Project title: Geothermal–Phase Change Materials Integrated Systems for Energy-Efficient and Climate-Adaptive Buildings

Lead Supervisor and Department: Dr Jingwen Weng, Department of Materials

Project Description:

This PhD project aims to develop an integrated *geocooling and phase change material (PCM) thermal energy storage (TES)* system to support low-carbon and climate-resilient cooling solutions. Cooling demand is rising rapidly worldwide due to global warming and urbanization, posing major challenges for electricity systems and carbon reduction goals. Geocooling offers a renewable means of utilizing the ground as a natural heat sink, while PCM-based TES can store and release latent heat to balance temporal mismatches between cooling supply and demand. Integrating these two approaches provides a pathway to substantially reduce energy use and associated emissions in building cooling.

Building on recent advances in PCM materials, Yao et al. (*Composite part A: applied Science and Manufacturing*, *Journal of Materials Chemistry A*, 2025; **Weng** as corresponding author) developed a *solid–solid skeleton PCM* with high thermal stability and tunable latent heat, suitable for both battery and building thermal management. The research will build on recent advances in lignocellulose–polyethylene phase change polymers (MPCPs), which exhibit excellent mechanical strength, anti-leakage capability, and tunable phase transition temperatures in the 20–45 °C range—matching the thermal comfort zone of buildings. These MPCPs, derived from renewable biomass, offer a sustainable alternative to conventional paraffin-based PCMs with lower embodied carbon and enhanced recyclability. To further improve thermal stability and conductivity, solid–solid PCM skeleton structures will be incorporated, inspired by recent developments in polymer-reinforced composite PCMs for thermal management. Leveraging this foundation, the PhD will tailor advanced PCMs for integration within geothermal–TES systems.

The research will proceed through four main Work Packages (WPs):

- WP1 – Material Development: Formulate bio-based MPCP composites with adjustable melting points, enhanced thermal conductivity, and cycling durability.
- WP2 – System Modelling: Employ transient simulations (EnergyPlus/TRNSYS/Modelica) to study coupled heat transfer among the ground loop, PCM layer, and building envelope under different climates.
- WP3 – Experimental Validation: Build a lab-scale prototype to measure charging/discharging performance and validate model predictions.
- WP4 – Impact Assessment: Quantify energy and carbon savings, perform life-cycle and techno-economic analyses, and propose integration guidelines for scalable deployment in buildings.

Expected outcomes include high-performance PCM composites, validated geothermal–PCM modules, and predictive models quantifying energy savings and CO_2 reduction. The research aligns with the **Grantham Institute's priorities** in climate mitigation, sustainable materials, and resilient cities, offering a nature-inspired solution for low-carbon, thermally comfortable, and climate-adaptive buildings, supporting the UK's transition to a low-carbon future.

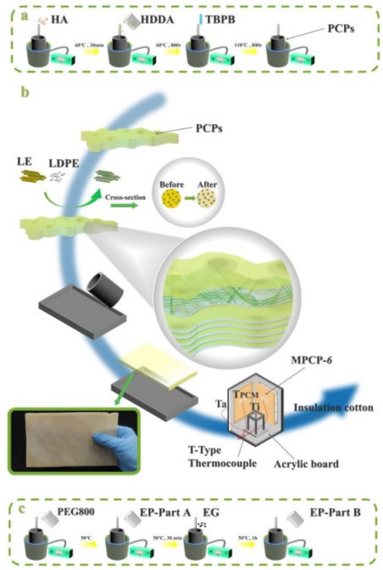

Figure 1. Schematic representation of the production and mechanism.
(*Composite part A: applied Science and Manufacturing*, 2025,Weng is the corresponding author)

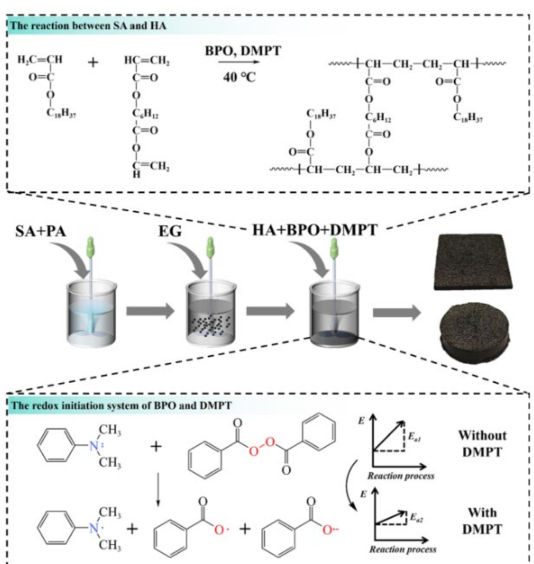

Figure 2. Schematic diagram of PESH-CPCM prototype preparation
(Journal of Materials Chemistry A, 2025,Weng is the corresponding author)

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To apply:
Please email j.weng@imperial.ac.uk with the following documentation:
- Statement of Purpose
- Your CV
- At least two references must be emailed to *Jingwen Weng* (by the referees)