

# Assessing the life cycle of temporary membrane structures based on two case studies

Zehra Eryuruk \*, Marijke Mollaert †, Danny Van Hemelrijck \*, Lars De Laet †

\* Vrije Universiteit Brussel (VUB) Dept. Mechanics of Materials and Constructions, Pleinlaan 2, 1050 Brussel, Belgium,

† Vrije Universiteit Brussel (VUB) Dept. Architectural Engineering, Pleinlaan 2, 1050 Brussel, Belgium

## ABSTRACT

Membrane structures are innovative lightweight spatial structures composed of a primary framework intricately combined with tensioned membranes. The use of membrane structures has become increasingly popular due to their flexibility and lightweight nature. However, as with any construction material, there is an environmental impact associated with their production and use. This research aims to assess the life cycle impact of membrane structures with temporary use and with a particular focus on the global warming potential (GWP) indicator, which is a widely recognised measure of greenhouse gas emissions. Life cycle assessment (LCA) is used as a methodology to evaluate the environmental impact of the membrane structures from raw material extraction to disposal.

This research is based on LCA of the temporary used membrane structures, including multiple installations of the structures at different locations over a 25-year life span. Two case studies, with temporary use function, are analysed: Wolke Marienfeld and Nomad Add-On rental sails. The LCA of a temporary structure consists of three distinct LCAs: one for the initial installation, one for each intermediate installation, and a final assessment for the end installation. New materials are needed for the initial installation, while at the end of life (EOL) stage of this first simulation, all materials are repurposed for subsequent installations. During each intermediate installation, the materials from the initial installation are reused, and at the EOL stage, all materials are once again repurposed. Eventually, the construction reaches its final installation phase, utilizing the existing materials for the last time. At the EOL stage of the last assessment, all materials follow their respective EOL scenarios, which may include recycling, incineration, or landfill disposal.

The study revealed that the membrane structures exhibit a significant environmental impact, primarily attributed to their high energy consumption during manufacturing and transportation. It is crucial to consider the effects of the 'end-of-life' stages (C1-C4) and the 'benefits and loads beyond the system boundaries' stage (D), particularly for temporary structures.

By examining the LCA results from case-studies, the sensitivity with respect to different parameters like material choice, service life, end-of-life treatment, fractions of re-used and recycled material etc. is analysed.

The objective of this research is to increase awareness regarding the environmental implications of membrane structures while providing a framework for sustainable design and construction approaches. Furthermore, this study explores potential strategies for reducing the environmental impact of membrane structures. These strategies encompass various aspects, including thoughtful material selection, innovative construction practices, and effective end-of-life management.

**Keywords:** lightweight structures, structural membrane, sustainability, environmental impacts, life cycle assessments (LCA)