



# E-PROCEEDINGS

## INTERNATIONAL TINKER INNOVATION & ENTREPRENEURSHIP CHALLENGE (i-TIEC 2025)

"Fostering a Culture of Innovation and Entrepreneurial Excellence"



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**23 January 2025**  
**PTDI, UiTM Cawangan Johor**  
**Kampus Pasir Gudang**

### **ORGANIZED BY:**

Electrical Engineering Studies, College of Engineering  
Universiti Teknologi MARA (UiTM) Cawangan Johor  
Kampus Pasir Gudang  
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**Editors**

Aznilinda Zainuddin  
Maisarah Noorezam

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## **A-ST111: DEVELOPMENT AND EVALUATION OF A RETRACTABLE PHASE CHANGE MATERIAL (PCM) ROOF FOR THERMAL COMFORT IN TROPICAL BUILDINGS**

Syahirah Natasya Muhd Syafiq Loke and Wan Nur Hanani Wan Abdullah  
Department of Built Environment Studies and Technology, College of built  
Environment, University Teknologi MARA, Perak Branch, Seri Iskandar Campus, 32610  
Seri Iskandar, Perak, Malaysia.

Corresponding author: Wan Nur Hanani Wan Abdullah, wanurhanani@uitm.edu.my

### **ABSTRACT**

This research focuses on the development and evaluation of a retractable Phase Change Material (PCM) roof designed to regulate indoor air temperatures in tropical building conditions. The innovation combines PCM, which absorbs and releases thermal energy to stabilize temperatures, with a retractable mechanism that adapts to varying weather conditions. By using simulation software, the study explores the roof's thermal performance, the influence of PCM properties and operational settings, and its potential to improve thermal comfort compared to conventional roofing systems. The retractable PCM roof offers several advantages, including enhanced thermal regulation, energy efficiency, and dynamic adaptability, making it uniquely suited for tropical climates. Its dual functionality addresses challenges posed by high temperatures and humidity while reducing dependency on mechanical cooling systems. The system contributes to environmental sustainability by lowering energy consumption and carbon emissions, aligning with global green building goals. This innovation holds significant commercialization potential, with applications in residential, commercial, and institutional buildings. It caters to markets in tropical and subtropical regions where passive cooling solutions are in high demand. By improving occupant comfort and supporting energy-efficient building design, the retractable PCM roof delivers socio-economic and environmental benefits, presenting a scalable and sustainable solution for the construction industry.

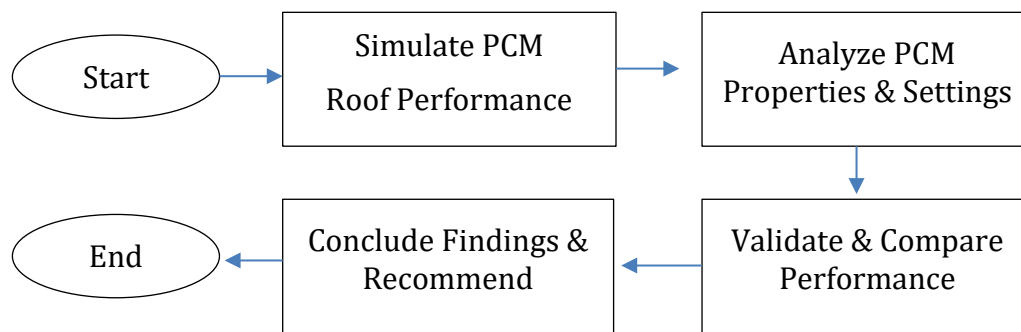
**Keywords:** PCM Roof, Thermal Comfort, Revit Simulation, Indoor Air Temperature, Retractable Roof Systems

### **1. Product Description**

The Retractable Phase Change Material (PCM) Roof is a cutting-edge innovation designed to enhance thermal comfort and energy efficiency in tropical climates. This system integrates Phase Change Materials, which absorb and release heat during phase transitions, with a retractable mechanism that adapts to changing weather conditions. Together, they stabilize indoor temperatures, reducing reliance on air-conditioning systems and promoting sustainability. PCMs store excess heat during the day and release it at night, creating a passive cooling effect. The retractable feature allows dynamic adjustments, such as shading during peak sunlight or increasing ventilation during cooler periods. This combination ensures optimal performance in diverse climatic conditions.

**Figure 1** outlines the research methodology, starting with thermal simulations of the PCM roof, analyzing PCM properties, validating results against theoretical models, and proposing recommendations. This systematic approach ensures reliability and practical insights. **Table 1** compares conventional and PCM-integrated roofs, highlighting the PCM roof's ability to maintain indoor temperatures within a comfortable range of 25–27°C, compared to 32–34°C with conventional roofs. These results demonstrate its effectiveness in reducing energy consumption while improving occupant comfort. This innovation addresses the challenges of tropical climates, providing a scalable and sustainable solution for modern green building technologies.

## 2. Method Flowchart and Simulation Results



**Figure 1.** Flowchart of the Research Process

**Table 1.** Simulation Results

| <i>Weather</i>            | <i>Roof<br/>(Open/Closed)</i> | <i>Indoor<br/>Temperature</i> | <i>Outdoor<br/>Temperature</i> |
|---------------------------|-------------------------------|-------------------------------|--------------------------------|
| <i>Sunny day</i>          | <i>Closed</i>                 | <i>35 – 38°C</i>              | <i>34°C</i>                    |
|                           | <i>Open</i>                   | <i>32 – 34°C</i>              | <i>34°C</i>                    |
| <i>Sunny day with PCM</i> | <i>Open</i>                   | <i>25 – 27°C</i>              | <i>34°C</i>                    |
| <i>Night with PCM</i>     | <i>Closed</i>                 | <i>24 – 25°C</i>              | <i>26°C</i>                    |

## 3. Novelty and uniqueness

The retractable Phase Change Material (PCM) roof introduces a novel approach to roofing systems by integrating PCM with a retractable mechanism. This design enables dynamic adaptation to real-time climatic conditions, a feature rarely found in traditional roofing systems. The roof can adjust to changes in temperature, solar radiation, and ventilation requirements, providing a responsive solution that optimizes indoor thermal comfort. Tailored specifically for tropical environments, the retractable PCM roof addresses the challenges posed by high solar radiation and humidity. PCM absorbs and releases thermal energy during phase transitions, stabilizing indoor temperatures throughout the day. The

retractable functionality enhances this effect by allowing manual or automated adjustments to maximize shading or ventilation, depending on external conditions. The dual functionality of this system combines the benefits of passive cooling with the active adaptability of a retractable design. This ensures enhanced energy efficiency, reduced dependency on mechanical cooling systems, and improved occupant comfort. Unlike conventional roofing systems, this innovation is uniquely positioned to meet the demands of tropical climates, offering a versatile and sustainable solution that aligns with modern green building initiatives. The retractable PCM roof is a step forward in bridging the gap between traditional passive designs and advanced adaptive technologies.

#### **4. Benefit to mankind**

The retractable Phase Change Material (PCM) roof significantly enhances thermal comfort by stabilizing indoor air temperatures. This reduces the discomfort caused by temperature fluctuations, especially in tropical climates where high heat and humidity prevail. By maintaining a consistent and comfortable indoor environment, the system directly improves the quality of life for occupants in residential, commercial, and institutional buildings. In addition to thermal comfort, the roof promotes energy efficiency by reducing reliance on mechanical cooling systems, such as air conditioners. This leads to lower energy consumption and decreased carbon emissions, supporting global sustainability efforts. Furthermore, the retractable PCM roof positively impacts health and productivity by improving indoor air quality and overall comfort. This is particularly beneficial for spaces like schools and offices, where a comfortable environment enhances learning and work performance. By addressing both environmental and personal well-being, this innovation offers substantial benefits to society.

#### **5. Innovation and Entrepreneurial Impact**

The retractable Phase Change Material (PCM) roof promotes innovation by combining passive cooling with active adaptability, creating a hybrid system that bridges the gap between traditional roofing and modern smart building technologies. This innovative approach addresses the challenges of tropical climates, offering an energy-efficient and sustainable solution that enhances thermal comfort and supports green building initiatives. This project fosters a culture of entrepreneurship by opening avenues for the development and commercialization of PCM-specific roofing materials and retractable systems tailored for tropical environments. It encourages collaboration between academic institutions, industries, and local businesses to produce affordable and scalable solutions. Additionally, the roof's potential integration with smart home automation platforms creates opportunities for startups and technology-driven enterprises. By introducing cutting-edge technology with practical applications, the project not only advances the construction industry but also inspires entrepreneurial efforts within the community and beyond.

#### **6. Potential commercialization**

The retractable Phase Change Material (PCM) roof has significant commercialization potential, particularly in tropical and subtropical regions where sustainable and energy-efficient building solutions are in high demand. Its target market includes residential homes,

commercial buildings, and institutional spaces such as schools and offices, which require reliable thermal comfort solutions to address high temperatures and humidity. The product's unique combination of passive cooling and dynamic adaptability positions it as a valuable innovation for construction firms and government bodies promoting green building initiatives. Its alignment with global sustainability goals enhances its appeal for organizations seeking eco-friendly infrastructure solutions. The modular design of the retractable PCM roof ensures scalability, allowing for customization to suit different building sizes and architectural needs. This flexibility, coupled with its energy-saving potential and occupant comfort benefits, makes the retractable PCM roof a viable commercial product for widespread adoption in the construction industry.

## 7. Acknowledgment

This research was supported by Universiti Teknologi MARA (UiTM) and guided by academic supervisor. We extend gratitude to simulation software developers and researchers who provided valuable insights into PCM and roofing technologies.

## 8. Authors' Biography



Syahirah Natasya is a final-year Bachelor of Science (Hons) in Construction Technology student at Universiti Teknologi MARA, Seri Iskandar Campus, currently in Semester 6. With a strong academic foundation, including multiple Dean's List recognitions, she excels in project and maintenance management. Syahirah has practical experience from her internship at UDA Dayaurus, where she worked on troubleshooting, preventive maintenance, and system upgrades at POS Malaysia Headquarters. Her final-year project, focused on retractable phase change material (PCM) roofs, showcases her commitment to innovative and sustainable construction practices. Proficient in AutoCAD, Revit, and Microsoft Project, she is eager to advance in the field.



Wan Nur Hanani Binti Wan Abdullah is a Lecturer at the College of Built Environment, UiTM Perak, Seri Iskandar Campus, specializing in building technology and sustainable architecture. She holds a Master of Science in Green Architecture and a Bachelor of Science (Hons) in Architecture. Her research focuses on daylight performance and sustainable building design, with conference contributions on natural lighting in classrooms. As an educator, she teaches diploma-level courses, including Structural Analysis and Building Technology. Dedicated to advancing green building practices, she combines academic expertise with professional experience to nurture future leaders in sustainable architecture.