

The Whole Life Carbon of Commercial-to-Residential Conversions

Aligning the Climate and Housing Imperative



Cover: The Watermark project, after conversion. (Helen Kozak Photography)

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About the Urban Land Institute

The Urban Land Institute is a global, member-driven organization comprising more than 48,000 real estate and urban development professionals dedicated to advancing the Institute's mission of shaping the future of the built environment for transformative impact in communities worldwide. ULI's interdisciplinary membership represents all aspects of the industry, including developers, property owners, investors, architects, urban planners, public officials, real estate brokers, appraisers, attorneys, engineers, financiers, and academics. Established in 1936, the Institute has a presence in the Americas, Europe, and Asia Pacific regions, with members in 84 countries.

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About the Randall Lewis Center

The ULI Randall Lewis Center for Sustainability in Real Estate envisions a net zero, resilient, healthy, and inclusive world where every person, community, and business thrives. To achieve our vision, the Center accelerates action for sustainability in real estate and cities by cultivating leadership and knowledge, catalyzing adoption of sustainability practices across the real estate value chain, helping solve land use and real estate challenges, and advancing policy solutions.

The Center pursues these goals through its four main programs—Decarbonization, Urban Resilience, Healthy Places, and ULI Greenprint—working closely with ULI members and partners to produce publications on cutting-edge issues, host global convenings, provide community technical assistance, and organize leadership networks.

Discover transformative practices for real estate and land use at uli.org/sustainability. Connect with the Lewis Center at sustainability@uli.org.

About Built Buildings Lab

Built Buildings Lab is a nonprofit dedicated to transforming existing buildings into humanity's greatest resource, elevating the knowledge, stories, and resources that people need to act on the embodied value of built buildings. Their work empowers community leaders, policymakers, building owners, and design professionals who care about and advocate for the whole life of the buildings.

About Architecture 2030

Architecture 2030 is a nonprofit, nonpartisan, independent organization established in 2002 in response to the ongoing climate emergency. Their mission is to rapidly transform the built environment from the major emitter of greenhouse gases to a central solution to the climate crisis. For nearly two decades, Architecture 2030 has provided the leadership and designed the actions needed to achieve the CO₂ emissions reductions for a high probability of limiting planetary warming to 1.5°C.

About This Report

As cities confront persistent post-pandemic office vacancies and an urgent need for housing, many are turning to commercial-to-residential conversions as an emerging practical and climate-aligned redevelopment strategy. *The Whole Life Carbon of Commercial-to-Residential Conversions: Aligning the Climate and Housing Imperative* provides an environmental overlay to past studies of the market conditions, physical attributes, and financial incentives driving the economic viability of conversions. This report provides a data-driven foundation for understanding the carbon implications of commercial-to-residential conversions and offers guidance for integrating carbon-reduction strategies into early-stage project planning.

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EXECUTIVE SUMMARY

As cities confront persistent post-pandemic office vacancies and an urgent need for housing, many are turning to commercial-to-residential conversions as an emerging practical and climate-aligned redevelopment strategy. *The Whole Life Carbon of Commercial-to-Residential Conversions: Aligning the Climate and Housing Imperative* provides an environmental overlay to past studies of the market conditions, physical attributes, and financial incentives driving the economic viability of conversions. It provides new evidence that commercial-to-residential conversion projects can deliver substantial carbon mitigation benefits compared to leaving existing commercial spaces unrenovated and the creation of ground-up housing units.

Behind the Facade: The Feasibility of Converting Commercial Real Estate to Multifamily, published by ULI in 2023, examined key factors that led to the successful conversion of 24 commercial buildings across the United States into multifamily housing. In this 2025 overlay study, Built Buildings Lab, with Architecture 2030 and ULI, expands upon previous findings to estimate the embodied, operational, and whole life carbon impacts of each of these 24 cases using Architecture 2030's CARE Tool. The team analyzes four of these buildings further to provide insight into leveraging regulatory and design drivers to minimize whole life carbon impacts of conversion projects as early as the planning phase.

Real estate developers, investors, policymakers, and city planners can use the evidence presented in this report to align investment strategies with climate goals. This report provides a data-driven foundation for understanding the carbon implications of commercial-to-residential conversions and offers guidance for integrating carbon-reduction strategies into early-stage project planning.

Through thoughtful planning and design, commercial-to-residential conversions can deliver measurable carbon emissions reductions compared to either new construction or maintenance of commercial use, while simultaneously revitalizing underutilized buildings.

Estimating the whole life carbon of 24 projects demonstrates the following effects of commercial-to-residential conversions:

- **Reducing embodied carbon:** On average, commercial-to-residential projects cut embodied carbon by an estimated 62 percent compared to new construction. Even structurally intensive conversions will outperform new builds in most instances.
- **Reducing whole life carbon:** Over a 15-year time horizon, conversions consistently outperform new construction in whole life carbon impact.
- **Challenging new construction norms of embodied carbon sources:** Mechanical, electrical, and plumbing (MEP) systems and interiors are estimated as the largest embodied carbon contributors—the inverse of new construction, where structural systems and envelope systems typically represent the majority of embodied carbon impacts.
- **Future-proofing against new climate policies:** Commercial-to-residential conversions offer an opportunity to anticipate and design for emerging energy codes and Building Performance Standards on operational and embodied carbon, reducing future retrofit costs and avoiding stranded assets.

While commercial-to-residential conversions are not a viable solution for every commercial building or a complete solution to the housing crisis, they offer a low, whole life carbon approach to new housing using existing buildings of all types, ages, and scales. Embodied carbon benefits derive from building reuse by avoiding a portion of the carbon impacts associated with new materials, assemblies, and systems. Reduced operational carbon emissions are achieved through energy efficiency and renewable energy upgrades, as well as converting from more energy-intensive commercial to less energy-intensive residential use.

The Whole Life Carbon of Commercial-to-Residential Conversions: Aligning the Climate and Housing Imperative provides actionable strategies for reducing whole life carbon and uniting the city- and statewide grants, programs, and incentives tackling housing needs with community and climate neutrality commitments. City leaders and developers pursuing commercial-to-residential conversions embrace a key pathway for linking economic, environmental, and housing objectives.



INTRODUCTION

While the housing and climate crises are often viewed in opposition, the conversion of commercial buildings to residential use offers a strategy to address housing shortages and high office-vacancy rates, while simultaneously reducing carbon emissions. Office-to-residential real estate conversion projects are gaining momentum, supported by a growing number of city- and statewide policy-based grant programs, incentives, and zoning regulation amendments.

The Whole Life Carbon of Commercial-to-Residential Conversions: Aligning the Climate and Housing Imperative is a companion report to ULI's 2023 [*Behind the Facade: The Feasibility of Converting Commercial Real Estate to Multifamily*](#). Evaluating the potential whole life carbon savings of the 24 projects showcased in the 2023 report provides new data and findings to facilitate the integration of climate outcomes into planning, policy, and real estate decision-making for commercial-to-residential conversions.

By estimating the carbon impacts of 24 commercial-to-residential conversion projects, this report seeks the following goals:

- To understand the embodied, operational, and whole life carbon implications of commercial-to-multifamily real estate conversions
- To quantify how much carbon is avoided by conversion compared to the construction of new residential units per square foot and per residential unit created
- To identify the most important factors impacting whole life carbon outcomes when evaluating commercial-to-multifamily opportunities
- To propose decision-making processes and design strategies developers can employ to reduce the carbon footprint of conversions

This analysis builds upon a growing body of evidence studying the physical and economic aspects of conversions, overlaying an understanding of the carbon outcomes of conversions for buildings of various types, ages, and scales across the United States. It illustrates how climate impact information can be a decision-making factor in adaptive reuse projects, providing developers with guidance on achieving the best decarbonization outcomes and informing the development of future policies and financial incentives.

Background

The COVID-19 pandemic left a [notable mark on commercial real estate markets](#), leading to reduced demand for class B/C office buildings and retail spaces. As it became clear that occupancy rates would not return to pre-pandemic levels, the industry faced challenging questions about what to do with a growing stock of underutilized or obsolete buildings.

In 2023, ULI, with support from the National Multifamily Housing Council (NMHC) Research Foundation, published *Behind the Facade: The Feasibility of Converting Commercial Real Estate to Multifamily*. It featured detailed profiles of 24 successful projects from across the United States, exploring the financial, spatial, and market factors that contributed to each project's viability. The report further identified key factors to accelerate future commercial-to-residential conversions, including zoning, the availability of buildings for acquisition, and the strength of the multifamily market.

Likewise, in 2023, the engineering and sustainability firm Arup published *Office to Residential Conversions: The Carbon Story*, offering an in-depth assessment of 12 mid- to high-rise building typologies in New York City constructed between the 1960s and 1980s. Arup's study examined neighborhood-scale carbon implications of local housing and climate regulations, finding that creating housing through office

conversions would yield a total carbon reduction of 49 percent by 2030 and 54 percent by 2050. While the results of Arup’s report are specific to one area of New York City and a subset of office building typologies, they illustrate the potential carbon benefits of conversions and highlight the critical importance of quantifying carbon outcomes to inform policies driving development.

Both 2023 reports coincided with a rapid increase in office-to-residential conversions in the United States, as seen in figure 1 from

CBRE. [CBRE](#) found that conversions have supplied 28,000 units since 2016, with another 38,000 planned as of November of 2024.

This growing trend, propelled by ongoing office vacancies and housing shortages, also reflects an increase in policies aimed at lowering economic barriers to conversions. By the end of 2024, [CommercialEdge](#) reported 12 U.S. cities offering incentives such as fast-tracked permitting, tax abatement, and relaxed zoning requirements to support conversions.

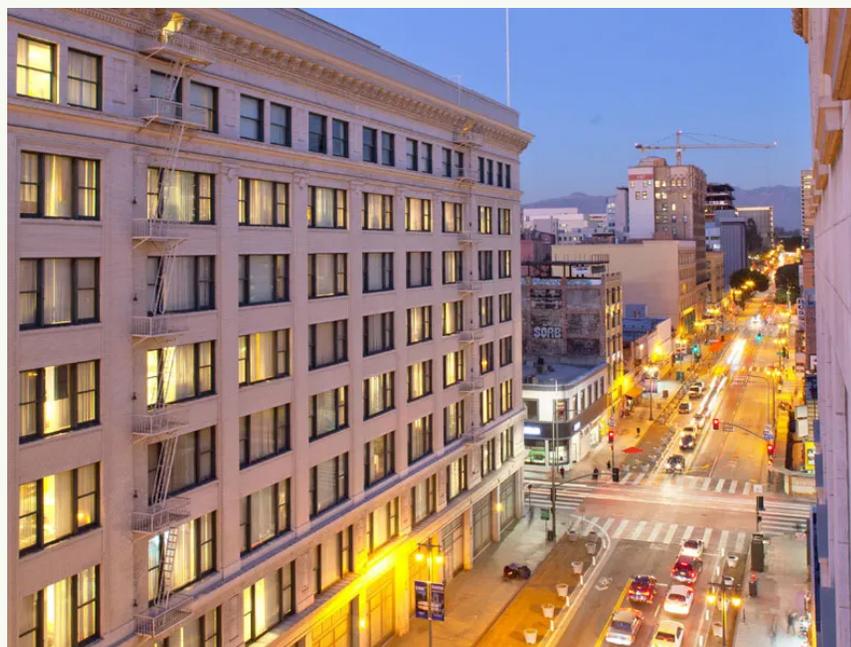
Office Conversions by Construction Status and Estimated Year of Completion



Figure 1. Office conversions by construction status and estimated year of completion. Totals include only conversion projects (excluding demolitions). Source: CBRE Research, Q3 2024.

The 24 conversion projects assessed in this study represent 14 state and 18 city jurisdictions. Between 2023 and 2025, lawmakers in eight of 14 state jurisdictions considered conversion-supporting policies, with four states passing, two failing to pass, and two continuing to review policy into summer 2025. A similar scan of city-level commercial-to-residential conversion activities between 2023 and 2025 revealed

community members, practitioners, developers, and policymakers building capacity through pilot projects, programs, studies, and symposiums. Four of 18 city jurisdictions passed measures to incentivize commercial-to-residential conversions; all but four of these cities plan to achieve carbon neutrality by 2050 at the latest.



Broadway Lofts. (ICO Group)

Bold Green = Commercial-to-Residential Conversion Supporting Legislation Passed between 2023 and 2025

Bold Yellow = Commercial-to-Residential Conversion Supporting Legislation in Review

Bold Blue = Commercial-to-Residential Conversion Supporting Legislation not passed

* City plans to achieve carbon neutrality by 2050 at the latest.

The commercial-to-residential conversion study includes 24 projects representing 19 cities and 14 states. A scan of city- and statewide commercial-to-residential conversion grants, programs, and legislation between 2023 and 2025 reveals an emerging policy landscape.

Projects Analyzed for This Report

| Project Name | State | City |
|--------------------------------|---------------------|------------------------|
| Watermark | - | Washington, DC* |
| The Foundry | Virginia | Alexandria* |
| Park + Ford | Virginia | Alexandria* |
| The Octave | Maryland | Silver Spring* |
| Mission Lofts | Virginia | Falls Church* |
| The Oronoco | Virginia | Alexandria* |
| 225 Baronne | Louisiana | New Orleans* |
| Mayflower Apartments | Texas | Dallas* |
| Six at Park | Missouri | Parkville |
| 508 West Apartments | Washington | Spokane* |
| Cityplace | Pennsylvania | Allentown |
| Stumpf Flats | Virginia | Richmond* |
| 22 Light Street | Maryland | Baltimore* |
| Broadway Lofts | California | Los Angeles* |
| Lofts @ Centennial Yards South | Georgia | Atlanta |
| The Wray | - | Washington, DC* |
| Equitable Building | Iowa | Des Moines* |
| The Barnett | Florida | Jacksonville* |
| R&T Lofts | Iowa | Des Moines* |
| Gadsden Place | South Carolina | Columbia |
| The Assembly | Indiana | Indianapolis* |
| The Tyler | Connecticut | New Haven* |
| Cecil Hotel | California | Los Angeles* |
| Singer Building | California | Los Angeles* |

Conversion Profiles

Watermark



Top, after conversion. Bottom, interior view after conversion. (Helen Kozak Photography)

The Foundry



Top, after conversion. Bottom, before conversion. (Perseus TDC)

Park + Ford



Top, after conversion. Bottom, before conversion. (Kip Dawkins Photography)

The Octave



Top, after conversion. Bottom, before conversion. (Promark Partners)

Mission Lofts



Top, after conversion. Bottom, before conversion. (David Madison Photography)

The Oronoco



Top, after conversion. Bottom, before conversion. (Thomas Arledge)

225 Baronne



Top, after conversion. Bottom, view of rooftop. (HRI Properties LLC)

Mayflower Apartments



Top, view from street. Bottom, bird's-eye view after conversion. (HRI Properties LLC)

Six at Park



Top, after conversion. Bottom, during conversion. (Fouch Brothers LLC)

508 West Apartments



Top, during conversion. Bottom, during conversion. (Brumback Real Estate)

22 Light Street



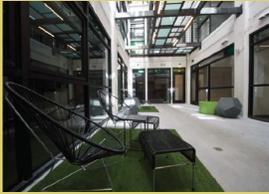
Top, after conversion. Bottom, interior unit after conversion. (West Photography and Osprey Property Company)

The Tyler



Top, rendering of exterior after conversion. Bottom, interior lobby after conversion. (Gregg Shupe, Shupe Studios)

Broadway Lofts



Top, exterior. Bottom, interior with skylight. (ICO Group)

Lofts @ Centennial Yards South



Top, south rendering of exterior. Bottom, interior unit after conversion. (CIM Group)

The Wray



Top, after conversion. Bottom, interior during conversion. (Insight Property Group)

Equitable Building



Top, during conversion. Bottom, interior unit after conversion. (Fouch Brothers LLC)

The Barnett



Top, exterior. Bottom, interior after conversion. (Sue Root Barker)

R&T Lofts



Top, exterior after conversion. Bottom, interior of unit kitchen after conversion. (TWG Development)

Gadsden Place



Top, kitchen after conversion. Bottom, exterior after conversion. (Gavin Design Group)

The Assembly



Top, exterior after conversion. Bottom, before conversion. (TWG Development/Indiana Landmarks)

Singer Building



Exterior after conversion. (Parker Brown, courtesy of Charles LeNoir)

Cityplace



Rendering of exterior. (HRI Properties LLC)

Cecil Hotel



Interior of the former Cecil Hotel, now the Stay on Main Hotel. (Agoda Stay on Main Hotel)

Stumpf Flats



Exterior. (Stumpf Flats)

Estimating Whole Life Carbon and Why It Matters



Carbon emission estimates associated with commercial-to-residential conversions can be purposefully leveraged as a decarbonization strategy by real estate developers, investors, planners, and policymakers.

To assess the carbon impacts of conversion projects, greenhouse gas (GHG) emissions of real-world commercial-to-residential conversions are estimated in units of [carbon dioxide equivalent](#) (CO₂e). This metric is used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). The terms carbon and carbon footprint are used interchangeably to describe the CO₂e from a material, assembly, or building.

The carbon emissions from conversions, and the pathways for reducing them, are better understood by breaking them down based on when, over the course of the building's life, they occur. [Embodied carbon](#)—the GHG emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building and infrastructure materials—offers a critical carbon benefit for conversions compared to new construction. By reusing portions of the pre-existing commercial building, new housing units can be created with far fewer new materials, and a far lower embodied carbon associated with manufacturing, transportation, and installation of those materials.

However, embodied carbon is only one piece of the equation. [Operational carbon](#)—emissions generated by fuel consumption for heating/cooling, supplying fresh water, ventilation, and power over the course of a building's lifetime—has historically been the focus of built environment

decarbonization efforts. These emissions can also represent the majority of a conversion's carbon footprint, particularly relative to their low embodied carbon. The point of conversion from commercial to residential use is an opportunity to implement energy efficiency measures, electrification, and renewables needed to reduce these emissions.

Ultimately, the goal is to reduce [whole life carbon](#): the combined total of embodied and operational emissions over the whole life cycle of a building. For commercial-to-residential conversion projects, this is achieved by using a low-embodied carbon approach to conversion, balanced with major reductions to the operational emissions of the pre-existing buildings. Note that this study estimates whole life carbon as the sum of GWP impacts across [life cycle stages](#) A1–A3 (product stage) and B6 (operational energy).

The carbon estimation method (described more in the [Carbon Estimation Approach](#) section) is used to evaluate the potential embodied, operational, and whole life carbon of converting commercial properties to residential use. Applicable in any U.S. location, for buildings of all ages, scales, and sizes, this estimation method applies to early project planning phases. It provides real estate developers, investors, planners, and other stakeholders with the carbon information needed to make high-impact decisions to minimize carbon emissions and investment cost while maximizing housing outcomes.

Navigating This Report

For decision-makers seeking to understand the high-level findings and their implications, read the [Actionable Guidance: Implementing Low-Carbon Conversions](#) and [Conclusion](#) sections. These sections suggest decision-making processes to evaluate and reduce whole life carbon in commercial-to-residential conversions and offer key findings to situate this redevelopment approach as a tool for achieving climate goals while supporting the creation of new housing and reactivation of underutilized commercial assets.

For real estate developers and design and construction professionals, read through the [Embodied, Operational, and Whole Life Carbon Outcomes](#) section to gain a full picture of the life cycle carbon impacts

of commercial-to-residential conversions. The section provides a detailed understanding of the factors contributing to embodied, operational, and whole life carbon impacts, which can inform future approaches to low-carbon conversion projects. [Understanding Decarbonization Drivers](#) further explores external drivers, such as codes and utility grids that affect conversion projects, support assessment of when conversion is the right approach for an existing commercial building, and show how developers can position themselves for the lowest-carbon outcomes from the outset.

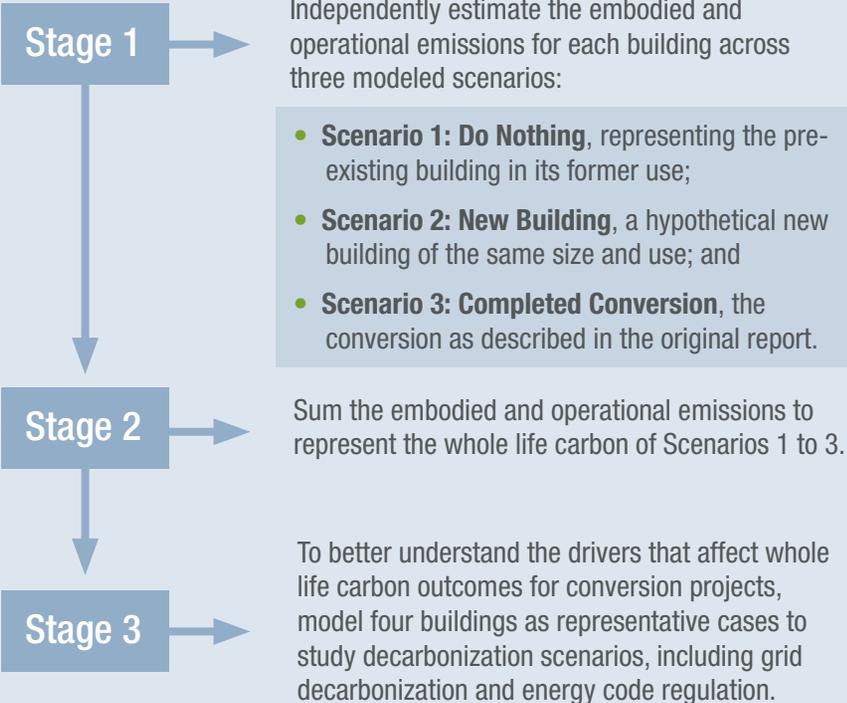
For decarbonization experts and those who ask “how,” start with the [Carbon Estimation Approach](#) section for an explanation of the analysis approach. The [Appendixes](#) provide detailed reference information for the analysis assumptions.



CARBON ESTIMATION APPROACH

To estimate the whole life carbon impacts of the 24 adaptive reuse cases previously featured in *Behind the Facade*, Architecture 2030's CARE (Carbon Avoided Retrofit Estimator) Tool provides the underlying data and calculation. Equivalent new construction alternatives and hypothetical decarbonization scenarios enable a comparative lens to understand the conversion approach taken for each project. The analysis results are high-level embodied and operational carbon emission approximations of each project, indicating general findings that can guide decision-making and broadly assess the whole life carbon impacts of commercial-to-residential conversions.

Carbon of commercial-to-residential conversions is assessed in three stages:



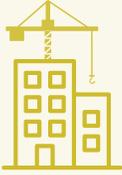
CARE Tool

Architecture 2030's [CARE Tool](#) estimates and compares the embodied, operational, and avoided carbon impacts and benefits of reusing and upgrading existing buildings or replacing them with new construction. Policymakers, planners, building owners, developers, heritage building officers, architects, and others use the CARE Tool for pre- or early-design, high-level assessments of total carbon emissions associated with building reuse versus replacement.

The CARE Tool aggregates data from a number of government, scientific, and industry sources to estimate operational and embodied carbon emissions. It includes life cycle stages A1–A3 (product stage) and B6 (operational energy) and structural, enclosure, interior, and mechanical, electrical, and plumbing scope in its estimations. A full description of the CARE Tool's [data and calculation methods](#) can be found on the tool's website.

Using Project Descriptions to Estimate Whole Life Carbon

The narrative descriptions and project data published in *Behind the Facade* provide the basis for estimating embodied and operational carbon. Embodied carbon inputs are interpreted from descriptions of each building's pre-existing condition, size, and number of floors, and the approaches used in converting it to residential use. Photography of the pre- and post-renovated conditions provided additional information about the extent of facade intervention and new additions. Operational carbon emission analysis inputs are based on the project location and pre- and post-conversion building sizes and uses. A summary of assumptions is shown on the following pages.



Embodied Carbon

Embodied carbon of conversion is calculated based on each project's approach to **structure, envelope, interiors, and MEP systems**, while embodied carbon of **new construction** (for additions associated with conversion and new buildings) is based on industry benchmark data.

- Structure:
 - The primary structural type (e.g., concrete frame, timber and masonry hybrid) degree of structural intervention required for conversion are interpreted from narrative descriptions.
 - Structural embodied carbon is estimated as the percentage of the structural system that is substantially repaired or replaced multiplied by the embodied carbon intensity of a new structure of the same type.
- Envelope:
 - The approach to building envelope (e.g., restoration, window replacement, overcladding) and the approximate window-to-wall ratio are derived from photography and narratives.
 - Envelope embodied carbon is estimated based on a carbon intensity of the envelope approach multiplied by the opaque and glazed facade areas.
- Interiors:
 - The analysis assumes complete interior replacement, including new partitions and finishes, is required to create residential units out of previously commercial space.
 - Historic spaces that were restored are not accounted for in the assessment, resulting in potential overestimation of embodied carbon for these minimal spaces.
 - Interiors embodied carbon is estimated based on a constant carbon intensity per square foot of finished floor area multiplied by the total area of the converted space.
- Mechanical, Electrical, and Plumbing Systems:
 - The analysis assumes complete MEP system replacement is required to create residential units out of previously commercial space.
 - MEP embodied carbon is estimated based on a carbon intensity per square foot of finished floor area that scales based on building size.
- Additions and New Construction:
 - All new construction, including additions constructed as part of conversion projects, is modeled as standard steel and concrete construction.
 - Embodied carbon of new floor area is based on a constant carbon intensity multiplied by the new construction floor area.



Operational Carbon

The operational emissions analysis explores fewer variables at the building level. Operational emissions and pathways for reducing them are well established. Additionally, the data available for the case study buildings do not indicate energy efficiency, electrification, or renewable energy, so this assessment uses industry averages and local energy code requirements.

Operational emissions are derived from the predicted energy consumption of each building before and after conversion based on the following inputs.

- Building Use:
 - Narratives and case study data described the pre-conversion uses and total building area.

- Energy Use:
 - Architecture 2030's Zero Tool and U.S. Environmental Protection Agency (EPA) data were used to estimate the pre-conversion energy use intensity (EUI) of each building based on its uses.
 - Post-conversion energy use reflects the energy code of each building's jurisdiction.
- Emissions Factors:
 - EPA and CAMBIUM data were used to predict electricity, gas, and total operational emissions for each building, now and under future grid conditions.
 - Electricity grid emissions were calculated by project location.

See [Appendix A](#) for a detailed description of input assumptions related to both embodied and operational emissions.

Limitations of This Approach

This carbon estimation study is limited by the following factors.

Assessment based on interpretation of previously published cases does not represent detailed materials inventories, life cycle assessments, or energy models of the modeled buildings. The analysis in this study is based on information provided by building owners for the *Behind the Facade* report. Building owners, design teams, or other project contacts were not interviewed for this report.

Carbon estimations are based on benchmark data and a broad set of assumptions made about each building. Given the uncertainty of the assessment, the outcomes should be considered representative or directional rather than precise analytical results. However, the consistent outcomes and trends observed from the data reinforce the analysis findings, even if the results for each building are not exact.

Biased selection of case studies conversions can result in a high embodied carbon intensity if most of the structural systems are replaced, if the majority of the square footage is new construction, or due to other potential factors. It is likely that because the *Behind the Facade* report highlighted cost-effective projects, this set of buildings is pre-filtered to exclude these high-carbon edge cases.

Whole life carbon emissions are assessed over a short 15-year window, as opposed to a full life cycle of 60 years often modeled. This modeled timeframe emphasizes embodied carbon and near-term operational emissions. Modeling the same buildings over a longer timeframe would result in a higher proportion of operational emissions.

EMBODIED, OPERATIONAL, AND WHOLE LIFE CARBON OUTCOMES



The outcomes of stages 1 and 2 of the assessment illustrate the embodied, operational, and whole life outcomes of the 24 study projects. Embodied carbon outcomes explore the environmental impact of the materials and assemblies added to existing buildings to convert them from commercial to multifamily residential use. Operational carbon outcomes illustrate how change of use, improvements to energy efficiency, and local utilities impact the emissions associated with use of converted buildings over time. Whole life carbon impacts over a 15-year time horizon demonstrate the relative impacts of embodied versus operational emissions for commercial-to-residential conversions and project the potential reductions that can be achieved using this development approach.

Interpreting Embodied Carbon Estimates

The embodied carbon estimation for each of the 24 commercial-to-residential conversions and a hypothetical new construction replacement of each conversion allow several scales of interpretation. At a high level, the outcomes demonstrate the potential magnitude of embodied carbon avoided by creating housing through the conversion compared to new construction. A closer look at the data reveals more nuanced outcomes illustrating the sources of embodied carbon in typical conversions and how different approaches to conversion may come with different embodied carbon “price tags” or results.



Embodied Carbon

Embodied carbon outcomes explore the environmental impact of the materials and assemblies added to existing buildings to convert them from commercial to multifamily residential use.



Operational Carbon

Operational carbon outcomes illustrate how change of use, improvements to energy efficiency, and local utilities impact the emissions associated with use of converted buildings over time.



Whole Life Carbon

Whole life carbon impacts over a 15-year time horizon demonstrate the relative impacts of embodied versus operational emissions for commercial-to-residential conversions and project the potential reductions that can be achieved using this development approach.

Embodied Carbon of Completed Conversion vs. New Building

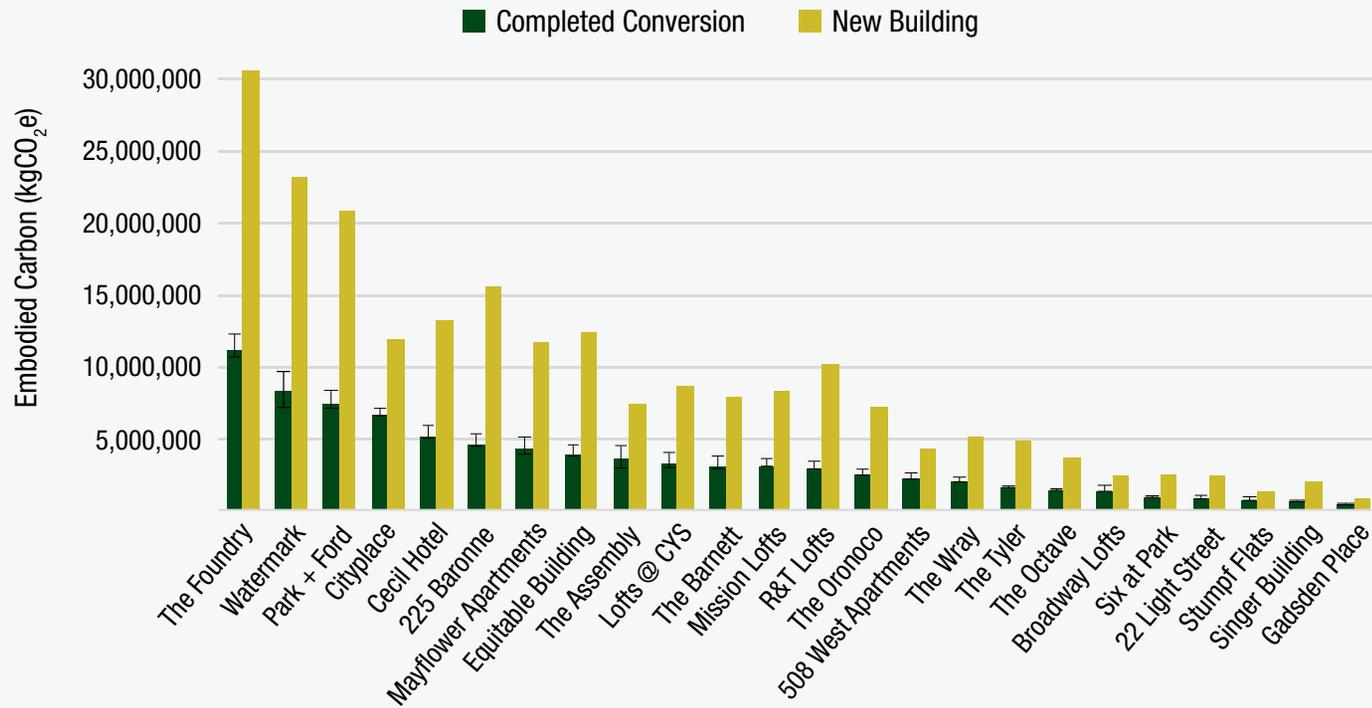


Figure 2: Converting each commercial case study building to residential use results in lower embodied carbon impact estimates when compared to a hypothetical new version of each case study building. The black whisker lines indicate the range of embodied carbon outcomes associated with the uncertainty of structural system modifications.



Commercial-to-Residential Conversions vs. New Construction

The first step of the embodied carbon assessment is to estimate the overall embodied carbon of each conversion project. The outcomes, illustrated in figure 2, demonstrate that in each of the 24 cases, the embodied carbon of conversion was significantly lower than the embodied carbon of a replacement building of the same size and use.

The avoided embodied emissions of conversion compared to new construction ranged from an estimated 39 to 72 percent reduction below new construction, with an average reduction of 62 percent. This finding aligns with the previously cited [Arup report](#), which found an average 61 percent reduction in embodied carbon.

Embodied Carbon Intensity of Completed Conversions

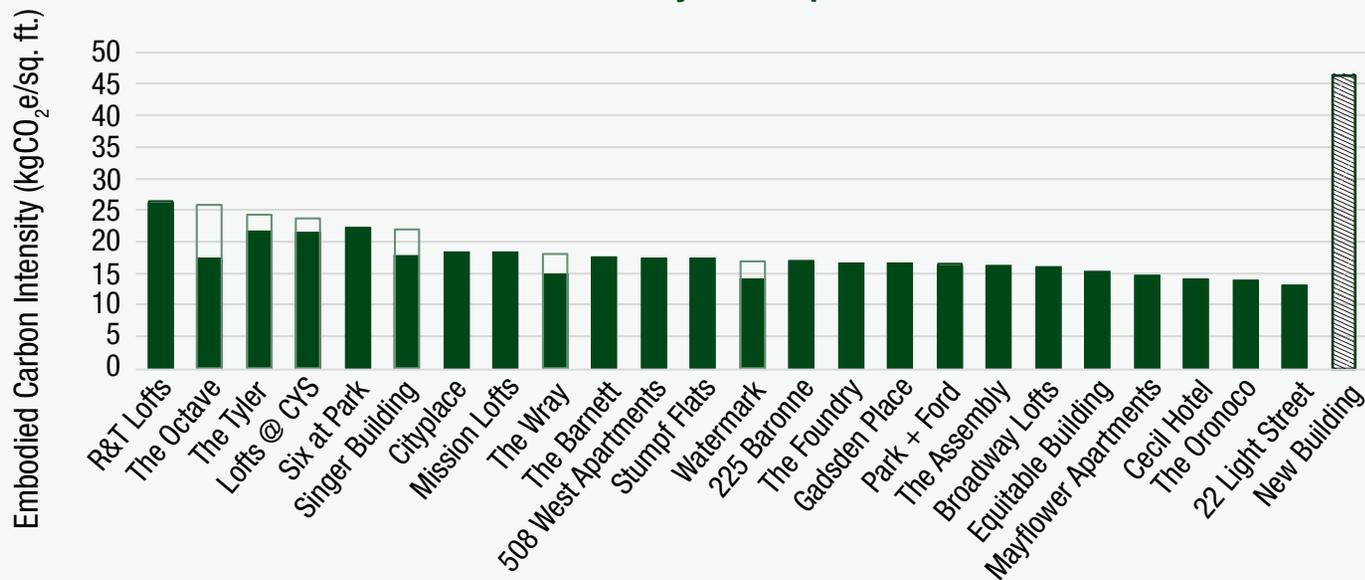


Figure 3: Graph illustrating the embodied carbon per unit area for each project, in descending order. The solid filled area represents the intensity of only the renovation aspect of each project, while the outlined areas include additions.



Embodied Carbon Intensity

Embodied carbon intensity, or embodied carbon per unit of floor area, is calculated for each building (see figure 3), allowing for a comparison across the projects, regardless of their size. The embodied carbon intensity ranges from 13 to 26 kgCO₂e per square foot, as compared with an average of approximately 47 kgCO₂e per square foot assumed for typical new construction. This range illustrates that while converting commercial buildings to residential use lowers embodied carbon compared to new construction, the architectural approach matters. The outlined bars indicate how much embodied carbon is due to additions constructed to increase the number and/or size of units created. Even absent additions, this chart illustrates that the most intensive

renovations have nearly twice the embodied carbon footprint of the least intensive examples.

Embodied carbon per residential unit created is an alternative approach to evaluating embodied carbon intensity through a lens of housing creation. Based on these 24 buildings, the embodied carbon released to create a single residential unit through conversion ranged from about 9,000 kgCO₂ per unit up to approximately 40,000 kgCO₂ per unit, with a single outlier as high as 100,000 kgCO₂ per unit. While this metric provides a potentially useful pathway to integrate carbon and housing outcomes when planning for conversion projects, variables such as unit size and number of occupants per unit are both important to consider.

Embodied Carbon Intensity of Conversion (w/out Addition)

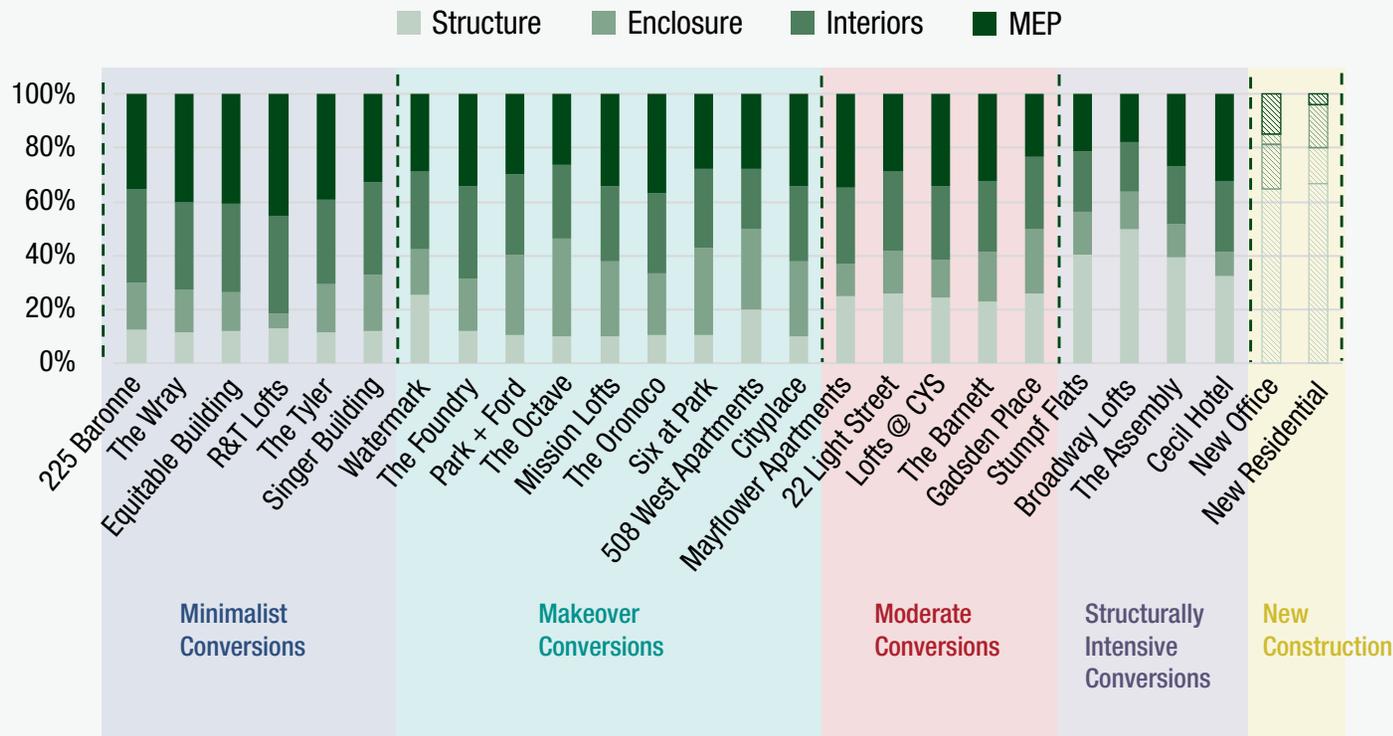


Figure 4: Percentage of estimated embodied carbon impacts resulting from structure, enclosure, interiors, and MEP systems for each building. Breakdowns for new office and residential buildings are included as a point of comparison. Projects are grouped by embodied carbon typologies that emerge based on the relationship between the architectural approach to conversion and the associated distribution of embodied carbon.

To better understand the variables driving embodied carbon intensity, the results are further differentiated by the carbon footprint by sub-category of project scope. Figure 4 explores the relative embodied carbon intensity of the structural, envelope, interiors, and MEP scope for each individual building, while figure 5 explores the aggregated impacts of each system across the set of buildings. The distribution of embodied carbon impacts per system based on these cases are the inverse of those for typical new construction, with structural systems typically responsible for the lowest embodied carbon footprint, followed by envelope, interiors, and MEP systems.

MEP systems on average represent the highest embodied carbon footprint, between 4 and 6 kgCO₂e per square foot. This translates to 18 to 45 percent of each building's total embodied carbon. The absolute value of these impacts are relatively consistent due to the assumption that all new systems are required for these conversion projects. This number may be reduced for projects that are able to reuse components of the pre-existing MEP systems.*

* It is worth noting that the CARE Tool uses data from the Carbon Leadership Forum (CLF) 2020 study [LCA of MEP and TI in Buildings](#). *The Beginners Guide to Embodied Carbon in MEP* published by MEP 2040 and the CLF in 2025 indicates that the product stage embodied carbon of systems may be up to twice as high as previously assumed. Based on this new data, the embodied carbon of MEP systems included in this report is a conservatively low estimate.

Average Embodied Carbon Intensity by System

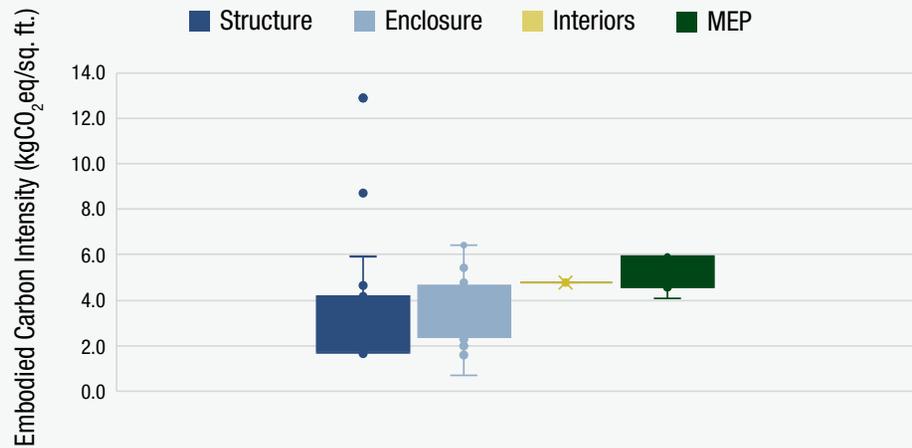


Figure 5: A box plot of embodied carbon of each system across the case study projects illustrates the average embodied carbon of each system and the potential variation. MEP systems and interiors tend to represent a high proportion of embodied carbon, but structure, while often the lowest contributor to embodied carbon, can have the highest impacts depending on the conversion approach.



New interior construction in all scenarios results in a constant embodied carbon intensity of just under 5 kgCO₂e per square foot. This represents 18 to 35 percent of total embodied carbon in these projects.

Building envelope upgrades have a higher range of embodied carbon intensity. While most projects cluster between 2.5 and 4.5 kgCO₂e per square foot, there are outliers in each direction. On the low end, projects that require minimal repair or allow minimal upgrade due to historic preservation considerations may have an embodied carbon intensity of less than 1 kgCO₂e per square foot, while projects that require extensive exterior repair, energy upgrades, or new cladding have embodied carbon intensities of up to 6.5 kgCO₂e per square foot. Overall, envelope contributes between 5 and 30 percent of conversion embodied carbon.

Structural systems have the biggest range in embodied carbon. Where projects require minor structural alterations, the embodied carbon clusters between 2 and 4 kgCO₂e per square foot, which can represent as little as 10 percent of the total embodied carbon impacts. However, projects with more extensive structural work have a structural carbon intensity of 13 kgCO₂e per square foot, representing up to 50 percent of the overall embodied carbon impacts and potentially even more depending on the amount of new structure installed.

Guidance for reducing embodied carbon of conversions based on the potential embodied carbon by system is synthesized in [The Embodied Carbon Hierarchy](#) and [Minimizing Embodied Carbon](#) diagrams.

Understanding Conversion Typologies through Embodied Carbon Estimates

Four commercial-to-residential conversion typologies begin to emerge by estimating the percentage of embodied carbon impacts associated with the structural, envelope, interiors and MEP systems (see figure 4). These typologies can be useful for setting embodied carbon impact goals in early phase design, establishing expectations and design standards for the scope of conversion work.

- **Minimalist Conversions:** Light-touch conversions with minimal structural and envelope scope
- **Makeover Conversions:** Conversions that replace or overlaid the facade for a new look and improved thermal performance
- **Moderate Conversions:** Projects that require floorplate manipulation (e.g., light well insertions) to accommodate the change to multifamily use
- **Structurally Intensive Conversions:** Conversions requiring substantial structural remediation, strengthening, or reconfiguration

Minimalist Conversions: See figure 6. These projects have the lowest embodied carbon footprint. They restore and upgrade the original building envelope and require relatively light structural upgrades to accomplish the change in use. Their embodied carbon footprint is less than 15 kgCO₂e per square foot, and MEP and interiors are the primary sources of embodied carbon (60 percent or more).

Makeover Conversions: See figure 7. These projects re-clad or overlaid the existing commercial building, reusing the buildings' structural systems and replacing nearly everything else. The embodied carbon intensity of makeover conversions is estimated to range from 14 to 16 kgCO₂e per square foot with one outlier of more than 20 kgCO₂e per square foot. In these cases, the building envelope contributes up to one-third or more of the embodied carbon footprint.

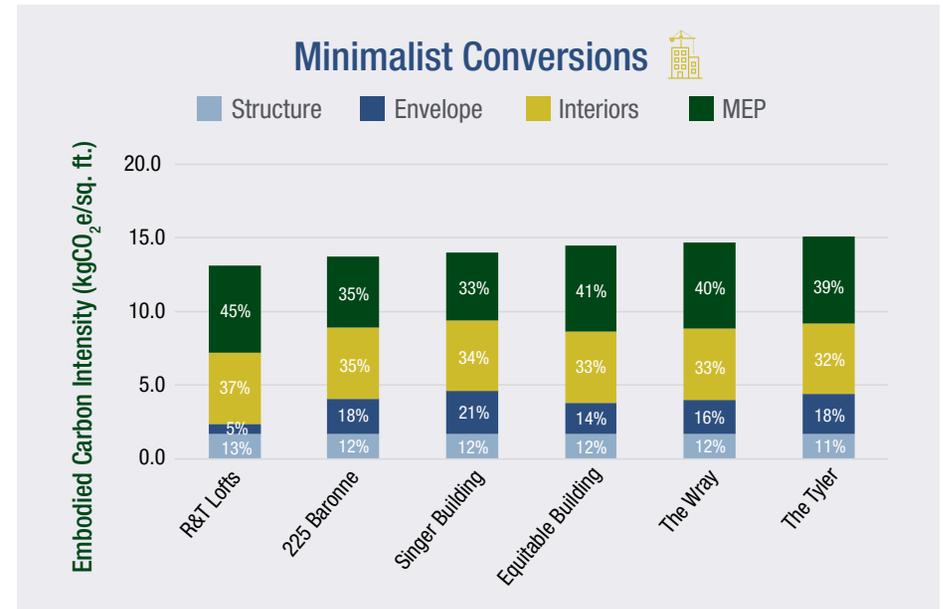


Figure 6: Minimalist conversions are light-touch projects with embodied carbon emissions resulting primarily from new interiors and MEP systems needed to create residential units from commercial buildings.

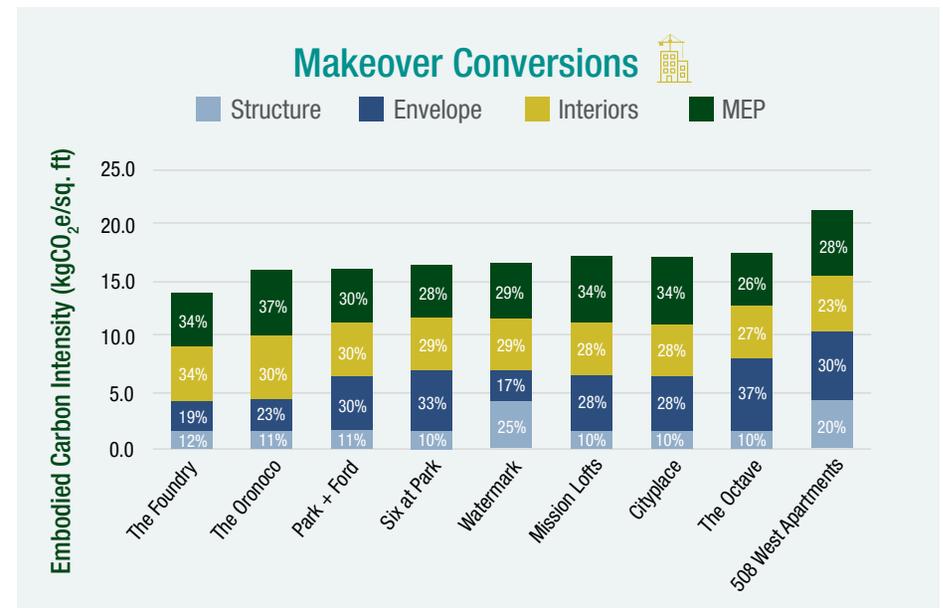


Figure 7: Makeover conversions apply a new facade to existing buildings, resulting in a higher proportion of embodied carbon from the building envelope.

Moderate Conversions: See figure 8. These projects require slightly more structural work than minimalist conversions. For example, they may include the insertion of new courtyards to break up a deep commercial floor plate and bring more natural light to residential units. The embodied carbon intensity of this subset ranges from approximately 15 to 18 kgCO₂e per square foot. While this range is similar to that in the makeover conversions category, moderate conversions have greater embodied carbon impacts from structural rather than envelope systems.

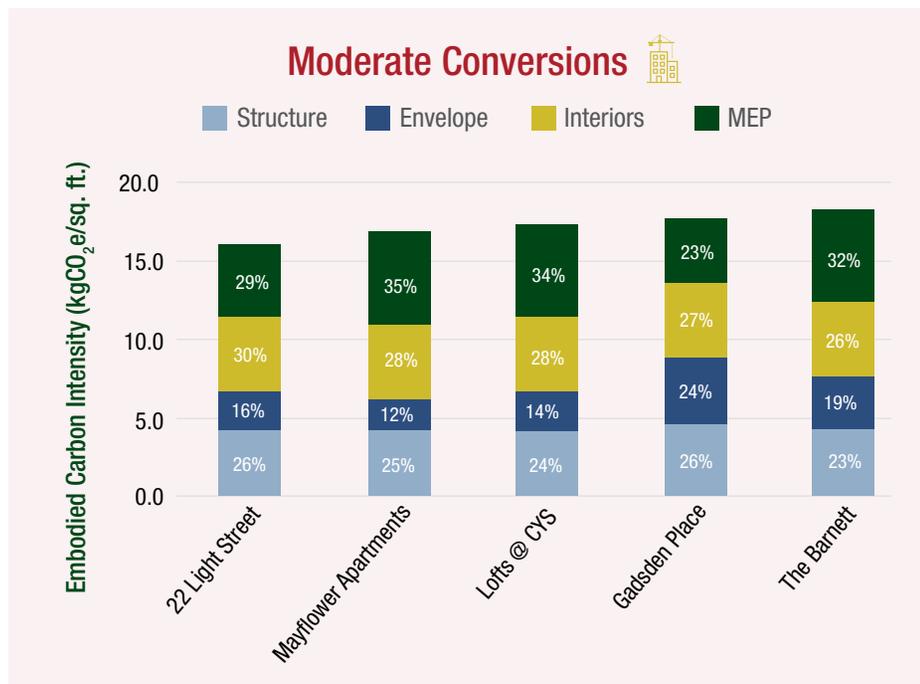


Figure 8: Moderate conversions require a deeper structural intervention compared to minimalist conversions, resulting in embodied carbon similar to the makeover conversion typology.

Structurally Intensive Conversions: See figure 9. These projects require a greater degree of structural work, whether due to the poor physical condition of the original building, the need for seismic upgrades, or a more dramatic reconfiguration of the original layout (upgrades not necessarily tied to a change to residential use). Structural work in these projects contributes between one-third and one-half of the total embodied carbon (up to 60 percent using the high-range estimates). Because structural systems represent the highest source of embodied carbon in new construction, the degree of structural intensity is the one factor that has the greatest potential to drive the embodied carbon of renovation closer to that of new construction.

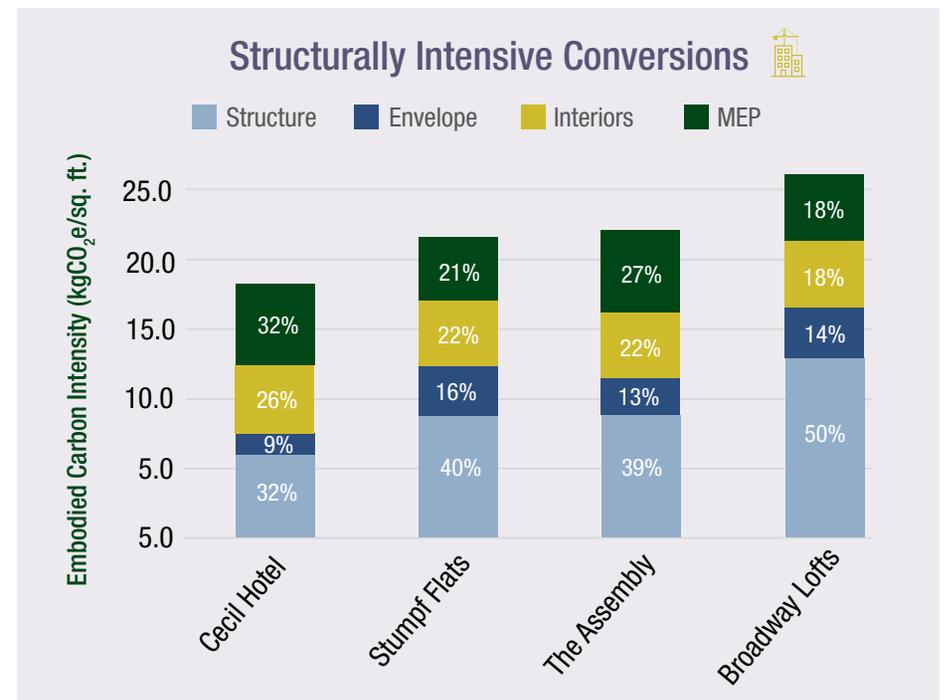


Figure 9: Structurally intensive conversions typically have the highest embodied carbon due to seismic retrofits, structural repairs, or extensive structural reconfiguration required for upgrade and conversion to residential use.

Interpreting Operational Carbon Estimates

The operational carbon estimates of commercial-to-residential conversion projects suggest that for all but one of the 24 buildings studied, the impacts associated with the Completed Conversion scenario were significantly lower than the impacts associated with the Do Nothing scenario (see figure 10). The Completed Conversion scenario results in operational emissions (excluding the outlier) ranging from an estimated 31 to 88 percent reduction below the Do Nothing

scenario, with an average reduction of 74 percent. This reduction reflects both improvements to energy efficiency and the fact that commercial uses typically have a higher energy use intensity than multifamily residential use.

The outlier, Gadsden Place, had a pre-conversion primary use type (Distribution Center) that was exceptionally low energy intensity in comparison to the post-conversion primary use type (Multifamily), resulting in an operational emissions increase of 57 percent.

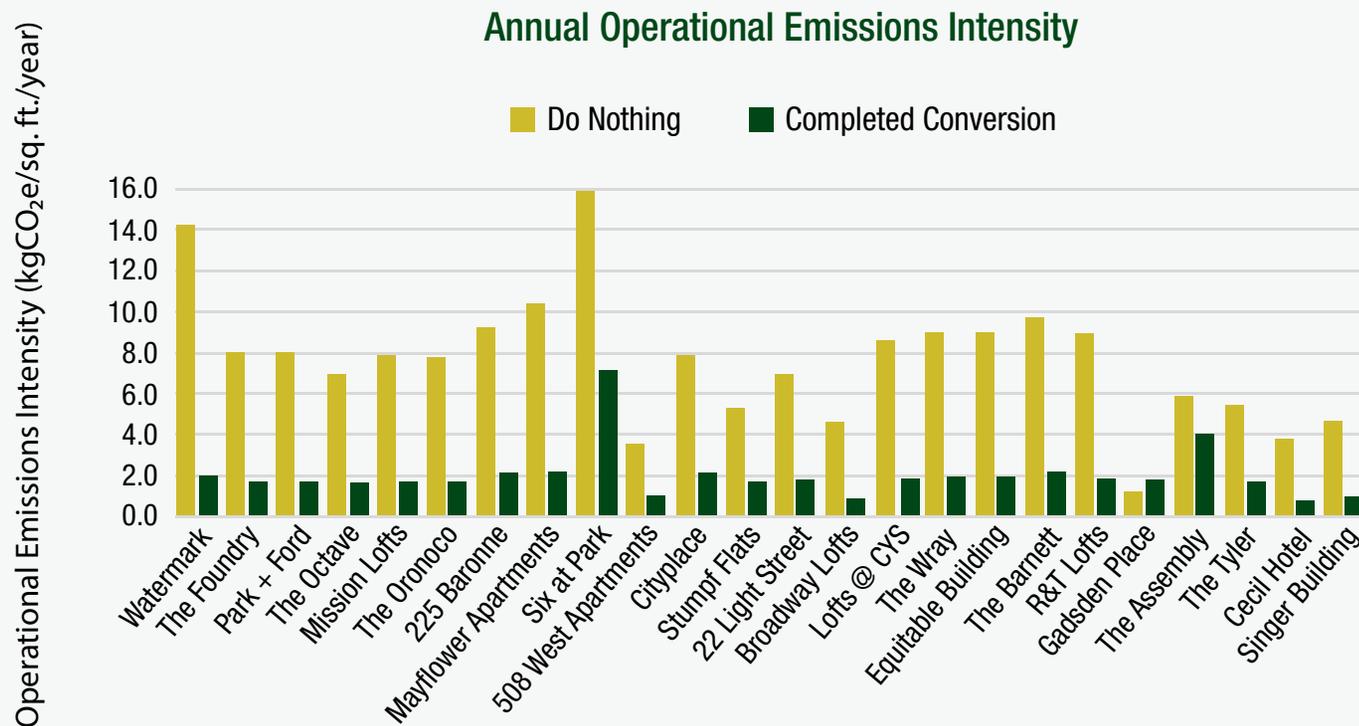


Figure 10: The operational emissions intensity pre- and post-conversion illustrates the reduction typically achieved through improved energy efficiency and the change to a lower intensity use.



Figure 11 visualizes each building's post-conversion emissions (Completed Conversion scenario) with its energy code [Zero Energy Performance Index \(zEPI\) score](#), sorted from highest zEPI score to lowest (the lower the score, the more stringent the code). This demonstrates the correlation between post-conversion operational

emissions and energy code stringency, highlighting the role of building energy codes in driving sectorwide emissions reductions and demonstrating how energy codes (e.g., ensuring a building meets national model energy code standards, whether required to or not) can be used to help meet energy efficiency targets.

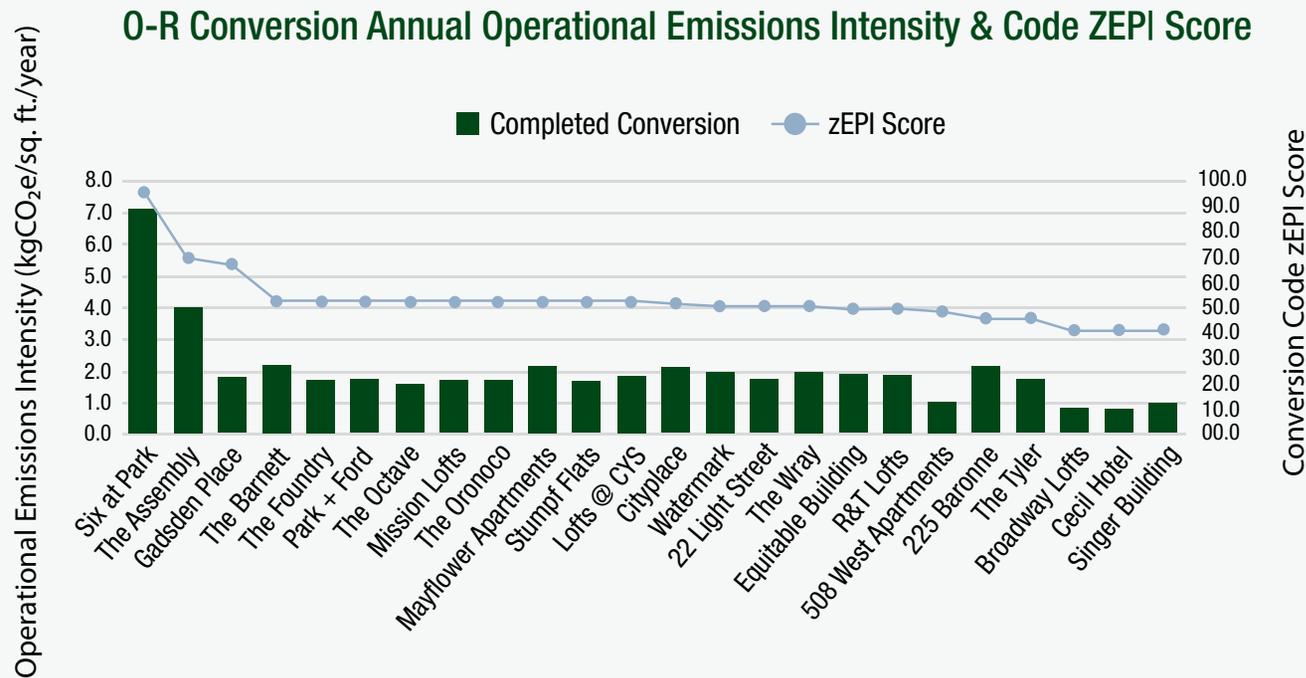


Figure 11: A plot of each building's operational emissions intensity compared to the zEPI score of the jurisdiction in which each project is located illustrates the correlation between energy codes and building performance.



In addition to energy efficiency improvements, operational emissions in the Do Nothing and Completed Conversion scenarios are driven by electricity grid intensity, as is demonstrated in figure 12, which shows a positive correlation between grid GHG emissions intensity and operational emissions. While regional grid emissions intensity is largely

outside of the control of developers, understanding local grid intensity can help drive emissions reduction decision-making. In localities with low-intensity grids, electrification is likely to be an impactful carbon reduction strategy in the near term.

Annual Operational Emissions Intensity and Grid Emissions Intensity

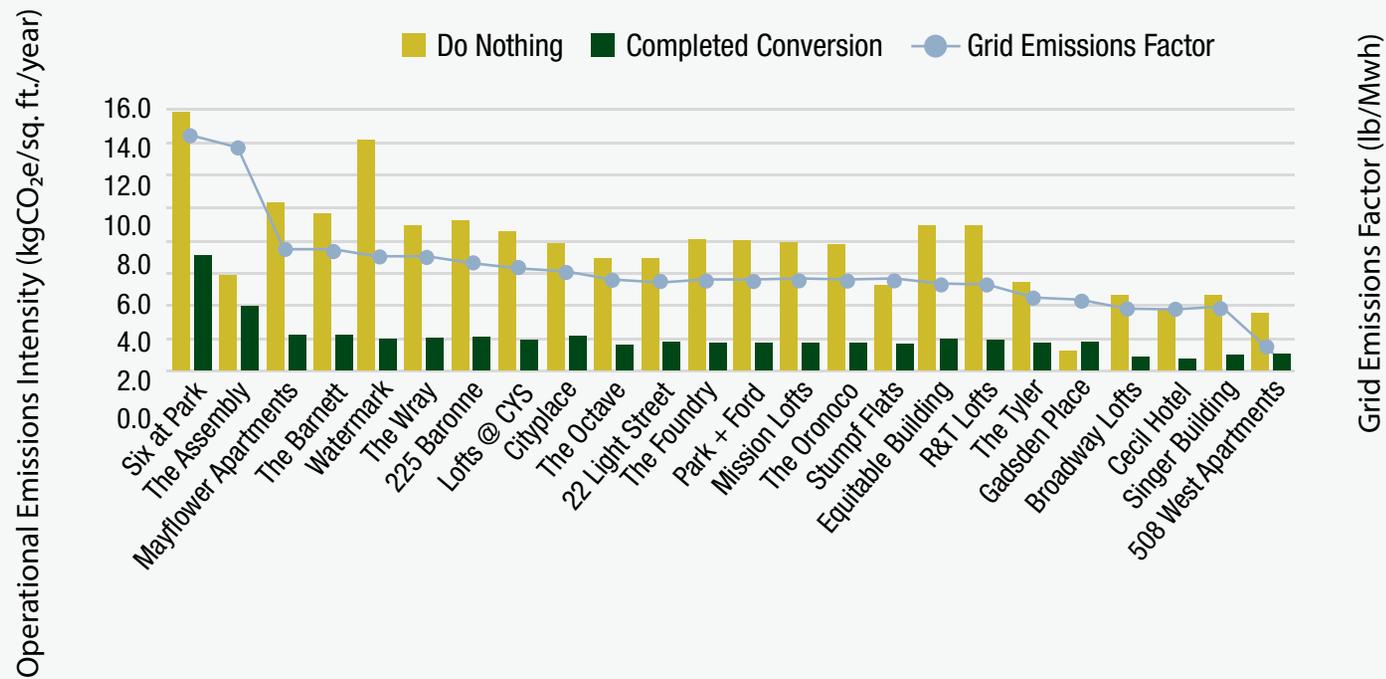


Figure 12: This graph overlays the operational emissions intensity of each building with the local electricity grid emissions factor, illustrating the correlation between grid emissions and building-level operational emissions.



Whole Life Carbon

Embodied and operational carbon emissions are combined for each building to estimate the whole life carbon footprint over a 15-year period (2025–2040) under the Do Nothing, New Building, and Completed Conversion scenarios. This assessment period allows comparison across the projects by modeling each conversion as occurring in the present year as opposed to in their varying years of construction. It also emphasizes the importance of the [time value of carbon](#) and the imperative to reach a [zero emissions built environment by 2040](#) to stay within established global carbon budgets.

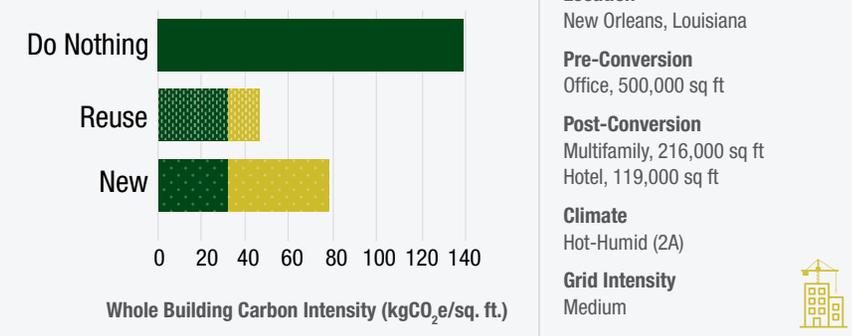
Whole life carbon outcomes for each building are illustrated in figures 13 through 16. These graphs highlight several findings:

- **If the reuse and new construction have the same operational emissions in compliance with a local building code or emissions target, the embodied emissions avoided through reuse will always make conversion a lower-carbon option.** For this reason, the minimalist conversions tend to have the best total carbon savings through reuse due to their lower upfront embodied emissions.
- **The relative contribution of embodied and operational emissions varies widely by building.** Whether attributed to the local grid intensity or the stringency of local energy codes, the lower the operational emissions, the more embodied emissions matter. Conversely, for buildings such as Six at Park (a makeover conversion) with high operational emissions, the embodied carbon saved through reuse represents a lower proportion of overall emissions.

Minimalist Conversions: 2025–2040

■ Operational Emissions ■ Embodied Emissions

225 Baronne



The Wray

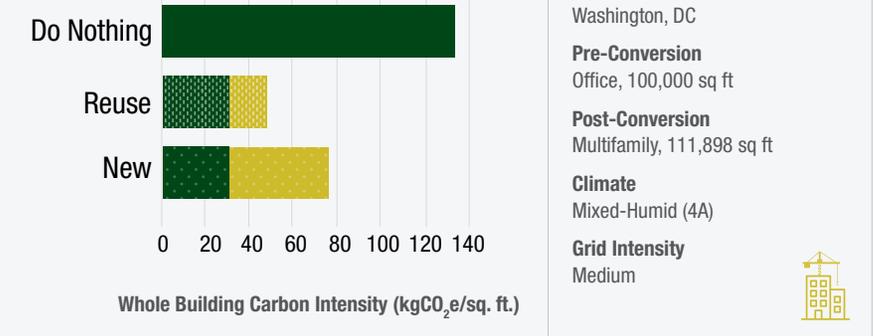
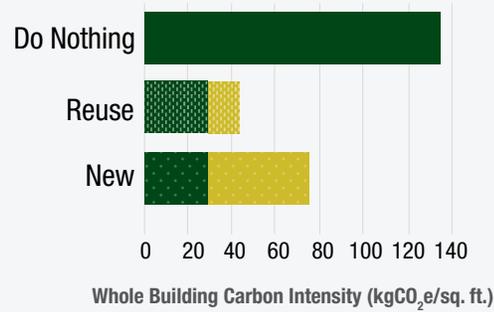


Figure 13: Whole life carbon of minimalist conversion projects. Minimalist conversions are light-touch projects with embodied carbon emissions resulting primarily from new interiors and MEP systems needed to create residential units from commercial buildings.

Figure 13, continued

Equitable Building



Location
Des Moines, Iowa

Pre-Conversion
Office, 267,000 sq ft

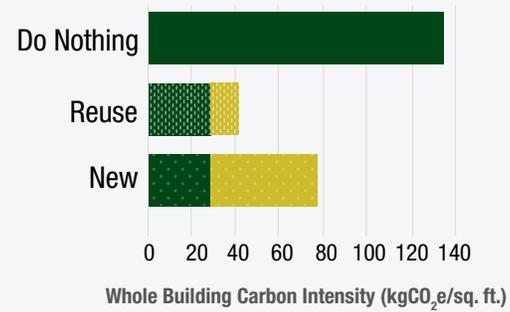
Post-Conversion
Multifamily, 239,000 sq ft
Office, 28,000 sq ft

Climate
Cold (5A)

Grid Intensity
Low



R&T Lofts



Location
Des Moines, Iowa

Pre-Conversion
Office, 220,000 sq ft

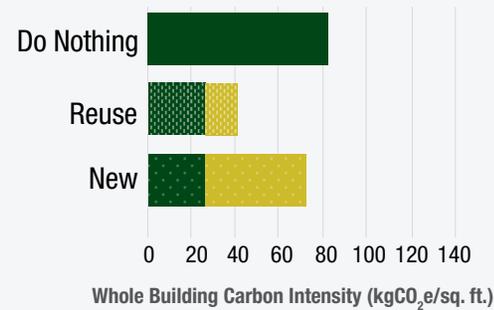
Post-Conversion
Multifamily, 197,041 sq ft
Retail, 14,580 sq ft

Climate
Cold (5A)

Grid Intensity
Low



The Tyler



Location
New Haven, Connecticut

Pre-Conversion
K-12 School, 144,000 sq ft

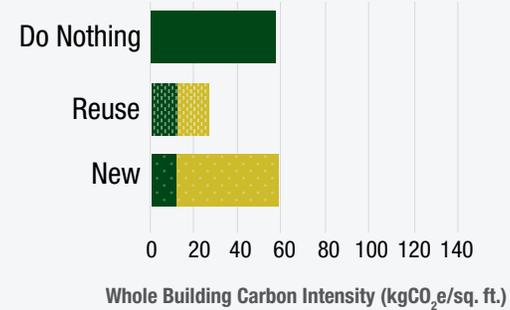
Post-Conversion
Multifamily, 104,000 sq ft

Climate
Cold (5A)

Grid Intensity
Low



Cecil Hotel



Location
Los Angeles, California

Pre-Conversion
Hotel, 285,000 sq ft

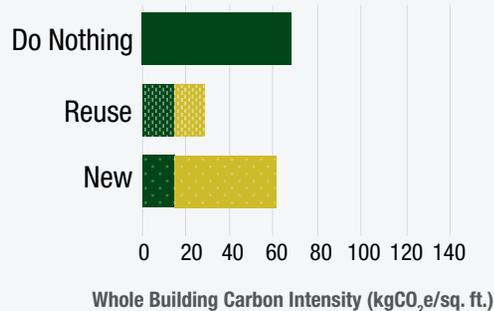
Post-Conversion
Multifamily, 285,000 sq ft

Climate
Hot-Dry (3B)

Grid Intensity
Low



Singer Building



Location
Los Angeles, California

Pre-Conversion
Office, 47,789 sq ft

Post-Conversion
Multifamily Housing, 34,967 sq ft
Retail Store, 8,748 sq ft

Climate
Hot-Dry (3B)

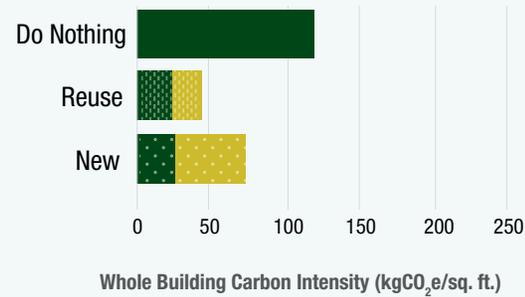
Grid Intensity
Low



Makeover Conversions: 2025–2040

■ Operational Emissions ■ Embodied Emissions

The Foundry



Location
Alexandria, Virginia

Pre-Conversion
Office, 660,000 sq ft

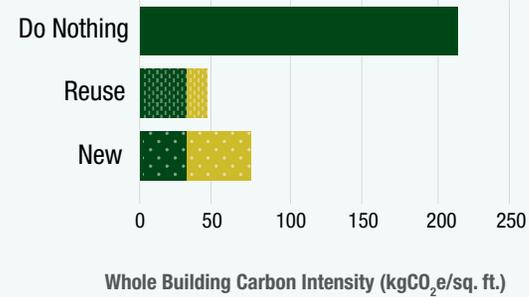
Post-Conversion
Multifamily, 635,000 sq ft
Retail, 25,000 sq ft

Climate
Mixed-Humid (4A)

Grid Intensity
Low



Watermark



Location
Washington, D.C.

Pre-Conversion
Office, 609,000 sq ft

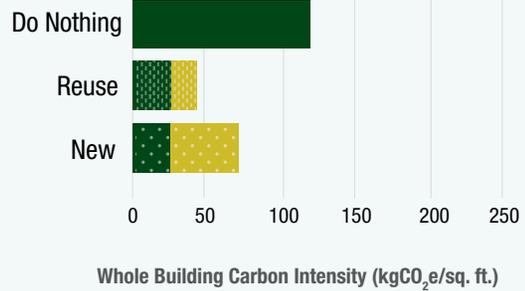
Post-Conversion
Multifamily, 483,000 sq ft
K-12 School, 17,000 sq ft

Climate
Mixed-Humid (4A)

Grid Intensity
Medium



Park + Ford



Location
Alexandria, Virginia

Pre-Conversion
Office, 230,000 sq ft

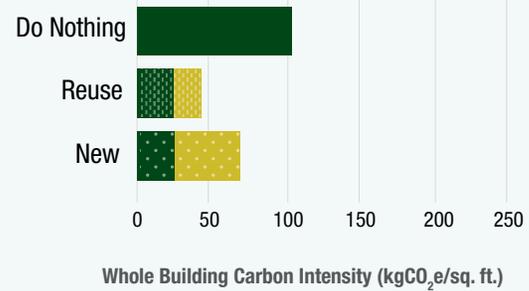
Post-Conversion
Multifamily, 450,000 sq ft
Preschool/Daycare, 10,000 sq ft

Climate
Mixed-Humid (4A)

Grid Intensity
Low



The Octave



Location
Silver Spring, Maryland

Pre-Conversion
Office, 80,000 sq ft

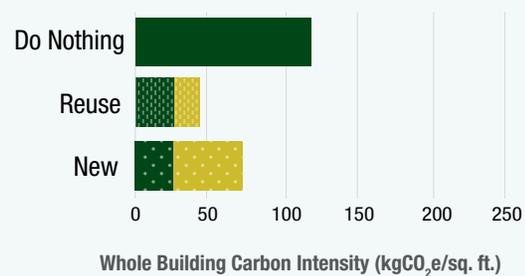
Post-Conversion
80,000 sq ft

Climate
Mixed-Humid (4A)

Grid Intensity
Low



Mission Lofts



Location
Falls Church, Virginia

Pre-Conversion
Office, 178,000 sq ft

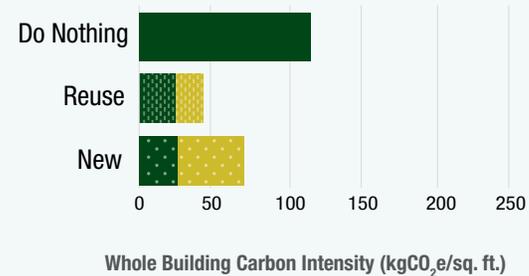
Post-Conversion
178,000 sq ft

Climate
Mixed-Humid (4A)

Grid Intensity
Low



The Oronoco



Location
Alexandria, Virginia

Pre-Conversion
Office, 155,000 sq ft

Post-Conversion
155,000 sq ft

Climate
Mixed-Humid (4A)

Grid Intensity
Low

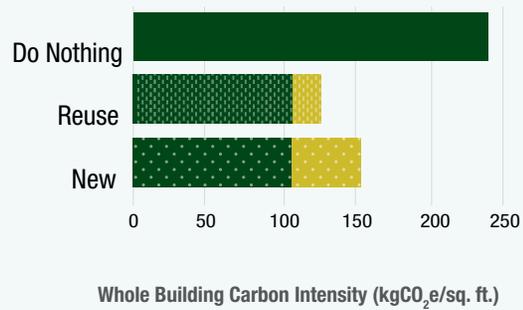


Figure 14: Whole life carbon of makeover conversions. Makeover conversions apply a new facade to existing buildings, resulting in a higher proportion of embodied carbon from the building envelope.

Figure 14, continued

■ Operational Emissions ■ Embodied Emissions

Six at Park



Location
Parkville, Missouri

Pre-Conversion
Office, 54,000 sq ft

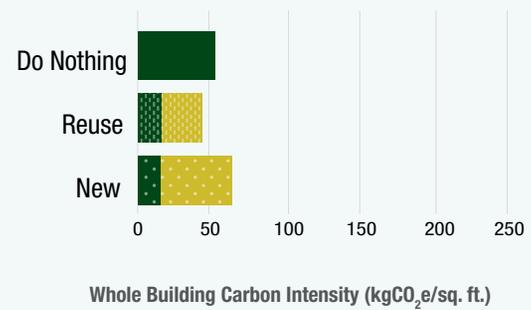
Post-Conversion
Multifamily, 27,000 sq ft
Office, 27,000 sq ft

Climate
Cold (5A)

Grid Intensity
High



508 West Apartments



Location
Spokane, Washington

Pre-Conversion
Office, 83,000 sq ft

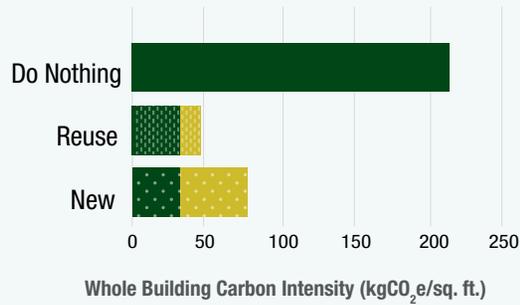
Post-Conversion
Multifamily, 91,500 sq ft

Climate
Cold (5A)

Grid Intensity
Low



Cityplace



Location
Allentown, Pennsylvania

Pre-Conversion
Hotel, 180,972 sq ft

Post-Conversion
Multifamily, 256,325 sq ft

Climate
Mixed-Humid (4A)

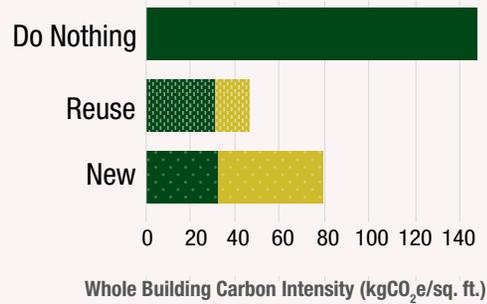
Grid Intensity
Medium



Moderate Conversions: 2025–2040

■ Operational Emissions ■ Embodied Emissions

Mayflower Apartments



Location
Dallas, Texas

Pre-Conversion
Office, 361,000 sq ft

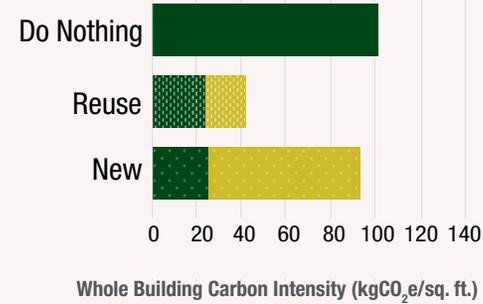
Post-Conversion
Multifamily, 253,200 sq ft

Climate
Hot-Humid (2A)

Grid Intensity
Medium



22 Light Street



Location
Baltimore, Maryland

Pre-Conversion
Office, 57,000 sq ft

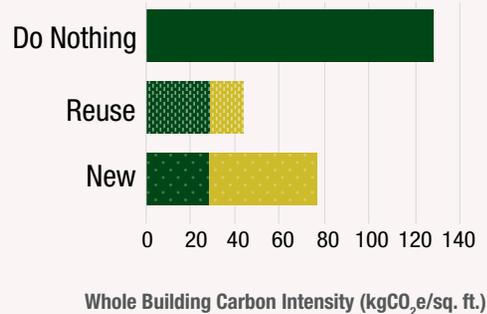
Post-Conversion
Multifamily, 48,000 sq ft
Retail, 4,000 sq ft

Climate
Mixed-Humid (4A)

Grid Intensity
Low



Lofts @ Centennial Yards South



Location
Atlanta, Georgia

Pre-Conversion
Office, 248,040 sq ft

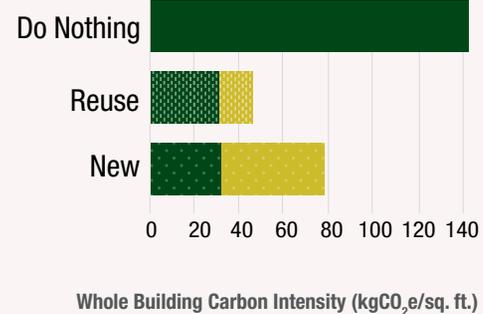
Post-Conversion
Multifamily, 157,889 sq ft
Retail, 29,267 sq ft

Climate
Mixed-Humid (4A)

Grid Intensity
Medium



The Barnett



Location
Jacksonville, Florida

Pre-Conversion
Office, 170,000 sq ft

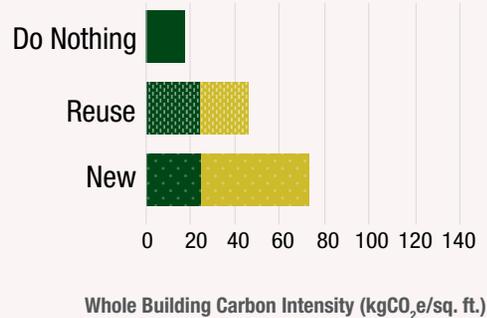
Post-Conversion
Multifamily, 134,000 sq ft
Office, 36,000 sq ft

Climate
Hot-Humid (2A)

Grid Intensity
Medium



Gadsden Place



Location
Columbia, South Carolina

Pre-Conversion
Distribution Center, 11,667 sq ft

Post-Conversion
Multifamily, 17,500 sq ft

Climate
Mixed-Humid (4A)

Grid Intensity
Low

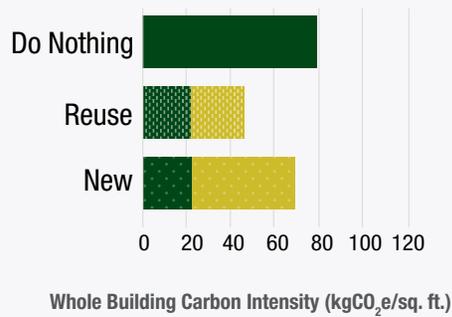


Figure 15: Whole life carbon of moderate conversions. Moderate conversions require a deeper structural intervention compared to minimalist conversions, resulting in embodied carbon similar to the makeover conversion typology.

Structurally Intensive Conversions: 2025–2040

■ Operational Emissions ■ Embodied Emissions

Stumpf Flats



Location
Richmond, Virginia

Pre-Conversion
Hotel, 25,200 sq ft

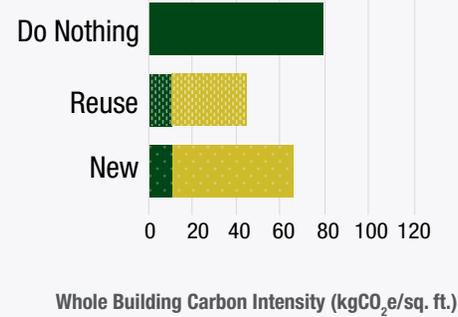
Post-Conversion
Multifamily, 28,350 sq ft

Climate
Mixed-Humid (4A)

Grid Intensity
Low



Broadway Lofts



Location
Los Angeles, California

Pre-Conversion
Office, 49,638 sq ft

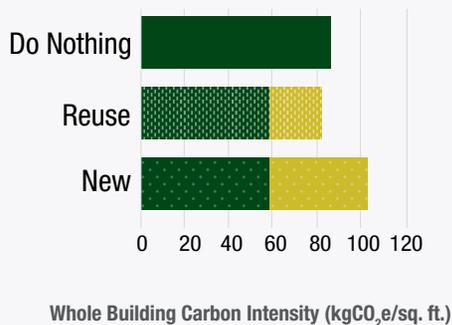
Post-Conversion
Multifamily, 39,579 sq ft
Retail, 3,064 sq ft

Climate
Hot-Dry (3B)

Grid Intensity
Low



The Assembly



Location
Indianapolis, Indiana

Pre-Conversion
Non-Refrigerated Warehouse, 160,000 sq ft

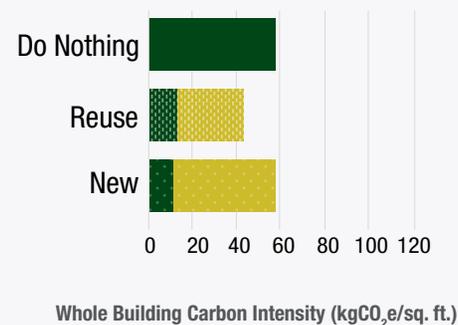
Post-Conversion
Multifamily, 122,000 sq ft
Office, 38,000 sq ft

Climate
Cold (5A)

Grid Intensity
High



Cecil Hotel



Location
Los Angeles, California

Pre-Conversion
Hotel, 285,000 sq ft

Post-Conversion
Multifamily, 285,000 sq ft

Climate
Hot-Dry (3B)

Grid Intensity
Low



Figure 16: Whole life carbon of structurally intensive conversions. Structurally intensive conversions typically have the highest embodied carbon due to seismic retrofits, structural repairs, or extensive structural reconfiguration required for upgrade and conversion to residential use.

UNDERSTANDING DECARBONIZATION DRIVERS

The single-building analyses in this report illustrate a static snapshot of each project’s estimated emissions. However, a range of contextual factors determine how and to what extent each project can reduce its whole life carbon footprint. Some external factors, such as **grid decarbonization**, will automatically reduce the emissions of every building with no action by developers; these are considered “by default” drivers. Other factors, such as rigorous **energy codes** and **Building Performance Standards**, mandate additional emissions improvements for most or all projects within a jurisdiction.

Developers have some control over these drivers to the extent that they select the jurisdictions in which they pursue commercial-to-residential conversions and have discretion over how they comply with requirements. Owners can further elect to design and implement low-carbon approaches such as **electrification** and **low or zero operational emissions conversions**; these are “by design” drivers that developers must commit to undertaking. Figure 17 illustrates this range of decarbonization drivers as potential scenarios. Scenarios 1 to 3 are the Do Nothing, New Building, and Completed Conversion scenarios represented previously. Scenarios 4 to 8 describe factors that impact whole life carbon, arranged from those that drive decarbonization by default to those that decarbonize by design. A comprehensive description of the embodied and operational emissions assumptions of each scenario can be found in [Appendix B](#).

The Octave, 225 Baronne, The Assembly, and the Cecil Hotel were selected to represent geographic and size diversity. The scenarios evaluated operational, embodied, and whole-building emissions from 2025–2040. See [Appendix A](#) for detailed analysis inputs for each scenario.

| | THE OCTAVE | 225 BARONNE | THE ASSEMBLY | CECIL HOTEL |
|---------------------------------|---------------------|------------------------|-----------------------------------|-----------------------------------|
| Location | Baltimore, Maryland | New Orleans, Louisiana | Indianapolis, Indiana | Los Angeles, California |
| Climate | Mixed-humid | Hot-humid | Mixed-humid | Warm dry |
| Grid Emissions Intensity | Medium | High | High | Low |
| Building size | 80,000 sq. ft. | 335,000 sq. ft. | 160,000 sq. ft. | 285,000 sq. ft. |
| Building age | 61 | 63 | 110 | 97 |
| Typology | Makeover conversion | Minimalist conversion | Structurally intensive conversion | Structurally intensive conversion |



Figure 17: Many factors affect whole life carbon, some within the control of developers and some beyond their control. These eight scenarios represent a range of decarbonization drivers that impact the whole life carbon of office-to-residential conversions.

Decarbonization Scenario Results

The outcomes demonstrate that there isn't a one-size-fits-all approach for the most impactful emissions reduction pathway.

Decarbonization by Default: Greening the grid will reduce whole life carbon of every building by default. Grid decarbonization alone can result in reductions of between 10 and 20 percent below completed conversions and 30 to 50 percent below new construction. However, these reductions vary widely by region, and it is challenging to predict exactly when and how each regional grid will decarbonize.

Decarbonization by Regulation: Energy codes and building performance standards have the potential to significantly reduce operational emissions by 20 and 40 percent below a typical conversion. However, carbon savings are highly dependent on the specific rigor and criteria of the policies.

Decarbonization by Design: Developers ultimately have the greatest agency to decarbonize by implementing low or zero operational emissions conversion projects. Zero operational emissions renovations will always yield the lowest total carbon outcomes. These scenarios result in reductions in total carbon of between 45 and 70 percent below completed conversions and a 70 to 80 percent reduction compared to new construction.

Embodied and Operational Carbon Tradeoffs: While embodied carbon is slightly higher for high-performance conversions, this increase in emissions is negligible compared to the operational emissions savings over a 15-year timeframe. The additional embodied carbon associated anticipated to comply with model energy codes and Building Performance Standards is predicted to be overcome by operational reductions within less than five years. For zero operational emission conversions, that payback time is shown to be less than two years.

The results of the whole life carbon analyses in figures 18 through 21 illustrate the embodied and operational emissions of each scenario and the reduction in total emissions achieved by each scenario compared to both new construction and the completed conversion project.

The Octave (figure 18) was subject to stringent codes and standards at the time of conversion, meaning that only small reductions are gained in all scenarios barring a net zero operational emissions conversion. It also illustrates that when operational emissions are low in every scenario, embodied emissions play an even greater role in whole life emissions.

225 Baronne (figure 19) had high operational emissions pre-conversion, in contrast to The Assembly (figure 20), which had low operational emissions. Both projects are in locations with less stringent codes in place at the time of conversion. The result is that for 225 Baronne, operational emissions represent at least half of the 15-year whole life carbon in all scenarios barring net zero operational emissions.

The Cecil Hotel (figure 21) has the lowest operational emissions of the four buildings. This means that the various decarbonization drivers result in lower reductions in whole life emissions, and embodied emissions represent the majority of whole life carbon in all scenarios—both new construction and conversion.

Figures 22 through 26 examine each decarbonization driver across all four buildings rather than each building separately. Each graph plots the cumulative embodied plus operational emissions over time for each building under the Completed Conversion scenario and an isolated decarbonization driver scenario. This visualization examines the varied efficacy of each driver compared to business as usual, which depends on factors such as the local grid, the anticipated fuel sources of buildings in different regions, and existing energy and emissions policies.

Each chart identifies the carbon payback year for each building, meaning the year in which the embodied carbon required to upgrade the performance of a given building through improved building envelope and MEP systems is overcome by reductions in operational emissions (like a simple dollar payback).

The effects of grid decarbonization across the four buildings (figure 22) illustrate that buildings in locations with the highest emitting grids currently, like 225 Baronne and The Assembly, have the most to gain. Conversely, these projects have higher carbon footprints in the near term and over their life span without additional upgrades such as efficiency improvements and electrification, regardless of the grid's improvement.

The impacts of grid decarbonization also vary depending on existing grid intensity, as well as fuel split. 225 Baronne, for example, has an assumed energy consumption fuel split of approximately 70 percent electricity/30 percent gas. Given how electricity-dominated the building is, decarbonizing the grid has a substantial impact on reducing emissions. The Assembly, however, is the opposite, with an assumed fuel split of approximately 30 percent electricity/70 percent gas, resulting in a much smaller impact in the Grid Decarbonization scenario. Because grid decarbonization is external to the conversions and the analysis does not account for embodied emissions associated with adding clean energy at the utility scale, the carbon payback for all buildings is immediate.

The importance of energy codes in driving operational carbon reductions is highlighted by comparing The Octave to The Assembly in figure 23. The Octave was subject to a much more stringent energy code than The Assembly at the time of conversion. The result is that the impact of applying a model energy code to the Octave is minimal, while for The Assembly, it is significant. A similar story can be seen with Building Performance Standard conversions (figure 24), in which buildings without strict emissions or energy requirements for the

completed conversions see a much greater potential reduction in emissions as a result of Building Performance Standards.

Due to the stringency of both Building Performance Standard and Energy Code + Electrification conversions, both of these scenarios bring every building close to zero operational emissions (a flat line) by the year 2040. For each building, some additional envelope and MEP upgrades are required to meet this level of performance, which means they have a higher embodied carbon footprint. The resulting carbon payback is between one and four years.

Electrification is a design choice shown in figure 25 to be an effective carbon investment for most projects. If a project already requires new MEP systems to convert from commercial to residential use, installing electric systems is a low-embodied carbon option that maximizes reductions in operational emissions as the grid is increasingly powered by renewables.

Figure 26 illustrates that embodied carbon represents the totality of the carbon footprint for any building that decarbonizes its operations. This scenario will always yield the greatest total reduction in emissions in the long term. Additionally, while there is an additional embodied carbon cost associated with envelope and MEP upgrades, these embodied emissions are made up for by eliminating the operational emissions within one to two years.

Understanding the local context is critical to determining the most effective decarbonization pathway for each building (see [Actionable Guidance](#) for more details). However, regardless of local conditions, a building's operational emissions can always be reduced by reducing energy consumption, switching to all-electric systems, and using electricity that comes from GHG-free sources.

Total Carbon 2025–2040

The Octave

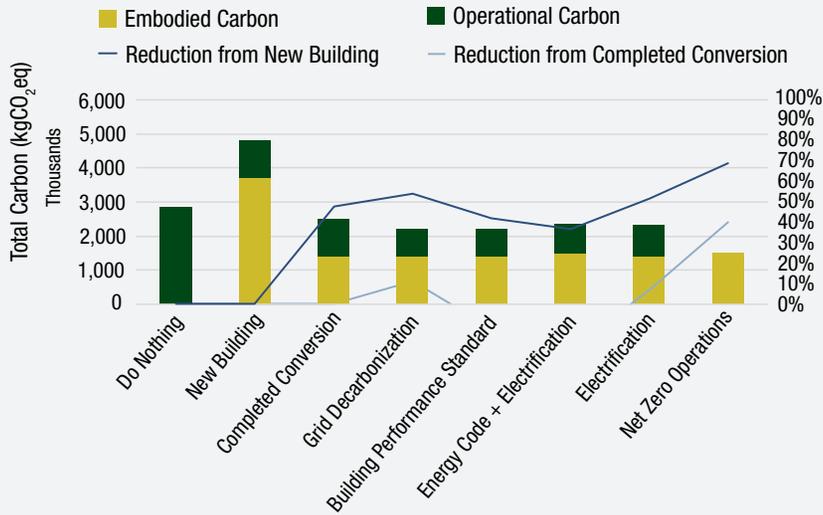


Figure 18: The Octave’s whole life carbon under decarbonization scenarios.

The Assembly

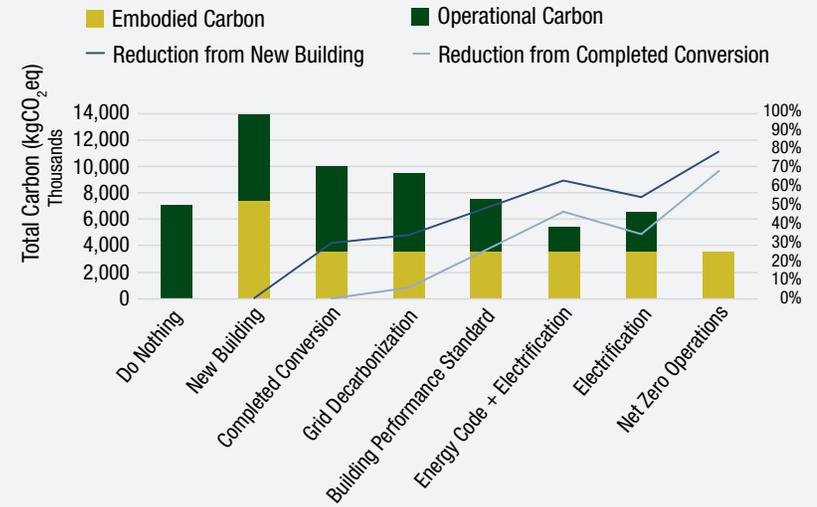


Figure 20: The Assembly’s whole life carbon under decarbonization scenarios.

225 Baronne

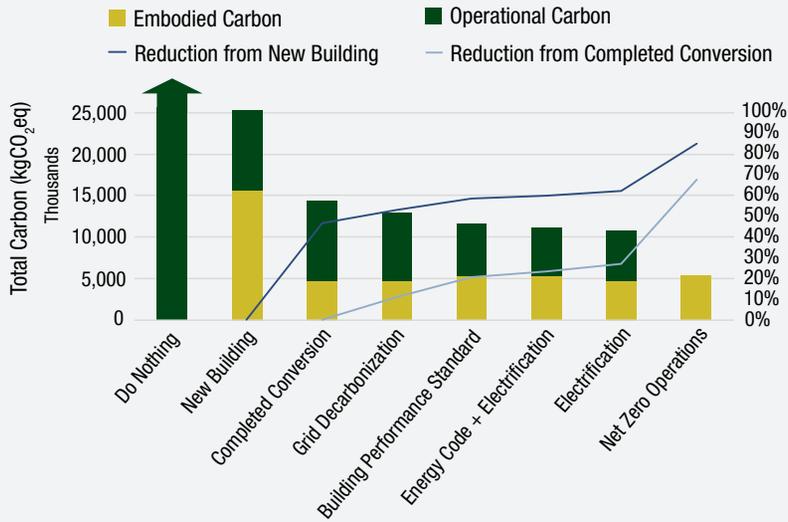


Figure 19: 225 Baronne’s whole life carbon under decarbonization scenarios.

Cecil Hotel

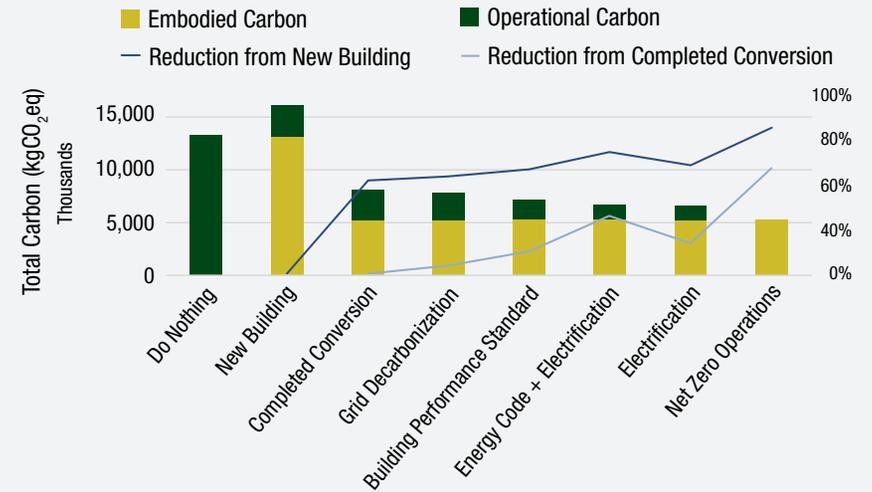


Figure 21: The Cecil Hotel’s whole life carbon under decarbonization scenarios.

Impacts of Decarbonization Drivers on Cumulative Emissions from 2025–2040

- The Octave – Completed Conversion
- The Octave – Decarbonization Scenario
- 225 Baronne – Completed Conversion
- 225 Baronne – Decarbonization Scenario
- The Assembly – Completed Conversion
- The Assembly – Decarbonization Scenario
- Cecil Hotel – Completed Conversion
- Cecil Hotel – Decarbonization Scenario
- Carbon Payback Year

Grid Decarbonization 2025–2040

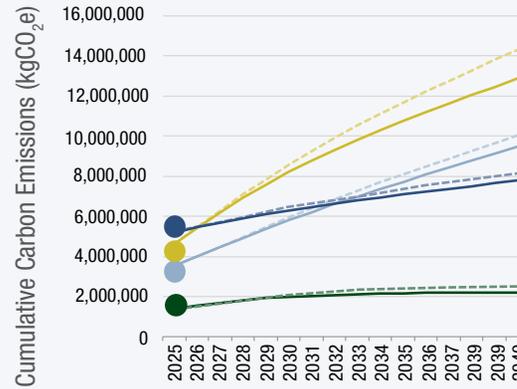


Figure 22: Impacts of Grid Decarbonization compared to Completed Conversion scenarios.

Model Energy Code + Electrification 2025–2040

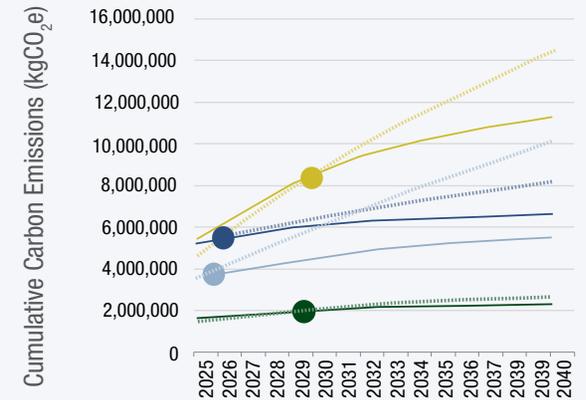


Figure 23: Impacts of Energy Code + Electrification compared to Completed Conversion scenarios.

Building Performance Standard 2025–2040

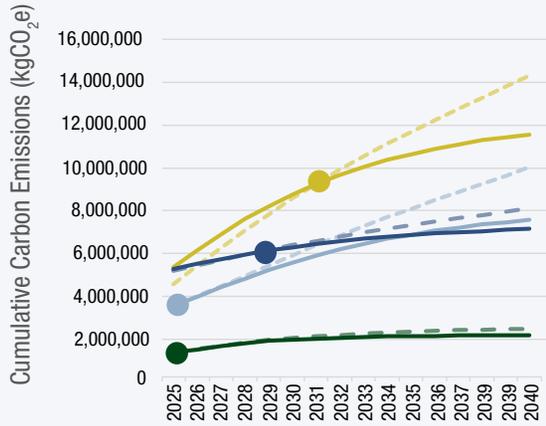


Figure 24: Impacts of Building Performance Standard compared to Completed Conversion scenarios.

Electrification 2025–2040

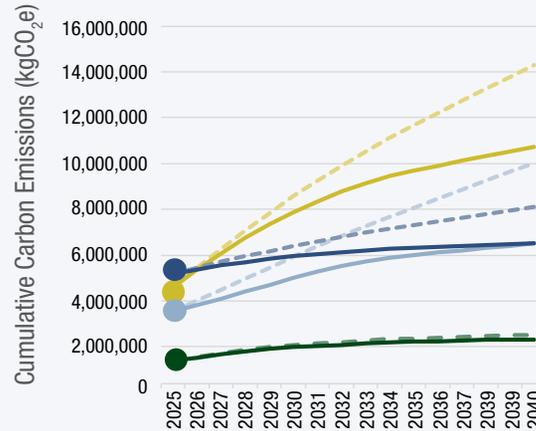


Figure 25: Impacts of Electrification compared to Completed Conversion scenarios.

Zero Operational Carbon Conversion 2025–2040

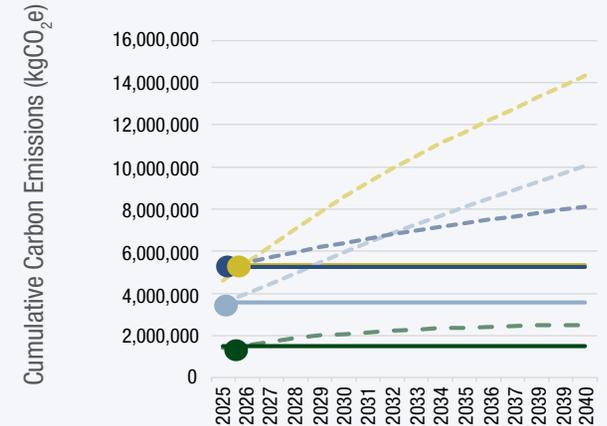


Figure 26: Impacts of Net Zero Operations compared to Completed Conversion scenarios.

ACTIONABLE GUIDANCE: IMPLEMENTING LOW-CARBON CONVERSIONS

The decisions made early in planning for commercial-to-residential conversions can have the greatest impact on whole life carbon outcomes. Understanding which decisions matter, and how to prioritize them, is important to set projects up for low-carbon success from day one. This section includes three decision-making tools:

- **Planning for Low-Carbon Commercial-to-Residential Conversions** illustrates decision-making flows relative to three key external drivers that impact planning for decarbonization at the earliest stages of development.
- **The Embodied Carbon Hierarchy** provides a high-level overview of reducing embodied carbon system by system.
- **Minimizing Embodied Carbon** suggests a decision-making hierarchy to guide the design process toward a low embodied carbon footprint.

A few overall considerations should be kept in mind when planning to reduce whole life carbon through commercial-to-residential conversions:

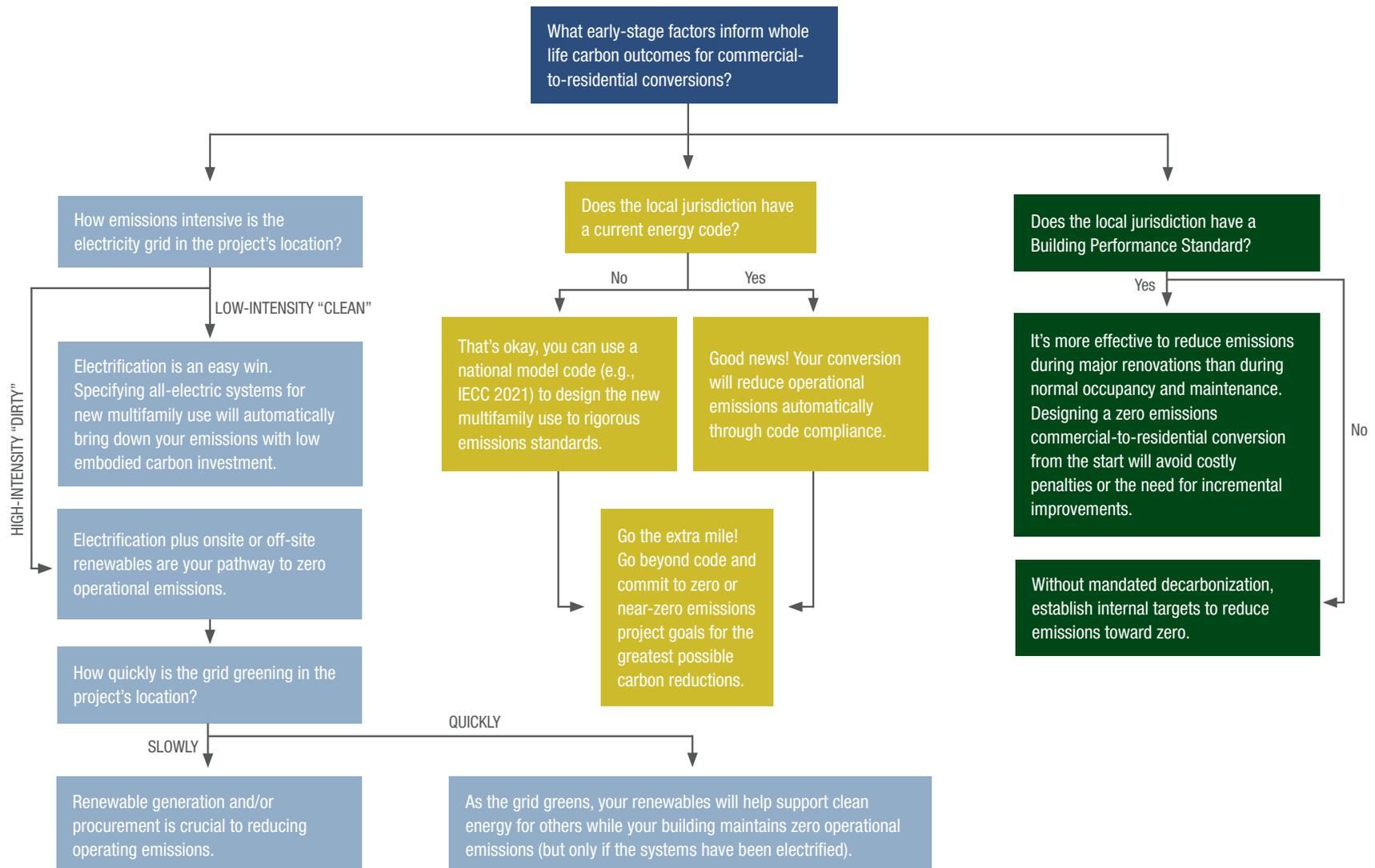
- **Account for embodied and operational emissions tradeoffs.** While embodied and operational emissions are often measured independently, design decisions to reduce emissions in one category may increase emissions in the other category. Using early analytics will support design strategies that meet ambitious operational emissions targets with smart, low-embodied carbon approaches.

- **To reduce operational emissions, think efficiency, electrification, and renewables (but not necessarily in that order).** The best practices to reduce operational emissions are energy efficiency, electrification, and renewables. The order and extent to which each of these strategies is pursued will depend on factors both within and beyond the control of a development team.
- **Embodied carbon regulations are emerging.** While the operational emissions guidance is heavily policy-focused, it is important to note that embodied carbon regulations are emerging. Often contained within buy clean/buy fair policies, zoning regulations, and emerging within energy codes, these policies may require carbon accounting and/or embodied carbon reductions.
- **Reassess new construction best practices.** Prescriptive guidance for energy reductions in new construction may not be optimal for renovation. Using a performance-based approach supported by analytics such as energy modeling and life cycle assessment enables decision-making based on carbon, cost, cultural, or other tradeoffs.
- **Timing is everything.** Getting ahead of policies and emissions limits helps avoid stranded assets. Installing electric, high-performance HVAC and upgrading the building envelope at the point of conversion will avoid the need to replace these systems and materials in the future to comply with standards in the coming years, reducing cost, embodied carbon, and waste.

Planning for Low-Carbon Commercial-to-Residential Conversions

Local codes and standards, policies, and utility grids all affect the whole life carbon outcomes of commercial-to-residential conversions. Understanding these variables when assessing a commercial property's

viability for conversion to multifamily use and early in project planning and design can inform decision-making to reduce carbon emissions in the long run.



The Embodied Carbon Hierarchy



This hierarchy illustrates a suggested flow order for prioritizing embodied carbon reduction strategies in commercial-to-residential conversions for the greatest impact. Unlike in new construction, where

structural systems typically contribute the highest embodied carbon, followed by envelope, interiors, and MEP systems, this composition is often inverted for commercial-to-residential conversions.

1

MECHANICAL, ELECTRICAL, AND PLUMBING SYSTEMS

Often excluded from whole building life cycle assessments, MEP systems can make up the largest percentage of embodied carbon in commercial-to-residential conversions. New systems are often required to accommodate the change in use and new floorplan layouts. They are also key for reducing operational emissions.



2

INTERIORS

Interior construction and finishes needed to create residential units from commercial spaces make up a substantial portion of embodied carbon in conversion projects. Smart interiors approaches can make a big impact.



3

ENVELOPE

Commercial-to-residential conversions use a range of approaches from minor envelope repairs to wholesale recladding. Optimizing the approach to the building envelope can balance embodied carbon emissions with operational carbon reductions and establish the brand for new housing.



4

STRUCTURE

While typically the most carbon-intensive system in new construction, structure may have the lowest contribution in commercial-to-residential conversions. However, intensive structural repairs or upgrades can quickly increase the embodied carbon of any project.

Minimizing Embodied Carbon



The following steps guide embodied carbon reduction decisions within each level of the embodied carbon hierarchy of commercial-to-residential conversions.

1 MEP Systems

- ↓ Assess the potential to reuse any equipment or distribution from existing MEP systems.
- ↓ Minimize the size of new MEP systems by maximizing passive performance. In historic buildings, identify and use original passive strategies where possible.
- ↓ Use life cycle assessment to minimize embodied carbon of new systems.

2 Interiors

- ↓ Minimize the quantity of new materials needed. For example, consider exposing existing finishes or systems rather than covering them with new materials.
- ↓ Use salvaged materials. These may be materials deconstructed and reused within the building, or they could be sourced from another local project or a reuse center.
- ↓ Use low-carbon interior construction and finishes.
- ↓ Plan for end of life. Use materials that can be disassembled, salvaged, and reused wherever possible.
- ↓ Use materials that are durable and easy to maintain. Maximizing service life will reduce future embodied carbon.

3 Envelope

- ↓ Limit new envelope materials. Overcladding may be desirable for brand transformation to create a residential image from commercial buildings or for optimizing thermal performance, but exterior restoration to extend the life of the existing facade is typically a much lower-carbon solution.
- ↓ Use a data-drive approach to balance embodied carbon of new materials, such as insulation, with the operational carbon benefits. Don't assume more is better.
- ↓ Use salvaged or low embodied carbon materials--including insulation and cladding--wherever possible.

4 Structure

- ↓ Start with a building that already has the structural capacity for use as housing to minimize structural reinforcement. For example, former industrial or office buildings were designed to carry heavier loads than required for residential use.
- ↓ Use the existing structural layout as much as possible. While certain structural typologies are more adaptable than others, working with the existing grid to create residential units will minimize reframing and the need for added structural supports.
- ↓ Complete structural repairs with low-carbon materials. If a building is in poor condition, structural repairs can significantly increase the embodied carbon emissions. However, using timber, low-carbon concrete, or salvaged elements can keep the embodied carbon to a minimum.

CONCLUSION

The outcomes from *The Whole Life Carbon of Commercial-to-Residential Conversions: Aligning the Climate and Housing Imperative* validate the findings of previous research and demonstrate that across climate zones, jurisdictions, and building types, commercial-to-residential conversion projects dramatically reduce embodied carbon compared to ground-up construction. When undertaken with energy performance improvements or operational emissions targets—whether in response to regulations, climate commitments, or market drivers—conversions can also lead to substantial reductions in whole life over the long term.

Key Takeaways

Embodied Carbon

- **Commercial-to-residential conversions reduce embodied carbon**, consistently avoiding embodied emissions compared to new construction, with an average reduction of 62 percent.
- **Conversions reprioritize embodied carbon reduction strategies.** In conversions, MEP systems and interiors often make up half or more of the total embodied carbon, compared to new construction in which structures and the envelope tend to be the greater source of embodied emissions.
- **Embodied carbon typologies can guide low-carbon conversion.**
 - **Minimalist Conversions:** Light-touch conversions that require minimal structural and envelope work have the lowest embodied carbon footprint.
 - **Makeover Conversions:** Conversions that replace or overclad the facade for a new look and improved thermal performance tend to result in mid-range embodied carbon.

Operational Carbon

- **Operational emissions are an important part of the equation.** Between 2025 and 2040, operational emissions will account for half or more of the whole life carbon for most buildings within this assessment. Improvements to energy efficiency, electrification, and renewable energy generation or procurement are all important to reducing emissions.
- **Converting the commercial space to residential use typically reduces operational emissions.** The operational emissions of conversions ranged from an estimated 31 to 88 percent reduction below the prerenovated buildings, with an average reduction of 74 percent over a 15-year period.
- **Project jurisdiction drives operational emissions.** Factors such as local energy code and local electricity grid emissions have a major impact on operational carbon outcomes and are an important part of early-stage project planning.

- **Commercial-to-residential conversions offer a carbon win.** Assuming a converted commercial building and new construction have similar operational emissions in compliance with a local building code or emissions target, conversion will always be a lower-carbon way to create new housing units.
- **Many factors impact whole life carbon.** Understanding the physical opportunities within an existing commercial building, local climate regulations and standards, the local electricity grid, and the market benefits of high-performance projects when pursuing conversions will inform smart decision-making to achieve the lowest carbon outcomes.
- **Policy alignment is key to scale commercial-to-residential conversions.** While these projects offer a clear pathway to align housing and climate outcomes, incentives at the local and state level are emerging to improve economic viability for more buildings in more markets.

Commercial-to-residential conversions represent a rare alignment of market opportunity and climate responsibility. As this study demonstrates, conversions consistently outperform new construction in whole life carbon performance, delivering substantial embodied carbon savings while meeting growing demand for housing.

For developers, the message is clear: adaptive reuse of underutilized commercial properties into housing is not only a viable strategy, but a competitive advantage in a carbon-constrained future. By leveraging tools such as CARE, aligning with emerging policies, and prioritizing low-carbon design strategies, developers can unlock the full value of underutilized assets while positioning their portfolios for long-term resilience and regulatory readiness. As the real estate industry evolves to meet the demands of a decarbonizing economy, conversion is an increasingly essential real estate development approach.

APPENDIX A: ANALYSIS ASSUMPTIONS

Embodied Carbon Assumptions

The CARE Tool estimates the embodied carbon of renovations based on the scope of intervention to the building's structure, envelope, interiors, and MEP systems. Additional detail about the backend data sources and calculation methods can be found in the [Data and Methodology](#) page of the CARE Tool. The team used the available narrative information to approximate each project's scope as follows.

Structure

To estimate the structural embodied emissions:

- The existing structural system (wood-framed, hybrid masonry and timber, or concrete/steel) was determined based on photographs and the description of the original building.
- The analysis assumed all additions use conventional steel/concrete based on photographs and descriptions.
- The analysis assumed all hypothetical new buildings use conventional steel/concrete construction methods.

Structural systems have the greatest potential contributions to embodied carbon. They also present an area of uncertainty in the assessment due to the lack of specificity in the original case study narratives. For example, the project narratives describe cutting light wells into buildings or repairing deteriorated concrete, but they do not offer material quantities, levels of structural intervention, or detailed descriptions of structural approaches. To address uncertainty and explore the sensitivity of structural modifications in the results, the project team used “low,” “medium,” and “high” percentage values to model a range of potential extent of structural alteration or replacement for each case. Findings illustrate the medium scenario unless otherwise noted.

Envelope

To estimate the enclosure embodied emissions:

- Window-to-Wall Ratios (WWRs) were determined by visual review of building elevations from photographs. Each case study was assigned to one of the following three categories, supported by this [visual reference](#):
 - Highly glazed curtainwall buildings: WWR = 60 percent
 - Punched opening, modern buildings: WWR = 40 percent
 - Punched opening, historic buildings: WWR = 20 percent
- Where a full re-cladding was apparent based on comparison of pre- and post-conversion facades, analysis assumed the building included all new windows, cladding, and roofing.

Interiors

To estimate the interior embodied emissions:

- The analysis assumed a full interior renovation, including new partition walls and finishes and reconfiguration of spaces to accommodate residential use.
- Some historic buildings preserve historically significant interiors in public spaces. Given the small proportion and unknown square footage of these spaces, they were not calculated separately. Embodied carbon impact figures associated with interiors may be overestimated in these cases.

Mechanical, Electrical, and Plumbing Systems

- Unless noted otherwise, the analysis assumed all new MEP systems to support a change in use from commercial to residential and new plan layouts.

Additions and New Construction

For both the hypothetical new construction scenarios and for additions completed as part of the conversion projects, a flat embodied carbon intensity, inclusive of the structure, envelope, interiors, and MEP systems, was applied to the square footage of new construction. This carbon intensity is based on industry standards for typical commercial steel and concrete construction to reflect the types and scales of buildings considered in this study.

Operational Carbon Assumptions

Commercial Use – Pre-Conversion

Architecture 2030's [Zero Tool](#) was used to estimate the pre-conversion energy use intensity (EUI) of each building (pre-conversion building-specific energy consumption/utility data was unavailable). The Zero Tool estimates EUI for buildings operating around the year 2000 (based on [CBECS 2003](#)), and normalizes EUI by use type, climate zone, and floor area. Electricity, gas, and total operational energy consumption were estimated based on [EPA fuel mix data](#). Using [eGRID2020](#) electricity grid emissions data (the eGRID data closest to the renovation years) and the [EPA national average gas emissions factor](#) plus a conservative leakage rate of 2.8 percent, operational emissions were estimated for each building.

Residential Use – Post-Conversion

The same methodology as above was followed to estimate post-conversion operational energy consumption and emissions, except that a percent reduction was applied to the Zero Tool-generated EUI to estimate the EUI assuming the building met its jurisdiction's energy code. The energy code of each building's jurisdiction was determined, and energy code percent reductions from CBECS 2003 were calculated using [energy.gov's Estimated Model Energy Code Improvement chart](#).

APPENDIX B: DECARBONIZATION SCENARIO ANALYSIS ASSUMPTIONS

Scenario 1: Do Nothing

Pre-conversion yearly operational electricity consumption was multiplied annually by 2025–2040 [Cambium 2024](#) electricity emissions factors using the Midcase LRMER CO₂e Combustion + Precombustion Cambium scenario for each building's generation and emission assessment (GEA) region, then summed to determine total electricity emissions over the study period. These were combined with the building's pre-conversion annual gas emissions, summed from 2025–2040, to estimate total operational emissions over the study period.

The Octave is subject to a statewide [Building Performance Standard \(BPS\)](#) requiring it to achieve specific operational emissions intensities starting in 2030. The above methodology was followed until 2030, at which point the operational emissions were assumed to meet BPS requirements.

Embodied emissions were considered zero for each Do Nothing scenario.

Scenario 2: New Building

The same method as Scenario 1: Do Nothing was followed for operational emissions using annual post-conversion electricity consumption and gas emissions. This assumes new buildings meet local codes and policies, including assuming The Octave meets its local BPS requirements starting in 2030.

Embodied carbon inputs are described for new buildings in [Appendix A](#).

Scenario 3: Completed Conversion

The same method as Scenario 2: New Building was followed for operational emissions.

Embodied carbon inputs are as described in [Appendix A](#) and reflect upgrades needed to comply with local operational emissions or energy requirements.

Scenario 4: Conversion + Grid Decarbonization

Post-conversion yearly electricity consumption was multiplied annually by emissions factors starting with current grid GHG intensities and reducing linearly to complete grid decarbonization by 2040, resulting in 0 electricity emissions in 2040. These were combined with the building's post-conversion annual gas emissions, summed from 2025–2040, to estimate total operational emissions over the study period.

For The Octave, this methodology was followed until 2030. Beginning in 2030, the pre-BPS annual emissions fuel split between electricity and gas was calculated. This was then multiplied by the building's required BPS emissions intensities to determine electricity and gas emissions from 2030–2040. Electricity emissions from 2030–2040 were reduced linearly to complete grid decarbonization by 2040, resulting in 0 electricity emissions in 2040.

Since this scenario explores the external variable of the grid rather than a different approach to the conversion, the embodied carbon is equivalent to Scenario 3: Completed Conversion. The embodied carbon associated with the addition of renewables to the grid is not included within the scope of the study.

Scenario 5: Conversion + Building Performance Standard

Electricity consumption and gas emissions were calculated using the same methodology as in Scenario 2: New Building. A stepped GHG emissions reduction BPS was then modeled and applied to the total operational emissions, assuming BPS criteria calling for a 0 percent reduction in total operational emissions by 2025, a 25 percent reduction by 2030, and a 75 percent reduction by 2040. Linear reductions from 0 to 25 to 75 percent were assumed.

It was assumed The Octave meets its active local BPS requirements.

Embodied emissions are based on Scenario 3: Completed Conversion. However, in this scenario, all buildings include envelope performance upgrades for glazing and insulation, even if that scope was not included in the Completed Conversion. Additionally, the embodied carbon of MEP systems was increased to reflect the installation of high-performance systems. While these performance enhancements may not be required at the year of conversion, they would most likely be needed by the year 2040 to comply with step-down requirements of the BPS.

Scenario 6: Conversion + Energy Code + Electrification

The same methodology for operational energy and emissions as Scenario 7: Conversion + Electrification was followed (see below), but assuming that instead of meeting the requirement of the local energy code, each building was constructed to perform at the level of current national model energy code (IECC 2024/ASHRAE 90.1 2022) standards. The exception was the Cecil Hotel; its local code (2022 Building Energy Efficiency Standards) is more stringent than IECC 2024/ASHRAE 90.1 2022; so as in Scenario 3: Completed Conversion, it was assumed to be performing at the level of its local code.

For The Octave, the above methodology was used until 2030, at which point it was assumed that the building was meeting its local BPS requirements. Meeting local BPS requirements results in greater emissions reductions than meeting the national model code.

Embodied emissions are as described in Scenario 5: Conversion + Building Performance Standard.

Scenario 7: Conversion + Electrification

Pre-electrification electricity consumption was calculated using the same methodology as in Scenario 2: New Building. Thirty-three percent of total pre-electrification gas consumption was then added to the electricity consumption, to represent the additional load taken on by electric systems after electrification, assuming a 300 percent efficiency improvement in electric systems compared to the most efficient (95 percent efficiency) gas systems. All gas emissions were assumed to be zero starting in 2025 and continuing to 2040.

Embodied emissions are based on Scenario 3: Completed Conversion. As the baseline conversions already assume a complete replacement of MEP systems and the embodied carbon of MEP systems do not distinguish based on system typology, no additional embodied carbon was represented in this scenario.

Scenario 8: Conversion + Net Zero Operations

All operational emissions from 2025–2040 were assumed to be zero because the buildings are assumed to be all electric using only GHG-free electricity sources.

Embodied emissions are as described in Scenario 6: Conversion + Energy Code + Electrification.



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