Life Cycle Assessment Report

Measuring Embodied Carbon in Value-Add Real Estate Investing Compared to New Construction

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Literature Review and Life Cycle Assessment Report

The present document provides a summary of the literature on the carbon footprint of multifamily renovation and reports on life cycle assessment (LCA) results of three value-add real estate investment projects that represent various types of property improvement and renovation strategies.

Building renovation can be broadly categorized into three groups: adaptive reuse, retrofitting (including deep retrofitting), and minor renovation. Adaptive reuse involves repurposing an existing building for a different new function through significant spatial transformation, along with major upgrades to the building envelope and systems. In contrast, standard and deep retrofitting focuses on building performance improvement, particularly energy efficiency, through targeted interventions in the building envelope and systems (e.g., adding insulation, replacing windows, and HVAC system upgrades), while maintaining the building's original function. Minor renovation entails limited modifications that do not change the building's function but enhance its livability and aesthetics through repainting, envelope repair, or fixture replacement. Among these, adaptive reuse generally offers the greatest potential for both embodied and operational carbon savings, while retrofitting – especially deep retrofitting – is primarily intended to reduce energy use and associated operational carbon.

1. Multifamily Sector: Housing Supply and Carbon Footprint

The increasing frequency and severity of climate change-induced natural disasters, such as hurricanes, wildfires, heatwaves, and flooding, have augmented the urgency to reduce carbon emissions across all sectors of the economy. In the building sector, the expected growth of residential and commercial floor areas, driven by population dynamics and urbanization, combined with current patterns of building energy use and greenhouse gas emissions, underscores the urgent need for decarbonization. Buildings are responsible for 37-43% of global greenhouse gas (GHG) emissions, with 28% of emissions being associated with building energy use, referred to as operational carbon, and 9-15% of GHG emissions related to building materiality and construction (e.g., building material manufacturing, construction, maintenance, demolition, and related transportation), referred to as embodied carbon [1].

The United States is currently experiencing an estimated housing shortage of 3.85 million units [2]. To address this deficit and meet the future needs driven by population growth and evolving market dynamics, it is projected that an average of 1.6 million new single-family and multifamily housing units will be initiated annually over the next decade [3]. Given the average size of a US housing unit is 1,818 square feet [4], this translates to an annual addition of roughly 2.9 billion square feet of residential space – totaling 29 billion square feet between 2024 and 2034. With multifamily housing accounting for 27% of the market share [5], approximately 7.83 billion square feet of new multifamily housing is expected to be delivered during this period through both new construction and adaptive reuse projects. This presents a strategic opportunity to reduce the carbon footprint of the residential sector, especially because multifamily is the most embodied carbon-intensive segment of the residential sector [6]. Notably, post-pandemic trends in office space downsizing have created substantial potential for converting non-residential buildings into housing. In 2023, 151,000 apartment units were under development via adaptive reuse – primarily office-to-housing conversions - marking a 24% increase over the previous year [7]. These projects now contribute approximately 10% to the projected annual housing supply, underscoring their growing role in addressing the nation's housing needs. Moreover, renovation and adaptive reuse offer a valuable pathway for reducing both embodied carbon - primarily through material conservation - and operational carbon, particularly when renovation scope extends to envelop retrofitting.

2. Energy Savings of Multifamily Renovation

Comprehensive energy-efficiency retrofits in multifamily housing across the United States present a substantial opportunity to reduce energy consumption and utility costs. Reported whole-building energy savings from multifamily retrofitting vary from 15-30% savings suggested by the American Council for an Energy-Efficient Economy (ACEEE) [8], to 22% by the New York State Energy Research and Development Authority's Multifamily Performance Program [9], 24% by the U.S. Department of Housing and Urban Development [10], and 38% by California's Low-Income Weatherization Program for Multifamily Properties [11]. In Europe, reported energy savings through multifamily retrofitting vary between 45% and 70% [12]. Liu et al [13], for instance, report 50% savings in energy use and 48% in associated carbon emissions in multifamily retrofitting in Sweden. ACEEE suggests that targeted improvements focused on space and water heating account for over 62% of potential energy savings, followed by lighting upgrades (21%), efficient air conditioning (10%), and energy-efficient appliances (6%) [14]. According to ACEEE, the energy-efficient renovation interventions in multifamily housing can result in an estimated $3 billion in utility cost savings nationwide, underscoring the economic and environmental value of investing in energy-efficient retrofits for multifamily housing [8].

3. Embodied Carbon Savings of Multifamily Renovation

The Carbon Leadership Forum (CLF) has proposed three benchmark levels for embodied carbon intensity in multifamily housing, intended to serve as reference points for future regulatory compliance. CLF recommends 520 kg CO2-eq/m2 as the maximum embodied carbon budget for new multifamily construction projects. It also establishes 390 kg CO2-eq/m2 and 320 kg CO2-eq/m2 as additional benchmarks, providing the construction industry with reference points to measure and reduce embodied carbon intensity. CLF also suggests that major renovations with new additions, on average, save 160 kg CO2-eq/m2 in embodied carbon intensity compared to new construction projects. Minor renovations' embodied carbon intensities are reported to be 60 to 210 kg CO2-eq/m2 lower than major renovations and new construction projects, respectively. Literature also documents the embodied carbon savings of adaptive reuse projects. For instance, Hasik et al. [15] reported 75% savings in embodied carbon in the adaptive reuse of a beer bottle planting facility in Philadelphia converted to an office building. Hu et al [16] suggest that the thermal envelope retrofitting and replacement of windows, floor, and roofs in an adaptive reuse of a historic school building converted into a medical facility saved 82% in embodied carbon compared to new construction.

4. Life Cycle Assessment of Three Multifamily Renovation Projects

We conducted Life Cycle Assessment (LCA) on three renovation projects owned by investment funds sponsored by ABR Capital Partners. These projects include 21st Street Lofts, The Forum Apartments, and Riverfront Village Student Housing. The scope of renovation in these projects ranged from full adaptive reuse and major conversion in the case of the 21st Street Lofts project, to window replacement, painting, and floor finishing in the Forum Apartments, to minor renovation, including repair with minor cladding replacement in the case of the Riverfront Student Housing project. For each project, we conducted the LCA under two scenarios of 25-year and 60-year service life. The LCA scope included new materials used in the project renovations. New materials were estimated based on architectural and structural drawings and other project information. The existing materials from previous projects were outside the scope of LCA as they didn't entail additional embodied carbon. A full life cycle LCA (i.e., cradle to grave and beyond) was conducted. Specifically, raw material extraction, manufacturing, construction, future demolition, potential recycling and reuse, and associated transportation across the stages were included for new materials used in these projects. Operational energy and water use were excluded from LCA. Tables 1.1, 1.2, 2.1, 2.2, 3.1, and 3.2 report project information and LCA scopes. Tables 1.5, 1.6, 2.5, and 2.6 report bill of materials included in the LCA assessment of these projects.