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Product Development Training on Renewable Energy

Yuliana[1,3], Rasidah[1,3], Ani Mahrita[2], Jonathan[1], and Ahmad Sidik[1]
[1]Chemistry Department, Faculty of Mathematics and Natural Sciences, Universitas Palangka Raya, Palangka Raya, Indonesia
[2]Management Department, Faculty of Economics and Business, Universitas Palangka Raya, Palangka Raya, Indonesia
[3]Nutriscience Laboratory, Palangka Raya, Indonesia
*yuliana@mipa.upr.ac.id

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Abstract

The energy crisis in Indonesia is becoming increasingly alarming as the population and human activity continue to grow. In addition, there are concerns about environmental pollution and deteriorating human health due to the use of fossil fuels. The development of renewable energy, such as biomass, has great potential to supply sustainable energy in the future. Charcoal briquettes made from biomass waste are a solid fuel that can be used as an alternative solution to energy scarcity at the household level. This activity focused on training students majoring in Renewable Energy Technology at SMKN 1 Palangka Raya to recognize the quality and process high-quality charcoal briquettes, as well as manage the business. The results of this activity were improvements in production and management aspects. After applying technology and innovation during the training, the students' practical results increased to 30 kg per two weeks. Additionally, the students' knowledge and skills in processing charcoal briquettes and conducting business planning improved, from initially having no knowledge to gaining an understanding. The evaluation results stated that the activity had been carried out well, with effective material delivery (90%), adequate facilities (88.57%), alignment with interests (84.29%), and beneficial activities (92.86%).

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INTRODUCTION

Indonesia is experiencing rapid population growth and industrial development, which requires a large energy supply. Meanwhile, national energy fulfillment still relies heavily on fossil fuels with limited availability, such as coal (46%), petroleum (31%), and natural gas (18%) (Azhar & Satriawan, 2018; Puspita & Nugrahe, 2024; Solikah & Bramastia, 2024). Only about 5% of biofuel comes from renewable energy sources (Sugiyono, 2020; Ministry of Energy and Mineral Resources/KESDM, 2024). Currently, fuel oil consumption has reached 505 million barrels, with prices reaching USD 76.81 per barrel in January 2025 (KESDM, 2025). In addition, concerns have arisen regarding environmental degradation, including high pollution levels, greenhouse gas emissions, and declining human health due to the use of fossil fuels (Singh et al., 2020; Zubaydah et al., 2024). On the other hand, renewable energy is environmentally friendly and contributes to reducing global warming. Renewable energy utilizes raw materials in the form of agricultural and plantation waste, making it low-cost, abundantly available, and sustainable (Eka & Andasuryani, 2017). Therefore, the development of renewable energy is necessary to address energy scarcity and achieve energy self-sufficiency in the future.

SMKN 1 Palangka Raya is a vocational secondary school located in the city center, precisely at Jl. Tambun Bungai No. 77, Langkai, Pahandut District, Palangka Raya City, Central Kalimantan. The school is highly attractive to students as it offers 13 areas of expertise. One of the newer and less popular programs is Biomass Energy Engineering, which has now been renamed Renewable Energy Engineering (Teknik Energi Terbarukan/TET), with a total of 58 students from grades X to XII (National Education Database, 2025). Most students choose this program because they were not admitted to public schools or to more popular vocational programs such as computer engineering, electronics, or automotive/mechanical engineering. In fact, renewable energy development has significant potential to address the energy crisis. In Palangka Raya, long queues for fuel oil and LPG shortages are frequently encountered, causing prices to rise sharply (IDR 40,000 per 3 kg LPG cylinder).

As a relatively new program, the TET department at SMKN 1 Palangka Raya already has practicum facilities and infrastructure, although they are still incomplete. The existing practical facilities include a carbonization furnace and charcoal briquettes produced from students' practicum activities, as shown in Figure 1. Based on interviews with Ms. Misdiani, a TET teacher, it was revealed that students had previously produced charcoal briquettes from coconut shells; however, the results were not optimal in terms of product quality or selling price. The mixture of charcoal powder and binder was manually compacted and shaped without a molding machine, resulting in insufficient density, inconsistent unit weight, and non-uniform shapes that did not meet the targeted standards. Moreover, the charcoal briquettes were not tested in accordance with the Indonesian National Standards (SNI 01-6235-2000), so their quality could not be assured. The lack of students' knowledge and skills in producing high-quality charcoal briquettes and managing business aspects has affected the product's bargaining power and market price.

The development of renewable energy from biomass, such as charcoal briquettes, has gained considerable attention because it utilizes waste-based raw materials that do not contain sulfur, resulting in lower pollution levels and being more environmentally friendly (Qistina et al., 2016). Briquettes can be produced from lignin- and cellulose-rich materials such as rice husks, sawdust, corn cobs, and bamboo. These raw materials are carbonized, after which the charcoal is crushed and mixed with binders such as tapioca starch (10% w/w). The mixture is then compacted in molds and dried. Once dried, charcoal briquettes are ready to be used as an alternative household fuel to LPG (Milya et al., 2023). This product not only reduces dependence on LPG but also supports energy self-reliance.

High-quality charcoal briquettes are characterized by low moisture content, ash content, volatile matter, and combustion rate, while having high density, calorific value, and flame or ember temperature. These qualities are influenced by the type of biomass, carbonization method, and type of binder used. As a result, charcoal briquettes can produce a high calorific value of up to 7,204.56 cal/g. In addition, high-quality briquettes are easy to ignite, smokeless, resistant to mold growth, and do not leave black residue on the hands (Iswara et al., 2024). Charcoal briquette combustion can generate a calorific value of up to 7,204.56 cal/g.

On the other hand, the expansion of oil palm plantations in Central Kalimantan generates waste from processing activities, such as palm kernel shells. These shells resemble coconut shells but are smaller. Processing one ton of fresh fruit bunches (FFB) produces approximately 65 kg (6.5%) of shell waste. The utilization of shell waste in plantations remains very limited, often left piled up and allowed to decompose, potentially attracting oil palm pests. Similarly, coconut shells, which account for about 20–30% of the fruit's weight, accumulate in large quantities in traditional markets in Palangka Raya and remain underutilized by the community. In fact, palm kernel shell waste has a calorific value of approximately 4,000–4,500 cal/g, equivalent to low-rank coal (lignite) or grade IV coal (Nasikin, 2015). Coconut shells have an even higher calorific value of around 6,500–7,600 cal/g, comparable to grade I coal, making both materials highly potential renewable energy sources. When processed into briquettes, the calorific value of palm kernel shell briquettes increases to 6,930.11 cal/g, while coconut shell briquettes reach 7,204.56 cal/g (Milya et al., 2023; Marchel et al., 2017). Briquette production also generates a by-product, liquid smoke, from the condensation of vapor produced during carbonization. Liquid smoke has high economic value and is used as a natural preservative, antioxidant, disinfectant, and natural pesticide (Haji et al., 2006).

Based on the above description, efforts are needed to optimize students' learning processes and the utilization of palm kernel shell waste as raw material for charcoal briquette production at SMKN 1 Palangka Raya. This activity not only optimizes waste utilization but also represents an initial step in supporting *Asta Cita* point 2: promoting national self-reliance through energy self-sufficiency, and point 3: encouraging entrepreneurship. In addition, it supports the targets of the Sustainable Development Goals (SDGs), specifically SDG 4: Quality Education; SDG 7: Affordable and Clean Energy; and SDG 8: Decent Work and Economic Growth.

This community service program focuses on empowering students in the Renewable Energy Engineering (TET) Department at SMKN 1 Palangka Raya to develop biomass energy technology by producing high-quality charcoal briquettes and initiating the development of a flagship school product based on renewable energy. Through this activity, it is expected to provide comprehensive learning experiences for students of SMKN 1 Palangka Raya, particularly those in the TET program, in producing high-quality charcoal briquettes and managing their business as an alternative energy source to address fossil energy scarcity. This program also offers an opportunity to develop a flagship renewable energy-based school product while providing problem-based learning experiences for the involved university students to address real-world challenges.

METHODS

The community service activity employed the Asset-Based Community Development (ABCD) approach, which helps partners understand their internal conditions, potential for change, and desired goals. Assistance was carried out through five stages: Discovery, Dream, Design, Define, and Destiny. The ABCD method was used to explore partners' potential from the preparation stage through business mentoring, with a focus on producing high-quality charcoal briquettes and strengthening entrepreneurial capacity. An infographic illustrating the stages of the implemented activities is presented in Figure 1.

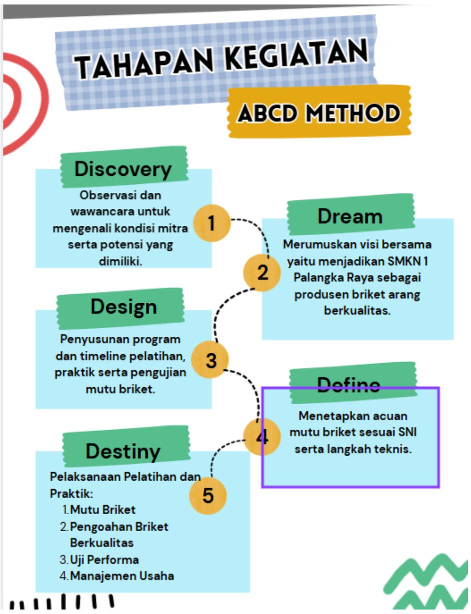


Figure 1 Flow diagram of the community service implementation method at SMKN 1 Palangka Raya

RESULTS AND DISCUSSION

Based on the results of the initial identification, the partner institution faced four priority problems: suboptimal processing of charcoal briquettes, low levels of students' knowledge and skills in producing high-quality briquettes, limited practicum facilities, and underdeveloped business management. Through the implementation of this integrated training program, these four issues were addressed gradually and in an integrated manner.

The first problem, related to the suboptimal processing of charcoal briquettes, was addressed through technical training (Figure 2), referring to the quality parameters of SNI 01-6235-2000. High-quality charcoal briquettes are a key determinant in encouraging communities to shift from conventional energy sources to renewable energy sources. The quality of charcoal briquettes must comply with SNI 01-6235-2000 standards, which include moisture content (8%), volatile matter (15%), ash content (8%), fixed carbon (77%), and calorific value (5,000 cal/g). Through this training, participants were expected to understand the quality benchmarks for charcoal briquettes that would later be produced by the Renewable Energy Engineering (TET) Department of SMKN 1 Palangka Raya. This activity also addressed the second issue, namely the gap between knowledge and skills, through training based on an applicative and participatory approach. In addition to material delivery by academics, the activities involved structured practice, direct mentoring, and the introduction of recent research findings. Students not only understood the theory but also carried out hands-on practice in briquette production, starting from carbonization, charcoal grinding, material mixing, briquette molding, proper drying, and performance testing. Briquette performance tests—including ease of ignition, smokeless combustion, resistance to mold growth, and the absence of black residue on hands—were conducted by both the team and participants to determine feasibility. The production results were also tested in laboratories to determine compliance with moisture content, ash content, calorific value, and other compositions, so that practical activities were no longer routine-based but instead aligned with national quality standards. This undoubtedly enhanced students' insights into technological innovations in briquette processing and their understanding of product quality analysis.

Figure 2 Delivery of training materials

Before carrying out the practicum, students needed to understand the basic concepts explaining why and how certain processes are performed. Therefore, students were provided with knowledge of briquette production and quality. The presentation of this material provided an overview and explained the principles to be implemented in practice. Delivering theoretical material before practice helped students see the connection between what they learned in class and its application in real-world contexts, making the material more relevant and easier to understand. This activity also emphasized the importance of consistency and measurability in practice. Theoretical material provided standards or guidelines to follow during practice, so that the results obtained were more consistent and measurable. For example, theory regarding proper material proportions ensures that anyone performing the process will produce briquettes of relatively consistent quality.

By understanding the theory, students became more aware of the purpose of each practical step and its benefits in achieving the targeted SNI briquette quality standards used as benchmarks, enabling them to be more focused and motivated. With good theoretical knowledge, students understood correct procedures and what constitutes good-quality briquettes, helping them avoid mistakes during practice. For instance, students learned the appropriate material composition for producing quality briquettes and the factors influencing briquette quality, such as combustion temperature, which must be controlled. When students understood what they were doing and why it was important, they felt more confident in carrying out the practice. Theoretical understanding also helped them feel better prepared to face challenges during practice. Students could more easily analyze and evaluate processes or outcomes if they understood the underlying theoretical background, identified potential errors, and understood how to minimize or correct them.

Hands-on briquette production practice by students began with dividing them into small groups to apply the process under direct guidance from the team at each stage, ensuring students fully understood the process and could perform it independently later. In addition, students conducted observations and recorded qualitative test results to evaluate briquette quality before and after the community service program, including durability, burning power, and size. Meanwhile, laboratory test results were used to evaluate briquette quality quantitatively.

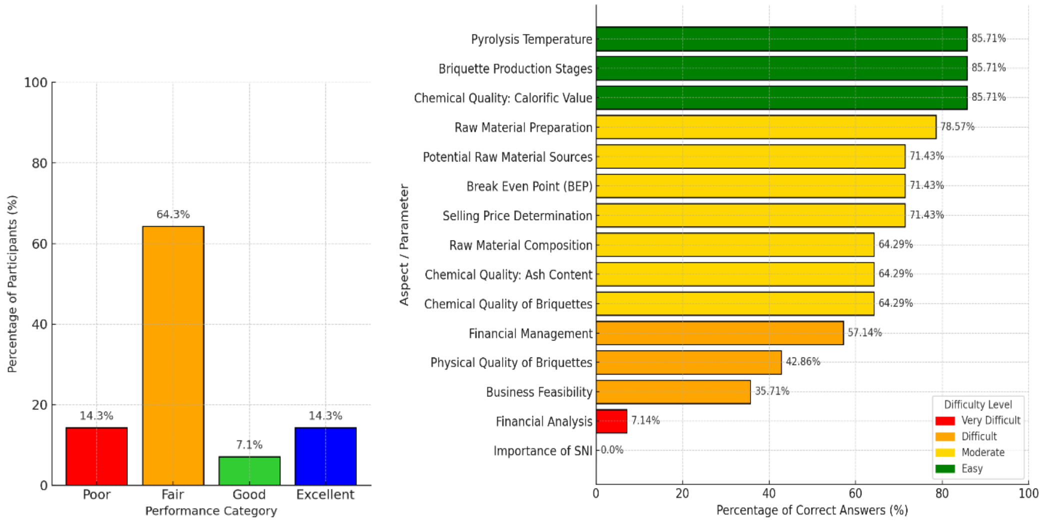
Furthermore, to address the third issue—limited facilities—the implementation team facilitated the procurement or loan of equipment such as grinders (charcoal crushers) and briquette molding machines, which were previously unavailable in the TET department's workshop (Figure 3). This support enabled students to carry out the entire production process independently.

Figure 3 Illustration of the briquette production process before and after the application of technology in the community service activity

The fourth issue, related to underdeveloped business management, was addressed through training in entrepreneurship, packaging, and digital-based marketing. Students were trained to produce briquettes with uniform shapes and weights, conduct weighing, and develop standardized product packaging. Product packaging was improved from simple transparent plastic to more marketable designs suitable for sale, not only for internal school needs but also for external business development. This training aimed to equip students to manage briquette production (Figure 4) as a real, market-oriented business opportunity. Overall, the series of training activities not only improved participants' technical knowledge and skills in producing high-quality briquettes but also fostered an entrepreneurial mindset that is adaptive to technological developments and future renewable energy needs.

Figure 4 Briquettes produced from the community service activity

Figures 5 shows that participants' understanding of the importance of SNI standards was still relatively low, even though this aspect is crucial for safety, effectiveness, and product competitiveness in the market. Participants also experienced difficulties in the aspects of business feasibility and briquette quality parameters, with percentages below 50%. Test results further showed that participants had a stronger grasp of the technical aspects of the production process compared to quality standards and business analysis aspects, such as briquette production procedures, combustion temperature conditioning, and target quality standard values, with the highest levels of understanding (≥85%). These results indicate that participants were stronger in technical aspects but weaker in quality concepts and business analysis. It can therefore be concluded that while participants understood what they were doing and the quality targets to be achieved, they did not yet fully understand why these quality targets needed to be achieved or the impact of meeting quality standards on the selling value of the resulting products.



(a) (b)

Figure 5 (a) Distribution of participants by performance category and (b) Percentage of participants' understanding of each aspect

The results of the service satisfaction evaluation showed that the activity was implemented effectively and provided significant benefits to participants (Figure 6). Effective material delivery (90%) and adequate facilities (88.57%) were the program's main strengths. Material delivery was rated very good, indicating that the speakers/facilitators presented the material clearly, systematically, and in an easily understandable manner. Meanwhile, the facility adequacy percentage of 88.57% indicated that the equipment used during the activity was considered highly sufficient, with supporting facilities available and well utilized by participants.

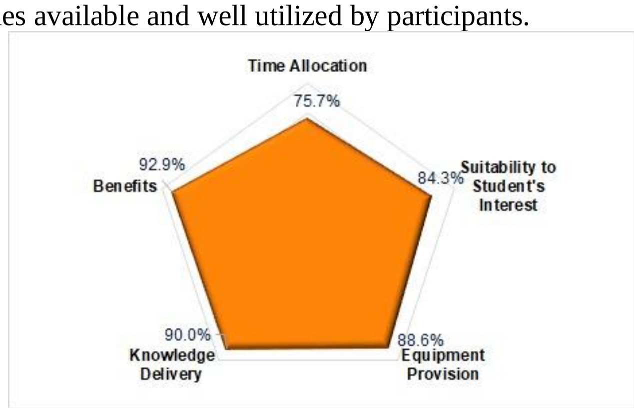


Figure 6 Level of satisfaction with community service activities

The high percentages for interest alignment (84.29%) and activity benefits (92.86%) reflect partners' positive response and enthusiasm. This indicates that the material presented was relevant to partners’ needs and provided direct added value to their capacity and knowledge. However, the time allocation indicator received the lowest score among the five indicators, suggesting that attention should be given to optimizing time allocation. Most participants rated the activity duration as good, at 75.71%. This suggests that high participant enthusiasm was not fully matched by sufficient implementation time. Partners may have felt that the activity duration was too short or dense to explore the material more deeply or to engage in more interactive discussions. When interest is very high and participants feel engaged, partners tend to desire longer durations to maximize learning and participation. Thus, the lower score for time allocation relative to other indicators serves as a positive signal that the activity was highly engaging—not merely a result of poor time planning, but rather of high participant involvement that made the available time feel insufficient.

CONCLUSION

This activity successfully integrated theory and practice effectively in briquette-making learning, where the delivery of material prior to practice was proven to enhance students’ understanding, skills, and readiness in carrying out each stage of the process. The implementation received positive responses with high satisfaction levels in terms of benefits (92.86%), material delivery (90%), facility adequacy (88.57%), and alignment with participants’ interests (84.29%). Although time allocation received the lowest score (75.71%), this primarily reflected high participant enthusiasm, making the available time feel insufficient. Overall, the activity was considered successful and had a positive impact on improving participants’ competencies, and it is recommended to be continued with adjustments to duration in line with the complexity of material deepening to optimize learning outcomes.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

All authors contributed to produce the final version of this article according to their respective expertise and roles.

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AUTHOR PROFILES

Yuliana, S.Si., M.Biotek.

Lecturer in the Chemistry Department, Faculty of Mathematics and Natural Sciences, Universitas Palangka Raya. Research interest: biotechnology, natural products, and bioremediation. Email: yuliana@mipa.upr.ac.id, Google Scholar: D4yTNOsAAAAJ, Sinta ID: 6848968, ORCiD: 0009-0006-9549-6230, and Scopus ID: 57215431140.

Rasidah, S.Pd., M.Sc.
Lecturer in the Chemistry Department, Faculty of Mathematics and Natural Sciences, Universitas Palangka Raya. Research interest: environmental chemistry, wastewater treatments, and natural products. Email: rasidah@mipa.upr.ac.id, Google Scholar: W7Ue_xIAAAAJ Sinta ID: 6718022, ORCiD: 0000-0001-6555-8986, and Scopus ID: 57222347509.

Ani Mahrita, S.E., M.Sc.
Lecturer in the Management Department, Faculty of Economics and Business, Universitas Palangka Raya. Research Interest: financial management, investment, and corporate management. Email: animahrita@feb.upr.a.id, Google Scholar: Z0M8m-UAAAAJ, Sinta ID: 6718102, ORCiD: 0009-0003-0702-1541, and Scopus ID: 57222590577.

Jonathan
Student of the Chemistry Department. Email: Jonathan27042006@gmail.com

Ahmad Sidik
Student of the Chemistry Department. Email: sidikq04@gmail.com