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Design and Development of Solar Powered Air-Cooling System

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Abstract: ***This paper presents the design and development of a solar-powered air cooling system using indirect-direct evaporative cooling (IDEC) technology. The system is an energy-efficient and eco-friendly alternative to conventional air conditioning, aimed at reducing electricity consumption and dependency on non-renewable sources. Powered entirely by a photovoltaic (PV) panel, it integrates sensors, automation, and water-efficient cooling pads. Performance analysis indicates the system can reduce ambient temperatures by 5°C to 7°C, making it suitable for dry and semi-arid regions.***
Keywords: Solar Cooling, Evaporative Cooling, Renewable Energy, Photovoltaic System, BLDC Fan.

I. INTRODUCTION

Increased global temperatures and the urgent need for sustainable energy solutions have triggered innovations in green technology. Cooling requirements, especially in rural and semi-urban areas with limited electricity access, are a prime concern. This paper focuses on an energy-efficient air cooling system powered solely by solar energy that employs indirect-direct evaporative cooling (IDEC) with automated temperature control.

II. LITERATURE REVIEW

Prior studies indicate the effectiveness of evaporative cooling and solar-powered systems in dry climates. Ambiator and IIT-led research highlighted IDEC systems for their energy efficiency. Safety standards, global EMF guidelines, and comparative system studies form the foundation of our approach. Our project incorporates renewable energy, DC components, and smart automation to develop a scalable and sustainable cooling solution.

III. METHODOLOGY

1) Component Selection: 12V, 40W solar panel; 12V lead-acid battery; PWM charge controller; BLDC fan; water pump; DHT11 sensor; Arduino microcontroller; honeycomb cooling pads.
2) Prototype Development: Phase 1 (Breadboard testing) and Phase 2 (PCB + automation).
3) Fabrication: System built into a compact casing with solar mount, ducts, and protective enclosure.

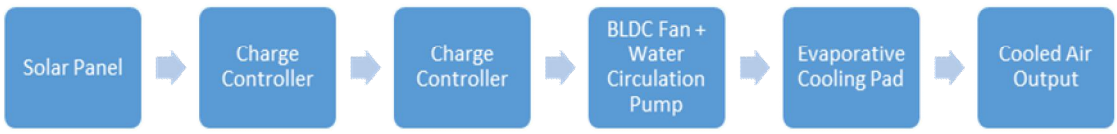

Fig. 1. Block Diagram of System Layout

IV. SYSTEM DESIGN AND IMPLEMENTATION

The IDEC system consists of a 12V, 40W monocrystalline solar panel that powers a BLDC fan and submersible water pump. Water circulates through a honeycomb cooling pad, and hot air is pulled through the moist pad, reducing the air temperature via evaporation. The Arduino controls the system based on temperature readings, activating components at 31°C and deactivating at 25°C.

Table 1 Component Specifications

Component	Specification	Qty	Estimated Cost (₹)
Solar Panel	12V, 40W	1	3,500
BLDC Fan	12V, 10W	1	1,000
Water Pump	12V, submersible	1	600
Battery	12V, 7Ah Lead-Acid	1	2,000
Charge Controller	PWM, 12V	1	500
Cooling Pad	Honeycomb Type	1	800
Arduino + Sensor	UNO + DHT11	1	600
Enclosure, Wiring	Misc. + Ducts	1	2,500
Total			₹13,500

V. RESULTS AND ANALYSIS

TABLE 2 Component Specifications

Parameter	Observed Result
Temp. Reduction	5°C to 7°C drop
Air Output Temp.	25°C to 26°C
Power Source	100% Solar
Runtime (daily)	5 to 6 hours (sunlight)
Water Consumption	~3 litres per day
Maintenance	Minimal
Cost Efficiency	High

The performance evaluation confirms reliable cooling under sunlight, with automation improving power management and user comfort. System was tested under ambient temperatures ranging from 32°C to 35°C.

VI. CONCLUSIONS

This paper presents a successful implementation of a solar-powered air cooling system suitable for rural and remote applications. The prototype effectively utilizes solar energy and evaporative cooling, reducing dependency on grid electricity. Automated controls optimize power use, and the design is cost-effective, scalable, and environmentally sustainable. Future versions could integrate IoT for remote monitoring, auto-refill water systems, and hybrid energy sources.

VII. ACKNOWLEDGMENT

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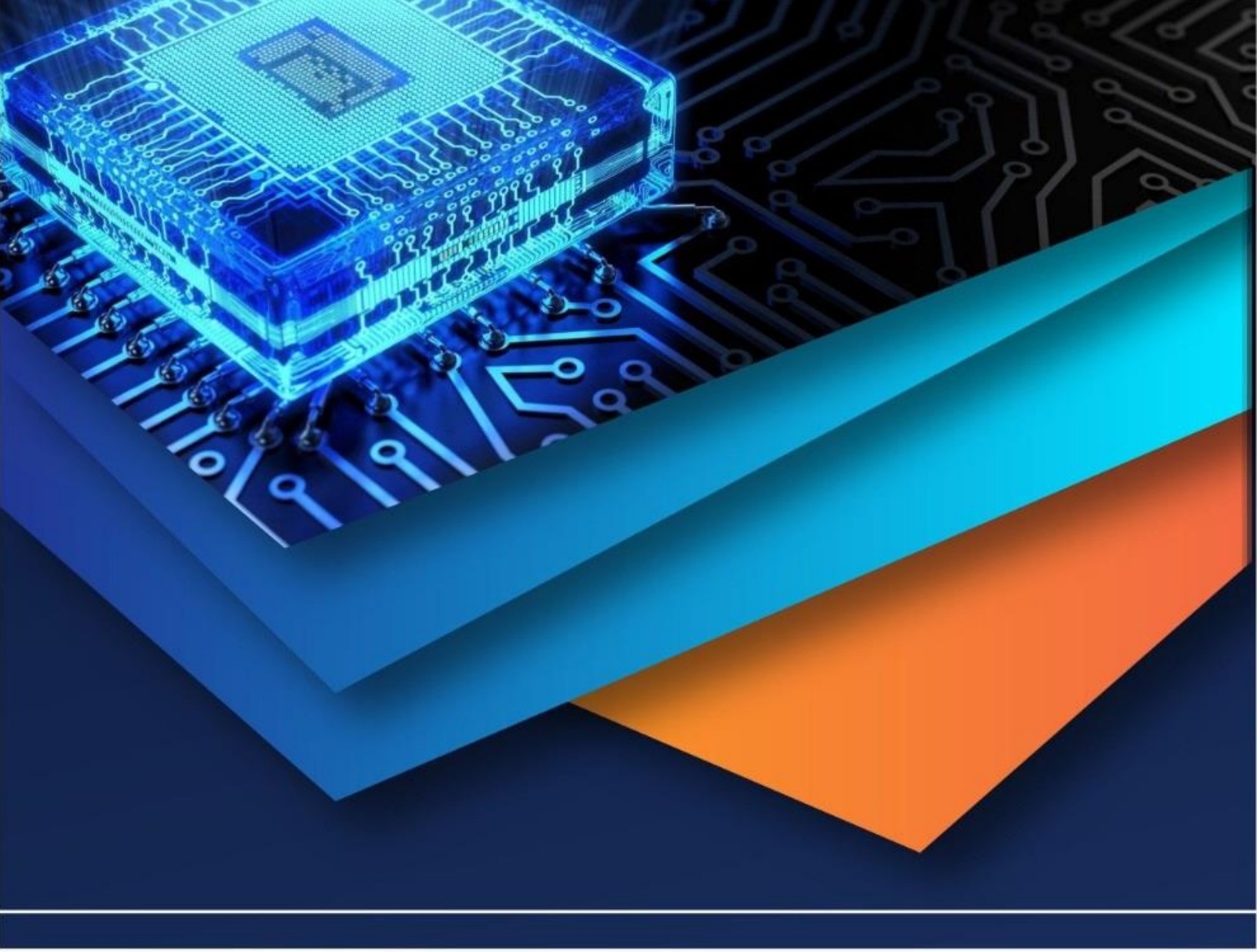

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