Implications of energy code evolution on energy performance of multi-family residential buildings in the US

Research Brief, Volume 3, 2018

PROBLEM

The International Energy Conservation Code (IECC), which is created by the International Code Council (ICC), standardizes expectations for the design and construction of buildings with regards to energy use and conservation over the structure's lifetime. With every new release these codes get more stringent. The goal of this analysis was to quantify how the evolution of these building codes has impacted the energy performance of buildings.

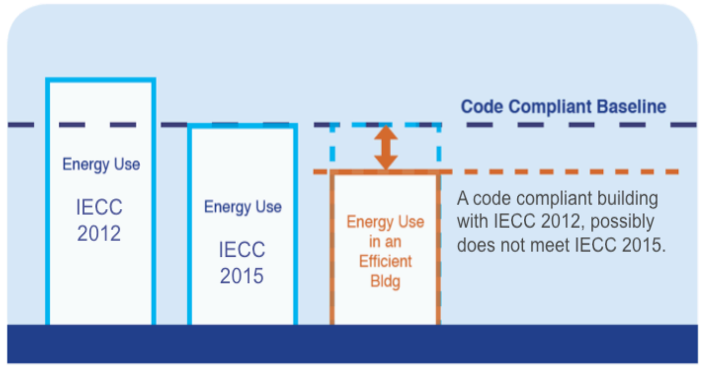

Fig 1. Code-compliant buildings compared to baseline.

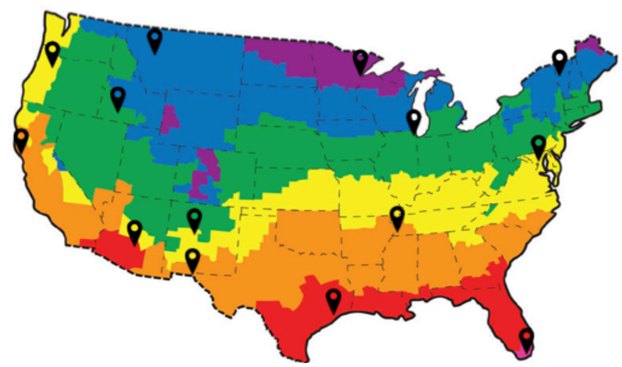

Fig 2. Selected climate zones and city locations.

APPROACH

We analyzed a reference building type for various design scenarios in a number of geographical locations. The reference building was a 100,000 sq. ft. multi-family residential apartment with mixed one and two-bedroom units. Our study looked at this structure over a life span of 50 years. Significant effort was invested to establish and account for a variety of design scenarios, including building envelope requirements for wood and insulated concrete form (ICF) wall systems, roof and slab insulations, air leakage requirements, and HVAC efficiencies.

We first investigated how energy load changes across different locations in the United States. IECC sets different baselines in each of the climate zones across the U.S., which are defined based on the number of heating and cooling degree-days[1] for the region in which the building is located. There are 14 climate zones within the continental U.S. We selected 14 cities, each representing one climate zone (Fig. 2), and studied a variety of design scenarios for one building in each using both 2009 and 2015 IECC codes. Overall, more than 600 cases were analyzed, with both site and source energy consumption of these building scenarios calculated. The energy model was created using BEopt software, which is developed by the National Renewable Energy Laboratory and builds on EnergyPlus to provide a detailed simulation-based analysis of a building's energy performance based on its characteristics.

WHY DOES THIS RESEARCH MATTER?

- This analysis explores whether updates to the International Energy Conservation Code (IECC), which have made the code more strict and costly to meet, yield demonstrable benefits.
- Researchers analyzed a reference building, assuming a variety of design scenarios, in 14 U.S. cities representing different climate zones and determined that updates to the code have had an impact.
- This work suggests it is more meaningful to compare building energy performance using the same code year basis and to report savings caused by changes to the building envelope in heating and cooling terms, and not in overall energy savings.

[1] A degree-day compares the average of high and low outdoor temperatures recorded for a location to 65° (F).

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FINDINGS

We found that the majority of the energy loads for the buildings we studied were constant across design scenarios, which include lighting, large appliances, and miscellaneous activities. These loads take up between 56 and 73 percent of the overall energy consumption of a building on average across all building scenarios for one location (see Figure 3). In addition, hot water load changes marginally across studied locations. This means that energy efficiency improvements mostly influence heating and cooling loads, which suggests that it is more meaningful to report savings caused by design decisions relating to the building envelope in heating and cooling terms, and not in overall energy savings.

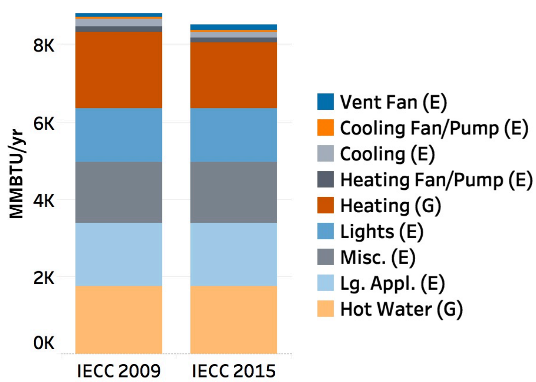

Fig 3. Energy consumption by end use for a concrete structure in Duluth, MN, designed to IECC 2009 and 2015 standards.

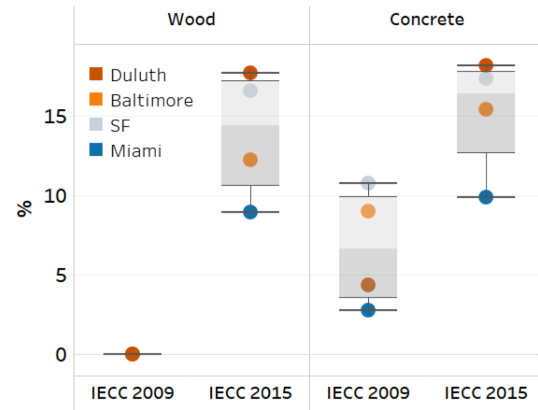

Fig 4. Heating and cooling savings compared to a conventional wood design.

Our analysis of building code evolution showed that a concrete structure built to 2009 standards demonstrated a considerable savings when compared to a conventional design built to the same standards (here we used a baseline wood structure as the alternative design). However, both wood and concrete designs built with 2015 standards perform almost equally; which emphasizes the significance of improvements in building codes on energy consumption of multi-family residential buildings. Figure 4 shows the heating and cooling savings for both wood and concrete multi-family structures in four sample cities. Through our analysis, we can also investigate how buildings perform using 2015 design standards, compared to 2009 standards as baseline (see Figure 5). Heating and cooling loads vary significantly by region and consumption is highest in cities with higher degree-days, bringing more savings in these areas.

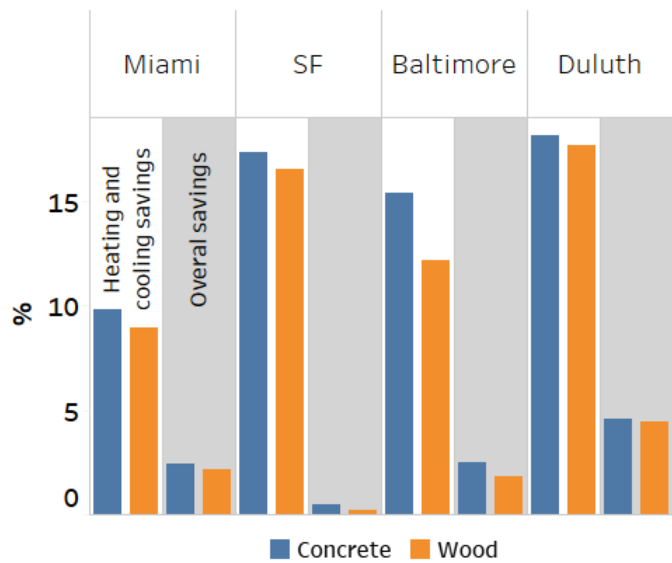

Fig 5. Performance comparison of concrete and wood buildings built to 2015 standards and compared to 2009 standards in four climates.

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