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Sustainable House Cooling (SusHoC) System

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Abstract

The study presents the preliminary development of a sustainable house cooling model (SusHoC) designed explicitly for Malaysia's hot and humid climate, which often compromises residents' comfort and reduces indoor environmental quality. The study is driven by the need to minimise dependence on conventional cooling systems such as air conditioners, which are energy-intensive and contribute significantly to greenhouse gas emissions. The SusHoC is based on the concept of car radiators, offering a more energy-efficient and sustainable solution. The system comprises radiators, water pumps, and transparent rubber pipes, and is integrated into a small-scale house model. The model adheres to the Similitude Law of Geometry to ensure a relevant and representative model. Its effectiveness is evaluated by measuring reductions in indoor temperature and humidity based on different coverage levels of the rubber pipes surrounding the model. The outcome shows that the indoor temperature and relative humidity were reduced to 4.2°C and 7% when the pipe fully covered the model. Thus, the findings are expected to support further advancement of similar studies, which in the end might provide a feasible and viable solution for the masses.

1. Introduction

Malaysia's tropical climate poses significant challenges in achieving indoor thermal comfort. High ambient temperatures combined with excessive humidity often led to overdependence on energy-intensive air conditioning systems. Conventional cooling methods, while effective in the short term, contribute to rising electricity costs and environmental degradation due to increased greenhouse gas emissions [1][2]. These issues highlight the pressing need for more energy-efficient and sustainable cooling alternatives.

Malaysia's housing landscape, which includes both traditional wooden homes and modern terrace houses, frequently suffers from poor thermal performance [3]. These challenges are further intensified by urban heat island (UHI) effects, particularly in major cities like Kuala Lumpur, where reduced vegetation and increased concrete surfaces contribute to elevated temperatures [4]. Additionally, consistently high indoor humidity levels, often exceeding recommended thresholds, not only degrade thermal comfort but also promote mould growth and affect indoor air quality [5].

Existing cooling strategies: both passive and active will offer limited effectiveness under these conditions [6]. Passive methods such as cross-ventilation can reduce energy usage but are insufficient during peak heat periods. On the other hand, active systems like air conditioners provide quick relief but significantly increase energy consumption and environmental impact.

To address these limitations, the study proposes a radiator-based cooling model inspired by automotive thermal systems. By utilising water's high heat capacity, the system is designed to deliver efficient and consistent cooling with reduced reliance on harmful refrigerants [7]. Water-based cooling has shown promise in tropical climates as a viable alternative to conventional systems, offering better energy performance and alignment with global sustainability goals [8]. In order to give resonance to the proposed model, a brief discussion on how a radiator-based cooling model works is provided.

Fig. 1 shows a typical engine cooling system, which uses water/ coolant. A standard automotive cooling system generally consists of [9]:

i. Engine cooling passages – a network of channels cast into the engine block and cylinder head, surrounding the combustion chambers to allow coolant circulation and removal of excess heat.
ii. Radiator – a heat exchanger made up of numerous narrow tubes and a honeycomb of fins, designed to rapidly dissipate heat from the hot coolant received from the engine.
iii. Water pump – typically a centrifugal type, responsible for continuously circulating the coolant throughout the system.
iv. Thermostat – a temperature-sensitive valve that regulates coolant flow to the radiator, maintaining engine temperature within an optimal range.
v. Cooling fan – which forces or draws ambient air through the radiator to enhance the cooling process.

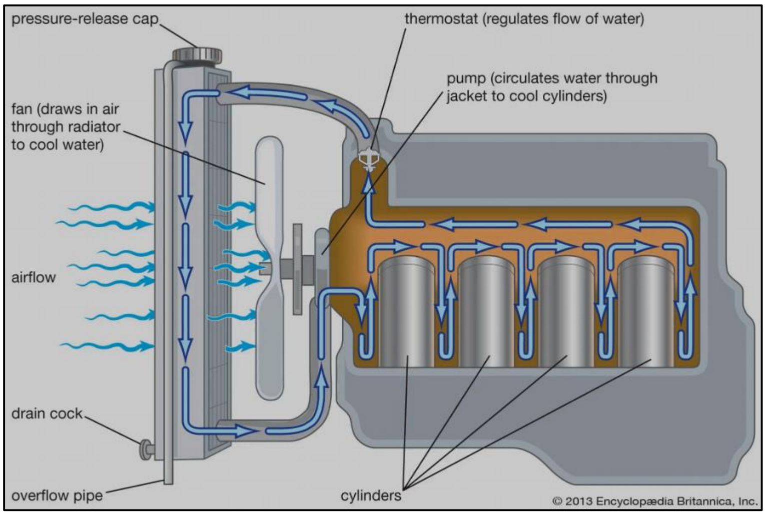

Fig. 1 *A schematic of a typical engine cooling system (adapted from Britannica, n.d.)*

Given that an engine might be churning out more than 100°C, a radiator-based cooling model is sufficient to regulate engine temperature, prevent overheating, and ensure optimal performance. Thus, imagine that the engine (plus the cylinder) is replaced by a typical house, which generally won't come close to 100°C. Therefore, the research introduces a Sustainable House Cooling system (SusHoC) aimed at bridging current gaps in Malaysia's residential cooling approaches. By integrating proven cooling principles with contextual housing and climate data, the model offers a practical, scalable, and environmentally friendly solution to improve thermal comfort in Malaysian homes.

2. Methodology

The methodology outlines the systematic approach employed in the study, focusing on the design, development, and testing of SusHoC for a wooden house model, as a preliminary scope. The research framework is structured into three main stages: 1. Design Stage, where the house model and SusHoC are created using Similitude Law and AutoCAD; 2. Development Stage, involving the assembly of components, namely vehicle radiator, fan, water pump, and transparent rubber pipes as a medium for water circulation surrounding the house model; and 3. The Testing and Measurement Stage evaluates the system's effectiveness by analysing indoor temperature and relative humidity. The methodology ensures transparency and reproducibility, emphasising the rationale behind each step to achieve credible results.

With regard to the Similitude Law, it states that two figures are considered similar if they have equal corresponding angles and proportional corresponding sides. This principle is central in geometry, trigonometry, and applications in construction and engineering (e.g., scale drawings, structural modelling, surveying) [10]. To maintain manageability in terms of construction, handling, and experimental procedures, the scale was deliberately limited to a maximum height of 3 meters (of actual building) without sacrificing proportional realism.

Accordingly, the study adopted a wooden house model at a 1:18.3 scale, which accurately represents typical Malaysian urban homes and ensures both practicality and proportional accuracy.

Key components of the cooling system include a car radiator-inspired liquid cooling mechanism, a fan to enhance airflow, an aquarium water pump for coolant circulation, and transparent rubber pipes to be attached to the surroundings of the model's wall. The system is powered by alternating current (AC) for efficiency, with a switch for manual control and safety. Water serves as the cooling element due to its high heat capacity, ensuring effective heat transfer.

The system setup is visually represented in Fig. 2, which illustrates the integration of the cooling system into the house's model structure. The design showcases the layout of the system, including the system's positioning to optimise cooling efficiency. The compact design emphasises adaptations made for reduced load conditions, enhancing the overall effectiveness of the cooling system.

Testing is conducted in an open area under direct sunlight to simulate real-world conditions. Tools such as a temperature and humidity meter are used to measure temperature and relative humidity before and after system activation. Fig. 3 shows the physical system on the testing site. The expected outcomes include maintaining indoor temperatures between 24°C-26°C and relative humidity within the optimal range of 40% to 60%, ensuring comfort and energy efficiency.

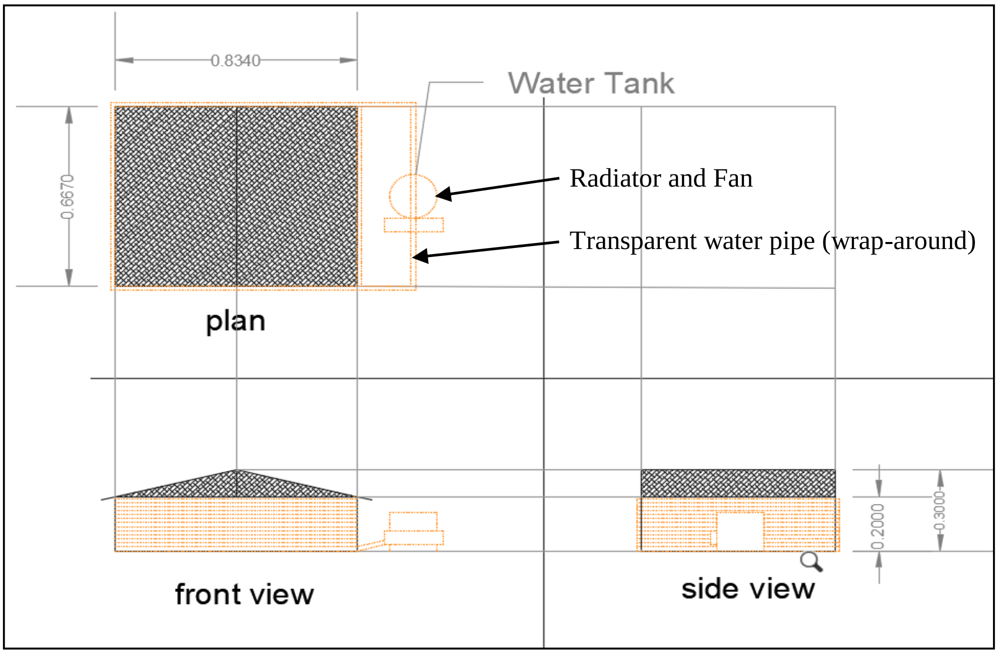

Fig 2 *SusHoC system's plan*

Fig. 3 *The SusHoC physical system*

3. Results

The cooling and humidity performance of the proposed SusHoC system was evaluated under three pipe coverage conditions, namely minimal coverage, partial coverage, and full wall wrapping. Each of these configurations was tested in order to observe how varying levels of pipe coverage influenced two key indoor environmental parameters: temperature and relative humidity. These parameters are crucial in determining the level of thermal comfort within a living space, particularly in Malaysia's hot and humid tropical climate. The outcomes of the study are summarised in Table 1, which compares the initial baseline value with the post-implementation results, as well as the corresponding improvements achieved in each case.

Table 1 *Results and Study Findings*

Pipe coverage conditions	Parameter	Initial Value	Post-Implementation	Improvement
Minimal	Temperature	32°C	31.1°C	0.9°C reduction
	Relative Humidity	65% RH	64% RH	1% reduction
Partial	Temperature	32.5°C	31.1°C	1.4°C reduction
	Relative Humidity	68% RH	64% RH	4% reduction
Full	Temperature	31.5°C	27.3°C	4.2°C reduction
	Relative Humidity	70% RH	63% RH	7% reduction

From the results presented in the table (Table 1), it is evident that the system's effectiveness increases proportionally with the level of pipe coverage. Under the minimal coverage condition, only a slight improvement was recorded, with the temperature reduced by 0.9°C and the relative humidity reduced by 1%. Although this demonstrates that the system was functioning, the slight reduction may not be sufficient to create a noticeable improvement in indoor comfort.

The partial coverage condition produced more substantial results compared to the minimal setup. With a temperature reduction of 1.4°C and humidity reduction of 4%, this configuration demonstrates that expanding the coverage area enhances the cooling potential of the system. While the results still fall short of recommended thermal comfort levels, the improvement is more meaningful, showing that intermediate coverage is a value, particularly in balancing system cost against performance.

Last but not least, the full wall wrapping configuration delivered the most significant and promising results. The system lowered indoor temperature by 4.2°C, which represents a considerable improvement, and also reduced relative humidity by 7%. These reductions are critical because they bring the indoor conditions closer to the internationally recognised comfort zone of 24-26°C, as suggested by ASHRAE, while also maintaining humidity within the acceptable range of 55-70% RH outlined in MS 1525 standards. By meeting these thresholds, the fully wrapped SusHoC configuration demonstrates its ability not only to improve comfort but also to meet industry standards for healthy indoor environmental conditions.

When comparing the three coverage options, the trend is clear: greater pipe coverage results in greater effectiveness. The minimal and partial setups did provide measurable benefits, yet their reductions in temperature and humidity were limited compared to full coverage. This indicates that for households in Malaysia and similar tropical climates, full wall wrapping may be the most suitable option for achieving significant improvement in both comfort and sustainability. This, of course, is coupled with the proposed radiator-based cooling model, as mentioned in the earlier part of the paper.

4. Conclusion

In Malaysia's tropical climate, where high temperatures and elevated humidity levels create persistent challenges for indoor comfort, the proposed SusHoC system offers a promising and environmentally responsible alternative to conventional air conditioning. The system is designed around the concept of low-energy water-filled wall pipes, which function in a manner similar to automobile radiators. This approach allows heat to dissipate effectively while relying on significantly less energy than conventional mechanical cooling systems. By avoiding the use of chemical refrigerants and reducing electricity demand, the system aligns well with the growing emphasis on sustainability and green technologies.

The experimental findings strongly support the viability of this approach. In particular, the full wall wrapping configuration demonstrated the highest degree of effectiveness, achieving a temperature reduction of 4.2°C and a relative humidity decrease of 7%. These improvements are not only statistically significant but also practically essential, as they move indoor conditions much closer to internationally recognised comfort ranges. The results suggest that with full coverage, the SusHoC system is capable of delivering meaningful enhancements in comfort while maintaining humidity at healthy levels, thereby creating a more pleasant indoor environment.

Beyond comfort, the system also carries potential energy-saving benefits. Based on the experimental data and performance analysis, it is estimated that the SusHoC system could reduce electricity usage by around 30% on average compared to a traditional cooling system - when comparing an hour usage of electricity between the two methods. Such savings are highly relevant in the Malaysian context, where electricity consumption for cooling contributes significantly to household utility bills. By reducing reliance on air conditioning, the system can also help lower peak electricity demand, indirectly support national energy goals and reduce strain on power generation systems.

The ability of the system to reduce indoor humidity also has important implications for health and well-being. Lowering humidity levels decreases the likelihood of mould growth, which is a common issue in tropical climates and a contributor to respiratory illnesses and allergies. Therefore, the SusHoC system not only improves comfort and reduces energy usage but also potentially contributes to better indoor air quality and occupant health.

However, while the initial findings are encouraging, it is essential to acknowledge the need for further research and long-term testing. More comprehensive studies are required to evaluate the system's durability, reliability, and adaptability across different building types and real-world conditions. Economic assessment would also be valuable to determine the system's affordability and cost-effectiveness for homeowners.

In conclusion, the SusHoC system presents a promising, sustainable, and health-conscious alternative to conventional air conditioning in Malaysia's tropical climate. By addressing both temperature and humidity through a low-energy design, it contributes to the development of environmentally friendly cooling solutions that balance comfort, health, and energy efficiency. The study findings provide a solid foundation for future research, demonstrating that the SusHoC system can play an essential role in advancing sustainable building technologies and helping communities to adapt to the challenge of living in hot and humid regions.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design****: Siti Hasmaliza Hasnizam, Muhammad Amir Irfan Ridzuan, Muhammad Nabil Farid Musa, Hairuddin Mohammad;* ***data collection****: Siti Hasmaliza Hasnizam, Muhammad Amir Irfan Ridzuan, Muhammad Nabil Farid Musa;* ***analysis and interpretation of results****: Siti Hasmaliza Hasnizam, Muhammad Amir Irfan Ridzuan, Muhammad Nabil Farid Musa;* ***draft manuscript preparation****: Siti Hasmaliza Hasnizam, Muhammad Amir Irfan Ridzuan, Muhammad Nabil Farid Musa, Haruddin Mohammad. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] Majoriti, "Rumah berbahang akibat cuaca panas melampau: Ini tip untuk sejukkan kediaman anda," [Online], Aug. 8, 2024. Available: https://majoriti.com.my/berita/2024/08/08/rumah-berbahang-akibat-cuaca-panas-melampau-ini-tip-untuk-sejukkan-kediaman-anda

[2] M. M. Kamal, A. S. Sazali, and S. S. Sarnin, *"Real-time indoor air quality monitoring association with humidity, temperature, and carbon monoxide level in the residential environment,"* Malaysia Journal of Chemical Engineering & Technology, pp. 107-113, 2021.

[3] S. H. Ibrahim, A. A. H. Liew, M. N. M. Nawi, and M. N. Yusoff, *"Reinventing traditional Malay house for sustainable housing design: Obstacle and proposed solution,"* J. Teknol. (Sci. Eng.), vol. 72, no. 1, Dec. 2015.

[4] N. A. S. K. Jumari, A. N. Ahmed, Y. F. Huang, J. L. Ng, C. H. Koo, K. L. Chong, and A. Elshafie, *"Analysis of urban heat islands with Landsat satellite images and GIS in Kuala Lumpur Metropolitan City,"* Heliyon, vol. 9, no. 8, Aug. 2023.

[5] I. S. Elsayed,*"A study on the urban heat island of the city of Kuala Lumpur, Malaysia,"* J. King Abdulaziz Univ., vol. 23, no. 2, pp. 121, Apr. 2012.

[6] W. Lin and B. Sunden, *"Vehicle cooling systems for reducing fuel consumption and carbon dioxide: Literature Survey,"* in SAE World Congress & Exhibition, Detroit, MI, USA, Art. No. 2010-01-1509, 2010.

[7] F. Afshari and H. Dehghanpour," A *review study on cooling towers; types, performance and application,"* ALKU Fen Bilimler Dergisi, pp. 1-10, Mar. 2019.

[8] C. Yu, W. Zhang, G. Wang, M. Huang, J. Sui, and H. Zhao, *"Experimental study of dual-cycle thermal management system for engineering radiator,"* Sci. Rep., vol. 14, no. 1, Art. No.19691, Aug. 2024.

[9] Cromer, O.C., Purdy, K.W., Cromer, G.C., Foster, C.G. (2025, September 6). *automobile. Encyclopedia Britannica*. https://www.britannica.com/technology/automobile

[10] Jacobs, H. R. (2017). Geometry: Seeing, Doing, Understanding. W. H. Freeman & Co.