UNIVERSITI TEKNOLOGI MARA

PASSIVE DAYLIGHTING IN PUBLIC HIGHER EDUCATIONAL BUILDINGS: RETROFITTING STRATEGIES AND PROCESS FRAMEWORKS FOR SUSTAINABLE SPACES

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ABSTRACT

The escalating global focus on green and sustainable development has seen an increased emphasis on the role of the built environment in reducing energy use and environmental impact. This is particularly evident in Higher Education Institutions (HEIs), where buildings are known to be substantial energy consumers, primarily in terms of electricity. One of the key drivers of this heavy electricity usage is the inadequate implementation of passive daylighting strategies. To address this, the 11th Malaysia Plan spotlights the need to retrofit existing government buildings with a focus on energy efficiency and low-carbon emissions by employing passive daylighting strategies. The emphasis on retrofitting implies a need for further exploration of effective strategies, especially those relating to daylighting. This research addresses this requirement, aiming to establish a process framework for retrofitting design using daylight passive strategies to reduce energy waste and achieve sustainable spaces HEIs buildings. This research has four objectives: first, To identify the various retrofitting designs using daylighting strategies needed for higher educational institution buildings ; second, to measure the existing illuminance level and Daylighting Factor (DF) level in a design studio at higher educational institution ; third, to investigate through simulation the appropriateness of daylighting strategy design for higher educational institution buildings in Malaysia; and fourth, to propose the Retrofitting Passive Daylighting Strategies Process Framework to achieve sustainable spaces and reduce energy waste for public HEI buildings. The study uses an experimental design that combines quantitative and qualitative research methods, executed in four phases. Data collection methods include document analysis, survey studies, field studies, and simulation studies. The building standards used for comparison are GBI Interior V1.3, MS1525: 2019, and CIBSE Lighting Guide 5: Lighting for Education. The study selects three public HEIs design studios in Malaysia as case studies, anonymising them due to privacy considerations. The collected data undergoes various analyses, including content analysis, statistical analysis, empirical analysis, and framework recommendation. The findings suggest that the five most frequently used daylighting strategies are windows, louvers, light shelves, skylights, and overhangs. These strategies are categorized based on four criteria: penetration, distribution, protection, and control. Survey studies reveal that students prefer brighter daylight in the studios to enhance their health and academic performance. However, there are several concerns related to daylighting, such as limited windows, excessive sunlight and heat gain, and uneven daylight distribution, as evidenced by existing illuminance and daylight factor readings. To address this, simulation studies are conducted to evaluate the effectiveness of various daylighting strategies by integrating them into the case studies. This process is crucial to propose effective daylighting strategies based on the current conditions of the case study. Finally, the research establishes the Retrofitting Passive Daylighting Strategies Process Framework. This process framework comprises three main stages: input data, process, and output data. The process framework offers a structured framework for implementing daylighting strategies in public HEIs buildings, providing a systematic approach to assessing, prioritising, and executing retrofitting projects. The process framework can be tailored to the specific needs of public HEIs, facilitating the integration of sustainable practices into building design and maintenance.

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‘The secret of making progress is to get started.’

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CHAPTER 1
INTRODUCTION

1.1 Research Background

In recent years, the global emphasis on green and sustainable development has grown, particularly focusing on the built environment's role in decreasing energy use and lessening environmental impact. The key principle in green building design is to create an energy-efficient and eco-friendly structure, a concept that aligns with today's sustainable development goals (Zen et al., 2016). Green building design has been widely applied in various residential, commercial, and educational buildings.

In Malaysia, commercial buildings, including offices, consume substantial amounts of energy (Yaman et al., 2022). Similarly, Higher Education Institution (HEIs) buildings are also heavy energy consumers, as they encompass office spaces. Furthermore, power consumption in educational campuses, such as universities, has escalated due to the construction of more buildings to accommodate an increasing student population (Ahamad et al., 2022; Dahlan et al., 2022). Due to their size, diverse functions, and continuous operation, HEI buildings are major contributors to energy consumption. For instance, buildings at Universiti Tun Hussein Onn Malaysia (UTHM) have shown a wide range of energy consumption, with some buildings recording high annual energy consumption due to the absence of a benchmarking, leading to values exceeding 141.0 kWh/m2/yr, which are considered poorly energy efficient (Shukri et al., 2022). Moreover, at Universiti Malaya, a detailed energy audit of an R&D building identified air- conditioning, lighting and PCs/ laptops as the primary energy consumer, with monthly energy usage ranging from 160 MWh to 250MWh (Birkha Mohd Ali et al., 2021). In summary, in tropical climates like Malaysia’s, the typically ranges in HEIs between 100 to 200kWh per square meter per year.

In Malaysia, a country with a growing HEIs sector and a commitment to sustainability, addressing energy efficiency in educational institutions is imperative. According to Baharum et al. (2016), one of the key elements of Malaysia's energy arrangement structure is the government's acquisition of energy efficiency. Sustainable Development Goals (SDGs) significantly influence campus planning and design, including Southeast Asian HEI (Mansor et al., 2023). Therefore, optimising energy usage on educational campuses through integrated approaches like retrofitting is