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by Meita Rumbayan 2

RESEARCH ARTICLE | JUNE 02 2023

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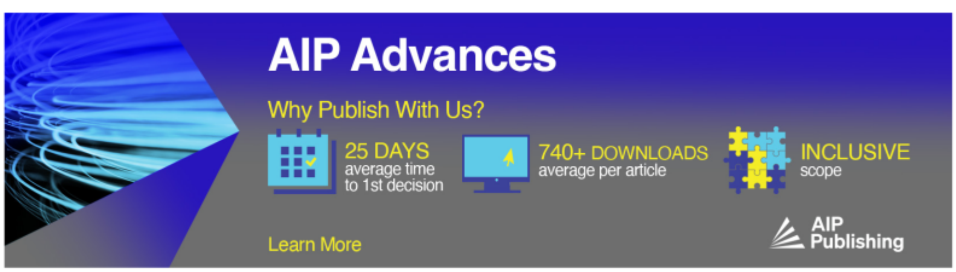
AIP Conference Proceedings 2601, 020024 (2023)
https://doi.org/10.1063/5.0129812



The Development of Appropriate Technology Prototypes for the Food Dryer Powered by Solar Photovoltaic

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Abstract. In Indonesia, traditional drying methods for preserving fish face numerous challenges, including a lack of solar heat, rain, and other issues that make the drying process inefficient. This study has the objective s of designing and developing a solar dryer using solar energy photovoltaics to power electricity for supporting the fish drying process. The research method used in this work consist of several stages of Research and Development (R&D), including analysis requirement, model design, prototype construction, and further development. The results of using the fish dryer with solar power can be produced more quickly and efficiently with additional pair DC fan and coil thermal that supply by electricity power from solar energy Photovoltaic (PV). For further development, the solar energy-based food dryers would be tested for other kinds of fish species and agriculture crops in remote coastal communities that face limited access to electricity from the grid.

INTRODUCTION

The utilizations of renewable energy as the alternative source for independent system electrical power become very interesting and useful to be explored. Solar energy as one of the forms of renewable energy is abundantly available for utilizing in many devices such as solar home systems and solar pump systems [1, 2]. In the previous study, the author has worked with solar energy for solar home systems and solar pump systems. Solar energy for utilizing in food dryers becomes challenging to be explored more for technology appropriate based on renewable energy.

It started from the research question of why the food dryer technologies need to be integrated with solar energy technology. There are many reasons as the background for this research, such as the food security and the energy security to be solved for both national and local problems. For food security, it is found that always important to provide food for sustainable communities. For energy security, it is found that always interesting to use renewable energy as a clean and alternative source for sustainable communities as well.

Indonesia has a rich natural source of food that comes from agriculture and maritime product. There is much food such as fishes, fruits, and herbs require drying technologies for final products. In this current project, we work with the fish solar dryer to be developed. We choose fish as one of the food products to be tested in our solar dryer due to we intend to work with coastal communities to solve their problem in fish dyer products. By proposing our solar drying type, it is expected to assist the traditional fish dryer process to become a modern process with appropriate technology with renewable energy-based.

Proceeding of the 7th International Conference of Science, Technology, and Interdisciplinary Research (IC-STAR 2021)
AIP Conf. [illegible] 2601, 020024-1–020024-5; https://doi.org/10.1063/5.0129812
Published by AIP Publishing. 978-0-7354-4465-2/$30.00

The traditional process of a fish dryer has some limitations or drawbacks, such as a long process for drying and hygiene issues for the product. The purpose of this work is to design, construct and test the solar energy-based for fish drying.

MATERIALS AND METHODS

Fish Drying Process

The drying process is frequently considered a cost-effective and energy-intensive method to improve the storability of many fishery and agricultural products. Furthermore, open-air sun drying remains the most favored method in rural areas considering its low cost. However, direct or traditional sun drying is highly dependent on environmental conditions and prone to dust, rain, wind, bugs, and rodents contamination [3]. A plethora of systems have been developed to address such issues—the greenhouse dryer and the hybrid solar dryer are some of them. The advantages of these systems are faster and more efficient process and possibly a more hygienic outcome; In addition, one of the expected impacts is a decrease in crop losses. Food from agriculture and fishery materials is dried in hybrid dryers using direct solar radiation and/or backup electricity or stored heat in the event of a power outage. Other additional energy sources, such as solar PV modules, electricity, liquefied petroleum gas (LPG), diesel, or biomass, are used to preheat the air [4].

Implementation of solar energy-based food dryers has also been reviewed in references. The ventilation system circulates hot air in the drying chamber or from the solar collector to the drying chamber in the active dryer. Electricity is used to power fans and blowers, which are acquired from a photovoltaic (PV) module or the grid [5]. In Burkina Faso, using a photovoltaic-driven system to power the fans for active solar dryers can supply affordable electricity while promoting a sustainable energy generation system. However, the application of the system faces some obstacles, such as theft, lack of standardization, and incompetent workers that handle the installation and maintenance process [6]. Kenya is one of a country in Africa that has efficiently adopted small-scale solar PV energy and begun to develop a thriving sector in this area. PV-based off-grid systems have also been used in rural regions for post-harvest applications [7]. In the Kashmir valley, Shahi et al. [8] constructed a poly-house type dryer for fruit and vegetables.

Process Implementation

The implementation of solar-energy-based fish dryer technology proposed for coastal communities would be measured to the community utilization of the prototype to know the outcomes of the product and to develop the next product of food dryer. The renewable energy-based food drying method is carried out in several stages as described in Fig. 1 and explained it as below.

Analyze requirement of solar energy-based fish dryer

The requirement of food or fish dryer has been analyzed based on survey and interview with the fisherman need to obtain the dry fish product for small fish Stolephorus species. The fisherman community needs a fish dryer device to support the drying process. The independent source of electrical power becomes an additional point due to the condition for remote and coastal communities that face the limitation of electricity from the grid.

Design the solar energy-based fish dryer

After identifying the requirement of a fish drying device, the design of the model was developed as a technical draw by the researcher team in solving fisherman communities' problems.

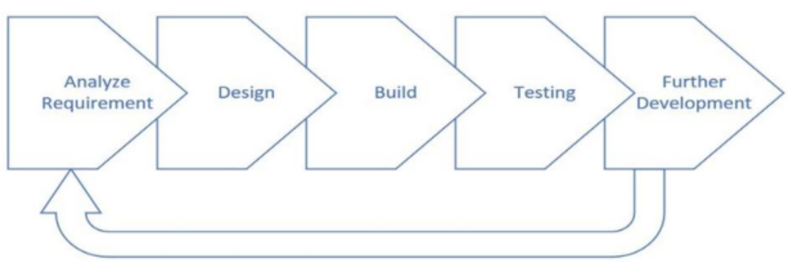

FIGURE 1. The methods of renewable energy-based food dryer

Build the solar energy-based fish dryer

In this stage, the method of approach is constructing the appropriate technology through the design of the solar energy-based for fish dryer product as a solution in solving communities' problems about electricity limitation from the grid. The solar energy utilization by PV is equipped to the drying device system as an independent power supply to support the drying process by forced DC fan and coil thermal.

Testing the solar energy-based fish dryer

Construction of a proposed solar energy power integrated into drying device system is followed by testing small fish drying process for one day. Additional testing of fish drying products will be conducted to get more data for further analysis and development.

Identify further development of the solar-energy-based fish dryer

The implementation of solar-energy-based fish dryer technology proposed for coastal communities would be measured to the community utilization of the prototype to know the outcomes of the product and to develop the next product of food dryer.

RESULTS AND DISCUSSION

The model design of solar-PV as the self-power supply integrated with the dryer device as depicted in Fig. 2. The systems must be correctly designed and scaled to match the requirements of various crops and conditions in order to achieve the necessary quality and ensure a good return for the user. The solar dryer consists of solar collector, reflector, heat exchanger, drying chamber and storage box of electricity self-supply by PV panel. The air is heated as it flows through a low-pressure drop solar collector, then into the drying chamber and over the drying trays through air ducts. The moist air is expelled from the chamber by air vents or a chimney at the top.

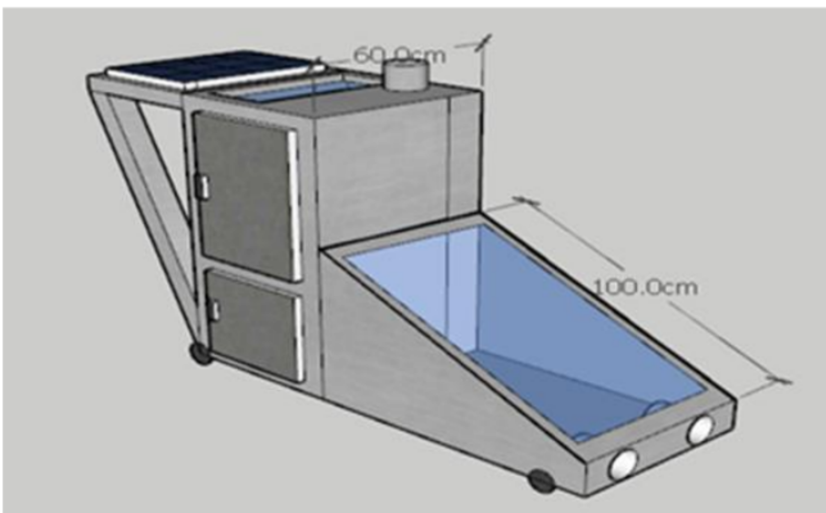

FIGURE 2. The model design of food dryer with PV integrated as self-sufficient power supply

The result of constructed solar dryer that has been designed and built as shown in Fig. 3. In this dryer device, convection and radiation modes of heat transmission are used to remove moisture from raw agricultural products during the solar drying process. At a temperature of 30°C–60°C , solar energy passes through a transparent sheet and is held as heat in a drying chamber or solar collector. In a passive system, thermal energy is transmitted to the drying chamber through natural convection; in an active system, heated air is blown into the chamber by fans or blowers. The conduction modes of heat transmission in the solar drying support by heat coil that power by a 50 Wp of PV panel.

FIGURE 3. The result of constructed food dryer integrated with Photovoltaic as the independent power supply

To test the performance of the constructed solar dryer, we compare the fish dryer process between the fish dryer process with solar dryer and without solar dryer. We measured the mass of fish product before and after the drying process for both solar dryers and without solar dryer activities. The testing result of constructed solar dryer performance compared to the conventional dryer is shown in Fig. 4.

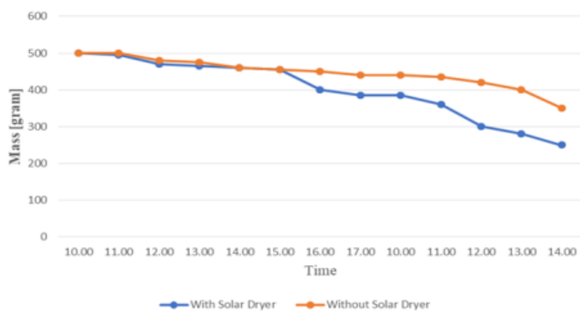

FIGURE 4. The testing result of fish drying process with and without solar dryer proposed

The experiments of the small fish dryer process have been conducted with solar dryer proposed and without solar dryer under the sun direct. It has been observed that the mass of fish dryer products with solar dryer mode is faster being reduced than without solar dryers. The average drying efficiency is about 40% which is lower than the direct solar dryer.

CONCLUSIONS

The solar energy-based with Photovoltaic fish dryer device has been designed and constructed for fishery communities in a coastal and remote area that electricity limited access to the grid. The testing of the proposed food dryer has been carried out by using the small fish dryer process. The solar energy-based dryer has a floor area of 1 m to 0.6 m with 1.2 m central height and 3 layers of trays 0.5 m x 0.5 m for drying are of product. The air collector has a slope of 30 ° with two DC fans to force the flow of air from outside to inside to support the drying process. One unit of 50 Wp photovoltaics module monocrystalline type was used in dryer construction for providing electrical power to operate a pair DC fan and thermal coil. This testing presented a study for fish drying process and determine that the drying time obtained in solar drying is lower compared to open-air. However, the cost-benefit analysis for propose model of solar dryer power with PV panel has not yet been conducted for comparison. For further development, the testing experiment for the fish drying process with another fish species will be conducted to test the performance of solar energy-based that has been constructed. It is also a challenge for future work to develop solar energy based on food and agriculture crops. The economic analysis of further development will be analyzed in the future studies.

ACKNOWLEDGMENTS

This research has been funded by Ministry of Education, Culture, Research and Technology Republic of Indonesia.

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