CERIS : Civil Engineering Research and Innovation for Sustainability

Dynamic assessment of building stocks – material selection at the urban scale

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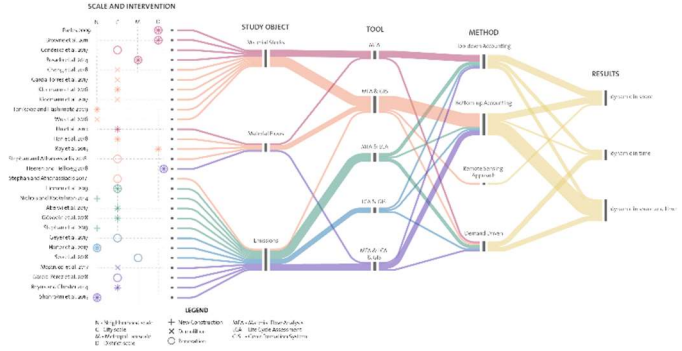
Summary

Current statistics and analyses of the built environment show that its production and maintenance is largely contributing to climate change and therefore is a threat for society. Modeling from a static point of view without integrating the dynamics of both the built environment and the delay of emissions to the atmosphere is misleading. The objective is to develop a method that allows more accurate modeling of CO_2 emissions induced by the materials used in the built environment depending on its defining parameters and dynamics over time. An extensive literature review on all related topics was the basis and the actual development of the method will be conducted on different levels of the built environment, these being its smallest level, the wall as a building element and with it improved insulation material choices; to a complete building, which will be assessed in detail regarding embodied and operational energy; to a complete residential building stock in a city. The aim is to analyze the current state of the art for retrofitting of European building stocks and compare it to improved material choices. The impact of deep retrofit will be evaluated focusing on the insulation material used, including bio-based ones. By focusing on the embodied energy and CO_2 emissions and sequestration of different types of bio-based materials I will be able to analyze the interesting dynamics of plant growth, its harvest cycles and the relationship between natural and built environment. A building typology will form part of the method to make a material inventory at the small scale. The obtained quantities for materials will be upscaled to a city scale and the application of MFA will allow to consider the dynamics of the built environment. For the assessment, the location characteristics are important and will be represented in space with a GIS, important both for data collection and results. The environmental impacts will be assessed with a hybrid LCI and dynamic LCA that integrates technology transitions, based on a fleet-based approach.

Furthermore, the potential benefits of concrete carbonation and the use of recycled aggregates in concrete will be considered. Along with the concept of carbon sequestration this approach will help to understand how to close construction materials cycles. The feasibility of the method will be tested with case studies: Different countries are chosen to illustrate different climate conditions and characteristics of the existing building stock (age and material composition). The introduction of a dynamic approach that combines Life Cycle Assessment, Material Flow Analysis and Geoinformation Systems allows to show the opportunities that the built environment can provide from now to 2050. The method is innovative in its combination of existing methods while at the same time considering the dynamics of emissions and the dynamics of "technology transitions", meaning big scale retrofitting, of the built environment. The outcome of this thesis will provide policy makers, city planners and engineers with a method to estimate the environmental impact of certain material alternatives for retrofitting at the urban scale based on the local context.

Keywords

Material Flow Analysis (MFA), Geoinformation Systems (GIS), Life Cycle Assessment (LCA), combination LCA and GIS, urban scale, urban modelling, building stock, building typologies, bio-based materials, insulation, retrofit, dynamic, fleet-based, carbon sequestration, concrete carbonation, cork, straw, wood, Lisbon, Zurich.



Dynamics, methods, and tools for the assessment of materials in building stocks.