

Renewable Energy Innovation through a Micro-Hydro Power Plant (PLTMH) by the CSR Program of PLN Nusantara Power UP Paiton to Promote Energy Independence and Economic Development in Batur Village

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Abstract. Electricity has become a primary necessity for society due to its crucial role in various aspects of life, making its availability essential. However, most electricity demand is still met through non-renewable energy sources. Therefore, innovation through the utilization of renewable energy is urgently needed. PT PLN Nusantara Power UP Paiton has introduced a community empowerment-based renewable energy initiative through its Tanggung Jawab Sosial Lingkungan (TJSL) program called ARUNA LESTARI, in Batur Village, Gading District, Probolinggo Regency. The program provides clean electricity to 334 residents in Neighborhood Units (RT) 8 and 9 of Tanah Merah Hamlet, who had been without access to electricity for many years. This study aims to examine the empowerment process comprehensively to understand the implementation of clean energy innovation at the community level and its role in improving the local economy through an asset-based community development approach. The research employed a descriptive qualitative method, with informants selected through purposive sampling. Data were collected through observation, interviews, and documentation involving PLTMH Group, Poktan Kopi Batur Pandan Wangi, and Kelompok Srikandi Batur. Data analysis was conducted through data reduction, data presentation, and conclusion drawing. The findings reveal that the ARUNA LESTARI Program, through the optimization of the PLTMH, has not only improved access to electricity for residents of Batur Village but has also served as a catalyst for the emergence of various productive economic activities based on local potential. Furthermore, the program has strengthened village assets and capital, particularly in the downstream development of local coffee products and the cultivation of laying hens.

Keywords: Social Innovation, Corporate Social and Environmental Responsibility, Micro-Hydro Power Plant (PLTMH), Renewable Energy, Asset-Based Community Development.

A. INTRODUCTION

Electricity has become a primary necessity for both rural and urban communities due to its significant role in economic activities, industry, transportation, tourism, and household life (Paturu & Yulianingrum, 2023). Electricity plays a vital role in supporting human life. Therefore, its availability must be maintained to prevent disruptions that could hinder daily activities. Furthermore, the continuity of electricity supply is a key factor contributing to improvements in people's quality of life (Sofyan & Sudana, 2022). Access to electricity enables individuals to obtain information and fulfill their basic needs effectively. Public access to electricity is a manifestation of social justice, a fundamental human right, and an indicator of a nation's welfare (Aminudin, 2020).

The growing demand for electricity is directly proportional to population growth (Alnavis et al., 2024). According to data from the Ministry of Energy and Mineral Resources

(2026), electricity consumption reached 1,584 kWh per capita, equivalent to 108.2% of the government's target of 1,464 kWh per capita. However, most electricity generation still relies on non-renewable natural resources such as coal, petroleum, and natural gas. In 2019, approximately 87.6% of electricity generation was still dependent on fossil fuels (Giwangkara, 2021). This situation poses a threat to Indonesia's energy security, as continuous exploitation will eventually deplete these energy resources. Therefore, innovation through renewable energy utilization is required to support sustainability and address energy inequality in areas facing barriers to electricity access (Magalhaes & Hartanto, 2020).

The utilization of New and Renewable Energy (NRE) has been mandated under Government Regulation No. 79 of 2014 concerning the National Energy Policy. NRE offers numerous advantages, including minimal pollution, reduced environmental degradation, and fewer health-related impacts (Rumahorbo & Nursadi, 2023). Indonesia has set targets for renewable energy to contribute 23% of the national energy mix by 2025 and 31% by 2050 (Paturu & Yulianingrum, 2023). Currently, water and solar energy are among the most widely utilized renewable energy sources for electricity generation. Renewable energy technologies that are efficient and environmentally friendly continue to be promoted as alternative energy solutions capable of reaching all segments of society.

Furthermore, in electricity generation, energy derived from flowing water (hydropower) has enormous potential to be harnessed as a source of electrical power generation. Water is an inexpensive and readily available energy resource that contains both potential and kinetic energy from flowing and falling water (Sofyan & Sudana, 2022). Indonesia's hydropower potential is estimated at 75,091 MW, while mini-hydro and micro-hydro resources account for approximately 19,385 MW (Alnavis et al., 2024). In addition to being widely available within local communities, hydro, mini-hydro, and micro-hydro power systems require relatively simple components to generate electricity. These systems generally consist of turbines and generators driven by the kinetic energy of flowing water.

One notable real-world example of renewable energy innovation at the community level is Batur Village, located in Gading District, Probolinggo Regency, East Java Province. Batur Village has been a community empowerment partner of the CSR program of PLN Nusantara Power UP Paiton since 2024. The village consists of four hamlets: Krajan, Rabunan, Kleppo, and Tanah Merah. Situated on the slopes of the Argopuro Mountains, Batur Village possesses stable river flows throughout the year. Despite these abundant natural resources, 334 residents still in RT 8 and RT 9 of Tanah Merah Hamlet do not have access to electricity, limiting their ability to develop both social and economic activities.

In response to these opportunities and challenges, the CSR program of PLN Nusantara Power UP Paiton has promoted renewable energy innovation through the development of a Micro-Hydro Power Plant (PLTMH) to provide electricity to areas of Batur Village that remain unserved by the electricity grid. As an electricity generation company, PT PLN Nusantara Power UP Paiton implemented this intervention as a means of sharing its core business competencies with the community. This initiative is particularly noteworthy because the renewable energy innovation for electricity provision in Batur Village is rooted in the community's local assets and is managed independently by residents, a practice that has not yet been widely implemented in other regions.

The intervention carried out by the CSR program of PLN Nusantara Power UP Paiton represents a form of private-sector participation in rural development. Rural development is a means of improving the quality of village areas as well as enhancing the capacity of local communities (Djahmiq & Salahudin, 2022). Its primary objective is to achieve community self-reliance through social transformation generated by collective community action. Villages are long-standing social entities that have survived for generations by utilizing their inherent

potential. Therefore, development interventions should accommodate local characteristics and preserve the roles of local change agents. In the context of rural development, entrepreneurship development serves as one approach to increasing the added value of villages through innovations based on local uniqueness and resources. Innovation is a crucial element in rural development because it fosters continuous learning and improvement processes (Djahmiq & Salahudin, 2022).

In rural development efforts, three key actors play important roles: the government, the private sector, and Civil Society Organizations (CSOs). The government serves as the primary driver, catalyst, and pioneer of development initiatives (Mondong, 2013, as cited in Djahmiq & Salahudin, 2022). Companies, such as through the intervention implemented by the CSR program of Tanggung Jawab Sosial Lingkungan (TJSL) (Nabilla & Hamid, 2021). Meanwhile, local communities themselves are the principal actors in rural development.

Companies contribute to rural development through TJSL programs as part of their responsibility for the externalities generated by their operational activities. Furthermore, TJSL emerges as a form of welfare pluralism that fills gaps in the welfare distribution process traditionally carried out by the state (Sumarto, 2007). TJSL programs enable communities to access alternative forms of social welfare services beyond those provided by the government. These initiatives are generally implemented through community development programs aimed at addressing social issues such as social vulnerability, poverty, low educational attainment, and other community challenges.

The TJSL intervention implemented by PLN Nusantara Power UP Paiton in Batur Village focused on reactivating the community group responsible for managing the PLTMH, which had previously ceased operation due to equipment damage. The PLTMH in Batur Village is independently managed by a five-member community management group. This initiative followed a bottom-up approach, originating from community aspirations and subsequently supported and facilitated by the company through the repair of the PLTMH generator and intake canal, consolidation of the management group, construction of an access road to the powerhouse, Occupational Health and Safety (OHS) training, and the provision of Personal Protective Equipment (PPE) for PLTMH operators. Following the involvement of PLN Nusantara Power UP Paiton's CSR program, the PLTMH resumed normal operations, while its operators experienced improvements in both technical capacity and workplace safety. The intervention successfully provided electricity access to 90 households, one school, eight places of worship, and three local industries in Batur Village.

The renewable energy innovation through the PLTMH in Batur Village has not only supplied electricity to residents of RT 8 and RT 9 in Tanah Merah Hamlet but has also generated significant social and economic benefits. With a stable electricity supply, community productivity has increased, access to information has improved, and local economic activities have expanded (Dwilestari et al., 2025). Socially, the introduction of electricity to several areas of Batur Village has strengthened community solidarity, optimized residents' nighttime activities, and improved the quality of local education. Economically, the PLTMH has provided renewable electricity for local enterprises, thereby enhancing community productivity and economic growth.

One of the businesses that emerged and developed as a result of the PLTMH initiative in Batur Village is Kopi Turi, managed by Kelompok Tani Batur Pandan Wangi. Kopi Turi was established as a follow-up program initiated by the CSR program of PLN Nusantara Power UP Paiton after the successful implementation of electricity provision through the PLTMH. The program was developed based on Batur Village's potential as one of the region's major Robusta coffee-producing areas, with annual production reaching approximately 400 tons. However, this potential had not been fully utilized because most farmers relied primarily on

selling wet coffee beans. In addition, the drying process depended heavily on sunlight, creating significant challenges during the rainy season.

In line with the intervention implemented through the PLTMH, and based on the existing potential and challenges related to coffee production, the CSR program of PLN Nusantara Power UP Paiton initiated an approach in 2025 by establishing a farmer group, assisting with the licensing of MSME products, and constructing the Kopi Turi production facility. Subsequently, in 2026, the coffee-processing equipment was electrified, including a dryer, roasting machine, grinder, and sealer. All of this equipment is powered by electricity generated by the PLTMH. Through this intervention, the income of members of the Batur Pandan Wangi Farmers Group has increased, as they are now able to sell downstream-processed coffee products in the form of ground coffee and roasted beans.

Furthermore, an empowerment program for laying-hen farming was developed for female Posyandu cadres who are members of Kelompok Srikandi Batur. This livestock activity is also supported by electricity generated by the PLTMH. The objective of this initiative is to increase the income of Kelompok Srikandi Batur through productive economic activities supported by locally generated renewable energy. In addition, the activity is intended to provide locally sourced supplementary food (Pemberian Makanan Tambahan—PMT) for undernourished toddlers. Thus, in addition to contributing to the economic empowerment of women members of Kelompok Srikandi Batur, the renewable energy innovation through the PLTMH also contributes to improving local nutritional conditions.

Several intervention processes, including the PLTMH, Kopi Turi, and laying-hen farming initiatives, employ an empowerment approach based on local potential. Empowerment is undertaken to create collective benefits and strengthen community capacity so that the condition of the community improves compared with its situation before the intervention (Baumgartner & Quaas, 2010, as cited in Magalhaes & Hartanto, 2020). This approach ultimately aims to achieve group self-reliance and program sustainability, enabling the initiatives to continue operating even after the company's facilitation and assistance have ended.

Empowerment based on local potential can serve as a strategy for stimulating the village economy through equitable resource allocation, institutional strengthening, and the enhancement of local resource capacity (Nugroho & Setyowati, 2014, as cited in Magalhaes & Hartanto, 2020). Capacity building can encourage changes in mindsets, thereby supporting a fairer resource allocation process, while institutional strengthening can enhance the effectiveness and efficiency of resource allocation. In this regard, both efforts have been implemented through the reactivation of the PLTMH, the strengthening of the institutional capacity and capabilities of Kelompok Tani Batur Pandan Wangi, and the empowerment program for Kelompok Srikandi Batur. Therefore, it is important to examine the empowerment processes involving the PLTMH Group, Kelompok Tani Batur Pandan Wangi, and Kelompok Srikandi Batur comprehensively to understand how the empowerment programs have been implemented and how renewable energy innovation at the community level contributes to creating new economic opportunities for the community.

B. METHOD

This study employed a descriptive qualitative method to explain the implementation of the community empowerment program conducted by the CSR program of PLN Nusantara Power UP Paiton. The descriptive qualitative method was employed to describe a phenomenon in a specific, systematic, and in-depth manner (Suryabrata, 2003, as cited in Sumanti, 2020). The study was conducted in Batur Village, Gading District, Probolinggo Regency. Batur

Village was selected as the research site because it is one of the company's CSR-assisted villages with various challenges and local potentials that can be further developed.

The informants in this study were selected using purposive sampling because specific criteria were established to obtain objective data. The selected informants included members of the PLTMH group, Poktan Kopi Batur Pandan Wangi, and Kelompok Srikandi Batur, which also serves as a beneficiary group in the laying-hen farming sub-activity. Three data collection techniques were employed: observation, interviews, and documentation. Observation was conducted through direct examination of the research setting in Batur Village. Interviews were conducted through face-to-face meetings with beneficiary groups participating in the CSR program. Meanwhile, documentation involved collecting data and information related to the implementation of the activities.

Data analysis was conducted in three stages: data reduction, data presentation, and conclusion drawing. Data reduction involved simplifying raw data into more concise and manageable information for analysis. Data presentation was conducted using tables and diagrams to facilitate the explanation of the findings. Conclusion drawing involved interpreting the analyzed data and presenting the results as meaningful information.

C. RESULT AND DISCUSSION

The renewable energy sector plays a strategic role in supporting development across various regions of Indonesia, a country rich in natural resources. Batur Village, Gading District, Probolinggo Regency, is located on the slopes of the Argopuro Mountains at an elevation of 400–700 meters above sea level. Its hilly geographical conditions and considerable distance from the urban center have resulted in various challenges for the local community, particularly regarding access to electricity. The absence of electricity in a particular area can hinder the community's social and economic activities (Kali, 2012; Sapthu, 2023). This is the situation experienced by residents of RT 8 and RT 9 in Tanah Merah Hamlet, who had lived without electricity for decades. The community also faces a double burden due to recurring natural disasters. According to the 2025 Regional Government Administration Report (LPPD) of Probolinggo Regency, rainfall intensity in Gading District exceeds 400 mm and is categorized as very high. This condition is a major trigger for floods and landslides in Batur Village. Within a year, the frequency of floods and landslides in Batur Village exceeds ten events, with varying intensity, locations, and levels of damage.

In response to these challenges, the CSR program of PLN Nusantara Power UP Paiton initiated the ARUNA LESTARI Program (Arus Energi Terbarukan Untuk Lumbung Ekonomi Batur Mandiri), which aims to address electricity access issues through the reactivation of a Micro-Hydro Power Plant (PLTMH). Based on field interviews, the PLTMH facility in Tanah Merah Hamlet has existed since 2012. At that time, the PLTMH infrastructure was constructed by the Probolinggo Regency Government. However, due to inadequate management and maintenance, the PLTMH equipment was damaged and ceased operation. The company responded to this situation by conducting social mapping to identify the challenges and potential resources that could serve as the basis for community empowerment activities in Batur Village. The mapping revealed that one of the village's key natural assets is the Tanah Merah River and the Rabunan River, both of which have relatively stable water discharge throughout the year. Subsequently, the CSR program of PLN Nusantara Power UP Paiton, involving several internal departments, revitalized the PLTMH infrastructure in 2024 by repairing the generator and constructing an access staircase leading to the powerhouse.

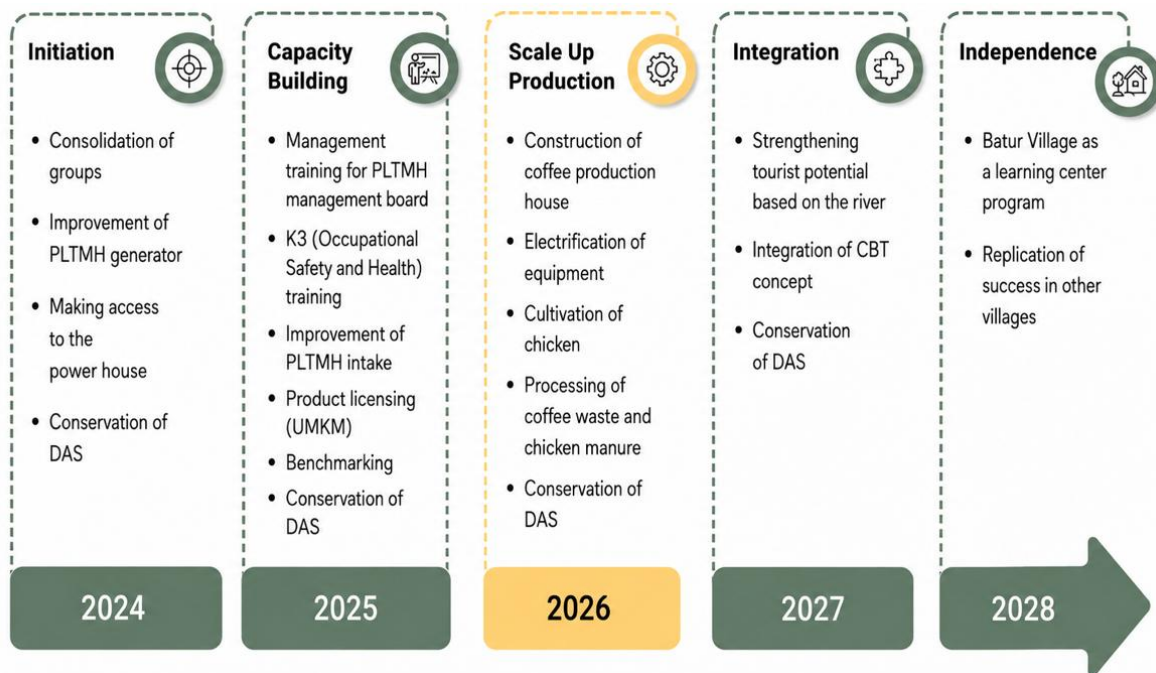


Figure 1. Roadmap of ARUNA LESTARI Program

Source: Company Data Processing, 2024

In accordance with the five-year program roadmap, the first year of implementation focused on consolidating the Tanah Merah PLTMH Group as the operator responsible for operating and maintaining the equipment, as well as managing the payment system for electricity users to the group. The company also implemented watershed conservation activities through a tree-planting initiative involving 1,000 trees annually. The trees planted included fruit-bearing species such as avocado and durian, which were considered beneficial not only from an ecological perspective but also because of their potential economic benefits for the surrounding community (Sjahrudin et al., 2026).

Subsequently, in 2025, the company improved the PLTMH infrastructure by rehabilitating the intake canal, which had previously been constructed using temporary materials such as wood and sand-filled sacks. During floods, the dam frequently collapsed because these materials were swept away by the strong water flow from upstream. Damage to the intake canal affected the reliability of PLTMH operations because large amounts of rocks and sand entered the penstock, causing the PLTMH to cease operating.

To support the operational reliability of the PLTMH, the company also installed a Flood Early Warning System (FEWS) upstream to monitor the river water level. When the river level rises, PLTMH operators receive notifications through a Wi-Fi-connected device, enabling them to promptly open the dam gates and prevent materials such as rocks and sand from entering the PLTMH penstock. In addition to supporting PLTMH operational performance, FEWS also serves as an early warning system for residents of Tanah Merah Hamlet, enabling them to take precautionary measures in response to potential flood hazards.

In addition to infrastructure improvements, the company sought to strengthen the capacity of the Tanah Merah PLTMH Group by conducting electrical safety training, with the company's Occupational Health and Safety (OHS) Department serving as the training resource team. The company also provided five sets of Personal Protective Equipment (PPE) for PLTMH operators and facilitated a benchmarking visit to Andungbiru Village, Tiris District, Probolinggo Regency. Andungbiru Village is one of the communities supported by the CSR

program of PLN Nusantara Power UP Paiton and has achieved operational independence, making it a best practice for PLTMH management at the Probolinggo Regency level.

The availability of a reliable PLTMH electricity supply has stimulated the growth of local enterprises, particularly in the coffee-processing sector. Whereas many coffee farmers previously sold coffee beans in their wet form, community practices have now shifted toward utilizing and processing coffee beans into ready-to-consume packaged products. This behavioral change aimed at improving the economic well-being of coffee farmers in Batur Village has also been supported by assistance from the company's CSR program. In 2026, the company provided support in the form of a production facility and coffee-processing equipment. Several machines, including a coffee dryer and coffee sorting machine, were fabricated by the Engineering Department of UP Paiton and specifically designed to meet the coffee-processing needs of the Batur Village community. The innovation of the coffee dryer has significantly reduced the coffee bean drying time, from three days using solar heat to only three hours through an engineered hot-air circulation system incorporated into the machine. The use of modern drying technology has the potential to improve production efficiency while providing greater economic benefits compared with conventional drying methods (Suherman et al., 2024).

Empowerment in the coffee-processing sector has not only sought to improve the economic well-being of coffee farmers but has also contributed to environmental improvement through waste utilization. Previous research has shown that coffee processing generates coffee husk waste amounting to approximately 50–60% of the total harvested crop weight (Efendi, as cited in Thamrin et al., 2022). Recognizing coffee husks as an environmental challenge, the company provided training to Kelompok Tani Kopi Batur Pandan Wangi on utilizing coffee husk waste as organic fertilizer. The addition of organic fertilizer to the planting medium has been shown to significantly affect coffee seedling growth, particularly in terms of plant height and leaf width (Falahudin et al., 2016).

As part of women's empowerment, the wives of coffee farmers have been involved in the packaging and digital marketing of a product branded "Kopi Turi." Currently, Kelompok Tani Kopi Batur Pandan Wangi produces three main products: packaged ground coffee, roasted beans, and coffee sachets. Coffee sales initially targeted nearby food stalls and shops and have since expanded to digital platforms such as Shopee and TikTok Shop. In addition, the group has established partnerships with several cafés, including Cafe & Resto Pantai Bohay, located in Binor Village, Paiton District, Probolinggo Regency. The group's marketing partnerships with various parties are formalized through Memoranda of Understanding (MoUs) to ensure market access and price certainty for the products sold.

Women's empowerment activities also address health improvement, particularly child growth and development. In 2026, the company provided four sets of laying-hen cages to the Srikandi Batur Group. The eggs produced daily can be sold as an additional source of group income, while some of the production is allocated to a child nutrition program for undernourished children through the Supplementary Feeding Program (PMT). Electricity also supports laying-hen farming by providing lighting, heating, and enabling cage automation, such as automatic water pumps.

In 2027, the utilization of natural capital in the form of stable river flows will be expanded beyond electricity generation through the PLTMH to include the development of a community-based river tourism destination. Through a Community-Based Tourism (CBT) approach, Rabunan River Tourism can serve as a platform that brings together various creative economic products developed in Batur Village. The CBT approach enables local communities to become the primary actors in destination management while simultaneously gaining social and economic benefits from tourism activities (Suyatna et al., 2024). The establishment of

business linkages between the Pokdarwis Rabunan and Kopi Turi can help ensure program sustainability, as the availability of markets is crucial for maintaining economic stability and circulation, particularly for micro, small, and medium-sized enterprises (MSMEs) (Pego & Dewi, 2024).

With its abundant natural resources, Batur Village has successfully transformed a condition of vulnerability into one of empowerment. The utilization of natural capital to strengthen the community's socioeconomic potential in Batur Village represents an implementation of the asset-based community empowerment model. Historically, asset-based empowerment approaches emerged in response to the shortcomings of the classical trickle-down effect development paradigm, which instead generated various serious problems, including poverty, inequality, and underdevelopment (Rahardjo, as cited in Maulana, 2019). The asset-based empowerment model proposes that development programs should be grounded in and directly driven by the community. Communities are empowered to identify, classify, and match the assets, strengths, and potentials available within their groups or communities (Setyawan et al., 2022; Sudarmanto as cited in Rahayu et al., 2022).

Green and Haines (2015) identify seven indicators that can be used in an asset-based approach: human capital, social capital, physical capital, financial capital, environmental capital, political capital, and cultural capital. In the context of Batur Village, empowerment activities implemented through the ARUNA LESTARI Program have successfully enhanced community assets and access, as reflected in the following forms of capital:

Table 1. Achievements of the ARUNA LESTARI Program

No	Capital Indicator	ARUNA LESTARI Program Achievements
1	Human Capital	Improved the skills of 5 operators in operating the PLTMH
		Improved the skills of 15 people in coffee processing
		Improved the skills of 21 people through training on producing organic fertilizer from coffee husk waste and chicken manure
2	Social Capital	Expanded the number of beneficiaries from 60 to 401 people
		Established 1 new group, namely the Srikandi Batur Group
		Integrated 3 community groups into the program
		Empowered 11 members of low-income households, 5 older adults, and 2 school dropouts through coffee-processing activities
3	Physical Capital	Constructed 1 staircase leading to the powerhouse and rehabilitated 1 PLTMH intake canal
		Established 1 coffee production facility and electrified 8 coffee-processing machines
		Installed 1 FEWS unit in Batur Village
4	Financial Capital	Increased coffee product sales to more than 1,670 packs per year
		Reduced expenditure on chemical fertilizers by IDR 11,200,000 per year
		Reduced PLTMH maintenance costs to IDR 1,000,000 per year
5	Environmental Capital	Sequestered 85 tons of CO ₂ equivalent through the planting of 3,000 fruit trees
		Utilized 2 tons of coffee husk waste to produce organic fertilizer

Source: Company Data Processing, 2026

From the perspective of human capital, significant changes have occurred among individuals who previously neglected Occupational Health and Safety (OHS) procedures when operating the PLTMH equipment and who now routinely use Personal Protective Equipment (PPE). Similarly, coffee farmers who previously burned or discarded coffee husk waste now

utilize it as organic fertilizer for crops. These behavioral changes have also contributed to improvements in the intellectual capacity and capabilities of the coffee group, as demonstrated by the acquisition of business licensing certificates, including a Business Identification Number (NIB), a Home Industry Food Production Certificate (PIRT), and a Halal Certificate for Kopi Turi products.

From a social perspective, the availability of PLTMH-generated electricity has improved the quality of life of 401 program beneficiaries, comprising 334 PLTMH users, 33 members of the Poktan Kopi, 22 members of Kelompok Srikandi Batur, and 12 undernourished toddlers who receive supplementary food through the PMT program. The program beneficiaries are heterogeneous in terms of gender, consisting of 252 males and 149 females. In terms of educational background, beneficiaries range from elementary school graduates to university graduates. In terms of occupation, they include farmers, teachers, entrepreneurs, private-sector employees, and government employees. The program has also successfully revitalized the community's tradition of cooperation (*gotong royong*) through the integration of three groups in organic fertilizer production activities, one of which is the newly established Kelompok Srikandi Batur. The coffee-processing activities have also empowered several vulnerable groups, including 11 members of low-income households whose incomes increased by IDR 1,200,000 per month, 5 older adults who were engaged in coffee husk waste processing, and 2 school dropouts who gained employment through coffee bean milling services, enabling them to earn approximately IDR 1,200,000 per month.

The infrastructure and facilities provided through the company's CSR program have also contributed to improving the economic conditions of beneficiaries. The rehabilitation of the PLTMH intake canal into a permanent dam successfully reduced PLTMH maintenance costs to IDR 1,000,000 per year. Similarly, the intervention for the coffee group, through the construction of a production facility and electrification of production equipment, increased coffee product sales to more than 1,670 packs per year. In addition, the group's ability to produce organic fertilizer from coffee husk waste and chicken manure has reduced expenditure on chemical fertilizers for crop maintenance by IDR 11,200,000 per year. Fertilizer production and tree-planting activities have also contributed to environmental improvement by sequestering 85 tons of CO₂ equivalent through the planting of 3,000 fruit trees and utilizing 2 tons of coffee husk waste to produce organic fertilizer.

D. CONCLUSION

This study analyzed the maintenance effectiveness of Hot Melt Machine 01 at PT. Nutech Pundi Artha Purwakarta using the MTBF and MTTR methods over the September 2025-February 2026 period. The results showed that the machine experienced fifteen failures across a total operating time of 992 hours, with an average MTBF of 69 hours per month and an average Availability of 94%, while the average MTTR was 3.9 hours per event out of a total downtime of 58 hours, with the weakest performance occurring in November and January. Pareto analysis identified spray-nozzle replacement, pump-PCB damage, and control-board damage as the dominant causes, with the top ten types of failure contributing nearly 80% of total downtime, while Fishbone analysis identified that the main root causes were the absence of a daily inspection checklist and inconsistent completion of the maintenance logbook.

These findings led to a proposal to develop a Daily Checklist for Hot Melt Machine 01 as an early-inspection medium and to optimize the use of the Maintenance Logbook as a medium for documenting failure and repair history. Both proposals are expected to enable earlier detection of potential damage, increase MTBF, reduce MTTR, and improve the Availability of Hot Melt Machine 01, thereby ensuring greater stability and efficiency of the BZ340 Carpet production process in the future.

For practical implementation, it is recommended that PT. Nutech Pundi Artha immediately apply the Daily Checklist and Maintenance Logbook consistently at the start of every work shift, accompanied by socialization and training for operators and maintenance technicians so that both documents function as part of the daily work routine rather than as administrative formalities. The company should also periodically evaluate the MTBF and MTTR data recorded in the logbook, particularly ahead of months with historically high failure frequency such as October, November, and January, so that the preventive-maintenance schedule can be adjusted more precisely, and should secure the availability of critical spare parts, such as spray nozzles, pump PCBs, heater guns, and control boards, through better inventory planning to reduce repair time (MTTR) in the event of sudden failure. Future research is recommended to extend the scope of analysis to include maintenance cost and the financial impact of downtime, to cover other machines within the production line, and to complement the root-cause analysis with direct technical testing of machine components, so that the results can more comprehensively support maintenance decision-making at PT. Nutech Pundi Artha.

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