

Beyond the Carbon Divide - Aligning Objectives: Combining Operational and Embodied Carbon through Whole-Life Carbon Assessment

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1. Executive Summary

Good building design provides people with shelter, safety, comfort, health, durability, affordability, and long-term value. In various combinations of priority, these objectives will continue to define building excellence. But none can be reliably sustained in the absence of a stable climate. Increasing climate disruption threatens building durability, occupant safety, infrastructure, insurance systems, supply chains, and affordability itself. Reducing greenhouse gas emissions produced by buildings is therefore a prerequisite for achieving every other objective of good building design.

More than 150 years ago, Henry David Thoreau posed a question that has only grown more relevant: *"What is the use of a house if you haven't got a tolerable planet to put it on?"* Today, that observation has become an increasingly practical challenge for the building sector. Buildings cannot truly be considered healthy, resilient, durable, or affordable if the cumulative emissions associated with constructing and operating them contribute to destabilizing the climate on which those qualities ultimately depend.

Buildings are central to both the climate challenge and the climate solution.

Across their full life cycle, buildings generate greenhouse gas emissions through two primary pathways: the emissions associated with energy required to operate them (operational carbon), and the emissions associated with building material production, their supply chains, construction techniques, maintenance, replacement, and end-of-life processes (embodied carbon). The sum of these pathways, operational and embodied emissions, over the lifetime of a building, is referred to hereon out as "whole-life carbon".

Over the past two decades, major progress has been made in reducing operational carbon emissions through high-performance building design, electrification of building systems, and renewable energy systems. More recently, growing attention has turned toward assessment of embodied carbon.

Both developments are necessary, but they have evolved in parallel rather than together.

In some corners of the industry, operational and embodied carbon have even come to be treated as competing priorities—as though improving one inevitably requires compromising the other. This false tradeoff has led to fragmented standards, policies, software tools, and professional practice.

The earth's atmosphere does not recognize this distinction.

Whole-life carbon is therefore the proper basis for measurement of a building's climate impact.

The next phase of building decarbonization must move beyond optimizing for reducing operational or embodied emissions separately and focus on whole-life carbon, with this metric becoming as routine a design parameter as energy, cost, durability and occupant health.

Fortunately, the industry is not starting from zero. Mature frameworks focused on assessing operational carbon already exist, while methodologies focused on assessing embodied carbon are rapidly advancing. The challenge is no longer invention, but *alignment*.

That alignment must occur across disciplines, standards organizations, software tools, certification systems, public policy, manufacturing, and project delivery processes. It must also acknowledge that buildings are not optimized for carbon alone. Cost, resilience, durability, health, constructability, grid impacts, and long-term adaptability all

matter. The challenge is to optimize these objectives together, rather than treating carbon emissions as an isolated design problem.

This paper is an invitation to join this transition toward industry alignment.

We envision a building sector that:

- Evaluates operational and embodied emissions together rather than separately
- Optimizes to minimize whole-life carbon alongside affordability, resilience, durability and health
- Aligns building industry standards, certification programs and assessment tools
- Prepares markets for increasingly comprehensive codes and policies
- Builds collaboration across disciplines that have historically worked in silos

Importantly, this transition does not require abandoning existing progress. The tools, standards, and expertise developed across the operational and embodied carbon communities are valuable foundations for the next stage of work. The opportunity now is to connect them.

The decisions made this decade will shape building-sector emissions for generations. The urgency of climate action therefore requires not only continued progress within individual domains, but greater coherence between them.

This paper reflects a shared commitment by organizations that have historically focused on different aspects of building decarbonization. Together, we believe the next phase of climate leadership requires integrating operational and embodied carbon into a common framework for decision-making.

2. How We Got Here: Two Carbon Conversations

The separation between operational and embodied carbon was simply the product of history rather than the result of competing philosophies.

Operational energy measurement has roughly a 30-year head start on embodied carbon. The infrastructure for measuring how a building performs in operation is mature, familiar, and woven into the way projects are designed, financed, and approved.

By the time embodied emissions emerged as a serious focus in the early 2010s, decades of work on energy efficiency had already been integrated into building codes, utility programs, appliance standards, energy ratings, and professional practice. Embodied carbon entered an industry that had already established measurement practices. It emerged from different professional communities—life cycle assessment, manufacturing, and architectural research—bringing its own terminology, assessment boundaries, standards, and software. These approaches evolved largely outside the workflows used by energy modelers and raters, creating two parallel professional ecosystems: one well-instrumented and codified, the other newer and largely voluntary.

This separation was not, by itself, unreasonable, given the differences in how operational and embodied emissions arise, are measured, and are influenced by different decisions. But the separation left practitioners and policymakers to reconcile different approaches themselves, reinforcing the perception that operational and embodied carbon were competing priorities.

The pivot now underway is being led, in part, by practitioners rooted in energy efficiency. The sector's attention shifted from energy as a *resource* concern to include emissions as a *climate* concern. It is clear to many efficiency experts that operational emissions are not directly equivalent to operational energy; the carbon intensity of the electric grid, the timing of energy consumption, and the choice of fuel all impact the emissions associated with energy use. Once that distinction became clear – that measuring

operational emissions is different from measuring operational energy – it was a short step to recognizing that the emissions associated with building materials, produced before a building ever draws its first kilowatt-hour, belong in the same accounting. Practitioner-led organizations, including the authors of this paper, have increasingly demonstrated that design teams responsible for operational carbon are well-positioned to evaluate the embodied carbon implications of material choices.

Today, the foundations for convergence of operational and embodied carbon are largely in place. The remaining challenge is the practical integration of the existing evidence, standards, and tools needed for the transition.

3. What the Evidence Now Shows

The growing body of whole-life carbon research is converging on three important conclusions.

1. **Total greenhouse gas emissions across a building's life cycle—not operational or embodied emissions in isolation—determine climate impact.** Whole-life carbon approaches help identify emissions that may otherwise be overlooked. Focusing on only one stage of the building life cycle can obscure significant emissions elsewhere, just as evaluating insulation without considering air leakage or solar gains can misrepresent overall energy performance.
2. **The timing of emissions matters, with early emissions exerting a disproportionate influence on cumulative warming.** Whole-life carbon assessment also requires consideration of *when* emissions occur, not only *how much* is emitted. Emissions released earlier begin influencing climate sooner and continue contributing to warming until they are removed from the atmosphere. Because most embodied emissions occur before a building is occupied, they begin contributing to atmospheric warming immediately and continue doing so throughout the building's life. Operational emissions accumulate more gradually over time. Therefore, two buildings with *identical whole-life emissions* may have

different climate impacts over the coming decades depending on when those emissions occur.

3. **Projects that achieve excellent operational performance can also achieve low embodied emissions; the two objectives are not inherently in conflict.**

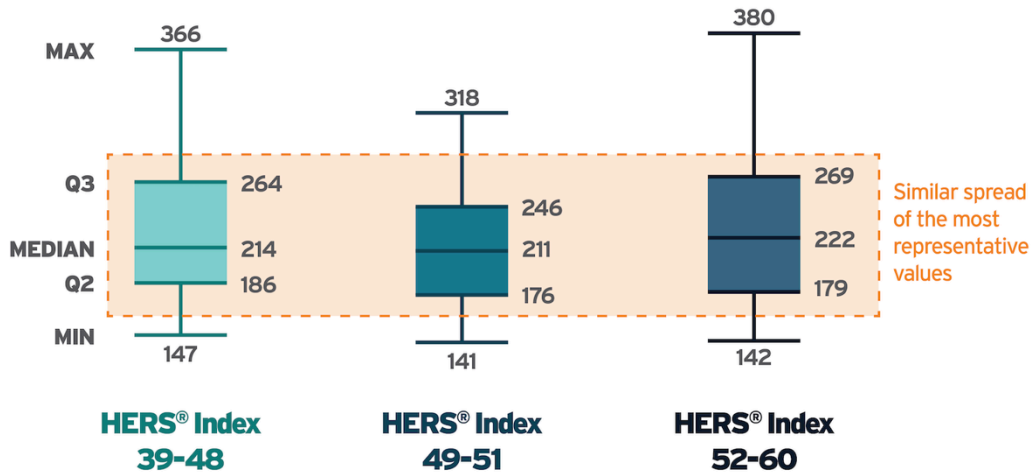
A common concern is that reducing operational emissions inevitably increases embodied emissions. Examples include additional insulation, higher-performance windows, or more complex mechanical systems. While individual design decisions can involve such tradeoffs, the evidence increasingly shows that these decisions do not need to compromise minimizing whole-life carbon emissions.

A growing number of studies demonstrate that buildings can achieve both low operational and low embodied emissions simultaneously, rather than supporting an either/or framing.

One such study, the Massachusetts 100 Homes Embodied Carbon Study (NEHERS et al, 2025), found that homes with the lowest HERS Index scores—the strongest operational performers—did not exhibit systematically higher embodied carbon than less efficient homes. Instead, embodied carbon intensities spanned similar ranges across all performance groups. These findings suggest that designers have sufficient flexibility in material and assembly selection to offset the embodied impacts of individual

energy-efficiency measures while still achieving excellent operational performance.

Net Embodied Carbon Intensities per Conditioned Floor Area by HERS® Index (kg CO₂e/m²)



Collectively, these findings support treating reductions in operational and embodied carbon as complementary aspects of whole-life carbon performance rather than competing objectives.

4. Tools and Standards Already Exist

If whole-building optimization is the appropriate design framework, the obvious question is whether today's tools and standards can support it. We believe they can.

Mature and rapidly improving tools for evaluating both operational and embodied carbon emissions currently exist. Although these tools were developed independently and are not yet fully harmonized, they already provide practitioners with practical pathways to whole-life carbon assessment.

The lack of harmonization among existing tools and standards is often called out as a sign of immaturity, but different tools produce different results because they were developed for different purposes and therefore use unique boundaries, assumptions, and methodologies. These differences do not necessarily indicate that one approach is correct and another is not; they reflect different assessment methods.

With so many variables, there is no single correct answer. Different assessment methods produce results that may each be appropriate for their intended purpose, but they are not always directly comparable. The challenge therefore is connecting tools in ways that simplify practice and enable better decisions.

Fortunately, examples of this alignment are already emerging between organizations in the residential sector.

- On the **operational carbon** side:
 - Phius provides a rigorous framework for evaluating building energy use, including source energy which correlates with operational carbon emissions.
 - Phius Certification is closely aligned with established residential programs including ENERGY STAR® and the RESNET HERS Index, allowing projects to leverage well-established energy modeling, rating, and verification practices.
 - RESNET's HERS Carbon Index further extends this framework by providing a standardized operational greenhouse gas metric alongside operational energy performance.
- On the **embodied carbon** side:
 - RESNET Standard 1550 (RESNET, 2025) establishes a framework for measuring, reporting, and verifying embodied carbon in low- and mid-rise residential buildings. The standard was intentionally developed to integrate with existing residential energy rating workflows, enabling practitioners who already perform energy assessments to incorporate embodied carbon assessments into their existing practice.
 - Builders for Climate Action's BEAM tool is implementing RESNET 1550 reporting, giving practitioners a practical pathway for conducting assessments within this standardized framework.

Taken together, these developments demonstrate something larger than the capabilities of any individual organization or tool. They show operational and embodied carbon assessment can now be integrated within a common professional workflow. By building on established energy-rating infrastructure while introducing consistent embodied carbon reporting, these complementary standards and tools provide an immediately available pathway toward integrated whole-life carbon assessment.

ASHRAE Standard 240 (ASHRAE, n.d.) under development is also taking a whole-life perspective on carbon emissions, and the building sector will continue to benefit from broader harmonization efforts such as the ECHO (Embodied Carbon Harmonization and Optimization) Project. (Architecture 2030 et al, 2023) But perfect harmonization is not a prerequisite for meaningful progress. The opportunity now is to extend this spirit of alignment across the broader building sector, accelerating the transition from parallel carbon conversations to integrated building practice.

5. A Better Design Framework: From Individual Performance Metrics to Whole-Building Optimization

Whole-life carbon is not another optional performance metric to be optimized independently or considered only after major design decisions have been made. Rather, whole-life carbon should be understood as a foundational design criterion that underpins the long-term success of every other design objective – occupant health, energy performance, resilience, constructability, and cost – throughout the design process.

Building professionals have always balanced multiple objectives simultaneously. Every project balances code compliance, structural requirements, cost, owner priorities, occupant expectations, constructability, and an expanding range of performance goals. Over time, the profession has successfully incorporated new priorities—including

energy efficiency, indoor environmental quality, resilience, and durability—into established design workflows. Whole-life carbon should follow the same path.

Importantly, incorporating whole-life carbon assessment into design does not mean minimizing carbon emissions at the expense of every other objective. It means recognizing that individual design decisions may involve trade-offs while the building as a whole can still be optimized across multiple dimensions. The evidence reviewed in the previous section demonstrates that buildings can simultaneously achieve low operational emissions, low embodied emissions, and excellent overall performance. Whole-building optimization—not isolated optimization of individual components—provides the appropriate framework for achieving these outcomes.

Every aspect of building performance has its own metrics, standards, and methods of evaluation. Good buildings emerge from integrating many forms of performance into a coherent whole. The future of building design lies in improving our ability to optimize buildings as integrated systems. Whole-life carbon is an essential part of that evolution, because a stable climate is the condition that allows every other measure of building excellence to endure.

6. Immediate Actions by Stakeholder

Whole-building optimization is not the responsibility of any one profession. It depends on coordinated action across the design, construction, manufacturing, financing, certification, and policy communities.

Practitioners

Architects, builders, energy raters, and sustainability consultants sit at the point where embodied and operational carbon conversations either converge or remain separate. The single most consequential change available right now is to evaluate carbon emissions as a combined metric, on every project, beginning in the earliest design

phase during which decisions about structure, envelope, and systems remain flexible. As methods for integrated operational and embodied carbon analysis continue to mature, well-supported prescriptive approaches will make these practices increasingly straightforward to implement.

As a starting point, practitioners should aim to:

1. Integrate whole-life carbon assessment into feasibility and schematic design alongside early-phase energy modeling, rather than as a post-design audit or solely for material selection and procurement.
2. Utilize the alignment already available—Phius for operational performance, RESNET 1550 with a compliant tool such as BEAM for embodied emissions—pending the development of a unified standard.
3. Maintain a design objective for low whole-life carbon, even when an individual design decision increases embodied or operational carbon emissions. Evaluate the whole-building outcome rather than the isolated tradeoff.
4. Build internal capacity where it most naturally lives: HERS and Phius Certified Consultants (CPHC)’s are the practitioner cohort closest to the workflows that embodied carbon assessment can now plug into.
5. Maintain pressure on policymakers and the demand-side. . Ask manufacturers to produce Environmental Product Declarations (EPDs). Insist on product transparency in specifications and procurement decisions. Advocate for carbon-based incentives and regulations

Programs / Certifiers

Certification programs and rating systems have done much of the work of translating sustainability intent into design practice. The next step is integration: enabling project

teams to report operational and embodied carbon together within a single whole-life carbon framework rather than through separate processes.

As a starting point, programs and certifiers should aim to:

1. Adopt, adapt, or recognize RESNET 1550 as the embodied carbon reporting standard for low- and mid-rise residential projects, in parallel with existing operational pathways.
2. Publish resources outlining a clear connection between programs that focus on operational carbon and those that focus on embodied carbon.
3. Develop and actively participate in harmonization efforts, with a goal to consistently co-analyze embodied and operational emissions together, as whole-life carbon.
4. Surface whole-life carbon as a headline result on certificates and labels so project teams, buyers, and homeowners see both operational and embodied carbon emissions reported.
5. Require EPDs for “hot spot” products, such as concrete, to further support demand-side pressure for product transparency.

Policymakers

Policy shapes the objectives that designers optimize toward. As whole-life carbon becomes a foundational dimension of building performance, public policy should encourage integrated evaluation rather than rewarding performance of one or the other in isolation.

As a starting point, policymakers should aim to:

1. Recognize embodied carbon reduction in any operational emission reduction-related building incentive, tax credit, or procurement program. At a minimum, begin by requiring disclosure, and ideally reward measured reductions.
2. Allow whole-life carbon performance as a compliance pathway in energy and emissions codes, on parity with operational-only pathways set to achieve broader climate goals.
3. Fund the research and data infrastructure required for embodied carbon assessment to become routine—default values, life cycle emissions reporting, public benchmarks, etc.
4. Establish data-driven prescriptive packages that support low-friction and efficient participation by practitioners already using prescriptive compliance approaches and align with prescriptive energy reduction policies.
5. Coordinate across jurisdictions to reduce reporting fragmentation; the more consistent the requirements, the lower the practitioner barrier to participation. Utilization of RESNET 1550 can support this alignment.

Manufacturers

The accuracy and usefulness of every embodied carbon assessment depends on the quality of the product data behind it. Manufacturers are not the only actors who can reduce embodied carbon, but they are the only actors who can improve the product data on which the rest of the system depends. Product transparency therefore enables better design decisions.

As a starting point, manufacturers should aim to:

1. Obtain and provide third-party-verified EPDs for all building products as part of standard product data packages, alongside Safety Data Sheets (SDS) and technical specification documents.

2. Disclose plant-specific and regional material data as appropriate for use in detailed product procurement tracking.
3. Invest in upstream emissions reduction—fuel switching, process changes, and other practices validated to provide carbon storage benefit —and report results transparently year over year.
4. Provide product data in digital formats compatible with the assessment tools practitioners use that allow for automated integration and analysis.

Investors / Developers

Investors and developers ultimately determine the objectives of a project. By treating whole-life carbon as a core measure of project quality rather than a reporting exercise, they can encourage design teams to pursue integrated solutions that deliver long-term environmental, economic, and social value.

As a starting point, investors and developers should aim to:

1. Require whole-life carbon reporting as a standard part of project due diligence, alongside pro forma and energy modeling.
2. Price whole-life carbon into capital decisions, particularly for choices that lock in long-term material configurations—structural system, envelope, primary HVAC distribution.
3. Favor retrofit and reuse where they reduce whole-life carbon, rather than defaulting to demolition-and-rebuild logic based on operational performance alone.
4. Communicate a building's whole-life carbon performance to occupants and buyers, because demand from end-users accelerates every other actor in this list.

None of these actions, taken individually, will transform building practice. Their significance lies in how they reinforce one another:

- *Designers require reliable product data.*
- *Manufacturers respond to market demand.*
- *Certification programs translate methodologies into consistent practice.*
- *Policymakers establish expectations that encourage adoption.*
- *Investors create incentives that accelerate adoption and innovation.*

Together, these actions move whole-life carbon from a specialized assessment to a foundational element of good building design and, ultimately, to an expected part of designing, constructing, and operating high-performing buildings.

7. Joint Call to Action

Buildings remain central to the climate challenge, and the climate solution. The building sector is entering a new phase of its response to climate change that no longer pits operational and embodied carbon against each other. The evidence now shows that both matter, both can be measured, and both can be reduced through whole-building optimization.

Our organizations have approached this challenge from different perspectives. We have developed complementary expertise in building science, operational performance, embodied carbon, and the tools and standards that support them. This paper reflects our shared conviction that these strengths are most powerful when they are brought together. Collaboration, not competition, will define the next generation of building decarbonization.

The tools exist and will evolve. The standards continue to mature. The evidence is compelling. What remains is the collective commitment to use them together.

We therefore call on every participant in the building sector—designers, builders, manufacturers, certification programs, policymakers, investors, researchers, educators, and owners—to make whole-building optimization, including whole-life carbon, the new standard of practice. Integrate the assessment into the earliest stages of design. Measure whole-life carbon consistently. Share data openly. Advocate for systems that create low-carbon outcomes. Continue improving and harmonizing the methods that enable better decisions. Above all, **recognize that reducing whole-life carbon is not separate from designing better buildings—it is fundamental to doing so.**

The buildings we design today will shape both the lives of their occupants and the climate they inherit. The next era of building excellence will be defined not by what any one discipline accomplishes independently, but by what we can accomplish together.

8. References

Architecture 2030, Building Transparency, Carbon Leadership Forum, International Living Future Institute, U.S. Green Building Council. 2023. ECHO Project - Embodied Carbon Harmonization and Optimization. [accessed 2026 Mar 31].

<https://www.echo-project.info/>

ASHRAE/ICC Standard 240P – Quantification of Life Cycle Greenhouse Gas Emissions of Buildings (in progress).

<https://www.ashrae.org/about/news/2025/ashrae-and-international-code-council-announce-second-public-review-period-for-proposed-emissions-quantification-standard>

NEHERS Alliance, Stephens & Company, Inc., Ekotrope, Builders for Climate Action, NMR Group, Inc. 2025. Massachusetts 100-Home Embodied Carbon Study. Boston, MA: Mass Clean Energy Center. [accessed 2026 Mar 31].

<https://www.masscec.com/resources/assessing-upfront-carbon-building-materials-homes>



RESNET. 2026. RESNET 1550-2025 Standard for Quantifying, Verifying and Reporting the Embodied Carbon of Buildings with Dwelling and Sleeping Units. Moorpark, CA: Residential Energy Services Network, Inc. [accessed 2026 Mar 31].

<https://drive.google.com/file/d/1S4UaMi9G5yqbWbR1-WBC5DOKh6StkWa-/view?usp=sharing>