DEVELOPMENT OF AN AI-POWERED DYNAMIC BUILDING ENVELOPE TO REDUCE ENERGY CONSUMPTION

PI: Aliisar Yahya
Department of Civil and Environmental Engineering
Co-PI: Elsa Maalouf
Bahaa and Walid Bassatne Department of Chemical Engineering

The building sector accounts for one-third of global energy use and 40% of overall CO2 emissions, which has raised environmental concerns. Thus, optimizing building envelopes is crucial for the decarbonization of the built environment. Phase-change materials (PCM) have high-energy storage capacity and can potentially reduce energy consumption in buildings. However, their usage still has major drawbacks. The first is that the PCM layer is not directly exposed to outdoor temperatures but is thermally protected by the insulating layer. This limits its capacity to store energy from the sun and is thus problematic for heating. The second is that accumulated heat in the PCM is mainly discharged to the indoor environment because the insulating layer limits its discharge to the outdoors, which is a problem during cooling. The third is that the optimal PCM choice differs between seasons. In this work, we propose a novel AI-powered dynamic building envelope that solves the above challenges through a system that allows for having more than one PCM and rotates to direct the PCM to the outside or inside as needed. The dynamics, governed by data collected from embedded sensors, will be optimized to minimize the heating and cooling loads. Artificial Intelligence (AI) will be used to accelerate the optimal decision making in real-time and various methods will be tested depending on the nature of data informing the system. Such a system has never been studied or tested, which supports the innovative component of this project. The research can revolutionize the design of building envelopes and lead to significant reduction in energy consumption and CO2 emissions. The application of such passive systems is impactful in a country like Lebanon suffering from high energy prices and severe pollution. The project has an interdisciplinary character, addresses human-centered and sustainable design needs, uses cutting- edge technology, and fosters international collaborations.