EMBODIED CARBON REDUCTION: DRAFT

OFFICE OF SUSTAINABILITY

UNIVERSITY *of* WASHINGTON

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DEFINITIONS

Scope 1 Emissions: Fossil fuels combusted on site: Direct emmissions through facilities, energy used, and vehicle miles.

Scope 2 Emissions: Indirect emissions "downstream" of the organization: investments, transportation and distribution of products, and so on. Largely purchased electricity.

Scope 3 Emissions: Indirect emissions "upstream" of the organization. Purchased goods and services, employee commute emissions, and so on.

Embodied Carbon: the emissions associated with materials and construction processes throughout the whole life cycle of a building

Operational Carbon: the emissions associated with energy used to operate a building

Project Delivery Group (PDG): UW Department managing capital projects and developments on campus, from repairs to renovations to new structures.

Energy Use Intensity (EUI): A measure in kBTU/sf of energy consumed by a building over a given period of time.

Benchmarks given in "Existing Policy".

SBC: Seattle Building Code

Schematic Design (SD): First phase of architectural design, laying out the basics of a project.

Detailed Design (DD): Second design phase. Building off of Schematic Design, this involves consulting engineers and other design professionals to develop the specifics of a design.

Construction Documents (CD): the final stages before construction, involving both architect and contractor.

Gould Hall, College of Built Environments

SUMMARY

The purpose of this document is to provide a brief overview of Embodied Carbon as it relates to UW's building and construction practices: existing policies, areas of opportunity for the university, and examples for how it might be implemented in the future as we work to amddress scope 3 emissions.

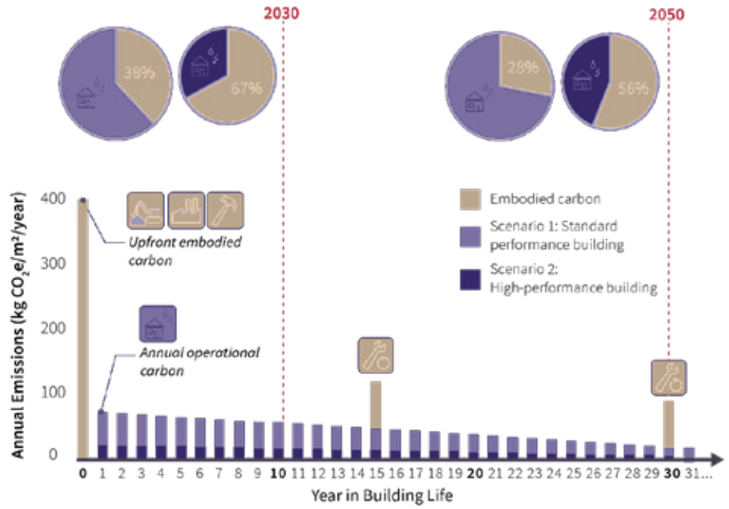
The University follows a mix of state, city, and organizational policies regarding Green Building standards. UW's current standard requires that each new construction be built to a minimum of LEED Gold with an energy conservation target of 15% and a water conservation target of 50% below values laid out in local building codes.

Each one of the standards mentioned above is changing, though. At the State level, a Buy Clean/Buy Fair study, conducted in 2021, was proposed as legislation. At the city level, the SBC is undergoing an update and revision with a Building Emissions Performance Standard, and finally, at the organizational level, our UW Green Building Standard is undergoing an overhaul in which we pivot closer to the models used by the University of British Columbia or UCs.

Through the project delivery process, we can target different types of projects and procurements. Recommending tools, resources, and regulations, influenced by existing research and organizations around Seattle allows us to monitor and reduce Embodied Carbon.

INTRODUCTION

Embodied Carbon is a measure of the footprint of architecture within its materials. 90% of this is accounted for before a building begins its operational lifespan, the remaining 10% is emitted during retrofits/upgrades/improvements. Contemporary commercial buildings are assembled from materials extracted through energy-intensive processes, manufactured using vast amounts of energy, and often transported thousands of miles. The electricity used in furnace operation at a recycled steel mill. The fuel burned while transporting concrete. The kilograms of CO2 released through burning in the production of Portland cement. Each of these sources fall into the category of embodied carbon. Embodied carbon is pervasive through every element of our built environment from structural members to insulation to roadways to interior finishes.



As in the figure above, EC emissions (in gold) are concentrated during construction times, while OC emissions are continuous over the lifespan. In the first 10 years of a building's operation, 66% of its carbon footprint is embodied. As operational carbon accumulates over the years, this percent decreases until it reaches 50% by the end of its functional lifespan.

As time goes on, 50% of carbon emissions are anticipated to be addressed through clean energy legislation, technology, and education. The embodied piece remains largely unaddressed, increasing its relative importance.

INTRODUCTION

EXISTING POLICY: OPERATIONAL CARBON

Operational carbon is addressed well through policy at both the city and the university level. We begin with these before moving to state regulations, as these are all changing differently. The UW lies within a Major Institutional Overlay (MIO) zone in the code and so must comply with both the Seattle Building Code (SBC) and additional UW requirements. These two sets of regulations are as follows:

With respect to commercial typologies for example- Seattle's 2015 energy code sets out the following approximate EUI baselines for commercial typologies, first approximated in 2012 through cursory analysis of numbers provided by various Seattle-area engineering firms:

Group B Office: 40 kBTU/sqft/yr

Group B medical office: 50 kBTU/sqft/yr

Group R-2 multi-family: 35 kBTU/sqft/yr

Group S01, S-2 warehouse: 25 kBTU/sqft/yr

Group E School: 45 kBTU/sqft/yr

Group M Retail: 60 kBTU/sqft/yr

Group I-2 Hospital: 150 kBTU/sqft/yr

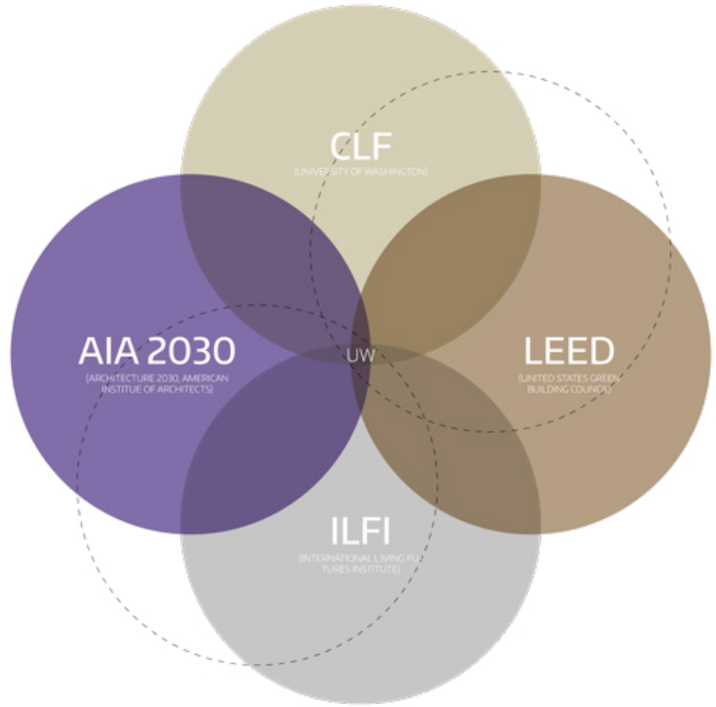
The University of Washington builds even further on this energy code, requiring 15% additional efficiency below the 2021 Seattle Energy Code for new construction.

The Washington Clean Buildings Energy Performance Standard (for new construction with mandatory compliance beginning in 2026) creates energy performance standards for commercial buildings over 50,000 SF. This is complemented by the Seattle Building Emissions Performance Standard, which is projected to reduce building emissions by 27% by 2050, and policy development on both these standards is scheduled through 2026.

UW's Sustainability Action Plan addresses operational carbon with a 45% reduction target from a 2005 baseline, however it does not address Embodied Carbon. UW plans to update the Sustainability Action Plan to include more aggressive targets around operational and embodied carbon emissions.

EXISTING POLICY: EMBODIED CARBON

The Carbon Leadership forum at the University of Washington is a globally recognized nonprofit providing technical expertise, research, and collaboration on embodied carbon. A key role of my internship is bringing UW Sustaiability and the CLF together to begin this work together, analyzing how we could best address embodied carbon. The following pages are a report on several existing standards that cover EC:



Embodied Carbon Resources in washington

LEED

The LEED framework revolves around 7 pieces, of which one is Materials and Resources. Within the Materials and Resources palette, Embodied Carbon is addressed briefly through points being awarded for completion of Whole Building Life Cycle Assessments and EPDs as well as minimization of material transport distance. LEED v4 added a set of LCA requirements which contribute towards points. These prerequisites and credits are applied during the Construction Phase for LEED Submittals,

closer to the end of the system phase than the project phase.

It is challenging to earn credits through procurement of low EC materials: to earn LEED v4 credit, EPDs cannot be compared unless they use compatible datasets, limiting any individual attempting to compare material types. Further, out of 100 possible LEED points, providing EPDs results in one singular credit, a small incentive for a large investment. LEED further requires the general contractor to compile a report with a summary of all quantities and supplier's locations (through completion of the primary structural frame) once construction documents are 100% complete. LEED awards a total of 1.5 points for a complete life cycle assessment; consequently in many situations designers determine that it is not worthwhile to conduct embodied carbon tracking to meet current standards. LEED v5 however will address embodied carbon in a slightly more comprehensive manner.

Note: Buy Clean Buy Fair

BCBF is a proposed state-level regulation (HB 1103) that regards reporting for materials and procurement. Pilot projects for this regulation include Milgard Hall in Tacoma and the Interdisciplinary Research Center in Seattle. The BCBF policy requires collection of EPD data and project quantities, and subsequent submittal to a database.

INTERNATIONAL LIVING FUTURES INSTITUTE:

The International Living Futures Institute's challenge (Living Building Challenge) revolves around 9 petals of which one is, similarly, Materials. The Materials petal specifies a short set of guidelines for documentation and data surrounding Embodied Carbon Reduction as outlined in the LBC Ready Documentation Requirements for 4.0.

OTHER STANDARDS

- Architecture 2030/AIA 2030 Committment

  The AIA challenges firms to reduce their material GWP to the following percents below current industry averages: 45% by 2025, 65% by 2030, and zero GWP by 2040. The DDx Database allows firms to see their own data across projects but is otherwise limited in functionality as it is neither publicly accessible nor simple to compare across firms.

- SE 2050

  This is a committment by Structural Engineers, firms sign on. The SEI, or Structural Engineering Institute, sets out guidelines to bring structural materials to zero embodied carbon by the year 2050.

- MEP 2040

  A committment by Mechanical, Electrical, and Plumbing, where participating firms committ to establishing a company plan that would bring components to net-zero by 2040, request EPDs, and require Low-GWP refrigerants.

Net-zero is an ambitious goal for each one of these fields in a unique way: architects, structural engineers, and MEP professionas all require the use of carbon-intensive components and assemblies. A great amount of innovation and dedication will be needed for every firm to meet their targets.

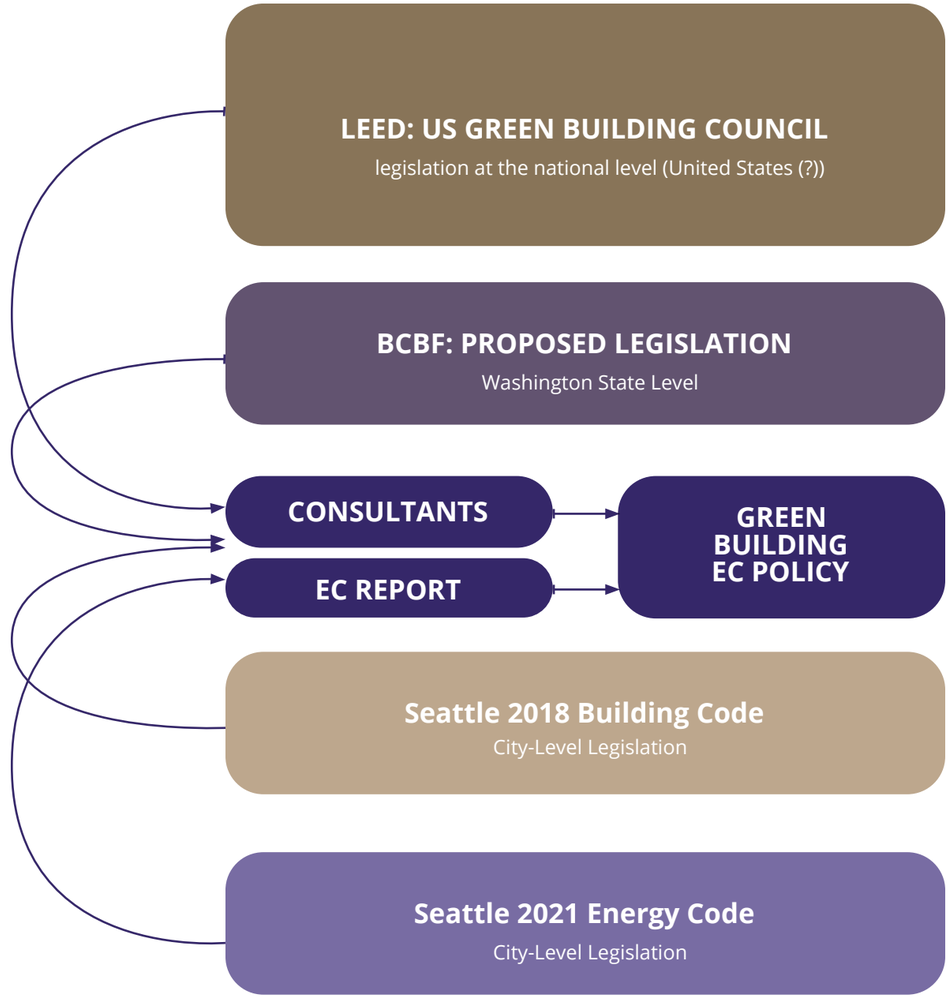


Diagram: Policy Landscape

EMBODIED CARBON STANDARDS

It is time for UW to address Embodied Carbon at an institutional level. Partnering with these existing organizations, this report should be used as a resource to better address embodied carbon reduction as UW updates its existing green building standard. In three sections, the first, Project, corresponds approximately to the Schematic Design and Concept Design phases, System is Design Detail (DD), and Procurement takes us through CD (Construction Documents), CA (Construction Administration), and Construction itself.

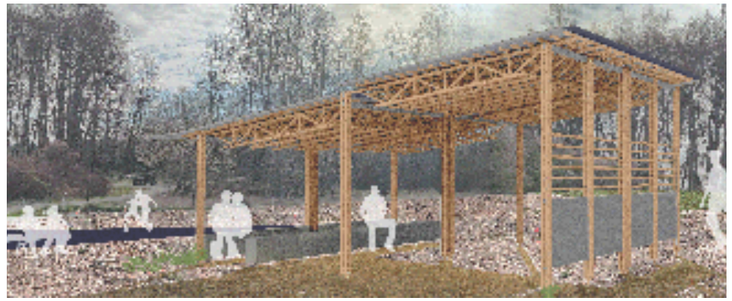


Photo Representing Conceptual/Schematic Design

SECTION 1: PROJECT

PROJECT TYPE

The first, or “project” phase of development, is led by Campus Planning as well as by the architect or designers involved. The decision to demolish or adaptively reuse is often one of the first made in this phase. As of now, it is stated within UW regulations that “Demolition may be permitted prior to future development where authorized by any required permit”, and “any grading work is reviewed under the Grading Code” (SMC Chapter 22.170).

The project phase encapsulates planning and Schematic Design (SD), generally carried out by

When it comes to new projects, although there are “greenfield sites” on campus that have not yet been developed, most projects fall under the category of redevelopments. Architecture 2030’s CARE Tool provides a starting point for determining whether replacement or reuse is the best path forward to minimize emissions.

SCOPE: CAMPUS MASTER PLAN FOR DEVELOPMENT

The campus master plan allows for approximately 17 million square feet of new development across 86 separate campus sites. Of that total, 12 million are slated for new construction while 5 million are sites on which existing structures or lots are already built.

Many of the proposed action sites are existing buildings slated for demolition and reconstruction or extensive renovation. The CARE Tool, widely used by architects around the Seattle area and developed by Architecture 2030, provides initial carbon emissions estimates for full demolition as compared to adaptive reuse. We recommend that the first step of the project phase consult the CARE Tool or a similar system to inform the decision regarding demolition or adaptive reuse.

After consulting the CARE Tool, consult with UW’s updated Green Building Standard ‘Project Types’ to identify what requirements will apply:

PROJECT TYPE	PROJECT BUDGET (USD)
New Buildings- Large	5M + (>3000 SF)
New Buildings- Small	5M + (<3000 SF)
Major Renovations	5M +
Partial Fit-Outs	1 - 5 M
System Upgrades	N/A

Project Types Chart

NEW CONSTRUCTION EC STANDARD

New constructions provide some of the greatest opportunities to reduce embodied carbon. Methods (suggested in chapter 3, Policy,) could include parametric modeling to select materials, life cycle assessment (LCA), and monitoring carbon impact using specifications.

RETROFIT/REMODEL EC STANDARD

Renovations and upgrades often target Operational Carbon in terms of building energy usage. However, similar standards can be applied in the sourcing of materials such as interior finishes. Thus, retrofit standards begin with procurement.

PHOTO: CULTURAL KITCHEN, NEIGHBORHOOD DESIGN BUILD STUDIO

SECTION 2: PROCUREMENT

PROJECT TYPE

The procurement phase encapsulates creation of specs/construction documents through final comissioning, or CD.

Systems engineering is the second phase of a project in which designs are finalized and construction documents are produced. The CLF provides a list of tools that can be used in this segment:

https://carbonleadershipforum.org/tools-for-measuring-embodied-carbon/

During the systems phase, architects must decide which investments in terms of EC are the most beneficial. Would a differing structural material choice lower carbon more, or would investment in different interior finishes be better given a certain timeframe and budget? These decisions are difficult to make independently of guidance and vary greatly from project to project. Consequently we leave it to the architect and project engineers to decide this.

The procurement phase includes all specification and purchasing of materials and services. Purchasing consequently is the point at which these guidelines begin falling into place in the real world.

Supply chain emissions are 11.4 times higher, on average, than their operational emissions (CLF Owner Toolkit). This means that as we strive for supply chain emission reduction, we can have greater than 10 times the positive impact. This is the power of sustainable purchasing.

The CLF recommends the following steps for low-carbon procurement:

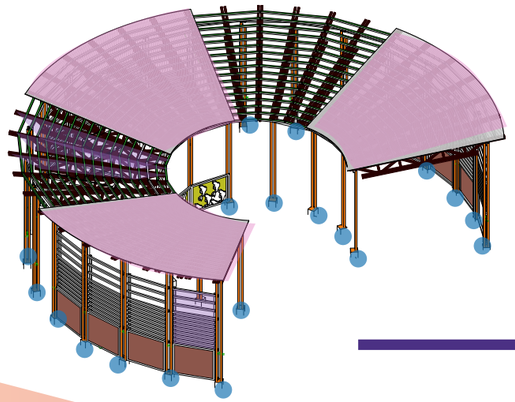
1. Setting the scope of the policy (established previously in the project section as new constructions and major renovations)
2. Establishing EC Data Requirements for reporting data measurement (in section “Policy” below)
3. Setting Emissions targets for each product ad the way each product would change over time (see CLF Material Baselines + Attached Project Report)
4. Providing incentive for high performance manufacturing/materials
5. Creating a system for tracking and measuring success.

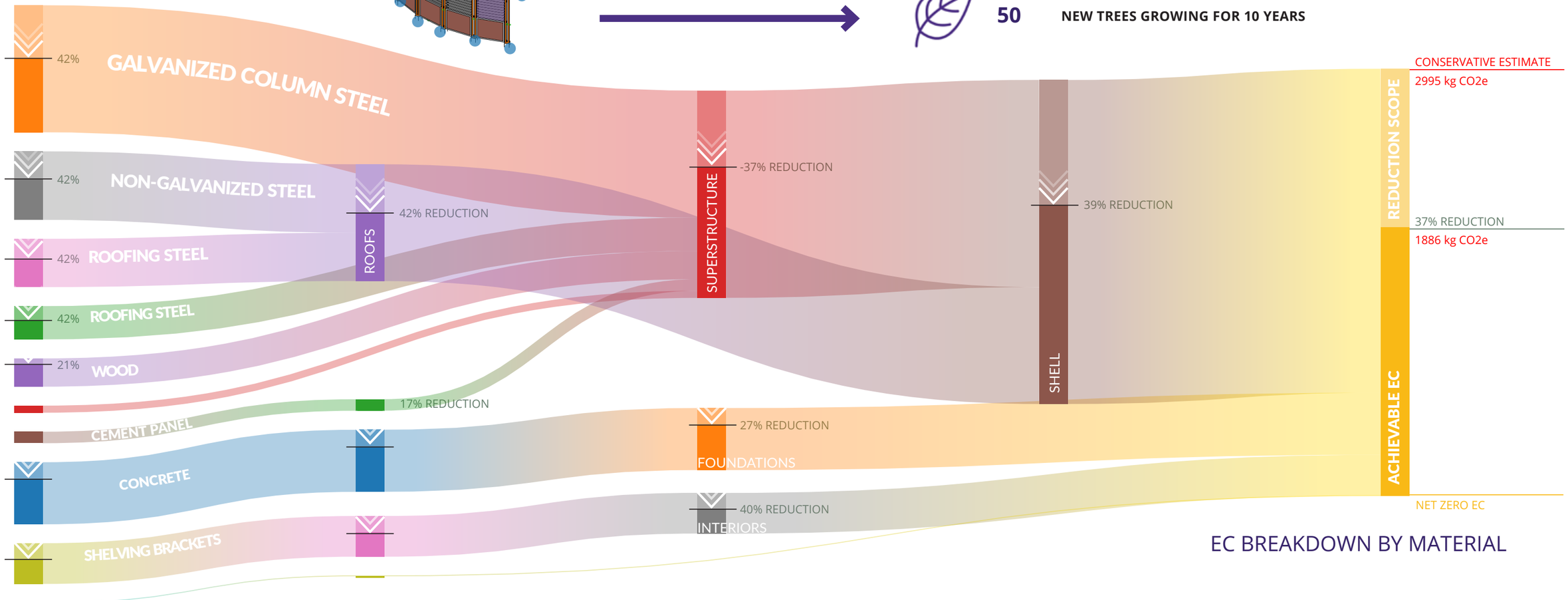
We follow this framework, referencing Material Baselines revised by the CLF in 2023 to provide sample specifications that set minimum standards or examples for low-carbon procurement.

On the following spread is a sample impact report of a UW project: the UW Farm Cultural Kitchen, completed in Spring of 2023 by the Neighborhood Design Build Studio within the Architecture department, uses simple materials procured from around the Seattle area. Cost and longevity took precedence over Embodied Carbon content, the reduction scope is shown along with a conservative estimate of carbon footprint. The impact report shows us how much regulating procurement can change.

SAMPLE IMPACT REPORT

The sample impact diagram below, generated using the EC3 tool , shows each material, the assembly it is a part of, and the possible reduction within this material. “Conservative Estimate” is a high approximation, given the products we chose, of the total embodied carbon, while the achievable EC is close to 37% lower through only procurement. The axonometric diagram illustrates where in the building each component is.





EC BREAKDOWN BY MATERIAL

EC NUMBERS IN CONTEXT

This building totals to 54 kgCO2e/m2, and over 600 SF, it is 2295.85 kg CO2e.

This figure is low relative to conditioned and interior-finished spaces, which generally fall between 300 and 400 kgCO2e/m2.

2995.85 kgCO2e is equivalent to the following:

8 **MONTHS OF CONTINUOUS DRIVING IN A PASSENGER CAR**

or

138 **PROPANE CYLINDERS USED FOR HOME BARBECUES**

or

50 **NEW TREES GROWING FOR 10 YEARS**

SECTION 3: POLICY

PRODUCT DATA REQUIREMENTS

Following the Carbon Leadership Forum's guidelines, given the UW is a leader in sustainability, we suggest that material procurement consult the CLF's "Acheivable" baseline and that designers consider obtaining part of the following procurement report. These steps also are nearly identical to those prescribed in the AIA 2030 challenge, which addresses similar potentials for each material.

Template for procurement report:

Global Warming Potential (GWP): All GWP information submitted shall be in the form of kgCO2eq/kg

OPTIONAL: Ozone Depletion Potential (ODP): All ODP information submitted shall be in the form of kgCFC-11/kg.

OPTIONAL: Smog Formation Potential (SFP): All SFP information submitted shall be in the form of kgO3/kg.

OPTIONAL: Non-Renewable Energy Consumption (NREC): All NREC information submitted shall be in the form of MJ.

These procurement guidelines are drawn from the Carbon Leadership Forum's Building Owner Toolkit as well as LEED v4 Material Specification Templates.

DATA SPECIFICATIONS

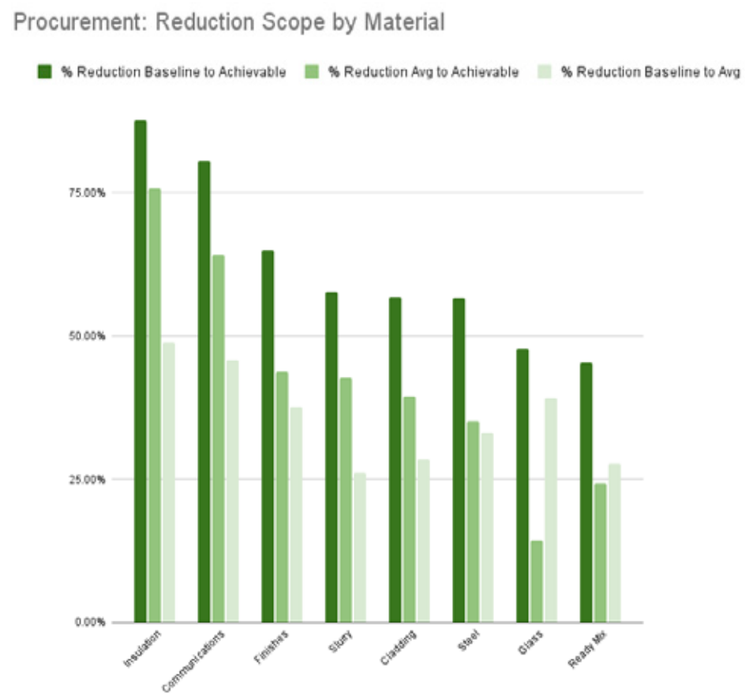
CLF's material baselines, updated 2023, are set at the 80th percentile. These are such that over 80% of materials fall under the umbrella of "meeting baseline requirements". Along with a Baseline measure, "Typical" (industry average) and "Achievable" (20% of industry average) guidelines are also set out for emissions, measured in kgCO2/kg. Note that specification of low-carbon materials to "achievable" as opposed to "baseline", regulating only procurement, can cut down the full life cycle carbon footprint up to 33%, as 50% of a building's footprint is embodied.

The building materials (Ready-Mix Concrete, CMU, Rebar, Insulation) with specification examples attached are those that are most frequently used. Their CSI MasterFormat specifications are listed on each one. Note that the EC3 tool, frequently used for procuring EPDs, can be accessed through MasterFormat and vice versa.

DATA: IMPACT TABLE

The following table, with data sourced from CLF's 2023 Material Baselines, shows the variance of each material from "baseline" to "typical" to achievable, demonstrating the impact that simply regulating the procurement of materials can have.

Note that Insulation has the highest potential for EC reduction through specification, and concrete falls close to the bottom. However, as shown in the attached sample report, steel and concrete have the highest impact due to the sheer volume of material used in each building.



SUMMARY OF RECOMMENDATIONS

1. We recommend, for demolitions or renovations, that the team consider embodied carbon when making the decision to renovate or tear down, whether through the CARE tool or other metrics.

2. For new constructions, we recommend that teams use parametric modeling to compare different material choices and assemblies' footprints.

3. Universally, requiring EPDs and using the EC3 tool to carefully monitor footprints and keep track of our EC reduction across university projects.

REFERENCES

UW GREEN BUILDING STANDARD

https://sustainability.uw.edu/campus/buildings/green-building-standards

CLF MATERIAL BASELINES 2023

https://carbonleadershipforum.org/clf-material-baselines-2023/

WASHINGTON CLEAN BUILDING ENERGY PERFORMANCE STANDARD

SEATTLE BUILDING EMISSIONS PERFORMANCE STANDARD

AIA-CLF ARCHITECTS TOOLKIT

https://carbonleadershipforum.org/clf-architect-toolkit/

USGBC LEED v4

https://living-future.org/wp-content/uploads/2022/07/LBC-Core_Documentation_Requirements_080822.pdf

SEATTLE BUILDING CODE

AIA-CLF ARCHITECTS TOOLKIT

https://carbonleadershipforum.org/clf-architect-toolkit/

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