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Design And Development of a Compact Improvised Biogas Harvester

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Abstract. This research project aimed to design and create an affordable and locally-sourced biogas harvester for backyard livestock raisers. The device is called Compact Improvised Biogas Harvester (CIBiH) and is a more cost-effective alternative to the foreign-made inflatable biogas harvesters available in the market. The study used the CDDIR model, a 5-phase technological development process consisting of Conceptualization, Designing, Development, Initial Testing, and Refinement stages. The goal was to create a prototype that is more effective, cost-efficient, and readily available, eliminating the need for external sources of energy like electricity and fuel in the biogas harvesting process. However, the project still requires further evaluation to determine whether it meets industry manufacturing standards for mass production.

Keywords: Biogas harvester; Renewable energy

1. Introduction

The adage "necessity is the mother of invention" still holds. It is the driving force behind humanity's continuous pursuit of technological advancements that can enhance our way of life. Despite the challenges posed by nature, we never stop striving to overcome our limitations. Our exceptional ability to develop technology empowers us to tackle the problems we face in our daily struggles. Through technology, we can effectively address and solve the challenges that arise. With this preliminary argument, two immediate problems require attention and action: energy source scarcity and solid waste mismanagement.

The need for alternative and renewable sources of energy has become more urgent than ever. In 2018, IPCC's Special Report on Global Warming of 1.5°C emphasized the urgency of transitioning to alternative energy sources to limit global temperature rise. Accelerated or artificially induced global warming has brought calamities, specifically typhoons, that are off the scale in terms of

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strength and devastation, and extreme weather patterns that endanger our natural environment. This artificially induced global warming is commonly attributed to our overreliance on the use of non-renewable energy sources. In response to this problem, governments worldwide and international organizations are working on policies and investments to promote the use of more sustainable and cleaner sources of energy. With all the international efforts to solve the problem, the International Energy Agency (IEA) Renewables 2021 Report stated there is remarkable growth of renewable energy sources, particularly solar and wind, in the global energy mix.

In the problem regarding solid waste mismanagement, a multi-faceted concern, one of the biggest, perhaps the biggest, is how most farmers manage farm waste, especially livestock manure. Livestock manure in large quantities, if not properly managed, is a potential cause for disease outbreaks, a breeding ground for pests and diseases, and a loss of opportunity. Most farmers don't see the opportunity embedded in the correct and entrepreneurial management of livestock manure. With the right mindset and technology, there is the possibility to utilize livestock manure as a renewable source of energy. According to Venier, F., & Yabar, H. (2017) livestock manure as a source of renewable energy has a good potential to generate electricity, thus, adding feasible alternative sources of energy to the table.

The high demand for Liquified Petroleum Gas (LPG) and limited supply has led to a significant increase in prices. A Compact Improvised Biogas Harvester (CIBiH) is a new technology that can use biogas from livestock manure as fuel for cooking and household electricity generation. Biogas complements wind and solar energy as it is not weather-dependent. The use of livestock manure to generate energy can also serve as a practical application of Farming Systems' principles for sustainable and environmentally friendly farm management. Furthermore, the study's findings can contribute to Industrial Technology's knowledge in renewable energy generation and solid waste management.

2. Methodology

This study was conducted using Research and Development (R&D) design. Technology Developers engage in a series of activities to innovate and introduce new products and services, which is collectively known as the Research and

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Development design process. Research and Development (R&D) is often the initial stage of product and technology development. Educational and Industrial institutions require talent, knowledge, and investment to pursue their R&D needs and goals. The primary purpose of R&D is to develop and introduce new products and services to the beneficiaries, which in turn adds to the availability of information and technology arsenal (Kenton, W., 2023).

A research framework was personally and specifically tailored to fit the context of this study. This model is to be called the CDDIR model, a technological development process with 5 phases (Phase 1- Conceptualization, Phase 2- Designing, Phase 3- Development, Phase 4- Initial Testing, and Phase 5- Refinement) to come up with a technological design, innovation, or prototype which is more effective, cost-efficient, and readily available.

This framework aims to solve social problems with technology and improve existing technologies available to the general public.

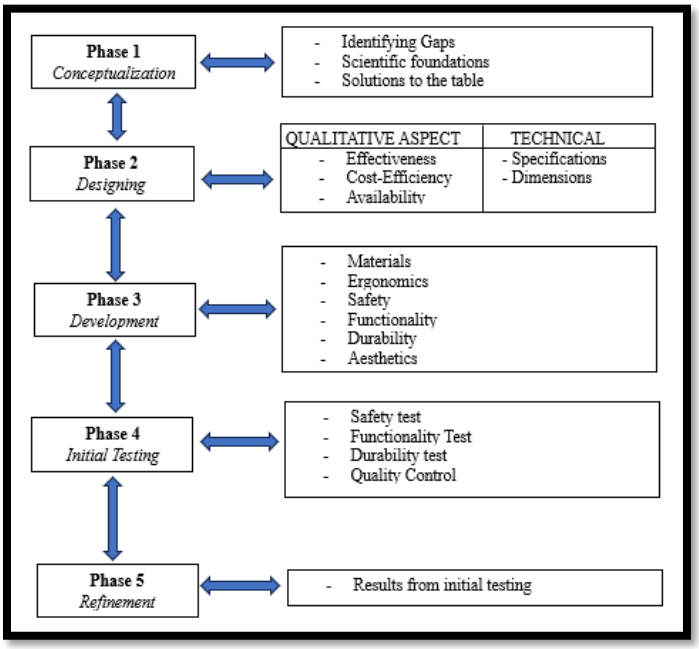

Figure 1 CIDDR Framework for the Design and Development of a Compact Improvised Biogas Harvester

3. Results and Discussion

Phase 1- *Conceptualization*

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The Gaps

Biogas from livestock manure is a renewable energy source that can solve pollution, energy scarcity, and high LPG prices. However, there's no available biogas harvester for household and backyard farming use in the Philippine market. Existing harvesters abroad are too large and expensive for household setups. They are also made using inflatable materials that consume a lot of space and are costly. Biogas harvesting can address issues in livestock-raising and backyard farming.

Scientific Background

Anaerobic digestion is a biological process that decomposes organic materials, including food waste, agricultural residues, and sewage, in the absence of oxygen. The process produces a mixture of methane (CH4) and carbon dioxide (CO2) known as biogas, as well as a nutrient-rich effluent called digestate. Anaerobic digestion is an eco-friendly technology that not only generates renewable energy but also efficiently manages organic waste (Otieno, E., et al., 2023).

Solution

To solve the above-mentioned problems, there is a need to develop a biogas harvester that is affordable, durable, functional, and made with locally available materials. This technology can utilize biogas for cooking and potentially, household-based electricity generation. The by-product from anaerobic digestion is an environmentally friendly and economical way of utilizing farm waste or animal/livestock manure as fertilizers for growing crops, thus, enabling nutrient cycling and sustainability.

Phase 2- *Designing*

Phase 2 (*Designing*) contains the design concept, isometric view and dimension, and interior components of the CIBiH.

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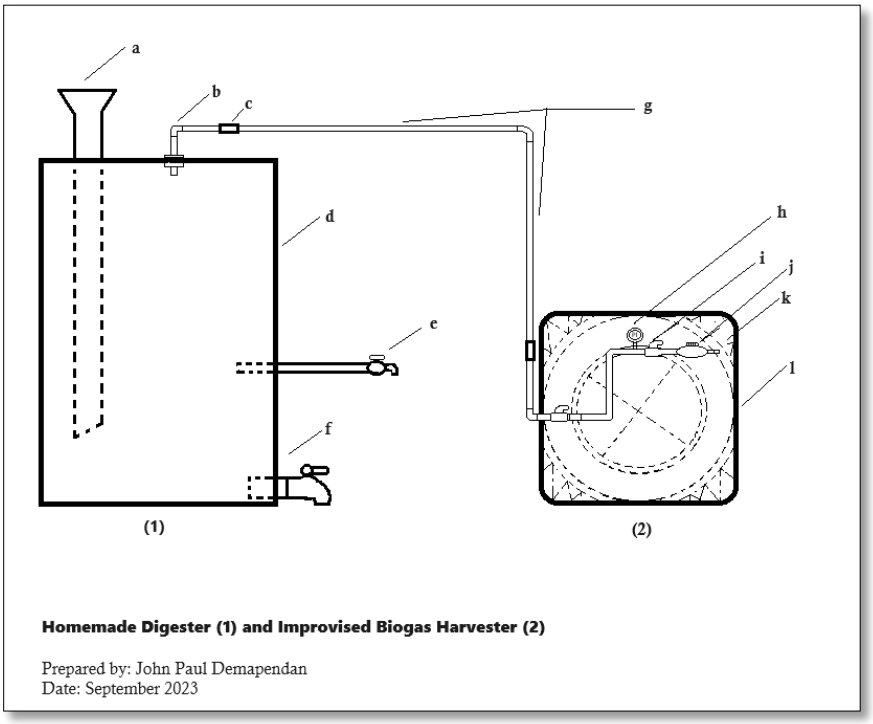

Figure 2 *Design Concept of the Compact Improvised Biogas Harvester (CIBiH)*

Figure 2 shows the main components of the biogas harvesting process, including the Homemade Digester and Compact Improvised Biogas Harvester (CIBiH).

The digester has six components: biomass funnel, biogas outlet pipe, coupling adapter, digester drum, effluent faucet, and sludge drainage valve.

The CIBiH has five components: connecting pipe, analog pressure gauge, choke valve, pressure regulator, inflatable material, and case. The design concept of the CIBiH prohibits the use of electricity or external energy sources, pressure pumps, or electric devices.

The design aims for simplicity, cost-efficiency, safety, durability, and aesthetics.

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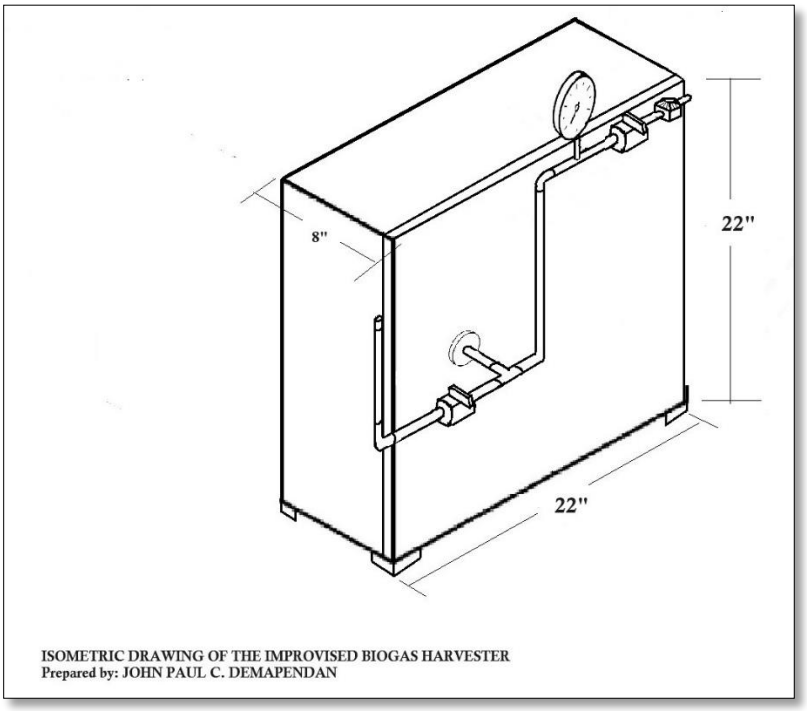

Figure 3 *Isometric View and Dimension of the Compact Improvised Biogas Harvester (CIBiH)*

The overall dimension of the CIBiH is 22" x 22" x 8". The size of CIBiH is ideal for household set-up with small spaces and convenient in terms of transportability.

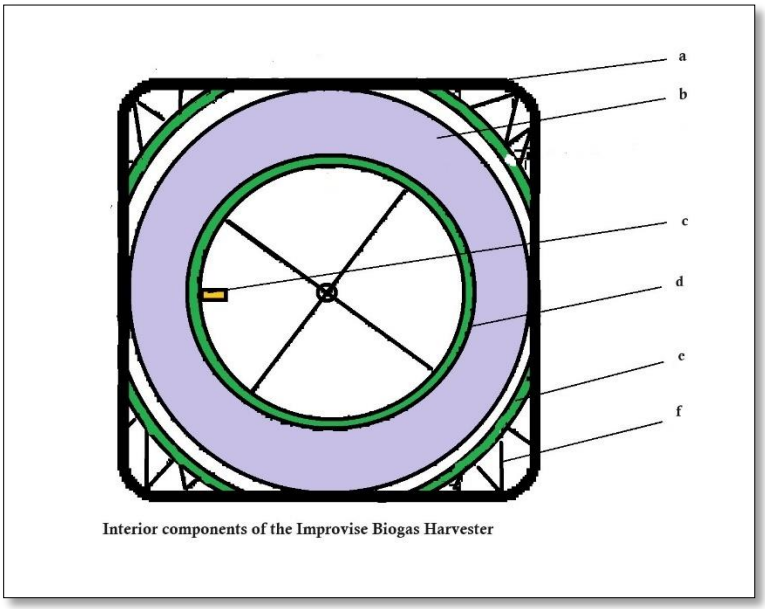

Figure 4. *Interior Components of the Compact Improvised Biogas Harvester (CIBiH)*

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CIBiH's interior consists of the following components: Case – contains inflatable material for collecting and storing biogas; Inflatable material – a rubber tube with two valves; Outlet valve – releases biogas; Inlet valve – collects biogas; Inner inflation guide – prevents shape deformation; Outer inflation guide – also prevents shape deformation, and; Reinforcement steel – strengthens the cylinders and maintains their position.

Phase 3– *Development*

This phase presents the actual development of the CIBiH. The development phase involves the selection of needed materials, the actual fabrication of the CIBiH, and the preparation of the Homemade Digester. To make the design concept of the CIBiH into realization, the needed materials were selected in consideration of the qualitative aspects of the *Designing* phase; effectiveness, cost-efficiency, and availability.

Table 1. List and Cost of Materials Used in the Preparation of Homemade Digester and Development of CIBiH

	Item	Description	Unit/Price	Quantity	Amount
Homemade Digester	1	High-density polyethylene drum 30 gal	1500/pc	1 pc	1500
	2	PVC pipe 4”	400/m	1 m	400
	3	Ball drain faucet	60/pc	2 pcs	120
	4	PVC rigid ¾”	150/3m	3m	150
	5	Pipe adapter set ¾”	20/set	3 sets	60
Total Cost					2,230 php
CIBiH	1	Galvanized sheet 4x8ft .3mm	700/pc	2 pc	1400
	2	Steel angle bar 1x1”	450/10ft	10ft	450
	3	FR12 TR13 tire tube	350/pc	1pc	350
	4	13mm bolt and nut set	10/set	8pcs	80
	5	Copper tube ¼”	300/m	.4m	120
	6	Hydraulic hose ¼”	40/m	1m	40
	7	Ball valve ¼”	100/pc	2 pcs	200
	8	Pressure gauge analog	120/pc	1 pc	120
	9	Flow regulator 10 mm	80/pc	1pc	80
				Total Cost	2840 php
				Grand Total	5070 php

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Table 1 compares the cost of materials for a homemade digester and the CIBiH. The homemade digester costs 2230 PHP, while the CIBiH costs 2840 PHP. Remember that material cost is just one aspect of the project budget.

To ensure timely completion and desired outcomes, a Gantt chart was used to track milestones during the development phase.

Table 2. Gannt Chart of the Development Phase for CIBiH

Development Activities	Timeline
	Day 1 Day 2 Day 3 Day 4 Day 5 Day 6
Purchasing of materials	
Measuring and cutting materials	
Fabrication of Frame and Sheet Cover	
Installation of Pipes and Valves	

Figure 5. Development of the CIBiH

The CIBiH project involves careful selection of materials and fabrication to ensure precise assembly, following the "measure twice, cut once" principle.

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Phase 4– Initial testing

The initial testing phase of a product is critical to ensure its safety, functionality, durability, and overall quality. The CIBiH product undergoes four types of tests: safety, functionality, durability, and quality control. During the refinement phase, any components that are not safe or durable enough are reinstalled or refabricated. The development team focuses on safety enhancement and durability improvement. This approach ensures regulatory compliance and contributes to the overall reliability and longevity of the CIBiH.

4. Conclusions

The study aimed to create a small improvised device (CIBiH) to extract biogas from a homemade digester. To achieve this goal, the study used the CIDDR model, which is a developmental research framework tailored to fit the context of this particular study. The study successfully met its objective by developing a compact biogas harvester The project requires further evaluation to establish its attributes and qualities to pass industry standards and fulfill its purpose to be a technology that utilizes livestock manure in generating biogas for household use.

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