Global CO$_2$e emissions by region since 1750
Urgent Action is Required and Buildings are Key

Global CO₂ Emissions by Sector

- Building Operations: 28%
- Building Materials: 23%
- Non-Building Mfg: 11%
- Transport: 6%
- Other: 6%
- Building Materials (core & shell): ~22% (32%--10%)
- Other Building Material Mfg: <10%

Adapted from 2019 Global Status Report, Global Alliance for Building and Construction (GABC) and Architecture 2030.

The building and construction sector has a vital role to play in eliminating carbon, as it is responsible for at least 3% of global carbon emissions.

Source: Architecture 2030; Adapted from RealClimate.org "How much CO₂ your country can still emit, in three simple steps"; and IPCC SR15, Table 2.2
California Building Sector Emissions – 12%?
CALIFORNIA 2017 GHG EMISSIONS - 424.1 MMTCO₂

California Building Sector Emissions ~ 33%

1. **Scope 1** - Direct - 12%
   on site combustion

2. **Scope 2** - Indirect ~ 11%
   Electricity for buildings

3. **Scope 3** - Indirect ~ 10%
   business travel, commuting purchased goods & services
capital goods, **building materials**
California GHG Emissions since 2000

- GDP
- Population
- GHG Emissions
- GHG Emissions per Capita
- GHG Emissions per GDP

Percent Change since 2000

2000 | 2008 | 2017
---|---|---
-60 | 0 | 50
-40 | -20 | 30
-20 | 0 | 10
-10 | 0 | 0
0 | 0 | 0

Yearly data points from 2000 to 2017 show the changes in various economic and environmental indicators for California.
California GHG Emissions since 2000

- GHG Emissions
- GHG Emissions per Capita
- GHG Emissions per GDP
- Population
- GDP

Percent Change since 2000:
- 2000
- 2008
- 2017
- 2030
- 2040

Targets:
- -65%
- -100% (zero)
Scope 1, 2 & 3 Emissions Reduction Strategies for buildings

Scope 1 – Direct, on site combustion

Scope 2 – Indirect - electrical grid

Scope 3 – Indirect – off site impacts including materials/construction

Embodied Carbon

Reduction Strategies

Increase Efficiency
Eliminate gas
Make new buildings electric
Convert Existing to electric

Clean electricity – PV’s wind...
On-site – install clean energy
Off-site – purchase clean energy

Use fewer materials
Use lower carbon materials
Use carbon sequestering materials
Building Materials: Embodied Carbon and California Buy Clean Policy

Kate Simonen, AIA SE
Director Carbon Leadership Forum
University of Washington
www.carbonleadershipforum.org
Science Based Targets: Urgent Action is Required

Peak x 2020
65%
50% x 2030
Zero x 2050
2040

Global Emissions in GtCO₂
500 GtCO₂
340 Gt CO₂

Global CO₂ Emissions by Sector
- Building Operations: 28%
- Building Materials [core & shell]: 23%
- Non-Building Mfg: 11%
- Other Building Material Mfg: 11%
- Transport: 23%
- Other: 6%
- ~22% (32%~10%)

Adapted from 2019 Global Status Report, Global Alliance for Building and Construction (GABC) and Architecture 2030.

The building and construction sector has a vital role to play in eliminating carbon, as it is responsible for at least 39% of global carbon emissions.

Source: Architecture 2030; Adapted from RealClimate.org “How much CO₂ your country can still emit, in three simple steps”; and IPCC SR15, Table 2.2
What about the ‘Carbon Loophole’?

Emissions from purchased goods emissions—when they are manufactured out of state?
Operating and Embodied Carbon

TC = EC + OC

Embodied Carbon
Manufacture, transport and installation of construction materials

Operational Carbon
Building Energy Consumption

Scope 3
 Scope 1+2

Total Carbon = Embodied Carbon + Operational Carbon

Image: S. Smedley Skanska
Total Carbon Emissions of Global New Construction from 2020-2050
Business as Usual Projection

- Embodied Carbon 2020-2030: 74%
- Embodied Carbon 2020-2050: 49%

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Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017
Life Cycle Assessment: Embodied Carbon

Emissions due to:
• Material extraction
• Transportation
• Manufacturing

Life Cycle Costing
Economic Dollars

Life Cycle Assessment
Environmental ‘Carbon’ etc.

Credit: Meghan Lewis
Embodied Carbon Estimates

- MATERIAL QUANTITY
- EMBODIED CARBON PER UNIT MATERIAL

= BUILDING EMBODIED CARBON (EC) ESTIMATE
Carbon Smart Building Strategies

Use Smart
- Re-use buildings
- Smaller footprint
- Program efficiency

Build Smart
- Alternate materials
- Efficient buildings
- Life cycle thinking

Buy Smart
- Transparency
- Policy
- Codes/Specs

Reduce the emissions from building material manufacturing-(embodied carbon)
Carbon Smart Building Strategies

Use Smart
- Re-use buildings
- Smaller footprint
- Program efficiency

Build Smart
- Alternate materials
- Efficient buildings
- Life cycle thinking

Buy Smart
- Transparency
- Policy
- Codes/Specs

Rules of Thumb
- Athena (free), OneClick Tally
- EPDs & EC3 Tool (free)
Environmental Product Declarations

Nutrition Facts

- **Serving Size**: 2/3 cup (55g)
- **Calories**: 230
- **Total Fat**: 8g
  - Saturated Fat: 1g
  - Trans Fat: 0g
- **Cholesterol**: 0mg
- **Sodium**: 160mg
- **Total Carbohydrate**: 37g
  - Dietary Fiber: 4g
  - Sugars: 1g
- **Protein**: 3g

**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): 1.68E-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): 2.95
- Eutrophication (kg N eq): 0.09
- Photochemical Ozone Creation (kg O₃ eq): 0.61
Environmental Product Declarations

EPDs Enable Embodied Carbon Transparency

EPD Results are like MPG

• Estimates based on standard assumptions (PCR)
• Known variability
• Directionally accurate
Embodied Carbon Estimates

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>QUANTITY</th>
<th>EMBODIED CARBON PER UNIT MATERIAL</th>
<th>BUILDING EMBODIED CARBON (EC) ESTIMATE</th>
</tr>
</thead>
</table>

**Operational Impacts**

<table>
<thead>
<tr>
<th>Task Description</th>
<th>Performance PEcc3FxK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Operating Energy (MJ)</td>
<td>38.6</td>
</tr>
<tr>
<td>On-Site Plant Fuel Consumption (MJ)</td>
<td>11.1</td>
</tr>
<tr>
<td>Concrete Batch Water (m³)</td>
<td>1.68E-01</td>
</tr>
<tr>
<td>Concrete Wash Water (m³)</td>
<td>1.91E-02</td>
</tr>
<tr>
<td>On-Site Waste Disposal (kg)</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Environmental Impacts**

<table>
<thead>
<tr>
<th>Impact Description</th>
<th>Value (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Primary Energy (MJ)</td>
<td>3.017</td>
</tr>
<tr>
<td>Climate Change (kg CO₂-eq)</td>
<td>4.45</td>
</tr>
<tr>
<td>Ozone Depletion (kg CFC 11-eq)</td>
<td>1.71E-08</td>
</tr>
<tr>
<td>Acidification Air (kg So₂-eq)</td>
<td>2.96</td>
</tr>
<tr>
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<tr>
<td>Photochemical Ozone Creation (kg O₃-eq)</td>
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</tr>
</tbody>
</table>

*Life Cycle Impact Results (per m²)*

Declared Unit: 1 m² of 10,000 psi concrete at 28 days
Lead Sponsors

- Autodesk
- Charles Pankow Foundation
- Interface
- Magnuson Klemencic Associates
- Microsoft
- Skanska USA Building

Pilot Sponsors

- Alexandria
- BASF
- Perkins & Will
- Port of Seattle
- Anonymous Owner
- Tally
- Walter P Moore
- Webcor

Association Sponsors

- ACI Foundation
- The American Institute of Architects
- ASC Alliance
- BlueGreen Alliance
- American Concrete Institute
- Central Concrete Supply
- Katerra
- LMN Architects
- National Ready Mixed Concrete Co
- Urban Fabrick
- WAP Sustainability

Early Adopters Sponsors

- Coughlin Porter Lundeen
- LeMessurier
- PCS Structural
- Nucor
- Saint-Gobain/Certainteed
- Salesforce
- SCS Global Services
- TK1SC
- Thornton Tomasetti
- WRNS Studio

Methodology Partners

- Arup
- Brightworks Sustainability
- Central Concrete Supply
- Katerra
- Kieran Timberlake
- LMN Architects
- National Ready Mixed Concrete Co
- Urban Fabrick
- WAP Sustainability

Material Sponsors

- Armstrong Ceiling & Wall Solutions
- Carbon Cure
- Kingspan
- Kingspan

Technology Partners

- Autodesk
- Climate Earth
- mindful Materials powered by Origin
- Sustainable Minds
- Tally

Project Leadership

- CLF
- Carbon Leadership Forum
- University of Washington

https://www.buildingtransparency.org
CLF Conservative Baseline:
If you don’t know the supplier, don’t assume ‘average’

Target:
At least 20% of products in EC3 are below this
Interpreting the EC3 tool Data Visualization

Baseline: CLF estimate of high embodied carbon of product

Burden of the doubt: Assume ‘high’ value not ‘average’

Product: CLF estimate of embodied carbon precision

Selection: products with the same search criteria
https://www.buildingtransparency.org
Our mission is to eliminate embodied carbon in buildings and infrastructure by inspiring innovation and spurring change through collective action.

<table>
<thead>
<tr>
<th>Research</th>
<th>Resources</th>
<th>Network</th>
<th>Initiatives</th>
<th>Sponsors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robust, useful data</td>
<td>The keeper of knowledge on embodied carbon</td>
<td>Brings together the stakeholders needed to enact change</td>
<td>Supporting SE2050, EC3 tool and more!</td>
<td>Supporting the mission, driving change</td>
</tr>
</tbody>
</table>

www.carbonleadershipforum.org
• What this means for UC capital plan 2020 – 2025
• Draft Carbon Calculator
2013 - 2019
Scope 1 & 2 emissions down 15%

2017 - 2018
Scope 1 emissions (gas) down 3%
Scope 2 emissions (lect.) down 14%

Goal: Climate neutrality
Scope 1 & 2 by 2025.
(some) Scope 3 by 2050
What about the Embodied Emissions in scope 3?
Embodied CO₂ by Construction Type & Material

- **Concrete**
  - Interiors
  - MEP
  - Envelope
  - Steel and Envelope
  - Interiors

- **Wood**

- **Envelope**

- **MEP**

- **Interiors**

- **Heavy Buildings**
  - 80lbs/sf (400 kg/m²)

- **Light Buildings**
  - 40lbs/sf (200 kg/m²)

- **Renovation**
  - 20-50lbs/sf (100 - 250 kg/m²)
  - ~35lbs/sf

- **Reuse**
  - 50 – 80% less than new Construction

- **Structure**
  - 50 – 80%
  - 25 – 50%
  - No Structure

- **Embodied CO₂ by Material**
  - **Concrete**
  - **Steel**
  - **Wood**
  - **Envelope**
  - **MEP**
UC construction

Display A: Space by Decade of Construction
(Gross Square Feet in Millions) - 133 million gsf

Embodied emissions ~ 1.5 mmt

UC Capital Financial Plan 2020 – 2025
- New construction - 30.2 million gsf
- Renovation - 22.9 million gsf

New 80lbs/sf 30.2 mmt
Renovate 35lbs/sf 1.1 mmt
UC construction

Display A: Space by Decade of Construction
(Gross Square Feet in Millions) - 133 million gsf

Renovate + upgrade
133 million gfs
@ 35 lbs/sf = 2.1 mmt
Characterization of campus building age factors is based on analysis by Sightlines. Sightlines specialize in higher education operations and management of facilities.
To Build or Not to Build - Carbon Calculator

<table>
<thead>
<tr>
<th>Existing</th>
<th>New</th>
<th>Replace</th>
<th>Retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficient ZNC</td>
<td>Efficient ZNC</td>
<td>Efficient ZNC</td>
<td>Efficient ZNC</td>
</tr>
<tr>
<td>2,501</td>
<td>3,000</td>
<td>2,600</td>
<td>-5,000</td>
</tr>
<tr>
<td>1,099</td>
<td>499</td>
<td>-1,300</td>
<td>-3,701</td>
</tr>
</tbody>
</table>

Tons CO₂e

Presented by Architecture 2030 & ARCHITECT

March 2–4, 2020 | Intercontinental Los Angeles Downtown
# To Build or Not to Build - Carbon Calculator

## Project Data
- **State:** California
- **Climate Zone:** Mixed-dry/hot-dry
- **Primary Use Type:** Office
- **Floor Area:** 5,000 sf
- **Operational Timeline:** 10 years

## Embodied Emissions (Kg/SF)

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Wood Structure</th>
<th>Concrete or Steel Structure</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrofit Existing</td>
<td>Efficient ZNC</td>
<td>12</td>
<td>Baseline Efficiency Retrofit + 2 kg/af for RE</td>
</tr>
<tr>
<td>New Building</td>
<td>Efficient ZNC</td>
<td>25</td>
<td>Baseline New Construction + 2 kg/af for RE</td>
</tr>
<tr>
<td>Replace Existing</td>
<td>Efficient ZNC</td>
<td>27</td>
<td>+ 2 kg/af for Demo</td>
</tr>
</tbody>
</table>

## Operational Energy and Emissions

<table>
<thead>
<tr>
<th>Baseline EUI</th>
<th>59 kBTU/sf-yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Fuel Split</td>
<td>62%</td>
</tr>
<tr>
<td>Gas Fuel Split</td>
<td>38%</td>
</tr>
<tr>
<td>Electricity Emissions Factor</td>
<td>0.0603 mmBtu/kW</td>
</tr>
<tr>
<td>Gas Emissions Factor</td>
<td>0.0659 mmBtu/kW</td>
</tr>
</tbody>
</table>

## Results: Tables

### Embodied Construction Description

<table>
<thead>
<tr>
<th>Embodied Emissions (CO2e, cradle to gate)</th>
<th>Added Tons</th>
<th>Avoided Tons</th>
<th>Total Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>No construction or upgrade</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>New Construction</td>
<td>25</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>New Construction, RE</td>
<td>27</td>
<td>135</td>
<td>135</td>
</tr>
<tr>
<td>Demo, New Construction</td>
<td>27</td>
<td>135</td>
<td>135</td>
</tr>
<tr>
<td>Demo, New Construction, RE</td>
<td>29</td>
<td>145</td>
<td>145</td>
</tr>
<tr>
<td>Interiors, EE upgrades, MEP</td>
<td>12</td>
<td>60</td>
<td>-5</td>
</tr>
<tr>
<td>Interiors, EE upgrades, MEP, RE</td>
<td>14</td>
<td>70</td>
<td>-5</td>
</tr>
</tbody>
</table>

### Operational Efficiency Description

<table>
<thead>
<tr>
<th>Operational Efficiency Description</th>
<th>Added Tons</th>
<th>Avoided Tons</th>
<th>Total Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBECS 2012</td>
<td>184</td>
<td>0</td>
<td>184</td>
</tr>
<tr>
<td>2030 Challenge</td>
<td>37</td>
<td>0</td>
<td>37</td>
</tr>
<tr>
<td>ZNC</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Total Operational & Embodied Emissions (tons CO2e, 10 years)

<table>
<thead>
<tr>
<th>Total Operational &amp; Embodied Emissions (tons CO2e, 10 years)</th>
<th>184</th>
<th>0</th>
<th>184</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZNC</td>
<td>182</td>
<td>0</td>
<td>182</td>
</tr>
</tbody>
</table>

March 2–4, 2020  | Intercontinental Los Angeles Downtown
To Build or Not to Build - Carbon Calculator

Compares

- Embodied carbon
- Operational carbon
- Avoided carbon

over different time frames

Existing, New & Reuse Scenarios

- Existing Building – no change
- New Building – vacant site
- Replace Existing w/New
- Reuse & Retrofit Existing
<table>
<thead>
<tr>
<th>Building Type</th>
<th>Embodied Carbon (lbs/sf, kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Building - Concrete/Steel frame</td>
<td>80 lbs/sf (400 kg/m²)</td>
</tr>
<tr>
<td>Light Building - Wood frame</td>
<td>40 lbs/sf (200 kg/m²)</td>
</tr>
<tr>
<td>Reuse Existing Building</td>
<td>20 lbs/sf (100 kg/m²)</td>
</tr>
</tbody>
</table>

*mostly from CLF Embodied Carbon Benchmarking study.*
# To Build or Not to Build - Carbon Calculator

## Operational Carbon

<table>
<thead>
<tr>
<th></th>
<th>Existing</th>
<th>Efficient</th>
<th>Retrofit</th>
<th>ZNC</th>
</tr>
</thead>
<tbody>
<tr>
<td>from CBECS 2012</td>
<td></td>
<td>80% less than existing</td>
<td>50% less than existing</td>
<td>0</td>
</tr>
</tbody>
</table>

## PROJECT DATA

- **State**: California
- **Climate Zone**: Marine
- **Primary Use Type**: Office
- **Floor Area**: 50,000 sf
- **Operational Timeline**: 10 years

---

March 2–4, 2020 | Intercontinental Los Angeles Downtown
To Build or Not to Build - Carbon Calculator

PROJECT DATA

State: California
Climate Zone: Marine
Primary Use Type: Office
Floor Area: 50,000 sf
Operational Timeline: 10 years

Operational avoided
Embodied Avoided

Existing
- No change: 2,501 Tons CO₂
  - Efficient: 2,500
    - ZNC: 2,600
  - Efficient: 2,600
    - ZNC: 2,700
  - Efficient: 2,600
    - ZNC: 2,700

New
- No change: 2,501 Tons CO₂
  - Efficient: 2,500
    - ZNC: 2,600
  - Efficient: 2,600
    - ZNC: 2,700
  - Efficient: 2,600
    - ZNC: 2,700

Replace
- No change: 2,501 Tons CO₂
  - Efficient: 2,500
    - ZNC: 2,600
  - Efficient: 2,600
    - ZNC: 2,700
  - Efficient: 2,600
    - ZNC: 2,700

Retrofit
- No change: 2,501 Tons CO₂
  - Efficient: 2,500
    - ZNC: 2,600
  - Efficient: 2,600
    - ZNC: 2,700
  - Efficient: 2,600
    - ZNC: 2,700

Presented by Architecture 2030 & Architect

March 2–4, 2020 | Intercontinental Los Angeles Downtown
To Build or Not to Build - Carbon Calculator

### PROJECT DATA
- **State**: California
- **Climate Zone**: Marine
- **Primary Use Type**: Office
- **Floor Area**: 50,000 sf
- **Operational Timeline**: 10 years

### Total Emissions
- **Operational**:
  - Existing: 2,501 Tons CO₂e
  - New: 3,000 Tons CO₂e
  - Replace: 2,600 Tons CO₂e
  - Retrofit: 1,099 Tons CO₂e

- **Embodied & Avoided**:
  - Existing: -4,000 Tons CO₂e
  - New: -3,701 Tons CO₂e
  - Replace: -3,000 Tons CO₂e
  - Retrofit: -2,000 Tons CO₂e

- **No change**: -5,000 Tons CO₂e

---

Presented by Architecture 2030 & ARCHITECT

March 2–4, 2020 | Intercontinental Los Angeles Downtown
Thank You

Larry Strain
Siegel & Strain Architects

Kate Simonen
Carbon Leadership Forum

Questions?
LCA/LCC Resources Links

Build Awareness

1. Watch 3 min Gates video. Share with network. https://www.youtube.com/watch?v=0__6kx-vTO4
3. Join the Carbon Leadership Forum to receive newsletters & resources and join network http://carbonleadershipforum.org/

Implement in Practice

3. Join our online network. Post questions, engage in discussions. (tag interest in online form in mailing list submission) http://carbonleadershipforum.org

Build Capacity