



Renewable Energy Technologies

Biogas



INTRODUCTION

Global temperatures are rising causing devastating extreme weather throughout the world. The average worldwide temperature for the past five years are among the highest on record [1]. SDG's – Sustainable Development Goals were introduced in 2015 by the United Nations to engage such issues which consists of urgent actions required to improve the social, ecological and economical situation worldwide [2]. The main contributor to global warming is burning of fossil fuel which leads to the release of greenhouse gases. The focus is to show what different types of renewable energy technologies exist and can be implemented in the daily lives of populations in developing countries (Sierra Leone) in order to archive climate action goals [3].



Source: www.go.greners.oz

CURRENT SITUATION IN SIERRA LEONE

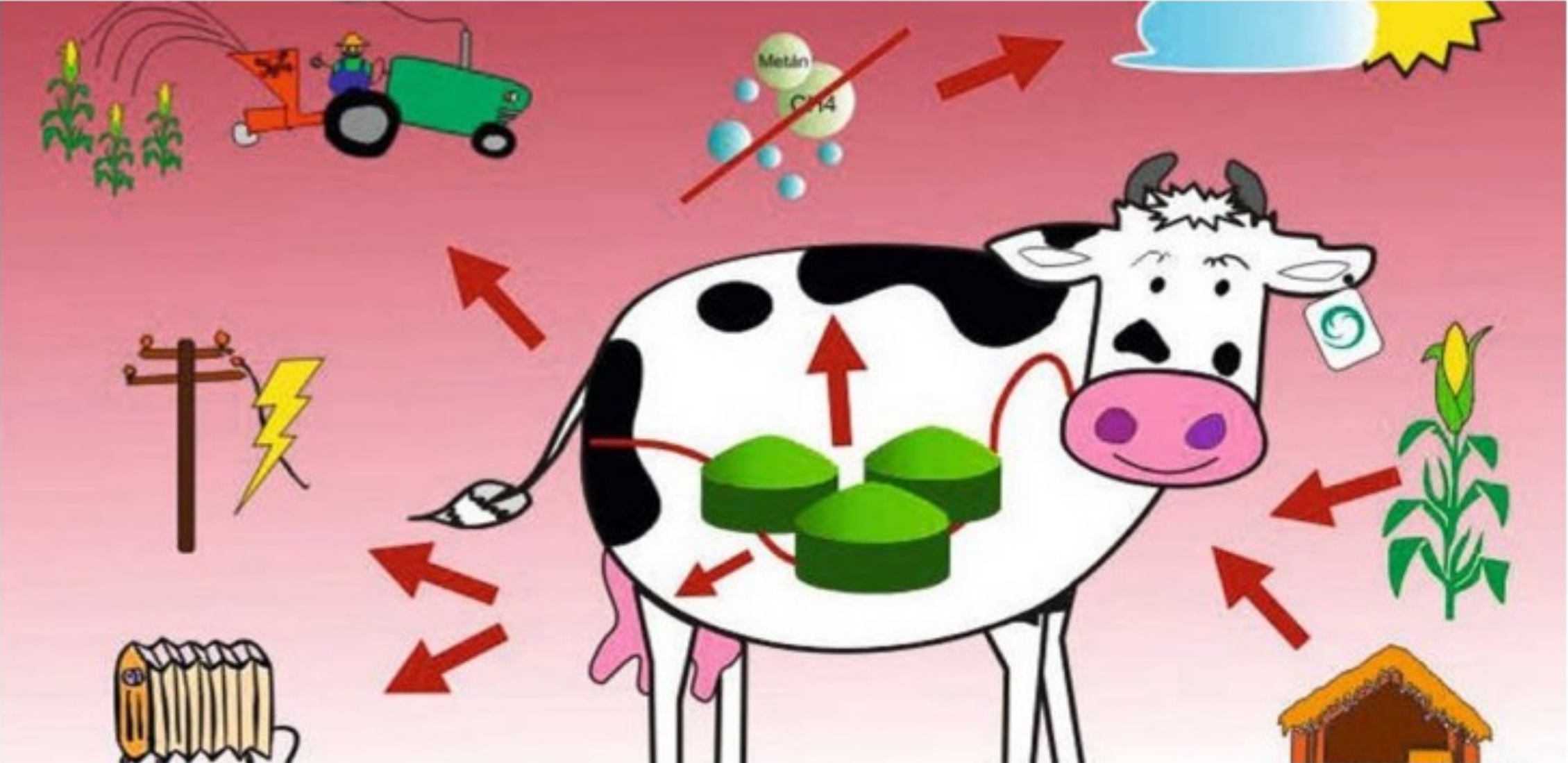
The economic situation in Sierra Leone is very dire. Nearly three quarters of the population of sierra leone struggle to get access to electricity .This is further exacerbated by the rise in prices for traditional energy sources e.g. fossil fuels , charcoal and electricity [4]. Our approach in solving this situation is to raise awareness about renewable energy technologies which already exist and which can be adapted to fit the needs of sierra Ionians .These decentralized renewable energy plants can then provide relief for the rising energy costs an make life more affordable.



Source: www.bbc.com / sierra leone

BIOGAS

Definition:
Biogas is a renewable fuel produced by the breakdown of organic matter such as food scraps , animal waste ,municipal waste ,Landfills and sewage waste.
Biogas Composition: different composition according to source material
Sewage digesters: contains between 55 to 65 % methane, 35 to 45 % carbon dioxide and < 1 % nitrogen.
Organic waste : between 60 to 70 % methane, 30 to 40 % carbon dioxide and < 1 % nitrogen.
Landfills :between 45 to 55 % Methane , carbon dioxide from 30 to 40 % and nitrogen from 5 to 15 % (Jönsson et al. 2003).
-Biogas also contains hydrogen sulphide and other sulphide compounds, siloxanes and aromatic and halogenated compounds.
-The first biogas plant for solid waste fermentation with digester volume of 10 m3 was developed by Issman and Duselier and built in Algeria in 1938[5].



Source: european-buissness.com

Acknowledgements

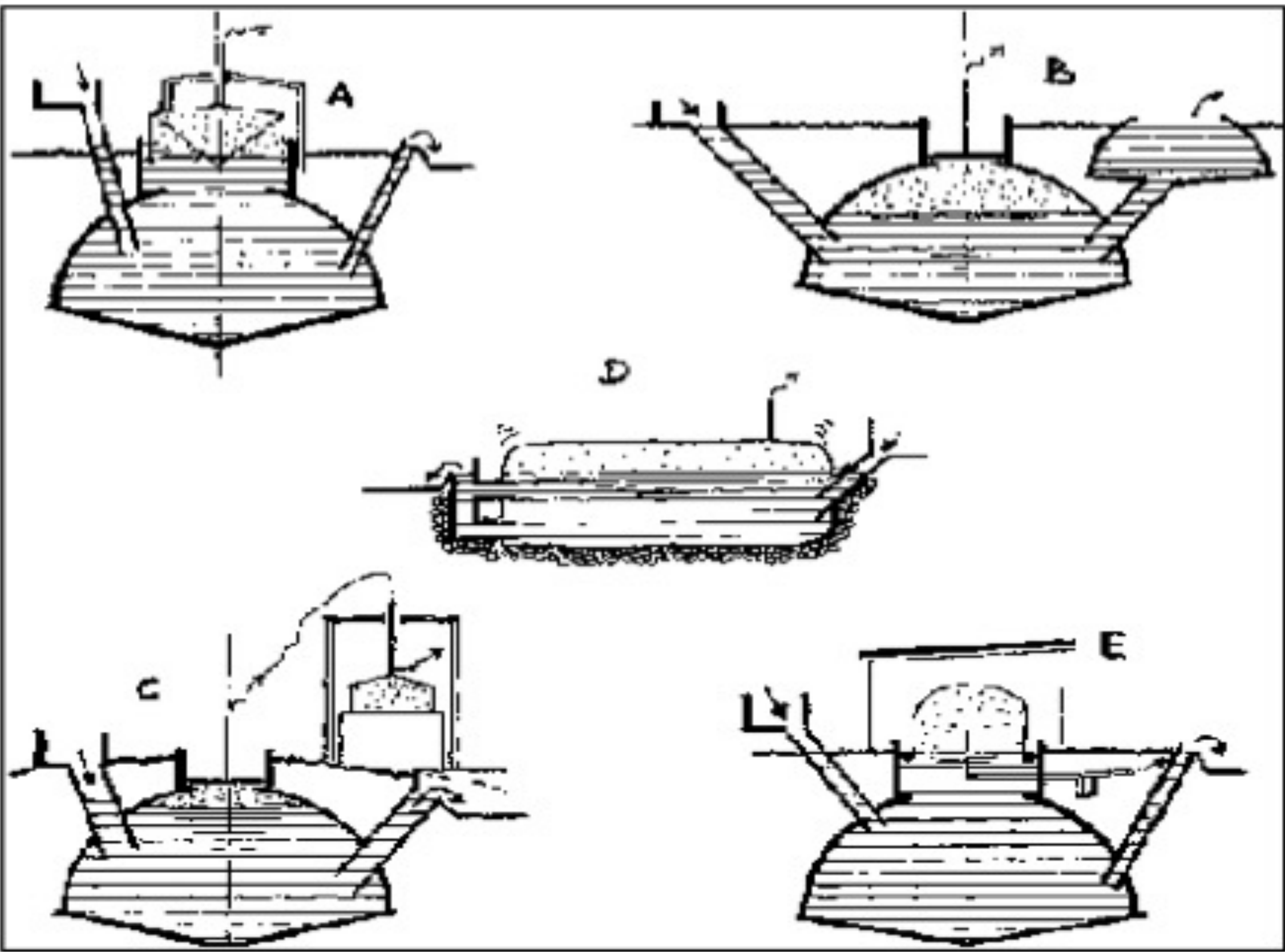
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BIOGAS PRODUCTION

Biological process: Anaerobic digestion with the help of Microorganisms
Process is divided into 3 Steps:

- Hydrolysis
 - Acidification/Fermentation
 - Methane formation
- **Hydrolysis :**
Breakdown of organic matter into long and short chains of complex carbohydrates and proteins into peptides and amino acids by extracellular enzymes (amylse, protease ,lipase , cellulose)
- **Fermentation:** Conversion of complex organic compounds (proteins , fats and carbohydrates) into much simpler compounds like amino acids, carbon dioxide, hydrogen sulphide and volatile organic acids. These are then used as nutrients for methane producing bacteria.
- **Methane formation:** Decomposition of compounds with low molecular weight by methane and acid producing bacteria under anaerobic conditions.
- These two bacteria have a symbiotic relationship. Acid producing bacteria create the ideal anaerobic conditions while methane producing organisms use the intermediates of the acid producing bacteria [6] .

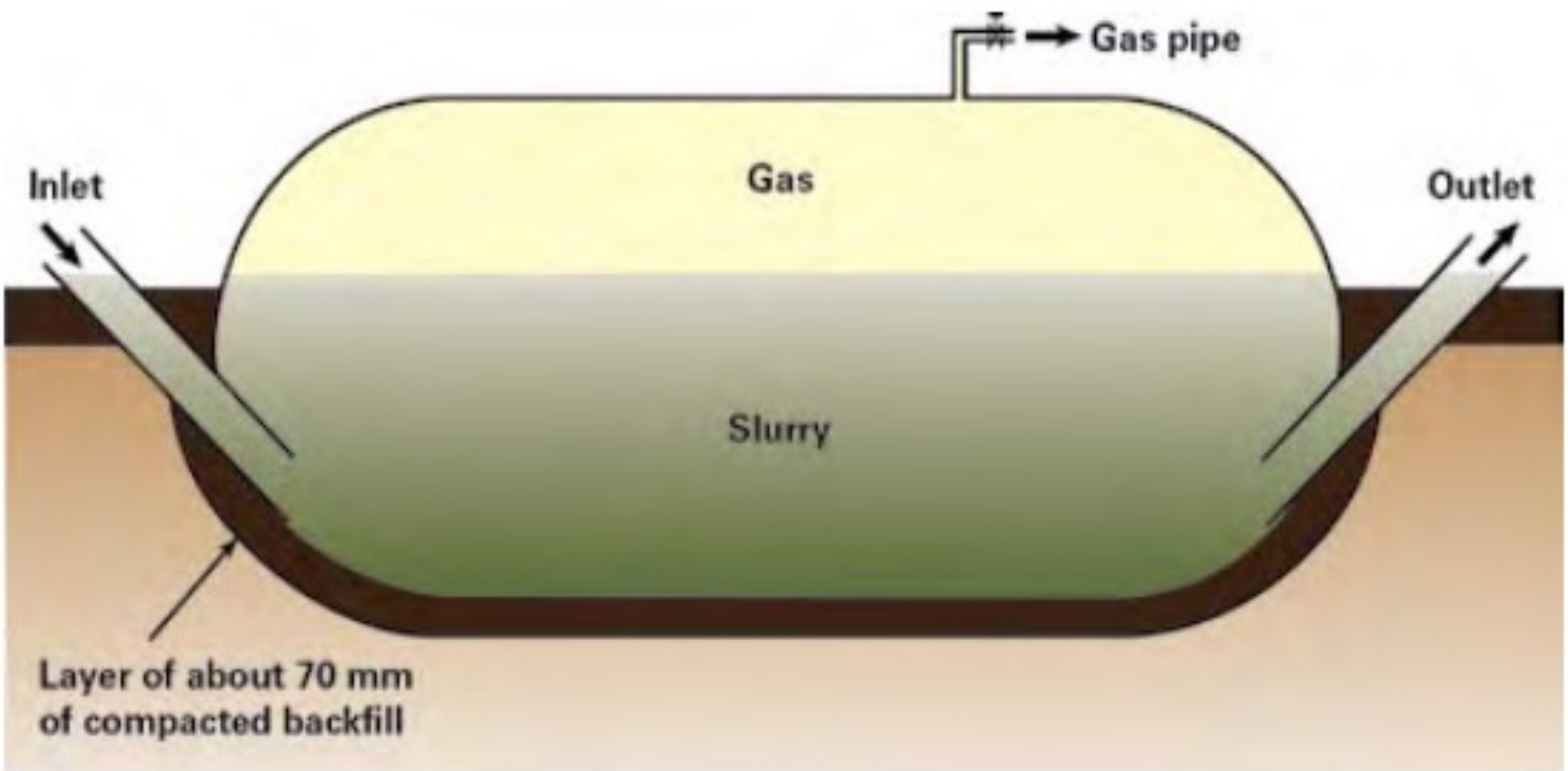
TYPES OF BIOGAS DIGESTERS



- A. Floating drum plant
- B.Fixed dome plant
- C.Fixed dome plant with separate gas holder
- D.Balloon plant
- E.Channel type digester with plastic sheeting and shed

For our purposes we will focus on the fixed dome plant, the balloon plant, the floating drum plant and the generic modern adaptations using water tanks.

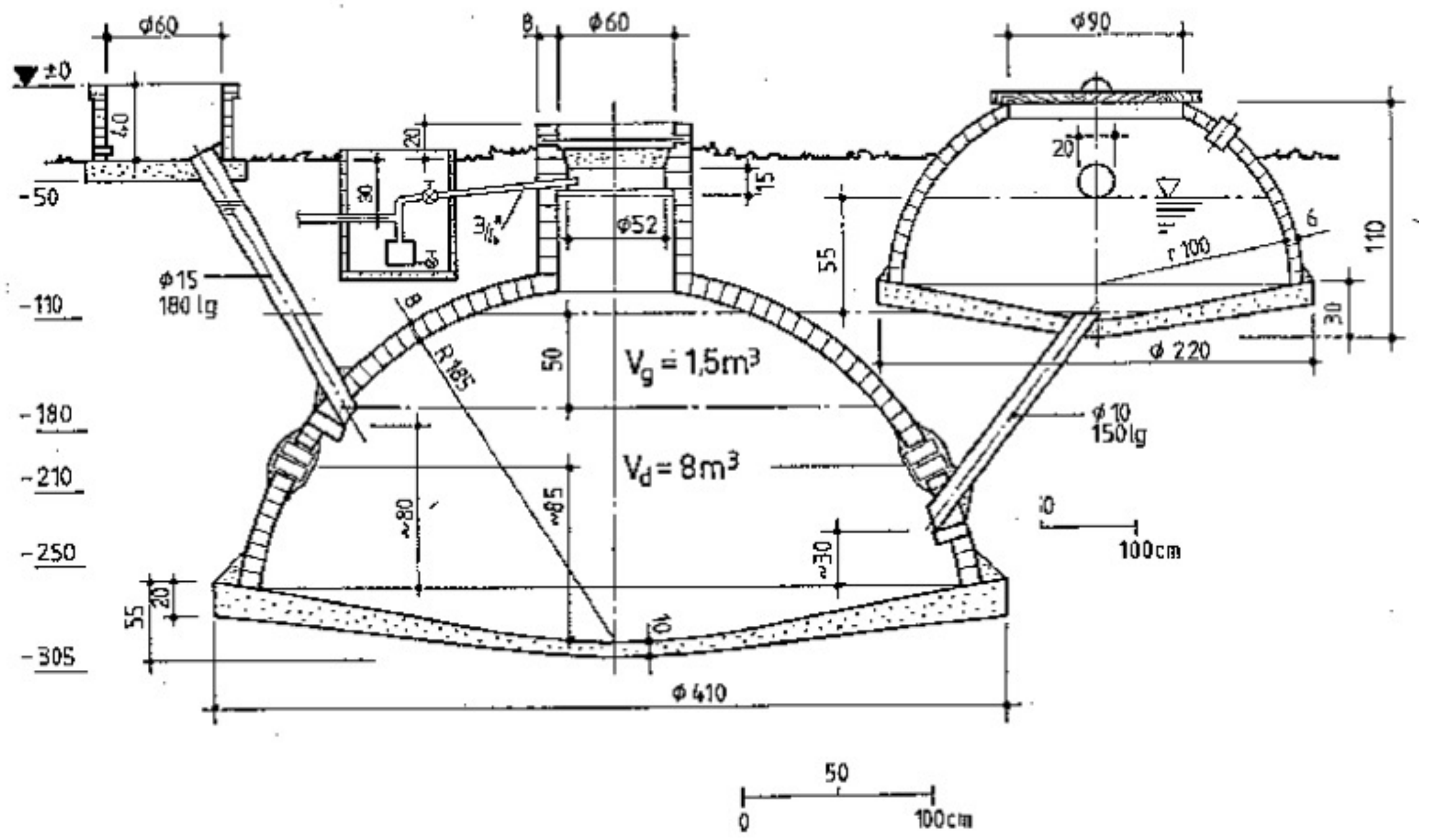
BALLOON PLANT



Source.AnaerobicdigestionofBiowasteinDevelopingcountries.pdf

This is a longitudinal shaped heat-sealed, weather resistant engineered plastic or rubber bag (balloon) that serves as digester and gas holder in one. The gas is stored in the upper part of the balloon. The inlet and outlet are attached directly to the skin of the balloon. The benefit of these digesters is that they can be constructed at low cost by standardised prefabrication. Additionally, the shallow below ground installation makes them suitable for use in areas with a high groundwater table. However, the plastic balloon is quite fragile and susceptible to mechanical damage and has a relatively short life span of 2–5 years (Nzila et al., 2012). Gas pressure can be increased by placing weights on the balloon while taking care not to damage it [7] .

FIXED DOME PLANT



A fixed-dome plant consists of a digester with a fixed, non-movable gas holder, which sits on top of the digester. When gas production starts, the slurry is displaced into the compensation tank. Gas pressure increases with the volume of gas stored and the height difference between the slurry level in the digester and the slurry level in the compensation tank. The costs of a fixed-dome biogas plant are relatively low. It is simple as no moving parts exist. Maintenance is low and they last a long time especially if no metallic materials were used in the construction (20 years or more can be expected) [8] .

DESIGN CALCULATIONS

Sizing factors	Example	Sample calculation
Daily substrate input, Sd	115 l/d	R = (0.76 • 8)1/3= 1.85 m
Retention time, RT	70 days	r = 0.52 R= 0.96 m
Daily gas production, G	2.5 m3 /d	h = 0.40 R= 0.72 m
Storage capacity,Cs	60 %	p = 0.62 R= 1.14 m
Digester volume, Vd	8m3	
Gasholder volume, Vg	1.5 m3	

DIY DIGESTERS USING WATER TANKS / INDUSTRIAL CHEMICAL HOLDING CONTAINERS

This is the most adaptable biogas digester for both rural and urban places. It is modular can be scaled up or down depending on the number of people in the house hold. The materials needed to construct these types of digesters are readily available off the shelf and in almost all hard ware and plumbing stores around the world. Minimal tools are required for the assembly of the digesters and after a few instructional videos on how to assemble ,almost any able bodied person can assemble them because no technical knowhow is needed [9] .



Source.AnaerobicdigestionofBiowasteinDevelopingcountries.pdf

BIOGAS APPLICATIONS

- Household cooking Stove
- Industrial burners
- Refrigerators 100 L
- Gas lamp, equivalent to 60 Watts Bulb
- Biogas / Diesel engine
- Fertiliser from Slurry

CONCLUSION

Anaerobic digestion reduces the amount of waste and generates products of value, such as biogas and nutrient-rich digestate. However AD still plays a negligible role as a treatment option for organic kitchen and market waste in cities of low-and middle-income countries. More still needs to be done to popularise its potential globally.



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[1] <https://public.wmo.int/en/media/press-release/climate-change-and-impacts-accelerate>
[2] <https://unstats.un.org/sdgs/report/2020/The-Sustainable-Development-Goals-Report-2020.pdf>
[3] [https://sustainabledevelopment.un.org/content/documents/960SIDS_Flyer_SEPT_27_09\[1\].pdf](https://sustainabledevelopment.un.org/content/documents/960SIDS_Flyer_SEPT_27_09[1].pdf)
[4] https://unfccc.int/resource/docs/publications/cc_sids.pdf
[5] https://www.energypedia.info/image/a8/biogas_plants_animal_husbandry
[6] <https://www.AnaerobicdigestionofBiowasteinDevelopingcountries.pdf>
[7] Nichols C. E. (2004). Overview of Anaerobic Digestion Technologies in Europe. Biocycle, Vol.45, No.1, p.47.
[8] House D. (2010). The Complete Biogas Handbook. Alternative House Information.
[9] [https:// www.AnaerobicdigestionofBiowasteinDevelopingcountries.pdf](https://www.AnaerobicdigestionofBiowasteinDevelopingcountries.pdf)