Reducing Embodied Carbon: How Local Governments Can Help

August 13, 2020 · 01:00 pm

Presenters:

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Agenda

Embodied Carbon: The Basics

What is it? Why does it matter? How do we measure it?

Local Governments & Embodied Carbon

How are governments well-placed to tackle this issue? Case studies from Marin County and Seattle.

Opportunities for Collaboration & Resources
Reducing the Carbon Footprint of Every Building.
Over the next 35 years, two trillion ft$^2$ of new and rebuilt buildings will be constructed in cities worldwide.

Source: IEA (2016), Energy Technology Perspectives 2016, IEA/OECD, Paris
An entire New York City
every 35 days
for 35 years!
Global CO₂ Emission by Sector

- Industry: 30%
- Transportation: 22%
- Building Materials and Construction: 11%
- Building Operations: 28%
- Other: 9%

Total Carbon Emissions of Single Building
Global Average Building Carbon Footprint: Business as Usual

Operational Carbon
+/-50%

Embodied Carbon
+/-50%

Reducing Embodied Carbon

What to do, when.

LCA Tools (Tally, OneClick, Athena)

Schematic Design

Design Development

Whole Building Life Cycle

Analysis of Building Components

Design Option Comparison

Construction Documentation

Project Procurement

Whole Building Life Cycle Analysis Report

Tally Bill of Materials Import

Embodied Carbon Assessment

Product Comparison and Procurement

Embodied Carbon Calculation

We did it!

New vs Retrofit? X vs Y system? X vs Y Mfr/Product?

Right size the building. Systems CO2 reductions. Mfr/Product CO2 reductions.

Carbon smart procurement. CO2 reductions realized.

*Start Supplier Outreach

Embodied Carbon reduction realized!
The Embodied Carbon in Construction Calculator (EC3) tool

- First free, open-access tool for upfront embodied carbon
- First free, open-access database of EPDs
- Over 50 industry partners supporting its development
- Over 7,500 registered users since its launch in Nov 2019
- New non-profit established to continue its development

Register for tool at:
www.buildingtransparency.org
Reducing Embodied Carbon

- Material Quantities (from Construction Estimates/BIM 360/Tally)
- Stages A1-A3 Embodied Carbon Emissions data
- Building Upfront Estimate and Realized Embodied Carbon
- Digital EPD Database for Comparing Product Embodied Carbon

EC3
**Kg CO2e from Environmental Product Declarations**

### Nutrition Facts

<table>
<thead>
<tr>
<th>Serving Size 2/3 cup (85g)</th>
<th>Servings Per Container About 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount Per Serving</td>
<td></td>
</tr>
<tr>
<td>Calories</td>
<td>230</td>
</tr>
<tr>
<td>Total Fat</td>
<td>8g</td>
</tr>
<tr>
<td>Saturated Fat</td>
<td>1g</td>
</tr>
<tr>
<td>Trans Fat</td>
<td>0g</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>0mg</td>
</tr>
<tr>
<td>Sodium</td>
<td>160mg</td>
</tr>
<tr>
<td>Total Carbohydrate</td>
<td>37g</td>
</tr>
<tr>
<td>Dietary Fiber</td>
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<td>1g</td>
</tr>
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<td>Protein</td>
<td>3g</td>
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<tr>
<td>Calories from Fat</td>
<td>40g</td>
</tr>
<tr>
<td>% Daily Value*</td>
<td>12%</td>
</tr>
</tbody>
</table>

*current database holds over 27,000 epds*

### Life Cycle Impact Results (per m³)

Declared Unit: 1 m³ of 10,000 psi concrete at 28 days

#### OPERATIONAL IMPACTS

- Plant Operating Energy (MJ): 38.6
- On-Site Plant Fuel Consumption (MJ): 11.1
- Concrete Batch Water (m³): 1.69E-01
- Concrete Wash Water (m³): 1.91E-02
- On-Site Waste Disposal (kg): 0.0

#### ENVIRONMENTAL IMPACTS

- Total Primary Energy (MJ): 3,017
- Climate Change (kg CO₂ eq): 445
- Ozone Depletion (kg CFC 11 eq): 1.31E-08
- Acidification Air (kg SO₂ eq): 2.96
- Eutrophication (kg N eq): 0.09
- Photochemical Ozone Creation (kg O₃ eq): 0.61
Local Governments & Embodied Carbon

Local governments are:

- Consumers
- Regulators
- Climate leaders
Local Governments as Consumers

**FIGURE 1**

United States public infrastructure spending (in billions of 2017 dollars) 2007 to 2017

Source: Brookings analysis of CBO data.
Local Governments as Regulators

Two hundred eighty-three (283) municipalities have adopted the Board of Building Regulations and Standards (BBRS) Stretch Code as of July 22, 2020.

Berkeley becomes first U.S. city to ban natural gas in new homes

Sarah Ravani | July 21, 2020 | Updated July 22, 2020 (1 min)
Local Governments as Climate Leaders

Local Governments Lead Efforts to Combat Climate Change

Local governments serve as idea labs for federal lawmakers as they consider changes to national climate and energy reform

By Douglas Fischer, The Daily Climate on May 21, 2010
Government Efforts & Case Studies: Bay Area Low Carbon Concrete Code

• Funded by BAAQMD’s 2018 Climate Protection Grant Program under “Fostering Innovative Strategies with long-term impacts in reducing GHG emissions.”

• A first-of-its-kind effort to address embodied emissions in an area of local government control.

• Partnership with local government, engineers, and academia, as well as a robust stakeholder group.
CARBON IMPACTS OF CONCRETE

INGREDIENTS:
- Limestone
- Silica
- Alumina
- Gypsum

1. MINING RAW MATERIAL
2. CEMENT MANUFACTURING
3. MIXING CONCRETE
4. TRANSIT
5. USE
6. END OF LIFE

END OF LIFE:
If not disposed of, concrete can be ground up at the end of its useful life to make aggregate for new concrete.

COMPONENTS OF CONCRETE
- AIR
- CEMENT
- WATER
- AGGREGATE
Government Efforts & Case Studies:
Bay Area Low Carbon Concrete Code

• Model code language for adoption by local governments
  • Low embodied-carbon concrete specifications for residential and non-residential applications
  • Adopted unanimously by County of Marin on November 19, 2019
• Opportunity for these standards to be adopted across Bay Area jurisdictions; and for the framework to be replicated beyond our region.

Figure 2: Green building market transformation pathway
* Bay Area Regional Collaborative Bay Area Green Building Policy Assessment Aug. 20, 2010
<table>
<thead>
<tr>
<th>Minimum specified compressive strength $f'_c$, psi</th>
<th>Cement limits</th>
<th>Embodied Carbon limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 2500</td>
<td>362</td>
<td>260</td>
</tr>
<tr>
<td>3000</td>
<td>410</td>
<td>289</td>
</tr>
<tr>
<td>4000</td>
<td>456</td>
<td>313</td>
</tr>
<tr>
<td>5000</td>
<td>503</td>
<td>338</td>
</tr>
<tr>
<td>6000</td>
<td>531</td>
<td>356</td>
</tr>
<tr>
<td>7000</td>
<td>594</td>
<td>394</td>
</tr>
<tr>
<td>7001 and higher</td>
<td>657</td>
<td>433</td>
</tr>
<tr>
<td>up to 3000 light weight</td>
<td>512</td>
<td>578</td>
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<tr>
<td>4000 light weight</td>
<td>571</td>
<td>626</td>
</tr>
<tr>
<td>5000 light weight</td>
<td>629</td>
<td>675</td>
</tr>
</tbody>
</table>
Government Efforts & Case Studies: Bay Area Low Carbon Concrete Code

• Four pilot projects receiving technical assistance to apply the specifications.
Barriers, Opportunities, & Questions

• How can this process expand to other building materials?
• How can we support innovative building materials without burdening applicants (both cost & process)?
• What is the right role for local government to play in materials regulations?
• How do we address consumption emissions in an economy rooted in consumption and growth?
Government Efforts & Case Studies: City of Seattle

- Established in 2000 to develop and coordinate environmental policies.
- Staff of ~30 bring innovation, passion, and creativity to respond to and lead on Seattle’s biggest environmental challenges.
- Advances racial, social, and environmental justice throughout Seattle’s environmental work.
- 2005 - Seattle’s first Climate Action Plan
- 2005 - Seattle City Light Becomes Carbon Neutral
- 2011 - Adopted Carbon Neutral Goal
- 2013 - Climate Action Plan
- 2018 - Mayor Durkan’s Climate Strategy
Building Energy
Fuel Use & Impact
COMMERCIAL & RESIDENTIAL

2008 Baseline

39% Reduction by 2030

Net Zero-Carbon by 2050

103K MgCO₂e
944K MgCO₂e
67K MgCO₂e

ELECTRICITY 25M MMBTU
FOSSIL GAS 18M MMBTU
OIL .9M MMBTU
What about embodied carbon?

Mayor Durkan Issues Executive Orders Underscoring Seattle’s Climate Commitment

by Kamaria Hightower on April 13, 2018

Seattle (April 13, 2018) – Seattle Mayor Jenny A. Durkan signed two Executive Orders that embed climate considerations more fully into City operations. The orders follow the release of new bold actions in Seattle to reduce carbon pollution from our transportation and building sectors and make Seattle a national leader in fighting climate change. The first executive order calls for accelerating the electrification of the City’s municipal fleet and phasing out fossil fuel use in City vehicles by 2030. The second executive order directs the Office of Sustainability & Environment to develop a process for assessing the greenhouse gas emissions and climate resilience of major city policies, capital projects, and purchasing decisions.
Climate Impact Toolkit: Scope

Seven “impact” areas:

- Transportation
- Land Use / Zoning
- Fossil Fuel Use in Buildings
- Fossil Fuels in Equipment
- Refrigerants
- Embodied Carbon
- SF6
Climate Impact Toolkit: Goals

- **Capacity building.** Building awareness and providing tools for city staff to ID low-carbon solutions in their work.

- **Transparency and Accountability.** Filling out the reporting form creates documentation that influences behavior, even if not every single report leads to significant project level GHG reductions.

- **Explicitly identifying and championing low carbon solutions,** so that we can track what these are, how much they may cost, and decide how to address them.
Step 2. Climate Impact Screening

Please answer the following questions about your project (i.e., capital project, program, policy, plan, or procurement) to the best of your ability. When you select "Yes," you will be directed to the relevant Sector Guidance in Step 3. Below each question are examples of projects that involve decisions regarding the respective sector. If you are unsure whether your project does or does not involve decisions about the given sector, select "Yes" to explore the Sector Guidance to learn more; you can then return to this step and change your answer if needed. Be sure to only select one answer per question. If you select both answers, the cells will highlight in orange to indicate that you need to unselect an option.

### Sector-Specific Information

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does your project involve decisions that could modify the use of FOSSIL FUELS WITHIN THE TRANSPORTATION SYSTEM?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Examples of City Decisions:</td>
<td>Road restringing or repaving</td>
<td>Parking rules or Investments</td>
</tr>
<tr>
<td>2. Does your project involve decisions that could modify the LAND USE OR ZONING CODE?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Examples of City Decisions:</td>
<td>Zoning or land use amendments</td>
<td>Building code amendments</td>
</tr>
<tr>
<td>3. Does your project involve decisions that include the use of FOSSIL FUELS IN BUILDINGS?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Examples of City Decisions:</td>
<td>New building construction</td>
<td>Building code changes</td>
</tr>
<tr>
<td>4. Does your project involve decisions that could modify the use of FOSSIL FUELS IN EQUIPMENT?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Examples of City Decisions:</td>
<td>Heavy machinery purchases or contracting</td>
<td>Construction equipment</td>
</tr>
<tr>
<td>5. Does your project involve decisions that could modify the use, maintenance, or purchase of products that contain REFRIGERANTS?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Climate Impact Toolkit: Framework

Tier 1: Avoid
- Can you avoid GHG emissions thorough the introduction of non-emitting systems, or using existing systems?

Tier 2: Shift
- Can you shift to lower impact types of products or processes by using alternatives?

Tier 3: Reduce
- Can you reduce GHG emissions by finding opportunities where the system or product that generates emissions is used less frequently?

Tier 4: Manage
- Can you manage the system to operate most efficiently through improved maintenance to minimize GHG emissions?
Please click on the following links to explore lower-carbon alternatives for your project. Guidance is provided for each sector that is relevant to your project (based on your responses in Step 2. Impact Screening). The information in these sections will help you complete the Reporting Form in Step 4. In addition, you may choose to review guidance for other sectors that are not directly relevant to your project, provided in the links in grey.

This white paper outlines options to aid in the decision-making process when choosing alternative refrigerants in commercial refrigeration equipment.

Embodied Carbon

Potential Impacts

The term “embodied carbon” refers to the collective impact of all the greenhouse gas emissions emitted during the manufacture, transport, and construction of buildings and infrastructure, as well as the end-of-life emissions. Embodied emissions are separate from operational emissions, which result from the energy used to run a building (heating, cooling, lighting, etc.).

As operational emissions are reduced through mitigation strategies, the impact of embodied emissions becomes increasingly significant. This is especially true in Seattle, where operational emissions are already lower due to our carbon-neutral electricity grid. For a typical office building in Seattle, 84% of its emissions are in embodied carbon over a fifty-year lifecycle. Once a building or piece of infrastructure is constructed, the embodied emissions of that structure are locked in and cannot be taken back or reduced. Therefore, it is crucial to address embodied emissions now to change the current upward trend in overall emissions.

The materials with the highest embodied carbon are those used in structures, such as concrete, steel, and timber, followed by building envelope materials, such as glazing, aluminum insulation, and metal framing. Asphalt, a material used in infrastructure, also contains significant embodied carbon. Infrastructure and ground-up construction projects tend to contain the highest emissions associated with embodied carbon due to their reliance on large amounts of concrete.

Relevant Projects

- Building construction
- Road paving
- Bridge and tunnel construction, rehabilitation, and replacement
- Reservoir construction
- Retaining/seawall construction

Best Practices

Avoid

The most impactful strategy is to avoid using materials with embodied carbon by eliminating the need for the project itself. Can the construction of a new building be avoided by purchasing and retrofitting an existing one? Can the provision of alternate modes of transit offset the need to build new road infrastructure? Will the lifespan of the project be negatively affected due to any future improvements or changes?

Shift

Explore project designs that promote the replacement of high-carbon materials with lower-carbon alternatives. For example, swapping out structural steel or concrete for cross-laminated timber can drastically reduce the embodied carbon of the project. Similarly, using high-recycled content materials in lieu of their virgin counterpart – particularly for metals like steel – can reduce embodied carbon by over 80%.
Embodied Carbon

IDEATE
Use the space below to brainstorm ideas for reducing the climate impact of your project.

CALCULATE (optional)
If you have quantitative data about your project and you would like to calculate estimated emissions for your project, click the calculator icon below to explore how emissions may vary under various project options/scenarios.

Please write any considerations or notes about the emissions calculation, if desired.

SELECT SOLUTIONS
Please describe the ideas you selected to move forward in your project for reducing climate impacts.
Collaboration & Resources

Peer Cities & Jurisdictions
Collaboration & Resources

CNCA + OneClickLCA Policy Framework

(52 detailed policies to reduce embodied carbon)
The Embodied Carbon Network

- First free, industry network focused on embodied carbon
- Over 15 local network chapters and growing
- Over 2,000 network participants currently engaging

Chapters active/forming in:
ECN Austin
ECN Australia
ECN Atlanta
ECN Bay Area
ECN Boston
ECN Calgary
ECN Chicago
ECN Hong Kong
ECN NYC
ECN Pittsburgh
ECN Portland
ECN Rocky Mountain (Denver/Boulder)
ECN Seattle
ECN Toronto
ECN UK
ECN Vancouver
ECN Yellowstone

Join the ECN at: https://carbonleadershipforum.org
Policy
Buy Clean California Act

State agencies, University of California and California State University System, construction materials industries, other interested parties can learn more about the embedded carbon emissions of construction materials used in public works projects.

Commercial Energy Code Adoption by State

Embodied
Bay Area Low-Carbon Concrete Code

- First open access model policy language for low embodied-carbon concrete
- First local specifications for low embodied-carbon concrete
- Supported by 4 jurisdictions and over 30 industry partners

Access the code at:
Tools & Certifications
Embodied ....and more!

Operational

LEED Zero

LIVING BUILDING CHALLENGE

ZERO ENERGY CERTIFICATION

cove.tool

Edge

ENERGY STAR® Portfolio Manager®

SF TOOL

....and more!
Thank you!