Design and Fabrication of Solar Powered Smart Air Cooler

Pooja Ingle
B.E. Electrical Engineering
Shri Sant Gajanan Maharaj
College of Engineering
Shegaon, Maharashtra, India
poojatingle@gmail.com

Pornima Lohakare
B.E. Electrical Engineering
Shri Sant Gajanan Maharaj
College of Engineering
Shegaon, Maharashtra, India
plohakare17@gmail.com

Roshani Dhole
B.E. Electrical Engineerging
Shri Sant Gajanan Maharaj
College of Engineering
Shegaon, Maharashtra, India
roshanidhole8261@gmail.com

Shreya Farkunde
B.E. Electrical Engineering
Shri Sant Gajanan Maharaj
College of Engineering
Shegaon, Maharashtra, India
shreyafarkunde2003@gmail.com

Shruti Palhade
B.E. Electrical Engineering
Shri Sant Gajanan Maharaj
College of Engineering
Shegaon, Maharashtra, India
shrutipalhade.12@gmail.com

Vaishnavi Pesode
B.E. Electrical Engineering
Shri Sant Gajanan Maharaj
College of Engineering
Shegaon, Maharashtra, India
pesodevaishnavi2o@gmail.com

***Abstract*— This paper introduces a solar-powered smart air cooler designed to offer a comfortable and energy-efficient cooling experience. The system runs on solar energy, which helps reduce electricity usage and is especially useful in places with frequent power outages. It's built with smart features that respond to real-time conditions like temperature, humidity, and even user presence using a PIR sensor. A PMDC motor is used and the system is managed by an ESP32 microcontroller. The cooler can be monitored and controlled remotely through the Blynk interface, allowing users to adjust settings from anywhere. Features like automatic shut-off, mist-based cooling, and humidity-based water control make it intelligent and easy to use. This cooler provides an eco-friendly, modern solution for keeping spaces cool while promoting energy savings and environmental care.**

Keywords—Solar-powered cooling, IoT integration, Smart automation, Energy efficiency, Remote monitoring.

INTRODUCTION

In today's world, where temperatures are rising and energy demands are constantly increasing, the need for efficient and eco-friendly cooling solutions is more important than ever. From homes and classrooms to offices and small shops, people depend on cooling devices to beat the heat. However, most of these devices, like air conditioners or standard air coolers, run on electricity. While they do their job well, they also consume a lot of power, which leads to high electricity bills. Most of this power still comes from non-renewable sources like coal, which adds to pollution and global warming. So, while we stay cool indoors, we're unknowingly warming the planet even more.

The situation becomes even more difficult in rural or remote areas where power cuts are common or electricity isn't available all the time. In such places, using a regular electric cooler or air conditioner isn't reliable or even possible. So, we design a cooler that doesn't depend on grid electricity, saves energy, and is smart enough to adjust to your needs.

Our project focuses on designing and fabricating a solar-powered smart air cooler. This cooler runs entirely on solar energy during the day and a battery setup. It provides a sustainable solution for cooling needs without depending on electricity from the power company. It also helps save on electricity bills, reduce carbon emissions, and provide a cooling option even in places with no power supply.

We've integrated a range of smart features into the cooler to make it convenient and efficient. We used sensors to monitor temperature and humidity in the room. Based on this data, the cooler automatically adjusts how it operates — like increasing the fan speed when the room gets hotter or turning on a misting function when the air is too dry. If the humidity is already high, the system saves water by adjusting the pump speed or switching it off. We also added a PIR (passive infrared) sensor that detects if someone is in the room. If no one is there, the cooler shuts off automatically to save power and water.

One of the core features is the remote-control capability. We've used the Blynk app to connect the system to a smartphone so users can control the cooler from anywhere — turn it on or off, switch modes, or check live temperature and humidity data. This gives full flexibility and adds a modern touch to a very practical device.

On the hardware side, we chose a PMDC motor to power the fan. For the mechanical structure, we used GI (galvanized iron) sheets, which are durable, rust-resistant, and easy to work with. The cooling part uses honeycomb and wood wool pads for dual cooling, which are excellent at absorbing water and allow more air to pass through for better cooling. A 12V DC water pump circulates water over the pads to create the evaporative cooling effect. In addition to all these features, we've also added an optional room freshener and sanitizing unit, which can be turned on manually.

What makes this project truly meaningful is its real-world impact. It's a working solution for people who face real challenges like power cuts, high electricity costs, and extreme heat. It's affordable, energy-saving, smart, and built using components that are easy to find and replace. Our goal is to make this smart air cooler available to more people — especially those living in rural areas, small towns, or anywhere the sun shines bright but the power supply is weak.

Through this project, we aim to show how renewable energy and smart technology can work hand-in-hand to improve lives, reduce energy stress, and move us closer to a more sustainable future.

LITRATURE REVIEW

Al-Yasiri et al. (2022), This review by Al-Yasiri and colleagues examines various solar-powered cooling and air-conditioning systems, highlighting their growing importance in energy-conscious building design. The paper covers different technologies like absorption and adsorption chillers, emphasizing their application in homes and commercial spaces. Benefits include reduced electricity usage and carbon emissions, especially in remote, off-grid areas. However, the authors also point out key limitations—such as high initial costs, technical inefficiencies, and challenges with energy storage. Ultimately, the study encourages further research to make solar cooling more efficient and affordable, particularly for small-scale and residential setups where current solutions fall short.

Amit A. Patil et al. (2020), Patil and his team designed a simple, solar-powered air cooler that's ideal for rural and remote areas without reliable electricity. Their model uses basic components—solar panels, a DC fan, and a water pump—to cool air through evaporation. It's cost-effective, environmentally friendly, and easy to maintain, offering a green alternative to traditional coolers. While the system performs well, it lacks smart automation or adaptability to changing conditions, limiting its usefulness in more advanced setups. Still, the study highlights its promise in sustainable development, especially where low cost and clean energy are top priorities.

Madhusudhan M. et al. (2020), This study introduces a solar-powered system that can cool in summer and heat in winter—making it a year-round solution. It runs on solar-charged batteries and uses a water pump and DC fan for air circulation. The setup includes basic automation, allowing it to switch modes without much human input. Performance tests show it's efficient and well-suited for areas with unreliable power. While the design is versatile, its complexity and cost may limit widespread use. Still, the dual-function system demonstrates how renewable energy can power smart, adaptable climate control in places that need both cooling and heating.

Awasare & Panchal (2023), Awasare and Panchal developed and tested a solar-based air cooler focused on energy savings and environmental impact. Using PV panels, the cooler runs a fan and pump to deliver evaporative cooling via honeycomb pads. The study shows the system effectively lowers indoor temperatures with minimal power use—ideal for eco-conscious users. It also explores cost, material choices, and airflow design, providing a well-rounded analysis. However, it notes limitations in energy storage and smart control, suggesting room for improvement. Overall, the paper supports solar coolers as clean, efficient alternatives to traditional systems, especially in hot, sun-rich climates.

Kranti Dhruw et al. (2024), This study explores the development of a solar-powered air cooler aimed at providing sustainable cooling solutions. The system utilizes solar energy captured via photovoltaic panels, which is stored in batteries to power the cooler. Emphasizing environmental benefits, the design focuses on reducing reliance on conventional electricity sources. The paper discusses the integration of solar technology into air cooling systems, highlighting the potential for energy savings and reduced carbon emissions. While the study underscores the feasibility of solar air coolers, it also notes challenges such as initial setup costs and the need for efficient energy storage solutions

A. Research gap

While several studies have explored solar-powered air coolers and their environmental benefits, most focus on basic models with limited automation or adaptability. Few systems integrate smart features like real-time sensor control, IoT connectivity, or user presence detection. Additionally, challenges related to energy storage, cost-efficiency, and year-round usability still remain underexplored, especially for compact, residential applications in regions with inconsistent sunlight.

B. Problem statement

Most solar-powered air coolers lack smart features and adaptability, making them inefficient in changing environments. There is a need for an affordable, intelligent cooling system that combines solar energy with automation for better performance in residential areas.

OBJECTIVES

1. Develop a solar-powered air cooler which ensures zero power consumption.
2. Reduce energy consumption by utilizing BLDC motor technology.
3. To enhance cooling effect by incorporating honeycomb pads, ice chamber and mist cooling mode.
4. To integrate a sanitizing and room freshening feature.
5. Implement auto shut-off based on user presence detection.
6. Enable remote operation for user convenience.
7. Integrate a temperature-sensing mist system for optimal cooling.
8. Develop an intelligent switching cooling system that adapts to temperature and humidity.
9. Humidity based water-saving system.

METHODOLOGY

The project was developed through a structured methodology divided into key phases:

Requirement Analysis

Listing the required features such as solar operation, automatic misting, and moisture-based water management.

Component Selection

Choosing suitable components including PMDC fan motor, RO mist motor, ESP32, solar panel, DHT11, PIR, and moisture sensor.

Design and Fabrication

Developing the mechanical structure using GI sheet and integrating electronic circuits. Fabricating the cooler frame, misting lines, water tank, and ice chamber.

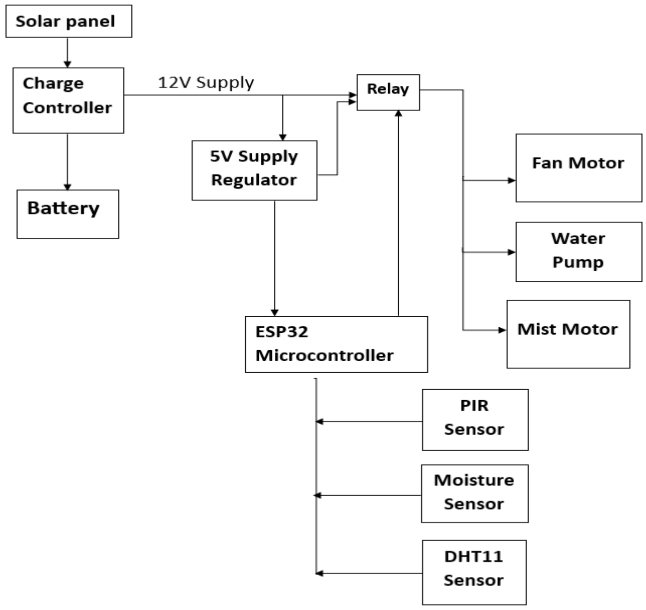

Fig. 1. Block Diagram

Circuit Implementation

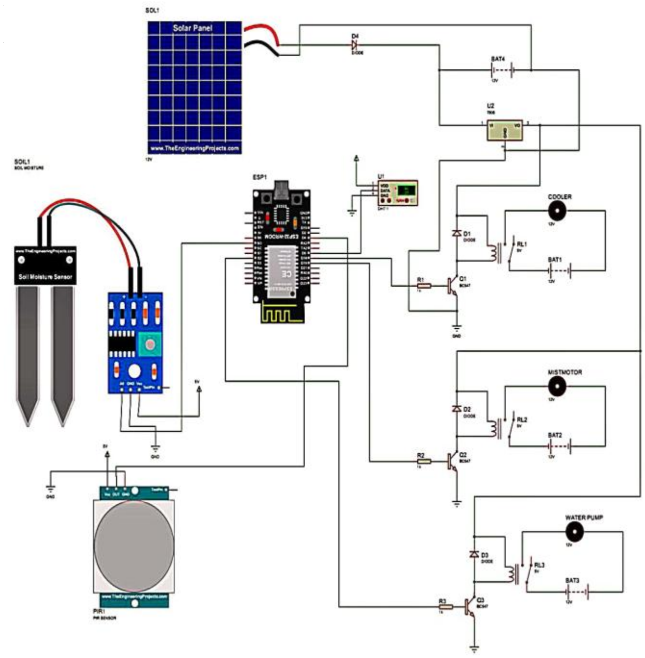

Fig. 2. Circuit Diagram

Programming and Testing

Writing embedded C code for ESP32 to process sensor data and automate operations. Repeatedly testing for different conditions (temperature, presence, moisture).

Performance Evaluation

Measuring temperature drop, energy consumption, and system response to ensure functionality and efficiency.

SYSTEM REQUIREMENT

Software specification

1. Blynk Interface
2. Arduino IDE

Hardware specification

TABLE I. COMPONENTS SPECCIFICATION

Sr. No.	Name of Component	Specification/Rating
1	Solar Panel	12V, 150W, 8.57A
2	Charge controller	12V, 15A
3	Battery	12V, Rechargeable Lead-Acid
4	Voltage Regulator	LM7805, 5V Output
5	Microcontroller	ESP32, Dual-core, Wi-Fi + Bluetooth, 3.3V logic
6	Temperature & Humidity Sensor	DHT11, Temp: 0–50°C, Humidity: 20–90%, 5V DC
7	PIR Sensor	Motion Detection, Digital Output, 5V DC
8	Soil Moisture Sensor	Analog + Digital Output, 5V DC
9	Relay Module	4-channel, 5V input, 10A 250V AC / 10A 30V DC contacts
10	Fan Motor	PMDC, 12V DC, 2.5A, 30W
11	Fan Blade	10-inch, Plastic
12	Water Pump	12V DC, 20W, 0.45A, 15 L/min Flow Rate
13	Mist Motor	12V DC, RO Pump, 1.5A, 18W
14	Cooling Pad (Honeycomb)	17 in (L) × 15 in (H) × 2 in (W)
15	Cooling Pad (Wood wool)	Single Layer over Honeycomb Pad
16	Cooler Body	18 in (L) × 20 in (H) × 16 in (W), 18 Gauge GI Sheet

SYSTEM DESIGN AND IMPLEMENTATION

To bring the concept of a smart air cooler into a working solution, we designed a prototype that integrates both mechanical and electronic components in a compact and functional manner. This section outlines how the physical structure was developed, how components were selected and installed, and how various subsystems like cooling, control, and power management were implemented. The aim was to create a practical and efficient model that could be easily fabricated and tested in real-world conditions.

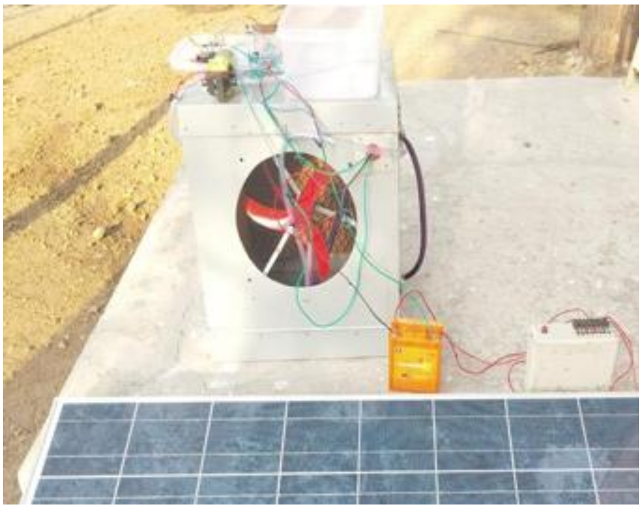

Fig. 3. 3D Model

A. Structural Design

The cooler housing is constructed using galvanized iron (GI) sheets, chosen for their strength and corrosion resistance. The cooler dimensions are 18 inches in length, 20 inches in height, and 16 inches in width. The central section of the body includes an 11-inch diameter circular cutout for the fan blade.

B. Cooling Components

The system includes a PMDC motor driving a 10-inch fan blade to circulate air. Honeycomb pads are installed on the lateral and rear walls for evaporative cooling. A single-layer wood wool pad is added over the honeycomb for additional moisture retention. A DC water pump feeds water from the reservoir to a perforated pipe positioned above the honeycomb pads, evenly wetting the pads. Below the pads, a soil moisture sensor monitors the wetness level to automate pump control.

To further enhance cooling, a misting system is incorporated. The mist motor activates when the room temperature rises above the set point of 28°C. The mist is delivered through nozzles positioned at the air outlet, improving air cooling through evaporative misting. The mist motor takes chilled water from an ice chamber located on top of the cooler, maximizing cooling efficiency during peak heat. Once the room temperature drops below 26°C, the misting motor automatically turns off, maintaining a comfortable indoor environment without overcooling.

C. Power and Control

A 12V solar panel powers the system, charging a battery that supplies electricity to all components. An LM7805 voltage regulator steps down the voltage for the relay module. A 4-channel relay module facilitates switching of the fan, water pump, and mist motor.

D. Configuration of the Microcontroller

The system's brain is the ESP32 microcontroller. It reads sensor data and adjusts relay outputs accordingly. Based on current environmental data, the control logic is set up to automate every task.

E. Integration of Sensors

The DHT11 sensor continuously measures the humidity and temperature of the surrounding air. The misting motor is activated based on a preset temperature. When the room temperature rises above 28°C, the mist motor turns ON automatically to enhance cooling. It remains ON until the temperature drops below 26°C, at which point the mist motor switches OFF, maintaining a steady and comfortable indoor environment.

PIR Sensor: Identifies people in the vicinity of the cooler. To save energy, the system shuts down if no movement is detected for more than a minute.

The soil moisture sensor gauges how wet the honeycomb pads are. The water pump is switched off if the pads are wet and on if they are dry.

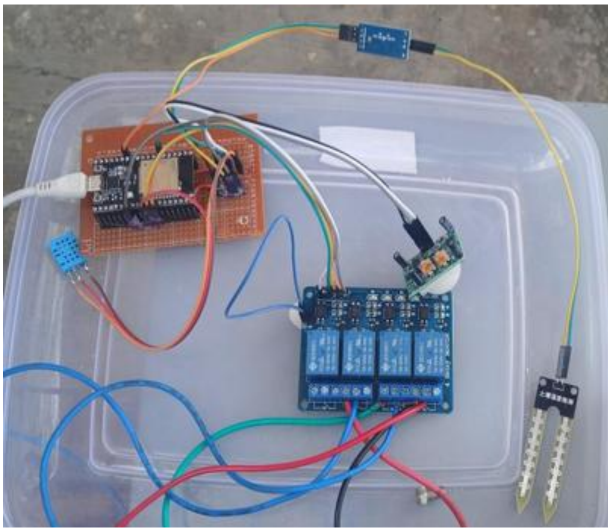

Fig. 4. Control Circuit

WORKING MECHANISM

The cooler begins operation when the PIR sensor detects human presence. The fan motor starts to circulate air. The water pump operates based on feedback from the moisture sensor to ensure optimal saturation of the honeycomb pads. The DHT11 sensor continuously monitors the surrounding temperature and humidity. If the temperature rises above the set point of 28°C, the misting motor activates, providing additional cooling through a fine mist. The chilled water from the rooftop ice chamber is fed to the misting nozzles to accelerate the cooling process. Once the room temperature falls below 26°C, the misting motor automatically turns off to prevent overcooling. If no human presence is detected for a set period, the system powers down to save energy.

This automation not only reduces energy consumption but also prevents unnecessary water usage, making the system highly efficient. The relay module provides electrical isolation and reliable switching for high-current devices, ensuring longevity and operational safety.

RESULT

After successful fabrication and testing, the smart air cooler demonstrated excellent performance in terms of energy efficiency and user comfort. The misting system, operating based on a preset temperature range, helped maintain a steady and pleasant cooling effect without unnecessary water consumption. The PIR sensor effectively controlled power usage by shutting the system down during inactivity. The moisture sensor helped in water conservation by ensuring the pump only operated when necessary. The comparison between a traditional AC-powered air cooler and our DC-powered air cooler project reveals several key differences in energy consumption. A traditional AC cooler typically consumes around 150 to 180 watts, combining the fan motor and water pump. In comparison, our DC air cooler operates on just 50 to 60 watts, including the fan, pump, microcontroller and sensors, leading to an estimated energy savings of 60–70%. This lower power requirement means the DC cooler uses much less electricity, making it a more energy-efficient and cost-effective option for daily use.

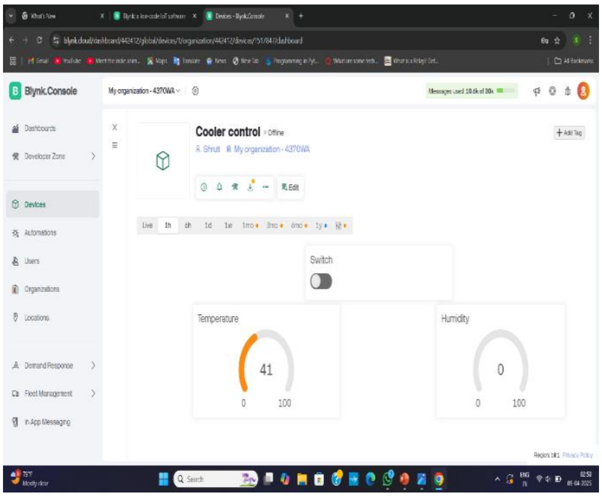

Fig. 5. Blynk Interface

CONCLUSION

The Solar-Based Smart Air Cooler presented in this paper offers a viable, eco-friendly, and intelligent solution to modern air-cooling challenges. It integrates sensor-based automation with renewable energy usage and smart feedback systems to deliver an energy-efficient, water-saving, and comfort-enhancing appliance. The system's modular design and low-cost components make it ideal for wide-scale adoption in both rural and urban areas. By using solar power as the main energy source, the cooler runs on clean and free energy from the sun, helping to cut down on electricity bills and reduce carbon emissions. This makes the air cooler not only cost-effective but also environmentally friendly. The smart features added to the system such as automatic temperature sensing, humidity control, and speed adjustment make the cooler more efficient and user-friendly. These features help the device to operate only when needed and at the right settings, which saves energy and improves comfort.

The fabrication process also focused on using easily available materials and simple design principles, which means the cooler can be built with low cost and minimum technical expertise. This makes it ideal for use in rural areas or places where electricity supply is inconsistent or unavailable.

REFERENCES

[1] S. Ahmad, S. Sofiyan, A. Zahid, S. Abrar, and M. H. Ali, "Smart cooler and room heater," International Journal of Creative Research Thoughts (IJCRT), vol. 6, no. 2, pp. 85-90, 2018.

[2] A. Shinde, C. Deshmane, V. Tate, S. Shikalgar, and R. S. Sundge, "Design and Fabrication of 360 Motion Air Flow Cooler," International Research Journal of Engineering and Technology (IRJET), vol. 9, no. 5, pp. 3482-3484, 2022.

[3] Al-Yasiri, Q., Szabó, M., & Arıcı, M. (2022). A review on solar-powered cooling and air-conditioning systems for building applications. Energy Reports, 8, 2888–2907. https://doi.org/10.1016/j.egyr.2022.01.172

[4] G. Kawle, N. Jha, A. Varhade, S. Gajpure, S. Kawale, and V. Jais, "Internet of Things IoT Controlled Solar Cooling System with Smart Features," *International Journal of Progressive Research in Engineering Management and Science (IJPREMS)*, vol. 03, no. 05, pp. 771-775, May 2023. doi: 10.58257/IJPREMS31319.

[5] Amit A. Patil, Uttam S. Bongarde, Atul J. Dhavale, Rahul R. Joshi, "Study on Solar Powered Air Cooler", International Advanced Research Journal in Science, Engineering and Technology, Vol. 7, Issue 11, November 2020 DOI: 10.17148/IARJSET.2020.71113

[6] Rushiprasad Watpade, "Solar Powered Air Cooler", International Research Journal of Engineering and Technology (IRJET), Volume 9, Issue 3, Mar 2022, e-ISSN: 2395-0056, p-ISSN: 2395-0072

[7] Shaik Mohammed Hussain, Mohammed Khalid Ahmed, Mohammed Asif Kattimani, Mohammed Abdul Jabbar, Mohammed Ismail Hassan Khan and Nawaf Ibn Kamil. 2024. "Development of Solar Evaporative Cooling System". International Journal of Development Research, 14, (09), 66659- 66663.

[8] Dhruw, K., Akram, M., Kumar, L., & Salam, G. (2024). *Design and Fabrication of Solar Air Cooler*. International Journal of Scientific Research in Engineering and Management (IJSREM), 8(5).

[9] Awasare, A. D., & Panchal, R. N. (2023). *Solar-Based Air Cooler: Design, Performance Evaluation, and Environmental Impact*. Zenodo. https://doi.org/10.5281/zenodo.10434358

[10] Nayak, M., Manjunath, H. N., & Madhusudhan, M. (2020). *Performance Studies on Automated Solar Powered Air Cooler / Air Heater*. International Journal of Scientific & Technology Research, 9(1), 3480–3483.