Vol. 14, No. 5 (2025): 1767 - 1777 https://doi.org/10.23960/jtepl.v14i5.1767-1777

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

# Application of Solar Energy for Coconut Grating Machine in Rural Areas

Husen Asbanu[1], Yendi Esye[2,✉], Yefri Chan[1], Danny Faturachman[3]

[1] Department of Mechanical Engineering, Faculty of Engineering, Darma Persada University, East Jakarta, 13450, INDONESIA.
[2] Department of Electrical Engineering, Faculty of Engineering, Darma Persada University, East Jakarta, 13450, INDONESIA.
[3] Department of Marine Engineering, Faculty of Marine Technology, Darma Persada University, East Jakarta, 13450, INDONESIA.

**Article History:**

Received : 28 April 2025
Revised : 02 July 2025
Accepted : 29 July 2025

**Keywords:**

*Appropriate technology,*
*Coconut processing,*
*Grating machine,*
*Renewable energy.*

Corresponding Author:
✉ yendiesye@gmail.com
(Yendi Esye)

**ABSTRACT**

*Manual processing of coconut and the expensive gasoline force farmers to sell copra at low prices. This study explores the potential use of solar energy for operating coconut grating machines. The experiment utilized a 100 Wp solar panel to run a coconut grating machine driven using ¼ HP electric motor. The observation parameters included solar irradiance, power, voltage, current, battery charging duration, and energy efficiency. The results indicate that a 100 Wp solar panel is insufficient to meet the power requirements of the 186 W electric motor. Therefore, adding at least two solar panels and increasing the battery capacity must meet the machine's operational requirements. The battery charging time, until complete, is recorded at 16 h. Without the support of solar panels, the battery can operate the machine for 3 to 4 h. Meanwhile, when the battery is recharged while the machine operates with the solar panel system, the operating duration can reach 6 to 7 h. Therefore, solar energy demonstrates great potential as a renewable energy solution that can be utilized in the agricultural processing process in rural areas in a sustainable and environmentally friendly manner. Testing of the coconut grating machine powered by solar energy, supported by a 12V 100Ah battery and a 1/4 HP motor, showed that it can operate for approximately 3.8 h in a single work cycle. With a grating duration of 2.6 min per coconut, the system can grate up to approximately 87 coconuts per operational cycle.*

## 1. INTRODUCTION

Coconut plants are one of Indonesia's most important oil-producing fruit crops, providing economic and nutritional benefits to rural communities (Murtius, 2024). Coconut plants are generally cultivated in rural areas, and their processing is still carried out traditionally at the household level, using inefficient methods that require a significant amount of time to produce coconut oil. This obstacle is generally caused by the low interest of the community in developing coconuts into economically valuable products. Innovations in the coconut processing process have the potential to bring positive impacts to rural communities by improving time and cost efficiency, as well as enhancing workplace safety (Sajil Raj *et al*., 2016). Coconuts play a strategic role in agricultural systems, particularly for farming communities in rural areas. However, coconut production has declined due to aging trees and suboptimal management practices, while the processing technology for coconut-based products has yet to develop (Muslim & Darwis, 2018). Nevertheless, small-scale coconut farmers are still among the lowest income levels. In addition to serving as a food source, coconuts are also used as raw materials in various industrial sectors. Therefore, adopting modern technology that can reduce production costs is essential to meet market demands and improve the quality of processed products. This modernization effort is expected to drive the development of the coconut industry and indirectly contribute to improving the community's living standards (Johnson *et al*., 2024).

Coconut is a primary food source for communities in rural areas, as this fruit provides a significant amount of calories through its oil content. Additionally, coconut meat contains protein and bioactive compounds with various health benefits (Karunakaran *et al*., 2023). Coconut oil processed using traditional techniques has a higher content of medium-chain fatty acids and saturated fatty acid glycerides. Although there is a debate regarding the health benefits and potential adverse effects of coconut oil, natural coconut products such as grated coconut, virgin coconut oil (VCO), coconut milk, coconut flour, coconut water, and coconut sugar, which do not undergo chemical processing, demonstrate highly beneficial nutritional content (Mat *et al*., 2022). Increased attention to coconut fruit's antioxidant activity and fiber content has driven consumer demand for natural coconut oil (Samarajeewa, 2024).

Optimizing the coconut processing process is a strategic step toward improving the quality and quantity of the oil produced, reducing production costs and time (Adekola, 2014). This increase in efficiency is expected to add value to coconut products, thereby strengthening food security and improving the economic well-being of rural communities (Andriansyah *et al*., 2024). One of the main challenges in developing the coconut oil processing industry in rural areas is the limited access to stable energy sources, such as gasoline or electricity, which are needed to operate oil processing machines and support the economic livelihood of rural communities (Mukherjee & Sovacool, 2014). Commercial coconut graters tend to have a high setup cost and high power demand. Consumption makes them unaffordable for poor rural communities. Population growth, urbanization, and the demand of processing coconut for the food and other industrial sectors has increased its energy demand. Resulting in the accelerated depletion of customary fossil fuel reserves, thus requiring the use of alternative energy, biomass and solar panels. (Prabhu *et al*., 2025). The transition to renewable energy sources can help the increasing the energy demand while posing a risk to the global food security (Das *et al*., 2022).

Solar energy can produce heat, which can be used to operate farm and food processing machinery (Rani *et al*., 2024). The major advantage of solar energy is the great potential which could solve many problems encountered by the food processing industry of coconut. A few barriers including poor infrastructure, the underdeveloped state of solar technologies, and lack of investment have hampered the commercialization of solar energy (Mustafa *et al*., 2024). However, solar energy is an emerging alternative that could make a meaningful contribution to future socio-economic growth (Ukoba *et al*., 2024). In recent times, the integration of solar energy into hybrid technologies, system designs, operational strategies, economic studies, and the processing of agro-food products has expanded considerably. As one of the most effective renewable energy sources, solar energy can significantly counter the reliance on fossil fuels (Khan *et al*., 2024). The reduction of fossil fuels has driven the development of green substitutes for electricity in the quest to solve energy problems alongside the protection of the environment. For rural communities, improvements to community productive coconut farming will benefit from the use advanced modular solar technologies. The solar technologies will be economically beneficial to the nation as well.

## 2. MATERIALS AND METHODS

### 2.1. Materials and Equipment

This study used coconut as the primary material sourced from rural areas. The coconut oil processing involves several stages, from obtaining coconuts from farmers, peeling the shells and husks, grating the coconut meat, and pressing the coconut milk. At the grating stage, this study utilizes solar energy to power the grating motor and reduce the workload of rural communities. The experiment was conducted for 7 working days at different weather (cloud) conditions.

This study utilized several key components, including a coconut grating machine powered by a 1/4 HP DC electric motor (approximately 186 Watts). This motor drives the grating shaft and is powered by a 100 Wp solar panel. The motor had a rotational speed of 1450 RPM and required 220 volts AC to operate. This voltage was supplied by an inverter that converted the direct current from the battery into alternating current. The inverter drew power from a 100 Ah, 12-volt battery, which was charged using a 100 Wp polycrystalline solar panel. The panel had a maximum power output of 100 W, an optimal operating voltage and current of 17.6 V and 5.7 A, and physical dimensions of 1002 × 670 × 35 mm. The system incorporated a Zeus brand battery, which had a capacity of 12 volts and 100 Ah, along with supporting devices that included a light intensity indicator, DC-AC inverter, tachometer, multimeter, and temperature sensor for Monitoring the system performance. In the assembly stage, the solar panel and electric motor for the coconut oil processing machine was integrated together, which was documented as shown in Figure 1. These photos of the documentation were taken as part of the research shown in Figure 2.

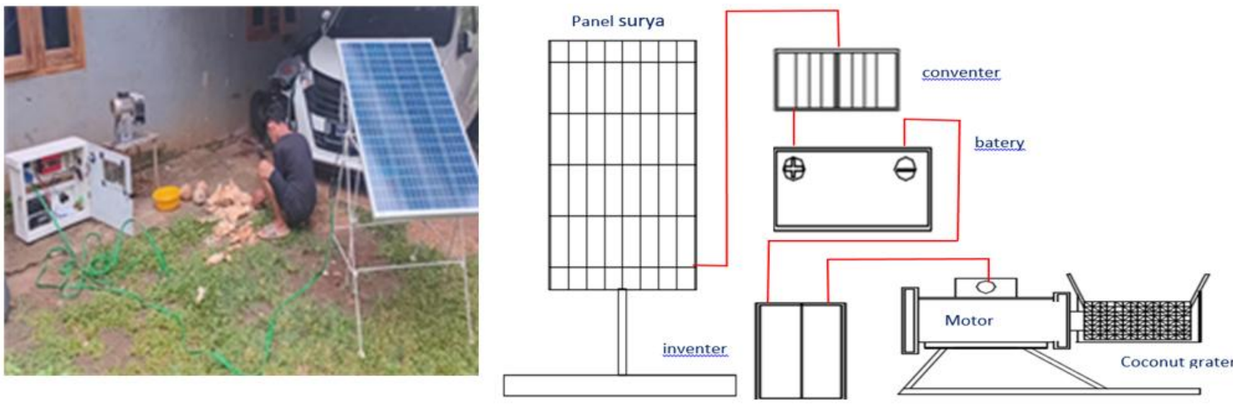


Figure 1. Solar-powered coconut grating machine circuit

Figure 2. Documentations of research implementation

## 2.2. Parameters and Measurements

Evaluating the performance of the solar panel involved several key parameters, such as measuring light intensity with a lux meter and the voltage and current that a digital multimeter provided. A wattmeter provided the system output power information so that energy conversion efficiency could be determined. Moreover, the battery charging and discharging processes involved observations on the voltage and current changes, recording the time taken for each stage, along with parameters at the beginning and the ending of each stage. The measured variables along with the methodology used for data collection are outlined in Table 1.

Table 1. The factors used to assess the performance of the 100 Wp solar panel in the experiment.

| Variable testing | | Measurement method | Unit |
|---|---|---|---|
| Ligth Intensity | | Light intensity meter | $W/m^2$ |
| Voltage (V) | | Multimeter | volt |
| Current (I) | | Multimeter | A |
| Power (P) | | Wattmeter | W |
| Battery Charging-Discharging: | Initial and final voltage | Multimeter | V |
| | Initial and final current | Multimeter | A |
| | Time required for charging-discharging | Stop watch | h |

## 3. RESULT AND DISCUSSION

The results of the 100 Wp solar panel performance test conducted from December 2024 to January 2025 are presented in Table 2.This test involved monitoring light intensity, voltage, current, and the power generated by the panel in the field. The collected data were used to assess the stability and efficiency of the solar panel in supporting the operation of coconut oil processing machines in rural areas. The test results indicate that solar radiation plays a significant role in determining the amount of power produced by the solar panel. The harnessing of solar energy has advanced rapidly alongside developments in computing technology.

Table 2. Results of solar panel testing

| Date | Time (Clock) | Solar intensity (W/m$^2$) | Input Power (W) | Voltage (V) | Current (A) | Power (W) | Efficiency (%) | Mark |
|---|---|---|---|---|---|---|---|---|
| 14 Dec 24 | 8.00 | 473 | 307.4 | 13.1 | 2.73 | 35.7 | 0.11 | cloudy |
| | 10.00 | 667 | 433.5 | 17.2 | 3.91 | 67.2 | 0.15 | sunny |
| | 12.00 | 867 | 563.5 | 17.3 | 4.24 | 73.3 | 0.13 | sunny |
| | 14.00 | 902 | 586.3 | 19.3 | 5.13 | 99.0 | 0.14 | sunny |
| | 16.00 | 569 | 369.8 | 13.5 | 3.02 | 40.8 | 0.11 | cloudy |
| | Average | 695.6 | 452.1 | 16.0 | 3.806 | 63.2 | 0.13 | |
| 27 Dec 24 | 8.00 | 476.2 | 309.5 | 14.5 | 2.72 | 39.4 | 0.12 | cloudy |
| | 10.00 | 743.5 | 483.2 | 15.8 | 3.55 | 56.1 | 0.11 | sunny |
| | 12.00 | 813 | 528.4 | 19.0 | 4.81 | 91.7 | 0.17 | sunny |
| | 14.00 | 981 | 637.6 | 20.9 | 4.82 | 100.7 | 0.15 | sunny |
| | 16.00 | 321 | 208.6 | 12.3 | 1.88 | 23.1 | 0.11 | drizzle |
| | Average | 666.9 | 433.5 | 16.5 | 3.556 | 62.2 | 0.13 | |
| 28 Dec 24 | 8.00 | 526 | 341.9 | 14.9 | 2.9 | 43.3 | 0.12 | sunny |
| | 10.00 | 739 | 480.3 | 18.7 | 3.7 | 69.19 | 0.14 | sunny |
| | 12.00 | 843 | 547.9 | 18.1 | 4.66 | 84.3 | 0.15 | sunny |
| | 14.00 | 800 | 520 | 18.9 | 4.2 | 79.3 | 0.15 | sunny |
| | 16.00 | 428 | 278.2 | 14.8 | 2.61 | 38.6 | 0.13 | cloudy |
| | Average | 667.2 | 433.6 | 17.0 | 3.614 | 62.9 | 0.14 | |
| 29 Dec 24 | 8.00 | 408 | 265.2 | 14.3 | 2.5 | 35.7 | 0.13 | sunny |
| | 10.00 | 719 | 467.3 | 15.9 | 3.79 | 60.2 | 0.12 | sunny |
| | 12.00 | 948 | 616.2 | 20.4 | 4.78 | 97.5 | 0.15 | sunny |
| | 14.00 | 982.4 | 638.5 | 21.3 | 4.81 | 102.4 | 0.16 | sunny |
| | 16.00 | 426 | 276.9 | 14.3 | 1.48 | 21.1 | 0.07 | cloudy |
| | Average | 696.6 | 452.8 | 17.2 | 3.472 | 63.4 | 0.13 | |
| 30 Dec 24 | 8.00 | 432 | 280.8 | 15 | 2.7 | 40.5 | 0.14 | sunny |
| | 10.00 | 723 | 469.9 | 18.3 | 3.98 | 72.8 | 0.15 | sunny |
| | 12.00 | 867 | 563.5 | 18.9 | 4.73 | 89.3 | 0.15 | sunny |
| | 14.00 | 812 | 527.8 | 18.5 | 4.31 | 79.7 | 0.15 | sunny |
| | 16.00 | 427.7 | 278.0 | 13.8 | 1.59 | 21.9 | 0.07 | cloudy |
| | Average | 566.8 | 424.0 | 16.2 | 3.462 | 60.8 | 0.13 | |
| 31 Dec 24 | 8.00 | 342 | 222.3 | 12.2 | 1.8 | 21.9 | 0.09 | sunny |
| | 10.00 | 789 | 512.8 | 16.7 | 3.8 | 63.4 | 0.12 | sunny |
| | 12.00 | 987 | 641.5 | 20.5 | 4.8 | 98.4 | 0.15 | sunny |
| | 14.00 | 1056 | 686.4 | 20.8 | 5 | 104 | 0.15 | sunny |
| | 16.00 | 469 | 304.8 | 14.8 | 2.1 | 31.0 | 0.10 | sunny |
| | Average | 728.6 | 473.5 | 17.0 | 3.5 | 63.7 | 0.12 | |
| 01 Jan 25 | 8.00 | 308.3 | 200.3 | 12.1 | 1.7 | 20.5 | 0.10 | sunny |
| | 10.00 | 734 | 477.1 | 18.2 | 3.5 | 63.7 | 0.13 | sunny |
| | 12.00 | 1068 | 694.2 | 19.8 | 4.9 | 97.0 | 0.13 | sunny |
| | 14.00 | 938 | 609.7 | 19.5 | 4.2 | 81.9 | 0.13 | sunny |
| | 16.00 | 635 | 412.7 | 17.5 | 3.2 | 56 | 0.13 | sunny |
| | Average | 736.6 | 478.8 | 17.4 | 3.5 | 63.8 | 0.12 | |

Previous research has successfully conducted analyses on forecasting and monitoring solar energy production using computer technology with high accuracy. The findings from these studies aim to optimize the utilization of solar energy, thereby supporting more efficient energy planning, reducing waste, and decreasing dependence on fossil fuels (Ledmaoui *et al*., 2023). Other studies have also documented improving the performance of smart, energy-efficient solar energy absorbers which assist in thermal energy harvesting in contemporary industrial setups, using a solar-driven deep learning model. This study created a hybrid fuzzy convolution architecture with an algorithm for managing distributed solar fields (DSFs) in the thermal and electric power generation systems of industries. This, and other, research indicates that the proposed control strategy has decreased temperature tracking errors by as much as

51%, and increased energy efficiency by 17.35%, when compared to the deep deterministic policy gradient without a model and model predictive control techniques. This illustrates the efficacy of the proposed strategy in controlling complex systems of DSFs within a variety of resource balancing objectives (Tilahun, 2024). This also points to the need for the widespread adoption of renewably integrated energy systems, which is critical for ongoing research. Future studies should concentrate on advanced technology development, the study of potential negative factors on the environment, and the development of adoption strategies in unserved rural regions. Information on temperature, humidity, wind speed, atmospheric pressure, and solar radiation was recorded periodically by diverse sensors. This information was used to train machine learning models that estimated the thermal energy output of the solar panels (Armghan *et al*., 2024).

### 3.1. Power and Current Analysis Generated by The Solar Panel

Analysis of power recorded during multiple day observation from December 14, 2025 to January 1, 2025 was descrbed in Table 2 and Figure 3. Maximum power in the observation period was recorded between 79.73 and 100 watts and minimum power in that period was recorded between 60.26 and 72.83. The average power generated was between 60.1 and 60.7 watts. Environmental factors and the intensity of solar radiation during the observation period contributed to the high power produced during the period.

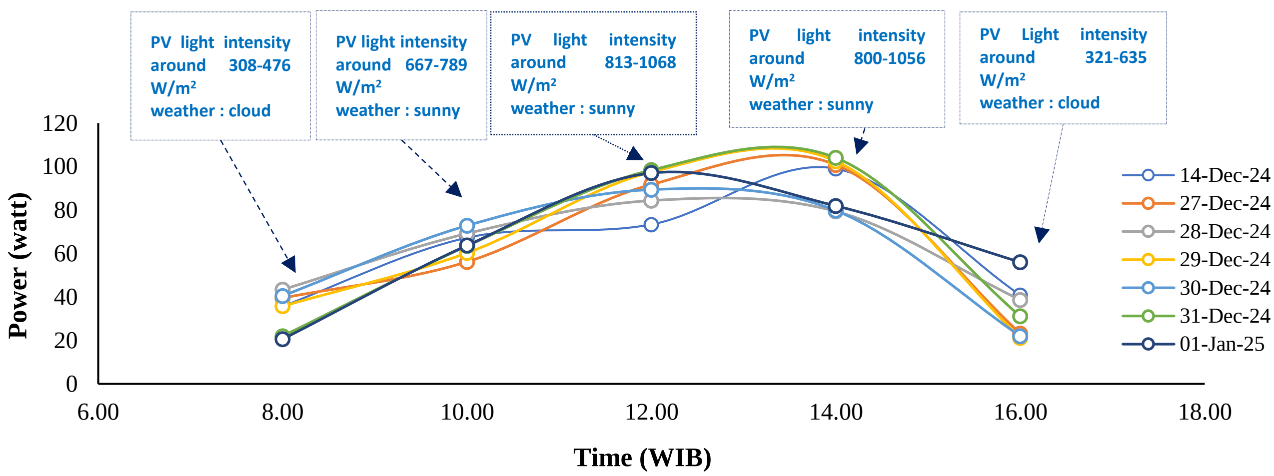


Figure 3. The effect of solar radiation intensity on the power generated.

The impact of temperature and solar irradiance on the surface of solar panels and the resultant electricity generation in it has been documented in the literature. Research has shown that the electricity generated is directly proportional to the intensity of the light. Other literature reports that the performance of solar panels is greatly impacted by the sunlight available and that it during clear days, high temperature and light intensity result in increased voltage and current generated in the panels (Venkateswari & Sreejith, 2019). Other studies have shown that the use of Maximum Power Point Tracking (MPPT) techniques yields optimization of energy production in photovoltaic power generation systems while noting variations in solar radiation. The output power of a solar panel is directly proportional to the amount of solar radiation received. More power is produced when there is more radiation while a decrease in radiation will produce less power (Badea *et al*., 2025).

The analysis of the period between December 14 to 01 January 2025 showed that the electric current ranged between 4.6 and 5 A and was primarily a function of sunlight intensity as given in Table 2 and Figure 4. The weather and its condition influenced the solar panel parameters of voltage, current, and power generated as can be observed from Table 2 and Figure 3-4. This indicates that the 100 Wp solar panel produced a current of which 5 amperes was the peak value and 1.7 amperes was the minimum value. The findings of this research affirm the previous research that had recorded the impact of light intensity and temperature on the surface of solar panels as well as the electricity generated. The findings are such that they show that the electricity produced is more with the observed light intensity

(Senaen *et al*., 2023). The study further showed that the efficiency of solar panels is dependent to a large extent on sunlight, with improved accuracy in weather resulting in enhanced light intensity falling on the panels (Sameera *et al.*, 2024). It has further been shown by other researchers that an increase in solar radiation intensity is directly proportional to the increase in voltage and current developed from solar panels and thereby enhances the performance of photovoltaic systems (Li *et al*., 2021).

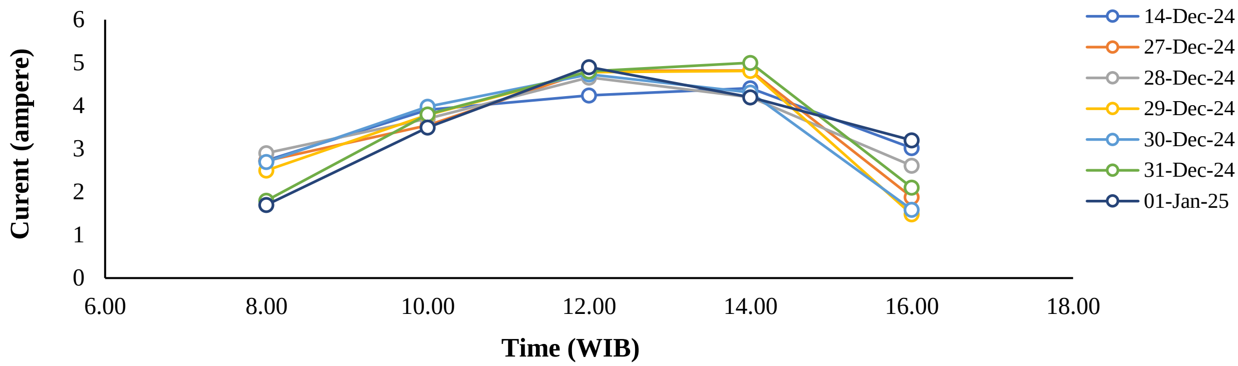


Figure 4. The effect of solar radiation intensity on the electrical current generated

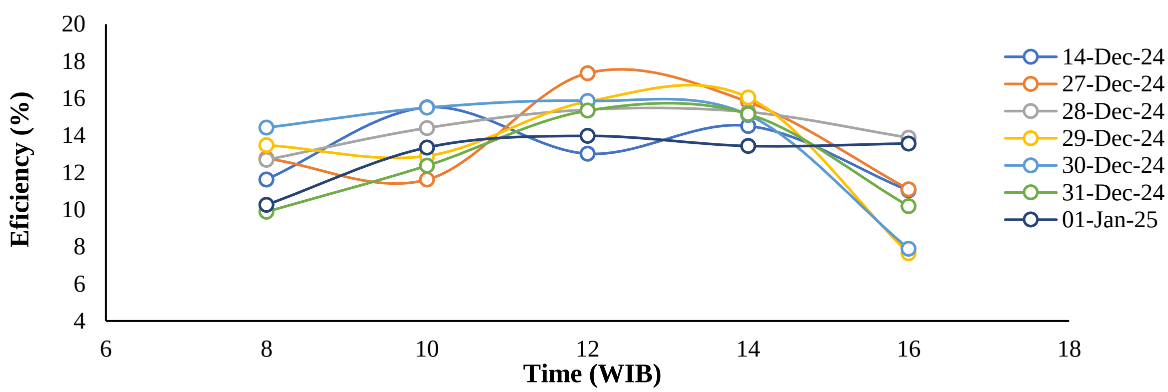


Figure 5. Efficiency of solar energy conversion

### 3.2. Solar Energy Conversion Efficiency

A solar panel with a rated capacity of 100 Wp is designed to deliver a peak output power of 100 watts, as indicated in Table 2 and Figure 5. The average conversion efficiency was determined to be on the order of 12–14%, whereas the solar energy conversion efficiency under different weather conditions was determined to vary from approximately 9–17%. These findings are consistent with those of previous researchers who presented the performance of photovoltaic panels with efficiencies ranging from 11.36% to 13.26% (Elibol *et al*., 2017). A different study analyzed the impact of weather on the performance of a 100 Wp polycrystalline solar panel and presented its efficiency as 16.04% (Nurhaida *et al.*, 2023).

### 3.3. Analysis of Solar Heat Supply and Energy Charging in the Battery

Table 3 presents observation data of the average performance of the battery charging process between December 14, 2024, and January 1, 2025. The observed parameters include solar radiation intensity, electric power from photovoltaic panels, voltage and current during charging, daily duration of charging, total energy from panels, battery terminal voltage, amount of energy stored successfully, and charging efficiency. Intensity of solar radiation during the period ranged between 566.8 and 736.66 W/m² with the peak on January 1, 2025. The system output power was more or less

Table 3. Average battery charging

| Date | Solar intensity ($Wm^2$) | Power (W) | Voltage (V) | Current (A) | Charging time (h) | Energy supply PV (Wh) | Voltage battery (V) | Energy in the battery (Wh) | Charging efficiency (%) |
|---|---|---|---|---|---|---|---|---|---|
| 14 Dec 24 | 695.6 | 63.2 | 16.8 | 3.8 | 8 | 505.6 | 13.8 | 419.52 | 82 |
| 27 Dec 24 | 666.94 | 62.2 | 16.5 | 3.3 | 8 | 497.6 | 13.5 | 356.4 | 71 |
| 28 Dec 24 | 667.2 | 62.9 | 17.0 | 3.6 | 8 | 503.2 | 13.7 | 394.56 | 78 |
| 29 Dec 24 | 696.68 | 63.4 | 17.2 | 3.7 | 8 | 507.2 | 13.9 | 411.44 | 81 |
| 30 Dec 24 | 566.8 | 60.8 | 16.9 | 3.4 | 8 | 486.4 | 13.3 | 361.76 | 74 |
| 31 Dec 24 | 728.6 | 63.7 | 17.0 | 3.5 | 8 | 510.24 | 14.1 | 394.8 | 77 |
| 01 Jan 25 | 736.66 | 63.8 | 17.4 | 3.5 | 8 | 510.48 | 14.4 | 403.2 | 78 |

constant and ranged between 60.8 and 63.8 watts. The panel output voltage ranged between 16.5 and 17.4 volts, and the charging current ranged between 3.3 and 3.8 amperes. The charging was done daily for 8 hours per day. The energy supplied to the system from the photovoltaic panels ranged from 486.4 Wh to 510.48 Wh. The increase in solar radiation intensity is directly proportional to the rise in energy received by the system. The battery voltage increased gradually from 13.3 volts on December 30 to 14.4 volts on January 1. The energy stored in the battery increased from 356.4 Wh to 419.52 Wh. The charging efficiency fluctuated between 71% and 82%, with the highest efficiency recorded on December 14 and the lowest on December 27. These results indicate that variations affect the performance of the battery charging process in solar intensity and electrical parameters. Nevertheless, the overall charging efficiency remained high and consistent throughout the observation period.

Charging a 12-volt 100 Ah battery using solar panels is greatly influenced by the level of sunlight; the higher the intensity of sunlight received, the greater the amount of electrical energy produced, as shown in the relationship between sunlight and output power in Tables 2 and 3. This condition speeds up the charging process and potentially reduces rural communities' dependence on conventional energy sources. This finding is consistent with previous studies, which confirm that applying a battery energy storage system in solar power generation can improve system performance while supporting efficiency and economic feasibility (Hill *et al*., 2012). The observation of charging a 12-Volt 100-Ah battery requires an appropriate strategy to ensure the charging process is carried out optimally and efficiently to support various usage needs. One important aspect affecting the charging duration is the positioning and orientation of the solar panel. This study aligns with previous research, which reported that when panels are appropriately directed and tilted at the optimal angle toward the sunlight source, energy absorption becomes more efficient, accelerating the charging process. Conversely, if the orientation and tilt are incorrect, the energy capture efficiency will decrease, resulting in a longer charging time (Laveyne *et al*., 2020).

The observation of the installation showed that the angle between the solar panel and the ground affects the amount of solar energy that the panel can absorb. Generally, a solar panel will generate maximum power if its installation angle is adjusted according to the latitude of the installation location. The results of this study are consistent with previous research findings, which indicate that the optimal tilt angle of solar panels varies depending on their geographical location. In principle, a panel orientation that is more accurately aligned with the direction of sunlight will increase the intensity of irradiation received, thus positively impacting the increase in electrical energy output from the photovoltaic system (Hariningrum, 2021). Based on observations, installing the panel at an angle that is too small or too large tends to reduce the amount of sunlight received, thereby decreasing the efficiency of the battery charging process. These results are consistent with previous studies that emphasized the importance of determining the correct tilt angle of solar panels to optimize battery charging (Sunarsono *et al*., 2023). Observations of the tested panel system (Table 3) indicate average efficiency of 72%, which is still feasible. However, this efficiency was influenced by the cloudy weather conditions that frequently occurred during December and January, resulting in a decrease in the optimal amount of energy generated. This finding is consistent with previous studies examining solar panels as power generators capable of converting solar energy into electrical energy (Arif *et al*., 2022).

### 3.4. Analysis of Charging Time for 12V 100 Ah Battery Using 100 Wp Solar Panel

The average battery charging analysis is presented in Table 4. The theoretical analysis in Table 4 shows that 16 h required to charge a 12V 100Ah battery using a 100 Wp panel is considered adequate under optimal conditions. However, during testing, cloudy and overcast weather occurred, leading to decreased efficiency. As a result, the charging time needs to be extended, or the panel capacity should be increased to achieve full charging. These findings are consistent with previous research, where electricity was observed to charge from solar power. The findings indicated that the fully charged battery could supply power for 10 hours without the solar panel. This fell to 8 and 6 hours with increased loads. Higher loads also increase battery uptake of energy, hence reducing usage time (Pangan *et al*., 2024).

Table 4. Analysis of battery charging time requirements

| Battery voltage (V) | Battery capacity (Ah) | Energy Required by the Battery (Wh) | Panel power (Wp) | System Efficiency (%) | Effective power Solar panels (W) | Charging Time (h) |
|---|---|---|---|---|---|---|
| 12 | 100 | 1200 | 100 | 70-80 | 75 | 16 |

As identified from the data in Figure 4 and Table 2, testing demonstrates that the solar panel has a current level of 3.5 to 5 A for 8 h. From these results, the shortest charging time of the battery is approximated to be around 16 h. These findings validate previous studies that tested the performance of a 100 Wp portable solar panel as a source of power for powering an electric blower (Rais *et al*., 2023). Other researchers have also reported the application of solar-powered electric motors on board boats utilizing a 12-volt 100 Ah battery charged by two 100 Wp panels (Dewantara, 2019).

### 3.5. Performance Evaluation of Solar-Powered Coconut Grater System

Performance analysis of the ¼ HP electric motor powered by the solar-powered coconut grater system with 12-volt, 100 ampere-hour battery storage is indicated in Table 5. Analysis was carried out to verify the efficiency of the solar-powered coconut grater system supported by 12-volt capacity of 100 ampere-hours. The total accessible power is 1,200 Wh, but only approximately 960 Wh are used in order to maintain battery health and prevent sudden performance decline. The motor used has a power of 1/4 HP (about 186.5 W), and the total power required to operate the system is about 233 W after taking into account the system efficiency of 80%. Based on the evaluation, this solar-powered device can operate for about 3.8 h in one cycle of use. Based on field testing, it takes about 2.6 min to grate one coconut. Thus, this solar-powered system can grate about 23 coconuts per hour. When multiplied by the duration of its operation, this system can grate about 87 coconuts in one complete cycle of use. These findings are in line with previous research that reported a battery charging time of 15 h and a battery usage time of 13 h and 4 min at a 72-watt load (Setyawan & Ulinuha, 2022).

Table 5. Performance testing of solar-powered coconut grater machine using a 12V 100Ah battery

| Number | Parameter | Value | Note |
|---|---|---|---|
| 1 | Battery capacity | 100 Ah | Battery 12V |
| 2 | Battery voltage | 12 V | DC System |
| 3 | Total battery energy | 1200 Wh | 12 V × 100 Ah |
| 4 | Effective energy (80%) | 960 Wh | To maintain battery life (1200 Wh x 0,8) |
| 5 | Electric motor power | 1/4 HP (186.5 W) | 1 hp = 746 W |
| 6 | Input Power (with efficiency 80%) | 233 W | 186.5 W / 0.8 |
| 7 | Machine operating time | ± 3.8 h | 960 Wh / 233 W |
| 8 | Grating time per fruit | 2.6 min | Field test |
| 9 | Number of coconuts per hour | 23 fruit | 60 min / 2.6 min |
| 10 | Engine capacity | 87 fruit | 3.8 h × 23 fruit/h |

Performance testing of solar grating machines (Table 5) can be used to compare with manual and gasoline-powered grating machines based on duration, cost, and labor intensity. The manual method takes 5–10 min per coconut without energy costs, but is not efficient for large-scale production. Solar-powered machines require a relatively high initial investment, but reduce grating time to about 2 min per coconut and eliminate operational costs. Meanwhile, gasoline-powered machines offer high speed and flexibility in locations without electricity, although their fuel consumption is relatively high. These findings are consistent with previous studies that emphasize optimization of design, cost, labor, energy efficiency, and injury risk mitigation (Atienza *et al*., 2025).

## 4. CONLUSION

The results of this study indicate that a 100 Wp solar panel is insufficient to operate a 1/4 HP electric motor, as the motor's power requirement (approximately 186 W) exceeds the panel's maximum output. Therefore, it is recommended that future research consider using three additional 100 Wp solar panels connected in parallel, producing a total of approximately 300 Wp to meet the motor's power demand. An alternative solution is to use a battery to store energy from the solar panels. The solar panel can charge a 12V 100Ah battery to supply power to the motor. The motor is estimated to require around 19.43 A of current. Based on theoretical analysis, this battery could operate the motor for approximately 16 h. However, field testing showed that the motor could only run for 3 to 6 h on a full charge. If the motor is operated continuously for over an hour, a higher-capacity battery and more frequent charging are required to ensure a sufficient power supply. Testing the operational time with the solar panel installation revealed that the battery was depleted after approximately 3 to 4 h of use. Therefore, this study may be applicable for small-scale farmers or could be optimised by increasing the battery and solar panel capacity.

## ACKNOWLEDGMENT

The authors expresses gratitude to Darma Persada University, Jakarta, for supporting this research grant.

## REFERENCES

Adekola, K.A. (2014). Optimum processing parameters for coconut oil expression. *Agricultural Engineering International: CIGR Journal*, ***16***(4), 240–244. https://cigrjournal.org/index.php/Ejounral/article/view/2977

Andriansyah, D., Ismail, R.M.L., Maryanti, R.S., Fazal, K.F., & Puspita, K.S. (2024). Mengoptimalkan potensi kelapa untuk meningkatkan perekonomian masyarakat Desa Gunungsari. *Rudence: Rural Development for Economic Resilience*, ***3***(2), 49–54. https://rudence-feb.unpak.ac.id/index.php/rudence/article/view/68

Armghan, A., Logeshwaran, J., Raja, S., Aliqab, K., Alsharari, M., & Patel, S.K. (2024). Performance optimization of energy-efficient solar absorbers for thermal energy harvesting in modern industrial environments using a solar deep learning model. *Heliyon*, ***10***(4), e26371. https://doi.org/10.1016/j.heliyon.2024.e26371

Atienza, A.H., Arce, J.L., Banawa, K.I., & Rabanal, M.C.T. (2025). Design and performance assessment of a combined grater and milk extraction mechanism for coconut meat. *Journal of Physics: Conference Series*, ***2947***(1), 12007. https://doi.org/10.1088/1742-6596/2947/1/012007

Badea, A.-M., Manaila-Maximean, D., Fara, L., & Craciunescu, D. (2025). Maximizing solar photovoltaic energy efficiency: MPPT techniques investigation based on shading effects. *Solar Energy*, ***285***, 113082. https://doi.org/10.1016/j.solener.2024.113082

Das, A.K., Shill, D.C., & Chatterjee, S. (2022). Coconut oil for utility transformers–Environmental safety and sustainability perspectives. *Renewable and Sustainable Energy Reviews*, ***164***, 112572. https://doi.org/10.1016/j.rser.2022.112572

Dewantara, B.Y. (2019). Perancangan perahu nelayan ramah lingkungan menggunakan motor listrik bertenaga surya. *Cyclotron,* ***2***(1). https://doi.org/10.30651/cl.v2i1.2530

Elibol, E., Özmen, Ö.T., Tutkun, N., & Köysal, O. (2017). Outdoor performance analysis of different PV panel types. *Renewable and Sustainable Energy Reviews*, ***67***, 651-661. https://doi.org/10.1016/j.rser.2016.09.051

Hariningrum, R. (2021). Analisa pengaruh sudut kemiringan panel surya 100 Wp terhadap daya listrik. *Marine Science and Technology Journal*, ***1***(2), 67–76. https://e-journal.ivet.ac.id/index.php/maristec/article/view/1585

Hill, C.A., Such, M.C., Chen, D., Gonzalez, J., & Grady, W.M. (2012). Battery energy storage for enabling integration of distributed solar power generation. *IEEE Transactions on Smart Grid*, ***3***(2), 850–857. https://doi.org/10.1109/TSG.2012.2190113

Johnson, V.B., Aguilar, E.A., Alouw, J., Biddle, J.M., Lacsina, J.C., & Manohar, E.C. (2024). The Future of Coconut as an Economic Crop WorldWide. In *The Coconut: Botany, Production and Uses*. CABI, Great Britain: 206–230. https://doi.org/10.1079/9781789249736.0014

Karunakaran, P., Osman, M.S., Karunakaran, S., & Karunakaran, A. (2023). Optimized design and development of a coconut meat extraction mechanism after weighing the cost and benefit to the environment. *E3S Web of Conferences*, ***405***, 2004. https://doi.org/10.1051/e3sconf/202340502004

Khan, S.A., Chakraborty, S., Dash, K.K., Dar, A.H., Shawl, F., Dash, S.K., Singh, S.K., Dwivedi, M., & Barik, D. (2024). Review of solar greenhouse drying systems in conjunction with hybrid technological features, designs, operations, and economic implications for agro-food product processing application. *Energy Technology*, ***12***(8), 2400176. https://doi.org/10.1002/ente.202400176

Laveyne, J.I., Bozalakov, D., Van Eetvelde, G., & Vandevelde, L. (2020). Impact of solar panel orientation on the integration of solar energy in low-voltage distribution grids. *International Journal of Photoenergy*, ***2020***(1), 2412780. https://doi.org/10.1155/2020/2412780

Ledmaoui, Y., El Maghraoui, A., El Aroussi, M., Saadane, R., Chebak, A., & Chehri, A. (2023). Forecasting solar energy production: A comparative study of machine learning algorithms. *Energy Reports*, ***10***, 1004–1012. https://doi.org/10.1016/j.egyr.2023.07.042

Li, Z., Yang, J., & Dezfuli, P.A.N. (2021). Study on the influence of light intensity on the performance of solar cell. *International Journal of Photoenergy*, ***2021***(1), 6648739. https://doi.org/10.1155/2021/6648739

Mat, K., Abdul Kari, Z., Rusli, N.D., Che Harun, H., Wei, L.S., Rahman, M.M., Khalid, H.N.M., Hanafiah, M.H.M.A., Sukri, S.A.M., Khalif, R.I.A.R., Mohd Zin, Z., Mohd Zainol, M.K., Panadi, M., Mohd Nor, M.F., & Goh, K.W. (2022). Coconut palm: Food, feed, and nutraceutical properties. *Animals*, ***12***(16), 2107. https://doi.org/10.3390/ani12162107

Mukherjee, I., & Sovacool, B.K. (2014). Palm oil-based biofuels and sustainability in southeast Asia: A review of Indonesia, Malaysia, and Thailand. *Renewable and Sustainable Energy Reviews*, ***37***, 1–12. https://doi.org/10.1016/j.rser.2014.05.001

Murtius, W.S. (2024). Agro-industrial development and valorization of coconut fruit waste in Indonesia: A review. *Open Access Research Journal of Science and Technology*, ***11***(1), 31–38. https://doi.org/10.53022/oarjst.2024.11.1.0063

Muslim, C., & Darwis, V. (2018). Peningkatkan kesejahteraan petani melalui inovasi teknologi produk turunan kelapa dalam di Sulawesi Barat. *SEPA: Jurnal Sosial Ekonomi Pertanian Dan Agribisnis*, ***14***(1), 18–27. https://jurnal.uns.ac.id/sepa/article/viewFile/21038/16336

Mustafa, M., Malik, M.O.F., & Maqsoom, A. (2024). Barriers to solar PV adoption in developing countries: multiple regression and analytical hierarchy process approach. *Sustainability*, ***16***(3), 1032. https://doi.org/10.3390/su16031032

Nurhaida, Susanti, I., & Puspitasari, D.U. (2023). A comparative analysis of the influence of temperature and wind speed on the efficiency of 100 wp solar panels of monocrystalline and polycrystalline types at Sriwijaya State Polytechnic. *International Journal of Research in Vocational Studies (IJRVOCAS)*, ***3***(3), 63–73. https://doi.org/10.53893/ijrvocas.v3i3.225

Pangan, J.M.A., Cayanan, T.R.M., Cordon, R.J.R., Mangalus, J.E., Ruado, J.P.M., Canlas, E.M., Canonero, C.M., & Favorito, R. (2024). Design and development of a mobile power charging station via solar and thermoelectric harvesting. *International Research Journal of Modernization in Engineering, Technology and Science*, ***6***(6), 1004–1010. https://doi.org/10.56726/IRJMETS58840

Prabhu, C.N., Dhanushkodi, S., & Sudhakar, K. (2025).Sustainable technology for coconut processing: Biomass-powered dryer and performance evaluation. *Resultsin Engineering*, ***25***, 104361. https://doi.org/10.1016/j.rineng.2025.104361

Rais, S., Tjiroso, B., Umar, K., Hardi, W., & Pratama, A.S. (2023). Pengujian *portable solar cell* kapasitas 100 Wp sebagai energi listrik penggerak blower pengering cengkeh 250 Watt. *Patria Artha Technological Journal*, ***7***(2), 185-188. https://www.researchgate.net/publication/365470036_Pengujian_Portable_Solar_Cell_Kapasitas_100_WP_Sebagai_Energi_Listrik_Penggerak_Blower_Pengering_Cengkeh_250_Watt

Rani, P., Dubey, A., Kumar, P., & Kumar, A. (2024). Sustainable renewable energy sources for food and dairy processing. In *Food Process Engineering and Technology: Safety, Packaging, Nanotechnologies and Human Health* (pp. 65–95). Springer. https://doi.org/10.1007/978-981-99-6831-2_4

Samarajeewa, U. (2024). *Coconut: Nutritional and Industrial Significance*. https://www.intechopen.com/chapters/1179190

Sajil Raj, P.R., Anshadh, A., Samuel, B.T.R., & Ahsana, A.N. (2016). Design of an innovative coconut grating machine using Tinkercad. *International Journal of Research in Mechanical Engineering*, ***4***(3), 178–182.

Sameera, Tariq, M., & Rihan, M. (2024). Analysis of the impact of irradiance, temperature and tilt angle on the performance of grid-connected solar power plant. *Measurement: Energy*, ***2***, 100007. https://doi.org/10.1016/j.meaene.2024.100007

Senaen, J.P., Rampengan, A., & Tumimomor, F. (2023). Analisis pengaruh intensitas radiasi matahari terhadap tegangan dan arus pada panel surya di Universitas Negeri Manado. *Jurnal Arjuna: Publikasi Ilmu Pendidikan, Bahasa dan Matematika*, ***1***(6), 220–231. https://doi.org/10.61132/arjuna.v1i6.327

Setyawan, A., & Ulinuha, A. (2022). Pembangkit listrik tenaga surya off grid untuk supply charge station. *Transmisi: Jurnal Ilmiah Teknik Elektro*, ***24***(1), 23-28. https://doi.org/10.14710/transmisi.24.1.23-28

Sunarsono, H., Rahmiati, S., & Mardiansyah, Y. (2023). Solution for battery charging by providing an optimum angle of solar panel during monsoon season. *AIP Conference Proceedings*, ***2665***, 020007. https://doi.org/10.1063/5.0134652

Tilahun, F.B. (2024). Fuzzy-based predictive deep reinforcement learning for robust and constrained optimal control of industrial solar thermal plants. *Applied Soft Computing*, ***159***, 111432. https://doi.org/10.1016/j.asoc.2024.111432

Ukoba, K., Yoro, K.O., Eterigho-Ikelegbe, O., Ibegbulam, C., & Jen, T.-C. (2024). Adaptation of solar power in the Global South: Prospects, challenges and opportunities. *Heliyon, **10***(7), e28009. https://doi.org/10.1016/j.heliyon.2024.e28009

Venkateswari, R., & Sreejith, S. (2019). Factors influencing the efficiency of photovoltaic system. *Renewable and Sustainable Energy Reviews*, ***101***, 376–394. https://doi.org/10.1016/j.rser.2018.11.012