

DESIGN AND FABRICATION OF AN EVAPORATIVE COOLING SYSTEM

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1. Motivation

The development of a solar-powered evaporative cooler with integrated temperature and humidity controls is a purposeful and ambitious project driven by our team's passion for renewable and sustainable energy solutions. We have identified existing inefficiencies and limitations in existing cooling technologies. And we are determined to leverage our fundamental knowledge in thermodynamics, fluid dynamics and Computer aided design to contribute to sustainable engineering solutions.

The primary purpose of this project is to design a sustainable, solar-powered evaporative cooler that enhances cooling efficiency and user comfort by integrating temperature and humidity controls. With temperatures increasing as a result of global warming the need for sustainable cooling solutions is now more than ever. The International Energy Agency (IEA) estimates that cooling accounts for approximately 10% of global electricity consumption, a figure expected to triple by 2050 without energy-efficient alternatives. Traditional air conditioners, which rely on energy-intensive vapor-compression cycles and high-global-warming-potential refrigerants (e.g., hydrofluorocarbons), exacerbate climate change and strain power grids, particularly in developing countries with limited electricity access. Evaporative coolers, which use the natural process of water evaporation to cool air, consume up to 75% less energy than conventional air conditioners, making them an environmentally friendly alternative. However, their performance is hindered by uncontrolled humidity, which reduces cooling effectiveness and comfort in moderately humid climates. Our project addresses this critical gap by developing a compact, solar-powered system that maintains optimal humidity levels while operating independently of fossil fuel-based electricity. This solution is particularly vital for off-grid communities, rural areas, and regions with abundant solar resources, aligning with the United Nations' Sustainable Development Goal 7 (Affordable and Clean Energy).

As mechanical engineering undergraduates with an interest in renewable and sustainable energy technologies we are committed to combat climate change and promote environmental stewardship. Our coursework in thermodynamics, where we specifically studied the principles of evaporative coolers, provided us with a strong foundation in heat and mass transfer processes critical to this project. Our hands-on experience with SolidWorks has enabled us to develop proficiency in designing mechanical components, housings, ducts etc. that will be necessary

for our project. Further, during the 5th semester, we are learning ANSYS, which will allow us to perform computational fluid dynamics (CFD) simulations to optimize airflow and heat transfer within the cooler, ensuring efficient performance.

When selecting an idea for our project we tried to identify a topic that is technically challenging, academically enriching, and socially impactful. Drawing on our thermodynamics coursework, we analyzed the psychrometric challenges of evaporative cooling and identified humidity control as a critical area for innovation. We also explored the potential of solar power through self-directed research and discussions with faculty advisors, recognizing its compatibility with off-grid cooling applications. Our SolidWorks experience informed our confidence in designing a prototype, while our upcoming ANSYS training will enable us to validate our design through simulations. We consulted with lecturers and instructors to ensure our approach is both novel and practical. This project represents a unique opportunity to apply our skills, push the boundaries of evaporative cooling technology, and make a meaningful contribution to sustainable engineering.

2. Overview

2.1 Significance of the Project

The significance of this project is rooted in the escalating global and regional demand for cooling, driven by climate change, population growth, and urbanization. According to the International Energy Agency's 2018 report, "The Future of Cooling," air conditioning and electric fans account for nearly 20% of total electricity used in buildings worldwide, a figure expected to grow substantially as cooling demand could triple by 2050 [International Energy Agency, 2018](#). This demand is particularly pronounced in hotter regions, with projections from Nature Communications indicating that the share of households with air conditioning could rise from 27% to 41% by mid-century, potentially doubling residential cooling electricity consumption to 1940 terawatt-hours per year [Nature Communications, 2024](#). This surge poses significant challenges for electricity grids, especially in developing countries like India and Indonesia, where extreme heat exposure is increasing [ScienceDirect, 2022](#).

The environmental impact of conventional cooling systems is a critical concern. Air conditioners, typically consuming 500-1500W, contribute to greenhouse gas emissions through both energy use and refrigerant leakage. Hydrofluorocarbons (HFCs), used in many units, have a global warming potential thousands of times greater than carbon dioxide, with studies suggesting they account for nearly 4% of global greenhouse gas emissions [EcoMENA, 2024](#). The production and disposal of these units further exacerbate environmental degradation, creating a feedback loop where increased cooling demand worsens climate change [Time, 2021](#). In contrast, the proposed solar-powered evaporative air conditioner, targeting ~120W, eliminates HFCs, offering a sustainable alternative that aligns with global efforts to reduce emissions.

The practicality and usefulness of this project are particularly relevant for developing countries, where access to reliable electricity is limited. The UNEP and IFC report highlights an \$8 trillion opportunity in sustainable cooling solutions, with the market in developing economies expected to grow from \$300 billion to at least \$600 billion by 2050 [UNEP and IFC, 2024](#). Sustainable cooling can slash emissions by almost 50% and save significant costs in electricity bills and power sector investments. Initiatives like the Clean Cooling Collaborative, supporting projects in India, Egypt, and Rwanda, underscore the need for innovative solutions such as solar-powered refrigeration for small-scale farmers and low-carbon cooling for slum houses [Sustainable Energy for All, 2022](#). The Borgen Project notes that lack of cooling in developing countries leads to 23% food production loss due to poor refrigeration, emphasizing the socioeconomic benefits of accessible cooling [The Borgen Project, 2018](#).

Academically, this project addresses a critical gap in evaporative cooling technology, particularly in humidity control. Evaporative coolers are efficient in dry climates but struggle in humid conditions, where the wet bulb temperature limits cooling capacity. Research, such as a review in WIREs Energy and Environment, identifies the need for advancements in dehumidification to extend evaporative cooling's applicability [Tejero-González et al., 2022](#). The proposed integration of desiccant wheels, high voltage precipitation, or thermoelectric dehumidification aims to fill this gap, contributing to academic knowledge and practical applications.

The potential impact includes significant energy savings, with the system consuming far less power than conventional air conditioners, reducing emissions, and lowering operational costs. Socioeconomic benefits include improved quality of life in off-grid areas, support for economic activities like food preservation, and alignment with global sustainability goals. The Asian Development Bank emphasizes the need for energy-efficient, low-carbon cooling systems to mitigate climate change while meeting growing demand [Asian Development Bank, 2024](#).

2.2 Description of the Project

The project focuses on designing a solar-powered evaporative air conditioner to address the limitations of current cooling technologies in humid climates. The problem identification highlights that standard evaporative coolers, while energy-efficient (100-200W), are ineffective in high humidity (>60% RH) due to reduced evaporation rates, and conventional air conditioners, consuming 500-1500W, are costly and environmentally harmful due to grid dependency and HFC use. This creates a need for a sustainable, low-cost solution for small spaces, particularly in off-grid or rural settings.

The simplified solution description outlines a system comprising a cooling pad for evaporation, fans for airflow, ducts for distribution, a water pump for pad wetting, a solar power system (~120W photovoltaic panel with minimal battery backup), temperature and humidity sensors (e.g., DHT22), a microcontroller (e.g., Arduino) for smart control (in furthermore upgrading phases), and a humidity control unit. The humidity control options—desiccant wheel (using silica gel, regenerated by solar heat), high voltage precipitation (using a 10,000V module for

droplet collection), or thermoelectric dehumidification (using a Peltier module for condensation)—will be selected via literature review, evaluating energy consumption, dehumidifying effect, practicality, cost, ease of integration, and suitability for a 30 m³ room.

The technical scope includes designing the system using SolidWorks for 3D modeling and ANSYS or other suitable software for airflow and heat transfer simulations, implementing the prototype with scavenged, fabricated, or purchased components (e.g., 3D-printed ducts, salvaged fans), and testing under simulated conditions (ambient 25-30°C, 50-60% RH, 150W heat load).

Intended outcomes include a functional prototype demonstrating sustainable, off-grid cooling, validated performance data, and documentation contributing to sustainable cooling research. The project's scalability for residential, humanitarian, or small-scale commercial use is a key goal, addressing energy poverty and environmental concerns.

2.3 Background of the Project

The background section provides a professional review of evaporative cooling fundamentals, current technologies, humidity control methods, and solar-powered cooling, supported by academic references.

Evaporative Cooling Fundamentals: Evaporative cooling operates on the principle of water evaporation absorbing heat, cooling the air, a process used historically in ancient Persian wind towers and modern swamp coolers. Its efficiency is tied to dry air; in humid conditions, the wet bulb temperature limits cooling, as noted in thermodynamics texts [Cengel & Boles, 2015](#). This limitation is a key challenge in humid climates.

Current Evaporative Cooling Technologies: Commercial systems typically feature a water-saturated pad and fan, consuming 100-200W, offering energy efficiency compared to vapor compression air conditioners but lacking humidity control. The ASHRAE Handbook—Fundamentals (2017) details their operation, noting struggles in humid environments and ongoing research into hybrid systems [ASHRAE Handbook, 2017](#).

Humidity Control Methods: To enhance evaporative cooling in humid conditions, advanced methods include:

- **Desiccant Wheel:** A rotating wheel with desiccant (e.g., silica gel) absorbs moisture, regenerated by hot air, often solar-heated. Jia et al. (2020) analyze solar-powered desiccant systems, highlighting energy efficiency [Jia et al., 2020](#).
- **High Voltage Precipitation:** Uses a high-voltage field to charge water molecules, precipitating them for collection, offering compact dehumidification. Zhang et al. (2018) review its air cleaning and dehumidification potential [Zhang et al., 2018](#).
- **Thermoelectric Dehumidification:** Employs Peltier modules for condensation, low-power and solid-state. Riffat and Qiu (2013) review thermoelectric air conditioners, noting challenges in heat dissipation [Riffat & Qiu, 2013](#).

Solar-Powered Cooling: Solar-powered systems use photovoltaic panels for cooling, ideal for off-grid regions. Li et al. (2019) review solar-powered air conditioning, emphasizing sustainability but noting challenges in panel sizing and sunlight variability [Li et al., 2019](#). This project's integration of solar power with humidity control addresses a gap in compact, sustainable cooling solutions.

Key Metrics for Comparison

To organize the comparison of cooling technologies, the following table summarizes key metrics based on the research:

Table 01: Comparison Of Cooling Technologies

Technology	Power Consumption (W)	Humidity Control	Environmental Impact	Suitability for Off-Grid
Conventional Air Conditioner	500-1500	Yes (Compressor-based)	High (HFCs, Emissions)	No (Grid-dependent)
Standard Evaporative Cooler	100-200	No	Low (No HFCs)	Yes (Low Power)
Proposed System	~120 (expected)	Yes (Advanced Methods)	Very Low (Solar, No HFCs)	Yes (Solar-Powered)

This table highlights the proposed system's advantages in energy efficiency, humidity control, and sustainability, particularly for off-grid applications.

In conclusion, this overview provides a robust foundation for the project, addressing global cooling needs, detailing the innovative solution, and grounding it in a comprehensive literature review. The project's alignment with sustainability goals and academic research gaps positions it as a significant contribution to the field of air conditioning technology.

3. Methodology

3.1 Design phase

Objective- Design a solar-powered evaporative cooler that actively controls temperature and humidity in a small room, selecting the most suitable humidity control method from three

options—desiccant wheel, high voltage precipitation, or thermoelectric dehumidification—based on a literature review evaluating energy consumption, dehumidifying effect, practicality, cost, ease of integration, and suitability for small spaces.

Proposed solution- The evaporative cooler comprises a cooling pad for evaporation, fans for airflow, ducts for air distribution, a water pump for pad wetting, a solar power system, temperature and humidity sensors, a microcontroller for smart control, and a humidity control unit. The humidity control unit will incorporate one of three methods, selected after a literature review:

- **Desiccant wheel:** A rotating wheel with a cost-effective desiccant (e.g., silica gel) absorbs moisture, regenerated by solar-heated air to release water vapor, reducing humidity efficiently.
- **High voltage precipitation:** A high-voltage field charges water molecules, precipitating them as droplets for collection, offering compact dehumidification and potential air purification.
- **Thermoelectric dehumidification:** A Peltier module cools a surface to condense moisture, with the hot side dissipating heat, providing a solid-state, low-power solution. The microcontroller adjusts fan speed, pump operation, and the humidity control unit based on sensor feedback to maintain user-defined conditions

Justification- The three humidity control methods were selected for their novel, practical approaches and compatibility with solar power. The desiccant wheel leverages solar heat for regeneration, minimizing energy use. High voltage precipitation is low-power and compact, ideal for solar-driven systems. The thermoelectric method's solid-state design reduces maintenance and aligns with low solar power budgets. A literature review will evaluate these methods against criteria—energy consumption, dehumidifying effect, practicality, cost, ease of integration, and suitability for small rooms—to identify the optimal solution. This approach ensures a sustainable, efficient cooler.

Comparison to alternatives- Unlike standard evaporative coolers, which lack humidity control and are ineffective in humid conditions, our system regulates humidity, enabling use in small, moderately humid rooms. Air conditioners, using compressor-based dehumidification, are larger, costlier, and consume significantly more energy (e.g., 500-1500W vs. ~100-200W for our system), relying on grid power and harmful refrigerants. Our solution is more compact (portable design), cost-effective (lower material and operational costs), sustainable (solar-powered, no refrigerants), and efficient (targeted humidity control), making it ideal for small-scale, eco-friendly cooling.

Technical challenges- Designing a cost-effective desiccant wheel requires optimizing wheel size and solar regeneration efficiency. High voltage precipitation demands safe insulation and voltage calibration to avoid ozone production. The thermoelectric method faces challenges in heat dissipation and achieving sufficient dehumidification in humid conditions. Solar power

integration involves sizing panels and batteries to handle variable sunlight while powering fans, pumps, and the humidity control unit. Our ANSYS training will aid in simulating airflow and heat transfer to address these challenges.

Merits- The design's sustainability, driven by solar power, supports off-grid use in rural or developing regions, reducing carbon emissions. Its low cost, enabled by a cost-effective desiccant and efficient components, enhances affordability. Precise temperature and humidity control ensures comfort in small rooms, addressing a critical gap in evaporative cooling. Our SolidWorks designs and ANSYS simulations ensure a robust, scalable solution, contributing to sustainable cooling technology.

3.2 Implementation phase

Objective- Construct a prototype of a solar-powered evaporative cooler to control temperature and humidity in a 30 m³ room, implementing the most suitable humidity control method (desiccant wheel, high voltage precipitation, or thermoelectric dehumidification) selected via a literature review, using scavenged, fabricated, or purchased components.

Implementation Scheme: Following a literature review to select the optimal humidity control method based on energy consumption, dehumidifying effect, practicality, cost, ease of integration, and suitability for a 30 m³ room, we will build the prototype over three months, leveraging SolidWorks for design and ANSYS for airflow simulations. The cooler includes a cellulose cooling pad, axial fans, PVC ducts, a low-power water pump, a solar power system (~120W photovoltaic panel, minimal battery for backup), DHT22 temperature/humidity sensors, and an Arduino microcontroller for basic control. Components will be sourced without purchase where possible (e.g., salvaged fans, donated panels), fabricated if feasible (e.g., 3D-printed ducts), or bought as a last resort (e.g., sensors). Off-the-shelf parts will be customized if needed for integration.

- **Desiccant wheel (if selected)-** A ~25 cm diameter wheel, coated with cost-effective silica gel, will be fabricated using a 3D-printed frame, sized for 30 m³ dehumidification. A small solar-heated air stream (via a panel-mounted heater) regenerates the desiccant, with ducts directing moist air outside.
- **High voltage precipitation (if selected)-** A 10,000V module will be sourced or built using a scavenged transformer, with a 3D-printed tray to collect precipitated water. Safety insulation and voltage regulation prevent ozone production, integrated post-cooling pad.
- **Thermoelectric dehumidification (if selected)-** A 60W Peltier module, sourced or salvaged, will condense moisture on its cold side, with a scavenged heat sink and fan for heat dissipation. A drip tray collects water, placed in the airflow path.

The cooling pad, fans, ducts, and pump will be assembled in a portable enclosure (SolidWorks-designed). The water pump wets the pad, and fans draw air through the pad and humidity

control unit. The solar panel directly powers components where possible, with a minimal battery for stability. The microcontroller adjusts fan speed, pump, and humidity control based on sensor data (e.g., 22-26°C, 40-60% RH), using basic Arduino code if programming is required.

Technical challenges- Sourcing materials without lab access is a primary hurdle, requiring scavenging or cost-effective purchasing (e.g., silica gel, high-voltage modules). Fabricating components like the desiccant wheel frame without workshop tools may limit precision. Completing the prototype in three months demands efficient sourcing and assembly, risking delays if parts are unavailable. Ensuring solar power reliability for direct powering, especially for high-power methods (e.g., 10,000V precipitation), requires precise panel sizing and weather resilience. Customizing off-the-shelf components (e.g., Peltier heat sink) without lab equipment poses integration challenges.

Merits- The implementation delivers a sustainable, solar-powered cooler, reducing emissions and enabling off-grid use in small rooms. Cost-effectiveness, achieved through scavenged/fabricated components, ensures affordability. Precise temperature and humidity control enhances comfort, overcoming evaporative cooling limitations. The adaptable sourcing strategy maximizes resourcefulness, while SolidWorks/ANSYS utilization ensures robust design. The prototype's simplicity supports scalability for residential or humanitarian applications.

3.3 Testing phase

Objective- Validate the solar-powered evaporative cooler's performance in controlling temperature and humidity in a 30 m³ room, ensuring the selected humidity control method (desiccant wheel, high voltage precipitation, or thermoelectric dehumidification) meets design goals for efficiency and comfort.

Testing plan- Testing will occur in the final 2-3 weeks of the 3-month implementation period in a 30 m³ room or closet (e.g., a small bedroom) with a 150W heat load (e.g., from electronics), under average ambient conditions (25-30°C, 50-60% RH). The prototype, incorporating the humidity control method chosen via literature review, will be tested for cooling performance, humidity control, energy consumption, reliability, and user comfort. With no testing equipment currently available, we will borrow or purchase low-cost tools (e.g., handheld hygrometers, thermometers, USB power meters) and use the prototype's DHT22 sensors for Arduino-based data logging. Tests will run over three 4-hour sessions on different days to account for ambient and solar variability.

Aspects to test-

- **Cooling Performance:** Verify the ability to maintain a predetermined temperature against a specific heat load, measured with thermometers and DHT22 data.
- **Humidity Control:** Confirm maintenance of 40-60% RH, using hygrometers. If the desiccant wheel is selected, measure moisture absorption rate; for high voltage precipitation, quantify water collected at 10,000V; for thermoelectric, assess condensation volume from the Peltier module.
- **Energy Consumption:** Monitor power draw (fans, pump, humidity control unit) with a USB power meter, ensuring compatibility with the ~120W solar panel's direct output.
- **Reliability:** Assess consistent operation over sessions, checking for issues like pump clogging, sensor accuracy, or solar power interruptions.
- **User Comfort:** Collect qualitative feedback from team members on temperature stability, humidity comfort, and perceived air quality (e.g., for high voltage precipitation).

Testing methods-

- **Setup:** Position the prototype centrally in the room, with sensors at multiple points to capture temperature and humidity gradients. Set the microcontroller to target a specific temperature and humidity.
- **Procedure:** Operate the cooler for 4 hours per session, recording data every 15 minutes via manual tools and Arduino logs. Test under ambient conditions, noting solar panel output to verify direct powering. If possible, increase humidity (e.g., via a borrowed humidifier) to stress-test dehumidification.
- **Method-Specific Tests:** For the desiccant wheel, evaluate solar regeneration efficiency; for high voltage precipitation, confirm safety and water collection; for thermoelectric, measure Peltier condensation and heat sink performance.
- **When and how-** Tests will begin post-assembly. Data will be logged manually (hygrometers, thermometers) and via Arduino, with team observations for comfort.

Technical challenges- Lack of measuring tools complicates accurate data collection, requiring reliance on borrowed or low-cost devices with potential calibration issues. No lab access limits control over ambient conditions, with variable temperature/humidity (25-30°C, 50-60% RH) affecting consistency. The 3-month timeline constrains testing duration, risking rushed data if assembly delays occur. Solar power reliability, critical for direct powering, may falter during cloudy conditions, impacting performance.

Merits- Testing validates the cooler's sustainability, confirming solar-powered, emission-free operation for off-grid use. The cost-effective approach, using affordable tools, ensures accessibility. Precise temperature and humidity control enhances comfort, surpassing standard evaporative coolers. Contribution to sustainable cooling research by demonstrating viability in a 30 m³ room, supporting scalability for small-scale applications.

3.4 Evaluation phase

Objective- Analyze test results to validate the solar-powered evaporative cooler's performance in a 30 m³ room, confirming the selected humidity control method (desiccant wheel, high voltage precipitation, or thermoelectric dehumidification) achieves efficient, sustainable temperature and humidity control.

Evaluation plan- Using data from three 4-hour test sessions in a 30 m³ room with a 150W heat load, collected via low-cost tools (hygrometers, thermometers, USB power meters) and Arduino/DHT22 logs, we will evaluate cooling performance, humidity control, energy consumption, reliability, and user comfort. Evaluation methods—graphs, hardware demonstration, and comparative analysis—will present results using Excel for data visualization and a prototype showcase for functionality.

Aspects to evaluate-

- **Cooling performance:** Confirm the cooler achieves a set temperature within a specified time range for a given heat load, using temperature data.
- **Humidity control:** Verify maintenance of 40-60% RH, assessing dehumidification rate (e.g., water collected for thermoelectric/high voltage precipitation, moisture absorbed for desiccant).
- **Energy consumption:** Ensure power draw (<120W) supports direct 120W solar panel operation, compared to air conditioners (500-1500W).
- **Reliability:** Validate no major failures (e.g., pump, sensors, humidity unit) across sessions.
- **User comfort:** Evaluate qualitative feedback on temperature/humidity stability and air quality

Evaluation methods and justifications-

- **Graphs:** Plot temperature, humidity, and power data over time (15-minute intervals) in Excel, creating line graphs to show trends
- **Hardware demonstrations:** Operate the prototype during a presentation in a 30 m³ setting, demonstrating real-time temperature/humidity control.
- **Comparative analysis:** Benchmark results against literature: standard evaporative coolers (100-200W, no humidity control) and air conditioners (500-1500W, grid-powered).

Success criteria-

The prototype succeeds if it achieves a given temperature within adequate time, maintains 40-60% RH, consumes <120W (far below air conditioners), operates without major failures, and receives positive comfort feedback. Method-specific metrics include adequate dehumidification

Technical challenges-

Interpreting limited data from low-cost tools risks inaccuracies due to calibration issues, complicating performance assessment. Lack of advanced software beyond Excel restricts complex analysis (e.g., statistical modeling), relying on basic visualizations. No lab access limits data validation, and variable ambient conditions may skew results. The 3-month timeline constrains iterative analysis, while subjective comfort feedback requires careful interpretation.

4. Features

1. Humidity Control Integration

Integrates one of three innovative humidity control methods—desiccant wheel, high voltage precipitation, or thermoelectric dehumidification—selected through literature review for optimal performance. This enables precise control of indoor humidity (40–60% RH), unlike traditional evaporative coolers that fail in humid conditions.

2. Solar-Powered Operation with Battery Backup

Operates fully on a ~120W photovoltaic panel with a compact battery backup system to ensure continued operation during cloudy conditions or short periods of low sunlight—promoting sustainability and off-grid capability.

3. Energy Efficiency

Consumes significantly less power (~100–120W) compared to conventional air conditioners (500–1500W), making it ideal for rural or low-resource settings where energy conservation is critical.

4. Cost-Effective and Sustainable Design

Utilizes low-cost or scavenged components (fans, heat sinks, solar panels) and 3D-printed parts dramatically reducing fabrication costs and making the system affordable for broader communities.

5. Scalability and Portability

The unit is compact and designed for small room applications (30 m³), with modular components that can be adapted or scaled for different room sizes or extended cooling needs.

6. Eco-Friendly Materials and Operation

Avoids harmful refrigerants and uses solar-regenerated desiccants or solid-state modules, contributing to a low-carbon footprint and aligning with green energy goals.

7. Smart Control System (If applicable)

An Arduino-based control system dynamically adjusts fan speed, pump operation, and humidity control based on real-time sensor data to maintain comfortable environmental conditions autonomously.

5. Project Planning

Since we're working with a 12-week timeline, we've adjusted our existing plan to fit within that duration while keeping all tasks and responsibilities aligned logically. Here's the revised 12-week project planning table:

Table 02 : Project Task Schedule and Team Allocation for Evaporative Cooling System Development

Task number	Task	Week	Team Members
1	Literature review on humidity control methods	1-2	All members
2	Finalize system design (SolidWorks), airflow simulation (ANSYS)	3	Anupama (CAD) Tharusha, Dishan (Simulation)
3	Component scavenging, purchasing, and fabrication begins	4	All members
4	Continue fabrication and begin system assembly	5-6	All members
5	Install solar system, sensors, and core cooling unit	7	All members
6	Implement chosen humidity control method (e.g., desiccant module)	8-9	All members
7	Full system integration and dry-run testing	10	All members
8	Testing in 30 m ³ room, data logging, troubleshooting	11	All members
9	Evaluation (graphing, analysis, report writing, presentation preparing)	12	All members

Gantt Chart of the process

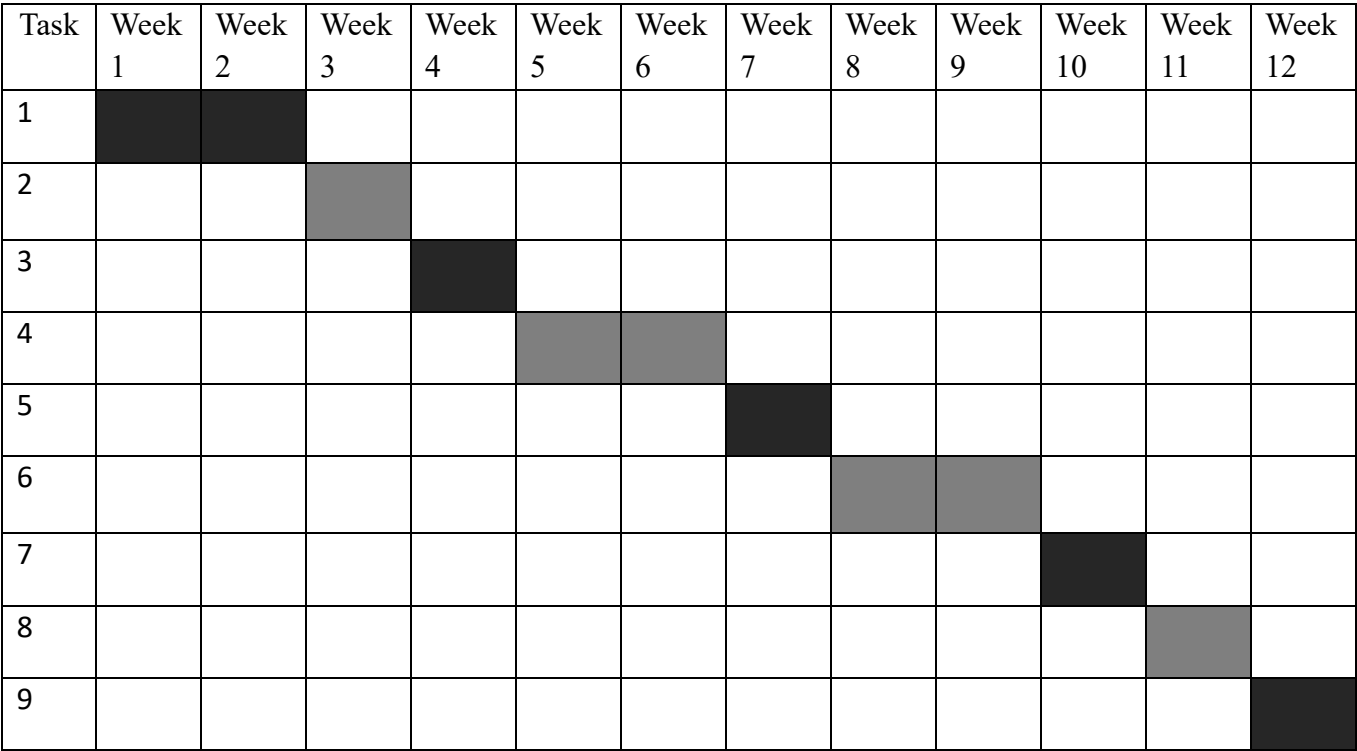


Figure 01: Gantt Chart Representing Project Task Timeline for Evaporative Cooling System Development

6. Hardware and Software requirement

Hardware requirements

Table 03: Hardware Requirements and Acquisition Plan for Evaporative Coolingl System

Component	Specification	Quantity	Purpose	Plan to acquire
Solar Panel	12V, 100W Polycrystalline or Monocrystalline	1	Power supply for the fan and water pump	To be purchased from local solar equipment suppliers or online (e.g., Daraz, Alibaba)
Desiccant Wheel	Silica gel or lithium chloride coated wheel	1	Dehumidifies air before or after cooling to improve performance	Custom-made or ordered from lab/industrial supply vendors
Heat Exchanger	Compact cross-flow or plate-type, aluminum	1	Recovers sensible heat, improves cooling efficiency	Fabricated or salvaged from HVAC components
Rechargeable Battery	12V, 18Ah Sealed Lead-Acid	1	Energy storage from solar panel	Online marketplaces or electronic component stores
DC Fan	12V, 5–10W axial/blower fan	2	Air circulation	Local electronic markets or salvaged from computer cooling systems
Submersible Water Pump	12V DC mini pump	1	To circulate water across the evaporative medium	Purchase from aquarium/hardware stores
Water Tank/Reservoir	~10–15L plastic container	1	Stores water for evaporation	bought from hardware stores
Sponge Pads / Cellulose Pads	300 mm × 300 mm × 30 mm	AS required	Evaporative medium	hardware stores
Silica Gel / Calcium Chloride	~2–5 kg	1 batch	Desiccant for humidity removal	Purchase from chemical suppliers or lab supply stores
Aluminum/Plastic Ducting	3-5 m	As required	Airflow channeling	Hardware stores
Microcontroller	Arduino Uno / ESP32	1	For automation and sensors (if implemented)	Electronics retailer or online

Temperature & Humidity Sensors	DHT11 / DHT22	1-2	Measurement and control (if applicable)	Local electronics stores
Miscellaneous	Screws, wires, piping, valves, frame	As required	Assembly and structure	Local hardware store

Software requirements

Table 04: Software Requirements and Acquisition Plan for Evaporative Coolingl System

Software	Purpose	Plan to Acquire
SolidWorks / AutoCAD	3D modeling and design of housing and frame	Already available
ANSYS Fluent	Computational Fluid Dynamics (CFD) simulation for airflow and heat exchange	Use ANSYS Student version
Proteus / Fritzing	Circuit simulation (if microcontroller used)	Free version
Arduino IDE	Programming the microcontroller (if applicable)	Free download from official site
Microsoft Excel	Data analysis and documentation	Already available
MS Word & PowerPoint	Report writing and presentation	Already available
MATLAB	Additional data analysis, modeling, or control simulation	Student license

7. Diagrammatic Representation

Preliminary sketches of the solar-powered evaporative air conditioner, illustrating the system's layout and basic idea is illustrated. Two sketches are included: one for the desiccant wheel method, showing its solar-regenerated wheel, and another for the high voltage precipitation and thermoelectric dehumidification methods, which share a similar design.

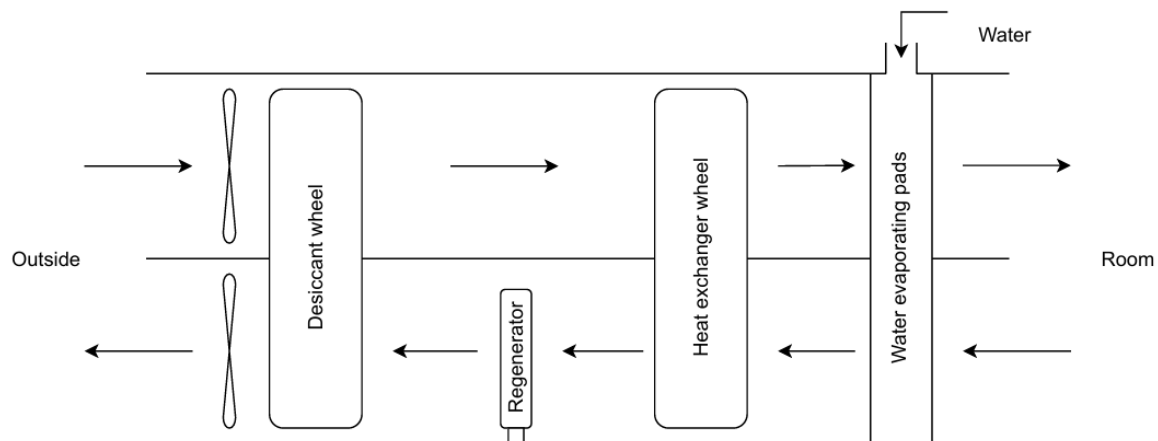


Figure 02: Conceptual Sketch of Solar-Powered Evaporative Air Conditioner with Desiccant Wheel

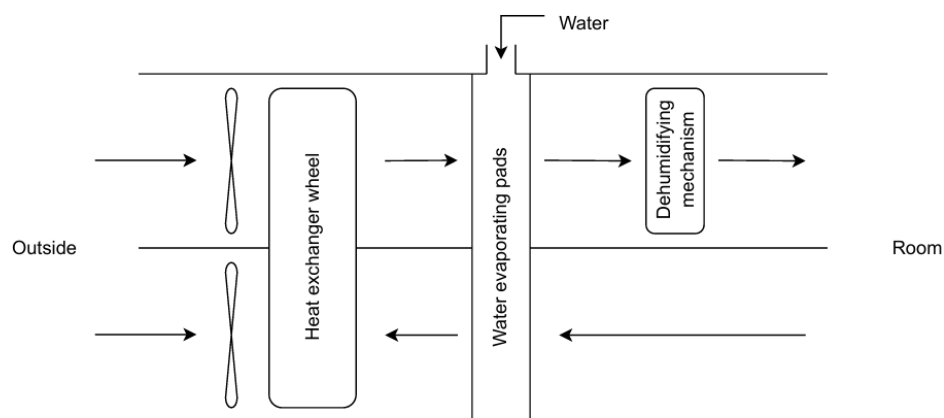


Figure 03: Conceptual Sketch of Solar-Powered Evaporative Air Conditioner with High Voltage Precipitation or Thermoelectric Dehumidification

8. References

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- [ScienceDirect article on global AC demand and heat](#)
- [Sustainable Energy for All access to cooling initiatives](#)
- [The Borgen Project on cooling in developing countries](#)
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