

# Large Scale IOT Based Green House Dryer

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**Abstract** - Enhancing the shelf life of agricultural products is a critical requirement, and solar greenhouse dryers play an important role in achieving this through efficient drying methods. The present work focuses on improving the performance of a greenhouse dryer by integrating latent heat storage using phase change materials (PCM) and forced air circulation. A modified Quonset greenhouse dryer was designed and evaluated using tomato slices as the test crop. Experiments were conducted under solar greenhouse drying conditions with the integration of PCM and a forced air circulation system to enhance the drying performance. The experimental results showed that the modified Quonset greenhouse dryer provided effective drying and improved moisture removal compared with conventional solar drying methods. Furthermore, the combined drying configuration consisting of forced air circulation and PCM improved the overall drying efficiency by approximately 38% when compared with conventional greenhouse drying. The results demonstrate that integrating latent heat storage and forced air circulation significantly enhances the performance of the modified Quonset greenhouse dryer, making it a promising and sustainable solution for efficient drying of agricultural products.

**Key Words:** Modified Quonset, Forced air circulation, Phase change materials (PCM), Agricultural products, Solar greenhouse dryer.

## 1. INTRODUCTION

Drying is one of the most essential and widely used preservation techniques for agricultural products, as it reduces moisture content, inhibits microbial growth, and extends shelf life. Traditional open sun drying, although simple and cost-effective, suffers from several limitations such as contamination by dust and insects, dependence on climatic conditions, uneven drying, and significant quality degradation of the final product. These drawbacks

necessitate the development of more efficient and controlled drying systems.

Solar greenhouse drying has emerged as a promising alternative that utilizes renewable solar energy to create a controlled drying environment. In greenhouse dryers, solar radiation enters through a transparent covering and is trapped inside, resulting in a rise in internal temperature due to the greenhouse effect. This elevated temperature enhances the moisture removal rate and improves drying efficiency compared to conventional methods.

Among various greenhouse configurations, the modified Quonset structure has gained attention due to its simple design, efficient solar heat absorption, and improved airflow distribution. The incorporation of advanced features such as forced air circulation further enhances heat transfer and moisture removal. Additionally, integrating phase change materials (PCM) enables thermal energy storage, allowing the system to maintain favorable drying conditions even during low solar radiation periods. Despite these advancements, maintaining consistently high temperature and low humidity within the drying chamber under fluctuating environmental conditions remains a challenge. Therefore, the present work focuses on the design and performance evaluation of a modified Quonset solar greenhouse dryer integrated with forced air circulation and PCM to improve drying efficiency and ensure reliable operation for agricultural applications.

## 2. LITERATURE REVIEW

Kumar Anil et al. (2013) [1] conducted an experimental analysis of a greenhouse dryer under no-load conditions. Their study focused on temperature distribution and thermal performance inside the greenhouse structure. The results showed that internal temperature was significantly higher than ambient temperature, confirming the effectiveness of the greenhouse effect in drying applications.

Kumar and Tiwari (2007) [2] analyzed the effect of product mass on the convective mass transfer coefficient during open sun and greenhouse drying of onion flakes. Their findings indicated that greenhouse drying improves mass transfer characteristics and reduces drying time compared to open sun drying.

Burnwal and Tiwari (2008) [3] developed a hybrid photovoltaic-thermal (PV/T) greenhouse dryer for grape drying. Their experimental study demonstrated that integrating photovoltaic systems enhances drying efficiency and provides better temperature control. This work highlights the potential of combining renewable energy technologies with greenhouse dryers.

### 3. MATERIALS AND METHODS

The construction and experimental evaluation of the modified Quonset solar greenhouse dryer required several structural and measuring components. These materials were selected based on their durability, availability, and suitability for solar drying applications. The main structural framework of the greenhouse dryer was fabricated using mild steel pipes to provide strength and stability to the structure. The dryer was designed in a modified Quonset shape to enhance solar radiation absorption and maintain uniform heat distribution inside the drying chamber. The entire structure was covered with

a transparent polycarbonate sheet, which acts as the primary covering material. This sheet allows solar radiation to enter the dryer while minimizing heat loss, thereby creating the greenhouse effect inside the drying chamber. To monitor the temperature conditions inside the dryer, K-type thermocouple sensors were used. These sensors can measure a wide range of temperatures with high accuracy and fast response time. The thermocouples were connected to a PICO temperature data logger, which was used to record temperature readings continuously during the experimental study through PicoLog software. In addition to temperature measurement, a digital humidity meter was used to measure the relative humidity inside the drying chamber. Monitoring humidity is important because it directly affects the moisture removal rate during the drying process. The collected temperature and humidity data were used to analyze the thermal performance of the modified Quonset solar greenhouse dryer. The list of materials and instruments used in this study along with their purposes is presented in Table 1.1. Materials and Purpose

**Table 1.1. Materials and Purpose**

S. No	Material / Instrument	Purpose			
1	Mild steel frame	Structural support for dryer			
2	Polycarbonate sheet	Transparent cover for solar radiation			
3	K-type thermocouple	Temperature measurement			
4	PICO temperature data logger	Data acquisition and monitoring			
5	Digital humidity meter	Humidity measurement			

### METHOD USED

The experimental method used in this study involves the design and performance monitoring of a modified Quonset solar greenhouse dryer for agricultural drying applications. Solar radiation enters the greenhouse structure through a transparent polycarbonate sheet, which creates a greenhouse effect and increases the temperature inside the drying chamber. The modified Quonset structure helps in trapping heat and maintaining suitable drying conditions inside the chamber. The overall working

principle of the system is illustrated in. 1.1. Fig block diagram Temperature inside the dryer was measured using K-type thermocouple temperature sensors connected to a data logger. The sensors were used to monitor both the internal dryer temperature and the atmospheric temperature outside the dryer. A digital humidity meter was also used to measure the relative humidity levels inside the drying chamber.

All the sensors were connected to a PicoLog data acquisition system, which continuously recorded the temperature data during the experimental period. The recorded data were transferred to a computer and analyzed

using PicoLog software to observe the temperature and humidity variations with respect to time.

The collected experimental data were then plotted in graphical form to evaluate the thermal performance of the modified Quonset solar greenhouse dryer.

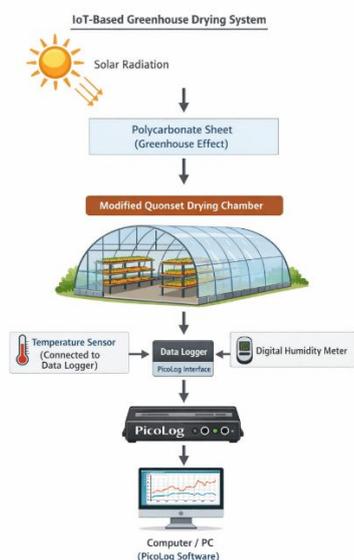


Figure 1.1 Block Diagram

## 4. RESULTS AND DISCUSSION

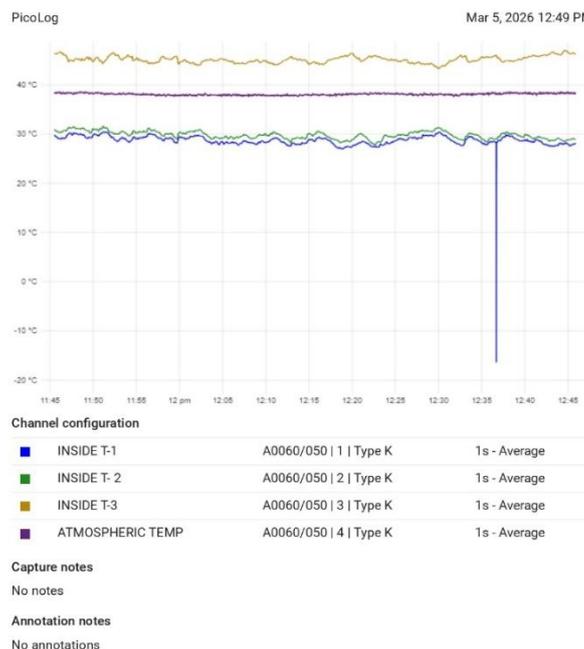
### Temperature Variation Inside the Greenhouse Dryer

The thermal performance of the modified Quonset solar greenhouse dryer was evaluated by analyzing the temperature readings recorded during three experimental days. Temperature measurements were taken using K-type thermocouple sensors connected to a data acquisition system and monitored through PicoLog software. The sensors were placed at different locations inside the dryer and in the surrounding environment to compare the internal temperature with the atmospheric temperature.

On the first day of the experiment, three temperature sensors were placed inside the dryer to observe the temperature distribution within the drying chamber, while one sensor was used to measure the atmospheric temperature. The recorded data showed that the temperature inside the greenhouse dryer increased gradually with the increase in solar radiation during the daytime. The internal temperature remained higher than the atmospheric temperature for most of the observation period, indicating the effective heat retention capability of the greenhouse structure.

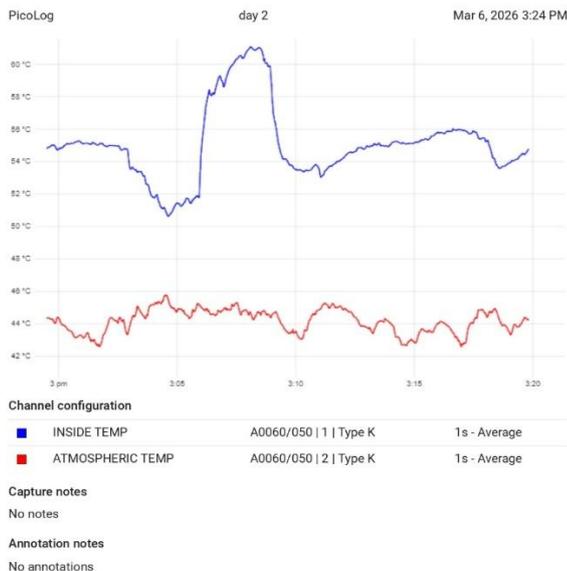
The temperature variation recorded on Day-1 for the internal sensors and the atmospheric sensor. The results indicate that the greenhouse dryer successfully

trapped solar energy and maintained a higher internal temperature compared to the surrounding environment.

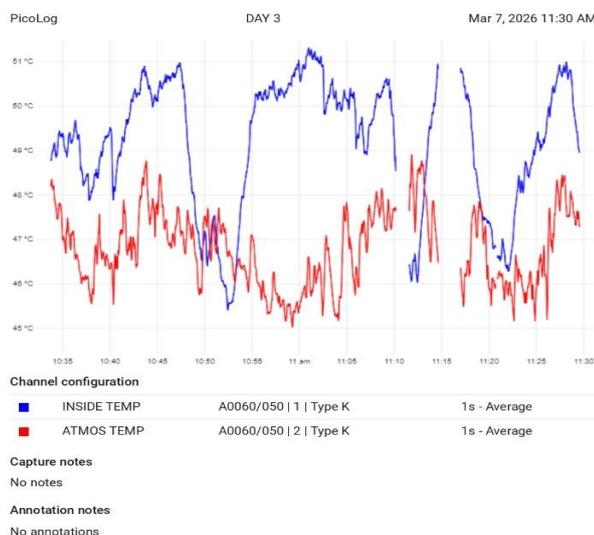


During the second day of the experiment, one temperature sensor was placed inside the dryer and another sensor was used to measure the atmospheric temperature. The temperature readings again showed a clear difference between the internal and external conditions. The internal temperature increased during the daytime due to solar radiation entering through the transparent polycarbonate sheet covering the dryer.

Illustrates the temperature profile recorded on Day-2. From the graph, it can be observed that the temperature inside the dryer was consistently higher than the atmospheric temperature. This temperature difference confirms the ability of the greenhouse dryer to create favorable thermal conditions for agricultural drying.



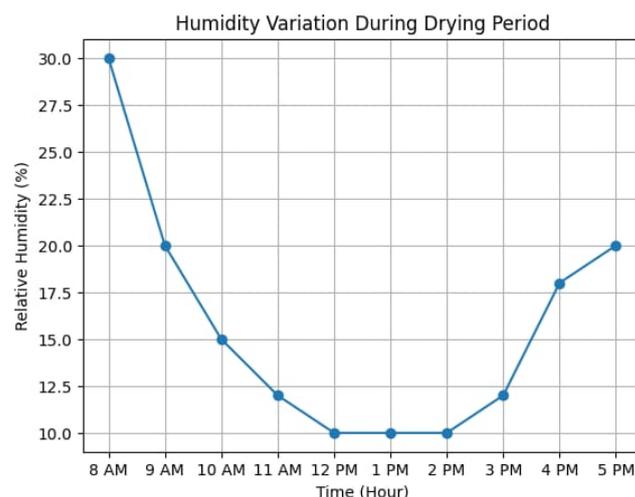
Similar observations were recorded on the third day of experimentation. Temperature measurements were taken using one internal sensor and one atmospheric sensor to analyze the thermal behavior of the dryer. The internal temperature inside the drying chamber increased during the daytime and remained higher than the surrounding atmospheric temperature for most of the experimental period. The temperature variation recorded on Day-3. The results again confirm that the modified Quonset greenhouse dryer effectively retains solar heat inside the drying chamber, which is essential for efficient moisture removal from agricultural products.



All the experimental observations were carried out using 2 kg of tomato as the sample product during the drying experiment.

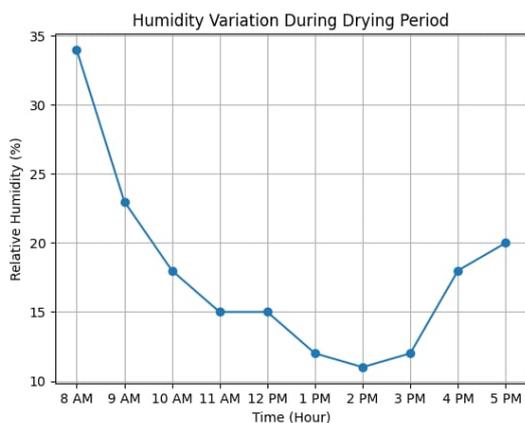
The variation of relative humidity inside the modified Quonset solar greenhouse dryer was observed under two different conditions: without product (no-load condition) and with product loading. Monitoring humidity levels is important to understand the drying environment inside the greenhouse dryer and its effect on moisture removal.

Under no load conditions, the relative humidity inside the dryer gradually decreased from 30% at 8 AM to around 10% during the peak solar hours between 12 PM and 2 PM. This reduction in humidity occurred due to the increase in internal temperature caused by solar radiation entering through the transparent polycarbonate sheet. After 3 PM, the humidity level began to increase slightly and reached about 20% by 5 PM, as solar intensity decreased during the evening period.



When the dryer was loaded with the product, the relative humidity inside the drying chamber showed a slightly higher value during the morning period due to the presence of moisture in the agricultural product. The humidity level started at approximately 34% at 8 AM and gradually decreased to about 11% at 2 PM as the drying process progressed. The decrease in humidity during the peak solar hours indicates effective moisture evaporation from the product. Later in the afternoon, the humidity increased again and reached around 20% by 5 PM due to reduced solar radiation and lower evaporation rates.

## Humidity Variation Inside the Dryer Relative Humidity Analysis (With and Without Product)



The comparison of both conditions indicates that the presence of the product slightly increases the humidity inside the dryer during the initial drying period. However, during peak solar hours, the greenhouse dryer is capable of maintaining lower humidity levels, which is favorable for efficient moisture removal. These results demonstrate that the modified Quonset solar greenhouse dryer provides suitable environmental conditions for agricultural drying applications.

### Overall Performance of the Greenhouse Dryer

The combined analysis of temperature and humidity observations demonstrates that the modified Quonset solar greenhouse dryer provides suitable environmental conditions for agricultural drying. The greenhouse structure allows solar radiation to enter the drying chamber and traps heat inside, resulting in higher internal temperature compared to the surrounding atmospheric conditions.

At the same time, the decrease in humidity during peak solar radiation hours enhances the moisture evaporation process from the agricultural products. These favorable drying conditions improve the overall drying efficiency of the system.

Therefore, the experimental results confirm that the modified Quonset solar greenhouse dryer is capable of maintaining higher temperature and lower humidity conditions required for efficient solar drying.

### 5. CONCLUSION

The present study analyzed the thermal performance of a modified Quonset solar greenhouse dryer for drying agricultural products. The experimental results showed that the temperature inside the dryer was consistently higher than the outside atmospheric temperature due to the greenhouse effect created by the transparent polycarbonate sheet. The humidity level inside the dryer

also decreased during the peak sunlight hours, which helps in faster moisture removal from the products. The temperature and humidity observations indicate that the dryer provides suitable conditions for effective drying. Overall, the modified Quonset solar greenhouse dryer can be considered an energy-efficient and environmentally friendly method for agricultural drying.

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