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AUTONOMOUS PV-POWERED SMART WINDOWS: ACTIVE GLASS HEATING IN NZEB APPLICATIONS

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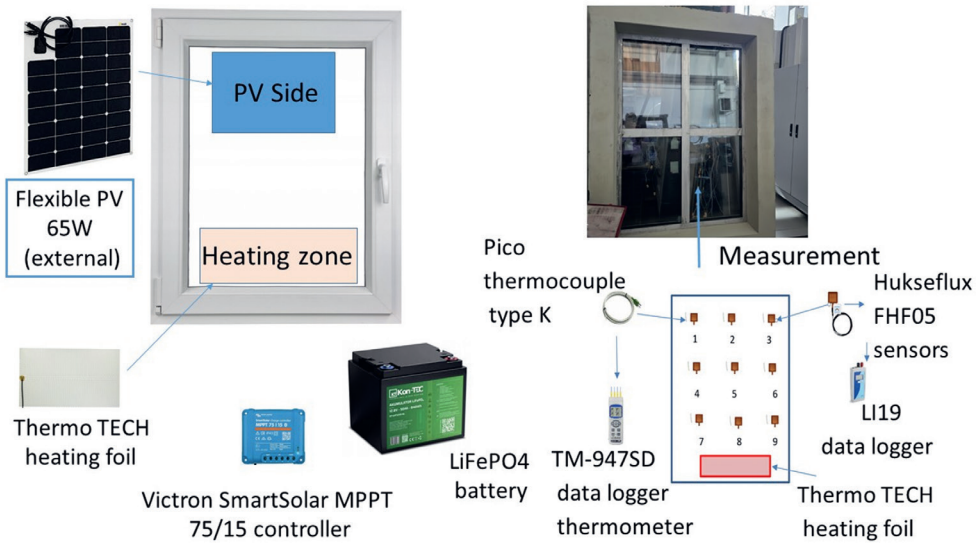
Abstract – The building sector is a primary contributor to global energy consumption, with windows identified as the least efficient component of the building envelope. This study investigates the thermal performance of an "active" smart window system featuring an integrated electrical heating element (Thermo TECH) powered by an autonomous renewable energy microgrid. The research was conducted in two stages. First, experimental trials were performed in a specialised dual-zone climatic chamber at the Kielce University of Technology to evaluate heat flux dynamics across an external temperature range of –25 °C to +5 °C. Second, in-situ measurements were carried out on a physical installation at the university premises to account for real-world meteorological fluctuations. The results demonstrate that precise modulation of the heating element enables the achievement of a "near-zero thermal balance," effectively transforming the window from a thermal bridge into a thermally neutral element. While active heating increases external heat dissipation, it effectively eliminates the "cold pane" effect, raising the internal surface temperature from +12 °C to +18 °C at an outdoor temperature of –25 °C. The study concludes that integrating PV modules with active window heating offers a viable pathway for achieving NZEB standards by providing by providing a self-sustaining solution for energy loss reduction.

Keywords – Active window heating; energy balance; photovoltaics; smart windows



Schematic layout of the monitoring and heating smart window system:
(a) the functional power management and active heating system components in-situ natural experiment configuration; (b) the laboratory measurement configuration for climatic chamber testing

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