

Design and Development of an IoT-Based Salted Fish Drying System for Small-Scale Home Industries Using the Blynk Application

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ABSTRACT

The process of drying fish is a preservation technique that involves reducing the moisture content in the material through weight loss, thereby enhancing the fish's shelf life. Traditional drying methods that rely on sunlight have limitations because they are significantly affected by environmental conditions, making the drying rate difficult to manage and inconsistent. The objective of this study is to design and implement an automated fish drying system based on the Internet of Things (IoT) using NodeMCU ESP32 to create a drying process that is more precise and controllable. This system incorporates a load cell sensor to monitor weight changes in the fish, a PZEM-004T sensor for monitoring electrical parameters, a DHT22 sensor for measuring humidity, and a DS18B20 sensor for regulating the drying room temperature. All measurement data can be observed in real time through the Blynk application. Test results indicate that manual drying leads to a weight reduction of approximately 35% over a span of 28 hours with an unstable drying rate. In contrast, the automatic drying system can achieve a weight reduction of about 39–40% in a shorter duration, specifically around 15–26 hours, with a more consistent drying rate. Moreover, the readings from the PZEM-004T energy sensor indicated that the system used approximately 2.41 kWh of energy over the 26 hours of the drying process. These findings suggest that the IoT-based automated fish drying system improves process stability and drying efficiency compared to manual drying methods.

Keywords: Fish drying, Internet of Things (IoT), ESP32, Loadcell Sensor, Energy Monitoring PZEM-004T.

Date of Submission: 09-10-2026

Date of acceptance: 20-10-2026

I. INTRODUCTION

One of the most common method of preserving food is the drying of salted fish; this process is generally still done traditionally by utilizing sunlight and heat as the primary energy source[1], [2]. The purpose of drying is to reduce the moisture content to 38–40% [3]–[9] in order to inhibit bacterial growth[10–11]. This method involves drying the fish on bamboo racks or nets outdoors. Although this natural drying method has advantages such as low operating costs, this approach also has several drawbacks, namely weather instability, which causes inconsistent drying results, while the time required for drying is relatively long—about 5 to 8 days[8],[12–15] at an average temperature of 30–33°C. In addition, the outdoor drying process makes the fish vulnerable to contamination from dust, flies, and dirt from the environment, which can lower the product's hygiene standards[16]. In some groups that process fish in coastal areas, traditional salted fish drying methods remain the primary choice due to the ease of using the equipment and low operational costs. The production capacity of members of the Putri Bogowonto(Riau Province) group is approximately 10 kilograms of fresh fish per day, yielding about 3.5 kilograms of dried salted fish after the sun-drying process. On the other hand, members of the Srikandi group process about 2 to 3 kilograms of fresh fish per day, yielding between 0.6 and 0.9 kilograms of dried salted fish. However, the results of open-air drying in on a small-scale, home-based level, salted fish are still produced using conventional methods involving salting and natural drying in the sun. This process is highly dependent on weather conditions; thus, when the weather is cloudy or rainy—and since production activities are still manual, the drying time becomes longer, and product quality is inconsistent. This situation poses a major challenge for home-based producers in maintaining the consistency of their output. This study uses IoT to ensure

that these parameters remain stable without human intervention, thereby minimizing the possibility of errors. In addition, the IoT-supported system enables remote monitoring through applications such as Blynk, so that home industry operators do not need to always be on-site, which improves work efficiency and production output. The use of IoT in designing fish drying equipment offers various benefits, such as real-time monitoring and automatic control. IoT enables real-time monitoring via sensors. Data can be accessed remotely through the Blynk app dashboard for automatic control.

II. RESEARCH METHOD

a. Mechanical Design

Figure 1 shows mechanical design of the chamber. The chamber was modified to accommodate three trays. These trays serve as storage compartments for dried fish and are arranged to facilitate uniform heat distribution and adequate air circulation throughout the drying chamber.

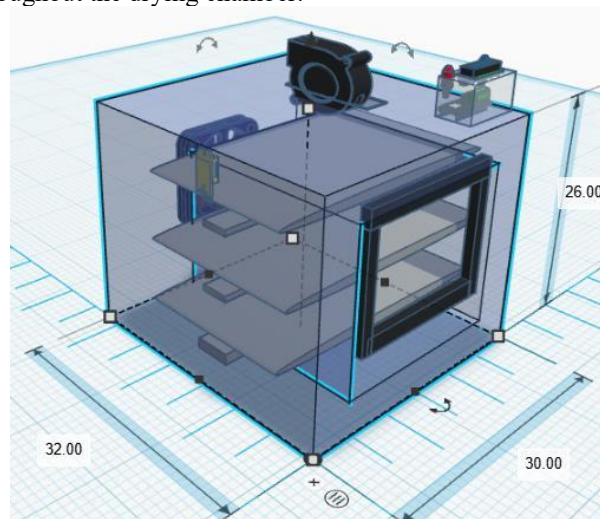


Figure 1. System Block diagram

The system design emphasizes functionality and efficiency to ensure effective drying. The drying chamber was designed to ensure uniform heat distribution and sufficient capacity to accommodate trays containing dried fish in accordance with the operational capacity typically required in a home-based industry. The NodeMCU ESP32 control unit is positioned at the upper section of the apparatus to facilitate accessibility and maintenance while minimizing direct exposure to heat generated within the drying chamber. This configuration was developed to optimize system performance by considering thermal efficiency, air circulation, and the ease of integrating essential components, including fans, blowers, sensors, and heating elements.

b. Control Design

Figure 2 shows the input-output block diagram of the system built for the experiment and a more detailed wiring diagram is shown in Figure 3. The developed drying system employs the NodeMCU ESP32 as the primary microcontroller and Wi-Fi module, which is responsible for processing input data and receiving control commands from the Blynk application. The system is equipped with several sensors to monitor the drying process. The load cell sensor is used to measure the weight of the salted fish throughout the drying process, allowing the remaining weight to be determined. Meanwhile, the DS18B20 sensor measures the temperature inside the drying chamber, while the DHT22 sensor monitors the humidity level. In addition, the PZEM-004T sensor measures the electrical energy consumed by the heating element, thereby providing information regarding the system's energy consumption.

The system also incorporates two push buttons labelled as Start and Tare to facilitate manual operation. The Start push button is used to initiate the drying system, whereas the Tare push button is used to reset the weight measurement of the container to zero before the drying process begins. To control the air circulation, Relay 1 and Relay 2 are employed to operate the 12 V DC fan and 12 V DC blower, respectively. These components support the distribution of heat and air within the drying chamber, contributing to a more uniform drying process. Furthermore, an LCD (Liquid Crystal Display) is integrated into the system to present text messages, sensor readings, and the operational status of the system components in nearly real time.

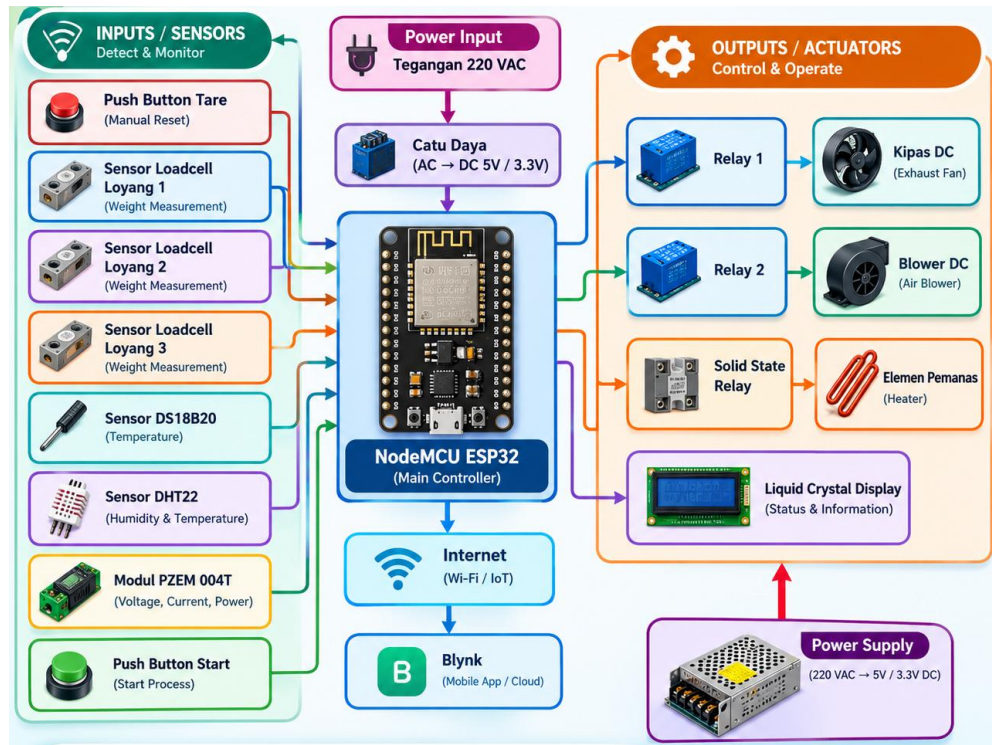


Figure 2. Input-Output diagram

For temperature control, a Solid-State Relay (SSR) is used to regulate the heating element, particularly because the heating element operates at a relatively high electrical power. The SSR enables the heating element to be controlled electronically based on the programmed operating conditions. Meanwhile, an Internet connection serves as the communication medium between the NodeMCU ESP32 and the Blynk application, enabling remote monitoring and control of the drying system. Through this integrated configuration, the system can monitor temperature, humidity, weight, and energy consumption while simultaneously controlling the fan, blower, and heating element, thereby supporting an automated, efficient, and remotely monitored salted-fish drying process.

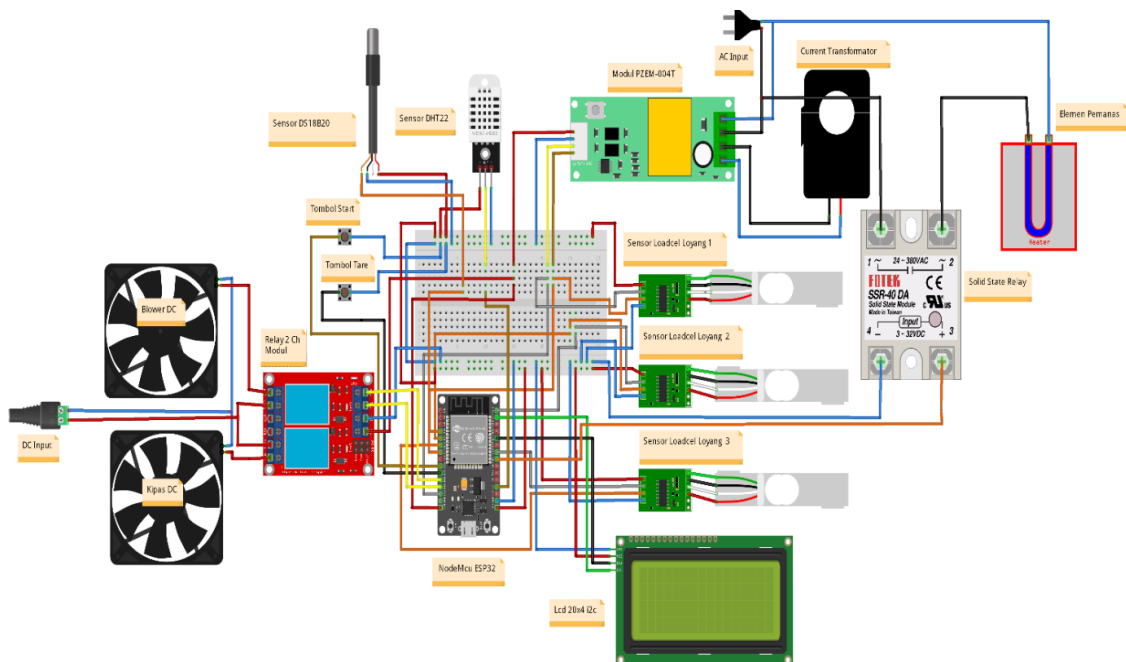


Figure 3. Wiring diagram

III. RESULTS AND DISCUSSION

a. Hardware

Figure 4 shows the prototype in this study. The dimensions of the drying chamber are $30 \times 32 \times 26$ cm, and it is equipped with three rack levels. Each rack has dimensions of 28×24 cm, resulting in a rack surface area of 672 cm^2 . The *Sardinella sp* fish used in the drying process has an average size of 14×5 cm, corresponding to an area of 70 cm^2 per fish, with an average mass of 85 gr per fish. Based on these dimensions and the available rack area, the drying chamber can accommodate approximately nine *Sardinella sp.* per rack, resulting in a total capacity of approximately 27 fish across the three racks.



Figure 4. Prototype

The chamber consists of an insulated drying chamber and a control unit positioned on top of the chamber. The drying chamber is designed to accommodate the fish during the drying process while minimizing heat loss to the surrounding environment. The upper control unit houses the electronic control components used to operate and monitor the drying process, while the connected cables and components provide the necessary electrical and control connections between the sensors, actuators, and controller. The chamber is designed to support controlled heat distribution and air circulation, allowing the moisture content of the fish to be reduced under controlled conditions. Overall, the prototype integrates the mechanical drying chamber with an electronic control system to improve the consistency, efficiency, and automation of the fish-drying process.

Inside the chamber are a heater, a fan, and sensors. The heater and fan generate hot air that is distributed throughout the chamber. As shown in the setup, a DS18B20 sensor and a DHT22 sensor are installed to continuously monitor temperature and humidity levels within the chamber. Thermal energy is supplied by a centrally mounted heater, while a fan ensures uniform heat and airflow distribution across the drying racks. Additionally, a load cell is incorporated into the system to measure the weight reduction of the fish in real time, allowing the microcontroller to accurately determine the completion of the drying cycle.

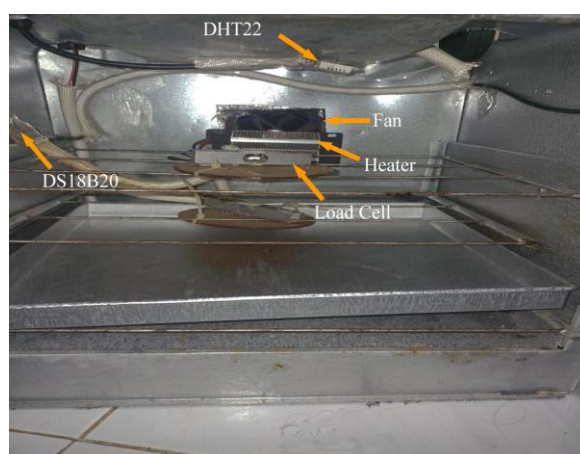


Figure 5. Position of the sensor inside the chamber

b. Monitoring application

Figure 5 shows a smartphone screen monitoring interface, which provides real-time information on the operating conditions of the drying process. The interface displays several key parameters, including temperature, humidity, voltage, current, power consumption, and electrical energy consumption.

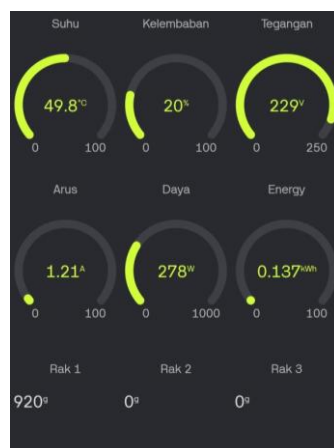


Figure 5. Blynk dashboard interface

As shown, the drying chamber operates at a temperature of 49.8°C and a relative humidity of 20%, while the measured electrical parameters are 229 V, 1.21 A, 278 W, and 0.137 kWh, respectively. The interface also provides information on the weight of fish placed on Rack 1, Rack 2, and Rack 3, allowing the drying progress to be monitored based on changes in fish weight. This real-time monitoring system enables the operator to evaluate the drying conditions, energy consumption, and reduction in fish weight, thereby supporting more effective and controlled operation of the fish-drying machine.

c. Functional test

A manual fish-drying test using a sample of four fish was conducted as a comparison to the automated fish-drying system that had been designed. This manual method utilizes direct solar heat, similar to the traditional practices commonly used by salted fish processing. The purpose of this test was to gain an understanding of the characteristics of weight loss and physical changes in the fish during the drying process without the aid of a temperature and airflow control system. These initial conditions served as a crucial foundation for the manual drying test, since the water evaporation process depends entirely on the intensity of sunlight and the ambient temperature. The lack of control over temperature and time means that the drying rate is heavily influenced by weather conditions and external disturbances, so the results of manual drying tend to vary. Figure 6 shows the results of the manual drying test; the fish weight decreased from 636 gr to 411 gr equivalent of a reduction of 35.4%—over 28 hours. The weight loss did not occur uniformly because the drying process is only effective when the fish are exposed to sunlight; at night, although water evaporation continues, the drying rate is much slower due to lower ambient temperatures. This indicates that the manual method is heavily influenced by natural conditions, making it difficult to maintain a stable drying rate.

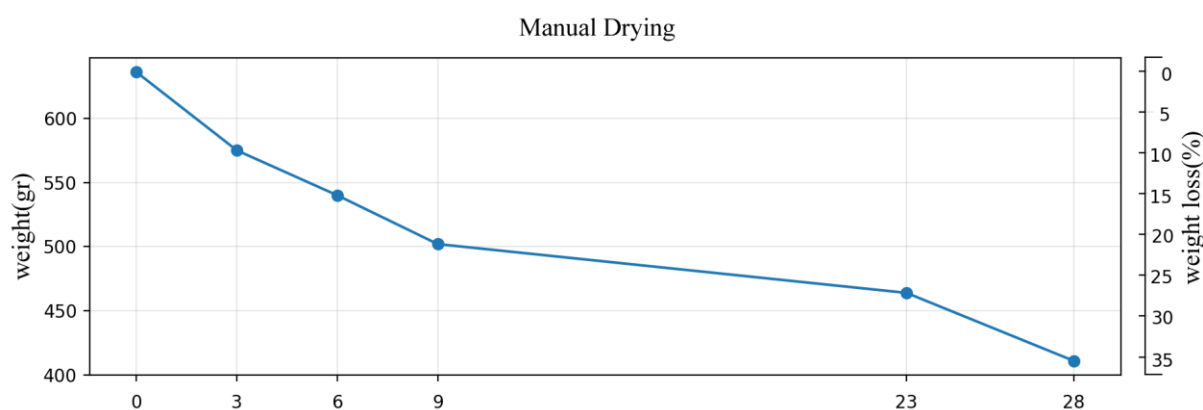


Figure 6. Manual drying graphic

Figure 7 shows automated drying graphic using three fish with a total initial weight of 654 gr(Figure 8). It showed a significant decrease in weight as the drying process progressed. After 3 hours, the fish's weight had decreased to 564 gr, indicating that water evaporation occurred quite rapidly at the beginning.

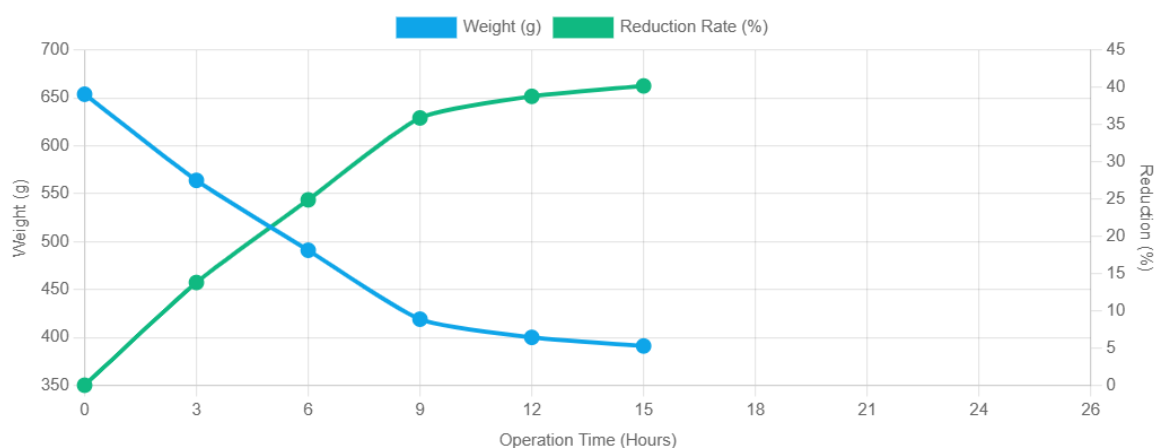


Figure7. Automated drying graphic

The weight continued to decrease after 6 hours to 491 gr, and after 9 hours to 419 gr, indicating that the drying process was still proceeding well, particularly with regard to free water. In the next phase, the rate of weight loss began to slow, reaching 400 gr after 12 hours and 391 gr after 15 hours; this indicates that most of the water had already been removed and the remaining water was retained within the fish's tissue. This situation reflects that the drying process proceeded effectively, with the most significant weight loss occurring at the beginning of the phase and slowing down in the final phase. Fish weight reduction can be achieved more quickly than with manual drying methods.



Figure 8. Automated Dried fish processing : initial and final stages

This study also evaluated the electrical energy consumption and operating costs of an Internet of Things (IoT)-based salted fish drying system during the drying process. Electricity consumption was monitored using PZEM-004T sensors integrated into the system and calculated at successive intervals throughout a 26-hour drying cycle. During this period, the heating element operated relatively consistently, indicating stable heating performance.

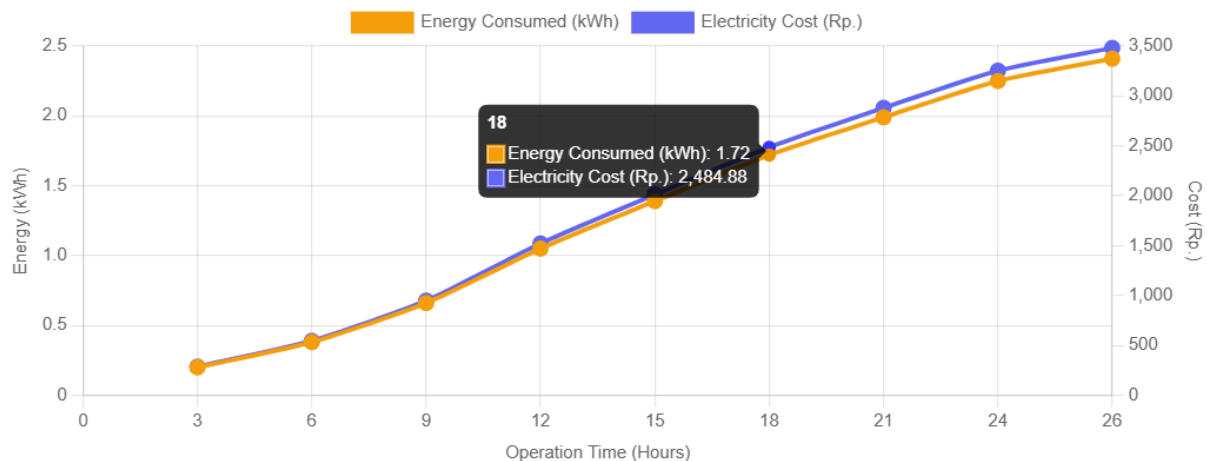


Figure 8. Electricity cost

The assessment aimed to quantify the total electrical energy required and estimate the associated operating costs for a single drying cycle. As presented in Figure 8, the system consumed a total of 2.41 kWh of electrical energy over 26 hours, with an estimated electricity cost of Rp 3,481.73. These findings indicate that the developed dryer has relatively low energy requirements and potentially offers an energy-efficient solution for household-scale fish drying. Moreover, the estimated operating cost is relatively affordable, suggesting that the system could provide a cost-effective alternative to conventional fish-drying methods. Overall, the results demonstrate the potential of the proposed IoT-based dryer to support more economical fish-drying practices, although further comparisons with conventional methods would be necessary to establish its relative efficiency and cost-effectiveness.

IV. CONCLUSION

This study developed and tested the performance of a fish-drying machine and compared it to manual methods. In the manual method, the fish weight decreased from 636 gr to 411 gr, corresponding to a 35.4% weight reduction after 28 hours. In contrast, the automated closed-system dryer achieved a weight reduction of 39–40% within 15–26 hours across the three racks. These results suggest that the automated closed-system dryer can achieve a greater weight reduction in a shorter drying time than the manual method. This improvement is attributed to the controlled drying temperature of 50–55 °C and active air circulation, which promote moisture evaporation. However, because the initial fish weights and testing conditions may differ between the two methods, the results should be interpreted as an indication of performance rather than a definitive measure of comparative efficiency. The energy consumption of the automated closed-system dryer was also evaluated using a total fish load of 1,576 gr distributed across three racks. During a drying period of up to 26 hours, the system consumed approximately 2.41 kWh of electricity. These data provide a basis for estimating operating costs and assessing energy requirements. Overall, the automated closed-system dryer demonstrates potential for household and small-scale commercial applications by combining faster drying performance with measurable electricity consumption.

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