Master's Thesis Engineering Technology

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Design and implementation of a hybrid biogas plant to reduce environmental pollution and food waste

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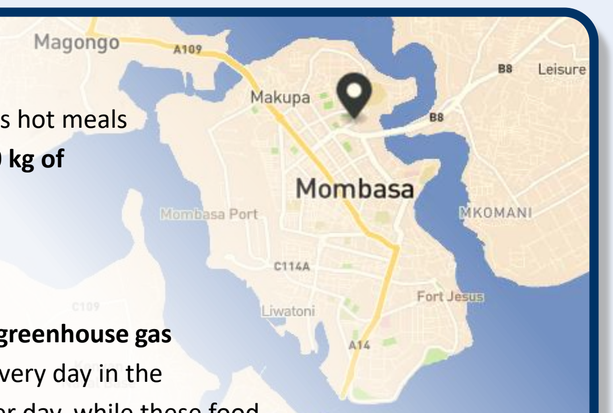
Situation

The **Technical University of Mombasa (TUM)** provides hot meals for about 2,000 students per day. To achieve this, **800 kg of wood and 120 kg of LPG** per month is needed.



Problem definition

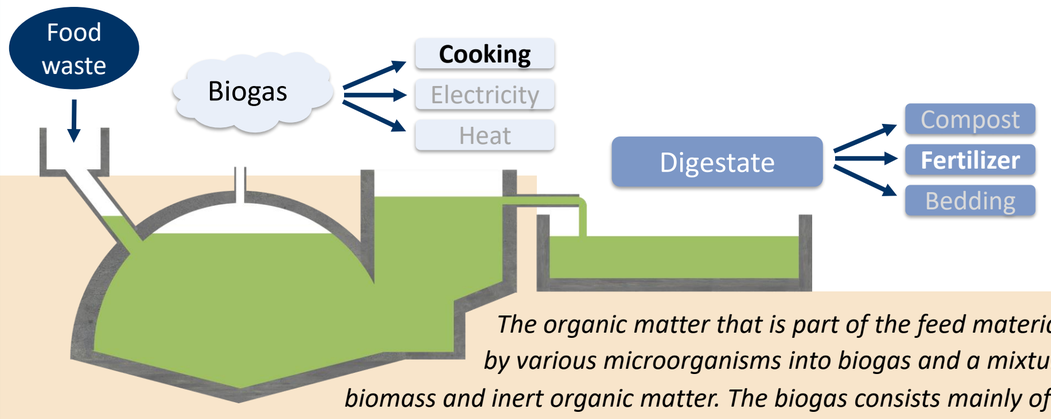
The use of fossil fuels is **expensive** and contribute to **greenhouse gas emissions and climate change**. Providing hot meals every day in the university results in **100 kg of organic (food) waste** per day, while these food residues could be used as an energy source.

Objectives

This master's thesis focuses on designing a biogas plant that converts food waste into biogas. The food waste from TUM will be converted as efficiently as possible into biogas which will be used for cooking.

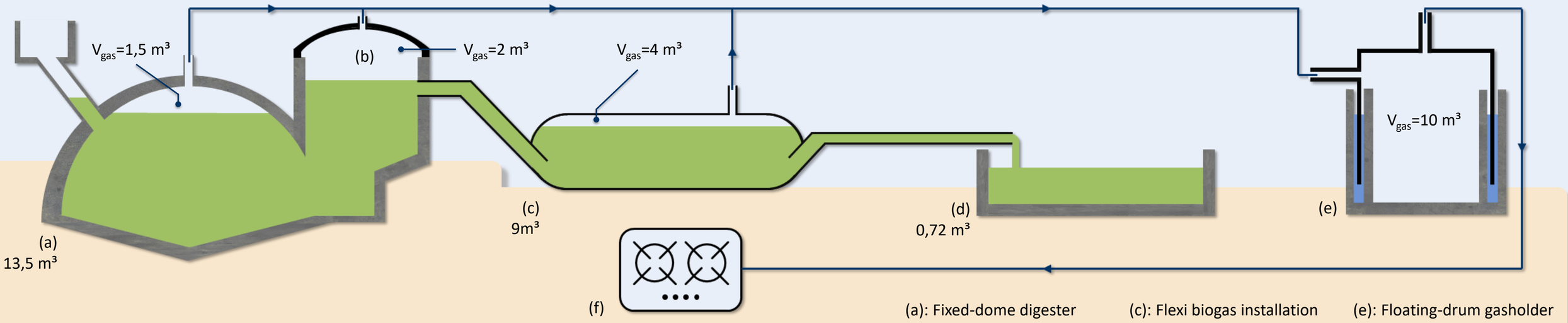
Method

To begin with, an extensive **literature study** on the different types of biogas digesters took place. The selected digester was conceptually **developed and dimensioned**. On site in Mombasa the plant was expanded to a hybrid biogas installation. Finally, the biogas plant was **implemented** in TUM.



The organic matter that is part of the feed material is converted by various microorganisms into biogas and a mixture of bacterial biomass and inert organic matter. The biogas consists mainly of methane and carbon dioxide. The digestate is a good organic fertilizer.

Figure 1: Biogas plant operation



(a): Fixed-dome digester
(b): Covered overflow tank
(c): Flexi biogas installation
(d): Digestate storage
(e): Floating-drum gasholder
(f): Biogas stove

Figure 2: Hybrid biogas installation

(a) Fixed-dome digester

The **fixed-dome digester** is one of the simplest and most common digesters in developing countries. A well-founded installation can withstand high **external loads** and high **internal pressure**, resulting in a **lifespan of up to 25 years**.

Properties

- Robust design
- No moving parts
- Underground construction
- Low efficiency (= biggest disadvantage)
- Building materials: bricks and cement

Figure 3: Fixed-dome digester, overflow tank and inlet reservoir

Hybrid biogas installation

Purpose of the hybrid installation

- Eliminating the disadvantages of the fixed-dome digester
- Making the installation more interesting for educational purposes

(b) Covering the overflow tank

- Eliminate gas losses in the overflow tank
- Reducing greenhouse gas emissions

(c) Expansion with a flexi biogas installation

- Improve efficiency
- More complete digesting process

Figure 4: Biogas site

(e) Floating drum gasholder

Properties

- Provides constant pressure
- Adjustable pressure by placing weight on the drum
- Buffer difference between consumption and production
- Visual representation of gas content by height of the drum

A **simulation** shows that a **total gas storage** of **15,09 m³** is required. Considering a safety margin of 20% and the other gas storages, **10,4 m³** should be stored in the floating drum gasholder.

The size of the gasholder depends on:

- Size of the gas storage in the other digesters
- Production = 11,88 m³/day
- Consumption

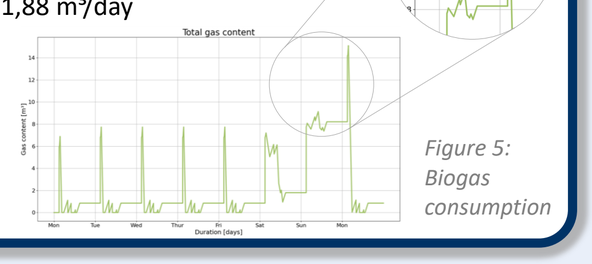


Figure 5: Biogas consumption

Conclusion

At the time of departure to Belgium, the plant was mostly complete (as shown in figure 4) but some tasks still need to be completed. Therefore, in June 2021, the works on the biogas plant are still in progress. As the project is part of a multi-year project, the continuation of the works is guaranteed. Close consultation is taking place with the university staff in order to bring the implementation of the biogas plant to a successful end.

Supervisors / Co-supervisors / Advisors

Prof. dr. ir. Wim Deferme
Dr. Juma Saulo Michael

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