Network Overview

Communication and knowledge building platform

1108 members from industry, nonprofits, governments, academia

Common mission to phase out emissions from buildings and construction materials
ECN Focus Groups

10 Focus Groups

- Academic
- Buildings
- Construction
- LCA Data/Tools
- Materials
- Nodo Hispano
- Outreach
- Policy
- Renewables
- Reuse
Series Overview

Research, case studies, strategies to measure and reduce embodied carbon

Six online sessions  Subject matter experts  AIA CE Credits
Webinar Series Disclaimer

This session is provided as part of the Embodied Carbon Network 2019 Webinar Series. We invite guest speakers to share their knowledge and insight on topics related to carbon emissions attributed to building materials. The series aims to introduce topics that lead participants to think and talk about building industry strategies for reducing carbon emissions.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use. Please note the opinions, ideas, or data presented by speakers in this series do not represent members of the Embodied Carbon Network or constitute endorsement by the Network.
Logistics

- 15-minute Q&A session after presentations
- To receive AIA continuing education credit: send your AIA member number to info@embodiedcarbonnetwork.org
- To access past webinar recordings, visit: www.embodiedcarbonnetwork.org/resources

Save the Date!

- Upcoming Materials Focus Group call - Dec 6th at 9am PST
- Upcoming webinar: Session 6 - LCA Data and Tools – Dec 13th at 9am PST
Webinar Overview

San Francisco Airport WBLCA Case Study using Tally

Raphael Sperry
Associate
Arup

Office Building WBLCA Case Study using One Click LCA

Anthony Pak
Principal | LCA Consultant
Priopta
Webinar Overview

Concrete Mix LCA and Case Studies for LEED v4.1

Baha Sadreddin
High Performance Design Specialist
ZGF

Setting up the Baseline for Building Enclosure and Structure

Victoria Herrero-Garcia
Sustainability Consultant, WBLCA Analyst
Ambient Energy
SFO Boarding Area B – Whole Building LCA

Raphael Sperry, AIA, LEED AP BD&C ID&C, WELL AP
Associate | Sustainability
Arup | San Francisco

raphael.sperry@arup.com
SFO Boarding Area B

Area: ~500,000 square feet
Cost: ~ $1 Billion
Schedule: 2015 - 2022
100% SD LCA – Structure Only
Tally Analysis

View of building structure at 100%SD

Results per CSI Division, itemized by Material

Legend

Global Warming Potential

Primary Energy Demand
100% SD LCA – Structure Only
Tally Analysis

Comparison of whole structure using Typical and Low-cement concrete mixes; steel structure unchanged
(Tally results exported to Excel for comparison)
Sometimes a Revit model is not available in SD…
we exported envelope material takeoffs from a Rhino model in SD

100% SD – Nonstructural materials
Sometimes a Revit model is not available in SD... in this case, using a consistent data set is essential

100% SD – Nonstructural materials
Quartz database analysis

<table>
<thead>
<tr>
<th>Epoxy terrazzo flooring</th>
<th>Linoleum flooring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Energy (x10^5 MJ)</td>
<td>Acidification Potential (x10^2 lbs SO2eq)</td>
</tr>
<tr>
<td>Concrete Masonry Units</td>
<td>Metal panels</td>
</tr>
<tr>
<td>4.50E+02</td>
<td>4.00E+02</td>
</tr>
</tbody>
</table>

Option 1 - Base Case

Option 2 - Alternate Flooring
100% CD LCA – Low Cement Concrete

Mix # 3FAE75Q2

<table>
<thead>
<tr>
<th>Material Code</th>
<th>Description</th>
<th>Source Supplier</th>
<th>Design Cubic Yd</th>
<th>Design Cubic M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>ASTM C1150</td>
<td>Calibre Portland</td>
<td>1244 lbs</td>
<td>0.04</td>
</tr>
<tr>
<td>Fly Ash</td>
<td>ASTM C618</td>
<td>Central Concrete</td>
<td>147 lbs</td>
<td>0.00</td>
</tr>
<tr>
<td>Coarse Aggregate</td>
<td>ASTM C330</td>
<td>Central Concrete</td>
<td>1725 lbs</td>
<td>0.08</td>
</tr>
<tr>
<td>Fine Aggregate</td>
<td>ASTM C330</td>
<td>Central Concrete</td>
<td>1154 lbs</td>
<td>0.06</td>
</tr>
<tr>
<td>Water</td>
<td>ASTM C1294</td>
<td>Central Concrete</td>
<td>29.2 lbs</td>
<td>0.08</td>
</tr>
<tr>
<td>Admixture</td>
<td>ASTM C948</td>
<td>Central Concrete</td>
<td>0.5 lbs</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Air Target: 2.50% by Weight

Mix # 361112C1

<table>
<thead>
<tr>
<th>Material Code</th>
<th>Description</th>
<th>Source Supplier</th>
<th>Design Cubic Yd</th>
<th>Design Cubic M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>ASTM C1150</td>
<td>Calibre Portland</td>
<td>1170 lbs</td>
<td>0.04</td>
</tr>
<tr>
<td>Fly Ash</td>
<td>ASTM C618</td>
<td>Central Concrete</td>
<td>137 lbs</td>
<td>0.00</td>
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<tr>
<td>Coarse Aggregate</td>
<td>ASTM C330</td>
<td>Central Concrete</td>
<td>1700 lbs</td>
<td>0.08</td>
</tr>
<tr>
<td>Fine Aggregate</td>
<td>ASTM C330</td>
<td>Central Concrete</td>
<td>1154 lbs</td>
<td>0.06</td>
</tr>
<tr>
<td>Water</td>
<td>ASTM C1294</td>
<td>Central Concrete</td>
<td>29.2 lbs</td>
<td>0.08</td>
</tr>
<tr>
<td>Admixture</td>
<td>ASTM C948</td>
<td>Central Concrete</td>
<td>0.5 lbs</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Air Target: 2.50% by Weight

Optional to be reviewed upon request.
100% CD LCA – Assign Tally Materials

![Tally Environmental Impact Tool](image: Autodesk)
100% CD LCA – Structure and Enclosure
Tally Analysis: Baseline Case

Results per Division

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.326E+08</td>
<td>27.674</td>
<td>12.288</td>
<td>6.098E+07</td>
<td>1.014</td>
<td>3.073E+01</td>
<td>5.017E+08</td>
<td>4.785E+08</td>
<td>2.311E+07</td>
</tr>
</tbody>
</table>

Legend

Divisions
- 03 - Concrete
- 04 - Masonry
- 05 - Metals
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing

Baseline case Tally output
100% CD LCA – Structure and Enclosure Tally Analysis: Design Case

Results per Division

Legend

Divisions
03 - Concrete
04 - Masonry
05 - Metals
07 - Thermal and Moisture Protection
08 - Openings and Glazing

Design case Tally output
It can be hard to use the Design Options feature of Revit to get Tally to show side by side reports...
It can be hard to use the Design Options feature of Revit to get Tally to show side by side reports...

<table>
<thead>
<tr>
<th>Column1</th>
<th>Acidification Potential (kgSO2eq)</th>
<th>Eutrophication Potential (kgNeq)</th>
<th>Global Warming Potential (kgCO2eq)</th>
<th>Ozone Depletion Potential (CFC-11eq)</th>
<th>Smog Formation Potential (kgO3eq)</th>
<th>Primary Energy Demand (MJ)</th>
<th>Non-renewable Energy Demand (MJ)</th>
<th>Renewable Energy Demand (MJ)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (typical cement mix)</td>
<td>320,092</td>
<td>15,564</td>
<td>69,647,095</td>
<td>1</td>
<td>4,555,735</td>
<td>602,722,891</td>
<td>576,889,241</td>
<td>25,928,986</td>
<td>139,714,746</td>
</tr>
<tr>
<td>As-Designed (low-GWP concrete mixes)</td>
<td>280,400</td>
<td>14,649</td>
<td>61,930,455</td>
<td>1</td>
<td>4,051,094</td>
<td>571,850,604</td>
<td>545,971,939</td>
<td>25,971,372</td>
<td>139,887,038</td>
</tr>
<tr>
<td>Design compared to baseline</td>
<td>-12%</td>
<td>-6%</td>
<td>-11%</td>
<td>-5%</td>
<td>-11%</td>
<td>-5%</td>
<td>-5%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Thank you!

Raphael Sperry, AIA, LEED AP BD&C ID&C, WELL AP
Associate | Sustainability
Arup | San Francisco

raphael.sperry@arup.com
Office Building pursuing LEED Gold
Modelled with Revit model and One Click LCA

Anthony Pak
Principal
anthony@priopta.com
Source of Impact Reductions

1) Concrete Mixes with higher %SCM

<table>
<thead>
<tr>
<th>Element</th>
<th>Baseline</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation Slab</td>
<td>25 MPa 10 GU Benchmark</td>
<td>25 MPa 15 GU air</td>
</tr>
<tr>
<td>Foundation Footings</td>
<td>35 MPa 10 GU Benchmark</td>
<td>35 MPa 30 GU air</td>
</tr>
<tr>
<td>Parkade Floor Slabs</td>
<td>35 MPa 10 GU Benchmark</td>
<td>35 MPa 30 GU air</td>
</tr>
<tr>
<td>Above Grade Floor Slabs</td>
<td>35 MPa 10 GU Benchmark</td>
<td>35 MPa 25 GU</td>
</tr>
<tr>
<td>Columns (P6-L2)</td>
<td>50 MPa 10 GU Benchmark</td>
<td>50 MPa 35 GU air</td>
</tr>
<tr>
<td>Columns (L2-Roof)</td>
<td>35 MPa 10 GU Benchmark</td>
<td>35 MPa 25 GU</td>
</tr>
<tr>
<td>Shear Walls (P6-L2)</td>
<td>40 MPa 10 GU Benchmark</td>
<td>40 MPa 30 GU air</td>
</tr>
<tr>
<td>Shear Walls (L2-Roof)</td>
<td>30 MPa 10 GU Benchmark</td>
<td>30 MPa 25 GU</td>
</tr>
<tr>
<td>Stairs</td>
<td>50 MPa 10 GU Benchmark</td>
<td>50 MPa 30 GU air</td>
</tr>
<tr>
<td>Exterior Walls</td>
<td>35 Mpa 10 GU Benchmark</td>
<td>35 Mpa 25 GU air</td>
</tr>
<tr>
<td>Parkade Walls</td>
<td>35 MPa 10 GU Benchmark</td>
<td>35 MPa 30 GU air</td>
</tr>
<tr>
<td>Roof</td>
<td>35 MPa 10 GU Benchmark</td>
<td>35 MPa 25 GU air</td>
</tr>
</tbody>
</table>

2) Post Tensioned (PT) Slabs

Compared to similar past project, post tensioned slabs compared to conventionally reinforced slabs of similar spans, loading, and strength specifications:

- 11” conventional = 9” PT
- 15” conventional = 12” PT

No increase in cement content in concrete mixes for PT slabs
Environmental Product Declarations (EPD)

Select relevant North American industry average EPDs instead of generic material datapoints from One Click LCA where available.

Adjust default concrete transportation distances from 200km to 40km.

<table>
<thead>
<tr>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>No EPD available. Generic LCI data.</td>
</tr>
<tr>
<td>Industry Average EPD</td>
</tr>
<tr>
<td>Manufacturer Specific EPD (May not be what is specified)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source name</th>
<th>Country</th>
<th>Focus</th>
<th>Size</th>
<th>Resource</th>
<th>Environmental declarations</th>
<th>Notes</th>
<th>Source of EPD</th>
<th>Industry Average EPD</th>
<th>Manufacturer Specific EPD</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

Select relevant North American industry average EPDs instead of generic material datapoints from One Click LCA where available.
Proposed Building Reductions –

- Global warming (kg CO2e): 14.9%
- Acidification (kg SO2e): 12.3%
- Eutrophication (kg Ne): 14.3%
- Ozone Depletion (kg CFC11e): 0.0%
- Formation of tropospheric ozone (kg O3e): 13.6%
- Depletion of nonrenewable energy (MJ): 11.2%
Carbon Heroes Embodied Carbon Benchmark (kgCO2e/m2)

Baseline Building

Proposed Building
GWP – Breakdown of Reductions

- Foundations: 0.8%
- Floors: 11.6%
- Stairs: 0.0%
- Interior Walls - Structural: 1.6%
- Exterior Walls - Above Grade: 0.1%
- Exterior Walls - Parkade: 0.5%
- Exterior Windows: 0.0%
- Doors: 0.0%
- Roof: 0.3%
- Total Reduction: -14.9%
Smog Formation Potential
Non-Renewable Energy Use

- Exterior Walls - Above Grade 27.5%
- Floors 35.7%
- Roof 6.4%
- Interior Walls - Structural 14.8%
- Foundation 7.1%
- Exterior Walls - Parkade 2.9%
- Other classifications 5.5%
- Concrete 45.9%
- Steel and other metals 46.6%
- 15.6% Rebar
- 13.3% Structural steel
- 10.8% Other steel/iron
- 6.9% Aluminium
- 38.8% Ready-mix, walls & floors
- 2.0% Ready-mix, structures
- 1.2% CMU
- 1.1% Ready-mix, Foundations
- 1.1% Ready-mix, high strength
- 0.1% Other resource subtypes
Ozone Depletion Potential
Thank You

Anthony Pak
Principal
anthony@priopta.com
WBLCA Workflow and Concrete

Baha Sadreiddin
High-Performance Design Specialist
ZGF Architects
Why LCA?
Total global CO2 emissions

Building operations
= 28% of global GHG emissions

Embodied carbon of building materials
= 11% of global GHG emissions

Source: original graphic from Architecture 2030, UN Environment Global Status Report 2017
Annual New Construction Carbon Emissions 2020-2050
billion tons of co2/yr

Source: original graphic from Architecture 2030, UN Environment Global Status Report 2017
Embodied carbon is as important as operational carbon.
LEED v4.1

Offers four paths to achieve credit.

1. Conduct an LCA (1 point).
2. 5% reduction (2 points).
3. 10% reduction (3 points).
4. 20% reduction + building reuse and/or salvaged materials (4 points).
Workflow through case studies
Revit design options difficult to work with in WBLCA.

Detached models and worksets can work well.
Identify and optimize/replace high impact materials through LCA of the baseline model
Product stage
Extraction, Transport, Manufacturing

Transportation stage
To site

Maintenance & replacement
Expected service life

End of life stage
Demolition, Recycling, Disposal

Module D
Benefits & loads beyond sys boundary
Results per Life Cycle Stage

Legend

Net value (impacts + credits)

Life Cycle Stages
- Red: Product [A1-A3]
- Blue: Transportation [A4]
- Grey: Maintenance and Replacement [B2-B5]
- Yellow: End of Life [C2-C4]
- Green: Module D [D]

Mass: 6.05E+007 kg
Global Warming Potential: 2.38E+007 kg CO2eq
Acidification Potential: 82,745 kg SO2eq
Eutrophication Potential: 3,898 kg NOeq
Smog Formation Potential: 1,234,557 kg O3eq
Non-renewable Energy: 2.42E+008 MJ
## Results per Division

<table>
<thead>
<tr>
<th>Division</th>
<th>Impact Category</th>
<th>Impact Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>kg</td>
<td>6.05E+007</td>
<td>10%</td>
</tr>
<tr>
<td>Acidification Potential</td>
<td>kg SO2eq</td>
<td>70.410</td>
<td>11%</td>
</tr>
<tr>
<td>Eutrophication Potential</td>
<td>kg Neq</td>
<td>3.671</td>
<td>14%</td>
</tr>
<tr>
<td>Smog Formation Potential</td>
<td>kg O3eq</td>
<td>1.14E+007</td>
<td>16%</td>
</tr>
<tr>
<td>Non-renewable Energy</td>
<td>MJ</td>
<td>2.18E+008</td>
<td>11%</td>
</tr>
<tr>
<td>Global Warming Potential</td>
<td>kg CO2eq</td>
<td>1.29E+007</td>
<td>16%</td>
</tr>
</tbody>
</table>

**Legend**

- **03 - Concrete**
- **04 - Masonry**
- **05 - Metals**
- **07 - Thermal and Moisture Protection**
- **08 - Openings and Glazing**
- **09 - Finishes**
Results per Division, itemized by Material

Legend

03 - Concrete
- Coarse aggregate
- Gravel
- Perlite
- Portland cement, PCA - BPD
- Sand
- Steel, reinforcing rod
- Water
Results per Revit Category

Legend

Revit Categories
- Ceilings
- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roof
- Structure
- Walls
- Windows
Identify, optimize, replace high impact materials.

Steel/Metals  Insulation  Wood  Concrete
• If the cement industry was a country by itself, it would be the 3rd largest contributor to GHG emissions after only the U.S. and China.
Concrete mix designs

Whole Building LCA

Concrete Structure Enclosure

UPDATE
Concrete mix designs

Whole Building LCA
## Concrete LCA Tool

### Proposed Mix Designs

<table>
<thead>
<tr>
<th>Application</th>
<th>Floors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix Design #/Name</td>
<td>54010A</td>
</tr>
<tr>
<td>Strength (psi)</td>
<td>4000 psi</td>
</tr>
<tr>
<td>Total CY of Mix in Building</td>
<td>1 cubic yard</td>
</tr>
<tr>
<td>SCM Ratio</td>
<td>18.0% &lt;&lt;&lt; Less SCM than baseline!</td>
</tr>
<tr>
<td>Cement lbs to Total lbs Ratio</td>
<td>13.8% &lt;&lt;&lt; Less cement than baseline.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Weight (lbs)</th>
<th>Acidification (kgSO2eq)</th>
<th>Eutrophication (kgNeq)</th>
<th>Global Warming (kgCO2eq)</th>
<th>Ozone Depletion (CFC-11eq)</th>
<th>Smog Formation (kgO3eq)</th>
<th>Non-renewable Energy Demand (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly ash</td>
<td>4.013</td>
<td>0.01</td>
<td>0.38</td>
<td>0.0000</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Slag</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0000</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Coarse Aggregate (sand)</td>
<td>1.532</td>
<td>0.03</td>
<td>0.10</td>
<td>0.0000</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>Water</td>
<td>0.359</td>
<td>0.00</td>
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<td>0.0000</td>
<td>0.00</td>
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<tr>
<td>Steel Reinforcement</td>
<td>0.19</td>
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<td>0.00</td>
<td>0.0000</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>Total Impact</td>
<td>4.137</td>
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<td>0.48</td>
<td>0.0000</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Impact % vs Baseline</td>
<td>-8.0% -11.1% -11.7% 0.003% -9.0% -7.9%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

### Baseline Mixes Designs

<table>
<thead>
<tr>
<th>Application</th>
<th>Floors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix Design #/Name</td>
<td>NRMCA 6. Pacific Southwest Region</td>
</tr>
<tr>
<td>Strength (psi)</td>
<td>4000 psi</td>
</tr>
<tr>
<td>Total CY of Mix in Building</td>
<td>1 cubic yard</td>
</tr>
<tr>
<td>SCM Ratio</td>
<td>15.0%</td>
</tr>
<tr>
<td>Cement lbs to Total lbs Ratio</td>
<td>17.4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Weight (lbs)</th>
<th>Acidification (kgSO2eq)</th>
<th>Eutrophication (kgNeq)</th>
<th>Global Warming (kgCO2eq)</th>
<th>Ozone Depletion (CFC-11eq)</th>
<th>Smog Formation (kgO3eq)</th>
<th>Non-renewable Energy Demand (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly ash</td>
<td>674.8</td>
<td>0.71</td>
<td>0.48</td>
<td>0.0000</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>Slag</td>
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### Comparison

**Environmental Impact Comparison - Total Volume of Concrete in the Building**

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**Better or Worse?**

- Acidification
- Eutrophication
- Global Warming
- Ozone Depletion
- Smog Formation
- Non-renewable Energy Demand

### Proposed vs Baseline - Floors - 4000 psi - Impact Comparison

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**Better or Worse?**

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### Regional Practices

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**Better or Worse?**

- Acidification
- Eutrophication
- Global Warming
- Ozone Depletion
- Smog Formation
- Non-renewable Energy Demand
Concrete LCA Tool

- Doesn’t need Revit model or any geometry
- Doesn’t require LCA expertise
- Applicable SD-CA
- Live LCA of concrete mix designs
- Can be used real time in meetings with project partners
- Focuses on Portland cement content vs. SCM
- Data can be updated in the future

We are making it available to others for free lca-tool@zgf.com
Portland cement

20,764,320 lbs in baseline

To

16,310,855 lbs in proposed

21.4% reduction in cement content
California Air Resources Board - WBLCA

2 points under LEED v4.1
DGS Clifford L. Allenby Building
Zero Net Energy Office Building
400,000 sf
Portland cement
15,932,315 lbs in baseline
To
11,875,038 lbs in proposed

25.5% reduction in cement content
DGS Clifford L. Allenby Building - WBLCA

3 points under LEED v4.1
To get a free copy of the ZGF Concrete LCA tool email lca-tool@zgf.com

Baha Sadreddin
High-Performance Design Specialist
ZGF Architects
ECN Webinar 5
Creating a WBLCA Baseline

Victoria Herrero-Garcia
Sustainability Consultant,
Daylight & WBLCA Analyst
Building Stock Market Predictions
By year 2060, the world is projected to add 2.5 trillion ft$^2$ of buildings for the next 40 years.
Total Carbon Emissions of Global New Construction from 2020-2050
Business as Usual Projection

<table>
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<tr>
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<th>Embodied Carbon</th>
<th>Operational Carbon</th>
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<tbody>
<tr>
<td>% Carbon Emissions</td>
<td>49%</td>
<td>51%</td>
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Architecture 2030
“Zero CO2 Emissions by 2040”
HIGH PROBABILITY OF MEETING 1.5°C
(67% CHANCE)

- Peak Emissions in 2020
- reduction by 2030
- 500 GtCO₂ (1.5°C, 50% Chance)
- 340 GtCO₂ (1.5°C, 67% Chance)

Global Emissions in GtCO₂

2020 2025 2030 2035 2045 2050

Zero CO₂ Emissions
Creating a Baseline
Elements to include in LEED WBLCA

Building enclosure and Structure

- Envelope
- Roof Assemblies
- Structural wall assembly (cladding to interior finishes)
- Superstructure
- Structural floors and ceilings (not including finishes)
- Footings and Foundations

Optional Elements:
- Interior non-structural wall
- Interior finishes
Baseline vs Proposed – LEED requires to be comparable in....

1. Size
2. Programmatic Function
3. Orientation
4. Energy Performance per EA Prerequisite Minimum Energy Performance:
   ASHRAE Standard 90.1 Appendix G Table 3.1
Building Enclosure
Early Design

- Use ASHRAE Standard 90.1 Appendix G Table 3.1 for your climate zone
- Research typical Assembly types for your climate zone based on building type
- Insulation type and thickness
- Coordinate with Energy Modeler
Opaque Assemblies. Opaque assemblies used for new buildings or additions shall conform with the following common, lightweight assembly types and shall match the appropriate assembly maximum U-factors in Tables 5.5-1 through 5.5-8:

- **Roofs**—Insulation entirely above deck
- **Above-grade walls**—Steel-framed
- **Floors**—Steel-joist
- **Opaque door** types shall match the proposed design and conform to the U-factor requirements from the same tables.
- **Slab-on-grade floors** shall match the F-factor for unheated slabs from the same tables.
See ASHRAE 90.1 for:
- Vertical Fenestration
- Skylights and Glazed Smoke Vents
- Roof Solar Reflectance and Thermal Emittance

* ASHRAE 90.1-2010 (Colorado Zone 5B)
## Coordination with Energy Modeler

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<tr>
<th>Energy Model Input</th>
<th>Standard Reference</th>
<th>Proposed Design</th>
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<tr>
<td>Roof</td>
<td>R-30 ci (U-0.032)</td>
<td>Roof const + R-40 ci (U-0.025)</td>
</tr>
<tr>
<td>Exterior Wall Type 1</td>
<td>8” CMU + R-11.4 ci (U-0.088)</td>
<td>3-5/8&quot; brick + 1&quot; airspace + 3-3/8&quot; spray foam + 7-5/8&quot; CMU + airspace + 3-5/8&quot; brick interior (U-0.041)</td>
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<tr>
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<td>R-10 for 24”</td>
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Final WBLCA – Construction Documents
Baseline and proposed – Equal U-factor

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If proposed design U-factor is better or worst than ASHRAE’s prescriptive enclosure requirements, the recommended U-factor for baseline should be the same U-factor as proposed design.
Structure
Whole Building
Life Cycle Assessment
REFERENCE BUILDING STRUCTURE AND STRATEGIES
WBLCA Guide Special Project
Working Group
Edited by Frances Yang, S.E.
Structure Baseline:

- What structural elements have been avoided?
- What is the typical reinforcement or spacing?
- Has the slab been reduced or modified?
- Has the roof framing changed from metal to wood?
Values from American Iron and Steel Institute (AISI) for North America Steel
Concrete Baseline:

- Contact local concrete producers
- Supplementary Cementitious Materials (SCMs) might not always be available in your area
  - Fly Ash
  - Slag
  - Silica Fume
- i.e. In Denver area, baseline concrete has 0-3% fly ash
Final Thoughts
Final Thoughts

- WBLCA is not Energy Modeling
- Start the talk early in design
- To meet 2020 goal = 40% reductions
  - To meet 2030 goal = 65% reductions
- ECN is a place to share your Knowledge and ask questions
Thank you

Victoria Herrero-Garcia
Sustainability Consultant, Daylight and WBLCA Analyst
vherrero@ambient-e.com
Thank you!

Embodied Carbon Network | 2019 Webinar Series

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@embodiedcarbnet