RP2007

APPLYING A MIXED-UNIT HYBRID LCA FRAMEWORK TO THE RECYCLING OF CONSTRUCTION MATERIALS

Research Question

What is the most comprehensive way to quantify a full 'carbon profile' of construction materials using a combination of physical and monetary units as well as life cycle inventory (LCI), input-output (IO) and material flow data? What is this method useful for?

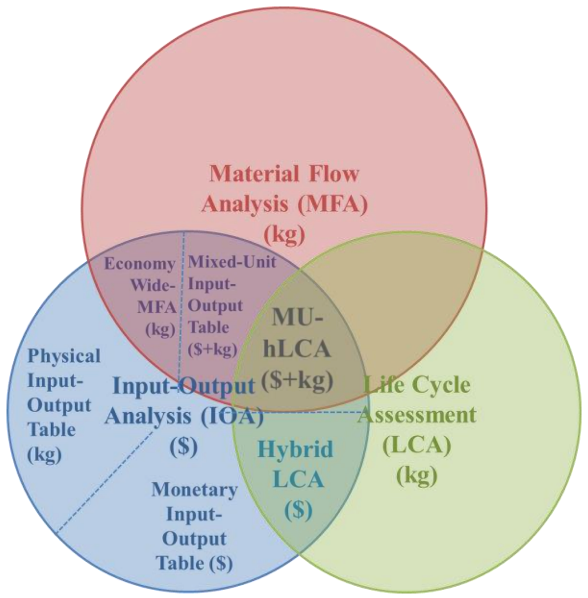

Figure 1: Relationship of methods and proposed methodology of MU-hLCA

The goal of this study is to compare the results of the Mixed Unit-Hybrid Life Cycle Assessment (MU-hLCA) approach with that of IO-hLCA and LCA using geopolymer concrete (GPC) as a case study. The application and the usefulness of the MU-hLCA method is demonstrated through modelling the use of recycled materials and by-products in concrete and steel.

Methodology

The MU-hLCA method connects a top-down IO matrix with a comprehensive set of bottom-up LCI process matrix through the upstream cut-off (C_u) and downstream cut-off (C_d) matrices. To calculate the carbon footprint intensity (CFI) with the MU-hLCA method, the direct intensity multipliers of the process and IO system are multiplied with the Leontief inverse.

Results

The results derived from the MU-hLCA approach is compared to that of IO-hLCA and LCA methods. The CFI results of GPC using the MU-hLCA method is 8% lower than that of IO-hLCA and 87% higher than that of LCA.

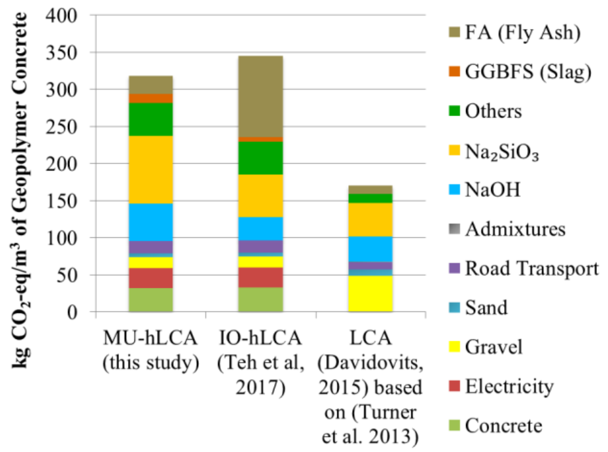

Figure 2: Contributions of main GHGEs for the production of GPC by MU-hLCA, IO-hLCA and LCA

In the concrete application study, a greenhouse gas emmission (GHGE) reduction of 1% is observed when 100% of Recycled Concrete Aggregate (RCA) is replaced with Natural Aggregate (NA) in both GPC and Ordinary Portland Cement (OPC) concrete. Due to cement production being the largest contributor of GHGE in OPC concrete, a maximum GHGE reduction of 40% can potentially be achieved with RCA GPC compared to NA OPC concrete.

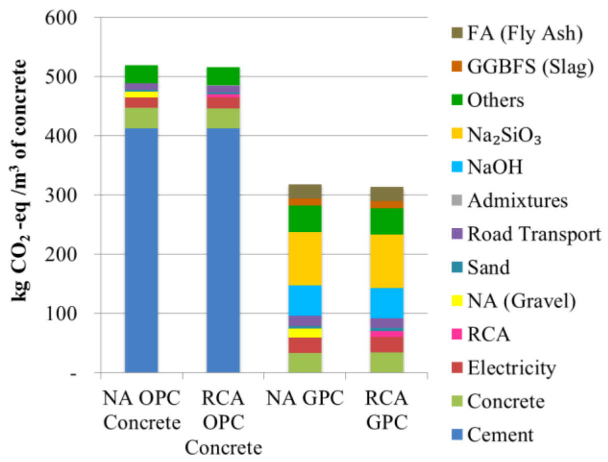

Figure 3: CFI of two types of concrete investigated with either NA or a 100% replacement with RCA

In the steel application study, 45% GHGE reduction is achieved via the Electric Arc Furnace (EAF) route, produced mainly from iron and steel scrap, compared to the Basic Oxygen Furnace (BOF) route, demonstrating the environmental benefit of scrap usage.

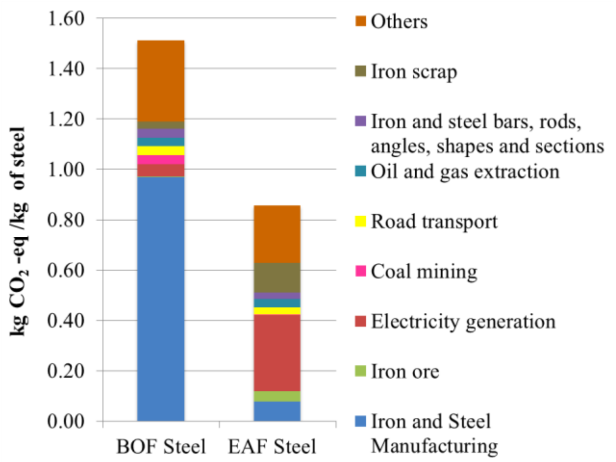

Figure 4: CFI of two types of BOF and EAF steel with the use of iron and steel scrap investigated

Conclusions

The MU-hLCA approach produces more accurate results as it incorporates Australian process-specific physical flows and benefits from having an economy-wide system boundary. To demonstrate the flexibility and practicality of the MU-hLCA methodology, it is applied in case studies relating to recycled construction materials and by-products. By using the MU-hLCA framework, all phases including the use, disposal and recycling stages can be represented in physical units, allowing specific recycled products to be represented without altering the aggregated IOT sectors.

Anticipated impacts

The MU-hLCA approach improves the accuracy and specificity of results as it i) i) reflects Australian process-specific LCI flows and economy-wide material flows, ii) resolves price variability issue, and iii) represents recycle and disposal stages.

A comprehensive assessment of life cycle emissions of green and alternative materials can inform best practices adopted in the construction industry.

An economy-wide scenario analysis can be conducted with MU-hLCA to assess the potential GHGE reduction in the built environment.

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