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A Hybrid Cooker for Nabamba Village in Mbulamiti Sub-County as a Renewable Energy Solution

Kibirige David[1], Kanyana Ruth[2], Nakitto immaculate[3], Makumbi David[4],Bobrich Mwecumi[5],Nalugya Aisha[6], Kitone Isaac6

Ndejje University, Luweero, Uganda
semkibirige@gmail.com[1],kanyanaruth@gmail.com[2],nakittoimmy@gmail.com[3], makumbidavid92@gmail.com[4]
bmwecumi@gmail.com[5],ayshakaddu@gmail.com[6]
6Department of Electrical Engineering, Kabale University, Kabale, Uganda
kitonei@gmail.com

***Abstract**: The increasing reliance on unsustainable energy sources, particularly wood for cooking, due to fossil fuel shortages poses significant challenges for developing countries. In Uganda, approximately 3% of forests are cut down annually for fuel, leading to severe deforestation and environmental degradation, with projections suggesting potential forest loss within the next 25 years. This unsustainable practice contributes to one of the highest deforestation rates globally and results in serious health risks from indoor air pollution associated with traditional cooking methods. This study introduces an innovative solar cooker equipped with a solar tracking system that optimizes sunlight capture, thereby enhancing cooking efficiency. Furthermore, it proposes a hybrid cooker that combines solar energy with biomass briquettes made from organic waste, ensuring reliable cooking capabilities even during cloudy weather. Conducted in Nabamba village, Kamuli district, this research underscores the potential of hybrid cooking technologies to mitigate deforestation, promote renewable energy use, and improve the quality of life in rural areas. The findings suggest that integrating solar tracking and biomass energy can significantly enhance cooking practices while supporting environmental conservation efforts in developing regions.*

Keywords—biomass briquettes, Solar energy, cooking, hybrid

1. INTRODUCTION

Many developing countries are grappling with fossil fuel shortages due to high levels of consumption. To address this issue, the use of renewable energy sources, with a focus on long-term sustainability, is increasingly being recommended. In these regions, a significant portion of energy used for domestic purposes, such as cooking, is still derived from basic and unsustainable methods, particularly the use of wood [1]. For instance, in Uganda, nearly 3% of the country's forests are cut down annually for fuel, agriculture, and to accommodate the growing population. This deforestation is exacerbated by the fact that only about 10% of the rural population in Uganda has access to electricity. As a result, the majority of people are forced to rely on alternative energy sources, mainly wood, to meet their daily needs. The widespread cutting of trees in Uganda is contributing to one of the highest deforestation rates in the world. At the current pace, Uganda is projected to lose all of its forests within the next 25 years. The consequences of this rampant deforestation are becoming increasingly apparent. Not only has the landscape been dramatically altered, but environmental changes are also taking place. The dry seasons are becoming longer and more severe, resulting in frequent droughts [2]. When heavy rains do come, they cause destructive floods due to the loosened, unprotected soil. Additionally, crop yields are declining, further straining the food supply in these communities. The wood harvested from trees is primarily used to fuel stoves for cooking, a practice that has its own set of health and environmental concerns. Inside homes, the smoke from these stoves accumulates, leading to respiratory issues, particularly for family members who spend extended periods cooking. Furthermore, burning wood releases carbon dioxide into the atmosphere, contributing to rising CO2 levels [3]. The problem is compounded by the fact that fewer trees are available to absorb this excess carbon dioxide. Given the large number of developing countries that rely on wood for cooking, this widespread practice has significant long-term implications for both human health and the environment.One potential solution to this issue is the expansion of solar cooker usage in these areas. Solar cookers can reduce the need to cut down trees for cooking fuel, thereby decreasing CO2 emissions and helping to slow deforestation. Solar cookers offer numerous advantages: they use free, renewable solar energy, emit no greenhouse gases, and alleviate health risks associated with indoor air pollution. However, despite these benefits, there are some practical challenges to the widespread adoption of solar cookers, particularly in rural areas.One of the most notable drawbacks of solar cookers is the increased cooking time. Solar cookers depend on the sun's energy, and as the sun moves throughout the day, the angle of sunlight changes. The sun shifts its position by about fifteen degrees per hour, which can significantly affect the efficiency of a solar cooker [4]. If the cooker is not properly aligned with the sun, it loses energy, and the cooking process slows down. This is particularly problematic for people in rural areas who often need to cook large quantities of food for their families quickly.To address this problem, a solar tracker can be used in conjunction with the solar cooker. A solar tracker adjusts the position of the cooker to follow the sun's movement throughout the day, ensuring that it is always facing the sun and operating at maximum efficiency. In this study, a solar cooker equipped with a tracking system was developed to solve the issue of reduced efficiency. The solar cooker designed for this research consists of five main components: a radial reflector plate, body and legs, a solar tracker, an electric motor, and a photovoltaic panel. The solar tracker allows the cooker to maintain optimal alignment with the sun, increasing its overall effectiveness. Several tests were conducted with this solar cooker, and the results showed that the tracking system significantly improved performance. By continuously adjusting the cooker's position to face the sun, the cooking time was reduced, and energy losses were minimized. This innovation holds great promise for improving the practicality of solar cookers in rural settings [5].The idea of using solar energy for cooking is not new. In fact, the first solar oven was invented in 1767 by Swiss physicist Horace de Saussure. Although de Saussure likely had no idea that his invention would still be relevant centuries later, his work laid the foundation for modern solar cooking technology. However, despite the advancements made in solar cookers, they still face a significant challenge: the inability to gather enough energy on cloudy days [6].This limitation led us to develop a hybrid cooker that combines solar energy with an alternative fuel source. Our project involves designing a cooker that uses both solar energy and chemical energy stored in biomass in the form of briquettes. Biomass briquettes are made from organic materials such as agricultural waste, wood chips, and other biodegradable matter. When burned, these briquettes release energy that can be used for cooking, much like wood, but with fewer harmful emissions.The hybrid design offers a practical solution to the main issue of solar cookers—low energy collection on cloudy days [7]. On days when sunlight is insufficient, users can switch to burning biomass briquettes to continue cooking. This system provides flexibility and ensures that families in rural areas are not solely dependent on solar energy, which can be inconsistent depending on weather conditions [8].Developing countries face critical challenges related to energy consumption and environmental degradation. Deforestation, fueled by the widespread use of wood for cooking, is contributing to long-term damage to ecosystems and human health. Solar cookers present a viable, sustainable alternative to traditional cooking methods, but their effectiveness is limited by their reliance on direct sunlight. By introducing solar tracking systems and hybrid cookers that utilize both solar energy and biomass, we can offer a more practical and reliable solution [9]. This approach will not only reduce deforestation and CO_2 emissions but also provide a healthier, cleaner way for people to cook their food in rural areas. With further research and development, these technologies have the potential to make a significant positive impact on the environment and the lives of those living in developing countries.

This Study was carried out from Nabamba village in Mbulamiti Sub-county, Kamuli district. The village is small and an averagely developed area in contrast with the whole district. Nabamba village is blessed with the sun throughout the year and we found out that, the people this village just like most parts of Uganda, depend on use of biomass in form of fire wood and charcoal for preparing their meals which is a danger to the environment [10]. To maintain entirely clean and safe environment free from deforestation, a hybrid cooker project which involves harnessing solar energy and chemical energy in briquettes for cooking is designed.

2. Methodology

The solar concentrator was formed from aluminum foil **on the manila paper to achieve a reflecting parabolic surface** which is a good reflector of sun radiation. Briquette were done using biomass especially cow dang.

Figure 1: Assembly of the prototype

3. Operation of the prototype

The briquette burner was fixed into the formed frame; wires were used to tie firmly the solar concentrator onto the adjustable side arm in such a way that heat from the sun is concentrated onto the saucepan

4. Testing

Quantity of briquettes used to boil 4 liters of water while aided with solar energy from
solar concentrator = 200g
Amount of stored energy in briquettes utilized when cooking using briquettes alone
= mass*calorific value of briquettes
=0.25*4785*103cal/kg
= 1196250cal/kg
Energy =1196.25kcal/kg
Amount of stored energy in briquettes liberated when aided with solar energy collected
using solar heat concentrator
Energy=weight of briquettes*calorimetric value which is 4785/kilogram.
=0.2*4785*103 calories per kilogram
=957000cal/kg
=957kcal/kg
Energy saved while aiding the briquette burner with a solar concentrate is 239.25Kcal/Kg

5. Conclusion

Unlike a briquette cooker, the solar cooker cannot function effectively on its own due to its reliance on consistent sunlight. However, combining both systems significantly enhances efficiency. The solar cooker reduces the need for briquettes when the sun is available, while the briquette stove provides stable energy when solar radiation fluctuates or during cloudy periods. This hybrid model not only ensures continuous cooking but also improves energy efficiency by reducing the amount of biomass needed. As a result, it promotes energy conservation, decreases reliance on biomass, and helps preserve the environment by limiting deforestation and reducing emissions.

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