CERIS Civil Engineering Research and Innovation for Sustainability

Integrated cost and environmental life cycle analysis of windows

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Summary

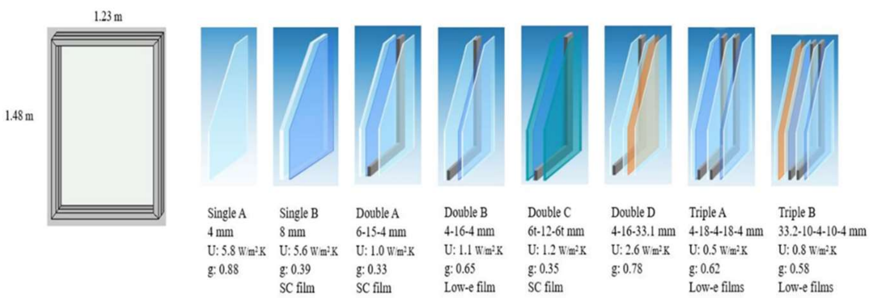
There is an increasing need for energy-efficient windows; but these windows can have high embodied impacts and can be costly. Hence, it is important to wisely select optimal windows that minimize energy consumption, costs, and environmental impacts throughout their life cycle. However, life cycle assessments (LCAs) are time-consuming and resource-intensive, and usually performed at late-design stages when the potential to make changes is low. The selection of windows with the lowest life cycle cost (LCC) and environmental impacts in an early-design stage can potentially minimize the environmental impacts and costs of buildings. Thus, it is important to streamline LCA and LCC of windows to support early-stage building design decisions. The main goal of this PhD thesis is to investigate both full and streamlined LCA approaches to support the selection of windows to improve the life cycle environmental and economic sustainability of European office buildings.

Some recommendations are provided to enhance the economic and environmental performance of windows in European office buildings based on the full LCA results. The optimal window solutions for warm climates highlighted low solar factor windows, while for cold climates low thermal transmittance solutions. The glazing is the component with the greatest influence on the LCA results (mainly operational). The impacts depend to a very great extent on the thermal transmittance values and solar factors. LCC shows that the initial investment in the windows has a high impact on the overall cost, even for a lifespan of 30 years. A sensitivity analysis on a set of window solutions allowed to conclude that the highest influential parameter on LCA and LCC is window-to-wall ratio, for all orientations and locations. In addition, other influential parameters depend on the location: for warmer climates, smaller windows are recommended or bigger windows with low solar factors; for colder climates, bigger windows or small windows with high solar factors. Thermal transmittance value has a large influence on smaller windows in warmer climates, while in colder climates on bigger windows.

The streamlined LCA model has proved to be effective in providing robust results to support the selection of windows, at early-design stages of buildings, by specifying very few window- and operation-related attributes (less than 8). The confidence in the results has been confirmed by comparing the results with the full LCA results. This PhD research covers a large range of windows available in the market in terms of thermal transmittance and solar factor values. Hence, future market window solutions with random values of thermal transmittance and solar factor can be assessed using this approach to promote a better cost and environmental performance of buildings. In addition, this PhD research develops a streamlined model to assess the environmental and cost performance of windows with limited inventory data about most design attributes. Following that, it is not essential to perform a time-consuming and resource-intensive full LCA to select the most appropriate window solution in terms of environmental and cost performances. The streamlined model enables designers to select window solutions that improve the life cycle cost and environmental performance of buildings, when limited information is available at an early-design stage.

Keywords

Window, solar factor, thermal transmittance, life cycle assessment, life cycle costing, sensitivity analysis, attribute ranking, early-stage decisions, streamlining, uncertainty.



Embodied impacts of window systems: a comparative assessment of framing and glazing alternatives