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Implementation of a Solar-Powered Air Control System in Broiler Chicken Closed House Farming

Risse Entikaria Rachmanita ^{1*}, Hariadi Subagja ², Denny Trias Utomo ³, Yuana Susmiati¹ and Beni Widiawan ⁴

¹ Renewable Energy Engineering Study Program, Department of Engineering, Politeknik Negeri Jember, Jl. Mastrip 164 Jember, Indonesia 68121; risse_rachmanita@polije.ac.id, yuana_susmiati@polije.ac.id

² Poultry Business Management Study Program, Department of Animal Husbandry, Politeknik Negeri Jember, Jl. Mastrip 164 Jember, Indonesia 68121; , Jl. Mastrip 164 Jember, Indonesia 68121; hariadi_subagja@polije.ac.id

³ Information Technology Study Program, Department of Information Technology, Politeknik Negeri Jember, Jl. Mastrip 164 Jember, Indonesia 68121; beni@polije.ac.id

⁴ Digital Business Study Program, Department of Information Technology, Politeknik Negeri Jember, Jl. Mastrip 164 Jember, Indonesia 68121; denny_trias@polije.ac.id

* Correspondence: risse_rachmanita@polije.ac.id; Tel.: +6285604843067

Abstract: Closed-house broiler chicken farming enhances productivity and animal welfare by maintaining optimal environmental conditions. However, reliance on grid electricity for air control systems increases operational costs and environmental impact. This study investigates the implementation of a solar-powered air control system to regulate temperature, humidity, and ventilation in closed-house broiler farming. The system integrates photovoltaic (PV) solar panels, energy storage, and a smart control mechanism. The system's performance is evaluated based on energy consumption, solar energy generation, and environmental parameters. Results show the system effectively maintains optimal broiler growth conditions while reducing energy dependence. Energy savings of up to 10% are achieved, leading to lower operational costs and improved sustainability. The findings demonstrate the feasibility of solar-powered solutions in broiler farming, reducing greenhouse gas emissions and enhancing farm resilience. Future work will explore IoT integration for real-time monitoring and further energy optimization.

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Keywords: Solar Power, Air Control System, Closed-House Farming, Renewable Energy, Sustainability.

1. Introduction

In today's modern era, the demand for sustainable and efficient energy sources is becoming increasingly urgent, particularly in the agricultural and livestock sectors. One of the challenges faced by poultry farmers, especially in closed house broiler systems, is the precise control of temperature and humidity to ensure optimal growth performance of broiler chickens. Traditional closed house systems often still rely on conventional energy sources, which are not only expensive but also potentially harmful to the environment.

The use of renewable energy technology, such as smart solar energy systems, offers a promising solution to address these issues. By harnessing sunlight as an energy source, these systems can reduce dependence on fossil fuels and lower operational costs. Moreover, the integration of Internet of Things (IoT) technology in closed house control systems allows for more accurate monitoring and regulation of environmental parameters, such as temperature and humidity. This technology enables farmers to access real-time data, helping them make better decisions based on accurate information.

The combination of smart solar energy systems and IoT technology in air control within closed house broiler systems not only increases energy efficiency but also optimizes broiler productivity and reduces mortality rates. With a smart system in place, farmers can ensure that optimal conditions for broiler chickens are consistently maintained, ultimately boosting productivity and profitability.

This research aims to develop and analyze the implementation of a smart solar energy system integrated with IoT technology in closed house broiler systems. Through this research, it is expected to make a significant contribution to sustainable and efficient farming practices and open opportunities for further innovation in resource management within the agricultural sector. Thus, this research is not only academically relevant but also has broad practical implications for the poultry industry.

The integration of smart solar energy systems and IoT-based air control systems in closed house broiler farming represents a significant advancement in agricultural technology, particularly in improving the efficiency and sustainability of poultry farming. Recent developments in this field highlight several key innovations and trends.

IoT Integration in Closed House Systems, recent research has focused on the design and implementation of intelligent control systems for managing environmental parameters, such as temperature and humidity, in closed house farming. These systems enable real-time monitoring and control, which are critical for supporting optimal broiler performance. For instance, studies have demonstrated the effectiveness of IoT in automating environmental adjustments, allowing farmers to monitor their closed house systems remotely and receive notifications regarding environmental conditions [1].

Solar-Powered Systems, the construction of solar-powered closed house systems has gained traction, particularly in regions with unreliable access to electricity. These systems utilize solar panels to provide a sustainable energy source, ensuring that operations can run continuously without interruption [2]. This is particularly beneficial for small-scale farmers in remote areas who face limited access to grid electricity. The combination of solar energy with IoT capabilities allows for improved energy management and operational efficiency [3].

Advanced Control Systems, the development of advanced control systems, such as Proportional-Integral-Derivative (PID) controllers and fuzzy logic systems, has been pivotal in optimizing the closed house environment. These systems automatically adjust air conditions based on real-time data, ensuring that the environment remains optimal [2]. This level of automation reduces the risk of human error and improves broiler performance.

User-Friendly Interfaces, modern closed house systems are increasingly equipped with web applications and user-friendly interfaces that enable farmers to easily control and monitor the environment [4]. These interfaces provide insights into environmental conditions, allowing users to make informed decisions based on data analysis. The accessibility of such technology empowers farmers, especially those in remote areas, to improve their productivity [5].

Although previous studies implemented solar-powered systems in agricultural and livestock technology, few have addressed full-scale broiler closed houses. Sustainability and Efficiency, the combination of solar energy and IoT technology not only enhances energy efficiency but also supports sustainable farming practices. By reducing dependence on fossil fuels and minimizing the carbon footprint, these systems align with global efforts toward sustainable agriculture [6].

UD. Nor Rohman Farm Jember is a micro-enterprise engaged in broiler chicken farming using closed house systems. The business operates 2 closed house units, each measuring 30 meters by 70 meters. Each unit is equipped with 3 rows of light bulbs, with each row containing 20 light bulbs, each rated at 7 watts, to provide the necessary heat for broiler maintenance. Currently, the business faces several challenges affecting its operations:

- a. The heating system relies on electricity from PLN (the national electricity company) and uses a generator during power outages.
- b. Monthly electricity costs are significantly high, imposing a financial burden on the enterprise.
- c. Broiler performance decreases during PLN power outages, which disrupt the temperature regulation in the closed house systems.

The transition from electrical power to the generator is still performed manually. In the event of a sudden power outage, any delays in activating the generator can result in significant losses. This condition disrupts productivity and prolongs the broiler maintenance period. The purpose of this study is to implement an air control system in a closed house based on solar panels and IoT to provide a solution to UD Nor Rohman Farm's problems.

2. Materials and Methods

This approach utilizes an intelligent system to regulate temperature, humidity, and ammonia levels by applying a Fuzzy Logic System integrated with a hybrid solar energy setup. Real-time environmental data is captured using DHT22 sensors for temperature and humidity, while NH_3 sensors monitor ammonia gas concentrations [6].

The collected data is transmitted to an Internet of Things (IoT) server, where it is processed using the Fuzzy Logic system. The processing takes place within a three-tier server architecture comprising a database server, an IoT server, and a web server [7], [8]. The system's output is used to control components, such as activating exhaust fans to remove polluted air from the closed house or rearing box.

The system allows users to monitor and manage environmental conditions through web and smartphone applications. This feature enables real-time supervision of the rearing process and supports actions to maintain ideal conditions. Additionally, integrating hybrid solar energy ensures efficient and sustainable energy use, reducing dependency on traditional energy sources [9].

The smart control system is powered by a Hybrid Solar Photovoltaic (PV) Power System. This hybrid system combines solar panels with electricity from the national grid (PLN), merging aspects of off-grid and on-grid systems. It generates electricity similarly to on-grid systems while employing batteries for energy storage [10], [11], [12].

Energy storage provides a backup power source during grid outages, ensuring uninterrupted operation. The IoT-based smart control system implementation at UD. Norrohman Farm Jember [13], [14]. The total energy consumption for the system includes approximately 20 watts per day for the IoT-based control units and 200 watts for the 20 bulbs, resulting in a daily demand of 220 watts.

This approach improves energy efficiency and ensures the system remains operational even during power outages. Consequently, this research emphasizes developing a sustainable and efficient energy management solution for poultry rearing in closed houses.

Figure 1 shows a solar panel box system (also known as a combiner box or junction box) is an essential component of a solar photovoltaic (PV) system. It serves as a connection point for multiple solar panels, allowing the electricity generated by each panel to be combined and fed into a single electrical circuit [15, 16, 17]. The solar power system component specifications include a 400 Wp solar panel, four 100 Ah batteries, a 60 A MPPT solar charge controller, a 1000 watt inverter, a 63 A ATS, and an MCB.



Figure 1. Solar panel box system

Figure 2 shows the installation of 10 IoT-based systems in a **closed** house for poultry management. The environment includes automated infrastructure typically found in modern poultry farms. IoT System setup several devices and sensors (e.g., for temperature, humidity, and ammonia monitoring) are mounted along the structure of the closed house. These devices are likely responsible for real-time environmental data collection and transmission to the central monitoring system [18, 19, 20].

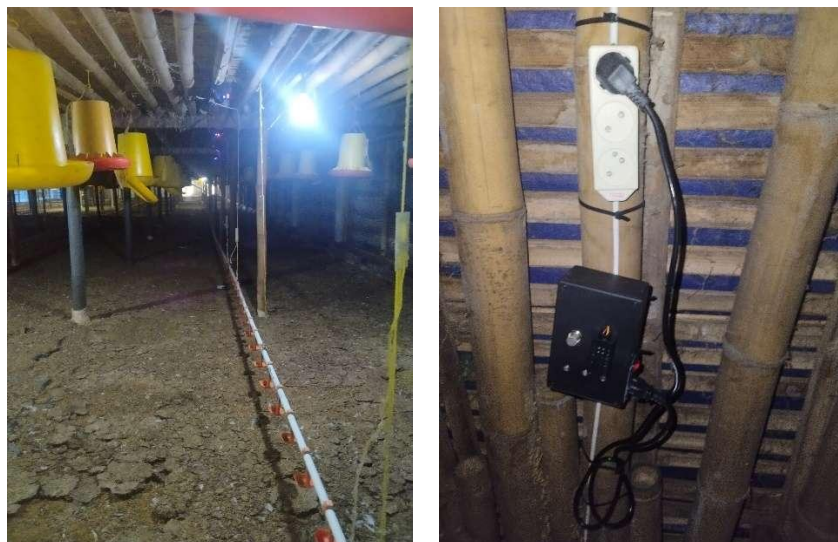


Figure 2. Installation of IoT system at 10 points in a closed house

3. Results and Discussion

The IoT-based monitoring system as shown at Figure 1 provides real-time tracking of temperature, humidity, and ammonia levels in a controlled environment, such as a poultry closed house. The interface displays three main components: temperature, humidity, and ammonia data, each represented through graphs and real-time values. The temperature graph indicates fluctuations over time, with the current reading at 35.2°C, which is updated regularly. Similarly, the humidity graph shows a notable decrease followed by an increase, with the latest value recorded at 84.5%. The ammonia concentration graph highlights variations over time, with the most recent value displayed as 442 ppm. Each real-time reading is accompanied by a color-coded status bar ranging from "Good" (Baik) to "Bad" (Buruk), allowing users to assess environmental conditions quickly. The system also includes timestamps for the last recorded updates, ensuring

accuracy and reliability. By integrating graphical trends and real-time indicators, this monitoring system enables users to analyze data effectively, identify changes, and maintain optimal environmental conditions for successful poultry management.

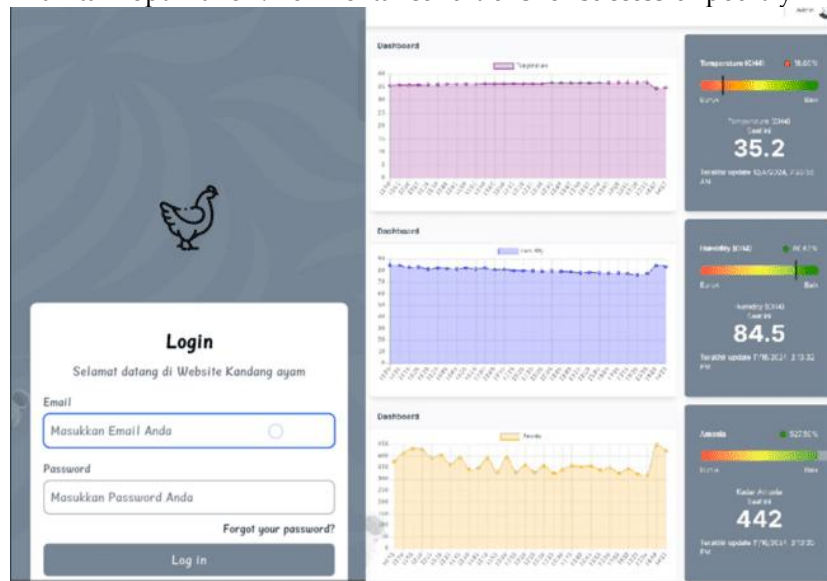


Figure 3. IoT-based monitoring system (<https://iqacs-chick.research-ai.my.id/login>)

The analysis of power consumption and energy usage by the 400Wp solar power system aimed to determine the daily power and energy demands of the load. Additionally, the measurements verified that the system's power consumption aligns with the design specifications and is fully supported by the solar panels. The load on the system consists of an IoT system and 20 bulbs, each with a power rating of 10 watts.

The solar power system includes four 100 Ah batteries, a 60 A MPPT solar charge controller, a 1000-watt inverter, a 63 A ATS, and an MCB. To evaluate power and energy consumption, voltage and current data were collected, focusing on the inverter's role in converting DC energy from the batteries into AC energy to power the IoT system and provide lighting for the closed house. A DC watt meter was used to gather the data at 10-minute intervals over a total period of 100 minutes, matching the recommended battery charging duration.

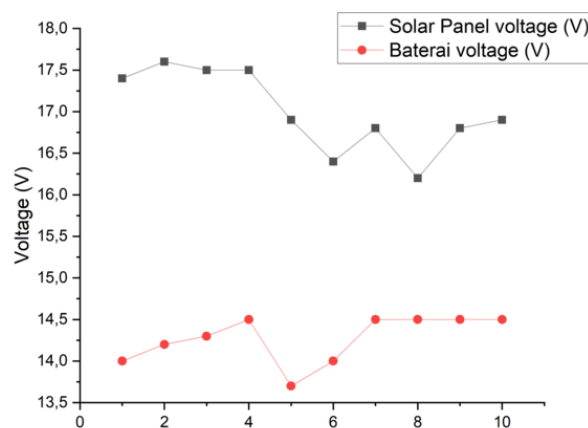


Figure 4. This is a figure. Schemes follow the same formatting.

The graph illustrates the voltage measurements taken 10 times for both the solar panel and the battery. The **solar panel voltage** is represented by the black squares, while the **battery voltage** is indicated by the red circles.

1. Solar Panel Voltage:

- The solar panel voltage starts at around 17.5 V and shows slight fluctuations throughout the measurements.
- Between the 4th and 6th measurements, there is a noticeable drop in voltage, reaching approximately 16.2 V.
- After the 6th measurement, the solar panel voltage rises slightly and stabilizes at around 16.8 V toward the 10th measurement.

2. Battery Voltage:

- The battery voltage remains relatively stable, starting at approximately 13.8 V in the first measurement.
- There is a gradual increase in voltage up to around 14.5 V during the 4th measurement, followed by a significant drop back to 13.7 V in the 5th measurement.
- From the 6th measurement onward, the battery voltage stabilizes at around 14.4 V and remains consistent until the final measurement.

Overall, the solar panel voltage demonstrates larger variations compared to the battery voltage, which stays relatively stable with minor fluctuations. This suggests that the battery effectively regulates and maintains its voltage despite variations in the input voltage from the solar panel. The implementation of PLTS can save electricity by 10% every month, thereby reducing electricity costs by 1 million rupiah per month.

4. Conclusions

The integration of smart solar energy systems and IoT technology into closed house broiler systems represents a significant advancement in agricultural technology, particularly in enhancing energy efficiency and sustainability in poultry farming. The implementation of these systems not only addresses challenges such as high electricity costs 10 % and dependence on traditional energy sources but also improves broiler productivity 10% and reduces mortality rates 20% by precisely managing environmental conditions. The combination of real-time data collection and intelligent control through IoT allows for more accurate monitoring of temperature, humidity, and ammonia levels, ensuring optimal conditions for poultry growth.

The use of hybrid solar power systems further supports the sustainability aspect, reducing the carbon footprint and providing uninterrupted energy supply even during power outages. The research conducted at UD. Nor Rohman Farm Jember demonstrates the practical applications and benefits of these technologies, offering a blueprint for other poultry farmers to follow. By optimizing resource management and leveraging renewable energy, this approach not only contributes to sustainable farming practices but also opens avenues for further innovation in resource management within the agricultural sector. The findings of this research are not only academically relevant but also have broad practical implications, paving the way for a more sustainable future in the poultry industry.

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