The selection of materials for sustainability

Dr Christopher Drew
The environmental movement has seen the emergence and management of significant global challenges over the past 50 years. Depending where you are in the world, the built environment contributes anywhere from 20-25% to almost 50% of a country’s carbon emissions. The direct relationship between buildings and environmental impact is very clear. What’s a little fuzzier though is what buildings can do to contribute toward a more sustainable environment. It may at first seem obvious – use less energy, less materials and take up less land? But, as with some many parts of an overall ecosystem, things are not that simple.

In this presentation, we explore the relationship between two current, often conflicting challenges - energy saving and life cycle emissions. We will highlight and discuss some approaches through materials selection, specification and analysis and take a close look at how these interface with the plethora of codes, building rating systems and sustainability initiatives locally and globally.
Dr Christopher Drew

Director of Sustainability

Adrian Smith + Gordon Gill Architecture

Dr Christopher Drew is Director of sustainability at AS+GG. He brings an understanding of the relationships of the built environment with the natural environment and urban ecosystems through over 20 years of experience, working as an ecologist, environmental scientist and sustainability manager.

Chris received his PhD in Ecology from the University of Stirling in Scotland, United Kingdom and lived and worked in the United Arab Emirates before moving to the USA to join AS+GG 9 years ago.
Learning Objectives

1. Understand the breadth of sustainable design challenges
2. Understand the relationship between operational and lifecycle emissions
3. Understand the role that material selection plays
4. Understand an approach to specifying low carbon materials
IN 1972 THE PESTICIDE DDT WAS BANNED IN THE USA
THE CLEAN AIR ACT WAS INTRODUCED IN 1977 TO REDUCE AIR POLLUTION
THE LARGEST HOLE IN THE OZONE LAYER WAS RECORDED IN SEPTEMBER 2006.....

THE AVERAGE SIZE BEING 27.5 MILLION SQUARE KILOMETRES
CLIMATE CHANGE – GLOBAL WARMING ASSOCIATED WITH INCREASED ATMOSPHERIC CO$_2$ LEVELS
SOCIAL MEDIA AND GLOBAL SOCIAL AND ENVIRONMENTAL AWARENESS

THE GREAT PACIFIC GARBAGE PATCH

NEONICOTINOID PESTICIDES - THE FACTS

The use of neonicotinoids has been a controversial topic. This pesticide, used for around 70% of the global agriculture market, has also been linked with negative environmental effects. This graphic looks at how they work, and the harm of the ecosystems surrounding them.

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INUNDATED WITH RATING SCHEMES
AND REGIONAL AND GLOBAL INITIATIVES
So what do I need to do?

NO QUESTION IS SO DIFFICULT TO ANSWER AS THAT TO WHICH THE ANSWER IS OBVIOUS

- George Bernard Shaw
**CODE DRIVEN IMPROVEMENTS**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<td><strong>SHGC</strong></td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.22</td>
<td>0.22</td>
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<tr>
<td><strong>Window U value</strong></td>
<td>6.8</td>
<td>6.8</td>
<td>3.24</td>
<td>2.8</td>
<td>1.9</td>
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<tr>
<td><strong>Opaque area wall u-value</strong></td>
<td>0.7</td>
<td>0.53</td>
<td>0.53</td>
<td>0.53</td>
<td>0.57</td>
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<tr>
<td><strong>Roof u-value</strong></td>
<td>0.36</td>
<td>0.36</td>
<td>0.27</td>
<td>0.22</td>
<td>0.3</td>
</tr>
</tbody>
</table>
THE TRAJECTORY OF GRID EMISSIONS

UAE ENERGY STRATEGY FOR 2050 (2018)

- 40% IMPROVED ENERGY EFFICIENCY OF BUILDINGS
- 70% CO₂ EMISSIONS FROM ELECTRICITY GENERATION

UK ELECTRICITY EF PROJECTIONS

- GCF 2017
- GCF 2016

Emissions intensity, gCO₂e/kWh

2014 2019 2024 2029 2034
EMBODIED CARBON EMISSIONS

EMBODIED CARBON

15% SIDEWALKS
63% ROADS AND ALLEYS
12% STORMWATER PIPES
3% POTABLE WATER PIPES
7% SANITARY SEWER PIPES

3% CMU BLOCKS
8% BRICKS
9% CONCRETE
57% FOUNDATION CONCRETE
20% FOUNDATION REBAR

<1% INSULATION
<1% INSULATED GLAZING
1% INSULATION PANELS
11% ALUMINIUM
11% WOOD

SUBURBAN HOUSE

NUMBER OF BUILDINGS: 2000
NUMBER OF UNITS: 1/BUILDING
BUILDING HEIGHT: 7M

INFRASTRUCTURE EC: 20,961 TONS
BUILDING EC: 232,070 TONS
TOTAL EC: 253,031 TONS

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EMBODIED CARBON EMISSIONS

CARBON EMISSIONS

- Embodied Carbon of Envelope
- 30 yrs Operational Emissions - Heat with Gas

Overall Envelope u-value

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REDUCING EMBODIED CARBON EMISSIONS

CARBON EMISSIONS

- Embodied Carbon of Envelope
- 30 yrs Operational Emissions - Heat with Gas
- 30 yrs Operational Emissions - Heat with Electricity

Embodied Carbon of Envelope

30 yrs Operational Emissions - Heat with Gas

30 yrs Operational Emissions - Heat with Electricity

Overall Envelope u-value

- Code compliant u-value (ASHRAE 90.1-2010)
- Passive House Standard u-value

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CORE AND SHELL OPPORTUNITIES

CONCRETE
- Establish GWP targets
- Specify EPD
- Cement replacement
- Recycled water
- Recycled Aggregate

STEEL
- Establish GWP target
- Specify EPD
- Renewable energy at the mill
- High recycled content in steel
- Local EAF steel

INSULATION
- Specify EPDs
- Zero HFC blowing agents
- Use of natural insulation products

GLASS
- Identify embodied CO2 target based on industry EPDs
- Identify glass manufacturers that use a high proportion of recycled clean glass cullet
- Identify glass manufacturing facilities that use renewable energy

FRAMING
- Establish GWP target
- Work with supply chain to produce very low embodied carbon aluminum
- Consider offsetting
ESTABLISH A TARGET FOR EMBODIED CARBON OF CONCRETE

Environmental Product Declaration

DUBAI READY-MIXED CONCRETE

EPD for concrete produced at eight ready-mixed concrete plants located in Dubai, United Arab Emirates
### Table 6. Summary Results [A1-A3]: United Arab Emirates average concrete, per cubic meter

<table>
<thead>
<tr>
<th>Indicator/LCI Metric</th>
<th>GWP</th>
<th>ODP</th>
<th>AP</th>
<th>EP</th>
<th>POCPP</th>
<th>PEC</th>
<th>NRE</th>
<th>RE</th>
<th>NRM</th>
<th>RM</th>
<th>CBW</th>
<th>CWW</th>
<th>TW</th>
<th>CHW</th>
<th>CNHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIX ID</td>
<td>kg CO₂</td>
<td>kg CFC-11</td>
<td>kg SO₂</td>
<td>kg N</td>
<td>kg O₃</td>
<td>MJ</td>
<td>MJ</td>
<td>MJ</td>
<td>kg</td>
<td>kg</td>
<td>m³</td>
<td>m³</td>
<td>m³</td>
<td>kg</td>
<td>kg</td>
</tr>
<tr>
<td>C30 - C35 (66%GGBS)</td>
<td>222.14</td>
<td>2.80E-05</td>
<td>6.62</td>
<td>0.60</td>
<td>79.32</td>
<td>2660.84</td>
<td>2624.88</td>
<td>35.96</td>
<td>2171.82</td>
<td>1.81</td>
<td>0.16</td>
<td>0.12</td>
<td>1.43</td>
<td>4.87E-03</td>
<td>87.17</td>
</tr>
<tr>
<td>C40 (36%GGBS)</td>
<td>328.30</td>
<td>3.52E-05</td>
<td>7.71</td>
<td>0.81</td>
<td>92.10</td>
<td>3321.78</td>
<td>3286.84</td>
<td>34.94</td>
<td>2400.42</td>
<td>2.56</td>
<td>0.14</td>
<td>0.12</td>
<td>2.32</td>
<td>2.88E-03</td>
<td>87.15</td>
</tr>
<tr>
<td>C40 (66%GGBS)</td>
<td>234.99</td>
<td>2.91E-05</td>
<td>7.67</td>
<td>0.68</td>
<td>90.98</td>
<td>2792.55</td>
<td>2754.43</td>
<td>38.12</td>
<td>2186.56</td>
<td>1.94</td>
<td>0.15</td>
<td>0.12</td>
<td>1.49</td>
<td>5.27E-03</td>
<td>87.17</td>
</tr>
<tr>
<td>C45 (36%GGBS)</td>
<td>334.08</td>
<td>3.56E-05</td>
<td>7.73</td>
<td>0.81</td>
<td>92.40</td>
<td>3367.17</td>
<td>3331.67</td>
<td>35.50</td>
<td>2388.95</td>
<td>2.62</td>
<td>0.14</td>
<td>0.12</td>
<td>2.37</td>
<td>2.96E-03</td>
<td>87.15</td>
</tr>
<tr>
<td>C45 (66%GGBS)</td>
<td>242.79</td>
<td>2.97E-05</td>
<td>7.71</td>
<td>0.70</td>
<td>91.54</td>
<td>2863.43</td>
<td>2824.04</td>
<td>39.39</td>
<td>2158.71</td>
<td>2.03</td>
<td>0.15</td>
<td>0.12</td>
<td>1.54</td>
<td>5.53E-03</td>
<td>87.18</td>
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<tr>
<td>C50 (36%GGBS)</td>
<td>340.80</td>
<td>3.60E-05</td>
<td>8.73</td>
<td>0.88</td>
<td>103.33</td>
<td>3421.07</td>
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<td>36.02</td>
<td>2377.83</td>
<td>2.67</td>
<td>0.15</td>
<td>0.12</td>
<td>2.43</td>
<td>3.02E-03</td>
<td>87.16</td>
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<tr>
<td>C55 (26%GGBS+5%M)</td>
<td>367.86</td>
<td>3.78E-05</td>
<td>8.76</td>
<td>0.92</td>
<td>103.85</td>
<td>3571.09</td>
<td>3535.93</td>
<td>35.15</td>
<td>2394.41</td>
<td>2.85</td>
<td>0.15</td>
<td>0.12</td>
<td>2.68</td>
<td>2.28E-03</td>
<td>87.15</td>
</tr>
<tr>
<td>C60 (26%GGBS+5%M)</td>
<td>373.87</td>
<td>3.82E-05</td>
<td>8.78</td>
<td>0.93</td>
<td>104.18</td>
<td>3620.30</td>
<td>3584.59</td>
<td>35.71</td>
<td>2396.71</td>
<td>2.90</td>
<td>0.15</td>
<td>0.12</td>
<td>2.72</td>
<td>2.34E-03</td>
<td>87.15</td>
</tr>
<tr>
<td>C65 (26%GGBS+6%M)</td>
<td>370.68</td>
<td>3.81E-05</td>
<td>8.78</td>
<td>0.92</td>
<td>104.14</td>
<td>3600.94</td>
<td>3565.32</td>
<td>35.62</td>
<td>2403.73</td>
<td>2.87</td>
<td>0.14</td>
<td>0.12</td>
<td>2.68</td>
<td>2.34E-03</td>
<td>87.15</td>
</tr>
<tr>
<td>C70 (26%GGBS+7%M)</td>
<td>372.96</td>
<td>3.84E-05</td>
<td>5.39</td>
<td>0.71</td>
<td>67.23</td>
<td>3617.10</td>
<td>3580.99</td>
<td>36.11</td>
<td>2418.34</td>
<td>2.90</td>
<td>0.14</td>
<td>0.12</td>
<td>2.69</td>
<td>2.40E-03</td>
<td>87.15</td>
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<tr>
<td>C75 (26%GGBS+7%M)</td>
<td>379.77</td>
<td>3.89E-05</td>
<td>5.41</td>
<td>0.72</td>
<td>67.57</td>
<td>3671.07</td>
<td>3634.43</td>
<td>36.64</td>
<td>2423.11</td>
<td>2.96</td>
<td>0.14</td>
<td>0.12</td>
<td>2.73</td>
<td>2.44E-03</td>
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<tr>
<td>C80 (26%GGBS+8%M)</td>
<td>384.36</td>
<td>3.93E-05</td>
<td>6.41</td>
<td>0.79</td>
<td>78.56</td>
<td>3714.68</td>
<td>3677.44</td>
<td>37.24</td>
<td>2411.99</td>
<td>3.00</td>
<td>0.14</td>
<td>0.12</td>
<td>2.76</td>
<td>2.52E-03</td>
<td>87.15</td>
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<tr>
<td>C90 (26%GGBS+8%M)</td>
<td>394.97</td>
<td>4.01E-05</td>
<td>6.45</td>
<td>0.81</td>
<td>79.08</td>
<td>3798.09</td>
<td>3760.00</td>
<td>38.09</td>
<td>2414.05</td>
<td>3.09</td>
<td>0.13</td>
<td>0.12</td>
<td>2.84</td>
<td>2.60E-03</td>
<td>87.16</td>
</tr>
</tbody>
</table>
ESTABLISH A TARGET FOR EMBODIED CARBON OF ALUMINIUM

Blend with recycled automotive components

Use Smelter located at a site that uses renewable energy

Select an extrusion pant located at a site that uses renewable energy
EMBODIED CARBON EMISSIONS

Production (million metric tons)

- Steel: 1250 mmt (96%)
- Aluminium: 33 mmt (3%)

CO₂ (Billion metric tons)

- Steel: 2.13 billion tons, (81%)
- Aluminium: 0.41 billion tons, (16%)

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Environmental Product Declaration
BREG EN EPD No.: 000131 Issue: 01
ECO EPD Ref. No.: 000425
This is to certify that this verified Environmental Product Declaration provided by Emirat Steel Industries Co. PJSC (member of UK CARES) is in accordance with the requirements of:
EN 15804:2012+A1:2013
This declaration is for:
Carbon Steel Reinforcing Bar (Direct Reduced Iron production route)

Company Address
P.O. Box 9002, Industrial City of Abu Dhabi (ICAD)
Abu Dhabi

Signed for BRE Global Ltd
Operator: Emma Baker
Date of First Issue: 22 September 2016
Date of Last Issue: 31 July 2019

Statement of Verification
BREG EN EPD No.: 000180 Issue: 2
ECO EPD Ref. No.: 00000612
This is to certify that the Environmental Product Declaration provided by Conares Metal Supply Ltd (member of UK CARES) is in accordance with the requirements of:
EN 15804:2012+A1:2013
and BRE Global Scheme Document SD207
This declaration is for:
Carbon Steel Reinforcing Bar (secondary production route - scrap)

Company Address
Plot No. S40506-508
Jebel Ali South
Dubai
2854
United Arab Emirates

Signed for BRE Global Ltd
Operator: Emma Baker
Date of First Issue: 19 December 2017
Date of Last Issue: 18 December 2020

The Statement of Verification is based on the information submitted by the manufacturer. The manufacturer is solely responsible for its accuracy and correctness. To check the validity of this EPD please visit the BRE Global website or contact the BRE Global Ltd, Greenford, Middlesex, UK or via email to info@bre.co.uk.
WHOLE BUILDING LIFE CYCLE CARBON NEUTRAL – How do we calculate it
### 1. Foundations

**Foundations and retaining structures**

All the subsurface structures are reported here, including materials used for basements, cellars and garages.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Add</th>
<th>Quantity</th>
<th>Filter by</th>
<th>Profile</th>
<th>Comment</th>
<th>Thickness, mm</th>
<th>Transport, kilometers</th>
<th>Service life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete C28/35 (rebar)</td>
<td></td>
<td>1.19</td>
<td>m³</td>
<td>Sandreinfill...</td>
<td>Combines 22 rows</td>
<td>150</td>
<td>200</td>
<td>Trailer combinator 1</td>
</tr>
<tr>
<td>Steel, structural steel construction pro...</td>
<td></td>
<td>4.67</td>
<td>m³</td>
<td>Rukk10014</td>
<td>Combines 11 rows</td>
<td></td>
<td></td>
<td>As building</td>
</tr>
</tbody>
</table>

### 2. Structural frame, facade, internal space elements and surfaces

#### Facade

**Facade, external surface**

<table>
<thead>
<tr>
<th>Resource</th>
<th>Add</th>
<th>Quantity</th>
<th>Filter by</th>
<th>Profile</th>
<th>Comment</th>
<th>Thickness, mm</th>
<th>Transport, kilometers</th>
<th>Service life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete C28/35 (rebar)</td>
<td></td>
<td>4.1</td>
<td>m³</td>
<td>Sandreinfill...</td>
<td>M_1000 Concrete - Cast-in-</td>
<td>150</td>
<td>150</td>
<td>Trailer combinator 1</td>
</tr>
<tr>
<td>Cement bonded wood particle board Celtrk...</td>
<td></td>
<td>27.44</td>
<td>m³</td>
<td>Okebk0101...</td>
<td>Combines 29 rows</td>
<td>10</td>
<td>300</td>
<td>Trailer combinator 1</td>
</tr>
<tr>
<td>Aerated concrete P2 04, unrefr.</td>
<td></td>
<td>57.00</td>
<td>m³</td>
<td>Okebk0101...</td>
<td>Combines 10 rows</td>
<td></td>
<td>200</td>
<td>Trailer combinator 1</td>
</tr>
<tr>
<td>Aerated concrete P4 05, re-inf.</td>
<td></td>
<td>9.09</td>
<td>m³</td>
<td>Foundation - 300mm Concrete</td>
<td>Combines 2 rows</td>
<td></td>
<td>200</td>
<td>Trailer combinator 1</td>
</tr>
<tr>
<td>Steel, structural steel construction pro...</td>
<td></td>
<td>0.021</td>
<td>m³</td>
<td>Rukk10014</td>
<td></td>
<td></td>
<td>300</td>
<td>Trailer combinator 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sector</th>
<th>Global warming kg CO2e</th>
<th>Ozone depletion potential kg CFC11e</th>
<th>Acidification kg SO2e</th>
<th>Eutrophication kg PO4e</th>
<th>Formation of ozone of lower atmosphere kg Ethane</th>
<th>Depletion of nonrenewable energy MJ</th>
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</thead>
<tbody>
<tr>
<td>A1-A3</td>
<td>Construction Materials</td>
<td>6.91E6</td>
<td>-53 %</td>
<td>2.82E2</td>
<td>-94 %</td>
<td>2.59E4</td>
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<tr>
<td>A4</td>
<td>Transportation to site</td>
<td>2.41E5</td>
<td>-26 %</td>
<td>4.71E2</td>
<td>-78 %</td>
<td>4.82E2</td>
</tr>
<tr>
<td>B1-B5</td>
<td>Maintenance and material replacement</td>
<td>4.04E5</td>
<td>-80 %</td>
<td>1.89E-3</td>
<td>0 %</td>
<td>1.92E3</td>
</tr>
<tr>
<td>C1-C4</td>
<td>Deconstruction</td>
<td>7.87E4</td>
<td>-42 %</td>
<td>5.91E-4</td>
<td>-98 %</td>
<td>5.91E2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7.63E6</td>
<td>7.24E2</td>
<td>2.89E4</td>
<td>2.7E3</td>
<td>1.53E3</td>
</tr>
</tbody>
</table>

**Comparing total results with: 5 01 Parcel A - Baseline**

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Total</th>
<th>1.55E7</th>
<th>2.48E-1</th>
<th>4.62E4</th>
<th>3.24E4</th>
<th>1.21E4</th>
<th>1.77E8</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 01 Parcel A - Baseline</td>
<td>-51 %</td>
<td>-71 %</td>
<td>-37 %</td>
<td>-92 %</td>
<td>-87 %</td>
<td>-50 %</td>
<td></td>
</tr>
</tbody>
</table>

**Results per denominator**

| Measurement | 5.81E2 | 5.52E-6 | 2.2E0 | 2.06E-1 | 1.17E-1 | 6.71E3 |

Please note. The following LCA or EPD standards are all fully compliant with the requirements of ISO 14044: ISO 14025, ISO 21930, EN15804.

Compensation to local conditions, if applied by the user, is made according to CEN/TR 15941. It is made on an empirical basis, quantitative when appropriate. When using the compensation for local conditions, the actual energy mix of the country producing defined construction materials is substituted by the energy mix of the target country of the compensation. The data used to achieve the energy mix compensation are from the International Energy Agency. The compensation applies to the contribution of the energy mix. This share is defined for material types or individual materials.
Most contributing building elements (GWP) - A1-A3

- Foundations and substructure - 68%
- Vertical structures and facade - 29%
- Horizontal structures: beams, floors and roofs - 2%

Most contributing material types (GWP) - A1-A3

- Steel and other metals - 55%
- Concrete - 37%
- Glass - 6%
- Plastics, membranes and roofing - 1%
- Insulation - 0%

Most contributing material subtypes (GWP) - A1-A3

- Ready-mix concrete, high strength - 35%
- Reinforcement for concrete (rebar) - 31%
- Aluminium - 18%
- Coated glass panes - 5%
- Structural steel and steel profiles - 5%

Most contributing materials (GWP) - A1-A3

1. Carbon Steel Reinforcing Bar (secondary production route - scrap) - 31.2% - show sustainable alternatives
2. Aluminium profiles, powder coating - 18.4% - show sustainable alternatives
3. Ready-mix concrete - 14.6% - show sustainable alternatives
4. Ready-mix concrete - 12.0% - show sustainable alternatives
5. Ready-mix concrete - 8.3% - show sustainable alternatives
6. Structural steel profiles, generic - 4.8% - show sustainable alternatives
7. Glass, body-tinted, blue - 4.5% - show sustainable alternatives
8. Ready-mix concrete - 1.5% - show sustainable alternatives
9. Insulated glazing, double pane - 1.2% - show sustainable alternatives
10. Plastic vapour control layer - 1.2% - show sustainable alternatives

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THANK YOU

DR CHRISTOPHER DREW
DIRECTOR OF SUSTAINABILITY
ADRIAN SMITH + GORDON GILL ARCHITECTURE