Politecnico di Torino

Honors Thesis

Master's degree Science in Sustainable Architecture

Abstract

Today's mainstream consumption and production patterns have led to a high quality of life in many parts of the world, but this has come at a high environmental price that is unsustainable and has led to climate change. In order to achieve a net-zero goal by 2050 a change in direction is essential. The current construction sector is responsible for a large percentage of global energy consumption and energy-related CO_2 emissions; it presents a key opportunity for impactful change. While efforts to improve building efficiency have gained momentum, it is crucial to consider the whole-life-cycle emissions of buildings, and the concern over embodied energy and material efficiency will increasingly become a key aspect to address. Integrating bio-based solutions could have the potential of reducing embodied emissions as part of mitigation strategies. To fully leverage the potential of bio-based materials, mainstream prefabrication production processes must be integrated, enabling better choices on a larger scale. The research methodology consists of conducting a comprehensive analysis and review of the scientific literature of the state-of-the-art in regards to the transition towards circularity and material efficiency and the use of bio-based materials within the European context. As a result, this thesis focuses on introducing guidelines with the primary objective of encouraging design-for-disassembly, waste reduction, and promoting reuse and recycling through the utilization of prefabricated bio-based elements and components. The focus is to facilitate informed decision-making during construction and retrofit processes and provide a comprehensive understanding of the potential and contribution of bio-based solutions toward a transition to circularity and material efficiency, as well as efficiently performing envelopes. The specific objective of this research is to provide a set of guidelines that aid the use

of bio-based building materials. By doing so, it aims to promote a more holistic approach as well as environmentally conscious decisions. The work is divided into three parts. The first part explores the current environmental impacts of the building sector and its effects and contribution to climate change, with a specific focus on manufacturing processes of building materials and products. This first part identifies solutions and strategies that combine material substitution, bio-based alternatives, and prefabrication processes. It highlights potential liked to prefabrication at different degrees and identifies the gap within that is the material choice. The second part explores material substitution with bio-based materials, defining their potential and contribution towards envelope performance and comfort, circularity, waste reduction, and recycling potential. Subsequently, this develops in the guidelines that consist of the heart of the thesis and aim to guide and support all actors involved in construction and retrofit processes. The third part is a result of an ongoing research project that sees the collaboration between the Politecnico di Torino, The Ne[s]t and the Club del Sole of the RE-TREE-T project: laboratory of innovative hospitality. This project chosen as a case study provides a possible application of the guidelines in order to assess material alternatives and optimization strategies. In conclusion, this master's thesis highlights the urgent need for a change in consumption and production patterns to address the high environmental price tag associated with today's traditional practices in the building sector. This sector, with its significant energy consumption and CO_2 emissions, presents a crucial opportunity for transformative change. Ultimately, the research presented in this thesis aims to provide information and facilitate the transition to circularity, material efficiency, and environmentally efficient envelopes of new and existing buildings in the context of the European Union.

Thesis Title

Bio-based materials and prefabricated production processes: Guidelines for the European context

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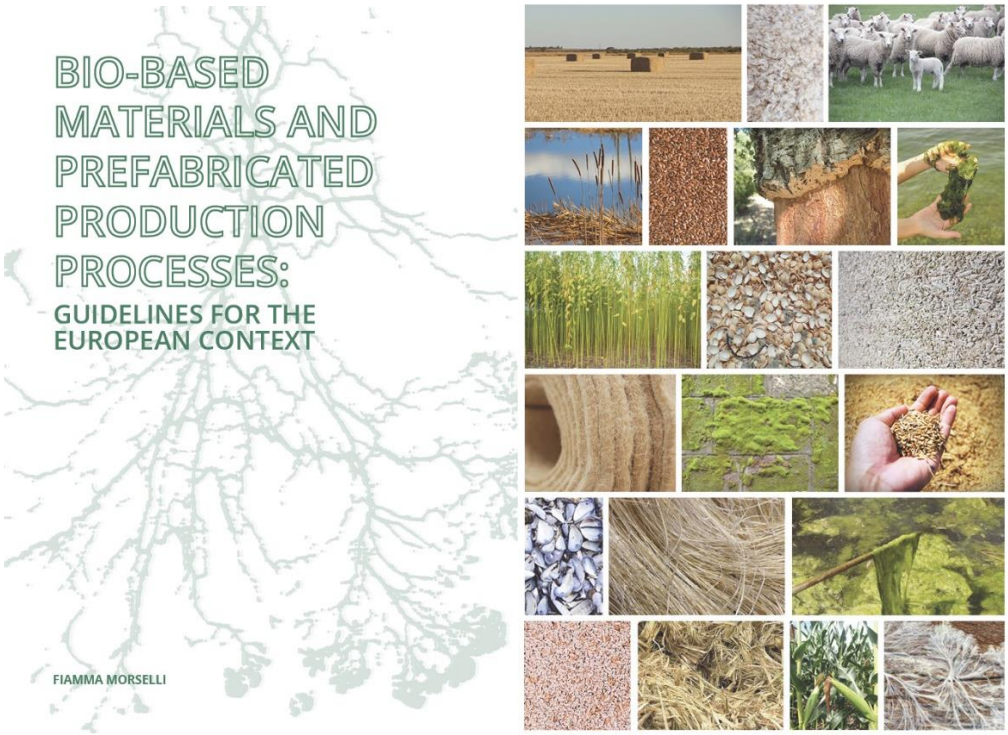

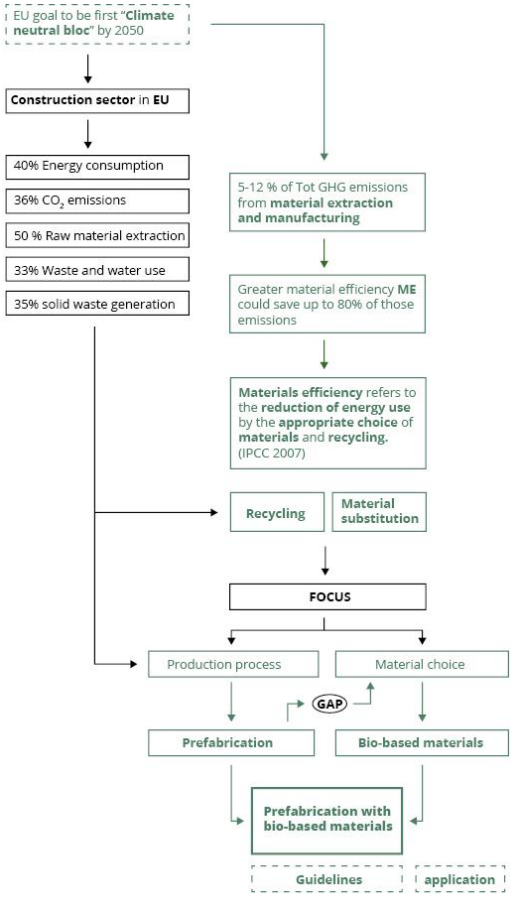

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