Leveraging building permit data for large-scale embodied carbon and circularity assessment of residential building construction

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https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5248436

Summary

Most research on the environmental impact of buildings focuses on new construction, but growing interest in the circular economy has shown that renovating existing buildings can also be a valuable way to provide additional housing while maximizing the use of existing structures. Using publicly available building permit data, this study quantified the embodied GHG footprint of over 65,000 residential construction projects completed between 2018 and 2023 across six North American cities. Through a hybrid approach that combines regional GHG emission factors and reported construction costs, we estimated embodied emissions for newly built residential units and dwellings added through renovations of existing buildings.

This work provides a practical methodology to estimate emissions from construction using publicly available permit data already collected by many municipalities. Further, this study offers a scalable, data-driven method that can help guide policies on sustainable housing and resource-efficient development.

Key Takeaways:

1) Our results show that dwelling additions represented a small share of housing provision in all 6 cities between 2018 and 2023, with most new housing units being in large multi-unit buildings, and most units added through renovation being in single-family buildings (e.g., basement subdivision, additional dwelling units).

2) Providing housing through renovations of existing buildings has a considerably lower GHG intensity than new construction, although the potential to reduce emissions is not uniform across building forms (see Figure 1 below):
    i. Newly built units in our sample are, on average, ~10 times more GHG-intensive than single-dwelling additions to existing buildings. Thus, the least GHG-intensive pathway to add housing units is by renovating small buildings (e.g., turning an existing single-family home into multiple units).
    ii. Newly built units in large multi-unit buildings are, on average, 1.5-3 times more GHG-intensive than additions to existing buildings depending on location.

3) The most GHG-intensive renovations can result in similar or higher emissions than new construction. For large multi-unit buildings in particular, 20-40% of housing units added through renovation resulted in higher emissions than the average newly built unit, depending on location. This is due to the large variability in the scope of renovation projects (see Figure 2 below), maintenance conditions of existing buildings, and regulations on retrofit projects (e.g., regulations to protect components of heritage buildings).

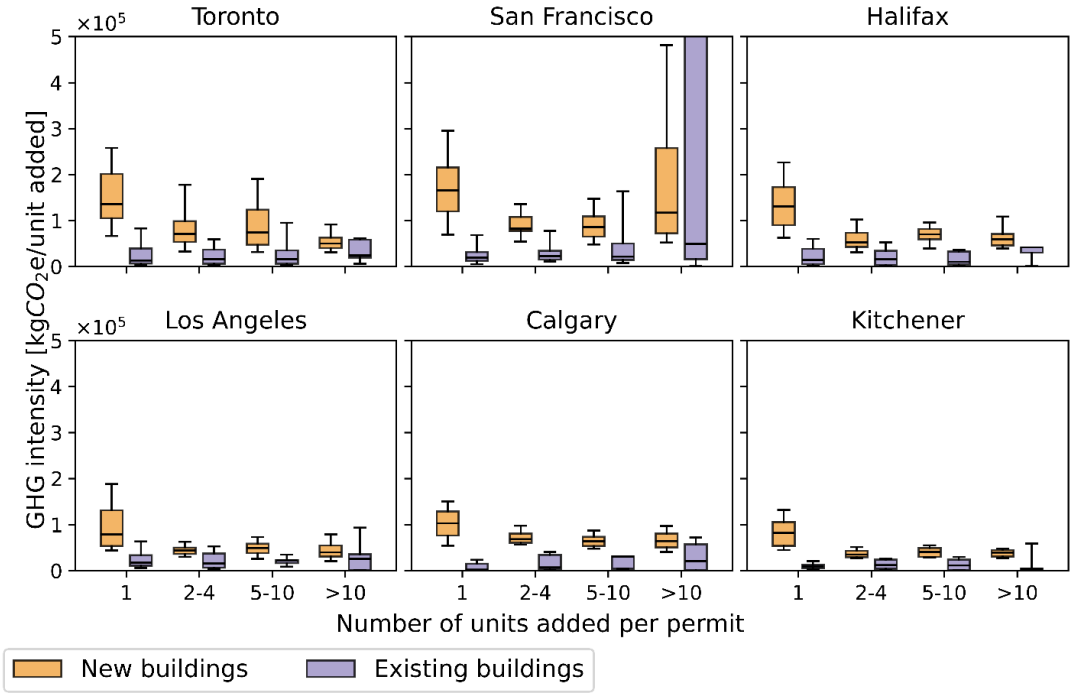

Figure 1: *Boxplot of the embodied GHG intensity (in kgCO2eq/dwelling) of residential units built between 2018-2023 for different building types (using number of units created per project as a proxy) across six municipalities in North America. The orange boxes show the embodied GHG intensity distribution of newly built dwellings, while the violet boxes show the embodied GHG intensity distribution of dwellings added to existing buildings through renovations.*

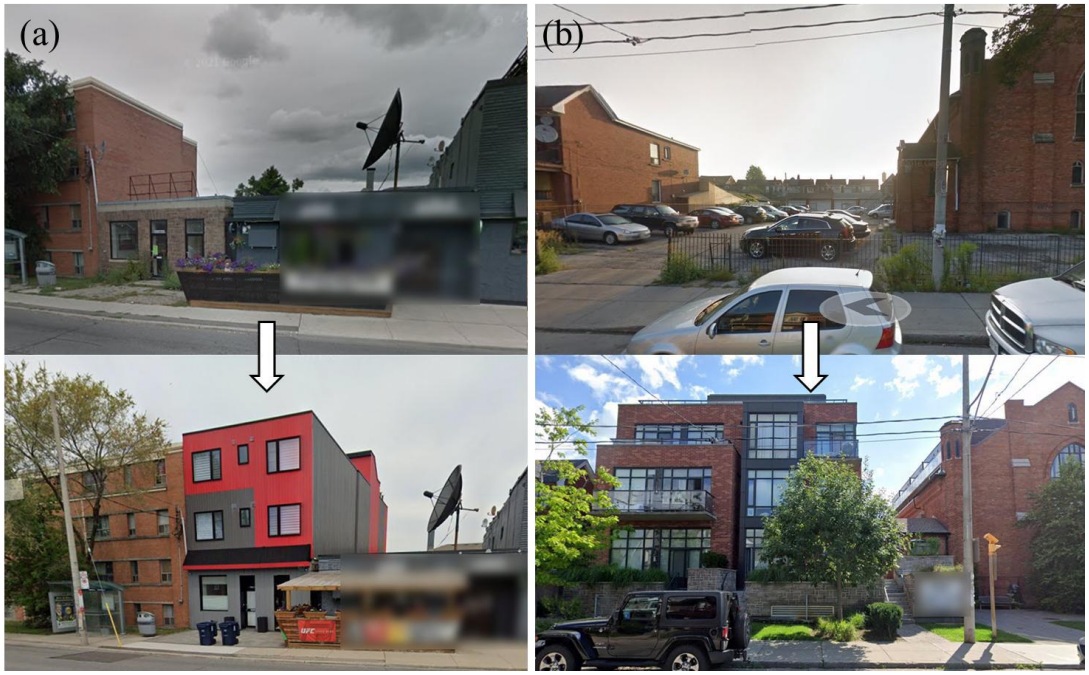

Figure 2: *Examples of residential renovation projects with additional housing creation in Toronto, Ontario. The street view picture above shows the buildings before the renovation projects, while the picture below shows the finished renovated buildings. Images taken from Google Streetview.*