A publication of the CLF WBLCA Benchmark Study (v2)

The California Carbon Report Summary:

Six Key Takeaways for Policymakers

REPORT | MAY 2024

Carbon Leadership Forum

CENTER FOR THE BUILT ENVIRONMENT

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The Carbon Leadership Forum accelerates the transformation of the building sector to radically reduce the greenhouse gas emissions attributed to materials (also known as embodied carbon) used in buildings and infrastructure.

We research, educate, and foster cross-collaboration to bring the embodied carbon of buildings and infrastructure down to zero.

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EXECUTIVE SUMMARY

In early 2024, we published *The California Carbon Report: An Analysis of the Embodied and Operational Carbon Impacts of 30 Buildings*[1] (henceforth, "the full report"), which explored the magnitude and timing of embodied and operational carbon emissions for 30 real building projects in California. This included estimating the whole life carbon impacts of the buildings over time, exploring variability across different projects, and identifying top contributors to carbon emissions.

This document serves as a summary of key takeaways from the full report. Though it is relevant for building designers, owners, builders, and engineers, the target audience for this document is policymakers working to decarbonize the building sector in the State of California. The six key takeaways for policymakers are:

1. **Embodied carbon impacts are substantial**
2. **The timing of emissions matters**
3. **It is critical to decarbonize the grid AND reduce fossil fuels in buildings**
4. **Concrete and steel emissions are big, but they aren't the only things that matter**
5. **Building-scale assessments are valuable**
6. **We don't yet know the full picture**

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[1] Benke, B., Roberts, M., Shen, Y., Carlisle, S., Chafart, M., and Simonen, K. (2024). The California Carbon Report: An Analysis of the Embodied and Operational Carbon Impacts of 30 Buildings. Carbon Leadership Forum, University of Washington. Seattle, WA. http://hdl.handle.net/1773/51287.

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INTRODUCTION

In 2022, and as part of California's Climate Commitment, multiple laws were passed to reduce the state's GHG emissions. These pieces of legislation establish clear goals and put California on legally binding pathways to establish a 90% renewable electricity grid by 2035, a 100% renewable grid by 2045, and achieve statewide net-zero carbon emissions by 2045.[2] If California is successful in implementing these goals and continues its push to electrify its buildings, then the operational carbon impacts of its building stock will decrease dramatically. This means the majority of carbon impacts from future projects will be attributable to embodied carbon. If the embodied carbon of buildings being constructed in California does not decarbonize on the same timeframe or faster than the electrical grid, then a significant source of emissions will be left unabated.

AB 2446 (2022) and AB43 (2023) amended California Health and Safety Code Section 38561.3 and 38651.6 to require the California Air Resources Board (CARB) to develop a framework for measuring embodied carbon for new construction for eligible projects and developing a strategy to achieve a 40% net reduction in embodied carbon by 2035. This framework is in parallel with policy efforts to limit industrial emissions from key sectors. For example, California was the first state to adopt Buy Clean in 2017, limiting the extraction and manufacturing emissions of several industrial materials to below the industry average on state-funded projects. CARB is also tasked with developing a strategy for the state's cement sector to achieve net-zero GHG emissions by 2045.[3] Additionally, CALGreen[4] adopted embodied carbon requirements that will go into effect on July 1, 2024. These policy efforts are in the early stages of development compared to similar operational carbon policy efforts and their impacts have yet to be seen.

In *The California Carbon Report: An Analysis of the Embodied and Operational Carbon Impacts of 30 Buildings*[5] (henceforth, "the full report"), we explored the magnitude and timing of embodied and operational carbon emissions for 30 real building projects in California. This included estimating the whole life carbon[6] impacts of the buildings over time, exploring variability across different projects, and identifying top contributors to carbon emissions. This document serves as a summary of key takeaways from the full report. Though it is relevant for building designers, owners, builders, and engineers, the target audience for this document is policymakers working to decarbonize the building sector in the State of California.

Methodology

This study was based on data submitted by design practitioners who used building life cycle assessment (LCA) tools, energy models, and utility data to provide the information for the research team to estimate the whole life carbon impacts of the buildings. The project types included a range of commercial, residential, and other buildings of varying sizes across three climate zones in California. It is critical to note that our study contained significant gaps in both the physical and temporal scope of the buildings we analyzed. Among others listed below in **Table 1**, these included impacts from missing life cycle stages, MEP equipment/systems, equipment and furnishings, sitework, and other impacts and considerations such as refrigerants, biogenic carbon, time-of-use operational impacts,[7] and a limited data sample size, to name a few. While we believe that our analysis is meaningful and can provide researchers, building owners, designers,

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[2] More details on all of these separate pieces of legislation can be found at: https://www.gov.ca.gov/2022/09/16/governor-newsom-signs-sweeping-climate-measures-ushering-in-new-era-of-world-leading-climate-action/

[3] This specific bill is SB596 which can be found at: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB596

[4] CALGreen is California's first green building code and first in the nation state-mandated green building code. More information can be found: https://www.hcd.ca.gov/building-standards/calgreen

[5] Benke, B., Roberts, M., Shen, Y., Carlisle, S., Chafart, M., and Simonen, K. (2024). The California Carbon Report: An Analysis of the Embodied and Operational Carbon Impacts of 30 Buildings. Carbon Leadership Forum, University of Washington. Seattle, WA. http://hdl.handle.net/1773/51287.

[6] "Whole life carbon" refers to the greenhouse gas (GHG) emissions resulting from the materials, construction, and use of a building over its entire life cycle, including its demolition and disposal. This includes both *embodied* and *operational* carbon.

[7] Our study used average annual operational carbon estimates which do not fully reflect the carbon intensity of the electric grid at various times of use.

builders, and policymakers with critical insights into the whole life carbon impacts of these select projects, our results and takeaways are underestimates of the full life cycle carbon impacts of buildings and are not generalizable. Readers are strongly encouraged to learn more about our methodology by reading the full report.[8]

Table 1. Summary of the scope included in our study compared to what was missing.

Included in Study	Missing from Study
Temporal Scope: • A1-A4, B4, partial B5, C2-C4, B6 **Physical Scope:** • Embodied Impacts: • Structures • Enclosures **Operational Impacts:** • Annual averages only • Electricity use • Natural gas use	**Temporal Scope:** • A0, A5, B1, B2, B3, full B5, B7, B8, C1, D **Physical Scope:** • Interiors • MEP Equipment including refrigerants and photovoltaics • Site work / Landscaping • Furniture, fixtures, and equipment **Other Considerations:** • Biogenic carbon • Carbonation • Time-of-use operational impacts • Other environmental and/or social impact categories

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[8] Particularly, see Section 3 of the full report which includes data collection, scope of assessment, and system boundary as well as Section 5 for a full list of limitations.

SIX KEY TAKEAWAYS FOR POLICYMAKERS

The following subsections outline six key takeaways for policymakers and provide context, analysis, figures from the full report, and discussions related to each.

1. Embodied carbon impacts are substantial

For the buildings analyzed in our study, **the embodied carbon impacts of structures and enclosures alone accounted for a larger share of emissions than operational carbon, on average.** By the year 2084 (60-year reference study period), the median embodied carbon intensity of the structure and enclosure of buildings was 390 kg CO_2e/m^2, the median operational carbon intensity was 230 kg CO_2e/m^2, and the median whole life carbon intensity was 730 kg CO_2e/m^2, as illustrated in **Figure 1.** The impacts of **embodied carbon accounted for an average of 60% of total carbon impacts and was a larger source of emissions than operational carbon for 21 out of the 30 buildings studied.** The importance of embodied carbon for meeting near-term climate targets was also significant when the timing of emissions was considered (see Key Finding #2). While embodied carbon impacts were typically larger than operational, the range of operational carbon impacts was wider. For several buildings, operational carbon far outweighed embodied. The factors leading to this wide range of operational carbon are discussed in Key Finding #3.

Though our dataset was small and the scope of our study limited, embodied carbon represented a substantial portion of emissions across projects' life cycles and therefore merits more focus within building decarbonization policy efforts.

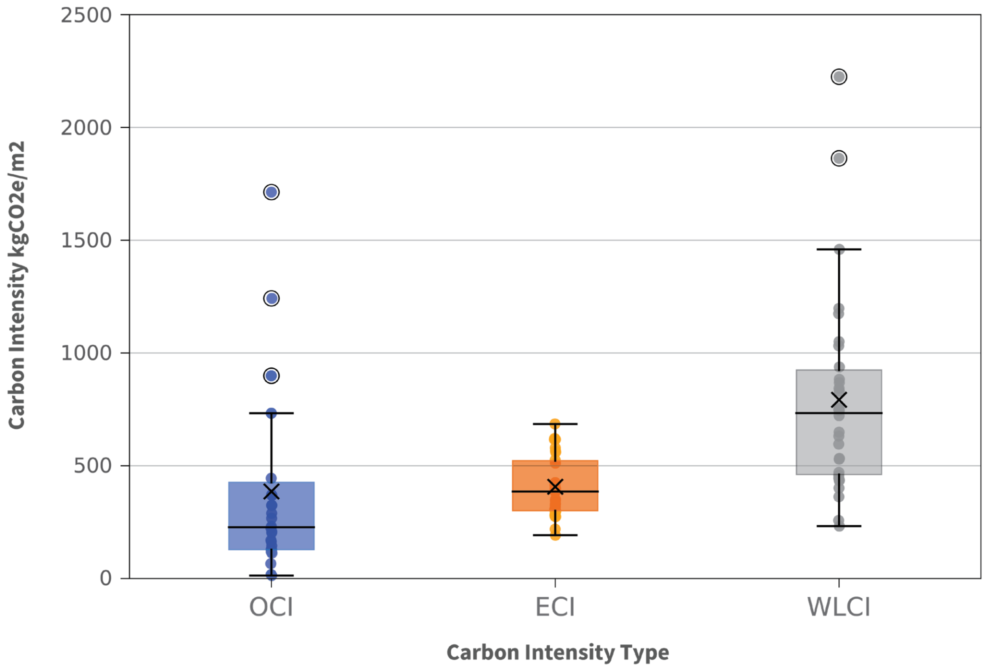

Figure 1. Operational carbon intensity (OCI), embodied carbon intensity (ECI), and whole life carbon intensity (WLCI) boxplots for all buildings. Results are shown for a 60-year reference study period with the mean values shown as a cross (x) and median values as a horizontal solid line within the box plots.

2. The timing of emissions matters

The timings and magnitudes of emissions are important considerations for near and long-term decarbonization priorities. The balance between embodied and operational carbon over time is illustrated in **Figure 2** with median carbon impacts shown annually (top) and cumulatively (bottom) by key years. Results are shown for all buildings (left), all-electric buildings (middle), and electric/gas buildings[9] (right).

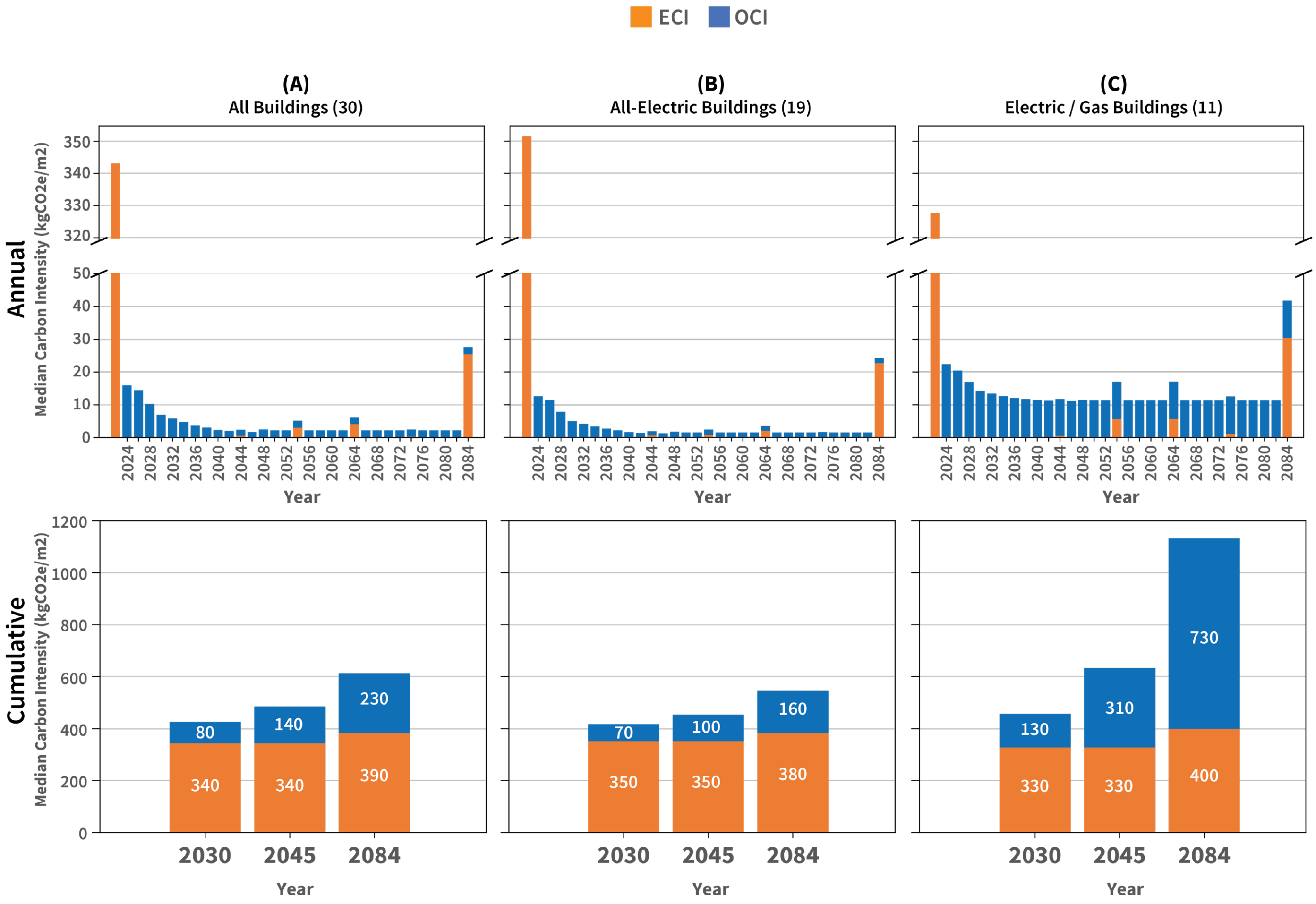

Figure 2. Annual and cumulative embodied carbon intensities (ECIs) and operational carbon intensities (OCIs) by key years. Results are shown as median annual values (above) over a 60-year reference study period and median cumulative values (below) by key years. Buildings are grouped by all 30 buildings (A), the 19 all-electric buildings (B), and the 11 electric/gas buildings (C). Note that the y-axis for annual impacts (above) is shown with a break between 50 and 320 kg CO$_2$e/m^2.

The first major source of emissions is the embodied carbon impacts that occur by the time the buildings are being completed (orange spike at year 0). In our study, these **upfront carbon[10] impacts accounted for over 80% of the life cycle embodied carbon impacts across projects on average.**[11] These emissions are particularly important as they can only be addressed during the design process. After the initial construction, embodied carbon had periodic impacts for the replacement of materials and eventual impacts from end-of-life (spike at year 2084). Annual operational carbon emissions (blue)

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[9] "electric/gas buildings" in this report refer to buildings that relied at least partially on the combustion of natural gas as an energy source.

[10] "upfront carbon" refers to the emissions from life cycle stages A1-A5. Notably, our study did not include the impacts for life cycle stage A5 due to limitations of data collection.

[11] See Figure 19 in Section 4.3.2.1 of the full report for more information on the contributions of life cycle stages.

can then be seen slowly declining on an annual basis due to assumptions regarding decarbonization of the electrical grid by 2050.[12] This was most pronounced for all-electric buildings (B), whose embodied carbon impacts far outweighed operational carbon over the full study period. However, for electric/gas buildings (C), the effects of decarbonization were less pronounced due to their continued reliance on the combustion of natural gas, and their median operational emissions eventually surpassed and far outweighed those of embodied carbon. Notably, and regardless of the energy source, **the median impacts from embodied carbon were larger than operational carbon in both 2030 and 2045.**[13]

This analysis suggests that **for new construction projects, mitigating embodied carbon should be a high priority, especially when considering near-term decarbonization goals** and targets in California. Reducing total energy demand, the reliance on fossil fuel-based energy sources[14] for buildings, and decarbonizing the electrical grid must remain important goals. However, the majority of these buildings' carbon emissions will go unabated without addressing embodied carbon. Furthermore, it is pertinent to mitigate carbon emissions released now in order to meet global climate targets.

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[12] See Key Finding #3 for further discussions and analysis of the potential impacts of different grid projections and assumptions.

[13] In California, SB100 and AB1279 mandate that by 2045, 100% of retail electricity be generated using zero-carbon sources and the entire state will achieve carbon neutrality by 2045, respectively.

[14] For the buildings we collected, natural gas was the only fossil-fuel combustion energy source used. However, many buildings utilize other fossil fuel sources such as coal, fuel oil, and diesel that are also important to reduce.

3. It is critical to decarbonize the grid AND reduce fossil fuels in buildings

The impacts of operational carbon varied widely across our dataset but there was a clear correlation with the drivers behind higher and lower operational carbon in buildings. Projects that reduced total energy demand and depended less heavily on natural gas consumption consistently produced fewer operational carbon emissions than those that didn't as illustrated in **Figure 3.**[15]

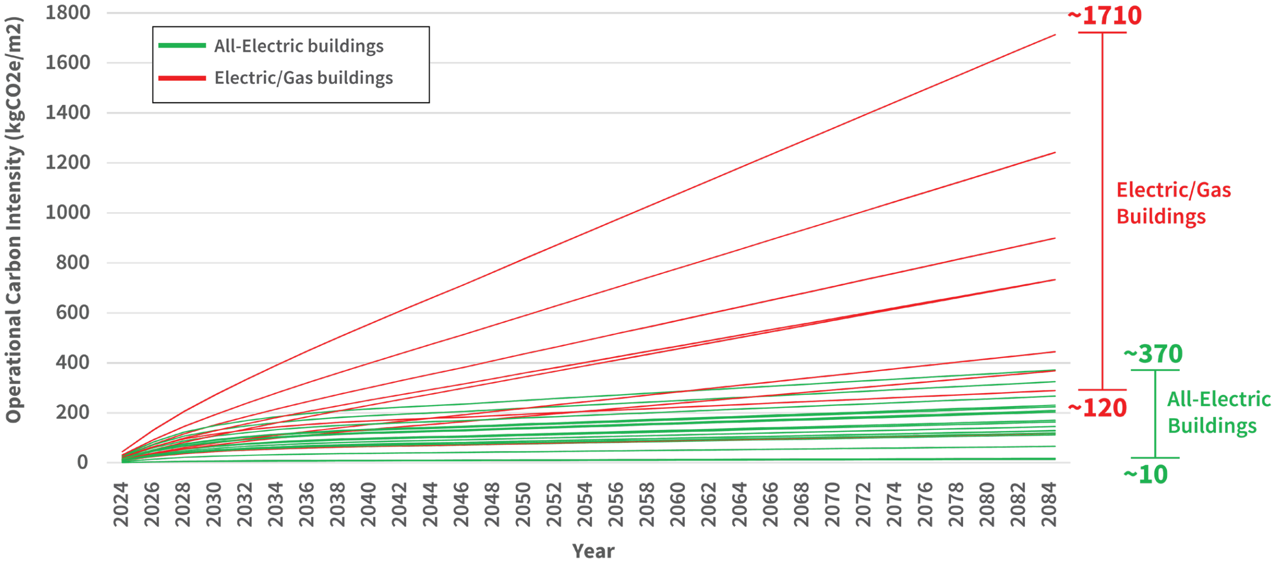

Figure 3. Cumulative operational carbon intensity (OCI) for all buildings by energy use category. OCI is shown for all-electric (green) and electric/gas buildings (red) over a 60-year reference study period.

When looking at the buildings by their energy use type **(Figure 4)**, the median embodied carbon impacts for all-electric buildings far outweighed those of operational and were a larger emissions type for every all-electric building analyzed (19 projects). Conversely, the median operational carbon impacts exceeded and far outweighed embodied carbon for electric/gas buildings (11 projects).

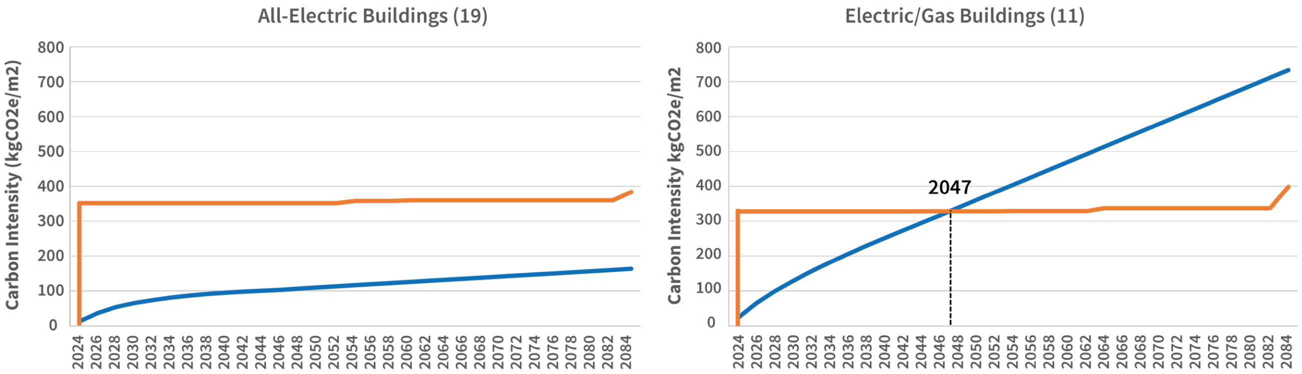

Figure 4. Median cumulative embodied carbon intensities (ECIs) and operational carbon intensities (OCIs) by energy use category. Results are shown over a 60-year reference study period with orange representing ECI, and blue representing OCI.

[15] It was also possible for several projects to consume more total energy and still produce fewer total emissions depending on their energy source. See Figure B2 of Appendix B in the full report for more analysis.

It's critical to note that **the carbon benefits of all-electric buildings are extremely dependent on the decarbonization of the electrical grid, as well as the energy demand and load profile of the building.**[16] In this study, we used assumptions about the decarbonization of the electrical grid over time that reasonably reflect the current mandates of California Senate Bill 100 to achieve a 100% zero-carbon energy grid by the year 2045.[17] We also explored a scenario in which California makes no further progress toward its decarbonization goals in **Figure 5.** Looking at the median of all 30 buildings, the black line reflects static grid emissions[18] for California that closely match the current reality of the grid, whereas the blue lines represent high, low, and mid-case grid decarbonization scenarios. Without any further grid decarbonization beyond current levels, median operational carbon impacts far outweighed those of embodied carbon over time.[19] However, under all three decarbonization scenarios studied, embodied carbon emissions outweighed operational emissions by the year 2084. This is why **it is critical to reduce fossil fuel combustion in buildings AND decarbonize the electrical grid.** The benefits of each will be lost if they are not achieved together and ongoing efforts in the State of California to do both of these, as well as reducing total energy demand, must remain important priorities.

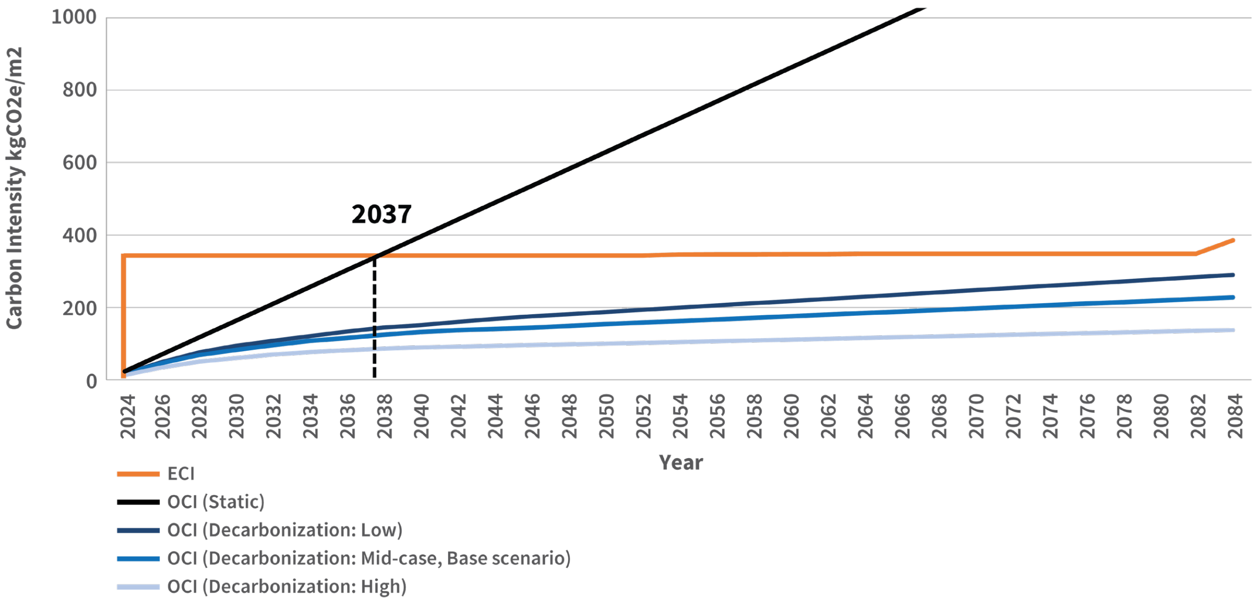

Figure 5. Comparison of the median cumulative OCI of projects studied when using static grid emissions (black line) and high, low, and mid-case grid decarbonization projections (blue lines).

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16. The carbon intensity of the grid is dependent on the types of power generation plants used to produce electricity at a specific time. This generation mix can change over time, influencing how and when it is least impactful and strenuous to consume grid electricity. For this study, average annual grid carbon intensity values were used, which represent the average of all plants used to generate electricity across the full year.
17. In this study, we used decarbonization projections from the 2022 NREL Cambium Dataset.
18. The static grid scenario was based on EPA's eGRID emission factors of 2022 data and represents what would happen if the grid does not change from its present structure and efficiency for California.
19. Buildings can support the decarbonization of the electricity grids by reducing total demand and flatten peaks in demand curves which correspond with times when more impactful generation plant are needed to meet increases in electricity demand. Although grid decarbonization is uncertain, the projections used have been rigorously developed to provide a reasonable estimate for likely future conditions.

4. Concrete and steel emissions are big, but they aren't the only things that matter

Most of our embodied carbon analysis focused only on the building's structure and enclosure, excluding other building elements and systems such as interiors, mechanical systems, and site work, due to limitations with our data collection. However, some data contributors submitted interior scope for their buildings and we found that including those **interior impacts increased the embodied carbon intensities of projects by an average of ~65 kg CO_2e/m^2,** representing an 18% increase in ECI when compared to structure and enclosures only. This increase was most significant for multifamily residential buildings which saw a 25% increase in ECI when compared to their respective ECI for structure and enclosure alone in **Figure 6.** The embodied carbon impacts of interiors are significant and should therefore be included as a minimum physical scope in building LCA policies. Interiors are also a key component when considering ECI in existing buildings that are renovated or retrofitted over time, which were not represented as part of this study.

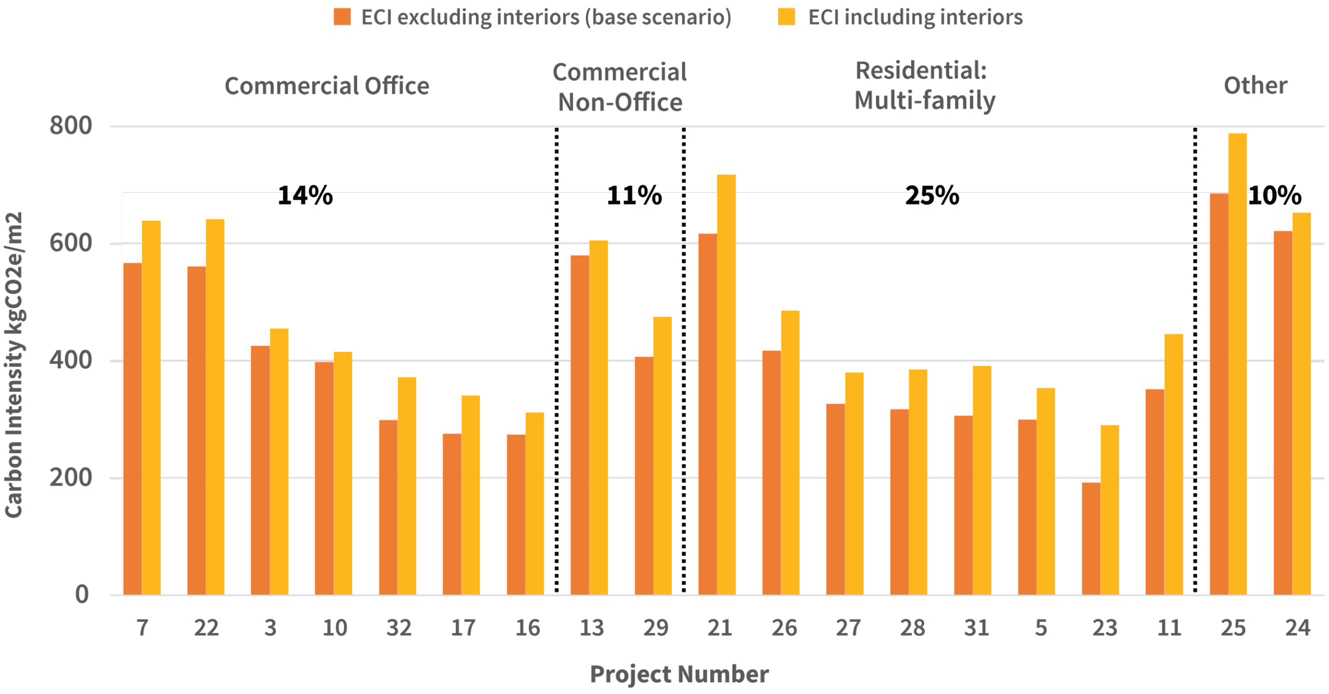

Figure 6. Comparison of embodied carbon intensity (ECI) for the 19 projects that contained interior scope when including and excluding the impacts of those interiors. Results are shown for each building's structure and enclosure impacts only (orange) and structure, enclosure, and interior impacts (yellow) assessed over a 60-year reference study period. Buildings are organized by their use type categories and the average percentage increases in ECI are shown for each type as a result of including interiors.

We also studied different contribution categories to see where the largest embodied carbon impacts were coming from. This was done by looking at structure and enclosure impacts only as well as the impacts of interior for projects that included them. The following findings are based on the projects that included interiors:

- **Division 03-Concrete** was the largest CSI division contributor[20] which averaged 47% embodied carbon impacts across projects followed by Division 05-Metals at 20%, and Division 09-Finishes at 10%. These were compared to other material categories like Masonry, Woods/Composites, Openings/Glazing, and others.

[20] Material categories/divisions were based on CSI MasterFormat which is a building material categorization system that is frequently used for developing design and construction specifications. Notably, most divisions include multiple types of materials and products. For example, Division 03 - Concrete, includes both the concrete and steel rebar or metal mesh used in most cast-in-place concrete elements.

- **Structural systems** were the largest building element contributor which averaged 62% of embodied carbon impacts compared to building enclosures and interiors.[21]
- **Life cycle stages A1-A3** (the product stages) were the largest life cycle stage contributors which averaged 78% of embodied carbon impacts compared to life cycle stages A4: Transportation, B4-B5: Repair/Replacement, and C3-C4: End of life.[22]

These large contributors are well understood by many building designers and policymakers and should remain important priorities. However, we also found that **the cumulative impacts of other contributors in each categorization can be significant, especially when looking at individual buildings.** For example, **Figure 7** shows the material division contributions of individual buildings. Here, the results are shown for structures and enclosures only (above), and for the buildings that included interiors (below). Buildings 16, 17, 23, and 32 all showed substantially higher impacts from materials associated with interiors, enclosures, and categories other than Div. 03-Concrete and Div. 05-Metals. For these projects and others, **focusing solely on upfront concrete or steel impacts would lead to significant gaps in embodied carbon accounting and miss out on critical opportunities for reducing the impacts of other materials, building elements, and life cycle stages.**[23]

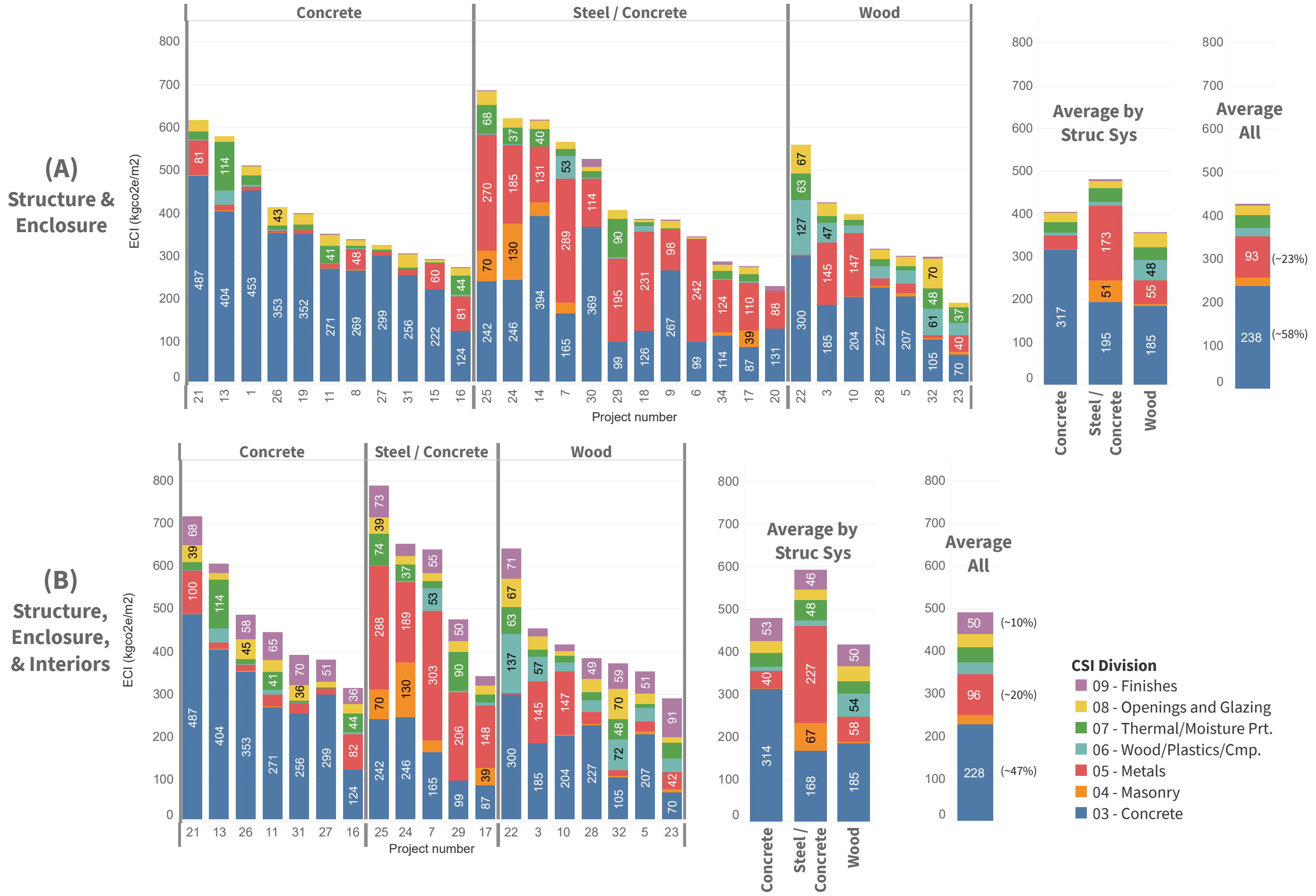

Figure 7. Embodied carbon contribution of CSI Divisions. Results are shown for the impacts of structures and enclosures only for all projects organized by the primary structural system (A), and for structure, enclosure, and interiors of the 19 projects that included interiors (B). All values are shown per individual project (left), and the average of projects (right) assessed over a 60-year reference study period. Results are in kg CO_2e/m^2.

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[21] This specific finding derives from Figure 20 in Section 4.3.2.2 of the full report.

[22] This specific finding derives from Figure 19 in Section 4.3.2.1 of the full report. For a full list of life cycle stages and names that were included in this study, see Figure 6 of the full report.

[23] When more physical building elements are included in life cycle assessments, embodied carbon impacts increase. Importantly, this also changes the relative percentage of contributions of different elements, life cycle stages, and materials. For more discussion see Key Finding #6.

5. Building-scale assessments are valuable

In order to meet the building sector's climate goals, we need to reduce all building-related emissions. For designers and policymakers, understanding the largest sources of emissions and the balance between embodied and operational carbon over time can be highly valuable. Life cycle assessment (LCA) and whole life carbon assessments (WLCAs) at the building scale can help contextualize the two types of emissions and offer pathways for their reductions.[24] As opposed to focusing on individual building components or selecting lower-carbon products based on EPDs alone, building scale assessments provide designers with the ability to **holistically account for all carbon impacts of buildings, understand where the largest contributors are, and when the largest carbon emissions will occur.** Rather than focusing on only a limited building scope, designers can make reductions across a larger range of materials and systems, from the beginning of the design process.

Even similar building types in similar geographies face different challenges during design and construction, as highlighted by the variability shown in **Figure 8.** With insights from building-scale assessments, designers can prioritize and select the specific decarbonization strategies that will work best for their unique and individual projects *during design.* For policymakers trying to regulate or incentivize decarbonization, building scale LCA policies also offers some of the largest potentials for embodied carbon reductions and the widest range of options for design teams attempting to meet policy requirements.[25] This is particularly important for the next few decades which are critical for reaching climate targets.

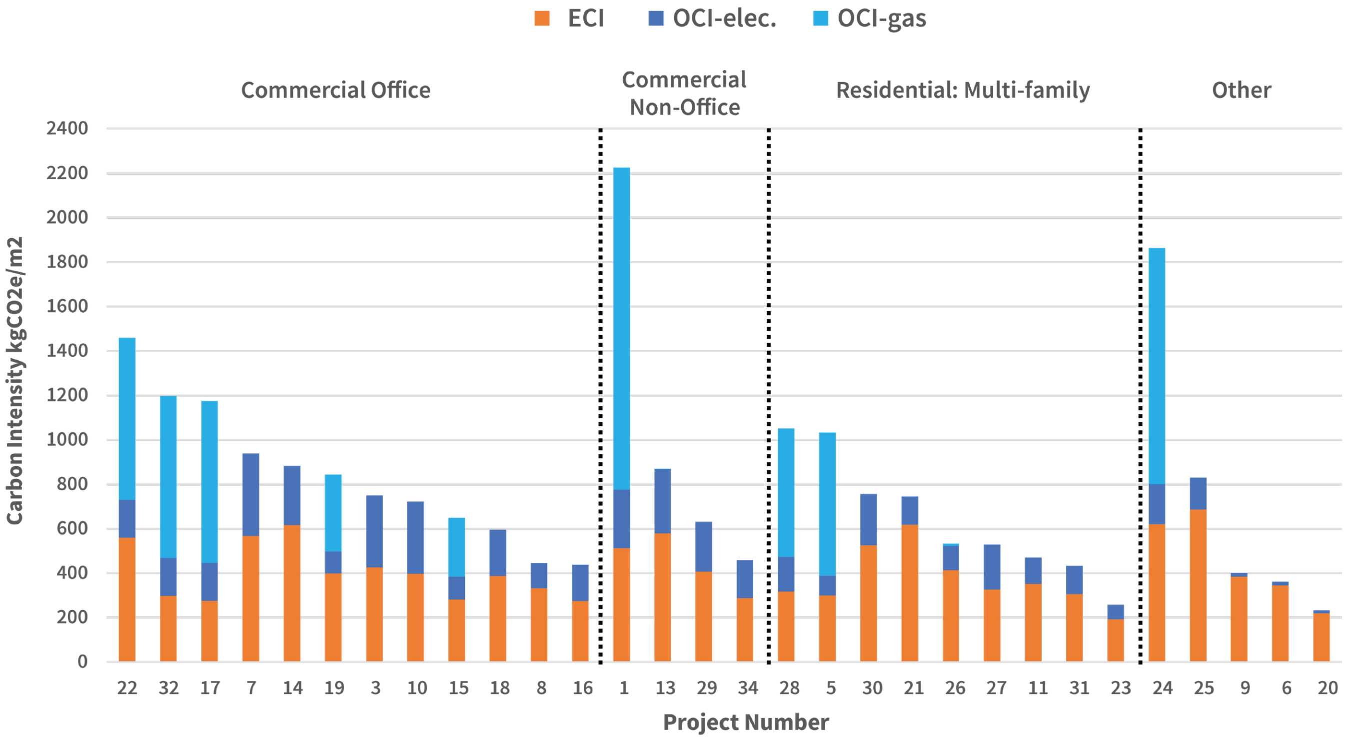

Figure 8. Embodied carbon intensity (ECI) and operational carbon intensity (OCI) of individual buildings. Results are shown for a 60-year reference study period with operational carbon impacts colored to show emissions associated with electricity consumption (dark blue) and natural gas combustion (light blue). Buildings are grouped by building use category.

[24] The difference between LCA and WLCA is that LCA focuses on multiple environmental indicators while WLCA looks only at carbon impacts (global warming potential, GWP).

[25] For more information on the potential benefits of a whole building approach, see CLF's past research on Developing an Embodied Carbon Policy Reduction Calculator..

All of the research and findings produced for this study were made possible by designers conducting building scale assessments. From a policy standpoint, **this shows the vast utility of information that is already being generated by many industry practitioners.** Policymakers can leverage similar data and methods for current or developing policies (such as AB2446) and also help improve the quantity and quality of LCAs being conducted. This can generate more information for researchers, designers, and policymakers to better establish benchmarks and decision-making strategies for building decarbonization at greater scales. Until researchers and policymakers have access to more and better data, a prescriptive list of decarbonization strategies that are effective at scale and for all projects will continue to be out of reach.

6. We don't yet know the full picture

The majority of data submitted by our contributors tended to reflect common LCA modeling and reporting practices used for compliance with existing policies, programs, and commitments such as the embodied carbon requirements of LEED, ILFI, AIA 2030, SE 2050, and others. We found that these practices demonstrate more consistent analysis of the upfront embodied carbon impacts for the structure and enclosure of buildings, but overlook or oversimplify the environmental impacts from other building elements and life cycle stages, which are often excluded from the scope of WBLCA assessments. As such, **the results and findings of our study are underestimates of full and comprehensive whole life carbon impacts.**

Additionally, our small data sample (30 buildings) made conducting statistical analysis difficult. For instance, we found no significant correlation between the embodied carbon impacts of buildings with different design attributes or categorizations, and we could not explain why some projects utilized more natural gas than others, or if its elimination would have been feasible for those buildings. While we believe our analysis is meaningful and can help inform current and future decarbonization policies, additional research is still needed to better understand the variability of impacts across projects before applying one-size-fits-all policies and design strategies that may not be effective, or even possible, for every project. Fortunately, our study suggests that the types of LCA requirements produced by mandatory or voluntary **reporting programs and policies can make a big difference in generating LCA data that can, in turn, generate more research, knowledge, and strategies for building decarbonization.**[26]

The following objectives were developed for policymakers that could help improve current and future building-scale LCA policies and research:

- **Require more building LCAs.** Publicly available data for the environmental impacts of building products and materials are growing quickly. However, there is still a lack of publicly available data on the carbon impacts of whole buildings that could be used to develop more accurate and meaningful benchmarks, targets, and reduction strategies for the whole life carbon impacts. Policymakers can:
    - Encourage the uptake of LCA and the generation of more data through voluntary or mandatory building-scale LCA policies.
    - Require or incentivize public disclosure of LCA results and impacts to aid in the development of transparent research and policy databases.
    - Encourage investment in public data (both material and building scale) at the federal level.
    - Include consideration of embodied carbon in existing policies and programs that currently focus on energy efficiency and operational emissions.
- **Expand the scope of building LCAs.** There are current limitations for quantifying every possible carbon impact of buildings. However, significant improvements and expansion to the scope of assessment used in this study are already possible within common LCA practices and tools. Expanding the status quo scope of assessment in current building LCA practices will lead to more realistic whole life carbon estimates

[26] Others have come to similar conclusions in a European context. See Towards embodied carbon benchmarks for buildings in Europe: #1 Facing the data challenge by Röck et al. for related discussion and recommendations.

and can help identify additional means for reducing the environmental impacts of buildings across their full life cycle. Policymakers can:

  - At a minimum, require the same scope of assessment used for this study (i.e., A1-A4, B4, B5, and C2-C4, for structure, enclosure, and interiors, plus B6 for building operations) which is entirely possible within current LCA tools and practices.
  - Expand the scope of assessment to require less common (but still feasible) physical and temporal scopes such as site work, MEP systems, and life cycle stages A5, B1, B2, B3, and C1.
  - Require or reference new and emerging WLC standards such as draft ASHRAE/ICC 240P[27] and RICS Whole Life Carbon Assessment (2nd Edition)[28] which provide additional methods and default values for scopes that are challenging to quantify using current building-scale LCA tools.
  - When concerned about data gaps or lack of industry capacity, consider pilot programs, reporting-only periods, or voluntary incentives.
  - Create frameworks that can be expanded easily over time as more building elements and life cycle stage scopes become more accessible.

- **Use consistent LCA methods.** The utility of LCA data for research, policymaking, and policy compliance relies heavily on making accurate and meaningful comparisons. Requiring consistent and harmonized LCA modeling and reporting methods enables appropriate comparisons across different buildings, geographies, and policies. This ultimately serves to better inform potential reduction strategies and policy pathways for more rapid decarbonization. Policymakers can:
  - At a minimum, develop clear modeling and reporting guidance as part of building scale LCA policies.
  - Encourage the use of standardized reporting templates.
  - Require or reference new and emerging WLC standards such as draft ASHRAE/ICC 240P and RICS Whole Life Carbon Assessment (2nd Edition) which provide clear and detailed modeling and reporting requirements.
  - Support standardized modeling and reporting of biogenic carbon in building-scale LCAs by aligning requirements with existing standards for the separate tracking of GWP from fossil fuel emissions and biogenic sources.[29]

For more policy recommendations, fact sheets, toolkits, and case studies related to embodied carbon, readers are encouraged to explore our policy resources at https://carbonleadershipforum.org/clf-policy-toolkit/.

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27. BSR/ASHRAE/ICC. (2024). Standard 240P, Evaluating Greenhouse Gas (GHG) and Carbon Emissions in Building Design, Construction and Operation: First Full Publication Public Review Draft. ASHRAE and International Code Council (ICC).

28. RICS. (2023). Whole life carbon assessment for the built environment (2nd Edition, Ed.) Royal Institute of Chartered Surveyors (RICS). https://www.rics.org/profession-standards/rics-standards-and-guidance/sector-standards/construction-standards/whole-life-carbon-assessment.html

29. Different methods are often used for assessing biogenic carbon that lead to incomparability between building LCAs. EN 15804:2012+A2:2019 is an LCA standard which includes clear requirements and guidance for reporting on climate impacts of fossil fuels (GWP-fossil), biogenic carbon (GWP-bio) and emissions associated with land use and land use change (GWP-luluc). EN 15804:2012+A2:2019 requires that each core impact category is reported separately and also requires that LCA results must include full cradle to grave impacts (A-C), which is especially important for biogenic carbon. Adopting this methodology in North American could greatly improve consistency and comparability of LCA results.

FIGURE NUMBER CONVERSION

The figures in this summary document are reproduced and renumbered from *The California Carbon Report: An Analysis of the Embodied and Operational Carbon Impacts of 30 Buildings*. **Table 2** lists the corresponding figure numbers in the full report to assist readers in cross-referencing between the two documents.

Table 2. Corresponding figure numbers between this summary document and the full report.

Document	Corresponding Figure Numbers							
The California Carbon Report Summary: Six Key Takeaways for Policymakers (this summary document)	1	2	3	4	5	6	7	8
The California Carbon Report: An Analysis of the Embodied and Operational Carbon Impacts of 30 Buildings (the full report)	9	11	14	12B	13	18	21	8

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