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Hybrid Cooling System

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Abstract

This project aims to develop an innovative hybrid cooling system that combines a Dual-Functional Rainwater Harvesting System that is environmentally friendly and capable of generating natural electrical energy. The main objective of this study is to produce a Hybrid Cooling system that can generate electrical power, identify its capability as an interior and exterior cooler, and determine voltage output to meet high voltage requirements. This study uses rainwater, sunlight, and wind as test parameters to assess the efficiency of water turbines, solar panels, and windmills in generating electrical energy. The tests aim to verify the turbine's capacity to produce electric currents that can drive fans for room cooling and water pump machines for roof cooling systems during the summer. Materials include turbines, water pumps, sprinklers, inverters, batteries, charge controllers, solar panels, and exhaust fans. Testing involves measuring indoor and outdoor temperatures using an infrared thermometer and voltage output using a multimeter. The study results show that the average indoor temperature after cooling system activation is 26.2°C in the morning, 30.3°C at noon, and 27.1°C at night, while the average external temperature is 26.6°C in the morning, 31.3°C at noon, and 27.1°C at night. Solar panels generate an average of 16V on sunny days, while water turbines generate up to 0.13V during rainfall. In conclusion, this study has successfully produced a system that offers sustainable and environmentally friendly solutions for residences. This system not only meets practical needs but also reflects an innovative approach to integrating renewable energy into everyday life, paving the way for more sustainable and energy-efficient homes.

1. Introduction

The development of the Hybrid Roof Cooler system, capable of generating natural electricity, addresses energy efficiency and sustainable cooling challenges. Malaysia is a country located in an equatorial climate which is hot and humid all year round. This is because Malaysia's position is located between lines 0 to 10 on the equator [1]. Due to Malaysia's environment, the traditional cooling methods relying on electricity contribute to high energy consumption and environmental impacts [2]. Integrating natural electricity generation aims to reduce grid dependency and promote renewable energy use. Evaluating the system's effectiveness in various conditions and voltage output is crucial for its applicability and compatibility with existing infrastructures [3].

The issue of high utility costs due to excessive electricity use for cooling rooms in buildings is a significant concern. This not only increases expenses but also strains energy resources. Addressing this problem is essential for cost savings and improved energy efficiency. Additionally, the use of harmful gases like CFCs from air conditioning systems has a detrimental impact on the environment, leading to ozone layer depletion and negative effects on human health and ecosystems. Reducing the emission of these gases is crucial for sustainable practices and environmental conservation. The issue is worsened by the low voltage generated by the previous study by a senior's Final Year Project, The Dual-Functional Rainwater Harvesting System [4]. The system cannot achieve the minimum quota needed to cool a building's interior and outdoor spaces if the voltage output is insufficient. This makes maintaining optimal energy efficiency while reaching acceptable comfort levels within the building extremely difficult.

The study aims to develop a Hybrid Cooler System that also serves as a nature-friendly house cooler generating high voltage for cooling purposes. It focuses on creating a Hybrid Cooler system that can produce natural electricity, assessing its effectiveness as an indoor and outdoor cooler, and determining the voltage output to meet high voltage requirements. According to Er and Catherine (2022), the scope of environmental management needs to be expanded to include all available resources to preserve current and future generations. It shows that cooperation needs to be done by various parties in playing a role to make this mission of preservation and conservation a success [5].

The Hybrid Cooler System offers a cost-effective and eco-friendly cooling solution for urban and rural areas by harnessing solar and rain energy. This innovative system aims to reduce utility costs and promote sustainable cooling practices. Utilizing renewable energy sources aligns with the increasing demand for energy-efficient technologies and highlights the potential of eco-friendly cooling solutions [6].

The development of home cooling systems has undergone significant advancements over the years, providing increased comfort and convenience to households worldwide. Initially, traditional methods such as natural ventilation and shade were utilized to combat heat. However, with the advent of technology, the concept of mechanical cooling systems emerged, revolutionizing the way we control indoor temperature [7]. The Hybrid Cooler system exemplifies sustainable energy solutions by harnessing rain and solar power. It seamlessly captures energy from rainfall currents, and solar radiation, ensuring a reliable supply of clean energy. This system provides comprehensive and effective cooling for indoor and outdoor environments, creating a comfortable atmosphere indoors and a refreshing ambiance outdoors. The Hybrid Cooler Generator System generates the expected voltage output consistently, highlighting its reliability and contribution to sustainable energy solutions.

2. Materials and Methods

Fig. 1 shows the flow of work required to meet the study's objectives. It was carried out by the steps indicated in the diagram.

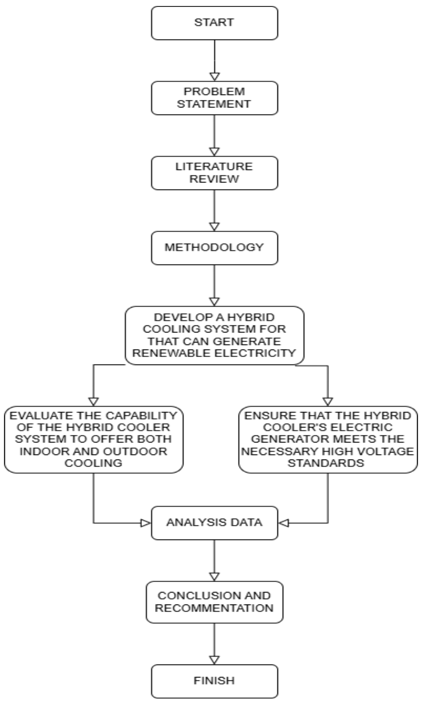


Fig. 1 *Flowchart of the study*

2.1 Materials

The materials used in this study for the hybrid cooling system are turbines and connecting wires, water storage tanks and filter nets, water pumps, water sprinklers, honeycomb cooling filters, inverters, batteries, charge controllers, solar panels, and exhaust fans. The turbine used is a cross-flow type with 12 V DC output, which can be directly used as an Arduino power supply. The maximum output current is up to 150 mA, which is sufficient for most light applications. In this experiment, a 40 V water pump was used to pump water up to the roof as far as 2.2 meters. Fig. 2 shows the development process for the rainwater harvesting system model. The model was then evaluated for the model's roof before and after water spraying, as well as the turbine's performance in flowing voltage current. Moreover, water storage tanks with sprinklers store water for cooling and maintenance. It supplies water to sprinklers on the roof, ensuring cooling pads stay moist for efficient evaporative cooling. Solar panels directly power the turbine, boosting energy efficiency and sustainability. These panels convert sunlight into electricity, ensuring continuous operation even during low light conditions with battery backup. By reducing reliance on conventional energy sources, the solar-powered cooler offers a greener and cost-effective cooling solution. The exhaust fan expels warm air, aiding temperature regulation and air circulation. Positioned strategically, it works alongside cooling components like evaporative pads and air conditioning units to maintain comfort levels. Automated and controlled by temperature sensors, it ensures efficient performance and energy use, essential for a healthy indoor environment. The solar charge controller manages the voltage and current from solar panels, ensuring optimal battery charging without overcharging or deep discharge. This controller maximizes energy harvest. Meanwhile, the battery stores excess solar-generated electricity, providing power during low sunlight or at night, ensuring continuous cooler operation. Together, they optimize energy utilization, enhancing system reliability and sustainability.

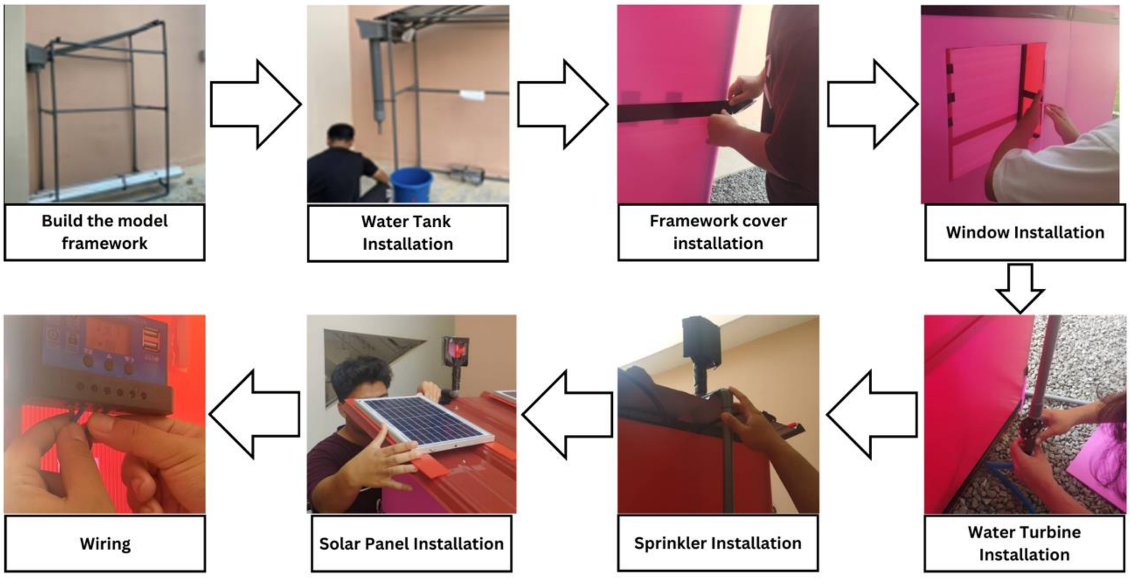


Fig. 2 *Process of development for the Hybrid Cooling System*

2.2 Methods

2.2.1 Design of Hybrid Cooling System

The design concept for the system of models is depicted in Fig. 3. This model was designed using engineering software, which is AutoCAD 2024. It was designed to collect rainwater and sunlight, produce electric energy, and cool the roof and the indoors of the house when the weather is hot. The rainwater that falls will flow through the turbine into the storage tank. Meanwhile, the solar panel will catch the sunlight during the day. When the weather is hot, the stored water will be pumped up and sprayed on the roof and the exhaust fan will operate to catch the hot wind from the indoors to the environment. The current generated through the rotation of the turbine and the solar panel will flow to the battery before being used for the exhaust fan.

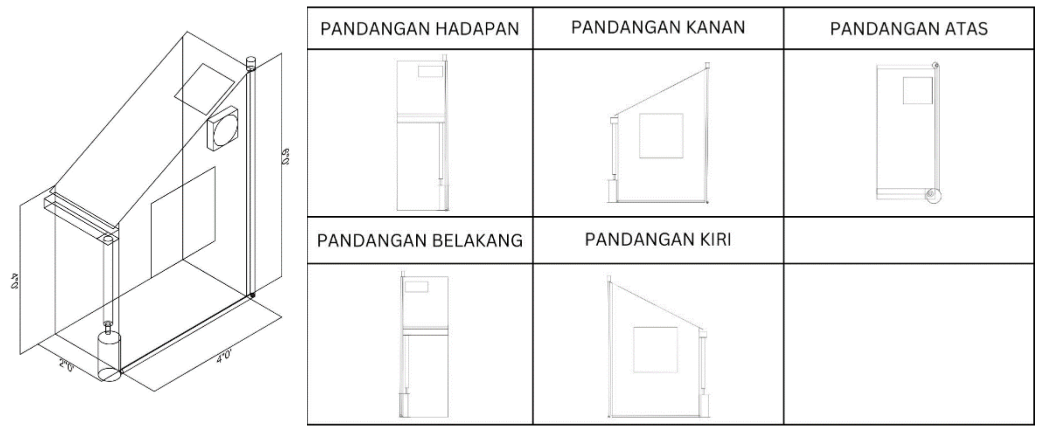


Fig. 3 *Schematic diagram of the proposed model*

2.2.2 Temperature Testing of Cooling System

An infrared thermometer used to test the cooling system for indoor and outdoor temperatures. The average reading value is calculated by taking three readings each time after the early temperature reading. The test was taken three times, each at 8.00 am - 8.45 am, 12.00 pm - 12.45 pm and 8.00 pm - 8.45 pm.

2.2.3 Measurement and Analysis of Voltage Output

The method used in the voltage test for the water turbine is the multimeter. The resultant current travels to the turbine, where magnetic flux is produced, via the water flow. The used turbine is a cross-flow turbine, which is both ecologically benign and appropriate for producing tiny amounts of electricity. Moreover, this turbine can be used at home because it doesn't require a high-water current to generate electricity. Five to ten kW of electrical energy are produced as a result. The operating flow of a typical turbine is between 40 and 5000 liters per second. Meanwhile, the same method used in voltage for solar panels which the energy sunlight absorbed by photovoltaic cells in the solar panel causes electricity to flow within the panel. This energy can be stored in batteries or directed either to the water pump or the sprinkler in the Hybrid Cooling System. In ideal conditions, the solar panel can generate up to 200 watts per square meter. This test is carried out by detecting the temperature on the inside and outside of the hybrid cooling system model. This test is carried out using a temperature detector which is an infrared thermometer. The main objective of this test is to identify the ability of the Hybrid Cooling System as an internal and external cooler.

3. Result and Discussion

3.1 Analysis of Indoor and Outdoor Cooling

Table 1 shows the temperature varies throughout the day due to the sun's position and its effect on heating the earth's surface. In the morning, the average temperature after activation of the cooler system is 26.2°C because the sun has just risen. By noon, the temperature peaks at an average of 30.3 °C as the sun is at its zenith, providing the strongest sunlight and heating the earth to its maximum. At night, the temperature drops to an average of 27.1 °C as the earth releases the heat absorbed during the day. Wind, air, and humidity are additional factors that influence temperature variations.

Table 1 *Indoor cooling reading*

Time	Morning			Noon			Night		
Early Temperature, °C		27.4			32.3			28.2	
Temperature, °C	26.2	26.3	26.2	30.5	30.3	30.0	27.3	27.0	27.0
Average, °C		26.2			30.3			27.1	

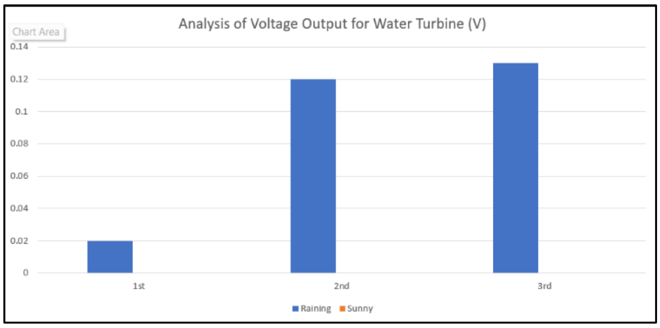
Referring to Table 2, The temperature fluctuates throughout the day due to the sun's position and heating effect. In the morning, the average temperature is cooler at 26.6 °C because the sun has just risen. By noon, temperatures rise to an average of 32.3 °C as the sun peaks, providing maximum heat. At night, temperatures drop to an average of 27.1 °C as the earth releases the heat accumulated during the day. This cooling continues through the night, making it the coldest part of the day, especially near dawn. Wind, air, and humidity also influence these temperature variations.

Table 2 *Outdoor cooling reading*

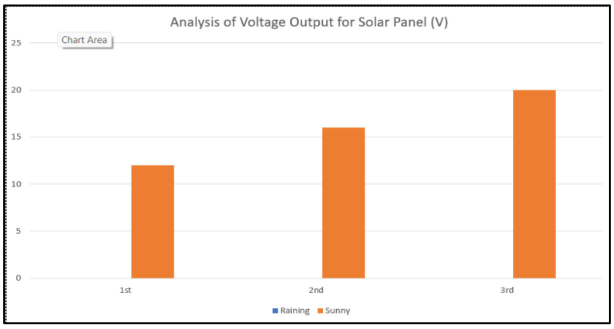
Time	Morning			Noon			Night		
Early Temperature, °C		28.3			33.2			29.2	
Temperature, °C	26.8	26.6	26.5	31.7	31.3	31.1	27.3	27.0	27.0
Average, °C		26.6			31.4			27.1	

3.2 Analysis of Voltage Output

The voltage output from a solar panel and a water turbine was tested using a multi-meter to measure power generation. The solar panel tests were conducted during the day when the sun was available, while the water turbine tests were performed during rainfall. Solar panels could not generate power during rain due to cloud cover blocking the sun. All voltage readings were systematically recorded and presented in (a) to simulate the collected data. The multi-meter was directly connected to both the solar panel and the water turbine for efficient voltage measurement.



(a)



(b)

Fig. 4 *Analysis of voltage output for water turbine (V) and analysis of voltage output for solar panel (v)*

The solar panel and water turbine generate power at different times, with the solar panel producing higher voltage outputs on sunny days and the water turbine generating power during rain. The solar panel generated a peak voltage of 20V, a low of 12V, and an average of 16V. In contrast, the water turbine produced a peak voltage of 0.13V and a low of 0.02V during rainy conditions. These readings are presented in (b). Overall, the solar panel provides a higher voltage output, making it sufficient for average weather conditions in Malaysia.

4. Conclusion

Overall, to optimize the effectiveness and efficiency of a hybrid roof cooler system, it's crucial to analyze its operation during the morning, afternoon, and evening. By examining variables such as roof temperature, indoor temperature, sunlight exposure, and energy consumption at different times of the day, stakeholders can gain valuable insights into the system's performance. This data analysis allows for adjustments to maximize energy efficiency and maintain consistent indoor comfort, extends the system's lifespan, and helps predict maintenance needs. This comprehensive analysis is vital for various building types residential, commercial, and industrial—especially in hot climates with significant temperature fluctuations. These insights facilitate the integration of hybrid roof cooler systems in new and existing buildings, promoting modern design practices that emphasize environmental sustainability and energy efficiency.

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Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm their contribution to the paper as follows: ***study conception and design***: Nor Baizura Binti Hamid; ***data collection, analysis, interpretation of results, draft manuscript preparation:*** Muhammad Syafiq Bin Rumimelinio, Mohamad Fakhrul Radzi Bin Razali, Muhammad Haikal Bin Mohd Hairul. All authors reviewed the results and approved the final version of the manuscript. This format ensures clarity regarding each author's specific contributions and confirms that all authors take responsibility for the content of the work.

References

[1] A. Salahuddin, and S. Curtis, "*Climate extremes in Malaysia and the equatorial South China Sea*," Global and Planetary Change, vol. 78, no. 3-4, pp. 83-91, 2011.

[2] M. T. M. Amin, "Heat, Comfort and Well-Being in a Changing Climate: Learning from Cooling Practices in Malaysian Households," The University of Manchester (United Kingdom), 2021.

[3] B. Tashtoush, and H. Qaseem, "*An integrated absorption cooling technology with thermoelectric generator powered by solar energy*," Journal of Thermal Analysis and Calorimetry, vol. 147, no. 2, pp. 1547-1559, 2022.

[4] M. N. Zaid, M. A. Amdan, N. H. Norafandi, and N. B. Hamid, "*Dual-Functional Rainwater Harvesting System*," Multidisciplinary Applied Research and Innovation, vol. 5, no. 1, pp. 155-162, 2024.

[5] M. N. Hassan, M. Awang, and A. B. Jaafar, "*Challenges of global environmental issues on ecosystem management in Malaysia*," Aquatic Ecosystem Health & Management, vol. 9, no. 2, pp. 269-283, 2006.

[6] H. N. Afrouzi, Y. P. Wimalaratna, J. Ahmed, K. Mehranzamir, S. C. Liew, C. Wooi, and B. M. A. Siddiquea, "Comprehensive review on Available/Existing Renewable Energy Systems in Malaysia and comparison of their capability of electricity generation in Malaysia," In IntechOpen eBooks, 2022.

[7] N. H. Mokarram, and H. Wang, "*Design and modeling of novel two-phase heat exchangers for a home cooling system with ice energy storage*," Applied Thermal Engineering, vol. 207, pp. 118175, 2022.