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Module 3: Green Construction- LCA of Building

By TUHH

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1 Introduction

The construction industry significantly contributes to global environmental degradation by consuming extensive natural resources and energy, producing substantial waste, and emitting large volumes of greenhouse gases. Recent studies indicate that cement production alone accounts for approximately 8% of global CO_2 emissions (IEA, 2023), emphasizing the industry's substantial carbon footprint. Moreover, construction and demolition (C&D) waste remains problematic, with only around 30% being recycled or reused (Eurostat, 2022). With ongoing urbanization and increasing demands for infrastructure, sustainable construction practices have become imperative. This micromodule employs Life Cycle Assessment (LCA)—an analytical method to evaluate the environmental impacts of buildings and materials across their entire lifecycle. Challenge-Based Learning (CBL) is utilized to engage students in practical, real-world sustainability challenges, enabling interdisciplinary teams to collaborate with stakeholders and innovate sustainable solutions.

2 Background and Motivation

Environmental challenges within the construction sector, such as CO_2 emissions, resource depletion, and waste generation, underline the urgent need for adopting sustainable practices. The sector's shift towards sustainability necessitates incorporating circular economy principles, encouraging material reuse, recycling, and prolonged retention within economic systems (Ellen MacArthur Foundation, 2023). Circular economy concepts thus play a crucial role in addressing these environmental challenges.

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3 Theoretical Framework

3.1 Key Concepts and Definitions

- Circular Economy in Construction: Promotes material reuse, recycling, and recovery to minimize waste and prolong resource lifecycles. Pre-demolition audits (PDAs) help identify reusable materials, reducing waste.
- Life Cycle Assessment (LCA): A systematic analysis of environmental impacts associated with all stages of a product's lifecycle, from extraction to disposal, guided by international standards (ISO 14040, 2022).
- Life Cycle Thinking (LCT): A comprehensive approach that assesses environmental impacts throughout a product's lifecycle, highlighting opportunities for improvement (Hauschild et al., 2020).
- Challenge-Based Learning (CBL): An educational methodology involving interdisciplinary teamwork to tackle real-world sustainability challenges, promoting innovative solutions in the construction sector.

3.2 Project

Students will form interdisciplinary teams employing CBL methodology to investigate improving the environmental performance of residential buildings through material selection. Utilizing OpenLCA software, they will evaluate various building materials' environmental impacts, assisting decision-making processes. The project site is located in Harburg, Hamburg, used by the Technische Universität Hamburg (TUHH) for laboratory and office spaces. It comprises several buildings, including a two-floor building facing the street, a single-floor building, and a four-floor brick structure. To avoide too much complixicity, students will focus on two-floor building facing the street.

Figure 1A view from the entrance and external view of the building

Figure 2A view from the backside of the building

4 Practical Applications

This module extends beyond academic exercises by directly addressing pressing sustainability challenges in real-world contexts. The construction sector significantly impacts environmental degradation, responsible for approximately 37% of global CO_2 emissions, 33% of global resource consumption, and substantial waste generation

(UN Environment Programme, 2023). Consequently, adopting sustainable practices is vital to mitigate these impacts. Digital tools, such as OpenLCA, enhance the accuracy of environmental assessments, optimize resource management, and facilitate efficient building design. Students in this module actively participate as agents of change, applying LCA principles and Challenge-Based Learning to foster practical sustainability solutions. By engaging directly with stakeholders and employing interdisciplinary approaches, students cultivate essential skills and mindsets necessary for advancing sustainable construction practices.

5 Summary and Take-home learning messages

In this module, students explored:

- The critical environmental impacts of the construction industry, particularly regarding resource consumption, emissions, and waste.
- The fundamental principles and benefits of applying LCA to construction, emphasizing informed decision-making in material selection.
- The importance of integrating circular economy principles to enhance sustainability in construction practices.
- Practical application of Challenge-Based Learning (CBL), enabling effective teamwork, collaboration, and real-world problem-solving skills.

6 Further Reading and Resources

Books:

- Hauschild, M.Z., Rosenbaum, R.K., & Olsen, S.I. (Eds.). (2020). Life Cycle Assessment: Theory and Practice. Springer International Publishing.
- Cheshire, D., & Morris, M. (2021). Building Revolutions: Applying the Circular Economy to the Built Environment. Routledge.

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Articles:

- Ellen MacArthur Foundation. (2023). Circular economy in the built environment. Retrieved from https://ellenmacarthurfoundation.org
- UN Environment Programme. (2023). Global Status Report for Buildings and Construction. Retrieved from https://globalabc.org

Websites:

- OpenLCA official website: https://www.openlca.org
- European Commission on Circular Economy: https://environment.ec.europa.eu/topics/circular-economy_en
- International Energy Agency (IEA) on Cement Sustainability: https://www.iea.org/reports/cement

7 Assignments and Assessments Strategy

Students will engage in small, practical assignments designed to familiarize them with LCA modeling and interpretation using OpenLCA. These tasks will involve assessing individual building materials, comparing environmental impacts, and extrapolating findings to building-scale scenarios. Such activities will build foundational knowledge and skills, preparing students for the comprehensive project outlined in section 3.2.

Grading Rubric and Evaluation Criteria:

- Research and Analysis (30%): Quality, depth, and analytical skills in addressing sustainability challenges.
- Collaboration and Participation (20%): Team effectiveness, communication, and individual contributions.
- Solution Design (30%): Creativity, innovation, and practicality of proposed sustainability solutions.
- Presentation and Defense (20%): Clarity, professionalism, and persuasiveness during presentations.