Air leakage has strong influence on building life cycle impacts

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PROBLEM

Heating, cooling, lighting, and appliance usage during occupancy result in the use phase being the life-cycle stage with the greatest environmental impacts in a typical modern building. There are many aspects of a building's design that can influence overall energy consumption during the use phase, including envelope insulation, the efficiency of HVAC systems and appliances, and the area and type of windows used. Air leakage of the envelope, which is influenced by a variety of factors including the wall system and the construction quality, is also known to be an influential parameter. This brief presents results from an analysis using the CSHub's streamlined building life cycle assessment (LCA) tool, the Building Attribute to Impact Algorithm, or BAIA, which compares the effects of changing air leakage in comparison to other influential parameters using limited information available in the early design stages.

APPROACH

BAIA predicts the material- and energy-related life cycle impacts based on uncertainty in an early residential building design. Using the tool, researchers modeled variants defining possible improvements to a 2,400-square-foot, 2-story building in Chicago. The baseline building used insulated concrete form walls with an effective R-value of 18 ft^2-hr-°F/Btu; a furnace with 85% annual fuel utilization efficiency; double-pane windows with a non-metal frame; and an R-19 roof. It was modeled with an air leakage of 7 air changes per hour at 50 Pa (ACH50). Other building attributes were randomly varied in each of a set of 1000 LCA iterations within one BAIA run to generate the distribution of life cycle impacts (global warming potential) for the baseline design. Different choices for air leakage, wall insulation, and HVAC efficiency were modeled to determine the comparative influence of these three attributes and the statistical significance of each possible design improvement was determined by calculating the percentage of impacts that were lower in the variant than in the baseline.

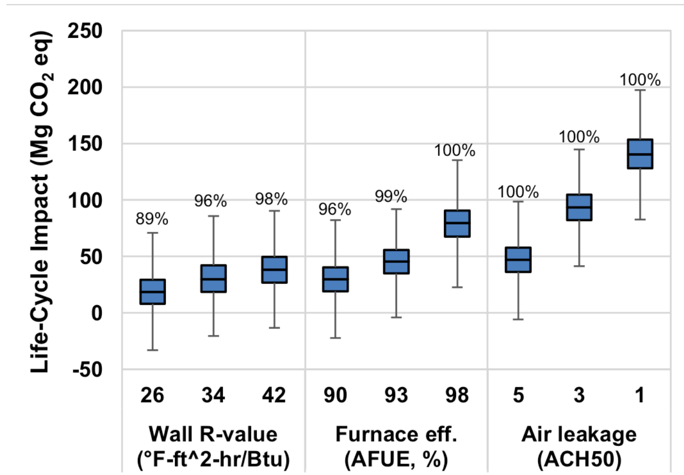

Figure 1 – Reductions in life cycle global warming potential compared to the baseline design (R-value of 18, furnace efficiency of 85% AFUE, and air leakage of 7 ACH50), accounting for early-design uncertainty. Box plots show 1st, 25th, 50th, 75th, and 99h percentiles. Labels indicate significance of comparison to baseline, or likelihood that variant is an improvement to the baseline.

FINDINGS

Though all but the first design variant lead to statistically significant reductions in global warming potential at a 90% confidence level, reducing air leakage led to the largest improvements (by magnitude and significance) of the design variants explored. Figure 1 summarizes the improvements in environmental performance and statistical significance of the comparison to the baseline for each design. This research suggests that blower-door tests should be conducted more regularly in new and existing buildings to reduce environmental impacts and to relate air leakage to design choices and building practices.

WHY DOES THIS RESEARCH MATTER?

- This research shows that air leakage is influential in determining the life cycle impacts of a residential building.
- Making informed decisions at the earliest stages of the design process can lead to improved building performance.
- The BAIA approach illuminates factors that most influence early-design decisions while requiring minimal data and design details.

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