more depending on the length of the gas tube before lighting .Lighter is recommended since biogas is less flammable compared to regular gas.</p>
<p>5</p> 	<p>The gas produced at first may contain a high level of CO₂ and will not easily ignite.</p> <p>If the flame is not steady or the gas does not ignite ,empty the gas tank by unscrewing the gas valve connector until the gas bag has completely deflated. Initially the bag may need to be emptied once or twice.</p>
<p>6</p> 	<p>Close the gas valve's screw on connector and wait for the bag to fill up again and then try to light the stove.</p> <p>If steady flame is not achieved repeat step 5 until good flame is achieved.</p> <p>Once you're able to easily light a steady flame ,the system is ready for use .At this point you may start to input food waste.</p>

Source: HOMEBIOGAS manual, 2021 [1]

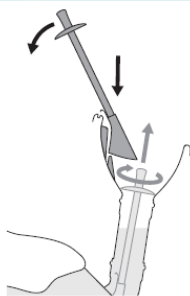
4. Daily Operation after Activation



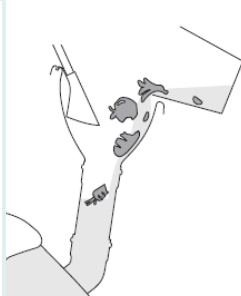
For kitchen waste, ensure that the waste matter is chopped into small pieces to allow for it to effortlessly move down the inlet pipe; as well as to improve the efficiency of decomposition and digestion by the anaerobic bacteria.



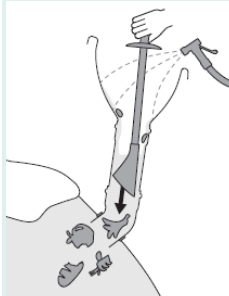
For animal manure, mix 1-part animal manure with 2-parts water to create a slurry.



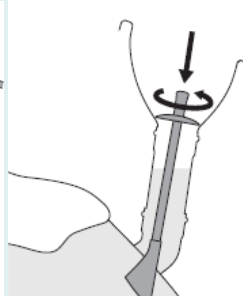
To open the plunger, turn it 180° and lift.



Gradually pour the prepared kitchen waste/manure slurry into the sink.



Push the waste down the inlet pipe into the digester tank, then rinse the sink (and container) with water.



Push the plunger all the way down the inlet pipe, then make sure to turn plunger 180° to "lock" it in place and properly seal sink.

Source: HOMEBIOGAS manual, 2021 [1]

5. Feeding the System

Once there is gas production check if the gas is flammable and if there is a steady flame you can start feeding in the system.

During the **first two weeks**, **feed only half the amount** because the bacteria is not ready for full feeding.

After two weeks you can feed daily up to:

Home Biogas	Food Waste	Animal Waste
HBG 2.0	6 L/day	15 L manure + 30 L water = 45 L slurry
HBG 4.0	12 L/day	25 L manure + 50 L water = 75 L slurry
HBG 7.0	36 L/day	36 L manure + 72 L water = 108 L slurry

Organic food waste such as rice, cheese, fruits and vegetables, peels/pulp, meat, bones, eggshells, cooking oil, and other "Wet" food waste.

Start feeding only when gas is flammable.

Clean manure must be added - do not add any straws, stones, soil, or sand.

Poultry dropping/ Chicken manure can be used for to 50% of the total daily waste input.

Note: Feeding Home biogas with more than the bacteria will cause a drop in the pH and an interruption of the gas production.

As gas accumulates in the gas bag the pressure starts to increase. The liquid column is pushed downward by biogas formation. The gas pressure is equal to liquid column height (1 cm – 1 millibar = 100 Pascal). When full the pressure is 12 mbar, and the extra biogas is release to the atmosphere from the combined airflow openings.

Gas bag contains pockets which are filled by sandbags that regulate the pressure in the gas bag. Table below shows numbers of sandbag and weight for the different system size.

System size	No. of Sandbag (1L)	Weight (kg)
HBG 2.0	40	56
HBG 4.0	48	155
HBG 7.0	56	157

The bags are distributed evenly around the gas bag, so pressure is constantly exerted even when the gas bag is nearly empty. This guarantees the stove will be able to light even if the gas bag is not full.

When gas is used, the gas bag empties out and when being fed again, the cycle starts repeatedly daily. Since it's a closed cycle, when organic waste and water are added into the system, fertilizer will pour out of the outlet. The fertilizer should be diluted into a ratio 1:5 (fertilizer: water) and for trees 1:3.

6. Safety

General:

1. Do not light fire in the system area within a radius of 5 meters (15ft.) from the system.
2. No smoking near the system.
3. Do not drink liquid fertilizer.
4. Do not climb on the system.
5. Do not use sharp objects that could damage the system.
6. Do not breathe the gas released from the system.
7. Dispose of used gas filters properly and safely.
8. Do not place any object on top of the system.
9. Build a cage/fence around the system to protect from damage.
10. Provide one or more dry powder extinguishers in a clearly visible location near the burner.
11. Ensure that the appliances are not sited near combustible material (e.g., under flammable shelving or close to curtains).
12. Keep the digester clean to reduce disease hazards as well as the spread of odors and fly populations.

Digester & Fixtures:

13. Ensure that only biodegradable matter is being fed into the digester and not matter that will cause a blockage.

Do Not Feed

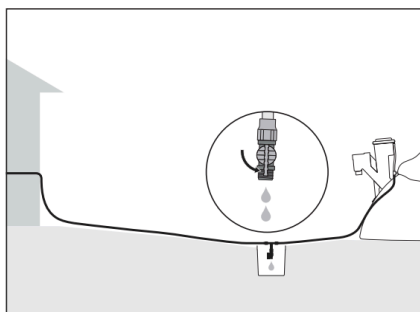
Citrus fruits: Up to 50 ml (one fruit per day). Citrus peel contains antibacterial oils, if added in large quantities, will affect the performance of the system.

Cooking oil: up to 50 ml. Large amounts of cooking oil can slow down the digester activity.

Garden waste: Take out any straw that is mixed in the slurry. Do not feed any grass, tree branches, dry leaves, twigs, wood shavings earth and sand.

Non-organic objects/household waste: Do not feed any metal. Plastic, glass, paper, and any non-organic liquids.

14. If fed too fast or too much fluctuation in temperature, the methanogenic process can decline and won't keep up with the acid production.
15. Inspect for gas leaks along the piping system using soap solution/ shampoo, and fix it where bubbles form.
16. Never test for leaks in an enclosed space with any flame or burning matches.
17. When handling waste material, exercise appropriate precautions by using personal protective equipment to avoid contact with manure.
18. Check shut-off valves for corrosion or mechanical damage and ensure free range of movement.
19. Check flexible tubing for signs of ruptures, cracking or perishing and replace if necessary.
20. Conduit/duct tubes to prevent exposure to sunlight to avoid cracking.
21. Locate piping at least 150 mm away from electric cabling.
22. Biogas contains water vapor that may condense during cooler nights and accumulate in the gas pipe, blocking gas flow. If your stove's flame is sputtering, you should empty the water by opening the valve, remove the water and close the valve.



Source: HOMEBIOGAS manual, 2021 [1]

7. Technical Specifications

Household Biogas System Technical Information

	HBG 2.0	HBG 4.0	HBG 7.0
System volume	2.1 m ³	3.9 m ³	6.8 m ³
Gas tank volume	700 L / 185 gal	1200 liters / 317 gal	2500 L / 660 gal
Digester tank volume	1200 L / 317 gal	2650 liters / 700 gal	4300 L / 1136 gal
Dimensions Assembled	210 x 115 x 130 (cm, L x W x H)	300 x 150 x 135 (cm, L x W x H)	400 x 180 x 150 (cm, L x W x H)
Weight Assembled (approx.)	1270 kg	2900 kg	4600 kg
Gas pipe max length	Up to 10m	Up to 20m	Up to 20m
Nominal gas pressure	10 mbar	10 mbar	10 mbar
Max energy capacity	4.4 kWh/15.4 MJ	4.4 kWh/15.4 MJ	4.4 kWh/15.4 MJ
Daily cooking time (single flame burner)	Up to 2 hours	Up to 3 hours	Up to 5 hours
Daily kitchen waste input*	Up to 6 L	Up to 12 L	Up to 18 L
Daily animal manure input**	Up to 15 L (45 L slurry)	up to 25 L (75 L slurry)	Up to 36 L (108 L slurry)
Daily fertilizer output	Up to 45 L (equal to input volume)	up to 75L (equal to input volume)	Up to 108 L (equal to input volume)
Operating temperature	>20°C/°68F	>20°C/°68F	>20°C/°68F
pH	Optimal range (pH 7 - 6.8)	Optimal range (pH 7 - 6.8)	Optimal range (pH 7 - 6.8)

*The system accepts a maximum feeding volume of 45 liters daily – a combination of up to 6 liters kitchen waste and up to 45 liters animal manure slurry (1 part manure + 2 parts water)
Example: 6 liters of kitchen waste and up to 39 liters of manure slurry (13 liters manure + 26 liters water)

** Animal manure must be mixed well with 2 parts waters.

8. Maintenance & Troubleshooting

How to keep system clean, avoid clogging, how to clean stove, how to safely install/maintain gas pipe, conduit/ducting to prevent exposure to sunlight – avoid cracking...

Possible problems of biogas plants and their solutions

PROBLEMS	POSSIBLE REASONS	SOLUTIONS
Gas does not burn.	The first gas coming from the plant may not burn.	Open the valves and allow the gas to flow out once or twice. It will start burning.
There is plenty of gas inside the dome but won't come in the stove.	Main valve is closed.	Open the main gas valve.
	Gas tap or gas jet may be blocked.	Clean the gas tap and gas jet.
	Pipeline may be blocked.	Open main gas valve and water drain. Remove the water or slurry through the water outlet.
Little gas production.	May be there is no adequate feeding.	Feed the digester as recommended.
	More water inside the digester.	Add less water during feeding.
	Leakage from the pipeline.	Check the joints and fittings with the help of soap water. If bubbles occur repair the leakage.

Flame is very weak and red.	There may be impurities in the gas tap and stove.	Clean the gas tap and stove weekly.
	Less gas inside the plant.	Close the main gas valve and collect the gas.
Gas burns with long flame; slurry comes through pipeline.	There may be blockage in the air regulating hole and ring.	Clean the hole and the ring.
	Inadequate feeding.	Feed the plant adequately.
	Gas used frequently.	Close the valve for about 10 hrs.
	Gas leakage	Check the main gas valve and other fittings with soap water and repair the leakage. If the problem is not solved contact the contractor.

9. Summary

1. Feed it properly:

Feed up to 6 liters of kitchen waste or 36 liters of animal manure slurry daily.

2. Keep system liquid temperature above 20°C/68°F.

Add a water heater or stop feeding completely until the temperature rises to an average of 20°C/68°F.

3. Ensure home biogas is full of water.

The system is full when water pours out from the fertilizer outlet.

4. Feed with kitchen waste or animal manure

Do not feed with paper, sand, plastic, leaves, branches, straw, dirt, sand, or large quantities of citrus peels or cooking oil; or with more than 50% chicken manure.

5. Feed only when the gas is flammable.

Gas is not flammable when home biogas is fed improperly or fed when temperature is under 20°C/68°F.

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1. HOMEBIOGAS, October, 2021. "Owner's Manual", HOMEBIOGAS, <https://www.homebiogas.com/system-owners/> (accessed on 02 June 2023).
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3. Tim Ozkurt, 2023, "Home Biodigesters – turning food waste into green energy", Mossy Earth Ltd, <https://www.mossy.earth/guides/energy/home-biodigester> (accessed on 13 June 2023).