https://doi.org/10.7250/CONECT.2023.026

REVOLUTIONIZING THE BUILDING ENVELOPE: A COMPREHENSIVE SCIENTIFIC REVIEW OF INNOVATIVE TECHNOLOGIES FOR REDUCED EMISSIONS

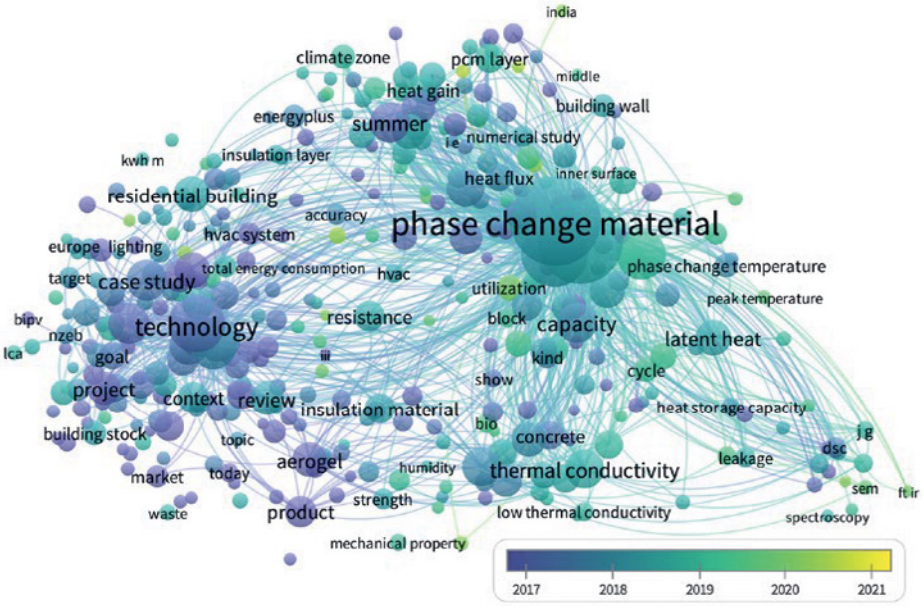
Jānis NARBUTS[1*], Ruta VANAGA[2]

[1–3] *Institute of Energy Systems and Environment, Riga Technical University, Āzenes iela 12/1, Riga, LV-1048, Latvia*

[*] ***Corresponding author.*** *E-mail address: janis.narbuts_1@rtu.lv*

Abstract – The energy and thermal performance of buildings is heavily dependent on the building envelope. As such, innovative environmental building envelope technologies are being developed to improve building energy efficiency and reduce greenhouse gas emissions. This paper provides a comprehensive review of the latest environmental building envelope technologies, such as phase-change materials (PCM), aerogel, and active and adaptive systems, to offer an overview of the current state-of-the-art in the field and identify future research directions. PCM technology has the potential to improve thermal comfort and reduce energy consumption by reducing peak heating and cooling loads. Paraffin wax is the most reliable PCM for use in building envelopes, and studies have shown that it can reduce heating and cooling energy consumption by up to 20 % compared to traditional insulation materials. Aerogel is a low-density and highly insulating material that has been shown to enhance thermal insulation and reduce heat transfer in buildings. Silica aerogel can provide thermal performance up to 2–4 times higher than traditional insulation materials, resulting in significant energy savings of up to 50 %. Active and adaptive systems, such as smart windows and dynamic insulation, allow for real-time control of building envelope performance, further improving energy efficiency and indoor comfort. Smart windows can lead to energy savings of up to 20–30 % compared to traditional windows, while dynamic insulation systems can provide energy savings of up to 50 % compared to traditional insulation materials. The review assesses various adaptive facade solutions based on their suitability for diverse climate zones, versatility in application, global availability of materials used, and energy efficiency. Despite the challenges and limitations of these technologies, including high costs, lack of widespread adoption, and limited understanding of long-term performance, the authors conclude that continued development and implementation of these technologies have the potential to make significant contributions to improving building energy efficiency and reducing greenhouse gas emissions. This review provides a valuable resource for researchers and practitioners working in the field of building envelopes and offers insights into the future research directions necessary to further advance the field.

Keywords – Aerogel; building envelopes; energy efficiency; phase-change materials



The visualization of keywords across innovative building envelope technologies.