

Alternative Household Fuel: Fruitless Palm Based on Gasification Biomass with Gasoline and Liquefied Petroleum Gas

Subakho Aryo Saloko^{1*}, Nurcahyono¹, Indra Kurniawan¹, Hartono¹, Sri Gunawan²,

¹Akademi Komunitas Perkebunan Yogyakarta, Yogyakarta, Indonesia

²Department of Agrotechnology, Faculty of Agriculture, Institut Pertanian Stiper, Yogyakarta, Indonesia

*Corresponding author: subakho.as@akpy-stiper.ac.id

Article History: Received: 30 April 2025, Final Revision: 27 June 2025, Accepted: 09 July 2025, Online Publication: 30 July 2025

ABSTRACT

Fuel sources derived from oil palm plants are abundant but have not been optimally utilized by the community. This study aims to show the performance efficiency of cheap fuel fruitless (*Brondolan*) using people's stoves as fuel substitutes for kerosene, coal, and Liquid Petroleum Gas (LPG). This study uses a quantitative observation method. The types of fuel and stove materials used include (1) conventional kerosene-fired stoves, (2) conventional LPG-fired stoves, (3) gasified biomass stoves fueled with palm fruit, (a) large stove size (Prime Brand), and (b) small stove size (People's Stove Brand). The research procedure is measured by heating 5 liters of water from room temperature to boiling (100°C). The results show that fruitless is more efficient than gasoline, coal, and LPG is more efficient. Based on trials, heat 5 liters of water to a boil at Rp. 200, Gasoline Rp. 1,650, and LPG Rp. 381. The government's role is to provide socialization and policies in applying alternative materials with lozenges to reduce the use of gasoline and LPG. Unrefined fuel can be an alternative material for household scale stoves.

Keywords: Fruitless; Gasification; gasoline; Liquid Petroleum Gas; Biomass Stove

INTRODUCTION

Palm oil is one of the plantation crop commodities with the largest land area and production in Indonesia compared to other plantation crops. Based on data from the Central Statistics Agency, the total area of oil palm plantations in Indonesia is 14,959,579 ha, with details of the area of large state plantations reaching 617,501 ha, the area of Large Private Plantations reaching 7,942,336 ha and the area of community plantations reaching 6,035,742 ha [1].

Data shows that fuel sources derived from palm oil are abundant [2]. Palm oil is a vegetable source for many food and non-food purposes, such as energy, feed, chemicals, and detergents [3].

The fuel source referred to here is dried fruitless (*brondolan*) palm, which comes from the drying of sunlight or by wind. Fruitless can become a biogas provider that benefits the community [4]. Fuel sources determine the benefits of the alternatives [5]. But the current conditions in the

field are still many people who have not been able to utilize the fruitless into fuel, so in general, the Indonesian people still use a lot of fossil fuel energy in the form of kerosene, coal, and also LPG because it is considered more practical [6], [7].

Fossil fuel reserves are decreasing, and it is becoming a serious challenge to direct the search for alternative fuel sources [8]. The utilization of fossil-derived fuels shows its disadvantages. Increasing energy demand and dwindling fossil fuel sources have called for exploring new energy sources [9], [10]. Renewable energy resources are considered good alternatives to fossil fuels [11]. The increasingly limited availability of natural resources is due to the fact that they are not renewable and can damage the environment (Rayner, 2020). On the other hand, the purchase price at the consumer level fluctuates along with the movement of crude oil prices on the world

market. It has a direct impact on increasing selling prices in the market.

So, energy sources are needed to replace fossil fuels, especially cooking. Oil palm waste shows potential as an alternative biomass fuel source [13]. Alternative fuels are expected to be easily available, cheap, and environmentally friendly. Biomass that is abundant and easy to obtain will be a good source of energy [14]. Using cooking utensils (stoves) that have low costs and are easy and practical to operate can make maximum use of these alternative fuels [15]. Thus, cheap and easy fuel alternatives can reduce public expenditure. So that people can be a little more frugal and save for their family lives [16]. This study aims to provide a picture of the performance efficiency of cheap fuel fruitless using people's stoves as fuel substitutes for kerosene, coal, and Liquid Petroleum Gas (LPG).

MATERIALS AND METHODS

Research Design

This study uses quantitative and descriptive observation methods, namely calculating each observation data in detail to become primary data and explained based on the values obtained. The research was carried out in September 2020 at the Machinery Lab at the Akademi Komunitas Perkebunan Yogyakarta, and this research compared the performance of three types of stoves with different types of fuel materials.

Types of Fuel Material

The types of fuel and stove materials used include (1) conventional kerosene-fired stoves, (2) conventional LPG-fired stoves, (3) gasified biomass stoves fueled with palm fruit, (a) large stove size (Prime Brand), and (b) small stove size (People's Stove Brand).

Procedure

The room temperature was measured using a room thermometer, and the water temperature in a 5-liter pot was measured using a stem thermometer immersed in a position 5 cm high from the bottom of the pot. Measure the length of

time needed to heat water using a digital clock. The efficiency of fuel use is evaluated by measuring the fuel consumed on each stove after heating 5 liters of raw water, starting at room temperature and ending after reaching a temperature of 100°C.

Conventional stoves are fueled with kerosene, and a measuring cup measures kerosene consumption. On LPG-fueled stoves, measurements of used LPG gas are carried out using digital scales. Meanwhile, digital scales are used to measure the lumps to be burned in measuring the fuel consumed on gasified biomass stoves.

Analysis Data

Qualitative descriptive data analysis techniques are used to collect, process, analyze, and present data descriptively. This technique presents the data as graphs based on the calculations obtained. Qualitative descriptive analysis techniques explain related variable measurement phenomena that can not only be measured by numerical data.

RESULTS AND DISCUSSION

Time needs

Comparative analysis between conventional and biomass stoves' fuel performance obtained good results. The fuel type affects the flame and the

time the flame is used [17]. The average time of generating Heat from cold start and hot start can be seen in Figure 1.

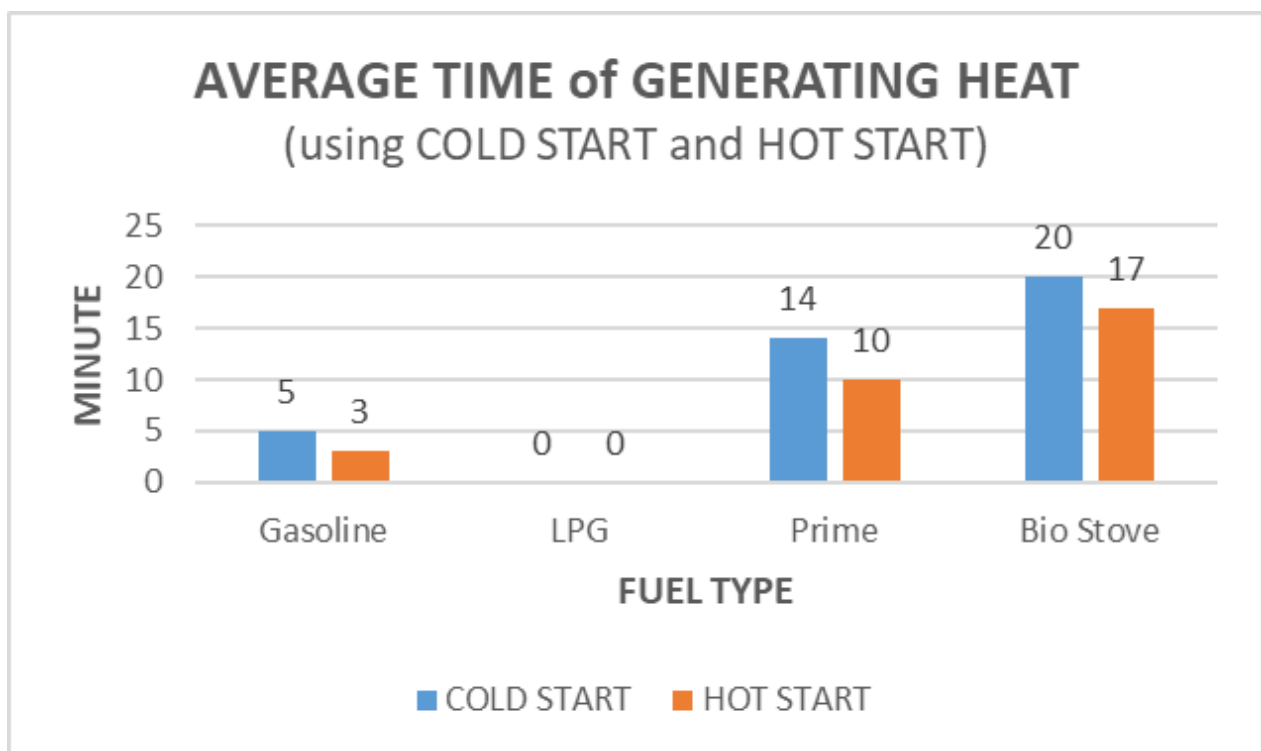


Fig 1. Average heat generation time from a cold start and hot start

Based on Figure 1, the stove with LPG fuel, once ignited, immediately gets a big fire at 0 minutes, both at the cold start and hot start, because LPG contains propane gas, which has a wave of 1 cm, which can grab sparks quickly [18], [19]. The stove with gasoline fuel (kerosene) in the cold start mode experiment to get the room temperature to 100°C takes 5 minutes, and in hot start mode only takes 3 minutes. Biomass stove with Fruitless palm, on prime type biomass stove to get the room

Fuel Requirements

temperature to 100°C takes 14 minutes in cold start mode, and then in the hot start mode takes 10 minutes. Biomass stoves with folk stove type to get the room temperature to 100°C take 20 minutes in cold start mode and 17 minutes in hot start mode. In hot start mode, the average temperature of the stove is 80-90°C [20], so when it is lit, it will get a big fire [21]. The type of stove used affects the results produced by the biomass stove [22].

The difference in the fuel used impacts the

final value based on the uniformity of results. The results for the fuel used to boil 5 liters of water can

be seen in Figure 2.

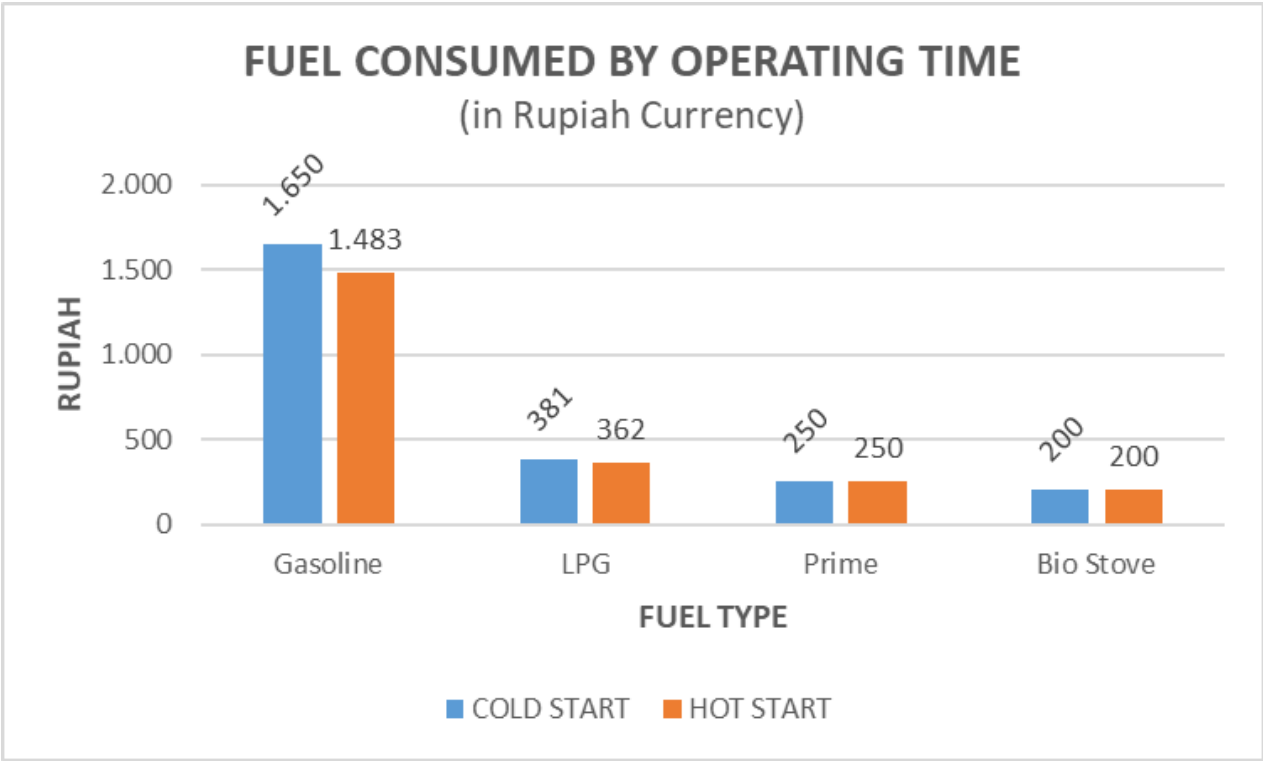


Fig 2. Fuel Needs

Based on Figure 2, the fuel requirement for boiling 5-liters of water is converted into Rupiah (Rp) to calculate how many rupiahs are needed in each stove model. Stove with gasoline fuel in cold start mode costs Rp. 1650.00/ 5-liters of boiling water. While in Hot start mode, it costs Rp. 1,483.00/ 5 liters of boiling water. Using an LPG stove in cold start mode costs Rp. 381.00/ 5 liters of boiling water, while in hot start mode, it costs Rp. 362.00 5-liters of boiling water. Prime brand biomass stoves, both in the cold and hot start modes, cost Rp. 250.00 / 5-liters of boiling water. Biomass stoves, which are made of people's stoves in the cold start and hot start modes, cost Rp. 200.00 / 5-liters of water.

Using biomass stoves, prime brands, and people's stove brands results in the lowest rupiah value compared to conventional stoves. Biomass

stoves with the People's Stove brand have a lower Rupiah value than other biomass stoves. It is shown that fruitless palms are very efficiently used by the community for cooking in the kitchen [15], [23]. Biomass Stoves with low-cost Rp. 200.00/ 5-liters of boiling water and the low price of loose lollipops can even be obtained free of charge by palm oil farmers. Oil palm waste has a high potential to be an alternative energy source [24]. So people do not need to spend more money and energy to get biomass stove fuel. Fruitless palms can be a new alternative energy source for alternative materials for community-scale stoves. Oil palm waste is an alternative energy source for the community and allows for the development of local plantation areas [25].

Biomass Stove Furnace Measurement

The two brands of biomass stoves with the lowest

cost were observed by measuring the stoves. The small stove is 19.6 cm², so it has a better effective fire time than the Prime stove, which has a larger stove size of 78.5 cm². Small furnaces require less energy to achieve effective gasification.

Meanwhile, the Prime stove requires more energy to conduct the gasification process in its large furnace [26]. Pictures of the diameter of the biomass stove can be seen in Figure 3.

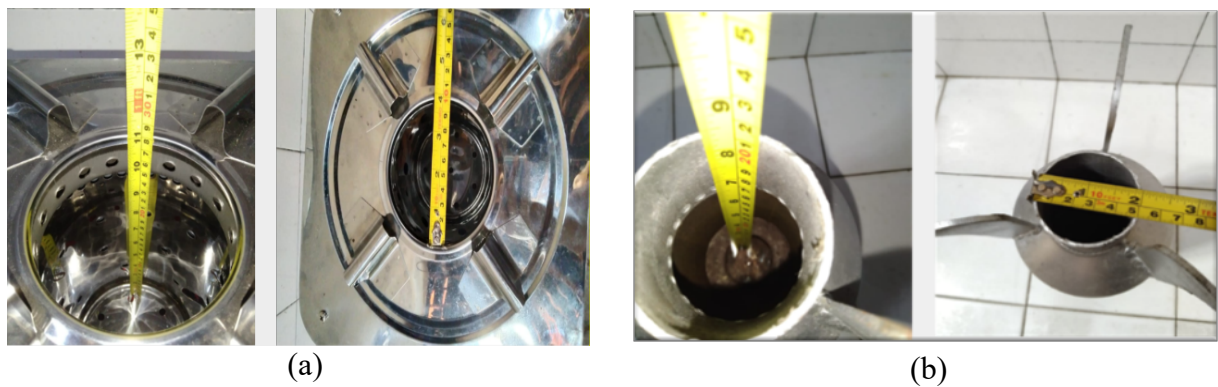


Fig 3. (a) "PRIME" Biomass Gasification Stove, (b) Small Stove Gasified Biomass Stove for People's Stove

Efficient Use of Biomass Stove Fuel

The Prime Stove and the People's Stove have relatively the same time to boil water. But they have different fuel requirements to burn 5-liters of

water from room temperature to 100°C. The results of calculating the fuel requirements for large and small biomass stoves can be seen in Figure 5.

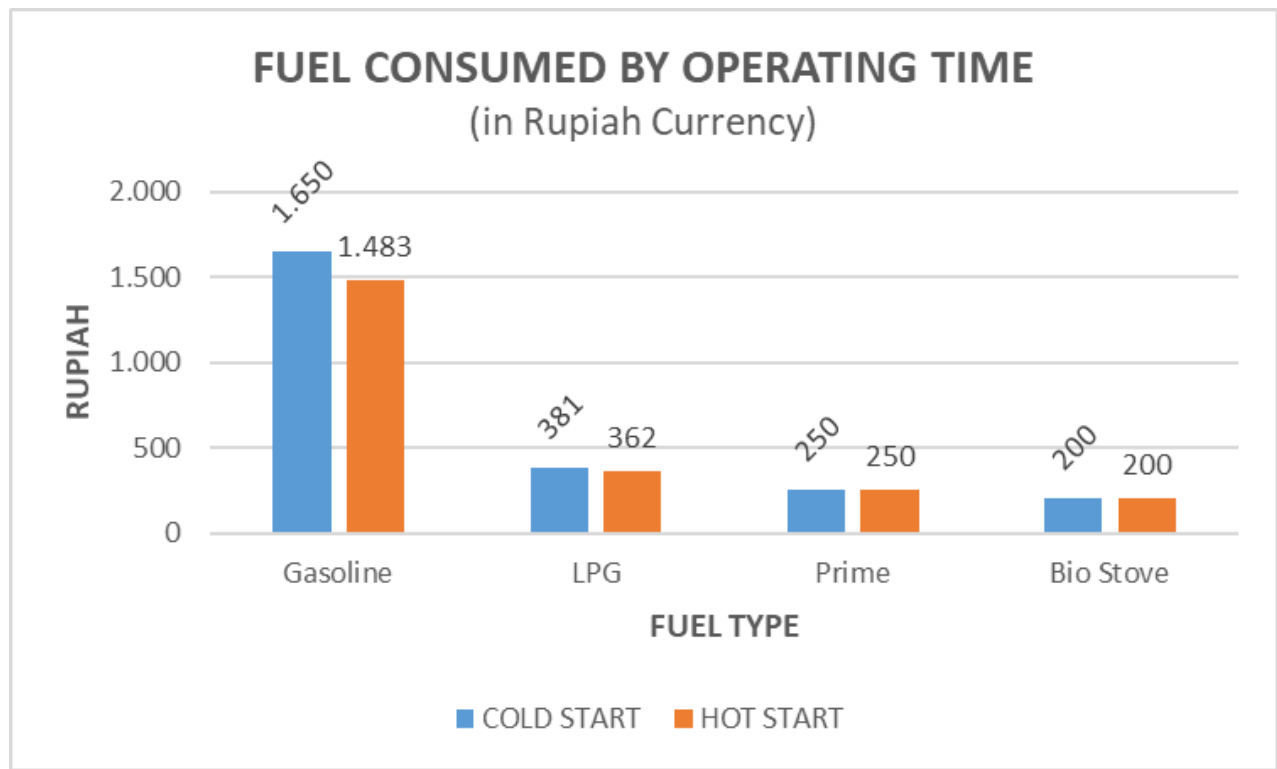


Fig 4. The Magnitude of Gasification Biomass Furnace Against Boiling Time

Figure 4 shows the effective time, which is relatively the same, but the amount of fuel used differs. The People's Stove uses as much as 200 grams of fruitless, while the Prime Stove requires 250 grams of fruitless to get the effective boiling time relatively the same at the Cold Start and Hot Start prefixes. The type of furnace will affect the amount of loose materials used. Fruitless that are not used and will become weeds can be used as an

energy source for biomass stoves. Fruitless that is not quoted and sold will impact the growth of palm oil. So, that fruitless can be used as a source of new energy. Unused palm oil can be an effective alternative energy [27].

Effective Flame of Biomass Stove

The effective flame on the large and small-size biomass stoves can be observed in Figure 5.

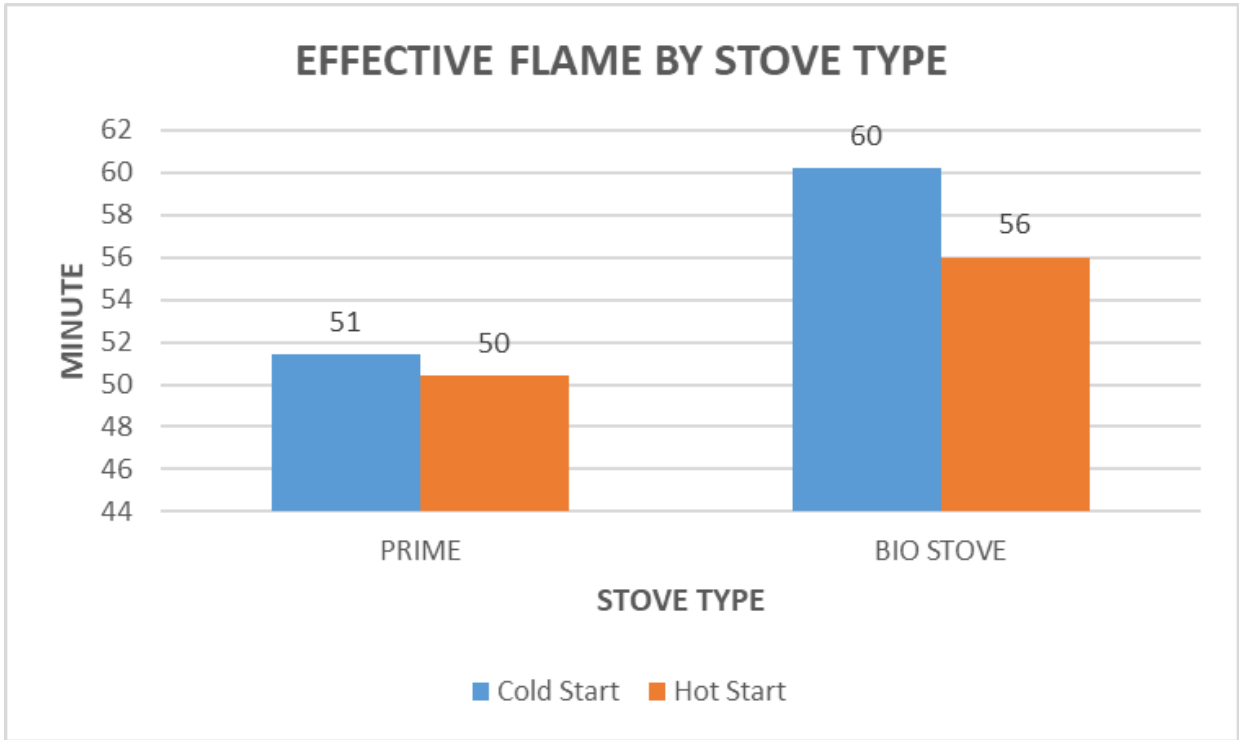


Fig 5. Effective Flame on Large and Small Size Biomass Stoves (Minutes)

Figure 5 shows the results of the most effective and fuel-efficient flame using the same fuel type (fruitless) as a small stove. The smaller size of the furnace uses a number of loose fruit at Rp. 200.00 / 5 liters of water, the stove can burn for 60 minutes in cold start mode. Meanwhile, the stove can burn for 56 minutes in hot start mode. Then, when compared with a large-size stove in cold start mode using the same fuel at Rp. 200.00 / 5 liters of water, the stove can burn for 51 minutes. Meanwhile, it can light up for 50 minutes in hot start mode because different furnaces influence fuel performance [28], [29].

Indonesian people can never be separated

from needing a stove [30]; [17]. A furnace is one of the family's primary needs, and it can answer the problems that exist in society. Loose-fired stoves have made a solution for the community, especially in the oil palm plantation environment. Efficient use of biomass resources can replace old biomass stoves, and policies using exergy are needed to increase sustainability [31]. Renewable energy resources are becoming more attractive for development and planting through long-term energy [32]. The role of oil in sustainable nutrition must be considered beyond pure nutritional facts such as local resources, health, employment, and socio-economic development [33].

CONCLUSION

Using a biomass stove with loose fuel has better efficiency than using a furnace with gasoline and LPG fuel. The efficiency of using fruitless palm as a substitute for household stoves has the lowest cost. A comparison of the performance of using conventional stoves with biomass stoves makes loose fruit an alternative fuel that helps the community. The stove is one of the household appliances that is needed for the cooking process. The most efficient flame is obtained by a small stove-size biomass stove with a fuel volume of 200 gr with the Hot Start prefix. Fruitless material can be used as an alternative for household stoves to replace gasoline and LPG. Unrefined fuel can be an alternative material for household scale stoves. The government's role is to provide socialization and policies in applying alternative materials with

lozenges to reduce the use of gasoline and LPG.

Based on the findings in this study, (a) the government's role is needed in adopting an integrated policy approach and increasing stakeholder collaboration; (b) raising awareness of the benefits of cooking with loose biomass stoves; (c) facilitating access to finance and present appropriate economic incentives; (d) implementing quality assurance mechanisms; (e) facilitating behavior change among stove users; (f) increase research, development, and technical capacity. This research has drawbacks regarding gas emissions from biomass stoves with loose fuel. So, further research is needed to measure the emissions released before being applied to the general public.

ACKNOWLEDGEMENT

The researcher would like to thank the Akademi Komunitas Perkebunan Yogyakarta for

permitting the use of the place (lab) to carry out this research, which was completed.

REFERENCE

- [1] Badan Pusat Statistik, 'Statistik Kelapa Sawit Indonesia, Indonesian Oil palm Statistics 2018', pp. 1–98, 2018.
- [2] E. Ivanchina, V. Chuzlov, E. Ivashkina, G. Nazarova, A. Tyumentsev, and Vymyatnin, 'Modeling of motor gasoline components complex production', *Catal. Today*, no. October, 2020, doi: 10.1016/j.cattod.2020.11.007.
- [3] P. Oosterveer, 'Sustainability of Palm Oil and Its Acceptance in The Eu', *J. Oil Palm Res.*, Jul. 2020, doi: 10.21894/jopr.2020.0039.
- [4] A. Haryanto *et al.*, 'Rancang Bangun Dan Uji Kinerja Digester Biogas Rumah Tangga Tipe Floating Tank Dengan Substrat Kotoran Sapi', *J. Ilm. Rekayasa Pertan. dan Biosist.*, vol. 9, no. 2, pp. 130–142, 2021, doi: 10.29303/jrpb.v9i2.255.
- [5] W. M. Champion and A. P. Grieshop, 'Pellet-Fed Gasifier Stoves Approach Gas-Stove Like Performance during in-Home Use in Rwanda', *Environ. Sci. Technol.*, vol. 53, no. 11, pp. 6570–6579, Jun. 2019, doi: 10.1021/acs.est.9b00009.
- [6] I. Kurniaty and H. Hermansyah, 'Potensi Pemanfaatan Lpg (Liquefied Petroleum Gas) Sebagai Bahan Bakar Bagi Pengguna Kendaraan', *Semin. Nas. Sains dan Teknol.* 2016, no. November, pp. 1–5, 2016.
- [7] A. Akhdiyatul, E. Radwitya, and Y. Chandra, 'Analisis Teknis dan Ekonomis

Dalam Penggunaan Bahan Bakar Biomassa Di Pusat Listrik Tenaga Uap Studi Kasus di PLTU PT. Suka Jaya Makmur', *Elkha*, vol. 10, no. 2, p. 49, 2018, doi: 10.26418/elkha.v10i2.26741.

- [8] N. Jafri, L. W. Yoon, W. Y. Wong, and K. H. Cheah, 'Power generation from palm kernel shell biochar in a direct carbon fuel cell', *SN Appl. Sci.*, vol. 2, no. 3, p. 386, Mar. 2020, doi: 10.1007/s42452-020-2189-2.
- [9] A. T. Hoang *et al.*, 'Progress on the lignocellulosic biomass pyrolysis for biofuel production toward environmental sustainability', *Fuel Process. Technol.*, vol. 223, p. 106997, Dec. 2021, doi: 10.1016/j.fuproc.2021.106997.
- [10] H. Yaqoob *et al.*, 'Potential of Waste Cooking Oil Biodiesel as Renewable Fuel in Combustion Engines: A Review', *Energies*, vol. 14, no. 9, p. 2565, Apr. 2021, doi: 10.3390/en14092565.
- [11] M. A. Mujtaba *et al.*, 'Critical review on sesame seed oil and its methyl ester on cold flow and oxidation stability', *Energy Reports*, vol. 6, pp. 40–54, Nov. 2020, doi: 10.1016/j.egyr.2019.11.160.
- [12] T. Rayner, 'Keeping it in the ground? Assessing global governance for fossil-fuel supply reduction', *Earth Syst. Gov.*, no. xxxx, p. 100061, 2020, doi: 10.1016/j.esg.2020.100061.
- [13] I. T. Sui Kim, V. Sethu, S. K. Arumugasamy, and A. Selvarajoo, 'Fenugreek seeds and okra for the treatment of palm oil mill effluent (POME) – Characterization studies and modeling with backpropagation feedforward neural network (BFNN)', *J. Water Process Eng.*, vol. 37, p. 101500, Oct. 2020, doi: 10.1016/j.jwpe.2020.101500.
- [14] S. G. Krishnan, F.-L. Pua, and E.-S. Tan, 'Synthesis of Magnetic Catalyst Derived from Oil Palm Empty Fruit Bunch for Esterification of Oleic Acid: An Optimization Study', *Bull. Chem. React. Eng. Catal.*, vol. 17, no. 1, pp. 65–77, Mar. 2022, doi: 10.9767/bcrec.17.1.12392.65-77.
- [15] M. L. Benka-Coker, W. Tadele, A. Milano, D. Getaneh, and H. Stokes, 'A case study of the ethanol CleanCook stove intervention and potential scale-up in Ethiopia', *Energy Sustain. Dev.*, vol. 46, pp. 53–64, 2018, doi: 10.1016/j.esd.2018.06.009.
- [16] H. Setyawan, I. Kurniawan, K. Setiawan, and H. Listianto, 'The Welfare Analysis of Oil Palm Smallholder Farmers In Pangkalan Banteng Sub-District, Central Kalimantan', *Bul. Penelit. Sos. Ekon. Pertan. Fak. Pertan. Univ. Haluoleo*, vol. 22, no. 1, pp. 43–50, 2020, doi: <http://dx.doi.org/10.37149/bpsosek.v22i1.13292>.
- [17] J. M. Hafner, G. Uckert, H. K. Hoffmann, T. S. Rosenstock, S. Sieber, and A. A. Kimaro, 'Efficiency of Three-Stone Fire and Improved Cooking Stoves using on-farm and off-farm fuels in semi-arid Tanzania', *Energy Sustain. Dev.*, vol. 59, pp. 199–207, 2020, doi: 10.1016/j.esd.2020.10.012.
- [18] H. V. Dantas, M. F. Barbosa, E. C. L. Nascimento, P. N. T. Moreira, R. K. H. Galvão, and M. C. U. Araújo, 'An automatic flow system for NIR screening analysis of liquefied petroleum gas with respect to propane content', *Talanta*, vol. 106, pp. 158–162, 2013, doi: 10.1016/j.talanta.2012.12.024.
- [19] R. Silambarasan and R. Senthil, 'Effects of nano additives on performance and emission characteristics of a diesel engine fueled with Annona methyl ester', *Biofuels*, vol. 7, no. 3, pp. 271–277, 2016, doi: 10.1080/17597269.2015.1132370.
- [20] E. Suhendi, G. U. Paradise, and I. Priandana, 'Pengaruh Laju Alir Udara Dan Waktu Proses Gasifikasi Terhadap Gas Producer Limbah Tangkai Daun Tembakau Menggunakan Gasifier Tipe Downdraft', *J. Bahan Alam Terbarukan*, vol. 5, no. 2, pp. 45–53, 2017, doi: 10.15294/jbat.v5i2.6054.
- [21] H. Duan, M. Jia, J. Bai, and Y. Li, 'Combined effects of fuel reactivity, ϕ -sensitivity, and intake temperature on the

- performance of low-temperature gasoline/polyoxymethylene dimethyl ethers combustion', *Fuel*, vol. 288, no. September, 2021, doi: 10.1016/j.fuel.2020.119612.
- [22] K. R. Bilsback *et al.*, 'A Laboratory Assessment of 120 Air Pollutant Emissions from Biomass and Fossil Fuel Cookstoves', *Environ. Sci. Technol.*, vol. 53, no. 12, pp. 7114–7125, Jun. 2019, doi: 10.1021/acs.est.8b07019.
- [23] A. S. Harris and S. Mahmudsyah, 'Studi Pemanfaatan Limbah Padat dari Perkebunan Kelapa Sawit pada PLTU 6 MW di Bangka Belitung', *J. Tek. ITS*, vol. 2, no. 1, pp. B73-B78–B78, 2013.
- [24] M. R. Rahim *et al.*, 'Utilization of Synthesis Gas Generated from Agricultural Waste as Clean Sustainable Fuel', *ASEAN Eng. J.*, vol. 13, no. 2, pp. 159–164, May 2023, doi: 10.11113/aej.v13.19218.
- [25] F. J. S. Bandeira, J. A. S. Ribeiro Junior, A. L. A. Mesquita, A. L. A. Mesquita, and E. A. Torres, 'Potential Use of Palm Oil and Cocoa Waste Biomasses as Sources of Energy Generation by Gasification System in The State of Pará, Brazil', *Eng. Agrícola*, vol. 43, no. spe, 2023, doi: 10.1590/1809-4430-eng.agric.v43nepe20220151/2023.
- [26] R. Andhika and H. Susanto, 'Gasifikasi Cangkang Sawit dalam Updraft Fixed Bed Gasifier: Pengukuran Laju Gasifikasi Spesifik', in *Prosiding Seminar Nasional Teknik Kimia "Kejuangan" Pengembangan Teknologi Kimia untuk Pengolahan Sumber Daya Alam Indonesia*, 2017, no. April, pp. 1–8, [Online]. Available: <http://jurnal.upnyk.ac.id/index.php/kejuangan/article/download/1887/1674>.
- [27] C. V. Jemima Romola *et al.*, 'Improvement of fuel properties of used palm oil derived biodiesel with butyl ferulate as an additive', *Renew. Energy*, vol. 175, pp. 1052–1068, Sep. 2021, doi: 10.1016/j.renene.2021.05.065.
- [28] B. Purwantana and B. Prastowo, 'Gasifikasi Tandan Kosong Kelapa Sawit: Konversi Limbah Tandan Kosong Kelapa Sawit untuk Sumber Energi', *Semin. Nas. Inov. Perkeb. 2011*, pp. 196–205, 2011.
- [29] T. Makonese, H. J. Annegarn, and J. Meyer, 'Performance evaluation of three methanol stoves using a contextual testing approach', *Energy Sustain. Dev.*, vol. 55, pp. 13–23, 2020, doi: 10.1016/j.esd.2019.12.002.
- [30] A. Sugeng Widodo, 'Peningkatan Efisiensi Sistem Pemanasan dengan Penambahan Grid pada Perforated Burner', *J. Rekayasa Mesin*, vol. 7, no. 1, pp. 21–25, 2016, doi: 10.21776/ub.jrm.2016.007.01.4.
- [31] H. Chowdhury, T. Chowdhury, P. Chowdhury, M. Islam, R. Saidur, and S. M. Sait, 'Integrating sustainability analysis with sectoral exergy analysis: A case study of rural residential sector of Bangladesh', *Energy Build.*, vol. 202, p. 109397, Nov. 2019, doi: 10.1016/j.enbuild.2019.109397.
- [32] Salmah Omar, Shafini Mohd Shafie, Norsiah Hami, Zakirah Othman, and A. Hariths Numan Djaohari, 'Environmental Analysis of Power Generation from Pineapple Waste', *J. Adv. Res. Fluid Mech. Therm. Sci.*, vol. 105, no. 2, pp. 88–98, Jun. 2023, doi: 10.37934/arfmts.105.2.8898.
- [33] P. M. Mannucci *et al.*, 'Sustainable nutrition and the case of vegetable oils to match present and future dietary needs', *Front. Public Heal.*, vol. 11, May 2023, doi: 10.3389/fpubh.2023.1106083.