Beyond Good Intentions: A Step-by-Step Guide to Low-Carbon Building Design

The building industry is grappling with its significant contribution to global carbon emissions (nearly 40% worldwide), and architects find themselves at the forefront of climate action.

The AIAVT COTE Committee is committed to working with members to uncover ways to approach low-carbon building design. This phase-based decision roadmap was developed for architects who recognize the urgency of reducing the level of embodied carbon in their projects but need guidance on when and how to implement low-carbon strategies.

This is both a planning tool and a project management resource. We hope it helps you translate broad goals into actionable decisions, whether you're taking your first steps toward net-zero carbon design or looking to systematize your existing sustainability practices.

THE CHECKLISTS

- Predesign
- Schematic Design
- Design Development
- Construction Documents and Bidding
- Construction Administration

THE SOURCES

American Institute of Architects. *AIA Framework for Design Excellence*. Washington, DC: American Institute of Architects, 2023.

Carbon Leadership Forum. *Strategies for Reducing Embodied Carbon*. Seattle, WA: University of Washington College of Built Environments, 2023.

Kuittinen, Matti, Alan Organschi, and Alex Ruff. *Carbon: A Field Manual for Building Designers*. New York: W. W. Norton & Company, 2022.

London Energy Transformation Initiative (LETI). *LETI Client Guide for Net Zero Carbon Buildings*. London: LETI, 2023.

London Energy Transformation Initiative (LETI). *LETI Specification and Procurement Guide*. London: LETI, 2023.

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PREDESIGN (PRE)

Client Role:

- Decide if you need a new building or if you can renovate an existing one.
- Set operational energy and embodied carbon targets.
- Establish a bid procurement strategy aligned with carbon goals.
- Confirm your budget and flexibility to incorporate low-carbon design.
- Develop your net-zero carbon brief (see checklist in LETI guide) to guide your decisions, priorities, and decision criteria
- Explore government incentives for low-carbon design.

Design Team Role:

- Include iterative energy modeling into the design budget for comparison of options and to support the LCA process.
- Frame energy modelling as a cost-control measure, not an add-on for sustainability.
- Include a commissioning agent in the design budget to establish testing requirements and assist in energy modeling and LCA.

SCHEMATIC DESIGN (SD)

Client Role:

- Set initial embodied carbon targets
- Communicate the low-carbon design intent to the whole design team.
- Communicate future maintenance requirements to design team early.

Design Team Role:

- Identify major carbon drivers (structure, envelope) to focus reduction efforts.
- Choose structural systems with low embodied carbon early. Structural systems have a large impact on embodied carbon in buildings so large reductions are possible with this decision.
- Right-size the building (improve user experience while reducing space).
- Build Less, reduce new floor area. Reduce below-grade construction
- Place the building on site to reduce soil displacement and removal of carbon-storing plants.
- Reduce mechanical scope and costs by working with existing shading, sun exposure, and windbreaks.
- Minimize the floor area to building surface area ratio to reduce volume, life cycle costs, foundation extent, and thermal exposure (HVAC loads and concrete volume).

- Examine tradeoffs between volume, daylight, electric light, ventilation, and energy use with the streamlined LCA[1].
- Simplify building volume/mass to reduce impacts from joints (additional material, structural detailing, lost energy during operation, vulnerability to weather, repair cycles).
- Optimize Daylight not with gross area of glazing, but effective placement (the most effective means of reduction by avoiding energy use).
- Reuse more existing building space or reclaimed materials.
- Build lighter by using less material and efficient structural systems.. Avoiding structural gymnastics = large carbon savings.
- Reduce operational energy use by controlling size, shape, and solar orientation.
- Reduce operational energy use with a well-designed envelope.
- Design a well-integrated and accessible service infrastructure to ease repair, replacement, and renovation.
- Make plans to generate or store energy for some demands (solar, wind, geothermal).
- Maximize the use of high-carbon materials when you must use them. (Use smaller quantities, configure their size and shape for future reuse, and make them durable to amortize their GWP over longer periods of time to balance their upfront emissions and reduce landfill waste).
- Document embodied carbon limits in project documents.
- Design continuous air barriers for efficiency (higher impact on energy use than thermal insulation).
- Study insulation and Mechanical systems for best results without diminishing returns on system cost.
- Use operable windows to turn off mechanical systems in good weather.
- Use energy benchmarks to evaluate design choices and established carbon reduction goals.
- Eliminate fossil fuels (Electrify).
- Plan ways to create energy on site (NZE).
- Investigate PV-ready.
- Use WBLCA to evaluate design choices.

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[1] Carbon: A Field Manual for Building Designers, Kuittinen, Organschi, and Ruff, 2022: Ch 2, pg 83. The streamlined LCA includes using BIM tools to report material quantities (BOM) and energy modeling to anticipate operational use. This shortcuts a full LCA process and is more feasible to design teams working on a fee budget, yet allows decisions to be made about system configuration and material GWP without requiring inordinate amount of design time.

DESIGN DEVELOPMENT (DD)

Client Role:

- Audit the design against carbon targets.
- Use carbon modeling (LCA) to test design options.
- Use Facilities Management best practices to mitigate refrigerant pollution and replacement impact by managing HVAC systems to avoid refrigerant leakage.

Design Team Role:

- Select materials with low production stage carbon (A1-A5) using EPDs and LCA tools.
- Ask manufacturers and vendors for EPDs.
- Substitute low-carbon materials for high-carbon ones.
- Choose insulation carefully, avoid petrochemical-based materials, and HFC-containing blowing agents.
- Select salvaged or refurbished materials.
- Source wood from sustainable, managed sources.
- Engineer the envelope to reduce operational energy use.
- Optimize physical assemblies for ease of construction and disassembly during and after the useful life.
- Acknowledge that the product selection process is not cut-and-dry. Tradeoffs will be necessary, and the lowest GWP products may not always work best for the matrix of project requirements.
- Use the hierarchy of material priorities to compare materials according to specific project conditions.[2]
- Assess relative weights and volumes of selected materials in building assemblies, then seek low-carbon alternatives, and quantify those you can't avoid for later evaluation/comparison/benchmarking.
- Minimize operational energy use, but weigh the emissions and toxicity of production and EOL stages of available air sealing, insulation, and other materials involved. What is the tradeoff between healthier materials and performance?
- Consider the future disassembly of the building (connections and fastening) to lay groundwork for reusability and avoiding the waste stream. Minimize

[2] Carbon: A Field Manual for Building Designers, p202: Hierarchy of Material Priorities (highest impact to lowest): 1) absorb and store carbon, 2) Reused/Reclaimed , 3) Recycled or high recycled content, 4) Virgin from non-renewable sources, 5) Chemically harmful.

adhesives, indiscriminate nailing, and interwoven assemblies that make razing easier than disassembly.
- Consider optimization, repeatability, and minimizing inconsistencies in pieces to lay the groundwork for reusability.
- Optimize the structural bays and beam/column sizing to minimize overdesign and lighten the weight of the structural system, reducing the volume of concrete needed in foundations and reducing fuel needed for transportation and erection.
- Ascertain what systems and materials have the greatest carbon reductions and prioritize your attention there.
- Research and adopt bio-based materials as much as possible (lower upfront emissions, can store carbon for the life of building[3]).
- Use passive design strategies to reduce the need for HVAC refrigerants. Use low-carbon refrigerants when necessary (possible higher cost – but significant reduction in carbon emissions).
- Continue to update the WBLCA to evaluate design choices and evaluate tradeoffs.

CONSTRUCTION DOCUMENTS AND BIDDING (CD AND BN)

Client Role:

- Finalize carbon reduction targets and agreeable options to meet them, and confirm design team includes them in an acceptable way in specifications
- Review constructability and supply chain issues against net-zero carbon criteria with the design team.
- Review substitutions of products and design changes to confirm equivalency in embodied carbon impacts

Design Team Role:

- Protect valuable decarbonization decisions made in SD and DD
- Clearly communicate decarbonization criteria for materials as each discipline writes their specification sections and annotates their drawings.
- Communicate decarbonization criteria, product evaluation requirements, and submittal requirements to the contractor in the specifications. Coordinate acceptable strategies, processes, and language with the owner.
- Prepare a range of potential material and system substitutions that satisfy the decarbonization goals. Obtain EPDs for the potential materials for supporting decisions and substitutions during construction.

[3]Carbon Leadership Forum: Strategies for Reducing Embodied Carbon: Includes mass timber, laminated bamboo, fiberboard, straw, hem, linoleum, cork.

- Develop criteria for assessing proposed changes.
- Integrate EPDs into submittals and GWP limits into specifications.[4]
- Optimize concrete mix for low-cement content in specifications.
- Evaluate cost and carbon in the bid process.
- Specify commissioning to make sure results match specifications. Expensive, but pays back quickly based on quality assurance.
- Include whole-building blower door testing in the specs, ideally with a maximum infiltration rate close to passive house (0.08 cfm @75 Pa)
- Cross-check the design team's documentation periodically to coordinate decisions being made by other people, and how secondary materials and systems impact decarbonization. [5]

CONSTRUCTION ADMINISTRATION (CA)

Client Role:

- Commission a post-completion carbon summary to document targets and achievements.
- Identify an owner's representative to be a site-based Net Zero Carbon champion/manager who communicates the strategy to achieve NZC to all contractors and stakeholders.
- Review product substitutions for carbon impacts with the design team.
- Track construction-phase emissions (A5).
- Keep Net Zero Carbon risk register[6].
- Measure planned vs actual carbon reduction.
- Measure planned vs actual energy use.
- Retro-commission for the first three to five years to adjust systems to stay within the success criteria and to document achievement for publishing.

Design Team Role:

- Protect design decisions and the carbon reduction goals when reviewing submittals, RFIs, substitutions, and change orders.
- Review EPD and GWP criteria with contractors in construction meetings so unfamiliar participants know what is expected.

[4] Refer to LETI's Procurement and Specification Strategy for more information about specification techniques to incorporate low-carbon design into your project manual. The AIA Framework for Design Excellence also contains similar information.
[5] (Are high-carbon materials being used to fasten, flash, or support low-carbon materials? Are adhesives being included that don't support disassembly goals?)
[6] Refer to LETI Client Guide for checklist and risk register templates/examples.

- Be aware of ways conventional solutions may impact the carbon reduction goals of the project and get ahead of them (i.e.: more sealant to solve a layout problem, more adhesive than necessary, rogue decisions that increase material volumes).
- Provide general oversight of construction, with extra emphasis on continuity of the air and water control layers.
- Support owner's work to measure carbon during construction so post-occupancy analysis is meaningful.