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*Research Article*

# Teaching and Learning Innovation in Management of Technology and Innovation: Bioku, Mobile Home Biogas Digester System

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***Abstract:*** *BioKu is a compact and mobile home biogas digester system developed to address household food waste and rising dependence on fossil fuels in Malaysia. The system converts organic kitchen waste into renewable biogas for cooking while producing organic fertilizer as a valuable by-product. Designed to be lightweight, user-friendly, and scalable for both urban and rural households, BioKu offers an environmentally friendly and cost-effective energy solution. The innovation supports waste reduction, sustainable energy use, and lower household expenses while aligning with the United Nations Sustainable Development Goals (SDGs). BioKu demonstrates strong potential for community empowerment, environmental sustainability, and long-term commercialization.*

## 1. INTRODUCTION

Our world today, with the double imperatives of rising energy demands and rising environmental pressures, has stretched the imaginative boundaries to greener solutions. Being a developing country with rising urbanization and population, Malaysia is confronting pressing energy issues particularly in its domestic sectors. Most Malaysian houses are heavily dependent on traditional energy sources like liquefied petroleum gas (LPG) and electricity for home cooking and heating needs. This reliance raises long-term sustainability issues, especially with high fuel costs and finite supplies of non-renewable energy sources.

This innovation project presents the BioKu, Compact and Mobile Home Biogas Digester System as a breakthrough solution to address this technological and social divide. The system is specifically designed for household-level application, allowing users to process daily kitchen waste into usable biogas and organic slurry through anaerobic digestion in a simplified, compact, and portable system. Its overall goal is to bring green technology within the reach of middle- and low-income households, particularly in rural and semi-urban communities.

By enabling energy self-sufficiency and reducing food wastage, this innovation not only solves near-term energy and environmental problems but also aligns with the national development agendas like the Twelfth Malaysia Plan (12MP) and the United Nations Sustainable Development Goals (SDGs), specifically Goal 7 (Affordable and Clean Energy) and Goal 12 (Responsible Consumption and Production).

In brief, the BioKu is a testament to the effectiveness of grassroots innovation in leveraging systemic change via local, low-cost, and ecologically friendly technology.

## 2. LITERATURE REVIEW

Malaysia's issue of food wastage is increasing at a staggering pace. Based on statistics published by the Solid Waste Management and Public Cleansing Corporation (SWCorp), more than 16,000 tonnes of food are wasted every day and as much as 60% of it is preventable waste from households. It is all sent to landfills, where it breaks down anaerobically and releases methane a greenhouse gas with more than 25 times the global warming potential of carbon dioxide. Without waste treatment and separation facilities, organic waste is not being utilized for its potential as an energy source or soil amendment.

Meanwhile, domestic organic waste, mainly food and kitchen waste still play a part in deteriorating the environment. Based on Solid Waste Management and Public Cleansing Corporation (SWCorp Malaysia), food waste accounts for over 40% of domestic waste, and a large proportion of it is disposed of in landfills. This sort of organic waste, if not efficiently treated, not only adds to greenhouse gas emissions but also results in leachate issues as well as land constraints for future landfill expansion.

In addition to this, the nation's high dependence on LPG as the primary domestic fuel for cooking poses some very real challenges. When global fuel prices escalate and government subsidies are removed, Malaysian households are exposed to price volatility. For rural and B40 households, such economic pressures further restrict the access to affordable energy. Additionally, LPG is a non-renewable energy source whose production, transportation, and utilization release greenhouse gases into the atmosphere.

In spite of the well-documented advantages of biogas technology, including reduced emission, energy savings, and production of organic fertilizer, its use in Malaysia has largely been confined to either industrial or agricultural settings. Conventional biogas systems are bulky, immovable, and expensive to establish, thereby making it not possible for small-scale or household-level users to enjoy such advantages.

While there are industrial biogas plants, they are not economically feasible for household use because of their high capital cost, complexity in operation, and infrastructural requirements. Therefore, low-cost, small-sized, household-level biogas systems are urgently needed that can promise to transform household kitchen waste into renewable energy inexpensively, conveniently, and safely.

Therefore, BioKu aims to fill this gap by providing a complete solution that tackles food waste and home energy insecurity. Through the daily conversion of kitchen waste into clean biogas and organic fertilizer, it targets to reduce methane emissions, landfill burden, home energy expenses, and allow people to become agents of sustainable living.

## 3. METHODOLOGY

BioKu is a modular, prefabricated system that can effectively digest household kitchen waste and produce biogas and organic fertilizer in an efficient and clean manner. The anaerobic digester tank forms the heart of the system, which is made from strong chemical-resistant materials like high-density polyethylene (HDPE) or fiberglass-reinforced plastic. The capacity of the tank usually ranges between 100 and 200 litters, suitable for household use on a daily basis.

The system is a continuous-feed system. The users input food waste such as vegetable skins, fruit peels, leftover rice, and other biodegradable organic wastes through an input hatch. Anaerobic bacteria in the digester break down the organic material without oxygen. It releases biogas, mainly a combination of methane and carbon dioxide, which gathers in the top part of the tank and is piped via a closed pipe to a flexible gas storage tank or directly to a gas stove.

At the same time, the digestion process leaves a semi-liquid waste known as bio-slurry, which is full of nutrients like nitrogen, phosphorus, and potassium. The by-product is discharged through a separate outlet and can be collected and utilized as a natural fertilizer for home gardens or small farms. The whole apparatus is set on a wheeled base for mobility so that it can be easily shifted and accommodated in different kinds of home settings, such as small kitchens or outside.

Safety and ease of use are primary considerations in the design. The system incorporates pressure relief valves, non-return valves, and hand controls for regulation of gas flow and pressure. Maintenance is low, with the only regular tasks being feeding, periodic stirring, and input or output port cleaning. The modular nature also allows customization and scale-up, meaning that it can be adjusted to fit various user requirements and family sizes.

## 4. FINDINGS

### *4.1. Functional Specifications of Product Innovation*

BioKu is a friendly, small-scale, off-grid biogas generator specifically designed for Malaysian home consumption. Its underlying technology relies on the anaerobic digestion method, a natural biological process by which microorganisms digest organic wastes in the absence of oxygen to produce biogas consisting primarily of methane and carbon dioxide. While this process is usually applied in industrial setups, the innovative aspect here is miniaturizing and adapting the mechanism for domestic use without compromising performance and safety.

The device has multiple main components that collectively ensure efficient and safe operation. In the middle of the unit is a digester tank with a volume of 100 to 200 litters constructed of food-grade plastic or fiberglass and sealed tight to maintain anaerobic conditions. Kitchen waste weighing up to 2 kilograms is added daily through a feeding inlet with splash guard and funnel to prevent spills and contamination. Optional manual or mechanical mixing chamber may be incorporated in certain models to provide equal feedstock distribution to ensure maximum bacterial digestion. Biogas generated during digestion is held in a flexible gas collection bag or low-pressure PVC tank with a capacity of 1 to 2 cubic meters. Storage has a pressure gauge and safety valve to control and monitor gas pressure.

The system also consists of a slurry outlet typically a valve or pipe that off-flows around 1 to 1.5 litters of daily bio-slurry that can be used directly as an organic fertilizer. Gas produced is piped to the burner via a closed piping system made of food-grade PVC with a manual shut-off valve for security. The gas is then piped into a regular biogas-compatible burner, which will fit either outdoor or indoor stoves. For convenience and portability, the whole system rests on a light steel frame that holds four caster wheels, making relocation easy. When it is empty, the entire system weighs less than 30 kilograms.

The working process of the system begins with the consumption of household kitchen waste such as peels of vegetables, fruit fragments, cooked rice, and leftovers in the feeding inlet. The waste is decomposed by anaerobic bacteria over a period of 7-to-10-day long digestion, which results in the production of methane gas. The gas is trapped in the storage bag and then used for cooking purposes, and the leftover digested material emerges as bio-slurry.

From a safety and user experience point of view, the system is made simple for easy use with minimal training required. The system has basic safety components like backflow prevention through one-way valves, ignition protection through flame arresters, and locking latches for ensuring the integrity of the system. The whole setup has been designed to prevent typical problems like odour release, infestation by pests, and gas leakage. In accordance with that, BioKu will be examined and evaluated by the Standards and Industrial Research Institute of Malaysia (SIRIM) to ensure it passes the standard product quality and safety assurance. Overall, these specifications make BioKu a perfect, cost-effective, eco-friendly, and expandable solution for homes, small farms, ecotourism destinations, and schools.

*4.2. Details of the Product Innovation*


**Figure 1**. The product.

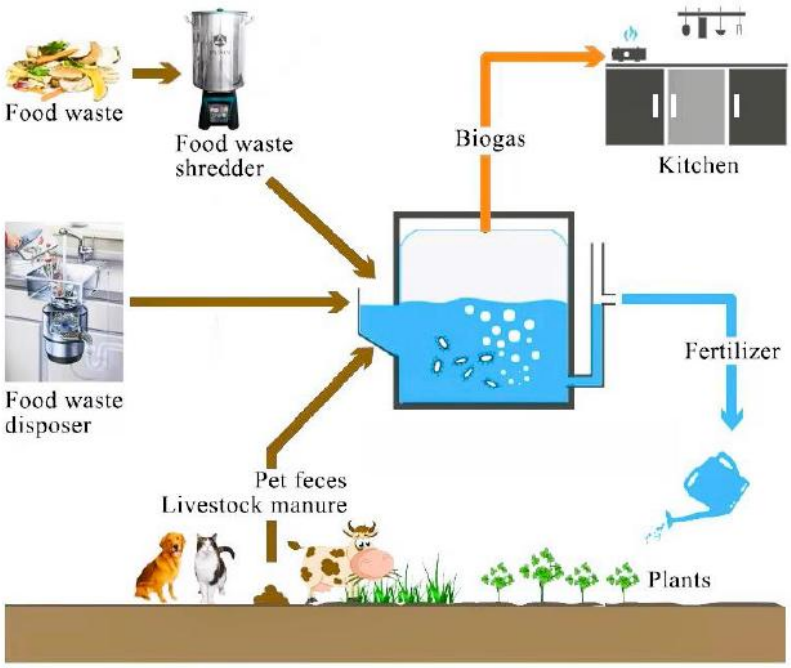


**Figure 2**. The system working.

## 5. DISCUSSION

### *5.1. Novelty and Uniqueness of Product Innovation*

BioKu is unique as a game-changing innovation in Malaysia due to its innovative combination of compactness, affordability, and universal applicability for urban and rural settings. Although biogas technology is widespread globally, its translation into a highly mobile, household-scale system is a radical departure with respect to accessibility and usability. Underlying this technology is its portability and compactness, a departure from conventional big cumbersome biogas systems. The light frame bearing wheels permits easy shifting, which makes it especially suited for small households with limited space such as terrace houses or small compounds.

Furthermore, the system is at the household level of customization, effectively treating 1 to 2 kilograms of organic kitchen waste daily, which is equivalent to the average waste produced by an average family. This right-sizing strategy reduces overcapacity, promotes effective digestion cycles, and maximizes the use of biogas. Its major advantage is that it is DIY-made from locally sourced low-cost materials including PVC, HDPE tanks, bicycle pumps, and simple valves. This reduces initial installation costs from RM200 to RM500 and makes it accessible to low-income families or rural consumers compared to industrial systems which easily exceed RM3,000. In addition, the system is a dual output utility, providing not only clean energy for cooking but also nutrient bio-slurry for powering urban agriculture and organic gardening. It is both an energy and food source that is sustainable, hence complementing the circular economy. In addition to the functional advantages, the system also boasts significant environmental and educative advantages, in the form of an efficacious utility in green consciousness campaigns, school environmental education, and grass-root motivated sustainability efforts.

Dissimilar to conventional biogas systems typically fixed, high-value, farm-scale machines based on human or animal dung and professional technicians, BioKu is designed for amateurs, processes domestic food waste, and aims for mobility and inclusivity. In shifting biogas technology from a farm-scale facility to one that is domesticated and communal in scale, this innovation embodies a pragmatic and practical response to Malaysia's energy and environmental challenges.

*5.2. Benefits to Mankind*

BioKu provides tremendous advantages in the environmental, economic, and social domains. By transforming domestic daily waste into energy and organic manure, this technology allows individuals and communities to become actors of climate action and sustainable life and improve their living standards. Environmentally, the system plays a meaningful role in reducing methane emission by preventing organic wastes from ending up in landfills. Methane is a highly potent greenhouse gas, and mitigation of the release is a straight contribution to climate change prevention. Also, the system maintains the principles of a circular economy since it allows for a closed-loop system where waste is used as valuable assets. It further assists in minimizing the amount of waste, thereby lessening the burden on municipal waste management services and landfill sites.

The biogas system is economically high yielding for households. Upon installation, it produces cooking gas free of cost, with the potential to reduce household energy usage by an estimated 10 to 20%, particularly for large families or regular cooks. The bio-slurry waste product is also a highly effective organic fertilizer, minimizing reliance on commercial chemical fertilizers and reducing gardening or farming expenses. The initial investment required to install or purchase the system is relatively minor, especially compared to other green technology like solar panels or energy-efficient appliances, and therefore it can be purchased by low and middle-income earners.

Socially, the innovation fosters energy independence, especially in off-grid disaster-affected or rural areas with low access. Its use at the community level may foster rural development initiatives, community kitchen initiatives, or food courts waste management, that trigger local green entrepreneurship and innovation. It can equally be a very effective teaching tool. The system may be used by schools, environmental NGOs, and community organizations to raise awareness of renewable energy, sustainable living, and environmental stewardship.

Regarding policy alignment, the project aligns with various national and global agendas. The project aligns with Malaysia's Green Technology Master Plan and the 12th Malaysia Plan (12MP), which highlight low-carbon development and circular economy. Globally, it addresses some of the most critical United Nations Sustainable Development Goals (SDGs), including SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). In these ways, BioKu offers a useful and viable means whereby citizens can actively contribute to climate change mitigation and the broader objective of environmental sustainability.

*5.3. Potential of Commercialization*

To transform BioKu into a commercially viable and scalable product, a phased commercialization strategy is proposed. Phase one involves prototype refinement and testing, where the system will be installed in ten rural and urban houses to receive feedback in real-life situations on key parameters such as gas yield, odour control, and ease of use. This stage will assist in optimizing the design, enhancing technical drawings, and refining safety features, especially gas pressure control systems.

During phase two, branding and awareness efforts will be undertaken. The product will be given an easy-to-use name like "BioKu", which a short form of Biogas Untuk Ku and be complemented

by educational materials such as instructional videos, English and Bahasa Malaysia manuals, and awareness campaigns. Partnerships will be formed with NGOs, local councils, and schools to organize product demonstrations and exhibitions, marketing the innovation at the grassroots level.

Stage three involves production and distribution. Partnerships will be formed with local SMEs or Technical and Vocational Education and Training (TVET) colleges for low-cost production. There are two models to be offered, which are a basic kit and a deluxe version with a biogas burner and garden hose. Distribution of the products will be through green retail stores, e-commerce platforms such as Shopee and Lazada, farmer cooperatives, and community-based organizations for the B40 income group.

In the fourth phase, funding and policy support will be sought to scale up the program. Proposals will be submitted to agencies such as the Malaysian Green Technology and Climate Change Corporation (MGTC) and the Ministry of Science, Technology and Innovation (MOSTI), and public-private corporate social responsibility (CSR) programs. Plus, the Standards and Industrial Research Institute of Malaysia (SIRIM) play an important role in the project to support and helps for product standards and security. The project will also advocate for tax rebates or green incentives for families adopting biogas solutions.

The pricing strategy is geared towards keeping the system within affordable limits and encouraging take-up. The target price range is RM200 to RM500 per unit, model dependent, with a break-even of six to ten months of use via gas and fertilizer savings. In addition, the system can be subsidized under green innovation grants at the state level or rural development programs, which would make it even more within the budget of the low-income group.

## 6. CONCLUSION

BioKu, the Compact and Mobile Home Biogas Digester System is an innovative technology that satisfies two of Malaysia's most urgent environmental and socioeconomic concerns facing household energy expenses and the rising problem of food wastage. Having a growing number of urban dwellers and conventional energy sources increasingly stressed by world market volatility and subsidy reductions, Malaysian households especially those from B40 or rural communities are disproportionately affected. This invention is an instant, site-specific solution that converts day-to-day kitchen garbage into renewable biogas and nutrient-enriched bio-slurry, offering clean cooking energy and an alternative to chemical fertilizers. This double-value functionality allows users to discontinue dependence on fossil energy and adopt eco-friendly and cost-effective behavior in daily life.

The worth of the system lies not only in its technological functionality but also in its convenience and flexibility. Unlike traditional biogas systems that utilize vast land areas, technical expertise, and expensive installation costs, BioKu is particularly designed for home use. It is portable, easy to operate, and made from locally available, cheap materials, and so it is the ideal tool for use in both rural and urban communities. Its lightweight design allows it to be used even in terraced houses or flats with small yard area, and its low maintenance options make it available to non-tech customers. All these traits facilitate the democratization of green technology so that clean energy is no longer an industrial or institution-based luxury, but a right that can be enjoyed at the household level.

From a technology and innovation management point of view, such a system is a case of frugal innovation and principles of social entrepreneurship. It illustrates that the most successful technological solutions are not necessarily developed from the high-tech lab or multinational corporations but can emerge from grassroots needs, society engagement, and context-specific design. By focusing on solving real-world problems in society through low-cost and reproducible solutions,

the project is well aligned with national innovation policies and global trends for inclusive, sustainable development. Secondly, it demonstrates how technological adaptation rather than pure invention can be a powerful key to creating local context-specific, pragmatic innovations addressing local socioeconomic and environmental realities.

Apart from its direct contribution to end users, the system is very valuable as an educational and market opportunity. It can serve as a learning system in schools, a demonstration system at universities, or a model of community-based green enterprise. Its scalability and production cost-effectiveness also make it an effective component to be included in the national sustainability plans, such as the 12th Malaysia Plan (12MP), the Green Technology Master Plan, and the Low Carbon Cities Framework. Internationally, it complements the United Nations Sustainable Development Goals, namely SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action).

Lastly, BioKu is not only a technical innovation, but an integrated innovation that transcends environmental stewardship, social justice, and economic resilience. It turns waste to wealth, allows individuals to contribute to climate action, and unlocks the promise of a more circular, self-reliant lifestyle. With effective facilitation of commercialization, policy integration, and people's participation, this system could potentially not only enhance household welfare but also lead to a broader cultural shift toward sustainability and technology equity in Malaysia and beyond.

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