Shaping Tomorrow's Built Environment Today

ASHRAE Task Force for Building Decarbonization

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Embodied Carbon Codes and Policies Summary

Introduction

Embodied carbon refers to the greenhouse gas (GHG) emissions generated by the manufacturing, transportation, installation, maintenance, and disposal of construction materials used in the built environment. The metric used to define embodied carbon is global warming potential (GWP), which is calculated using a standardized methodology called *life-cycle assessment* (LCA). GWP is quantified in pounds (kilograms) of CO_2 equivalent (lb or kg CO_2e). The "equivalent" or "e" in "lb or kg CO_2e" means that other greenhouse gases like methane, refrigerants etc., are included alongside carbon dioxide (and normalized to the impact of CO_2 based on their radiative forcing potential relative to CO_2).

Codes and policies related to embodied carbon can be implemented in a variety of ways, from codes and building regulations to zoning, green building incentive programs, climate action plans, and public procurement policies. For example, the "City Policy Framework for Dramatically Reducing Embodied Carbon" by the Carbon Neutral Cities Alliance and One Click LCA identified 52 policies that cities can adopt to reduce embodied carbon.[1]

This summary provides an overview of three areas of codes and policies related to embodied carbon (as of September 21, 2021):

- Embodied carbon in codes
- Low-carbon refrigerants in code
- Embodied carbon policies

Embodied Carbon in Codes

In the U.S., only one jurisdiction has successfully incorporated embodied carbon into its code, Marin County's Marin County Code Chapter 19.07. The code requires that all new commercial building projects starting in 2020, incorporate low-embodied carbon concrete, allowing two approaches: a

[1] https://carbonneutralcities.org/embodied-carbon-policy-framework/

prescriptive GWP limit per concrete strength, or a performance cement GWP limit regardless of concrete strength.

The advisory committee evaluated cement and embodied carbon (GWP) impacts of different design mixes in Northern California and used data from National Ready-Mix Concrete Association's (NRMCA), life-cycle assessment (LCA) reports for the US and Pacific Southwest (PSW), which includes California, data from Climate Earth, and data collected by structural engineers in the Structural Engineer's Association of Northern California (SEAONC).

The Marin County code was informed by a highly engaged local stakeholder group through a process funded by a grant from the Bay Area Air Quality Management District. The Bay Area in Northern California has the added benefit of a strong aggregate that allows for less cement, or cement alternatives than other regions. Therefore, Marin's conditions do not allow for simply duplicating their code in other regions without first understanding the regional variation and availability of concrete design requirements and components.

Low-Carbon Refrigerants in Code

California, Washington, Vermont, and New Jersey have adopted the 750 GWP limit and it is proposed in Colorado, Oregon, and Hawaii. The codes mandate that refrigerants used in new air conditioning equipment must have a GWP no higher than 750, and refrigerants used in new refrigeration systems with more than 50 lb (20.68 kg) of refrigerant must have a GWP no more than 150.

California has proposed a 150 GWP limit for new stationary refrigeration systems containing more than 50 lb (20.68 kg) of refrigerant.

The AIM Act from US Environmental Protection Agency (EPA), which was included in the Consolidated Appropriations Act, 2021, directs EPA to phase down production and consumption of HFCs in the United States by 85 percent over the next 15 years. A global HFC phasedown is expected to avoid up to 0.9°F (0.5°C) of global warming by 2100.

The European Union introduced in 2015 the F-Gas Regulation, with the goal to reduce the use of HFCs by 79% by 2030 (European Commission, 2015). This regulation controls the installation, servicing, sale, and decommissioning of fluorinated gases. Gradually the following restrictions will apply[2]:

- Restrictions on commercial use display units with HFC GWP ≤ 2,500, restriction ban, 1 January, 2020
- Restrictions on commercial use display units with HFC GWP ≤ 150, restriction ban, 1 January, 2022
- Market prohibition on stationary equipment that contains or that relies on HFCs with GWP ≤ 2,500, except for cooling equipment below –58°F (–50°C)
- Market prohibition on single split AC with less 6.6 lb (3 kg) of HFC refrigerant with GWP ≤ 750
- 2030: 79% HFC sales phase out when compared to sales between 2009 and 2012

[2] Refrigerants & Environmental Impacts: A Best Practice Guide - Integral Group, https://www.integralgroup.com/news/refrigerants-environmental-impacts/

Embodied Carbon Policies

A handful of jurisdictions are adopting embodied carbon policies that may pave the way for future embodied carbon codes that impact all buildings. There are two primary approaches to setting targets or limits on *embodied* carbon intensity:

- A **building-scale approach** focuses on the embodied carbon impact of a project as a whole, as well as the assemblies and systems that comprise a building. This approach typically requires the use of whole building life cycle assessment (LCA). A building-scale approach may include an entire building or a limited set of systems and may invite whole building strategies such as material and building reuse, material substitution, and material efficiency. Because materials are compared across the product categories, the entire life cycle of a product must be included when using whole building life cycle assessment (LCA) to compare the impact of design choices on embodied carbon.
- A **material-scale approach** focuses on the embodied carbon impact on the individual materials and incentivizes transparency and availability of products made with lower-carbon manufacturing practices. This approach typically requires the disclosure of third party verified product LCA data in the form of an environmental product declaration (EPD). A material approach is particularly relevant during the procurement phase of a project, when the product type and performance requirements have already been selected. Material-focused policies are well-suited for horizontal infrastructure, such as roads and bridges, in addition to buildings.

Both the building and material approach require embodied carbon disclosure and may include maximum GWP targets or limits. Policies using a building-approach would include GWP values on a per floor area basis (e.g., lb CO_2/ft^2, kg CO_2/m^2), whereas policies using a material approach would require GWP limits on a per unit basis (e.g., lb CO_2e/yd^3, kgCO_2e/yd^3 of concrete, etc.).

Material-specific GWP maximums often target the materials with the highest embodied carbon (concrete, steel, and aluminum) Whole building embodied carbon policies either set an absolute value to restrict the life-cycle carbon emissions or set an allowable emissions per area ($lb/CO_2/ft^2$, $kgCO_2/m^2$) Alternatively, whole building life cycle analysis (WBLCA) policies will set a percent-better-than requirement for building to achieve a specific GWP reduction, requiring life cycle analysis against a baseline building. In the U.S., the materials-approach has been the preferred path since WBLCA limits are still in their policy-infancy.

Building-Scale Approach

WBLCA policies are the most prevalent embodied carbon policy framework outside of the United States. Additionally, WBLCAs allow projects to take credit for building material reuse or material efficiency. As mentioned in the metrics section, WBLCA policies may set an absolute GWP value, emissions per area, or percent-better than baseline. WBLCA baseline buildings can vary by project team, making it difficult to compare one project to another. Policies must include rigorous guidelines for WBLCA modeling to ensure that baselines are used consistently and appropriately.

Example list of policies using a building-approach to reducing embodied carbon:

- In Vancouver, B.C., the Green Buildings Policy for Rezoning requires all rezonings in Vancouver to conduct a WBLCA study and report the embodied carbon (GWP). Reduction

requirements will be set in 2022.

- London Whole life carbon assessment guidance requires all referred schemes (development of 150 residential units or more development over 108.2 ft (30 m) to carry out whole life carbon assessment and submit information for planning following a specific reporting template. No targets are currently being given, but projects need to compare against current and aspirational benchmarks and show mitigation investigation measures.
- In France, RE2020, will require from September 2021 all new buildings to carry out embodied carbon as well as operational carbon calculations (in parallel to thermal comfort studies) and demonstrate meeting certain targets which will be reduced every two years (in 2031, the carbon emission thresholds will be reduced by an average of 52% in comparison to 2022). Embodied carbon calculations will rely on the national French database (2,000 data entries for construction products and around 450 for building services equipment) and follow a dynamic approach which is quite rare.
- In Finland, all new buildings will be required to measure whole life-cycle carbon emissions and meet GWP limit values after 2025.[3]
- In Denmark, all new buildings will be required to measure whole life-cycle carbon emissions from 2023, with limits brought in at the same time for large developments, and limits for all buildings brought in from 2025.[4,5]

Material-Scale Approach

The Marin County code described in the Embodied Carbon in Codes section above is an example of a policy that uses a material-approach, as it includes a performance-based compliance path that requires EPDs to verify that a concrete mix is below a particular maximum GWP limit value.

Buy Clean policies (also referred to as low carbon procurement policies) are the most common type of policy addressing greenhouse gas emissions in individual construction materials. The procurement policy approach incorporates low-carbon construction purchasing requirements for any project receiving jurisdiction funds. Policy components include disclosure (GWP), incentives (bid bonus), and standards (GWP limits). The Buy Clean approach can be applied at the federal, state, or local level and even used by private building owners.

Status of Buy Clean: The first Buy Clean policy was introduced and adopted in California in 2017. Similar policies are being explored, introduced, and adopted by other states (Washington, Minnesota, Colorado), cities (Portland, Oregon and Marin County, CA, Honolulu, HI), and even at the Federal level through the CLEAN Futures Act.[6] See Carbon Leadership's US Embodied Carbon Policy map for a more up to date list of policies.

Why Buy Clean is Important: According to the Carbon Neutral Cities Alliance, low carbon concrete policies can make the largest carbon reduction impact when it comes to new building materials.[7] Since jurisdictions are responsible for funding both buildings and infrastructure, they are

[3] https://journal-buildingscities.org/articles/10.5334/bc.30/
[4] https://baeredygtighedsklasse.dk/
[5] https://passivehouseplus.co.uk/issuu/digital-editions
[6] https://energycommerce.house.gov/sites/democrats.energycommerce.house.gov/files/documents/0128%20CLEAN%20Future%20Discussion%20Draft.pdf
[7] https://www.embodiedcarbonpolicies.com/

the largest purchasers of concrete, second only to residential construction.[8] With concrete often a local product, jurisdictions can make significant GHG reductions by specifying low embodied carbon concrete.

Example list of policies using a material-scale approach to reducing embodied carbon:

- Portland, Oregon's Low Carbon Concrete Initiative sets concrete GWP thresholds for City-funded construction projects.
- Hawaii's Carbon Dioxide Mineralized Concrete policy requires all state-funded projects that use concrete to include carbon capture.
- Quebec's Wood Charter asks project teams to consider building with wood for all publicly funded multifamily and infrastructure projects. The policy requires an GHG assessment using the Gestimat tool.
- The Netherlands adopted the UN Declaration of Material Rights which considers building material efficiency. At the time of permit, projects must declare key material mass per ft^2/m^2.
- California's Cooling Act adopts the same hydrofluorocarbon prohibitions that originated from the United States Environmental Protection Agency's (U.S. EPA).

Examples of a hybrid approach:

- General Services Administration (GSA) Advice Letter for low embodied carbon procurement offers two suggestions. The first is a GWP limit per material. The second recommendation is a whole building life cycle assessment approach for projects over $3M. This LCA approach requires a 20% carbon reduction, compared to a baseline building.
- Toronto's Waterfront Green Building Requirements address multiple materials, requiring more sustainable building materials, including 50% recycled metal in steel and rebar, low-carbon concrete (with 25% supplementary cementing materials), or timber products certified by the Forest Stewardship Council. Projects are also required to report the whole-building GWP.

Third party rating systems have always encouraged construction waste diversion, building and material reuse, and recycled content. When LEED v4 included credits on material transparency and whole building life cycle analysis, the design and construction community took notice and the awareness of embodied carbon really increased. LEED, Living Building Challenge, Green Globes, BREAM, Three Star, and some national-based rating systems (e.g., Australia Green Star, Japan Casbee, Singapore Green Mark, etc.) address embodied carbon.

Passive House has been in the embodied carbon hot seat as it is one of the top rating systems and it does not yet address embodied carbon. High embodied carbon products support Passive House goals of highly insulated and thermally sealed buildings. It's only a matter of time before the rating system addresses that the embodied carbon is higher than the operational carbon.

[8] 2016 US Cement Industry Annual Yearbook, http://www2.cement.org/econ/pdf/Yearbook2016_2sided.pdf