Calculating Carbon Savings from Building Reuse and Retrofit

**Jim Lindberg**, National Trust for Historic Preservation

**Alison Frazee**, Boston Preservation Alliance

**Lori Ferriss**, Goody Clancy

**Larry Strain**, Seigel & Strain Architects
Practical tools for preservation organizations and advocates
Coordinate efforts
Align communication
Develop resources
Multiply impact

Stronger preservation movement

PRESERVATION PRIORITIES TASK FORCE
NATIONAL PARTNERS NETWORK
National Trust for Historic Preservation
website: PreservationPriorities.org

2 Year partnership  4 Working Groups  50+ Volunteer Advocates
Supported by
The Moe Family Fund
for Statewide and Local Partners
C.A.R.E – Carbon Avoided Retrofit Estimator

Calculating Carbon Savings from Building Reuse and Retrofit

Larry Strain, FAIA

SIEGEL & STRAIN Architects

Lori Ferriss, AIA, PE
Total building emissions: +/- 40%

Global CO₂ Emissions by Sector

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

(Existing buildings)

(New buildings)

Time Value of Carbon

- Embodied Carbon: 80%
- Operational Carbon: 20%

New Buildings built between now and 2050

Why Existing Buildings Matter

- We have a lot of buildings
- They contain a lot of materials
- They are not very efficient
- We can’t afford to replace them all
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Compares
- Embodied carbon
- Operational carbon
- Avoided carbon

Existing, New & Reuse Scenarios
- Existing Baseline Building
- Replace Existing w/New Building (4 types)
- Reuse & Retrofit Existing – (menu of retrofit options)
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Partners

- Architecture 2030
- Carbon Leadership Forum (CLF)
- Zero Net Carbon Collaboration (ZNCC)
- Climate Heritage Network (CHN)
- EHDD and the EPIC Tool
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Data Sources

- Architecture 2030 Zero Tool
- CLF Embodied Carbon studies
- Athena Embodied Carbon Studies
- Residensity
- SEAOC Embodied Carbon Study
- Whole Building LCA studies – various sources
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User Interface:

- Dashboard with drop down menus
- A menu of renovation and upgrade options
- Four new building options
- Options for operational efficiency
- Embodied carbon modifiers
## C.A.R.E – Carbon Avoided Retrofit Estimator

### Building Retrofit - Embodied Carbon

<table>
<thead>
<tr>
<th>Structure</th>
<th>Envelope</th>
<th>Interiors</th>
<th>MEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light / Heavy</td>
<td>Low / High Carbon Materials</td>
<td>Residential / Commercial</td>
<td>Standard / High-Performance</td>
</tr>
<tr>
<td>No Upgrade</td>
<td>No Upgrade</td>
<td>No Upgrade</td>
<td>No Upgrade</td>
</tr>
<tr>
<td>Minor Reinforcing / Repair</td>
<td>Minor: Insulation, Air sealing</td>
<td>Minor: Replace 25%</td>
<td>Minor: New lighting &amp; Controls</td>
</tr>
<tr>
<td>Major Replacement</td>
<td>New Facade: Major</td>
<td>Major: Replace: 100%</td>
<td>Major: New Systems</td>
</tr>
<tr>
<td>Minor Lateral Reinforcing</td>
<td>New Façade: Major</td>
<td>Major: Replace: 100%</td>
<td>Major: New Systems</td>
</tr>
<tr>
<td>Major Lateral Reinforcing</td>
<td>New Façade: Major</td>
<td>Major: Replace: 100%</td>
<td>Major: New Systems</td>
</tr>
<tr>
<td>Calculated as a percentage of new structural system. Choose Light / Heavy structural systems</td>
<td>Calculated as a percentage of new envelope elements, accounts for carbon intensity &amp; wall:floor area ratio</td>
<td>Calculated as a percentage of new interiors accounts for carbon intensity of residential vs commercial</td>
<td>Calculated as a percentage of new HVAC system, accounts for standard or high-performance system</td>
</tr>
</tbody>
</table>
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### New Building - Embodied Carbon

<table>
<thead>
<tr>
<th>Light - Wood Framed Building</th>
<th>Mixed – Wood + Concrete / Steel</th>
<th>Mid-Rise Concrete /Steel</th>
<th>High Carbon Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 kg/m²</td>
<td>350 kg/m²</td>
<td>500 kg/m²</td>
<td>650 kg/m²</td>
</tr>
<tr>
<td>Existing Building Estimate</td>
<td>Retrofit Building Target</td>
<td>New Building Target</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------</td>
<td>----------------------------------</td>
<td></td>
</tr>
<tr>
<td>Baseline – Zero tool</td>
<td>Baseline - no efficiency upgrade</td>
<td>Baseline: Code Average</td>
<td></td>
</tr>
<tr>
<td>Or enter your own</td>
<td>20% better than baseline</td>
<td>20% better than baseline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40% better than baseline</td>
<td>40% better than baseline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60% better than baseline</td>
<td>60% better than baseline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>80% better than baseline</td>
<td>80% better than baseline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Net Zero Carbon</td>
<td>Net Zero Carbon</td>
<td></td>
</tr>
</tbody>
</table>
Building Example
Scope of renovation included:
- New windows with high-performance glazing
- Insulating interior face of exterior walls
- Roof insulation
- New VRF units and high-efficiency condensing boilers
- Preserved 86% of structure and enclosure
- Reduced operational energy use by 70%
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**BUILDING SITE & PROJECT USE TYPE**

Click in the white cells to select from a dropdown menu or enter information about your building site and planned project use type.

<table>
<thead>
<tr>
<th>State</th>
<th>Massachusetts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zip Code</td>
<td>2115</td>
</tr>
<tr>
<td>Primary Use Type</td>
<td>Education</td>
</tr>
<tr>
<td>Existing Building Floor Area</td>
<td>18,000 sf</td>
</tr>
<tr>
<td>Operational Timeline</td>
<td>15 years</td>
</tr>
</tbody>
</table>

*key climate dates: 2030 & 2040*

- **CBECS Use Type**
- **Total Carbon Emissions**
- **CBECS Climate Zone Mapping**
**C.A.R.E – Carbon Avoided Retrofit Estimator**

### RETROFIT
- **Primary Building Use**
  - Office: 20,000 ft²
  - Retail: 5,000 ft²

### OPERATIONAL ENERGY & EMISSIONS
- **Upgrading to all electric systems and equipment?**
  - Yes
- **Generating/procuring enough renewable energy to meet total energy demand?**
  - No

<table>
<thead>
<tr>
<th>Calculate Energy &amp; Emissions Baselines</th>
<th>Baseline EUI</th>
<th>Baseline Emissions Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>73 kBtu/sf-yr</td>
<td>74 kg/m²-yr</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EUI Target</th>
<th>Emissions Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>40% Better than Baseline</td>
<td>44 kBtu/sf-yr</td>
</tr>
<tr>
<td>80% Better than Baseline</td>
<td>15 kg/m²-yr</td>
</tr>
</tbody>
</table>

### EMBODIED EMISSIONS
- **Structural Upgrade**
  - Heavy
  - Light
- **Envelope Upgrade**
  - High EC
  - Low EC
- **Interior Upgrade**
  - Minor: 25% New
  - Medium: New Roof - underlayment, rigid insulation, membrane
  - Major: 25% New
- **MEP Upgrade**
  - Standard
  - High Perf.

- **Total Embodied Emissions Intensity**: 130 kg/m²

### Size of Renovated Building for Total Emissions
- Select from drop down menus

### Operational Energy and Emissions
- Select from drop down menus

### Embodied Carbon of Renovation
- No Upgrade
- Minor: Finishes Only
- Minor: 75% Retained
- Major: 50% Retained
- **All New: 0% Retained**
# C.A.R.E – Carbon Avoided Retrofit Estimator

## NEW BUILDING

<table>
<thead>
<tr>
<th>Primary Building Use</th>
<th>20,000 ft²</th>
<th>5,000 ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retail</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Add another use type? ⊳

## OPERATIONAL ENERGY & EMISSIONS

- **Upgrading to all electric systems and equipment?**
  - Yes
  - No

- **Generating/procuring enough renewable energy to meet total energy demand?**

**Calculate Energy & Emissions Baselines**

<table>
<thead>
<tr>
<th>Baseline EUI</th>
<th>Baseline Emissions Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>66 kBtu/sf-yr</td>
<td>67 kg/m²-yr</td>
</tr>
</tbody>
</table>

**EUI Target**

- 60% Better than Baseline

**Emissions Target**

- Zero Carbon

**EMBODIED EMISSIONS**

<table>
<thead>
<tr>
<th>Building Type &amp; Structure</th>
<th>Total Embodied Emissions Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed</td>
<td>325 kg/m²</td>
</tr>
</tbody>
</table>

**Drop down menu**

- Light
- Mixed
- Mid Rise
- High Carbon

**Size of New Building for Total Emissions**

**Operational EUI of New Building**

**Operational Emissions**

**Embodied Carbon of New Building**

Select from drop down menus
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Total Added Embodied & Operational Emissions Over 15 Years

- Do Nothing to Existing Building: 1,705 Tons CO₂e
- Retrofit Existing Building: 341 Embodied + 351 Operational = 692 Tons CO₂e
- Build New Replacement Building: 878 Tons CO₂e
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Cumulative Emissions Over Time

- Do Nothing to Existing Building
- Retrofit Existing Building
- Build New Replacement Building

Years

Tons CO$_2$e

0 0 351 578 806 992 1,136 1,105 2,273

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Historic Campus Growth

Photo credit: Agnes Scott Special Collections
Over its history, the college’s stewardship approach to growth has avoided embodied emissions equivalent to 34,000 metric tons of CO2e.

It would take a forest the size of the entire Agnes Scott campus more than 400 years to sequester that much CO2.
Campus Scale Annual Carbon Emissions 2007-2037

37% Reduction in Annual Emissions by 2018

- Do Nothing
- Replace Buildings at End of Life
- Renovate Buildings at End of Life
- Continuous Improvement and Renovate
Total Reduction in Carbon Emissions 2007-2037

- 0% Do Nothing
- 3% Replace Buildings at End of Life
- 10% Renovate Buildings at End of Life
- 41% Continuous Improvement and Renovate
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Potential Future Development

- Independent renovation and addition inputs
- Saved scenarios for comparison
- Manual emissions factors and fuel source options
- Expanded drop-down options
- Geographic expansion
- Portfolio function
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Thank you
Learn More

Preservation Priorities Task Force: PreservationPriorities.org

PPTF Climate Justice webinar: Early May

Forum webinar series: https://forum.savingplaces.org/forum-webinar

C.A.R.E. Tool Updates: https://www.znccollaboration.org/care
More about the PPTF:

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