Inland Norway University of Applied Sciences

Faculty of Applied Ecology, Agricultural Sciences and Biotechnology

Shaghayegh Moalemi

Master thesis

Fighting climate change with biogas

Supervisor: Christian Andre Haukaas

Master's Degree in Applied and Commercial Biotechnology

2BIO201

2023

Consent to lending by University College Library YES ☐ NO ☐

Consent to accessibility in digital archive Brage YES ☐ NO ☐

Acknowledgement

I would like to thank Christian Andre Haukaas my supervisor for his guidance and support throughout this thesis, and his motivation and encouragement during this study. I am grateful for his feedback and comments that helped me in writing my thesis. I want to thank Frøydis Myromslien, Head of the Biotechnology Department.

I’m also thankful for all the professors and faculty members of the Biotechnology department for their help and support.

Abbreviations

ABS	Acrylonitrile Butadiene Styrene
AD	Anaerobic Digester
BMC	Business Model Canvas
CE	Circular Economy
CO	Carbon monoxide
CO_2	Carbon dioxide
FAO	Food and Agriculture Organizations of united nations
FRP	Fiber-reinforced Plastic
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HDPE	High-density Polyethylene
LAC	Latin America and Caribbean
LPG	Liquid Petroleum Gas
PBD	Prefabricated Biogas Digester
PE	Polyethylene
PH	Plastic Hard
PP	Polypropylene
PS	Plastic Soft
PVC	PolyVinyl Chloride
ROI	Return on Investment

SAM	Serviceable Available Market
SOM	Serviceable Obtainable Market
TAM	Total Addressable Market

Table of Contents

Abstract

Climate change is a big challenge for our planet. A lot of companies are aiming to be greener in the long term, companies are looking for sustainable ways to reduce greenhouse gas emissions, through greener products or a greener supply chain. This paper proposes a product for a company to sell, to measurably contribute to reducing greenhouse gas emissions, namely a micro biogas digester, for waste management of cow manure. Poor waste management practices in South America and its large agricultural industry mean there is a large potential for reducing greenhouse gas emissions and a large potential market for biogas digesters in this region. That is why the focus region in this paper is South America, with a beachhead market that is Brazil.

Different types of biogas digester have been studied and a tubular biogas digester from Sistema.bio has been selected as the proposed product. Different business tools such as market segmentation, business model canvas and PESTLE analysis have been used to identify target customers and their pains and gains concerning this product. Finally, project plan development has been done to outline how to bring the product to market.

Key words: Biogas, climate change, greenhouse gas emission, green business model, project establishment, product development, market entry, value proposition design, design thinking.

1. Introduction

1.1 Context

This thesis is based on a hypothetical scenario where an intern is tasked with proposing to a company's CEO whether to distribute and/or manufacture a product. The model company chosen for this thesis is CNH industrial, but they are not involved, and have no knowledge of this thesis work. The scenario is as follows:

A large agricultural equipment manufacturer, CNH industrial, wants to expand its product range by adding environmentally friendly products to fight climate change. They currently produce and sell farm machinery such as tractors, harvesters, and generators in North and South America. They also offer financial services like loans and leases for agricultural equipment. The company's marketing team has identified micro-biogas digesters as a potential product line that could effectively reduce greenhouse gas emissions and enhance the company's product portfolio.

To assess the best approach, the CEO has assigned the research and development (R&D) team with the task of evaluating whether the company should develop and manufacture its own line of micro-biogas digesters. Or they are considering the option of partnering with an established micro-biogas digester producer and serving as their distributor. This decision will enable the company to expand its product offering while contributing to sustainability efforts and combating climate change.

1.2 Company Profile

CNH Industrial is a global company that specializes in providing world-class agricultural and construction equipment and services based in Amsterdam, Netherlands and its principal office located in London, United Kingdom.

This agriculture company designs, produces, and distributes an entire range of agricultural machinery and tools. This includes both two-wheel and four-wheel drive tractors, crawler tractors, combine harvesters, equipment for harvesting grapes and sugar cane, machinery for

hay and forage, as well as equipment for planting, seeding, soil preparation, cultivation, and material handling.

They are committed to supporting the agricultural and construction workers in a sustainable manner. With their strategic guidance, research and development capabilities, and substantial investments, CNH Industrial has led to the success of its core brands. The company has more than 180 years of experience in creating innovative equipment and services for farmers and builders worldwide. Everything that has been done is to support these farmers and builders. Their aim is to offer the finest machinery and technology to simplify their customers' lives and enhance the efficiency and profitability of their customers' businesses (*About Us | CNH Industrial*, 2023).

1.2.1 Customers

CNH industrial has various types of customers, some of them are described below:

Farmers and agricultural enterprises: these are the customers who buy the different types of equipment such as harvesters, tractors and planting and seeding equipment. These customers use the machinery to handle their crops and increase productivity.

Agricultural contractors: Contractors who provide services to farmers, such as planting, harvesting, and soil preparation, also require a variety of agricultural machinery to fulfill their contracts efficiently.

Livestock Farms: Farms with livestock mostly need hay and foraging equipment for animal feed preparation.

Distributors and Dealers: Distributors and dealers function as middlemen, acquiring CNH Industrial's equipment and then selling it to the final customers.

1.2.2 Competitors

The Agriculture and Construction equipment industries are very competitive. However, CNH is confident that they possess numerous strengths that will help them enhance their position in the markets where they are already well-established. CNH industrial competes with several types of companies. 1) Large global equipment manufacturers that offer a comprehensive range of products catering to various customer demands. 2) Product specialists who concentrate on specific industry segments either on a global or regional scale. 3) Regional

manufacturers, some of which are expanding globally to establish a worldwide presence. 4) Local manufacturers in individual markets, especially in emerging regions like Eastern Europe, India, and China, who focus on cost-effectiveness. In the agricultural equipment market, our main competitors are Deere & Company, AGCO Corporation, Claas Group, Kubota Tractor Corporation, Argo Tractors S.p.A., and the Same Deutz Fahr Group.

CNH has a wide variety of competitors in the construction equipment market, including, Caterpillar Inc., Komatsu Ltd., J C Bamford Excavators Ltd., Hitachi Construction Machinery Co, Ltd., Volvo Group, Liebherr Group, Doosan Group, Kubota Tractor Corporation, and Deere & Company (*About Us | CNH Industrial*, 2023).

1.2.3 Collaborators

CNH Industrial has a rich heritage of embracing open innovation and is home to renowned brands within the industry. Through extensive collaboration with customers, dealers, and suppliers over generations, they have gained valuable industry insights. They are dedicated to nurturing and supporting innovative startups in the agriculture and construction sectors, leveraging their expertise to guide them on their growth journey.

CNH Industrial Ventures builds upon successful innovation partnerships by providing not just financial backing, but also access to a seasoned team, a global network, and technological resources. Their commitment to 32 sustainability drives them to work closely with partners, promoting environmentally friendly solutions and fostering a sense of environmental stewardship. Their collaborators include Augmenta, Geoprospectors and EarthOptics. EarthOptics is an agricultural technology company that is currently working on advanced soil-sensing technologies. These technologies provide farmers with creative information and understanding of the physical properties of their soil (*About Us | CNH Industrial*, 2023).

1.3 Aim of the study

1.3.1 Scope

The scope of this project is limited to the product ideation, planning and feasibility phases. These phases will be carried out by desk research only. The R&D, project launch and transfer phases are outside the scope of this thesis. In the product ideation phase, we aim to find a product that helps waste management of agricultural solid waste for South American farmers

in an environmentally friendly way. For this we will look at different biogas digesters and identify which is best for the needs of the farmers. In the feasibility phase we will evaluate how feasible it is to sell or distribute this product. Finally, in the planning phase we will lay out a plan to bring a product to market.

The business case can be verified with interviews and facts and feedback from customers. But since we could not travel to South America during this assignment, field research should be done by the company in order to further inform planning, feasibility and subsequent stages of project establishment.

1.3.2 Objectives

The main objective of this thesis is to evaluate the viability of and make a business case for selling micro biogas digesters in South America. To make a viable business case we will make a recommendation about whether to manufacture or distribute the micro biogas digestor. We will make this recommendation based on the triple bottom line concept. The economic subobjective is for the company to be profitable. The social subobjective is to create value for the customers. Finally, the environmental subobjective is to have a positive environmental impact. All of these are for being more sustainable in the long term.

1.3.3 Evaluation Criteria

Master thesis evaluation criteria:

The company's CEO has tasked the research and development (R&D) team to evaluate whether the company should develop and produce its own line of micro biogas digesters. An alternative strategy is to select an existing producer of micro biogas digesters, and act as their distributor. The master student will take on the position of a summer intern within the research and development department of the company. During this time, the student will be responsible for conducting independent research and performing analysis on assigned tasks. The advisor, who will play the role of a middle manager within the company, will provide guidance, and assign tasks to the student. The student will be expected to do research and make recommendations for the company.

Company evaluation criteria for the project:

Profitability and being greener are key factors. We want to make sure that the proposed product can be profitable for the company. We should provide our customers with an advantage over our competitors' products. If the cost is higher, we can offer loans from financial institutions and governments in South America to support our customers to buy the product from us. Since CNH industrial already has connections with farmers, through selling agricultural equipment, it's easier to contact them for interviews and surveys to analyze the possibility of our success. Micro biogas digesters can be profitable product which can help the company to be greener in the long term.

1.3.4 Research Questions

Technology:

1. What is technology? What is biogas?
   1.1. What is a micro biogas digester? Why is it important to invest in?
   1.2. Why a tubular micro biogas digester? What are the alternatives? Key performance, quality, and…
   1.3. How can the company be greener in the long term?
   1.4. What methods can we use for this approach?

Business model:

2. Should the company manufacture or distribute the micro biogas digester?
   2.1. Does our business model offer cost advantages or disadvantages compared to our competitors?
   2.2. What are the substitutes?
   2.3. Do our technological advancements, distribution channels, or business relationships provide us with competitive advantages?

Market analysis:

3. Is there a market for micro-biogas digester?
   3.1. Determine if the market is sizable, considering factors such as population, willingness to pay, and measurable demand.
   3.2. Is the market mature or does it have growth potential? Evaluate the existing value chain.
   3.3. Where is the beachhead market?

3.4. How can we find the best market in South America? Which country?

3.5. Which state?

Market segmentation:

4. Making a list of customer profile groups based on occupation, geographic location, and income.
   4.1. How many target customers are out there?
   4.2. Segment customers based on similar need profiles, considering parameters, gains, and pains.
   4.3. Why do customers buy this product?

Profit:

5. Can it be profitable?
   5.1. How long will it take for the company to make a profit?
   5.2. How do they want to pay? Is it cash or with loan?

Product identification:

6. What is the identification of the micro biogas digester?
   6.1. What are the other alternatives to tubular digesters?
   6.2. What are the substitutes?
   6.3. How do you compare the alternatives?
   6.4. What are the product features and description?
   6.5. What are the key performance indicators? Life span, durability, compacity price
   6.6. What is the price?

Project plan:

7. What is the project timeline (start and end date)?
   7.1. What are the project requirements and constraints? the resources, and any other limitations or requirements that need to be considered.
   7.2. What are project risk and mitigation?
   7.3. What is the scope and boundaries of the project?
   7.4. What is our project plan? And how do we want to approach it?

2. Material and Methods

Multiple sources have been used to write this thesis. Searches included using websites of different companies, published articles, FAO (food and agriculture organizations of united nations), world bank and other reliable resources.

To write the business plan, different methods and business tools have been used, such as SWOT analysis, PESTLE, business model canvas, market segmentation, Maslow's hierarchy of needs, Gantt chart, and design thinking. All these methods have been used to analyze and evaluate the feasibility of the project for the company. To solidify a business plan, the Osterwalder business model canvas was used. It helps us to better understand our business model and clarify areas and strategies for more growth.

In order to give a recommendation about whether the company should distribute or produce micro biogas digesters in South America, a literature review was performed. For example, using Google Scholar and Pubmed. Based on this literature review, a business plan was developed by using a variety of methods and business tools.

SWOT analysis was used to determine the strengths, weaknesses, threats, and opportunities for our company related to selling tubular micro biogas digesters in Brazil. This analysis was based on a SWOT analysis done in the literature for biogas digesters in South America. The SWOT analysis in this thesis was performed with more focus on tubular biogas digesters in Brazil, based on findings from other papers, that were in agreement with the SWOT analysis from the literature.

To determine whether Brazil is a viable place to sell biogas digesters, PESTLE analysis was used. This analysis was used to assess political, economic, social, technological, legal, and environmental factors. The analysis was done for Brazil, based on an online tool for PESTLE analysis: Free PESTLE & PEST analysis (adamkasi, 2023). Maslow's hierarchy of needs has been used to gain a better understanding of customer needs. This method is used to find out whether our product aligns with the fundamental needs of our target customers.

3. Results

Different biogas digester technologies are available for livestock waste management. They include fixed dome, floating drum, and tubular biogas digesters. In this thesis, the focus was on manure from cows, which releases high amounts of CO_2 and can contain parasites. Thus, micro biogas digesters offer multiple benefits. Firstly, they generate fuel that can be used for heating and cooking, in an environmentally friendly way. As a byproduct, organic fertilizer is produced, which farmers can use for their own crops or sell. Finally, biogas digesters can improve waste management. This can have significant health benefits, as poorly managed manure can lead to parasite infections.

Tubular biogas digesters can be manufactured from different types of materials, such as PVC, PE, HDPE, metal, etc. There are advantages and disadvantages of using any of these materials in the digester. I finally chose a digester made from high quality PVC from Sistema.bio. This makes the tubular digester cheap, lightweight, and easy to install while still being durable. Other digester designs, like floating drum and fixed dome, have higher raw material cost, are heavier and therefore more difficult to transport, need more maintenance, and require more skilled workers to install and maintain.

Tubular digesters offer a variety of benefits for our target customers. These target customers could be rural families with cows and small to medium dairy farmers. They often live in remote locations, where it may be difficult to transport heavy equipment and materials. Tubular biogas digesters are convenient for transportation. They are lightweight and come in easy to move parts that can be installed without much difficulty on location. This makes them very suitable for hilly and remote regions. In addition, they are low cost compared to other biogas digester designs.

South America is a big market, so choosing a beachhead market can be challenging. The huge agricultural industry of Brazil means that it has a large potential market. Brazil has around 200 million cows that produce large amounts of CO2, and cow manure. Of these 200 million cows, 29 million are dairy cows. This manure is not being managed effectively by the state, so there is a large potential market for waste management solutions on the individual farm level. Another benefit of Brazil for CNH industrial is that they already have well-established logistics center in Sao Paulo State. This would make it easier to set up supply chains in the region. However, PESTLE analysis showed that Brazil could be a difficult market, due to lack

of governmental interest in to addressing environmental issues regarded to deforestation and waste management.

In conclusion, the recommendation is to distribute Sistema.bio PVC tubular biogas digesters to a target customer segment that includes families who keep cows and small to medium dairy farmers in the beachhead market of Brazil.

4. Discussion

Animal manure exposure has environmental consequences. This has motivated governments to look for strategies which could encourage “sustainable animal farming”. Poor waste management of manure can lead to greenhouse gas emission and health risks, whereas it can be a valuable resource if upscaled to biogas and fertilizer. Due to the high amount of nutrient and pathogen content in manure, storing manure in the open is associated with health risks. Improper handling of this valuable waste material can lead to contamination of soil, air, and water, as well as the accumulation of harmful microorganisms in the environment. Furthermore, green houses gasses like methane can escape from the manure into the atmosphere. One of the most effective manure management practices that also promotes sustainability is anaerobic digestion. This process not only allows for waste treatment, but also enables the production of bioenergy (Neshat et al., 2017). Anaerobic digesters produce biogas which consists of methane, carbon dioxide and traces of hydrogen sulfide that originate from anaerobic digestion of organic substances (Rajendran et al., 2013).

Traditionally, manure has been utilized as a valuable fertilizer across various farming operations to supply the necessary nutrients for crop growth (Neshat et al., 2017). Effectively managing the large quantities of manure generated on a daily basis presents a significant challenge. There is a growing need for smarter utilization of manure within the farm. While manure contains valuable nutrients, these same nutrients can pose a threat to the environment if not handled properly. Improper handling can result in harmful run-off that carries bacteria and nutrients, leading to contamination of local groundwater and posing risks to public health. It is almost inevitable to experience significant nutrient loss during the processes of collection, storage, distribution, and utilization of manure (Hulse, 2007).

There are several types of digesters that vary in size and shape. Including fixed dome, floating drum, and tubular digesters. Fixed dome digesters are commonly used in China, they have a dome shape and are constructed underground using bricks. The main drawbacks of this digester are gas leakage from pores in bricks, causing contamination of ground water. In India, floating drum digesters are prevalent. They have an iron floating drum positioned atop the digester. Due to the corrosive nature and high cost of iron, maintaining these digesters poses significant challenges (Rajendran et al., 2013). Another difficulty with the fixed dome and floating drum models is that, once they are installed, it is challenging to relocate them. As a

result, portable models named tubular digesters built above ground were developed (Rajendran et al., 2012).

Description of need of micro-biogas digester:

When organic waste is not properly treated, it can create a health hazard for both humans and animals due to the growth of harmful microorganisms. However, in small-scale agriculture and livestock production, organic waste can be transformed into fuel (in some cases) and natural fertilizers using methods such as anaerobic digestion. This is a clear benefit for our target customers. Furthermore, this waste management method also reduces greenhouse gas emissions from manure.

Because of the large burden of climate change, it is important to reduce greenhouse gas emissions. Anaerobic digestion can not only contribute to reducing GHG emissions via waste management, but also by providing a clean alternative to fossil fuel sources for cooking and heating and to chemical fertilizers, which require industrial chemical processes to produce.

Anaerobic digestion (AD) is a process in which bacteria break down organic matter in the absence of oxygen (see appendix Figure 17 for more details). Biodigesters have been developed to take advantage of anaerobic digestion to upscale manure into a usable green fuel source and organic fertilizer. Biogas digesters produce biogas (a type of fuel) and effluent/biol (a natural fertilizer) from the waste, which can be used as a tool to help reduce pollution (*Biodigesters – RedBioLAC*, 2023). Methane is a highly energy-dense compound that finds applications in cooking, lighting, and electricity generation. After the anaerobic digestion process, the remaining digestate or slurry contains substantial quantities of nitrogen, phosphates, and other nutrients, making it an excellent natural fertilizer for agricultural purposes (Itodo et al., 2007).

4.1 Product Identification (Ideation Stage)

4.1.1 Product Concept

Product identification is the initial stage where a business plan for ideas regarding a micro biogas digester will begin. The adoption of biodigesters aligns with circular economy (CE) principles, particularly concerning its biological cycle. Holm-Nielsen et al (Holm-Nielsen et al., 2009) proposed that animal waste should be regarded as a valuable resource for renewable

energy and agricultural nutrients, with a potential for at least 25% of future bioenergy to be derived from biogas. Moreover, the utilization of small-scale biodigesters is expanding globally, with widespread use observed in Asia and reports of adoption in Latin America and certain regions of West Africa (Cortez et al., 2022).

4.1.2 Product Alternatives

Technology alternatives:

Fixed dome:

Chines fixed dome digesters contain a cylindrical chamber, a digestate outlet and a feed stock inlet. Which is also called a compensation tank. The upper section of the chamber serves as storage for biogas (see Figure 1). As biogas production begins, the slurry is pushed into the compensation tank, which has the same volume as the biogas storage. The gas pressure rises proportionally with the amount of biogas stored and the difference in slurry levels between the digester's interior and the compensation tank. This underground structure is constructed using bricks and concrete. In terms of building, operating, and maintaining household biogas plants, constructing fixed dome digesters can be labor-intensive and requires skilled supervision. Additionally, obtaining construction materials may pose challenges in rural and remote communities, although they are typically more accessible in larger nearby areas. Additional maintenance may be required if cracks emerge in fixed dome digesters, due to changes in atmospheric temperature or earthquake (Pérez et al., 2014).

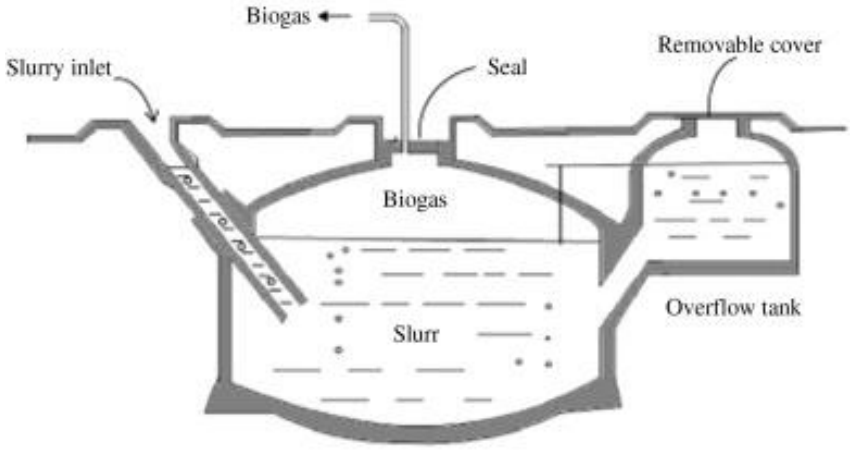


Figure 1: Schematic of a fixed dome digester (Pérez et al., 2014)

Floating drum:

A floating drum digester is a type of biogas reactor designed with a movable inverted drum positioned on top of a well-shaped digester (see Figure 2). The inverted steel drum acts as a storage tank, capable of moving up and down depending on the amount of accumulated biogas at the top of the digester. The weight of the inverted drum applies the necessary pressure to facilitate the flow of biogas through a pipeline for use.

Floating drum digesters produce biogas at a constant pressure with a variable volume. The position of the drum allows for easy detection of the amount of biogas accumulated underneath it. However, to prevent rusting, the floating drum needs periodic paint coating. In some cases, modifications have been made to the floating drum design, such as adding two cement jars on either side of the drum. The size of these digesters varies, with average sizes around 1.2 m3 and larger ones ranging from 5 to 15 m3, suitable for small to medium-sized farms (Rajendran et al., 2012).

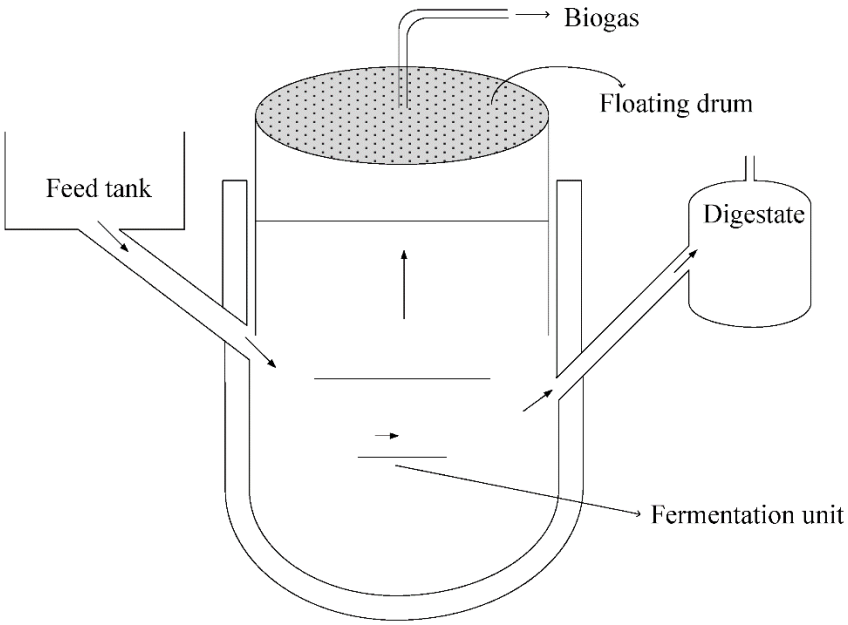


Figure 2: schematic of a floating drum digester (Rajendran et al., 2012)

Tubular digester:

The tubular digester has a simple design. Wastewater flows through a tubular polyethylene or PVC bag from the inlet to the outlet, while biogas is collected using a gas pipe connected to a reservoir (see Figure 3). The design does not involve heating or mixing. To enhance the process temperature and minimize overnight temperature fluctuations in cold mountainous areas, the tubular plastic bag is buried in a trench and covered with a greenhouse. Biogas generated in the reactor is stored in a reservoir and can be connected to the kitchen or cooking area. This allows the biogas to be utilized as a heat source, substituting commercial fuels like LPG and eliminating the need to burn wood. The dimensions and design criteria for the digester, trench, and greenhouse vary depending on the location and the needs of the farmer. The retention time can be altered to best suit the climate. For digestion, the manure is usually diluted to reduce the total solids (TS) concentration below 9%, which is close to the upper limit for wet anaerobic digestion (Ferrer et al., 2011).

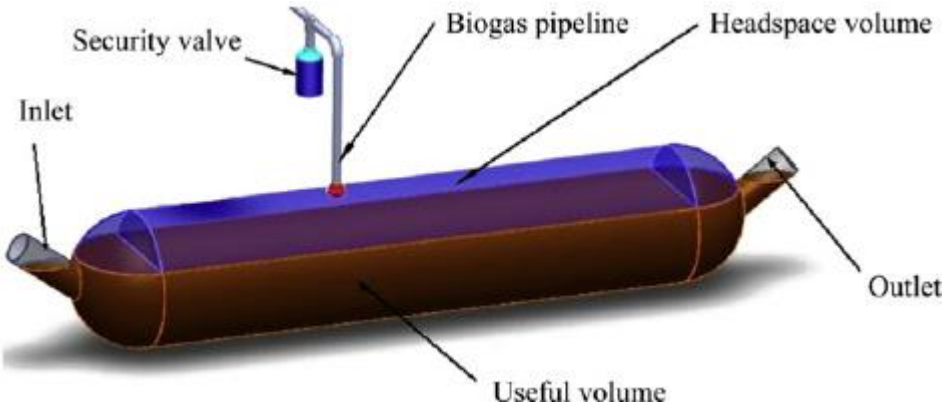


Figure 3: Schematic of a tubular biogas digester (Ferrer et al., 2011)

Tubular micro biogas digesters have several benefits:

Health benefits: The likelihood of contracting infections caused by *Cryptosporidium parvum* and *Giardia lamblia* through the consumption of leafy crops polluted by runoff water in San Luis de Monteverde, where tubular digesters are implemented, was notably reduced compared to the infection risk observed in La Florida, where untreated cattle waste was present, without using tubular digester (Kinyua, Wald, et al., 2016).

Agricultural benefits: effluent from anaerobic digestion contains nutrients such as nitrogen, phosphorus, potassium, calcium, and magnesium. The nutrient-rich effluent can serve as a soil amendment to enhance plant growth. This environmentally and economically appealing option

contrasts with the utilization of mineral fertilizers, which account for approximately 1.2% of the world's energy consumption and is responsible for around 1.2% of global greenhouse gas emission (G, 1998). Hence, the advantages in agriculture encompass both agronomic benefits, resulting from increased crop yield due to the application of anaerobic digester effluent, and economic benefits, which involve monetary gains and profits (Adeli et al., 2005).

Over 70% of rural inhabitants in developing regions rely on agriculture. Utilizing digester effluent to enhance crop yield could lead to more crops available for sale in the market (Kinyua, Rowse, et al., 2016).

Environmental benefits: Environmental benefits with tubular micro biogas digester are decrease of deforestation and water pollution from livestock manure and waste (Kinyua, Rowse, et al., 2016).

Tubular digesters have gained significant popularity in Peru in recent years, primarily because of their portability and low cost. These digesters offer several benefits, including easy installation, convenient handling, and the ability to adapt to harsh conditions found at high altitudes with low temperatures. In hilly regions, the expense of transporting materials for building traditional digesters is quite high, resulting in high capital costs. Conversely, tubular digesters can be easily transported, thereby reducing overall digester expenses. Moreover, constructing underground digesters with large volumes in high-altitude areas poses considerable challenge (Rajendran et al., 2012).

The transportation of materials required for tubular digesters is simpler and more cost-effective, as they can be easily carried by a donkey. This makes tubular digesters a suitable choice for poor farmers residing in isolated rural regions. Given these advantages, low-cost tubular digesters hold significant potential for knowledge transfer among farmers, enabling them to share and adopt this technology among themselves (Martí-Herrero et al., 2014).

Improving the living quality for rural areas is an important goal, by supplying environmentally friendly fuel to replace traditional biomass. The project also have the following goals: environmental preservation by decreasing greenhouse (GHG) emissions and deforestation, reduce household expenses on fuel and fertilizer, and also decline the work and time related to gathering firewood for women and children (Pérez et al., 2014).

Quality of different digesters:

Starting in the 1980s, China has introduced various types of household biogas digesters into the commercial or semi-commercial realm. These encompass a range of designs such as polyethylene (PE) digesters, partially rigid plastic digesters, iron-based digesters, glass-reinforced plastic, or fiber-reinforced plastic (FRP) digesters, composite digesters reinforced with glass fibers, acrylonitrile butadiene styrene (ABS) digesters, cement-based digesters made from a combination of iron and bamboo, and prefabricated cement digesters with wire mesh reinforcement (Cheng et al., 2013).

Currently, there exists a lack of precise categorization for digesters. As highlighted in the CAREI report, commercially available or prefabricated digesters are categorized into FRP digesters, plastic soft (PS) digesters, and plastic hard (PH) digesters. The archetype of PBDs is represented by FRP digesters, which were among the first in the market. These utilize unsaturated polyester resin and glass fiber cloth as primary materials. PS digesters, also referred to as bag digesters in certain regions due to their bag-like appearance, incorporate materials like soft polyvinyl chloride (PVC), red mud, polymethyl methacrylate, low-density PE, PE, and polypropylene (PP). On the other hand, PH digesters are typically characterized by their rigid structure. In contrast to soft digesters, PH digesters are manufactured from sturdy materials such as hard PVC, ABS, PE, PP, high-density polyethylene (HDPE), and linear low-density PE (Cheng et al., 2013). The plastic characteristics of the materials typically utilized for the production of PBDs are outlined in Figure 4, Figure 5 and Table 1 below:

Plastic material	Water absorption/24 h	Tensile strength/MPa	Recovery	Combustibility	Price[a] /CNY[b] per ton
UP	<1	700	Hard	Hard	11500
PP	<0.2	25–40	Easy	Sustained combustion	10750
PE	<0.05	8–30	Easy	Sustained combustion	9800
ABS	0.8–1.6	45–65	Easy	Sustained combustion	14500
PVC	0.1–0.8	45–80	Easy	Self-quenching	6100

a The price is referred to average quotation from China's chemical industry, June of 2012.

b 1 USD=6.207 CNY, 30/11/2012, Bank of China.

Figure 4: Related plastic properties for PBDsOCDs (Cheng et al., 2013).

Item	FRP digester	PS digester	PH digester	Masonry digester
Cost	High	Small	Normal	Normal
Construction period	Short	Short	Short	Very long
Transportation	Easy	Very easy	Easy	Impossible
Maintenance	Almost no	Almost no	Almost no	Frequent
Mechanical property	High	Weak	High	High
Service life	Long	Short	Long	Normal
Water adsorption	Low	Low	Low	High
Tightness	Good	Normal	Good	Normal

Figure 5 Qualitative comparison among PBDs and OCDs (Cheng et al., 2013).

Table 1 Advantages and disadvantages of PBDs (Cheng et al., 2013).

Category	Advantages	Disadvantages
FRP digester	Mature production process; Uniform	High cost of raw materials and fluctuations in prices;
	quality under industrial standard;	Floating where high underground water level persists;
	Good air-tightness;	Digester shape needs to be improved;
	High gas production;	Secondary pollution after breakdown
	Fast heating up	
PS digester	Low production cost;	Easily pierced by sharp items or animal tooth;
	Good air-tightness;	Aging of material;
	Fast heating up;	Extra pump required to transport biogas;
	Easy transportation	Inconvenient feeding and discharge

Category	Advantages	Disadvantages
PH digester	Low production cost;	Easily damaged by blunt so stress intensity should be
	Good air-tightness;	improved;
	Fast heating up	Floating where high underground water level persists;
		Material is easily oxidized when it is exposed to air or buried in the earth.

Product alternatives:

Table 2 below compares several different types of tubular biogas digesters. It details their shape dimensions, how they perfume, their expected lifespan and their price.

*Table 2: product alternatives (*Integrated Home Size Integrated Biogas Digester - Buy Teenwin Integrated Home Size Integrated Biogas Digester,Integrated Biogas Digester For Home,Teenwin Integrated Home Size Biogas Digester Product on Alibaba.Com*, n.d.;* Red Mud Biogas Digester, Soft Biogas Digester System, Home Biogas Digester Septic Tank*, n.d.;* Shop*, n.d.;* Sistema.Bio : The Biodigester Solution.*, 2023)*

Tubular digester	Size/shapes	Performance	Life span	price
Home biogas 4	System dimensions: 300x150x135 cm / 118x 59x 53 in Gas Tank volume: 1200 liters / 317 gal Digester Tank volume: 2650 liters / 700 gal	Up to 3 hours free cooking Maximum daily quantity of animal manure 75 liters / 20 gal of slurry: 25 liters / 7 gal manure + 50 liters / 13 gal water	2 years warranty	$1375
Red mud biogas digester	Size can be different, according to customer request	Contain more red mud than ordinary PVC	10 to 15 years	Vary based on size

Home biogas digester (TY-HSID-2.5)	China (teenwin) (Alibaba) Material: PVC	Application: organic waste treatment	5 to 8 years	$248.00-$298.00
Sistema tubular	Size can be different (6,8,12,16,20,30, 40)	PVC and HDPE materials	10 years warranty	Vary based on size

4.1.3 Substitutes

As an intern in the company, we should identify other products and services that have the same or similar function to our biogas digester. We should also look at what the benefits of our product are for customers and why they may prefer our product rather than other substitutes. This way we can find out what our advantages and potential weaknesses are compared to the competition. With that knowledge we could try to overcome the weaknesses. Substitutes for biogas digester are:

- Chemical fertilizer
- LPG
- Firewood
- Charcoal

According to the World Bank, in rural regions of developing countries, solid fuels like biomass (such as firewood, charcoal, manure, and agricultural residues) along with coal are frequently the main energy sources utilized for cooking.

Firewood: In Latin America and the Caribbean, firewood is regarded as the fuel with the most significant negative health effects, primarily because of its high emissions of particulate matter (PM2.5eq) and Carbon Monoxide (CO). Additionally, the collection of firewood by women and children consumes considerable time, and households often experience exposure to polluted indoor air due to faulty or outdated devices with inadequate air circulation. Due to lack of efficient firewood usage applications, appliances tend to consume a substantial amount of firewood to meet their energy requirements. Furthermore, it can be a particularly related factor to deforestation hazard. Nevertheless, it is currently widely acknowledged that deforestation is mainly caused by changes in land use resulting from the expansion of

agricultural activities, rather than the use of firewood for energy, as previously assumed (Pizarro-Loaiza et al., 2021).

LPG: In the Latin America and Caribbean (LAC) region, over 70% of the populace currently employs LPG as a cooking fuel. LPG is a clean-burning, effective, and portable energy source, generated as a byproduct of natural gas extraction and crude oil refining. With a higher calorific value, LPG generates fewer air pollutants per cooking session and exhibits a conversion efficiency up to five times greater than conventional fuels like kerosene, wood, charcoal, and coal. Even when comparing with renewable solid biomass fuels, LPG combustion produces fewer climate pollutants, primarily due to the emission of black carbon from biomass burning (Troncoso & Soares da Silva, 2017).

Table 3 shows the uses of a micro biogas digester and possible substitutes that can carry out the same jobs. The advantages and disadvantages of each substitute are listed.

Table 3:substitution products

Jobs	Micro biogas digester	Firewood	Charcoal	Chemical Fertilizer	LPG
Cooking	Yes	Yes	Yes	No	Yes
Heating	Yes	Yes	Yes	No	Yes
Waste management	Yes	No	No	Yes	No
Growing plants	Yes	No	No	Yes	No
Advantage	Source of income	Easy collection and affordable	Burn efficiently, less smoke	Improved crop yield	Clean and safe
Disadvantage	Maintenance is required	Air pollution, deforestation,	Air pollution More cost	Chemical ingredients	More expensive

4.1.4 Customer Segmentation

Customer segmentation can be used to identify all potential customers that might buy our product. In the case of tubular biogas digester, these include different groups of farmers, such as agricultural farmers and livestock farmers (see Figure 6). Livestock farmers are categorized by the type of animal they keep, namely poultry, pigs, or cows. Cow farmers are further subdivided into beef, dairy and family farmers. Livestock farmers are a good target customer segment, because the manure produced by their animals can be managed using tubular biogas digesters. More specifically, our target customer segment is dairy farmers. Dairy cows are usually kept in enclosed barns or shelters, making it easier to collect manure from dairy cows, as opposed to beef cows, who spend most of their lives outside on pastures. Dairy farmers can be large, medium, or small size farmers. Large dairy farmers fall outside our target customer segment.

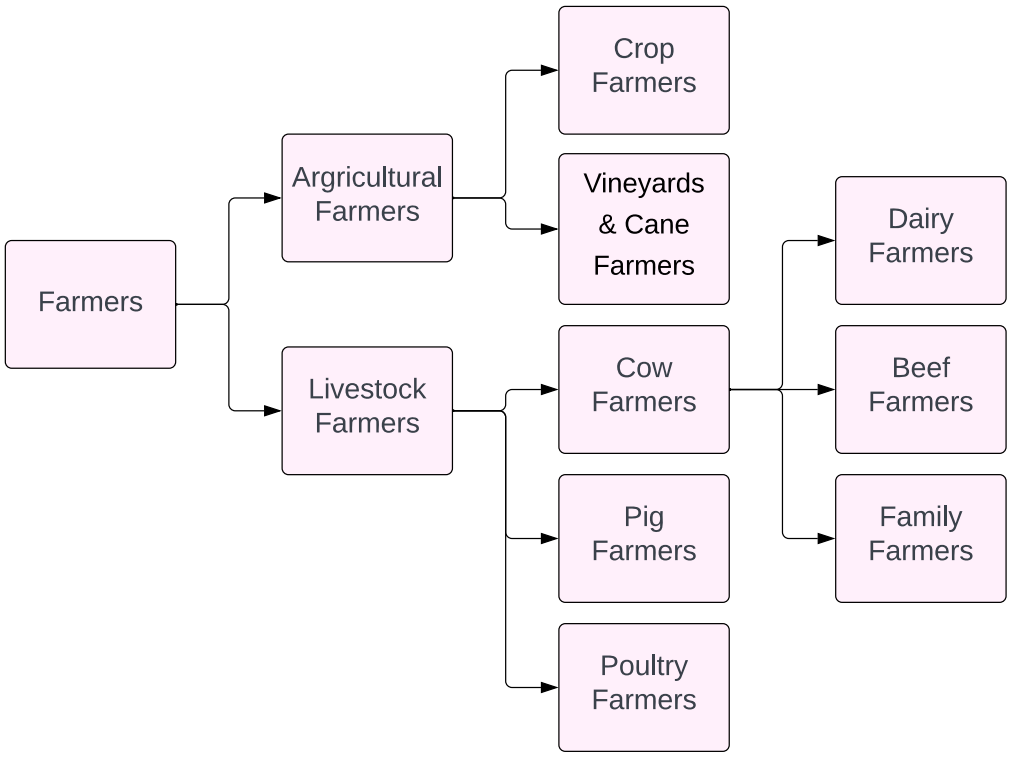


Figure 6: Customer segmentation

4.2 Product Prototyping

4.2.1 Product Description

Product description: Sistema.bio technology is a biogas hybrid reactor specifically created to manage the daily waste from animal farms. This innovative reactor utilizes a fermentation process that combines manure with water, resulting in the generation of biogas and a potent organic fertilizer.

Durability: The construction of this hybrid reactor involves high quality, UV-resistant geomembrane. For the piping and assemblies, it uses hydraulic PVC and HDPE materials, ensuring a prolonged lifespan even in the challenging conditions of rural areas.

- Reactor: High-quality, UV-resistant geomembrane
- Tubes and joints: hydraulic and sanitary PVC

Prefabricated kit: The system consists of a comprehensive set of prefabricated components, carefully designed for convenient packaging, transportation, and effortless installation. All parts are easily available for replacement. The production process complies with the highest quality control standards to guarantee a prolonged life for the product.

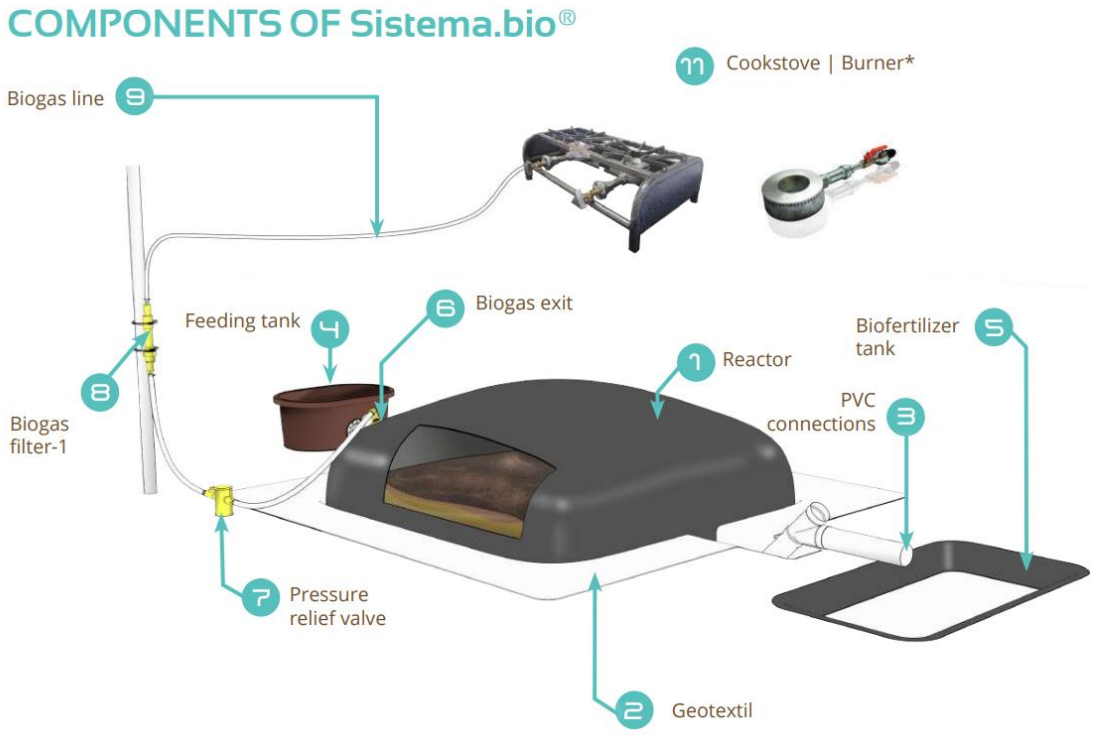
Variety of sizes: Biogas digester catalogue offers a different size of reactor, from 6 to 200 m^3, to provide the needs of small to medium farmers.

Modular: The design facilitates interconnection between reactors, effectively enhancing the system's treatment capacity. This adaptability enables Sistema.bio to accommodate various scenarios, letting farmers to expand the reactor as their specific needs.

Easy operation and maintenance: Any member of the family or worker on the dairy farm can easily work with a biogas digester (*Sistema.Bio : The Biodigester Solution.*, 2023).

Figure 7 shows the components that make up a Sistema.bio tubular micro biogas digester. The reactor (1) can be purchased in different sizes, according to the customers' need. As mentioned, this makes the design modular. The manure goes in through the feeding tank (4) and the biogas exits via a pressure relief valve and a filter, making it safe to operate.

*Figure 7:Components of tubular micro biogas digester (*Sistema.Bio : The Biodigester Solution.*, 2023)*



4.2.2 Target Customer Profiles

Table 4 below shows the target customer profiles for tubular biogas digesters. It lists their demographic, geographic location, their priorities, and their ability to pay for and buy the product.

Table 4: Target customer profiles

Demographic	Geographic	Customer priority	Ability to pay and willingness to pay
Large Family Low income 3 to 5 cows several pig	South America Country: Brazil Area: village	Low cost Clean and cheap energy for coking and heating Organic fertilizer	Low to medium ability to pay Medium willingness to pay

Small dairy farmers 5 to 9 cows Middle income	South America Country: Brazil Area: village	Waste management Biogas for heating and cooking	Medium ability to pay Medium to High willingness to pay
Medium size dairy farmers 10 to 30 cows High income	South America Country: Brazil Area: village	Manage manure Biogas for heating milk Biofertilizer	High ability to pay High willingness to pay

4.2.3 Customer Needs Analysis

Maslow's Hierarchy of Needs involves understanding how this psychological theory applies to their specific situation, and it illustrates how tubular biogas digesters align with the fundamental requirements of farmers. By addressing their physiological and safety needs, promoting community connections, boosting self-esteem, and enabling self-actualization, these digesters offer a holistic solution that goes beyond energy provision.

Maslow’s hierarchy of needs for customers: Figure 8

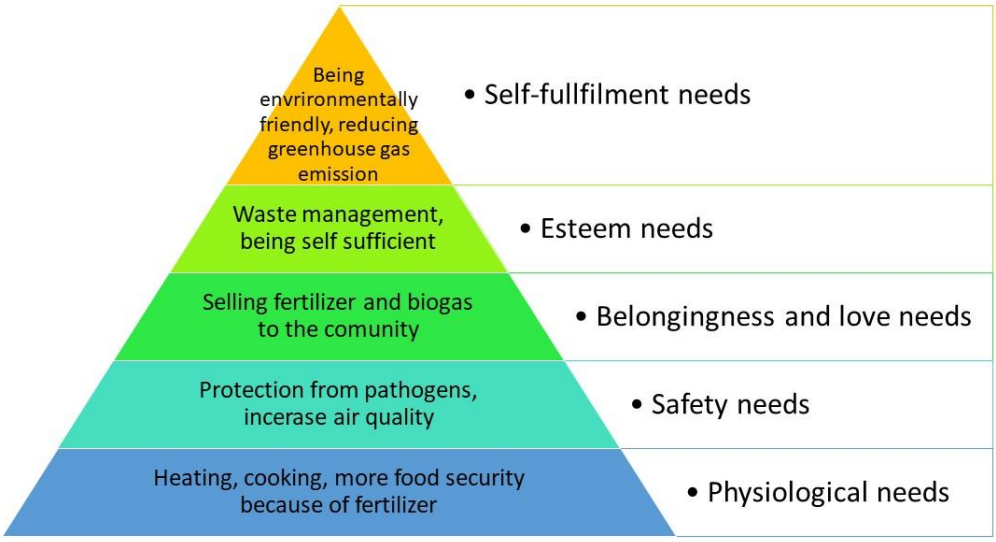


Figure 8: Maslow's Hierarchy of Needs

Table 5 below shows the requirements from different customer segments for a tubular digester system. The three segments are large families, small dairy farmers, and medium dairy farmers. The table shows the minimum requirements along with the optimal target requirements for each customer segment.

Table 5: Customer segmentation

Customer segmentation	jobs	Minimum requirement	target
Large family	Cooking, heating, bio fertilizer	3 hours cooking and heating	5 hours
Small dairy farmers	Heating, managing waste, biofertilizer	6 hours cooking and heating	8 hours
Medium dairy farmers	Heating, cooking, managing waste, selling biofertilizer	10-12 hours cooking and heating	15 hours

Data collection:

Being successful in today's highly technological and globally competitive world requires a person to develop and use a different set of skills than were needed before. One of these skills is called design thinking. Design thinking is commonly described as a combination of analytical and creative approaches that encourage individuals to explore, experiment, create, prototype, seek feedback, and refine their ideas and models. (Razzouk & Shute, 2012).

Design thinking can help to increase our understanding of customers. Stages of design thinking for this project is described below:

Stage 1 and stage 2: empathize and define a problem- in this step we should have complete understanding of the problem with specific group of customers that we are trying to solve.

The increasing prices of fossil fuels and energy taxes have raised concerns about finding alternative, clean, and cost-effective energy sources for households and nations. Per-capita energy consumption is linked to economic prosperity and quality of life, making it a crucial indicator of economic development. The high costs of transporting fuel and fertilizer to rural areas lead to expensive end prices, prompting people to seek alternative resources. Traditional energy sources like firewood, dung, crop residues, and paraffin are relied upon by many rural communities in developing countries, despite being expensive and time-consuming. Finding sustainable energy solutions is essential to address climate change, resource exploitation, and improve living standards (Rajendran et al., 2012).

Stage 3: Ideate: Your well-established background allows you to think creatively, exploring unconventional perspectives and seeking innovative ideas and solutions for the defined problem statement (Razzouk & Shute, 2012). Biogas serves as an alternative to firewood and cattle dung, fulfilling the energy requirements of rural communities. It is a renewable energy source that can effectively replace natural gas or liquefied petroleum gas (Rajendran et al., 2012). Micro biogas digester can be targeting product that can solve these problems with producing Biogas and Biofertilizer.

Stage 4: prototype and test: during prototype phase, the primary objective is to discover the most optimal solutions for each identified problem (Razzouk & Shute, 2012). Identifying different technology of micro biogas digester and then choosing tubular micro biogas digester as target solution.

Since I’m not traveling to South America, the testing phase is not part of the plan.

4.2.4 Value Proposition

Livestock waste may contain significant quantities of zoonotic pathogens, notably including the protozoan parasites *Cryptosporidium parvum* and *Giardia lambli*. Studies conducted by researchers across various regions have demonstrated that improper handling of swine and cattle manure has resulted in food and water contamination, potentially contributing to instances of foodborne outbreaks. These parasites have high infection rate, even at low dose, that contribute to increased public health issues (Kinyua, Wald, et al., 2016).

Waste disposal can be an added burden for our customers. When cow manure is not disposed of properly, it can not only pollute the environment, but even cause a health risk to the farmer

and their family. Pathogenic bacteria and parasites can contaminate the soil and water. The nutrients from the manure can cause dangerous bacteria to grow in surface water. The gases that are released can be bad for the air quality in the surrounding area and contribute to the greenhouse effect. Instead, using our product, the customer can turn this waste into useful products like fuel and organic fertilizer, by investing in a micro biogas digester. Below are the key advantages that our product offers our target customers.

- Renewable energy source through producing biogas
- Biogas that can be used for cooking and heating. Products provide consistent and eco-friendly energy supply.
- Turning waste to valuable products and solutions for their pains.
- It also makes them feel better, since they don't have to think about the odor of manure.
- Providing organic biofertilizer that can be used for growing crops.
- Cost saving since customers will not need to pay to buy LPG and fertilizer.
- Reduce deforestation through not using woods for their consumption.
- Easy installation and transportation, approximately affordable for farmers

Not only can farmers use micro biogas digesters to manage manure, but other organic waste like plant waste can be processed. The biogas that is produced offers our customers a clean fuel source for cooking and heating, rather than traditional fossil fuels. The other side product that is produced is organic fertilizer, which is a renewable, environmentally friendly alternative to costly chemical fertilizer. This can also make a farmer in a remote location more independent by producing their own fertilizer and heat source.

Fixed dome digestors are difficult to maintain and transport to remote areas. They require concrete for their construction. Tubular biogas digesters on the other hand, are lightweight and easy to transport and thus more accessible for farmers in South America. In addition, tubular reactors can be easily made to any size, to meet the needs of a particular farmer. They are also more space efficient than other biogas digestors, so the farmers don't need to use up a lot of space. Compared to floating drum reactors, tubular biogas digesters are safer because they are more closed off, whereas floating drum reactors may leak harmful gases.

Furthermore, we suggest a tubular biogas digester made from PVC and HDPE. These materials are ideal for our target customers for a number of reasons. Firstly, they allow for cheap and

fast construction of the digester. They are also lightweight, adding to the easy transportation of the digester, while still being strong enough to have a long-lasting service life. Next, these materials allow for the manure in the digester to heat up quickly, improving performance. Finally, these materials can be made very air-tight compared to other materials for tubular digesters, which results in less smell and gas leaking from the digester. Because of the reasons described above, we believe that a PVC/HDPE tubular biogas digester has the highest value for our target customers.

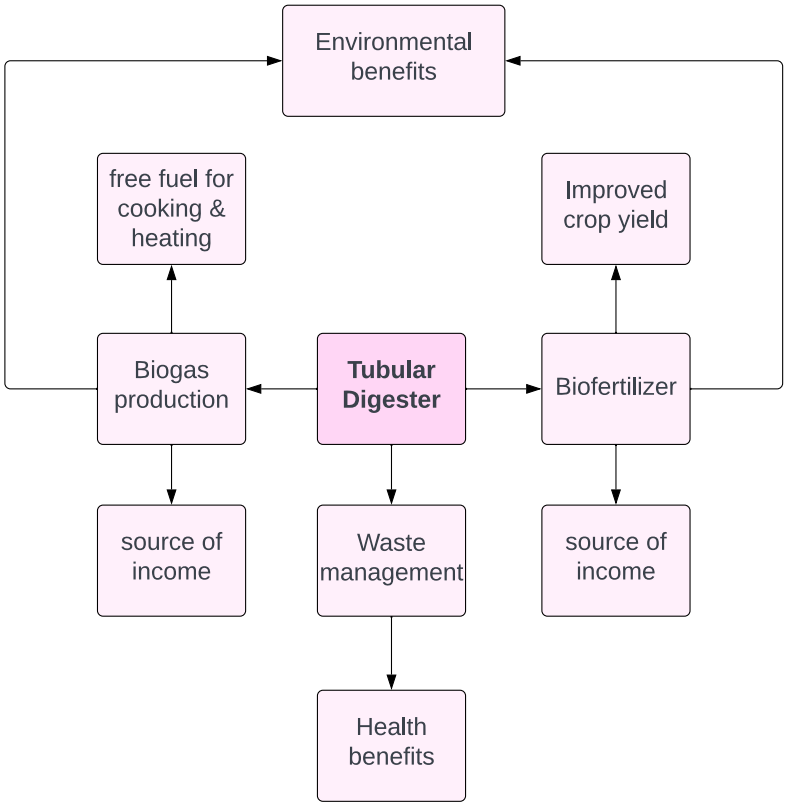


Figure 9: Value proposition

4.2.5 Price

The price of tubular micro biogas digesters depends on the size of the tubular digesters. Our customers can buy our product based on how many cows they have and how much biogas they want to produce per day. Table 6 shows the recommended type of digester depending on how many cows the farmer has. The table also shows the price of the digester of each size, how much area it will take up, how much biogas it will produce and how much water and solid waste it will use per day.

*Table 6: price of Sistema micro biogas digesters of different size (*Sistema.Bio : The Biodigester Solution.*, n.d.). the Price Includes following Items: LLDPE Digester Cost Imported Accessories Cost Local Accessories Cost Last Mile Transportation First Visit for Pit Marking Installation by Engineers First 30 day Free visit Next 60 day Free Visit Next 180 days Free Visit 100% Free Repair / Replacement Warranty for 1 year 10 Yr Warranty for Digester 20 yrs On Call Engineer Supprt GST @ 5%*

No. of cattle	Cow Dung Qty(kg)	Water Qty Bucket(16L) or litres	Amount of gas per day in hours on 1 burner	Monthly LPG Domestic Cycliner Equivalent Gas	Monthly production of Bio Fertilizer (Litre)	Good for Agriculture Land (Acres / year)	Min Area Required (Feet)	Digester Model	MRP (Incl of all Taxes)
3-4	45	6 buckets	3.3	1.5	4,050	12	12 x 20	Sistema 6	471 $
4-5	65	8 buckets	4.8	2.2	5,850	18	12 x 24	Sistema 8	665 $
8-9	90	12 buckets	6.7	3.0	8,100	25	12x30	Sistema 12	916 $
12-13	130	16 buckets	9.6	4.4	11,700	36	12x36	Sistema 16	1147 $
16-18	180	360 lit	13.3	6.1	16,200	49	15x44	Sistema 20	1379 $
24-26	260	520 lit	19.2	8.7	23,400	71	15x56	Sistema 30	1737$
33-36	350	700 lit	25.9	11.7	31,500	96	15x70	Sistema 40	2116$

Ability to pay:

Financial Services provides retail note and lease financing options to end-use customers for the acquisition of both new and pre-owned agricultural and construction equipment and components. These purchases are facilitated through the dealer network of CNH Industrial brands. Additionally, they offer revolving charge account financing and a range of other financial services. The Financial Services division also extends wholesale financing solutions

to dealers and distributors affiliated with CNH Industrial brands. Furthermore, they deliver trade receivables factoring services to various CNH Industrial companies. The European branch of CNH Industrial Financial Services receives support from the Financial Services segment of the Iveco Group. In turn, CNH Industrial Financial Services extends its financial services to Iveco Group entities across North America, South America, and the Asia Pacific regions.

CNH Industrial offers and manages retail note and lease financing to end-use customers aiming to acquire new and secondhand equipment and components sold via its dealer network. This also includes revolving charge account financing. The duration of retail notes and finance leases typically spans from two to six years. The interest rates are contingent on prevailing market interest rates and specific incentive initiatives associated with Industrial Activities. Revolving charge accounts generally entail higher interest rates compared to the company's other retail financing options. These accounts require minimum monthly payments and lack predetermined maturity dates.

Wholesale receivables mainly come from financing for dealers to manage their inventory and operations. These receivables often have a period without interest, which can last up to twelve months. The original repayment timeline can be as long as twenty-four months, but it speeds up when the dealer sells the equipment. The company offering the financing is compensated for the interest-free period based on current market interest rates. After this period, dealers are charged interest until the company receives full payment. The length of the interest-free period depends on factors like the type of equipment sold and the time of the sale. The company regularly evaluates dealers to determine their creditworthiness. In certain situations, like a change in ownership or default, the company might need to buy back the dealer's equipment. There were no significant losses related to ending dealer contracts in the three months leading up to March 31, 2023, and 2022 (*About Us | CNH Industrial*, 2023).

The company has mostly provided lease contracts for machinery, plants, and vehicles equipment. CNH industrial, primarily operating within its Financial Services sector, rents out equipment to retail clients through operating leases. These leases usually span from 3 to 5 years, with lessees having the option to buy the equipment when the lease period concludes. Income generated from components other than the lease is managed separately (*About Us | CNH Industrial*, 2023).

4.2.6 Promotion

While our target customers live in remote areas, the literature shows they are still relatively connected to the internet. In the regions of Rio Grande do Sul, Santa Catarina, Paraná and Goiás, there are 127 cities with access to fiber optic internet (*BNamericas - AXXEL Telecom Expands Its Fiber Internet Net...*, n.d.). When we look at Facebook statistics, we can see that many Brazilians use it regularly. In July 2023, facebook.com claimed the top position as the most visited social media website in Brazil, with instagram.com following closely behind in second place (*Top Social Media Networks Websites Ranking in Brazil in July 2023*, 2023). Since our target customers live in remote areas, but are generally still connected to the internet, online platforms offer a way for our company to reach out to our target customers. In addition, more traditional channels like radio, TV and local organizations could also reach Brazilian farmers. The following strategies can be good potential channels to promote our product and reach our target customers:

- Utilizing online platforms: Leverage digital marketing channels, including social media, website, and marketing Email, to reach many customers in Brazil. Social media platforms like Facebook and Instagram can be effective for reaching farmers.
- Offer incentives: through offering promotions, discounts, or other financing options we can motivate potential customers to adopt biogas digesters.
- Localized advertising: develop advertisements in Portuguese to connect with the local audience and show our commitment to the Brazilian market.
- Collaborate with local organizations.
- Advertising on TV, radio, and newspaper
- Ecommerce

4.2.7 Placement

The company already has a logistics center located in Sorocaba, Sao Paulo State in the southeast of Brazil (*CNH Industrial Logistics Center in Sorocaba, Brazil, Awarded Bronze in World Class Logistics Program | CNH Industrial*, n.d.). from where they can send digesters to retailers (business to business) or directly to customers (business to customers). E-commerce provides a platform for this distribution of tubular biogas digesters. There are different e-commers models that could be used, such as retail, white labeling and wholesale.

- Retail

Retail sales in an online shop involve the direct sale of a product from the seller to the buyer, omitting any intermediary parties. This represents a business-to-consumer (B2C) interaction. This method involves fewer participants than some alternative methods. This setup is relatively basic, which makes it suitable for companies that are new to e-commerce. In this way, the company can have an online store where customers can directly order tubular biogas digesters. When the customer places an order, the order can be sent out from the warehouse directly to the customer.

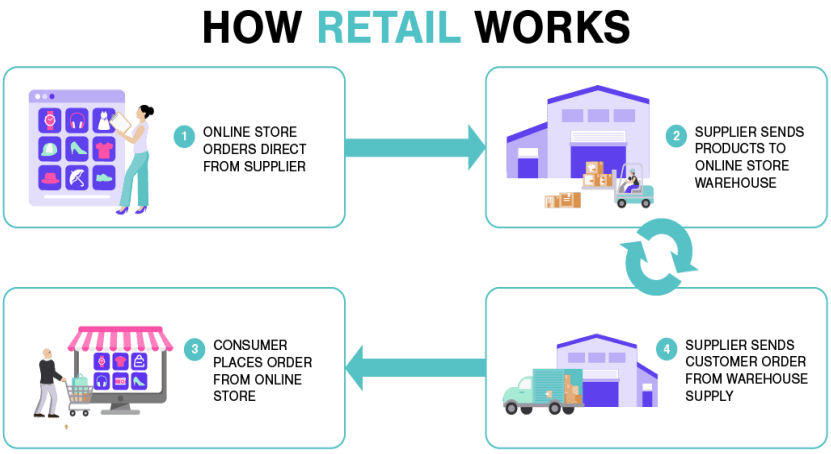


*Figure 10: How retail works (*What Is Ecommerce?*, 2023)*

- Wholesale

  Wholesale is the B2B equivalent of retail, but it involves the transaction of selling goods in larger quantities. In wholesale, the company would acquire digesters in bulk from the manufacturer and through a business-to-business exchange. Subsequently, these products would then be sold in large numbers to another business. This business then sells these wholesale products to end-users via their e-commerce platform, often at an increased price, to generate profit. In this scenario, the company doesn't need its own public website, but rather sells digesters to another business who is responsible for sales to end-users and maintaining the website.

- White Labeling

  White labeling involves using a product that is manufactured by another company and selling it under your own brand. Our company could acquire tubular digesters from a

manufacturer, (in this case from Sistema) and sell them with our own packaging and labeling. Adding our own branding can help the product to be more recognizable and build customer trust and loyalty. This can of course only be done with the permission of the manufacturer. The sales would then be handled via an online store just like with retail (*What Is Ecommerce?*, 2023).

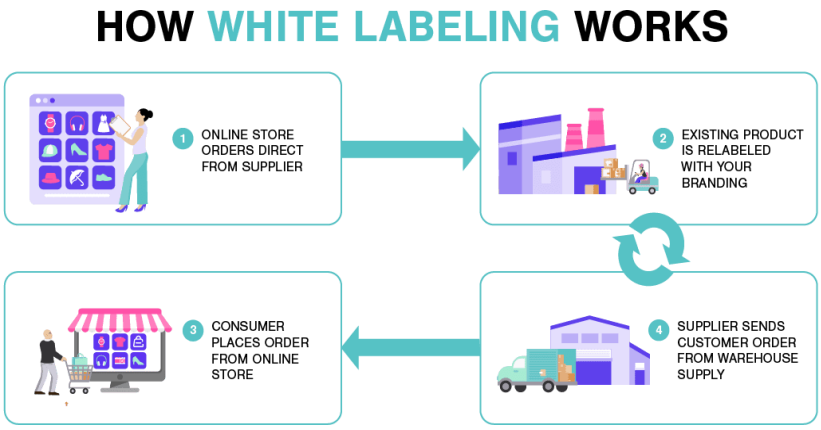


*Figure 11: how white labeling works (*What Is Ecommerce?, *2023)*

4.2.8 Business Model

Business model canvas is a tool that quickly shows a picture of what the idea contains. It also helps us to get a better understanding of our business and go through the procedure of making linkage between our idea and how to make it into a business. The customer-oriented aspects are emphasized on the BMC's right side(external), while the left side directs attention to internal business matters. The intersection of external and internal considerations occurs at the value proposition, representing the value exchange between your business and its customers/clients (Sheda, 2022). Business model canvas is brief and clear, that targeting farmers need and can be helpful to reduce the risk of failure (Young, 2018).

The Business Model Canvas (Figure 12) illustrates a strategic approach to introducing our tubular biogas digester to the Brazilian market. It is structured to address the unique needs of our customer segments. The business model canvas shows how we aim to offer value through sustainable energy production and waste management and establish key partnerships to ensure efficient distribution in our target market.

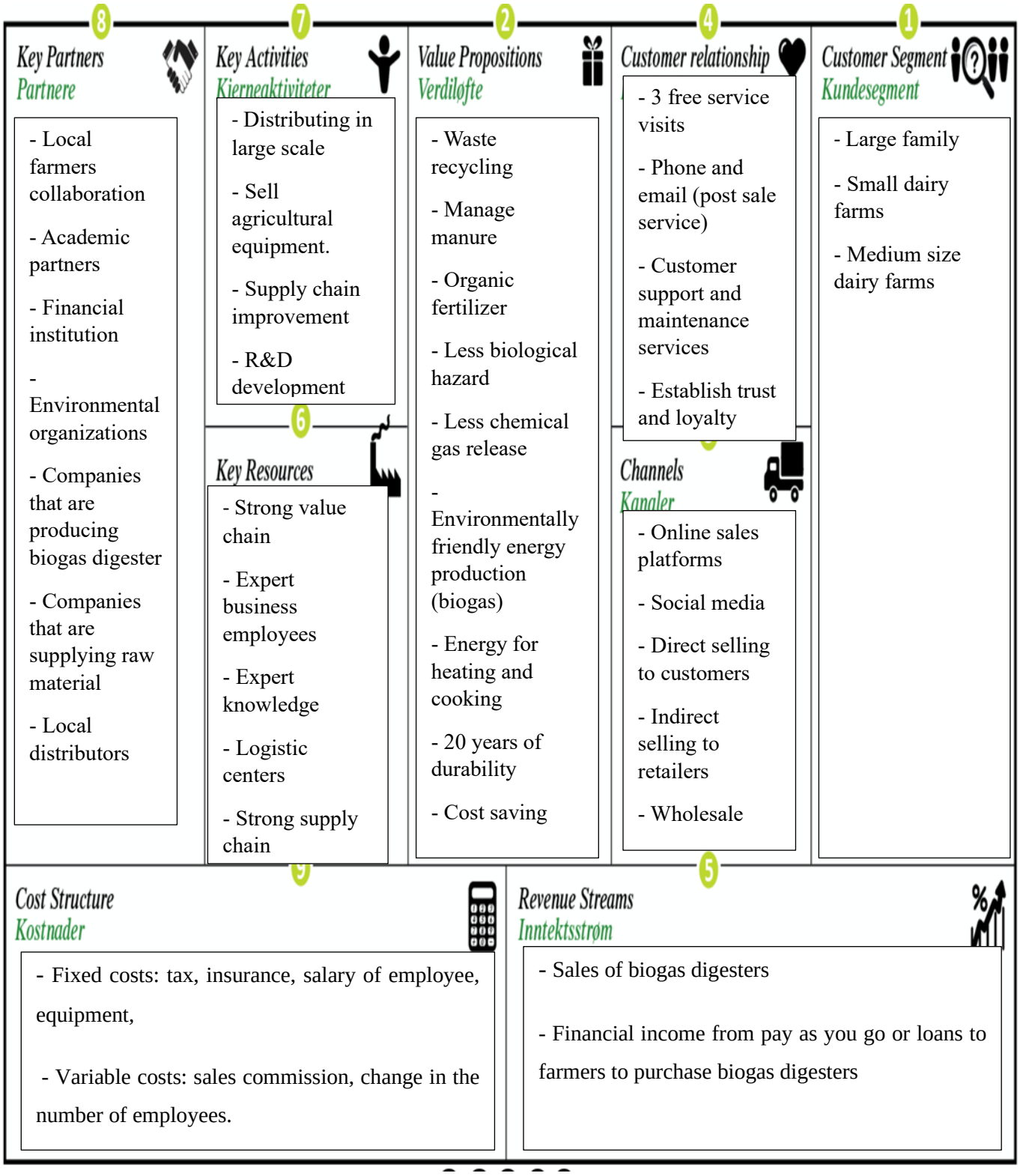


Figure 12: Business Model canvas

4.3 Feasibility Study

4.3.1 Market Estimate

Market analysis:

Since the 1970s, affordable biogas digesters have been increasingly adopted globally. Notably, in Latin America, the adoption of these cost-effective digesters was spurred following the oil crisis in the 1970s. Recently several successful implementations have been documented, particularly in rural communities. In Latin America, approximately 83 million individuals still lack access to novel and healthy cooking methods. Particularly in rural regions where the economy relies mostly on self-sustaining agriculture and family farming (Cucina et al., 2021).

In Latin America and the Caribbean (LAC), the focus of research and development (R&D) on anaerobic digestion (AD) of organic residues has predominantly revolved around small-scale digesters, commonly used for producing biogas for heating and cooking. These small-scale technologies have gained popularity due to their affordability and low maintenance requirements, leading to the success of various biodigester designs. To support and coordinate R&D efforts in the region, the Network for Biodigesters in Latin America, and the Caribbean (RedBioLAC) was established in 2009, with support from Green Empowerment, the US Environmental Protection Agency, and the Wuppertal Institute for Climate, Energy, and Environment.

In Latin America, the prevalent digester model is the plastic tubular digester. This popularity arises from its affordability and ease of implementation and management. Constructing and maintaining it doesn't require specialized skills. It includes a tubular polyethylene or PVC bag (the digester) buried in a trench. There's no mixing (to prevent material settling) or heating (to raise temperature). Despite often operating under psychrophilic conditions (15–20 °C), these digesters can generate sufficient biogas to meet users' needs due to a well-adapted microorganisms (Cucina et al., 2021).

Interestingly, there is also a growing interest in large-scale biodigesters in specific LAC countries such as Argentina, Brazil, Bolivia, Chile, Colombia, Costa Rica, Mexico, Paraguay, Puerto Rico, and Uruguay. Over the past decade, research on large-scale AD for treating residues has been conducted in the region, yielding promising findings on biomethane

potential and innovative techniques (Silva-Martínez et al., 2020). This could be an opportunity even when selling tubular digestors, because of investments in biogas technology.

Beachhead market:

South American countries are middle income countries according to FAO (*Latin American Forestry Sector Outlook Study Working Paper*, n.d.). Nearly half (46 %) of Latin America's agricultural GDP comes from livestock, and the majority of this production is situated in just five countries - Brazil, Uruguay, Paraguay, Mexico, and Argentina - which together make up 75 % of the region's output (Koop, 2021). 75 % of livestock production in South America originates in these five countries. Many Latin American countries heavily rely on beef exports as a top commodity. However, this has posed a significant challenge for policymakers as they face mounting pressure from both consumers and investors, who express growing concerns over the negative environmental and social effects of cattle farms (Koop, 2021).

Brazil:

Brazil is the strongest economy in the Latin America and Caribbean region and has a powerful agricultural and industrial sector. It is ranking as the fourth largest agricultural producer in the world, and the second-largest producer of soybean, beef and poultry (*Brazil*, 2023).

Over 60 % of the available biogas energy potential in Brazil is in the form cattle manure, primarily because of the substantial number of cattle in the country. However, it is difficult to realize this biogas potential, particularly due to the challenge of logistics, such as collecting the manure all over Brazil (Silva dos Santos et al., 2018). Furthermore, between 2008 and 2021 the total number of bovine livestock increased from 202.31 million to 224.6 million (*Number of Cattle Livestock in Brazil 2021*, 2023).

The number of family farms in Brazil is 4.4 million, comprising 85 percent of the total agricultural establishments in the nation (*As Brazilian Agribusiness Booms, Family Farms Feed the Nation*, 2019). Obtaining exact number of dairy farms can be challenging, however, there are an estimated 350 000 to 400 000 dairy farmers in Brazil. Brazil boasts an extensive number of dairy farms, ranking third globally with approximately 16.1 million cows actively producing milk and a total dairy cow population of 29 million. Furthermore, Brazil stands as the sixth-largest milk producer on a global scale (Azevedo, 2019).

The southern regions of Brazil (Rio Grande do Sul, Santa Catarina, and Paraná), along with the southeastern states (São Paulo and Minas Gerais) are main areas of dairy production, and produce high quality milk (Azevedo, 2019). Therefore, these regions have the highest numbers of dairy cows and modern farms in Brazil, making them suitable choices for a beachhead market.

Despite Brazil's prominent position as one of the world's major agricultural producers, it lacks effective policies for agro-industrial waste management. In addition to the favorable environmental outcomes, the use of biogas digesters presents an income-generating opportunity for farming communities in Brazil. However, there remains a need for increased awareness and better understanding of the advantages associated with recycling organic waste through digesters (Cortez et al., 2022). Base on this information I recommend Brazil as a suitable choice for beachhead market in South America.

4.3.2 Financial Analysis

Table 7 Shows the assumed population, TAM, SAM, and SOM based on the total number of dairy farmers in Brazil. It also shows the cost of digesters that are recommended for the different market segments. Finally, it shows the additional costs associated with selling biogas digesters in Brazil. As mentioned before in market estimate (4.3.1), there are an estimated 350 000 – 400 000 dairy farms in Brazil. We can make some broad assumptions to get an idea of the population of target customers in Brazil. Since our target customers don’t include large farms, we must exclude those. We are making the assumption that out of the total number of farms, around 250 000 are not large farms. Therefore, we can say our total assumed population of target customers is around 250 000. We then further divide those into 100 000 families, 100 000 medium-sized farms and 50 000 small farms. Next, we assume that all the farms in Brazil could be potential customers of biogas digesters. Thus, the total addressable market (TAM) would be 100 % of the target customer population. Of this TAM, it is likely that a significant portion of the market cannot be reached through our sales channels because the target population lives in remote areas. That is why we assume that the serviceable available market (SAM) is made up of 50 % of the TAM. Only a portion of the serviceable customers will be likely buyers, so we say that the serviceable obtainable market (SOM) is made up of 40 % of the SAM, which is 20 % of the TAM.

Table 7: financial analysis

Segment	**Region**	**assumed Population**	**TAM (Total Addressable Market)**	**SAM (Serviceable Available Market)**	**SOM (Serviceable Obtainable Market)**
Large Family with cow	Brazil	100 000	100 000	50000	20000
Small dairy farmers	Brazil	50 000	50 000	25000	10000
Medium size dairy farmers	Brazil	100 000	100 000	50000	20000
Total		250 000	100 %	50 %	20 %

Product	**Target Customer**	**Price per unit ($)**
Sistema 6	Large Family	USD 471,00
Sistema 8	Large Family	USD 665,00
Sistema 12	Small dairy farmers	USD 916,00
Sistema 16	Small dairy farmers	USD 1 147,00
Sistema 20	Medium size dairy farmers	USD 1 379,00

Sistema 30	Medium size dairy farmers	USD 1 737,00
Additional expenses	**Type**	
Fixed cost	Logistics	
	Shipping	
	Insurance	
	Advertising and promotion	
	Website maintenance	
	Spending on social media	
	Wages	
	Commissions	
	Out-of-pocket	
	Office rent	
	Office utilities	
	Postal charges	
	Supplies	
	Warehouse rent	
	Salaries	
	Payroll taxes	
	Pensions	
	Employee Benefits	
Variable cost	Sales commissions	
	Hiring employees	
	Employee bonuses	
	Interest rates	

Selling, General and Administrative Expenses:

During the quarter ending on March 31, 2023, the expenses related to selling, general, and administrative activities totaled $ 438 million, constituting 8.2 % of the overall revenues. This marks an increase of $ 60 million in comparison to the corresponding period in 2022, which accounted for 8.1 % of the total revenues (*About Us | CNH Industrial*, 2023).

4.3.3 Industry Analysis

PESTLE:

By conducting a comprehensive PESTLE analysis, stakeholders can gain valuable insights into the opportunities, challenges, and potential risks associated with introducing tubular micro biogas digesters in Brazil. This analysis can help in devising effective strategies for market entry, fostering partnerships with relevant stakeholders, and ensuring the technology's successful implementation and adoption in the country.

PESTLE analysis, also known as PEST analysis, is a marketing concept used as a tool by companies to assess the external environment in which they operate or plan to introduce a new project, product, or service(*What Is PESTLE Analysis?*, 2011). These letters stand for: P for political, E for economical, S for social, T for technological, L for legal and E for environment.

A PESTLE analysis for tubular micro biogas digesters in Brazil would involve evaluating various external factors that could impact the adoption, implementation, and success of this technology in the Brazilian market. Here's a breakdown of the analysis:

1. **Political Factors:**

Brazil has experienced political instability for several years, leading to uncertainty for organizations operating in the country. The protests that emerged after a shift in the government were fueled by anti-democratic sentiments, causing mass unrest in January 2023 and making the political climate highly volatile. In response to violent protesters in Brasilia, military intervention was necessary to restore political stability. The attack on state institutions escalated tension nationwide, and investors began perceiving Brazil as a high-risk region for investment. Another contributing factor is the unfavorable political climate and polarization. While Brazil had previously enjoyed a period of political stability from 1980 to 2012, the climate shifted after 2013, with riots and protests becoming common occurrences. This change in the political environment has had negative implications for business growth opportunities and created a discouraging atmosphere for investors (adamkasi, 2023).

2. **Economic Factors:**

The economic situation in Brazil indicates that the country has been facing difficulties in sustaining a consistent pace of economic growth. The outbreak of the pandemic and

inadequate government policies has further exacerbated the negative impact on the economy. The GDP growth has been notably sluggish, which points to deeper underlying economic problems. Although there has been some improvement in GDP from 2020 to 2021, Brazil still encounters economic challenges stemming from high unemployment, inflation, and poverty rates, all of which hinder the overall progress. Moreover, limited international trade opportunities and unfavorable tax policies for businesses also contribute to the slow economic advancement (adamkasi, 2023).

3. **Social Factors:**

Brazil is a culturally diverse country with a population of over 216.4 million people. The nation has made progress on the social front, evident in increased urbanization and improved living facilities for its people. Despite these positive developments, certain social issues are impeding rapid economic growth.

One major challenge for Brazil is the high crime rate, which includes problems like cargo theft and extortion. These crimes create a sense of insecurity for businesses, leading to reduced confidence and discouraging potential investors from making investment decisions.

The COVID-19 pandemic also brought about changes in consumer behavior. Many people shifted their spending patterns, with a larger proportion of income going towards healthcare-related items, while purchases of non-health and luxury items like clothing decreased. Additionally, the pandemic triggered a preference for online shopping over physical store visits. Even after the lockdown ended, the trend of online purchasing continued, indicating a lasting change in consumer buying behavior. The pandemic also had an impact on brands' market share, as customers responded to price differences and chooses brands with lower price (adamkasi, 2023).

4. **Technological Factors:**

Brazil has made significant investments in developing its technological capabilities, leading to notable advancements in this field. However, the country has not fully harnessed the potential benefits offered by various technologies. Strengthening Brazil's position in the technology sector can greatly support growth and innovation across different industries.

To create a favorable business environment, the government has taken measures to leverage digital development effectively (adamkasi, 2023).

5. **Legal Factors:**

Brazil's legal environment is encountering difficulties due to significant corruption and ineffective law enforcement. Although regulations have been designed to facilitate business operations, the prevalence of corruption creates unwarranted barriers to business growth. Nevertheless, the country is striving to build a more robust legal framework.

The legal system covers various aspects such as employment, labor management, consumer rights, and regulations concerning foreign employees working in the country. However, improvements are needed in the legal framework to make it more conducive for entrepreneurs and startups. The taxation system is another problematic area that requires modifications to emerge a favorable business environment (adamkasi, 2023).

6. **Environmental Factors:**

Environmental changes have spurred governments and environmental protection agencies to take necessary measures to mitigate environmental damage. While some countries have successfully implemented sustainable and green practices, others face challenges in adhering to eco-friendly business requirements.

Brazil falls among the countries that have been slow in making significant improvements in their business operations concerning environmental standards. Despite being home to the largest rainforests, the country faces threats from deforestation and high emissions from various industrial sectors.

According to the World Bank (2022), the Brazilian government lacks a clear and comprehensive strategy to address ongoing climate issues. While there are some guidelines for businesses and goals for reducing carbon emissions, there is an evident absence of a cohesive strategy to achieve these targets (adamkasi, 2023).

Brazil faces a challenging business landscape characterized by slow economic growth and concerns related to both economic and environmental matters. Nevertheless, by implementing appropriate policies and regulations, it is possible to mitigate the adverse effects stemming from these factors (adamkasi, 2023).

S.W.O.T Analysis:

("SWOT Analysis (and TOWS Matrix) EXPLAINED with EXAMPLES | B2U," 2017)

The SWOT (strengths, weaknesses, opportunities, and threats) analysis is a strategic framework employed to assess a company's competitive standing and extend strategic planning. It examines both internal and external factors, along with present and future possibilities (*SWOT Analysis*, n.d.).

SWOT analysis for tubular micro biogas digester as a business opportunity has been explained below:

Strength:

- Renewable energy source that can drive circular economy.

Brazil is a major agricultural producer but currently struggles with waste management from agricultural activity. Micro biogas digesters allow for effective reuse of organic solid waste. This can contribute to the closing of the circular economy in Brazil.

- Improved sanitation in remote areas

There is currently no proper system for management of solid waste from agriculture in Brazil. Biogas digesters can decentralize this waste management, thereby improving local sanitation and relieving the burden on centralized waste disposal.

- Improving economic power of small producers

Using the biofertilizer that is made as a side product from the tubular biogas digester can improve the pastures where the animals graze. This creates an opportunity for a farmer with a

biogas digester to generate a new source of income from their animal's solid waste. This way, the farmer with the biogas digester can improve their economic power.

Weaknesses:

- Lack of government incentive

The lack of interest from the Brazilian government to invest in biogas digesters can be seen as both a weakness and a threat. It is a weakness because if there was more investment in renewable energy in Brazil, there would be a greater marker for biogas, and farmers with a biogas digester would have more opportunity to sell the biogas they produce. Furthermore, this also means there is less interest in Brazil to fund companies specializing in biogas digester distribution.

- Lack of knowledge

There is little knowledge about biogas in the Brazilian population. This means they may not have any technical knowledge about how to use a biogas digester. It also means they may have uncertainties about investing in a new technology that is not familiar to them.

Opportunities:

- Carbon trading

Brazil has a lot of companies that produce a lot of CO_2. Paying for carbon offset is becoming more and more widespread in Brazil. This could present an opportunity for a farmer with a biogas digester to get money from large companies to offset their carbon emissions.

- Joint investments between farmers

Small farmers could come together to invest in a biogas digester. This way they can centralize their waste disposal and make their investment more viable. This also further improves local cooperation in farming communities. Alternatively, a farmer who has a digester could rent out the use of his digester to other farmers, facilitating waste management as well as creating a source of income.

Threats:

- Composting is more cost-effective waste treatment.

Composting could be a more cost-effective method to manage solid waste. If composting becomes widespread in Brazil, this may reduce the market for biogas digesters.

- Lack of government incentive

The Brazilian government is not interested in biogas and may decide to impose legislation that could make biogas digesters less attractive (Cortez et al., 2022).

4.3.4 Value Chain Analysis

Since we want to distribute biogas digester rather than producing it. We are not participating in the design and manufacturing of the product, but we should make sure that these steps are completely and well managed, because these are very important steps in the value chain. We should also have additional quality control steps to ensure the manufactured digesters meet our quality standards.

Warehouses: Tubular micro biogas digesters can be stored in bulk, close to the customers. This way we can avoid delayed deliveries because of issues in manufacturing or during shipping from the manufacturer. Getting tubular digesters in bulk and storing them locally can also make it easier and cheaper to transport the product to our customers.

Services: The company provides post sell services to customers. Installation services are included for free, to ensure that the digester is set up correctly and operates as expected. This also includes providing ongoing maintenance guidelines and support to help customers keep their digester in optimal condition. There are up to 3 services visits in case there are any technical problems with the digester.

Packaging and shipping: In this step of the value chain, it's essential, after receiving digesters from manufacturers and suppliers, to check the quality of the product. This should include validating the size of components and their operation and making sure no components are missing. Finally, the biogas digesters will be packaged with our brand name and shipped to distribution centers.

Distribution: After packaging and shipping, tubular digesters and components are mass delivered to the wholesaler, retailer, warehouses and directly to customers.

Figure 13 below shows the full life cycle of tubular biogas digesters, from raw material to post sell service and what value it brings to customers.

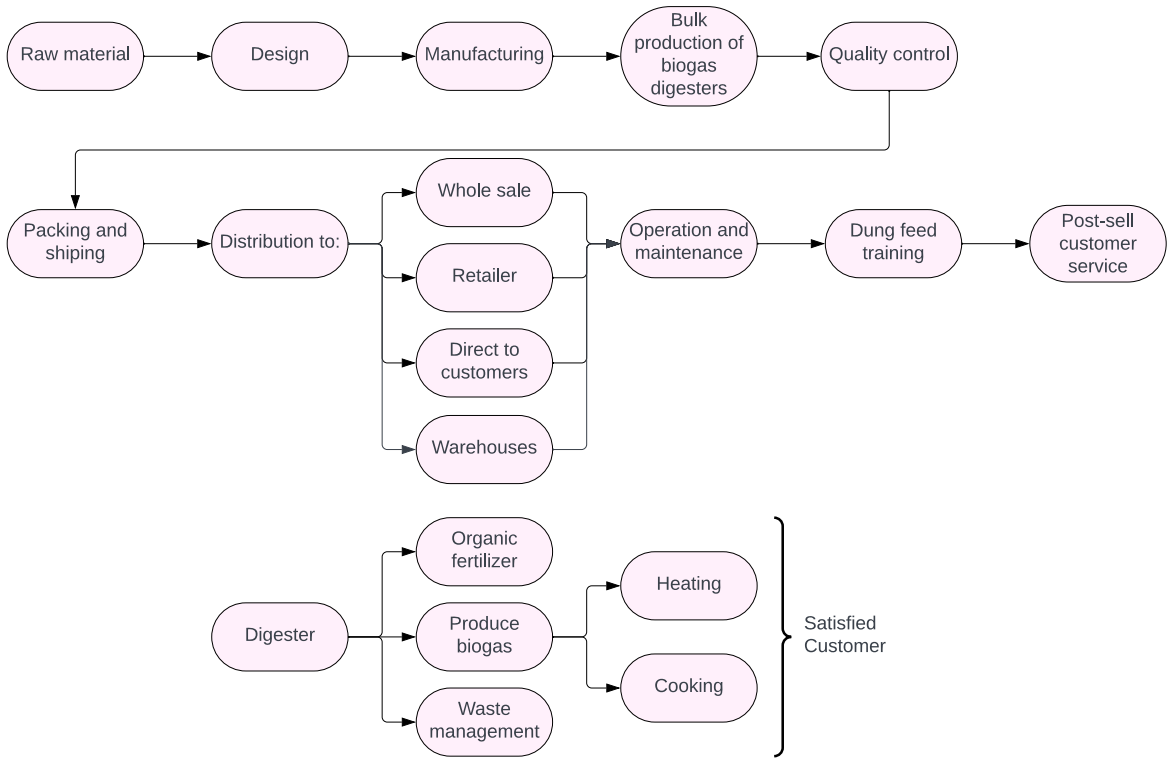


Figure 13: Value chain analysis

Biogas production steps are described in Figure 14 below.

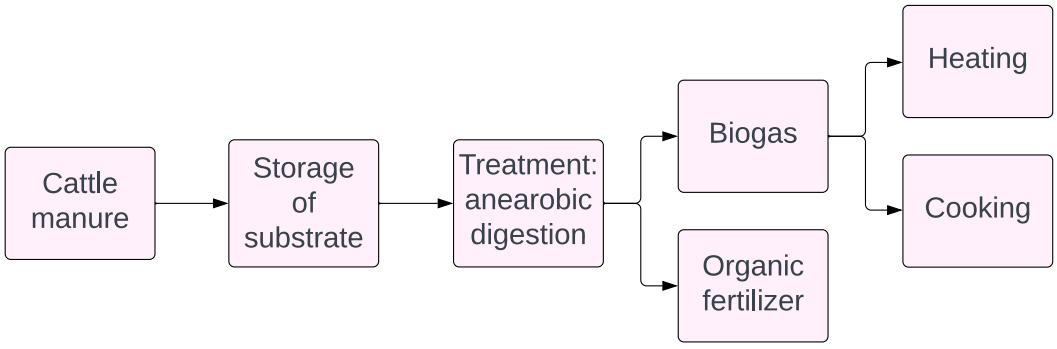


Figure 14: Biogas production steps

4.3.5 Intellectual Property and literature search

Based on a patent search using Espacenet (*Espacenet – Patent Search*, 2023), a patent for a PVC tubular biogas digester was found (US2015000357A1). The patent describes a tubular

digester made of polymer materials that makes use of anaerobic digestion of organic material and produces biogas and organic fertilizer. Based on this finding, it would be hard to come up with a novel patentable PVC tubular biogas digester. However, the design of the reactor can be protected via trademark. The company should have a brand that stands out from the competition. Then the design language of the company can be used in the biogas digester design so that customers can distinguish it from the rest of the market. We can trademark our brand and we should protect it to make sure others don't infringe on our brand and try to sell copies or damage our brand. It is also important to reserve a web domain. This way our customers can easily find information about our brand and contact us.

4.3.6 Quality Control

To ensure the quality of the tubular biogas digesters in South America, several key steps should be taken. Initially, upon receiving products from the manufacturing process, it's crucial to inspect the size and material quality, verifying their alignment with the specified standards. The materials used in the digesters' construction, such as HDPE or PVC, should meet quality specifications and be durable enough to withstand environmental conditions in South America. Furthermore, the company must guarantee the optimal functionality of the products. This involves conducting thorough testing of each digester unit before it is distributed. The contents included with the product should be checked to ensure no parts are missing or damaged. A pressure test can be used to detect any leaks in the digester. Any electronic components should be tested before shipping the product.

4.3.7 Health, Safety and Environmental Impact

The biogas generated by tubular digester is a clean fuel primarily consisting of methane and carbon dioxide. It serves as a substitute for conventional biomass like firewood and dried cattle dung in cooking. Employing a biogas cook stove brings substantial health benefits by reducing air pollution within enclosed and poorly ventilated kitchens. It also prevents the release of harmful emissions such as particulate matter and sulfur oxides that result from burning traditional biomass. Furthermore, anaerobic digestion of animal manure reduces the harmful risks associated with improper management of animal waste, which can have significant adverse effects on both soil and water quality. An example of this is the direct application of slurries on land.

Digestate, another outcome of anaerobic digestion, contains a wealth of nutrients, including nitrogen, phosphorus, potassium, calcium, and magnesium. It can serve as a biofertilizer to enhance crop yields in agriculture. The reuse of digestate in agriculture is just as crucial for rural households and small-scale farms in Latin America as the production of biogas (Cucina et al., 2021).

Safety related to use of product:

Inadequate care can lead to risks in any energy system. However, Sistema.bio is equipped with specific components, including a pressure relief valve and a filter, to reduce risks for farmers. Furthermore, the technical team provides training to users on essential security measures during the biodigester installation and operation, such as installing a perimeter fence. By following these recommendations and ensuring regular daily maintenance, these tubular biodigesters are entirely safe.

4.3.8 Risk Assessment

As a global company with a diverse business portfolio, CNH Industrial faces multiple legal risks in its regular operations. These risks include dealer and supplier litigation, disputes over intellectual property rights, product warranty and defective product claims, product performance issues, personal injury cases, regulatory and contractual issues concerning emissions and fuel economy, competition law investigations, and environmental claims. The most significant of these matters are explained below.

It is challenging to predict the outcome of ongoing or future legal proceedings, claims, or investigations with certainty. Unfavorable decisions in any of these cases could lead CNH Industrial to pay substantial damages, fines, undertake service actions, conduct recall campaigns, or incur other expensive obligations. Consequently, legal judgments might result in expenses that are not fully covered by insurance compensation payments, potentially affecting CNH Industrial's financial position and results.

The global economy is currently experiencing disruptions in commodity, labor, and transportation markets, and by the economic recovery from the pandemic and repercussions from geopolitical events, including the war in Ukraine. These disruptions have created an inflation, impacting the prices and availability of essential products and services necessary for the Company's operations.

In 2022, the Company faced supply chain disruptions and pressure because of inflation, which are expected to persist into 2023. As a result, the manufacturing operations have been affected, leading to inefficiencies and increased costs. However, the company is working on mitigating the impact of these issues to meet the demands of the end-market.

Given the fluid and evolving conditions, the company continues to closely monitor the situation to adapt and respond accordingly. Additionally, they are vigilant in monitoring global economic conditions and the effects of economic pressures, such as rising interest rates, fluctuating currency exchange rates, inflation, and recession fears, on the Company's business, customers, and suppliers (*About Us | CNH Industrial*, 2023).

Table 8 describes the potential risks associated with tubular biogas digesters. Each risk is described and the likelihood of them occurring and degree of impact when they occur are given. Finally, a mitigation strategy for each risk is described.

Table 8: Different types of Risk

Risk type	Risk description	likelihood	Impact	Mitigation strategy
Smell of gas (P2, S1)	Gas/rotten egg smell near the digester or in the kitchen	Medium	Low	Refer to How to use your system section
Slurry not entering the digester (P2, S1)	The biofertilizer does not come out of the digester	low	Medium	Unclog your inlet or outlet pipes from dry or solid material that may be blocking the flow.
Stove does not have light/gas (P1, S1)	There is no gas in bio stove and digester is inflated	low	High	In biogas line low points, water can accumulate and block the biogas from flowing. Elevate the gas line to direct the accumulated water towards the water trap or the PRV.

Copy our product or use our trademark	Another company copy our product and sell to the same customers	Medium	high	Register our trademark and work with legal professionals
Competitors (P2, S2)	Start selling similar product to our beachhead market	high	medium	Highlight unique product features. Continuously monitor and adapt to competitor actions.
Market demand fluctuations (P3, S1)	Changes in economic conditions can lead to fluctuating demand for our product.	Medium	High	Diversify product range to cater to varying demands. Implement flexible pricing strategies
Supply chain disruption (P2, S4)	Quality issues, delay in delivering or shortage of parts	low	High	Consider alternative suppliers\ maintain critical components in stock
Risk of pathogen	Risk of pathogen transfer into food chain	low	Medium	Teaching farmers how to stop contaminating water and food with manure and biofertilizer biproducts.
Credit and payment risk (P1, S2)	Delays in payment or defaults, impacting our cash flow	Medium	High	Implement credit checks before extending credit. Offer multiple payment options.
Global factors (P1, S3)	Factors like geopolitical tensions, trade regulations, or global health crises (like pandemics) can disrupt supply chains and affect sales on a broader scale.	low	High	Monitoring global factors that can affect the business market in Brazil

In Table 9, the risks are categorized based on the probability of them occurring and the severity of the risk. Risks colored in blue are acceptable risks whereas risks labeled in red are not acceptable.

Table 9:Risks probability and severity

Probability of occurrence	S1	S2	S3	S4	S5
P5					
P4					
P3	Market demand fluctuations				
P2	Smell of gas and slurry not entering the digester	Competitors		Supply chain disruption	
P1	Stove does not have light/gas	Credit and payment risk	Global factors	Fire and explosion	

4.4 Project Plan

4.4.1 Project Description

We aim to sell tubular biogas digesters in Brazil to rural dairy farmers. We have commercial goals, namely establishing a market presence in South America and achieving a significant market share in Brazil in a reasonable timeframe. In addition, we also have environmental and social goals. They include contributing to renewable energy production, reducing greenhouse gas emissions, waste management and public health.

For the success of our company, it is important that the assumptions made in this thesis are verified on location. We should go on site to identify potential issues, get a clear idea of customer expectations, and collect objective data about the market. Based on this data, the company can more clearly define the geological area where we should aim to launch our product.

It's also important to know all the regulations and laws in the Beachhead Market, our legal team can help through this. The company should reach out to local stakeholders and relationships and contracts should be made with them for cooperation. We should come up with how to measure the performance of our company, economically and with respect to achieving social and environmental goals. Then we can assess which portion of the market is most successful, which marketing strategies are most effective and how our partners perform. Then we can invest more in the most effective strategies to increase our market share.

4.4.2 Research and Development (R&D Phase)

Conducting market research is necessary to have better understanding of customer needs, preferences, and their ability to pay in Brazil. In the R&D phase we can do on-location market research. In the first stage, we should send investigators on site to observe the local conditions to identify potential risks to our company's success. This can include logistical problems or any potential concerns that come up while observing local farmers in the beachhead market. We should first focus on qualitative aspects of the field research. This can be done on a smaller scale by talking to farmers or doing surveys or in focus groups. People can go on location to see how farmers make use of tubular digesters, if they want to use the biogas and fertilizer themselves or sell to other people, and so on. In this way we can identify opportunities for our company. We want to get all the details about the needs and expectations of our target customers.

Our legal team should do an investigation into local regulations. They can identify potential problems for our company or potential opportunities. They should make sure that our business will comply with all local regulations. They need to make sure the product and services we want to provide are following the legislation and required local standards.

Finally, we should do quantitative market research. This is done on a larger scale, and it gives us an idea about the willingness and ability to buy our products in the beachhead market. We can use strategies like online surveys, social listening, or structured panels. Another good

option is to work with a local company who specialize in market research. They will have expertise and experience of the local regions. We want to get real numbers about expected sales and costs so that we can do budgeting and get an estimate of return on investment. It will also let us find out which regions may be the best to launch our product.

4.4.3 Transfer Phase

In this step, we should establish a strong partnership with manufacturers, suppliers, and distributors. Developing the supply chain is very important in this step. Making sure suppliers can provide material and components with no delays, shortages or quality issues that affect our commitment and ability to deliver to customers. We need to have a good quality control and quality assurance system in place. We should be collaborating with experts who know the beachhead market and ask for their feedback.

In short, we have done market research and identified where we should start to sell our product. Now we need to get everything in place to get our product and services to the customers without problems or interruptions. We need to have contracts with workers, to lease or buy infrastructure and with partners. Here are examples of what we need to have contracts and systems for.

Infrastructure:

- Warehouses to store the tubular digesters before going to the customer
- Vehicles to transport the digesters
- Testing equipment for quality control
- Offices for workers who will provide customer support
- Online infrastructure (website / store)

Workers:

- Technicians who will install the digesters for the customers
- Technicians to do quality control
- Sales personnel
- Customer support operators
- Logistics personnel
- Accountants

Partners:

- The manufacturer / suppliers
- Distributers
- Local logistics
- Legal partners
- Investors

When the transfer phase is complete. We will have everything in place to sell our product and to provide services to our customers. We will have contracts with suppliers who manufacture the tubular digester. They will go through the quality control process. We should fill our warehouses so that we can bring the digesters quickly when they are purchased. All the logistics will be in place to deliver and install the tubular digesters for the customers. We have marketing strategies ready, based on our data from the R&D phase. Our company has a website and communication channels for customers to reach us. The legal requirements are met. The customer support is in place. Now the company is ready to bring our product to the market and test the sales and marketing strategies.

4.4.4 Pre-Launch

Now we are ready to start to test our marketing and sales strategies. We can build our company's online presence and spread the word about our product. To launch the product, we can organize launch events to get people excited about our tubular digesters. We can start to advertise our product to potential customers and test different marketing strategies. We should make sure people become familiar with our brand. By providing high quality service and products, we can ensure people have a positive association with our company. Our social and environmental goals could provide an important aspect of our sales strategy. We could build a green image by reaching out and collaborating with other green initiatives. Providing comprehensive customer support and post sell services to satisfy our customers is necessary, that would help us have more customers through word of mouth. We will start to get real customer feedback which can inform us about how to improve the systems we have in place.

When we start the sales, we can measure performance in different regions. We should evaluate the performance based on our commercial goals, but also based on our social and environmental goals. Based on these metrics we can now identify our most effective sales strategies, marketing strategies, communication channels, and so on. Furthermore, we can

identify the customer profiles and sales regions that generate the most income for our company. Based on this knowledge, we can make our advertising more targeted by focusing on regions and demographics within our beached market that are responding in the best way.

4.4.5 Commercial Launch

Based on what we have learned from the pre-launch phase, we can now start to grow our market share. We can identify where and how we get the greatest return on investment and focus our efforts. We should put extra resources into the most effective advertising campaigns for the most likely buyers. This way we can increase our sales. To support the increased sales, we should invest more in distributors and partners that generate the highest ROI. By using what we have learned we can focus on growing our business in the most successful regions.

4.4.6 Post Launch

After a successful launch, we should go out to collect feedback about our product. To do this we can use customer surveys. This information can be valuable to inform product improvement or potential new product development. The post launch stage is essential in ensuring our product doesn't become outdated and the competition doesn't overtake our market share. Any customers who have complaints about our product can be future customers if their concerns are addressed. At the beginning of the launch, most customers will be the early adopters, whereas when the company grows, we should start to appeal to the majority audience. This can be done by giving them proof-based data. Now that we have sold many products, we can use the real data to show the value of our product to future customers who may not be convinced otherwise.

Another post launch strategy is to retain previous customers. This can be done by giving them special offers. A great way to generate more income from previous customers is by identifying shortcomings in our product based on their feedback. Then we can offer products that address those shortcomings. Another important aspect is to maintain high-quality, long-term support. This is especially important with products like biogas digesters that are expected to have a relatively long lifespan. The company could offer repair services or installations of new improved models for returning customers at a discounted price.

Gantt chart for project plan:

The proposed time schedule for the project plan is shown in the Gantt chart in Figure 15.

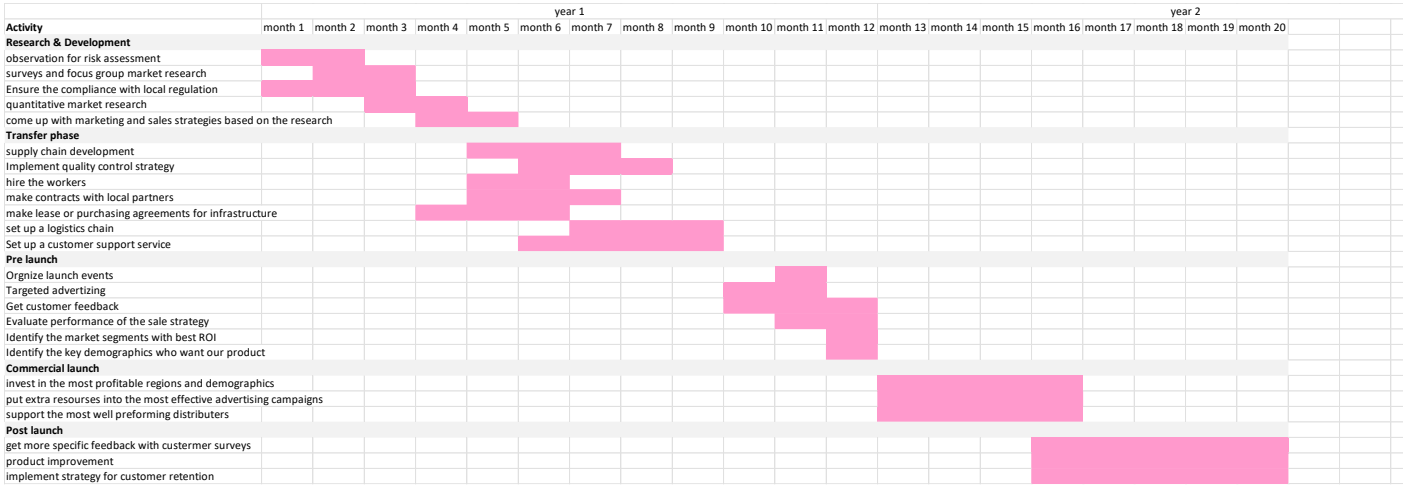


Figure 15: Gantt chart

5. Conclusion

In developing regions like South America, there is poor waste management of livestock manure. This leads to health issues and greenhouse gas emissions. Biogas digesters can offer a solution to this crisis and at the same time provide valuable renewable fuel for cooking and heating and fertilizer for crop cultivation. Different biogas digesters have been studied in this thesis. Based on our findings from the literature, I concluded that tubular micro biogas digesters are the most suitable for our target customers in South America. I proposed that the company should distribute the tubular biogas digester instead of manufacturing it. Designing and manufacturing a new kind of biogas digester would take lots of development time and research. Furthermore, based on the literature, it may be difficult to come up with any new patentable design. Therefore, I recommend the company to distribute biogas digesters from an established manufacturer instead of setting up a new manufacturing process from the ground up. The company should focus on quality control and establishing a recognizable brand with a positive image. For this purpose, a tubular biogas digester from Sistema.bio has been selected to distribute by the CNH company, because it is made from high quality PVC, it is easy to install, and reasonably priced. Brazil has been selected as a beachhead market because they are one of the biggest agricultural producers in the world and have more than 200 million cows, of which 29 million are dairy cows, while having poor waste management. The company already has a logistic center at Sorocaba, Sao Paulo State. That can help the company to store components and tubular digesters, it can lead to faster delivery to our customers and require no additional investment in a new logistics center.

The scope for this thesis was limited to desk research. Analyzing farmers and potential regulation that could stop our project in Brazil was not conducted, since I hadn’t traveled to South America.

6. References

12.1 Anaerobic Digestion | EGEE 439: Alternative Fuels from Biomass Sources. (2023). https://www.e-education.psu.edu/egee439/node/727

About Us | CNH Industrial. (2023). https://www.cnhindustrial.com/en-US/Our-Company

adamkasi. (2023, February 12). *PESTLE Analysis of Brazil | Free PESTEL Analysis*. https://freepestelanalysis.com/pestle-analysis-of-brazil/

Adeli, A., Varco, J. J., Sistani, K. R., & Rowe, D. E. (2005). Effects of Swine Lagoon Effluent Relative to Commercial Fertilizer Applications on Warm-Season Forage Nutritive Value. *Agronomy Journal*, *97*(2), 408–417. https://doi.org/10.2134/agronj2005.0408

As Brazilian agribusiness booms, family farms feed the nation. (2019, January 17). Mongabay Environmental News. https://news.mongabay.com/2019/01/as-brazilian-agribusiness-booms-family-farms-feed-the-nation/

Azevedo, D. (2019, February 12). *Brazilian dairy: On the road to recovery*. Dairy Global. https://www.dairyglobal.net/industry-and-markets/market-trends/brazilian-dairy-on-the-road-to-recovery/

Biodigesters – RedBioLAC. (2023). http://redbiolac.org/los-biodigestores/

BNamericas—AXXEL Telecom expands its fiber internet net... (n.d.). BNamericas.Com. Retrieved September 14, 2023, from https://www.bnamericas.com/en/news/axxel-telecom-expands-its-fiber-internet-network-from-12-to-127-cities

Brazil. (2023). IFAD. https://www.ifad.org/en/web/operations/w/country/brazil

Cheng, S., Li, Z., Mang, H.-P., & Huba, E.-M. (2013). A review of prefabricated biogas digesters in China. *Renewable and Sustainable Energy Reviews*, *28*, 738–748. https://doi.org/10.1016/j.rser.2013.08.030

CNH Industrial Logistics Center in Sorocaba, Brazil, awarded Bronze in World Class Logistics Program | CNH Industrial. (n.d.). Retrieved September 14, 2023, from https://www.cnhindustrial.com/en-US/media/press_releases/2021/september/CNH-

Industrial-Logistics-Center-in-Sorocaba-Brazil-awarded-Bronze-in-World-Class-Logistics-Program

Cortez, S. C., Cherri, A. C., Jugend, D., Jesus, G. M. K., & Bezerra, B. S. (2022). How Can Biodigesters Help Drive the Circular Economy? An Analysis Based on the SWOT Matrix and Case Studies. *Sustainability*, *14*(13), Article 13. https://doi.org/10.3390/su14137972

Cucina, M., Castro, L., Escalante, H., Ferrer, I., & Garfí, M. (2021). Benefits and risks of agricultural reuse of digestates from plastic tubular digesters in Colombia. *Waste Management*, *135*, 220–228. https://doi.org/10.1016/j.wasman.2021.09.003

Espacenet – patent search. (2023). https://worldwide.espacenet.com/patent/

Ferrer, I., Garfí, M., Uggetti, E., Ferrer-Martí, L., Calderon, A., & Velo, E. (2011). Biogas production in low-cost household digesters at the Peruvian Andes. *Biomass and Bioenergy*, *35*(5), 1668–1674. https://doi.org/10.1016/j.biombioe.2010.12.036

Fixed Dome Soft Bio Gas Biogas Digester—Buy Biogas Digester Bag,Aaerobic Digestion Bag,Biogas Digestions Pvc Bag Product on Alibaba.com. (2023). https://www.alibaba.com/product-detail/Fixed-Dome-Soft-Bio-Gas-Biogas_60559010741.html

G, K. (1998). Energy consumption and greenhouse gas emissions in fertilizer production. *IFA Tech. Conf., Marrakech, Morocco, 1998*. https://cir.nii.ac.jp/crid/1572543025728735488

Holm-Nielsen, J. B., Al Seadi, T., & Oleskowicz-Popiel, P. (2009). The future of anaerobic digestion and biogas utilization. *Bioresource Technology*, *100*(22), 5478–5484. https://doi.org/10.1016/j.biortech.2008.12.046

Hulse, J. H. (2007). *Sustainable Development at Risk: Ignoring the Past*. IDRC.

Integrated Home Size Integrated Biogas Digester—Buy Teenwin Integrated Home Size Integrated Biogas Digester,Integrated Biogas Digester For Home,Teenwin Integrated Home Size Biogas Digester Product on Alibaba.com. (n.d.). Retrieved September 14, 2023, from https://www.alibaba.com/product-detail/integrated-home-size-integrated-biogas-digester_1600608505466.html?spm=a2700.details.0.0.3bb0572eecSCyR

Itodo, I. N., Agyo, G. E., & Yusuf, P. (2007). Performance evaluation of a biogas stove for cooking in Nigeria. *Journal of Energy in Southern Africa*, *18*(4), Article 4. https://doi.org/10.17159/2413-3051/2007/v18i4a3391

Kinyua, M. N., Rowse, L. E., & Ergas, S. J. (2016). Review of small-scale tubular anaerobic digesters treating livestock waste in the developing world. *Renewable and Sustainable Energy Reviews*, *58*, 896–910. https://doi.org/10.1016/j.rser.2015.12.324

Kinyua, M. N., Wald, I., Camacho-Céspedes, F., Izurieta, R., Haas, C. N., & Ergas, S. J. (2016). Does the use of tubular digesters to treat livestock waste lower the risk of infection from Cryptosporidium parvum and Giardia lamblia? *Journal of Water and Health*, *14*(5), 738–753. https://doi.org/10.2166/wh.2016.032

Koop, F. (2021, March 8). Latin America takes first steps towards sustainable beef. *Dialogo Chino*. https://dialogochino.net/en/agriculture/41164-latin-america-takes-first-steps-towards-sustainable-beef/

Latin American Forestry Sector Outlook Study Working Paper. (n.d.). Retrieved September 14, 2023, from https://www.fao.org/3/j2459e/j2459e07.htm

Martí-Herrero, J., Chipana, M., Cuevas, C., Paco, G., Serrano, V., Zymla, B., Heising, K., Sologuren, J., & Gamarra, A. (2014). Low cost tubular digesters as appropriate technology for widespread application: Results and lessons learned from Bolivia. *Renewable Energy*, *71*, 156–165. https://doi.org/10.1016/j.renene.2014.05.036

Neshat, S. A., Mohammadi, M., Najafpour, G. D., & Lahijani, P. (2017). Anaerobic co-digestion of animal manures and lignocellulosic residues as a potent approach for sustainable biogas production. *Renewable and Sustainable Energy Reviews*, *79*, 308–322. https://doi.org/10.1016/j.rser.2017.05.137

Number of cattle livestock in Brazil 2021. (2023). Statista. https://www.statista.com/statistics/758526/ending-stocks-beef-cattle-brazil/

Pan, S.-Y., Tsai, C.-Y., Liu, C.-W., Wang, S.-W., Kim, H., & Fan, C. (2021). Anaerobic co-digestion of agricultural wastes toward circular bioeconomy. *IScience*, *24*(7), 102704. https://doi.org/10.1016/j.isci.2021.102704

Pérez, I., Garfí, M., Cadena, E., & Ferrer, I. (2014). Technical, economic and environmental assessment of household biogas digesters for rural communities. *Renewable Energy*, *62*, 313–318. https://doi.org/10.1016/j.renene.2013.07.017

Pizarro-Loaiza, C. A., Antón, A., Torrellas, M., Torres-Lozada, P., Palatsi, J., & Bonmatí, A. (2021). Environmental, social and health benefits of alternative renewable energy sources. Case study for household biogas digesters in rural areas. *Journal of Cleaner Production*, *297*, 126722. https://doi.org/10.1016/j.jclepro.2021.126722

Rajendran, K., Aslanzadeh, S., Johansson, F., & Taherzadeh, M. J. (2013). Experimental and economical evaluation of a novel biogas digester. *Energy Conversion and Management*, *74*, 183–191. https://doi.org/10.1016/j.enconman.2013.05.020

Rajendran, K., Aslanzadeh, S., & Taherzadeh, M. J. (2012). Household Biogas Digesters—A Review. *Energies*, *5*(8), Article 8. https://doi.org/10.3390/en5082911

Razzouk, R., & Shute, V. (2012). What Is Design Thinking and Why Is It Important? *Review of Educational Research*, *82*(3), 330–348. https://doi.org/10.3102/0034654312457429

Red mud biogas digester, soft biogas digester system, home biogas digester septic tank. (n.d.). Ruankai (RK) Group. Retrieved September 14, 2023, from https://www.ruankaitec.com/product-red-mud-biogas-digester.html

Sheda. (2022, October 28). How To: Business Model Canvas Explained. *Sheda*. https://medium.com/seed-digital/how-to-business-model-canvas-explained-ad3676b6fe4a

Shop. (n.d.). HomeBiogas. Retrieved September 14, 2023, from https://www.homebiogas.com/shop/

Silva dos Santos, I. F., Braz Vieira, N. D., de Nóbrega, L. G. B., Barros, R. M., & Tiago Filho, G. L. (2018). Assessment of potential biogas production from multiple organic wastes in Brazil: Impact on energy generation, use, and emissions abatement. *Resources, Conservation and Recycling*, *131*, 54–63. https://doi.org/10.1016/j.resconrec.2017.12.012

Silva-Martínez, R. D., Sanches-Pereira, A., Ortiz, W., Gómez Galindo, M. F., & Coelho, S. T. (2020). The state-of-the-art of organic waste to energy in Latin America and the Caribbean: Challenges and opportunities. *Renewable Energy*, *156*, 509–525. https://doi.org/10.1016/j.renene.2020.04.056

Sistema.bio: The Biodigester solution. (2023). https://sistema.bio/

SWOT Analysis (and TOWS Matrix) EXPLAINED with EXAMPLES | B2U. (2017, April 14). *B2U - Business-to-You.Com*. https://www.business-to-you.com/swot-analysis/

SWOT Analysis: How To With Table and Example. (2023). Investopedia. https://www.investopedia.com/terms/s/swot.asp

The role of livestock in poverty alleviation: An analysis of Colombia. (2023). https://lrrd.cipav.org.co/lrrd17/1/holm17011.htm

Top Social Media Networks Websites Ranking in Brazil in July 2023. (2023). Similarweb. https://www.similarweb.com/top-websites/brazil/computers-electronics-and-technology/social-networks-and-online-communities/

Troncoso, K., & Soares da Silva, A. (2017). LPG fuel subsidies in Latin America and the use of solid fuels to cook. *Energy Policy*, *107*, 188–196. https://doi.org/10.1016/j.enpol.2017.04.046

What Is Ecommerce? [Definition, How to, & More]. (2023). https://www.ecommerceceo.com/learn/what-is-ecommerce/

What is PESTLE Analysis? An Important Business Analysis Tool. (2011, November 25). https://pestleanalysis.com/what-is-pestle-analysis/

World Bank Open Data. (2023). World Bank Open Data. https://data.worldbank.org

Young, S. (2018, April 11). 5 key benefits of using a business model canvas instead of a business plan. *Medium*. https://chimera-swa.medium.com/5-key-benefits-of-using-a-business-model-canvas-instead-of-a-business-plan-55d5d727ba46

7. Appendix

Table 10: Types of manure (Kinyua, Rowse, et al., 2016)

Type of manure	Unit	Swine		Cow		Poultry	Horse
		Sow	Boar	Dairy	Beef		
Weight of excrete[a]	kg/animal-day	8.10	3.80	59.0	39.0	0.086	25.4
VS in excrete[a]	kg/animal-day	0.74	0.34	5.18	4.05	0.02	3.02
VS reduction at 20 °C[b]	%	49	49	31	41	56	31
Potential biogas yield[c]	m^3 biogas/kg VS	0.34	0.35	0.25	0.092	0.43	0.28
Potential biogas volume produced	m^3 CH_4/animal-day	0.15	0.06	0.52	0.16	0.004	0.26
Potential methane volume produced	m^3 biogas/animal-day	0.09	0.03	0.31	0.10	0.002	0.15
Heat energy production rate	MJ/animal-day	1.6	0.62	5.5	1.7	0.042	2.7

*Table 11: Subjective perceptions about the role of cattle ownership by agricultural producers who did not own cattle in five regions of Colombia during 2002 (*The Role of Livestock in Poverty Alleviation: An Analysis of Colombia, *n.d.).*

	Region				
8. Parameter	**Piedmont(n=33)**	**Caribbean (n=33)**	**Coffee (n=23)**	**Antioquia(n=25)**	**Cundi-boyacense (n=29)**

Farmers who would like to own cattle today, %	84.8	87.9	82.6	76.0	96.6
Reason for owning cattle, %					
To obtain milk and beef for family consumption	51.5	87.8	30.4	0	58.6
A mechanism for savings and building capital	54.5	100.0	47.8	74.0	86.2
To reduce and diversify risk due to crop failure	15.2	3.0	8.7	8.0	51.7
To use manure as fertilizer	9.1	0	8.7	0	34.5
Preferred animal category to own, % of farmers					
Milking cow	81.8	84.9	47.8	52.0	96.5
Female calf	6.1	0	8.7	24.0	31.0
Male calf	0	0	26.1	0	27.6

Steer	15.2	6.1	17.4	0	13.8
Bull	9.1	0	0	0	31.0
Desirable amount of animal category to own, number					
Milking cow	8.4	13.2	2.3	9.4	5.8
Female calf	1.4	0	0.3	2.5	1.6
Male calf	0	0	1.8	0	1.5
Steer	0.6	0.6	7.4	0	0.3
Bull	0	0	0	0	0.4
Necessary conditions to own cattle, %					
More land	21.2	78.8	39.1	4.0	75.9
Availability of credit	42.4	63.6	56.5	28.0	17.2
Security	18.2	6.1	0	8.0	0
Improve farm infrastructure	18.2	3.0	8.7	24.0	17.2

*Table 12: Growth rate and GDP of South American countries (*World Bank Open Data*, n.d.).*

country	Real GDP (PPP) (purchasing power parity)	Real GDP growth rate	Real GDP per Capita	Labor force occupation
Brazil	$3.128 trillion (2021)	4.62% (2021)	$14,600 (2021)	Agriculture: 9.4% Industry: 32.1% Services: 58.5% (2017)
Colombia	$754.645 billion (2021)	10.68% (2021)	$14,600 (2021)	Agriculture: 17% Industry: 21% Services: 62% (2011)
Argentina	$986.134 billion (2021)	10.4% (2021)	$21,500 (2021)	Agriculture: 5.3% Industry: 28.6% Services: 66.1% (2017)

Figure 16:SWOT analysis for the circular economy of biogas digesters (Cortez et al., 2022).

*Table 13: product alternatives (*Fixed Dome Soft Bio Gas Biogas Digester - Buy Biogas Digester Bag,Aaerobic Digestion Bag,Biogas Digestions Pvc Bag Product on Alibaba.Com, *n.d.).*

Fixed dome digesters	Size/quality	Life span	price
Fixed Dome Soft Biogas (teenwin)	Red mud PVC plastic	8 years	100$

	Size: from 6,8,10,20,30,40,50 ,100M³		

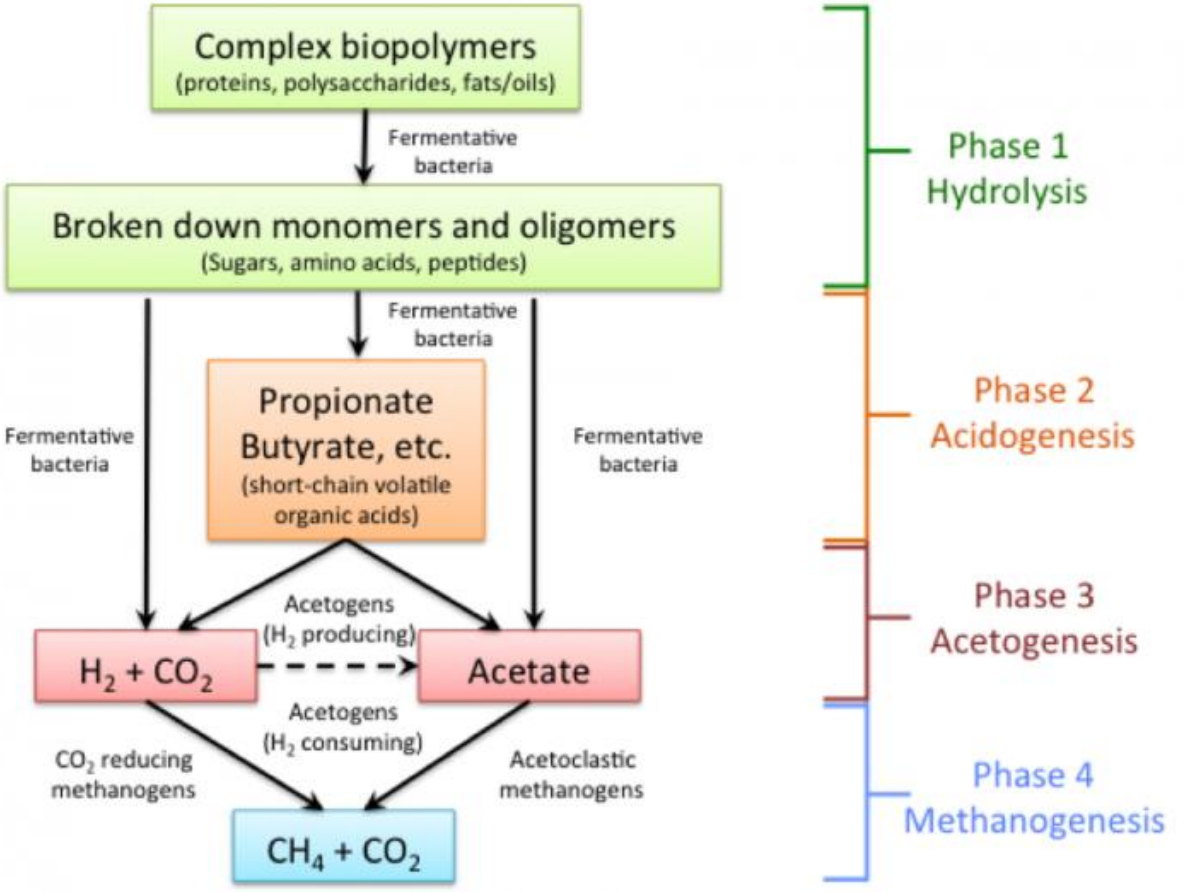


Figure 17: Steps of biogas production (12.1 Anaerobic Digestion | EGEE 439: Alternative Fuels from Biomass Sources, n.d.).

.

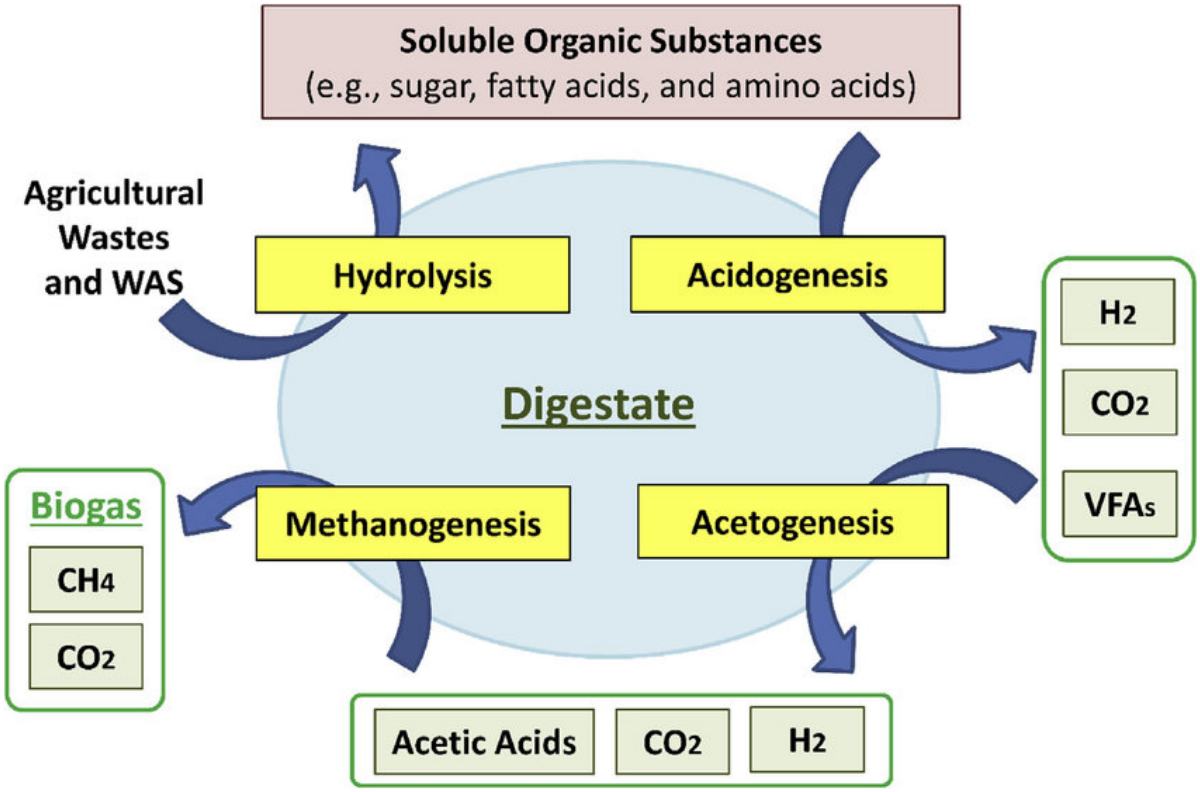


Figure 18: Products of biogas digestion (Pan et al., 2021).