UNIVERSITY OF TORONTO | Civil + Mineral Engineering

Vakalis D, Diaz Lozano Patiño E, Opher T, Touchie M, Burrows K, MacLean HL, Siegel JA. 2021. Quantifying thermal comfort and carbon savings from energy-retrofits in social housing. *Energy & Buildings*, **241**, 110950. DOI: 10.1016/j.enbuild.2021.110950

Abstract

Energy retrofits of existing multi-unit residential buildings (MURBs) are necessary to reduce their carbon emissions. While doing so there is an opportunity to influence the indoor environment. There is a need to quantify retrofit impacts across multiple dimensions, in terms of emissions and indoor environment, but also occupant perceptions. This paper characterizes carbon emissions and changes to indoor thermal conditions associated with energy-retrofits, such as replacement or updating of boilers, air-handling units, piping, valves, ducts, in-suite radiators and controls in seven social housing MURBs. MURBs are a building type opportune for energy-savings, and social housing residents may be more susceptible to heat stress. Using hygrothermal measurements taken inside a sample of apartments, modelled thermal comfort in most buildings showed statistically significant changes (in both directions), however nearly all of these changes were small (a less than10% change in time comfortable). Despite being of the same vintage, construction and location, pairs of buildings with similar retrofits did not always result in the same direction of changes to thermal comfort, either modelled or surveyed. Within individual buildings, modelled thermal comfort does not always agree with occupant survey responses about their overall seasonal comfort. Finally, a life cycle assessment of retrofit measures results in an important savings of annual global warming potential. Annual natural gas savings are of a magnitude such that the operational carbon savings to embodied carbon investment range from 23:1 to 97:1. The associated energy cost savings does not, on average, offset the capital costs if only taking into account reduced energy for space heating. More generally, these results suggest mechanical retrofits of MURBs may save energy and carbon, but may not consistently improve residents' thermal comfort.

Highlights

- Across similar buildings and retrofits, changes to thermal comfort may differ
- Models based on hygrothermal measurements disagreed with perceived comfort
- Less heating required after retrofit offsets embodied carbon in less than a year

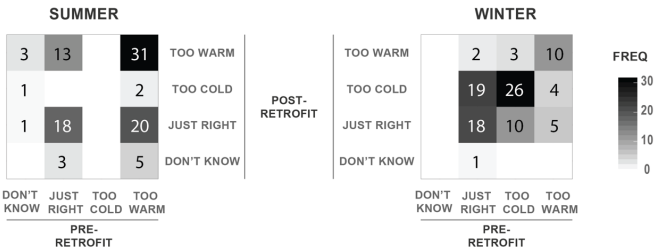

Figure 4. Matched responses of all survey participants who were surveyed both pre- and post-retrofit to the question "In the summer/winter months, how do you feel in the apartment/bedroom/living room?"

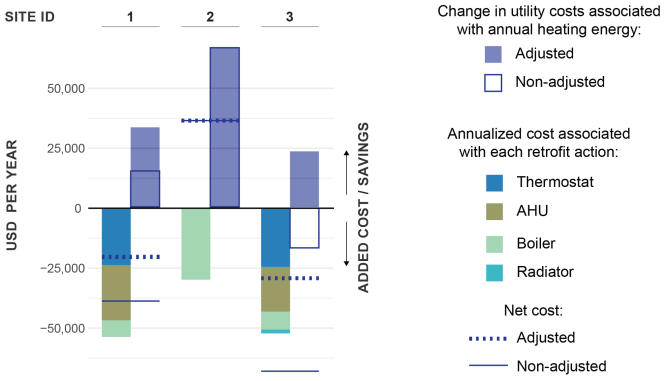

Figure 5. Comparison of annualized cost, U.S. dollars, of retrofit measures to one year's utility bill savings from reduced natural gas use for space heating. Adjusted amounts are estimates after keeping the ventilation air flow constant and non-adjusted amounts reflect the actual consumption.

Support provided by:

NSERC CRSNG | Natural Resources Canada / Ressources naturelles Canada | ENBRIDGE