

## Life Cycle Assessment-Based Environmental Assessment of the Production and Maintenance of Wooden Windows

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**Abstract :** The building sector plays an important role in addressing pressing environmental issues such as climate change and resource scarcity. The energy performance of buildings is considerably affected by the external envelope. In fact, a considerable proportion of the building energy demand is due to energy losses through the windows. Nevertheless, according to literature, to pay attention only to the contribution of windows to the building energy performance, i.e., their influence on energy use during building operation, could result in a partial evaluation. Hence, it is important to consider not only the building energy performance but also the environmental performance of windows, and this not only during the operational stage but along its complete life cycle. Life Cycle Assessment (LCA) according to ISO 14040:2006 and ISO 14044:2006+A1:2018 is one of the most adopted and robust methods to evaluate the environmental performance of products throughout their complete life cycle. This life-cycle based approach avoids the shift of environmental impacts of a life cycle stage to another, allowing to allocate them to the stage in which they originated and to adopt measures that optimize the environmental performance of the product. Moreover, the LCA method is widely implemented in the construction sector to assess whole buildings as well as construction products and materials. LCA is regulated by the European Standards EN 15978:2011, at the building level, and EN 15804:2012+A2:2019, at the level of construction products and materials. In this work, the environmental performance of wooden windows was assessed by implementing the LCA method and adopting primary data. More specifically, the emphasis is given to embedded and operational impacts. Furthermore, correlations are made between these environmental impacts and aspects such as type of wood and window transmittance. In the particular case of the operational impacts, special attention is set on the definition of suitable maintenance scenarios that consider the potential climate influence on the environmental impacts. For this purpose, a literature review was conducted, and expert consultation was carried out. The study underlined the variability of the embedded environmental impacts of wooden windows by considering different wood types and transmittance values. The results also highlighted the need to define appropriate maintenance scenarios for precise assessment results. It was found that both the service life and the window maintenance requirements in terms of treatment and its frequency are highly dependent not only on the wood type and its treatment during the manufacturing process but also on the weather conditions of the place where the window is installed. In particular, it became evident that maintenance-related environmental impacts were the highest for climate regions with the lowest temperatures and the greatest amount of precipitation.

**Keywords :** embedded impacts, environmental performance, life cycle assessment, LCA, maintenance stage, operational impacts, wooden windows

**Conference Title :** ICGCMLCA 2021 : International Conference on Green Construction Materials and Life Cycle Assessment

**Conference Location :** London, United Kingdom

**Conference Dates :** May 24-25, 2021