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Solar Dome Dryer-Based Smoked Fish Drying System for Rural Economy

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***Abstract*— The Solar Dryer is used as a drying system for fishery products or raw materials for ready-to-eat food within a "greenhouse" structure shaped like a "Dome Dryer." The dryer cover is made of clear polycarbonate, which effectively absorbs sunlight entering the drying chamber. Polycarbonate, a group of thermoplastic polymers, is easily moldable using heat. Its advantages include a density of 1.2–1.22 g/cm³, toughness retention up to 140°C, and stability down to -20°C. This material is highly transparent, capable of transmitting over 90% of light, similar to glass. Polycarbonate can also be designed to block ultraviolet radiation, providing 100% protection from harmful UV rays. It remains thermally stable up to 135°C, and its heat resistance can be further enhanced by adding flame retardants without compromising its properties. Solar thermal radiation enters the drying chamber, where it is reflected and absorbed by the polycarbonate. This results in heat transfer to the (wet) fish, leading to evaporation. The evaporation process creates a pressure difference between the inside and outside of the drying chamber, causing water vapor to flow out through the ventilation holes.**

***Keywords*— Dome Dryer, Energy Conservation, Rural Economy, Solar Cells.**

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I. INTRODUCTION

The Nurul Azhar Islamic Boarding School in Bagan Benio is located in Dusun 3, Tasik Serai, Talang Muandau Subdistrict, Bengkalis Regency, Riau Province. This pesantren is uniquely situated on a land area that becomes isolated during the rainy season, resembling an island. The isolation necessitates boat transportation for approximately 2 km. This geographical characteristic presents a significant advantage, as the region is abundant in fish varieties, particularly those suited for "salai" (smoked fish) production. This creates a market opportunity for the boarding school, which could potentially manage and develop smoked fish production as a sustainable business.

The processing of salai fish involves drying and smoking techniques. Many households in the surrounding community are already engaged in small-scale smoked fish production to meet their daily needs. However, the primary challenge lies in the conventional smoking technology employed by the villagers. Traditional smoking methods often result in inconsistent product quality and inefficient processing. Addressing these challenges requires innovative solutions to enhance efficiency, product consistency, and environmental sustainability.

The research aligns with the mission of Politeknik Negeri Padang (PNP) to focus on applied and impactful research that directly addresses societal challenges. This study is expected to contribute a solution through the design and development of a fish-smoking dryer, referred to as the “Room Dryer,” which integrates renewable energy sources such as Solar Power Plants (PLTS). This tool is anticipated to improve the economic conditions of rural areas, particularly the 3T regions (frontier, outermost, and least developed areas).

Additionally, this research supports the strategic research plan of Politeknik Negeri Padang, which emphasizes increasing the use of renewable energy as an alternative energy source, as outlined in the National Research Priorities (2020-2024). The development of the “Room Dryer” aims to elevate the local economy by enabling more efficient and environmentally friendly production of smoked fish.

Through this study, the research team seeks to provide practical solutions to empower fish-smoking artisans in Pondok Pesantren Nurul Azhar and its surrounding areas. By enhancing the efficiency and quality of smoked fish production, this innovation is expected to improve the economic well-being of the community. Furthermore, the research outcomes align with PNP's long-term strategic goals, including fostering research competitiveness, increasing faculty capacity for applied research, and expanding the societal impact of research outputs as articulated in PNP's Long-Term Development Plan (RPJP) 2015–2025.

This paper focuses on the design and fabrication of a fish-smoking dryer that utilizes solar energy. It is expected to serve as a model for addressing economic challenges in rural areas while promoting renewable energy utilization

II. METHODS

A. Drying Definition

Drying is a process of reducing the water content in materials, transforming them from high moisture levels to the acceptable levels required for subsequent processing. This drying system is commonly applied to materials that need specific temperatures and moisture levels to achieve the desired quality and taste for consumption, whether for daily use or market-ready food products.

B. Drying Methods

1) *Natural* Drying

Natural drying is a conventional method that relies on sunlight. This approach is heavily dependent on weather conditions, making it difficult to control the drying duration. Additionally, it does not ensure hygienic results due to the risk of contamination from dust, livestock, or unexpected rain.

2) *Artificial* Drying

Artificial drying, such as the Solar Dome Dryer (SDD), is a semi-circular (dome-shaped) drying tool enclosed in heat-resistant plastic, typically made of polycarbonate, creating a closed environment resembling a greenhouse. Polycarbonate is highly durable, lasting up to 15 years, and using SDD accelerates the drying process while maintaining hygiene by avoiding air pollution contamination.

The primary reasons for using a Solar Dome Dryer is overcoming challenges in traditional drying systems, such as contamination from dust and dirt, damage caused by animals, discoloration of dried products, and interruptions from weather conditions like rain and wind; Enhancing the drying process by offering faster drying times, weather resistance, cleaner products, better product quality, and temperature control based on specific needs; and providing competitive drying efficiency comparable to forced oven drying systems, with faster processing times than traditional methods.

C. Polycarbonate

Polycarbonate is a group of thermoplastic polymers that are easily shaped with heat and widely used in various industries. This material offers several advantages, including superior thermal resistance compared to other plastics, high impact resistance, and excellent transparency

Polycarbonate consists of polymers with carbonate groups (-O-(C=O)-O-) in their molecular chains, with bisphenol A (BPA) being the most common type. It is highly transparent, transmitting light more effectively than most glasses. Compared to polymethyl methacrylate (acrylic), polycarbonate is stronger and can withstand higher temperatures. It softens gradually at 150°C and melts at around 300°C.

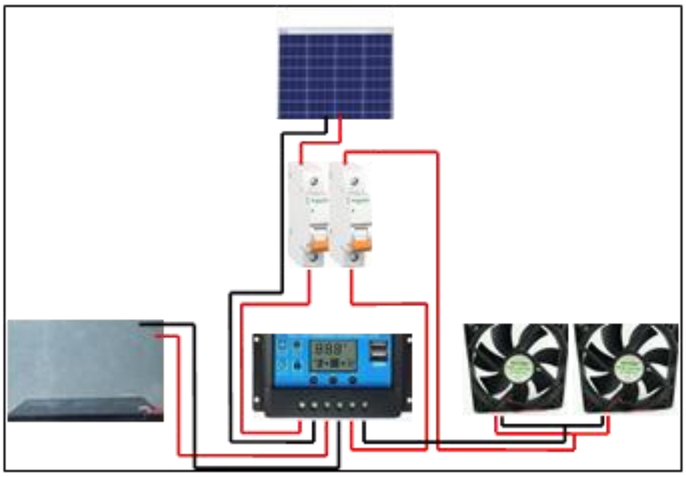

FIGURE 1. Solar Power Generation System

D. Solar Power Plant (PLTS)

The Solar Power Plant (PLTS) is a system that converts solar energy into electrical energy through photovoltaic cell conversion. The higher the intensity of solar radiation received by the photovoltaic cells, the greater the electricity generated. PLTS is a renewable energy source that is environmentally friendly, as it produces no greenhouse gas emissions or air pollution.

This study integrates the use of the Solar Dome Dryer with a PLTS system to optimize the drying process. The combination of these technologies ensures efficiency, sustainability, and quality improvement in smoked fish production, supporting economic development in rural communities.An easy way to comply with the conference paper formatting requirements is to use this document as a camera-ready template, as shown in Fig. 1.

E. Location

This collaborative applied research (PTK) was conducted between Politeknik Negeri Padang (PNP) and Politeknik Negeri Bengkalis to develop the rural economy at the Nurul Azhar Islamic Boarding School in Bagan Benio, located in Dusun 3, Tasik Serai, Talang Muandau District, Bengkalis Regency, Riau.

F. Spesification

TABLE I
Spesification of Systems

Solar Doom Dryer	
Dimensions	3 m (L) × 2 m (W) × 2.5 m (H).
Exhaust Fan	1 unit 50 Watt, 12 Volt dc
Incandescent Lamp	200 W
Battery	
Voltage	12 V
battery capacity	80 % 125 Ah
Required Battery Capacity	1.4 units of 100 Ah batteries
Photovoltaic	
Effiiciency	± 65%
Daily Power Consumption	6 hours
Unit	2
Solar Irradiance	100 Wp
Controller	
Operating Voltage	12 V DC
Temperature	-20°C to 60°C
Humidity Range	0%–100%.
Maximum Controlled Power	2,500 W (250 V AC, 10 A)

As shown in Table 1, outlines the technical specifications of the solar doom dryer system, including its dimensions, main components, and operational parameters. The specifications cover physical dimensions, exhaust fan capacity, incandescent lamp, battery requirements, the efficiency and number of photovoltaic panels, and control settings via the solar charge controller. This information provides a comprehensive overview of the system's power requirements, energy capacity, and performance to support an efficient and environmentally friendly drying process

G. System Design

The design shown represents a solar photovoltaic (PV) system integrated with energy storage and distribution components, suitable for off-grid applications. The PV panels serve as the primary energy source, converting solar energy into direct current (DC) electricity. This energy is regulated by a solar charge controller, which ensures optimal charging of the battery (Accu) while preventing overcharging or undercharging. The battery functions as an energy storage unit, supplying power during periods of low or no sunlight, such as nighttime or cloudy days.

Fig. 2 shows the system supports both DC and AC loads. DC loads, such as fans or LED lights, draw power directly from the battery or charge controller, while AC loads rely on an inverter to convert DC energy into alternating current (AC). To ensure safe and efficient power distribution to multiple AC appliances, the system includes a distribution panel (panel hubung bagi), equipped with safety features like circuit breakers and fuses. Additionally, exhaust fans connected to the DC load maintain proper ventilation, preventing system overheating.

Overall, the design provides a reliable off-grid energy solution by utilizing renewable solar energy, with provisions for energy storage and safe power distribution for both DC and AC applications.

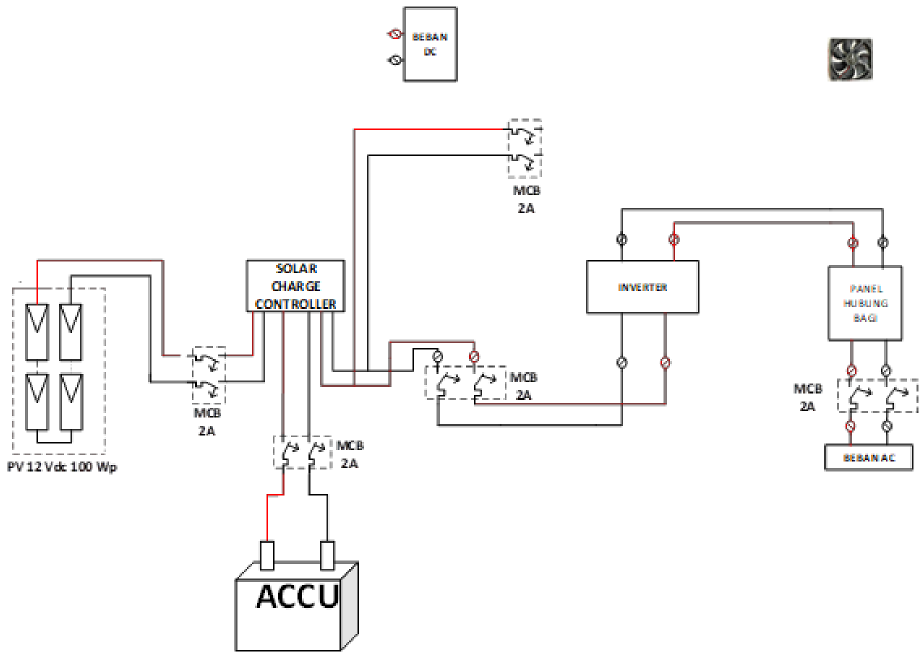

FIGURE 2. System Design

III. RESULT OF THE SOLAR CELL TESTS

A. Budget Utilization

Since the commencement of the Collaborative Applied Research (PTK) program in July 2024, the implementation team has undertaken various activities, including identifying challenges and business needs related to smoked fish production, signing the research contract, coordinating the design of equipment, fabricating frames and drying racks, constructing the Solar Dome Dryer (SDD) and Solar Power Plant (PLTS), and transporting the equipment from the PNP workshop to the project site at Pondok Pesantren Nurul Azhar in Bagan Benio, Dusun 3, Tasik Serai, Talang Muandau District, Bengkalis Regency, Riau.

B. Achievements

The construction of the Solar Dome Dryer (SDD), a greenhouse-shaped drying device made of polycarbonate, has been completed. It is designed to regulate and accelerate the drying process in a more hygienic manner, utilizing a Solar Power Plant (PLTS) as its energy source.This SDD is equipped with an air circulation system and lighting lamps that function as humidity control of the room temperature to prevent mold and dampness.

C. Test Result Data

Analysis of conditions before and after the implementation of consultancy is presented in Table 2

TABLE I
Spesification of Systems

No.	Type	Natural Dryer	Doom Dryer
1	Equipment	Sunlight, temperature 24-32°C	drying tool, temperature 35-54 °C
2	Drying Time	4-5 days depending on the weather	1-2 days (still depending on the temperature,. However, since 2 weeks ago, SOP has been added for the use of lights during the day, during rainy days, PLTS as the energy source
3	Quality	Less hygienic, due to ambient air pollution	More hygienic, safe from the threat of livestock and other animals
4	Convenience	More energy/workers are needed to regulate the entry and exit of fish that are being dried in the sun	Fish that are not yet dry can be left in the SDD without removing them from or putting them in the storage area

IV. CONCLUSION

The Solar Dome Dryer (SDD) has proven to be highly beneficial in improving the drying process, offering a faster, more environmentally friendly, and hygienic solution. It effectively controls humidity levels, particularly during the rainy season and nighttime, by utilizing Solar Power Plants (renewable energy) as its power source. Additionally, the SDD is versatile and can be applied to various drying needs, provided that the required heat composition is carefully managed. To ensure optimal functionality, it is recommended that the use of the SDD prioritize environmental safety, given its placement in open areas. Regular maintenance is also essential to prevent leaks or damage, which could allow unwanted air to enter and compromise the drying process

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