Streamlined Life Cycle Assessment of Buildings

PROBLEM

Life Cycle Assessment (LCA) is a method that building practitioners can use to analyze the environmental performance of a proposed building design. However, surveys of building practitioners have shown that LCA tools are not widely used to guide design development because the analyses are time-consuming, require burdensome data collection, and are poorly integrated with the design process.[1] In addition, predicting the use-phase energy consumption of a building often requires dedicated energy simulation software, so the design must be input into multiple programs to get a full picture of the life cycle impacts. Due to the added time and effort required, the use phase is often left out of LCA calculations despite the fact that it is a dominant source of environmental impacts for most buildings in the US today.

APPROACH

The MIT Concrete Sustainability Hub has developed a streamlined LCA methodology called the Building Attribute to Impact Algorithm, or BAIA, which features impact calculations for the full building life-cycle, uses a flexible building definition in which uncertain attributes can be *underspecified* (represented by a range or group of related options) and *triages* the probabilistic impact predictions to identify influential attributes. We use a regression model based on the results of thousands of detailed energy modeling simulations to predict the building energy consumption; this allows the estimation of both embodied and use-phase impacts using rough, early-design attributes that define the building geometry, assembly types (*i.e.*, type of system being used in the walls, floors, ceiling, roof, etc.), and the materials being used within each of the assemblies. When attributes are underspecified, the resulting variability is captured in the output. The user is then presented with the distribution of impacts as well as the triage results, which provide guidance on the attributes that should be specified further to reduce the variability in predicted impacts (Fig. 1).

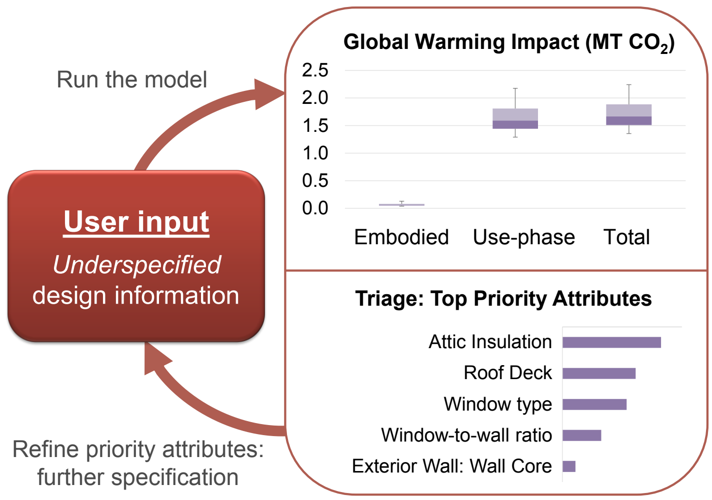

Fig. 1: Diagram of cyclical early-design LCA process where user inputs the available level of detail, receives feedback on the use-phase and embodied impacts of the proposed design from one common set of building attributes, and also sees a ranking of the attributes that are contributing the most to the variability in predicted impacts.

FINDINGS

Including use-phase impacts in LCAs provides a more complete picture of the environmental performance of a proposed building design. Further, using early-design attributes instead of a detailed model allows for more iterative design exploration at the conceptual design stage, which is when this information has the largest potential to influence the final design. By triaging the influential attributes, it is possible to arrive at precise estimates even when the majority of attributes are highly unspecified.

IMPACT

By allowing all significant impacts to be calculated from one common building description and capturing the variability from uncertain inputs, our streamlined methodology makes LCAs better suited to guide the building design process. Identifying influential attributes allows practitioners to focus on the parameters that matter and leave the rest underspecified. This speeds up the analysis process and leads to more informed design decisions.

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[1] Saunders, C.L., et al., Analyzing the practice of life cycle assessment: Focus on the building sector J. Ind. Ecol. Journal of Industrial Ecology, 2013. 17(5): p. 777-788.

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