Research Brief
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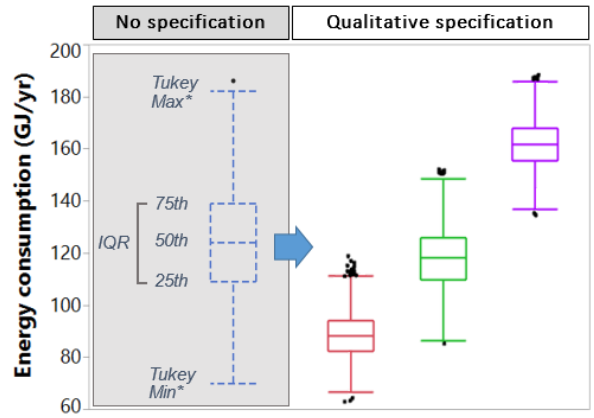
Streamlining residential building energy models

OVERVIEW

Energy consumption is a key contributor to the environmental impact of residential buildings, but quantifying this consumption typically requires a detailed building design and time-consuming energy modeling simulations. As a part of our streamlined life-cycle assessment methodology, the CSHub has been developing a model that can estimate the energy consumption of a building based on schematic or “underspecified” attributes (such as approximate U-values of external walls and roofs), rather than a comprehensive design and in-depth energy modeling. The goal of this framework is to determine which design decisions can be guided with low-fidelity information, as well as to identify key attributes for more detailed data collection. This brief explores the reduction of uncertainty in energy model results when qualitative information is given for key attributes that were previously unspecified.



Attribute	Qualitative attribute performance			
External wall U-value	**Any**	**Good**	**Avg.**	**Poor**
Ceiling or roof U-value	**Any**	**Good**	**Good**	**Poor**
Air Leakage	**Any**	**Good**	**Poor**	**Poor**

Figure 1: Distribution of energy consumption results from streamlined energy model for completely unspecified attributes (leftmost) and qualitatively specified influential attributes.

*Tukey boxplots display the min. and max. points within 1.5*IQR of the 25th and 75th percentiles.

APPROACH

Streamlined energy models were built using statistical analyses of data from thousands of EnergyPlus (building energy analysis software) simulations spanning a range of building designs and locations. Statistical analyses of each building attribute revealed three key contributors to energy use and thus to uncertainty in energy consumption: external wall U-value, ceiling or roof U-value, and air leakage. The next step was to observe the extent to which specifying each of these three attributes qualitatively could reduce the overall uncertainty in the estimate of energy use compared to a baseline wherein no information was known or specified about a building. The baseline for comparison was found by utilizing the streamlined model to estimate the energy of thousands of buildings with combinations of attributes pulled randomly from all available values (shown in blue in Figure 1). To create the qualitatively specified buildings, the range of possible values for each of the three key building attributes was divided into thirds creating three levels: good, average (avg.), and poor. The rest of the attributes remained unspecified. The streamlined models were run again, this time with each of the key building attributes set at good, average, and poor, and the remaining attributes were permitted to vary randomly across the same ranges as in the baseline simulations. The reduction in the uncertainty of the energy use estimates due to qualitative specification was then calculated for each of the combinations of key building attributes.

FINDINGS

Even when only external wall U-value, ceiling or roof U-value, and air leakage are known at a qualitative level and the rest of the attributes are completely unspecified, the uncertainty (represented by standard deviation, range, or similar metrics) of use-phase energy consumption is reduced by an average of approximately 50% from the corresponding measures of the baseline unspecified model. This is shown visually by the shrinking ranges and interquartile ranges (IQR) in the boxplots of Figure 1 before and after qualitative specification.

IMPACT

These findings demonstrate the significant reduction in uncertainty around the energy consumption of a building when only a few key attributes are specified qualitatively. Identifying key attributes will help inform building practitioners about which attributes to focus on in data collection for streamlined energy consumption calculations and/or life cycle assessments where little information is needed for the majority of inputs.

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