

Perkembangan urbanisasi di Indonesia menuntut solusi hunian vertikal seperti rumah susun sederhana sewa (rusunawa) guna mengatasi keterbatasan lahan dan *backlog* perumahan. Namun, tantangan utama dalam pengembangan ini adalah menjaga kenyamanan termal di tengah tingginya suhu lingkungan akibat fenomena *Urban Heat Island* (UHI). Penelitian ini bertujuan untuk mengevaluasi efektivitas integrasi *Phase Change Material* (PCM) pada sistem dinding bangunan dalam meningkatkan kenyamanan termal pada rusunawa di iklim tropis Indonesia. Studi dilakukan pada unit hunian bertingkat di kawasan Ibu Kota Negara (IKN), Kalimantan Timur, dengan pendekatan simulasi termal menggunakan perangkat lunak Rhinoceros 7, Grasshopper, Ladybug, Honeybee, dan EnergyPlus. Hasil simulasi menunjukkan bahwa penggunaan PCM mampu menurunkan *operative temperature* (T_o) dalam ruangan sebesar $0,7^{\circ}\text{C}$ hingga 1°C dibandingkan dinding tanpa PCM. Penurunan suhu paling signifikan terjadi pada siang hari mulai pukul 12.00 dan berlangsung selama sekitar tujuh jam, saat PCM mulai aktif menyerap panas ketika suhu mencapai titik lelehnya. Pada malam hari, PCM melepaskan panas yang tersimpan secara perlahan, menghasilkan profil suhu ruang yang lebih stabil dan mengurangi fluktuasi ekstrem. Kinerja terbaik ditemukan pada kombinasi material dinding *lightweight concrete* dengan PCM RT 27, yang titik lelehnya selaras dengan suhu lingkungan harian (27°C – 30°C). Sementara itu, variasi nilai *Heat of Fusion Latent* antar PCM memberikan pengaruh yang sangat kecil terhadap T_o , yakni hanya sekitar $0,01^{\circ}\text{C}$. Temuan ini menegaskan pentingnya kesesuaian titik leleh PCM dengan kondisi iklim lokal. Integrasi PCM terbukti efektif sebagai strategi pasif yang hemat energi untuk meningkatkan kenyamanan termal dan mendukung pengembangan bangunan tropis yang berkelanjutan.

Kata Kunci: *Phase Change Material (PCM)*, *Operative Temperature*, Rusunawa, Dinding, EnergyPlus

ABSTRACT

Rapid urban development in Indonesia necessitates vertical housing solutions, such as public rental apartments (rusunawa), to address land limitations and the growing housing backlog. A major challenge in this context is maintaining indoor thermal comfort amidst rising outdoor temperatures caused by the Urban Heat Island (UHI) effect. This study aims to evaluate the effectiveness of integrating Phase Change Material (PCM) into building wall systems to enhance thermal comfort in rusunawa located in tropical climates. The research focuses on mid-rise residential units in Indonesia's new capital city (IKN) in East Kalimantan, analyzing various wall materials combined with different types of PCM, wall orientations, and PCM characteristics, including peak melting temperature and latent heat of fusion. Thermal simulations were conducted using Rhinoceros 7 with Grasshopper, supported by Ladybug, Honeybee, and EnergyPlus plug-ins. Results show that PCM integration can reduce indoor operative temperature (T_o) by approximately 0.7°C to 1°C compared to walls without PCM. The cooling effect becomes most apparent from noon and persists for about seven hours, as PCM begins to absorb heat during its phase change when temperatures peak. At night, the stored heat is gradually released, resulting in a more stable and less extreme indoor temperature drop. The most optimal performance was observed in lightweight concrete walls combined with PCM RT 27, whose melting point (27°C – 30°C) aligns well with the daily outdoor temperature cycle in tropical climates. Variations in the latent heat of fusion among PCMs had only a minor impact on operative temperature, with differences around 0.01°C . These findings highlight the critical importance of matching PCM thermal properties with local climate conditions. Therefore, PCM integration in tropical building design proves to be a viable passive and energy-efficient strategy for improving thermal comfort and supporting sustainable urban housing development.

Keywords: Phase Change Material (PCM), Operative Temperature, Rusunawa, Walls, EnergyPlus