EMBODIED CARBON IN NEW CONSTRUCTION GUIDANCE

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INTRODUCTION

Executive Order 18-01 has established requirements for Washington State agencies to consider and lower the emissions associated with building materials, as stated below:

> *(1) When making purchasing, construction, leasing, and other decisions that affect state government's emissions of GHGs or other toxic substances, agencies shall explicitly consider the benefits and costs (including the social cost of carbon) of available options to avoid those emissions. Where cost-effective and workable solutions are available that will reduce or eliminate emissions, decision makers shall select the lower-emissions options.*
>
> *(1b) Directors shall ensure that all newly- constructed state-owned (including lease-purchase) buildings shall be designed to be zero energy or zero energy-capable, and include consideration of net-embodied carbon.*

The purpose of this document is to provide guidance to Agency project teams on how and when to make considerations related to embodied carbon, and what actions may be taken to reduce it.

DEFINITION + CONTEXT

Embodied carbon refers to the greenhouse gas (GHG) emissions associated with extracting, manufacturing, transporting, and installing the materials used in a building project. Embodied carbon is measured in units of carbon dioxide equivalents (CO_2e).

Most of a typical building's GHG emissions over its lifetime are from the operational carbon, or the emissions associated with energy consumption. However, as building energy efficiency increases, the embodied carbon of a building's materials become a significant percentage of a project's lifetime impacts. Studies have shown that in the first 30 years, embodied carbon can account for over half of emissions for a typical building and up to 80% of the emissions for a high-performance building*. Also, unlike operational carbon, embodied carbon cannot be reduced over time; any emissions generated in material production and construction cannot be taken back. Thus, embodied carbon is an important issue for consideration in the early stages of a project's development cycle.

State agencies can significantly reduce embodied carbon in their building projects by utilizing strategies that include reuse of buildings and materials, promoting material-efficient design, and selecting low-carbon products from the local region. The following page outlines key actions and strategies in each phase of the project development cycle; followed by material-specific guidance, tools and resources that can be referenced by project teams.

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* Architecture 2030, *New Buildings: Embodied Carbon* (2018)

PRE-DESIGN

Include low carbon emissions in the site selection and development criteria:

- ☐ Build only on previously developed sites
- ☐ Restore any undeveloped portions of the site area with native vegetation

Conduct an inventory of the site resources:

- ☐ Identify buildings or in-situ materials with highest potential for reuse

Include strategies to reduce building material quantities in the Pre-Design package, including:

- ☐ Reduce floor area by optimizing the program and considering multiple uses for spaces
- ☐ Design for flexibility to eliminate future waste (e.g. open floor plates, moveable partitions)
- ☐ Specify a compact and efficient structure that reduces or eliminates redundancy

DESIGN

Conduct iterative embodied carbon assessments[1]:

- ☐ Conduct an initial life cycle assessment (LCA) in Schematic Design to form a baseline of the embodied carbon of the project (see TOOLS)
- ☐ Use the LCA to identify "hot spots"; materials or assemblies with highest carbon intensities
- ☐ Set a carbon reduction target for the project
- ☐ Use the LCA to test lower carbon design or material alternatives, specifically for materials of the foundation, structure, and enclosure

Select building systems and assemblies that minimize embodied carbon:

- ☐ Specify pre-fabricated assemblies that reduce material waste and construction time
- ☐ Evaluate the use of carbon-sequestering structural systems such as mass timber
- ☐ Minimize the use of interior finish materials (e.g. polishing concrete instead of carpet, open structure without drop ceilings)
- ☐ Design for deconstruction to minimize waste generated at the end of the project life (e.g. mechanical fasteners, modular design)

Specify material characteristics[2] that result in low embodied carbon, including:

- ☐ Salvaged or reclaimed materials
- ☐ Locally harvested and/or manufactured
- ☐ Manufactured using renewable energy
- ☐ Contains high recycled content
- ☐ Naturally carbon-sequestering (e.g. wood, bamboo, cork, straw, hemp)
- ☐ Sustainably harvested with third-party verification (e.g. FSC certification for wood)
- ☐ High durability with long service life

Document embodied carbon design decisions in the final Basis of Design

- ☐ Summarize the methodology used to make decisions related to embodied carbon
- ☐ Record the embodied carbon of alternatives considered, and estimated avoided impacts (measured in CO_2e)

CONSTRUCTION

Request embodied carbon data during Contracting and Procurement:

- ☐ Select products with a type III Environmental Product Declaration (EPD), as defined by the International Organization for Standardization (ISO) Standard 14025, or equivalent
- ☐ Select product alternatives with lowest documented embodied carbon value

Reduce construction waste:

- ☐ Procure materials at appropriate quantities to eliminate extras and reduce packaging
- ☐ Divert the maximum quantity of construction waste from going to the landfill (i.e. recycling)

Document the as-built embodied carbon content:

- ☐ Inventory the final material and product selections, including quantities
- ☐ Conduct a final LCA to document the total embodied carbon of the project
- ☐ Consider carbon offsets to account for the remaining embodied carbon

[1] See **TOOLS** on the following page

[2] See **MATERIAL GUIDANCE** on the following page

MATERIAL GUIDANCE

Concrete

- Reduce cement content; use supplementary cementitious materials (SCMs)
- Specify local, recycled and strong aggregates
- Specify Portland limestone cement (PLC) instead of Portland cement
- Utilize appropriate mixes for each application; specify high-strength only where needed
- Select from the lowest energy kiln type; e.g. dry with preheater and precalciner
- Utilize CO_2 injection technology if applicable

Steel

- Procure steel produced in an electric arc furnace (EAF), avoid steel from a basic oxygen furnace (BOF)
- Avoid the use of hollow structural shapes and metal decking, utilize rebar only if needed
- Utilize salvage or reclaimed steel
- Specify high recycled content (90%+)

Wood

- Utilize reclaimed wood where possible
- Specify wood from certified sustainably managed forests (e.g. FSC certification)
- Specify fast-growing wood species
- Specify wood products manufactured using electricity and/or renewable energy

Insulation

- Minimize or avoid foam-based insulation products such as Expanded Polystyrene (EPS), Extruded Polystyrene (XPS), Polyisocyanurate (Polyiso), Structurally Insulated Panels (SIPs) and spray foam
- Use blown-in insulation in wall cavities
- Protect insulation from heat and water
- Consider natural insulation alternatives, such as wool, cork, denim or hemp

Information Source: Carbon Smart Materials Palette

See **RESOURCES** for additional guidance

TOOLS

Embodied Carbon in Construction Calculator (EC3)
https://buildingtransparency.org

Open-source materials comparison tool and EPD database that enables evaluation of embodied carbon data across material classes.

Tally
https://choosetally.com

LCA application that integrates with Autodesk® Revit® to allow comparison of design alternatives and direct reporting of environmental impacts.

Athena Impact Estimator
https://calculatelca.com/software/impact-estimator

LCA tool that allows users to create unique assemblies and envelope configurations, allowing flexibility for complex designs and existing buildings.

One Click LCA
http://www.oneclicklca.com/green-building-software

Web based LCA tool with editable baselines that permits rapid comparison of design and material alternatives. Based upon European product data.

eTool
http://etoolglobal.com

Free web based LCA tool that can either use predefined assemblies or allow the user to create their own. Based upon Australian product data.

RESOURCES

Zero Carbon Certification – International Living Future Institute (ILFI)
https://living-future.org/zero-carbon-certification

Certification system that addresses operational and embodied carbon.

Carbon Leadership Forum
http://www.carbonleadershipforum.org

Industry-academic collaboration of manufacturers, designers, builders and researchers focused on reducing embodied carbon in building materials.

Carbon Smart Materials Palette
https://materialspalette.org

Attribute-based design and material specification guidance for procuring low embodied carbon products in common material types.