Embodied Carbon Baseline Overview

These embodied carbon baselines are being developed to provide a starting point by which we can begin to assess the embodied carbon of materials per category within the EC3 tool. See the *Embodied Carbon in the EC3 Tool: Beta Methodology Report* for more information about the methods used to estimate these baselines.

As not all products or manufacturers are represented in the EC3 tool and that the ranges reported in the EC3 tool are dynamic-changing as more EPDs are included, users identified the need for a static baseline to compare results against. Additionally, this helps identify the order of magnitude of embodied carbon expected within current manufacturing practices. It is important to note that these estimates are created based upon a range of available data including:

- EPDs, both industry average and product specific.
- The Inventory of Carbon and Energy[1] which includes embodied carbon ranges of key materials.
- Published LCA studies.

These values are intended to give a rough order of magnitude of embodied carbon impacts per material category and are being published in support of the Beta release of the EC3 tool and to test and improve the methods used to assess embodied carbon of materials and products. Additionally, the EPDs in each of the broad categories include many unique products with unique performance characteristics that are not always possible to identify from the data currently included in EPDs. Better descriptions of the performance characteristics and creation of digital EPD system could help overcome these limits.

To learn more about this effort visit http://carbonleadershipforum.org/projects/ec3/

Items of note

Questions remain about the most useful and effective way to define baselines. These include:

- Should baselines be considered at the building or material scale? Or both?
- Is using a 'high' baseline appropriate? Will people start claiming more reductions than is reasonable? Even claiming reductions when they are still 'above average'?
- How to address the multiple performance aspects of material when not always included in EPDs? Examples include:
    - Some concretes need to get early strength, which is not a property that is published in EPDs.
    - Some ceilings have superior sound absorption characteristics.
    - How to integrate embodied carbon material assessments (e.g. aluminum and glass) into assembly assessments (e.g. curtain wall) that can impact use stage carbon emissions.
- How granular should the baseline categories be? Examples include:
    - Should all steel products have the same baseline?
    - Should all insulation products be together? Should baselines be grouped by form (e.g. 'board') as in the Beta EC3 tool, or by material (e.g. 'XPS board')?

[1] Circular Ecology, *Embodied energy and carbon - The ICE database V3.0 Beta*, 2019 < http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html#.XdDAHVdKjD4> [accessed 16 November 2019]

- How to address material decisions that impact use and end of life?
    - How to address the impact of blowing agents that occur during use and end of life? In the Beta version of the EC3 tool these are added to the A1-A3 impacts. Is this an appropriate method of comparing to different insulation options?
- The distribution of embodied carbon impacts is different in different material categories and strategies for improvement vary in ease and expense. How to address the material specific issues such as:
    - Recycled content and end of life recycling. Building product LCAs currently lump the estimates of burden and benefit of steel recycling into life cycle stage D which captures both upfront and end of life impacts. Is there a way to separate these out so that the near-term impacts can be considered alongside the cradle-to-gate A1-A3 impacts?
    - Is it possible to connect evaluation of forestry management practices carbon balance - assessing if a forest is carbon neutral, or a carbon sink or source - and link it to product embodied carbon?
- And there are more…we look forward to your help identifying key issues, helping to develop recommendations on how to overcome the issues.

Engage and Help Refine

We are actively looking for help to refine these methods and look forward to helping accelerate the standardization of calculation and reporting of uncertainty and variability in EPDs in order to help improve the quality, quantity and accessibility of embodied carbon data. If you are interested in engaging in the technical committees supporting the methodology development, please email CLFdataEC3@uw.edu to gain access to draft material reports and invitations to calls that provide updates and forums for discussion.

May 20, 2020 updates to this document include:

- Minor edits in the two text pages
- SI units baseline table page includes some formatting adjustments
- Addition of inch-pound / USA units baseline table page for reference
- Addition of appendix reporting differences due to rounding between units

Carbon Leadership Forum BETA Embodied Carbon Baselines 2019.11.16 SI units

updated 2020.05.20: addition of inch-pound / USA units sheet; addition of differences due to rounding appendix; formatting changes to SI sheet.

Note these are informed estimates of the range of embodied carbon within a material category. See the CLF EC3 Data Methodology reports for more information on the methods used to estimate these baselines. Note average data has been increased by the EC3 25% min uncertainty factor. We are actively looking to receive data that represents the actual variation in embodied carbon in each material category from those who have conducted the LCA studies. If you are able to provide this data, please email CLFdataEC3@uw.edu. Items shaded in BLUE are included as baselines in the EC3 Beta Launch.

		CLF BETA BASELINES					
		kg CO2e per declared unit					
Category	Subtype	**Low**	**Ave**	**High**	**Declared unit**	**Method**	**Notes: See CLF Methodology Report for details on method**
Steel							High all steel = 3.5 kgCO2e / kg steel, per ICE, Avg Data as noted below
Rebar		0.7	1.0	2.0	kg	1	EPD CRSI Fabricated Steel Reinforcement (industry-average)
Wire & Mesh		1.5	2.3	3.0	kg	1	ICE 3.0 "Steel," cell G139 ("Steel, Wire Rod")
PT Tendon		1.5	2.3	3.0	kg	1	ICE 3.0 "Steel," cell G139 ("Steel, Wire Rod")
Plate		1.0	1.5	3.0	kg	1	EPD AISC Fabricated Steel Plate (industry-average)
Structural Steel	HSS	1.5	2.4	2.5	kg	1	EPD
Structural Steel	Rolled Shapes	0.7	1.2	2.5	kg	1	EPD AISC Fabricated Hot-Rolled Structural Sections (industry-average)
Cold Formed Steel	Framing	1.5	2.3	3.0	kg	1	EPD SRI Industry-Wide Cold-Formed Steel Studs and Track manufactured in U.S. and Canada
Open Web Steel Joists	Not yet in EC3 tool	0.7	1.4	2.5	kg	1	EPD SJI Industry Average
Wood							30% Max variation per ICE "Timber" rows 511-516, conservative use 1.40xAvg. Avg. data noted
Dimensional Lumber		50	90	100	m3	1	AWC/CWC EPD
Engineered lumber	GLB/LVL/PSL/CLT	230	390	400	m3	1	Max value of AWC/CWC EPD for GLB, LVL, PSL
	I Joist	1.0	2.0	6	m	2	AWC/CWC EPD
	PLY/OSB	200	310	400	m3	1	AWC/CWC EPD
Concrete							High=NRMCA High per strength class x 1.25 (EC3 typ uncertainty factor)
Backfill/Slurry				600	m3	3	For BETA version of the EC3 tool, all concretes referenced to a single benchmark equal to average between 4,000 and 5,000 psi concrete. CLF Beta High Baseline Concrete = 600kgCO2e / m3
Shotcrete	Match Ready Mixed						
Ready Mixed Concrete	2500psi	230	290	380	m3	3	
	3000psi	260	320	420	m3	3	
	4000psi	310	390	520	m3	3	
	5000psi	380	490	640	m3	3	
	6000psi	400	510	670	m3	3	
	8000psi	470	620	790	m3	3	
Gypsum Board							
	All	TBD	TBD	4500	1000 m2	2	Values estimated from EC3 assuming EPD bias to lower impact products
Carpet							
	All	6	11	35	m2	2	Values estimated from EC3 assuming EPD bias to lower impact products
Ceilings							
	All	8	TBD	30	m2	2	Values estimated from EC3 assuming EPD bias to lower impact products
Aluminium							
	Cast Ingot	7	13	18	kg	1	ICE V3 Beta 9: Cell G73 Global ALuminum Production
Glazing							
	Glass (kg material)	1.2	1.4	3.5	kg	1	ICE V3 9 Glass Avg H472
Insulation							
Insulation by form	Board	4.0	70	100	m2-Rsi	2	Values estimated from EC3 assuming EPD bias to lower impact products
	Blanket	0.3	0.9	8	m2-Rsi	2	Values estimated from EC3 assuming EPD bias to lower impact products
	Foamed in Place	7.0	20	60	m2-Rsi	2	Values estimated from EC3 assuming EPD bias to lower impact products
	Blown	1.5	2.0	8	m2-Rsi	2	Values estimated from EC3 assuming EPD bias to lower impact products

Carbon Leadership Forum BETA Embodied Carbon Baselines 2019.11.16 inch-pound / USA units

updated 2020.05.20: addition of inch-pound / USA units sheet; addition of differences due to rounding appendix; formatting changes to SI sheet.

Note these are informed estimates of the range of embodied carbon within a material category. See the CLF EC3 Data Methodology reports for more information on the methods used to estimate these baselines. Note average data has been increased by the EC3 25% min uncertainty factor. We are actively looking to receive data that represents the actual variation in embodied carbon in each material category from those who have conducted the LCA studies. If you are able to provide this data, please email CLFdataEC3@uw.edu. Items shaded in BLUE are included as baselines in the EC3 Beta Launch.

		CLF BETA BASELINES kg CO2e per declared unit					
Category	Subtype	**Low**	**Ave**	**High**	**Declared unit**	**Method**	**Notes: See CLF Methodology Report for details on method**
Steel							High all steel = 1.59 kgCO2e / lb steel, per ICE, Avg Data as noted below
Rebar		0.3	0.44	0.91	lb	1	EPD CRSI Fabricated Steel Reinforcement (industry-average)
Wire & Mesh		0.68	1.0	1.4	lb	1	ICE 3.0 "Steel," cell G139 ("Steel, Wire Rod")
PT Tendon		0.68	1.0	1.4	lb	1	ICE 3.0 "Steel," cell G139 ("Steel, Wire Rod")
Plate		0.45	0.67	1.4	lb	1	EPD AISC Fabricated Steel Plate (industry-average)
Structural Steel	HSS	0.68	1.1	1.1	lb	1	EPD
Structural Steel	Rolled Shapes	0.3	0.53	1.1	lb	1	EPD AISC Fabricated Hot-Rolled Structural Sections (industry-average)
Cold Formed Steel	Framing	0.68	1.0	1.4	lb	1	EPD SRI Industry-Wide Cold-Formed Steel Studs and Track manufactured in U.S. and Canada
Open Web Steel Joists	Not yet in EC3 tool	0.3	0.63	1.1	lb	1	EPD SJI Industry Average
Wood							30% Max variation per ICE "Timber" rows 511-516, conservative use 1.40xAvg. Avg. data noted
Dimensional Lumber		40	70	80	yd3	1	AWC/CWC EPD
Engineered lumber	GLB/LVL/PSL/CLT	180	300	310	yd3	1	Max value of AWC/CWC EPD for GLB, LVL, PSL
	I Joist	0.30	0.61	2	ft	2	AWC/CWC EPD
	PLY/OSB	150	240	310	yd3	1	AWC/CWC EPD
Concrete							High=NRMCA High per strength class x 1.25 (EC3 typ uncertainty factor)
Backfill/Slurry				460	yd3	3	For BETA version of the EC3 tool, all concretes referenced to a single benchmark equal to average between 4,000 and 5,000 psi concrete. CLF Beta High Baseline Concrete = 460 kgCO2e / yd3
Shotcrete	Match Ready Mixed						
Ready Mixed Concrete	2500psi	180	220	290	yd3	3	
	3000psi	200	240	320	yd3	3	
	4000psi	240	300	400	yd3	3	
	5000psi	290	370	490	yd3	3	
	6000psi	310	390	510	yd3	3	
	8000psi	360	470	600	yd3	3	
Gypsum Board							
	All	TBD	TBD	420	1000 ft2	2	Values estimated from EC3 assuming EPD bias to lower impact products
Carpet							
	All	0.6	1.0	3.3	ft2	2	Values estimated from EC3 assuming EPD bias to lower impact products
Ceilings							
	All	0.7	TBD	2.8	ft2	2	Values estimated from EC3 assuming EPD bias to lower impact products
Aluminium							
	Cast Ingot	3	5.9	8.0	lb	1	ICE V3 Beta 9: Cell G73 Global ALuminum Production
Glazing							
	Glass (kg material)	0.53	0.65	1.6	lb	1	ICE V3 9 Glass Avg H472
Insulation							
Insulation by form	Board	0.37	7	9	ft2-R5.68*	2	Values estimated from EC3 assuming EPD bias to lower impact products
	Blanket	0.03	0.08	0.7	ft2-R5.68*	2	Values estimated from EC3 assuming EPD bias to lower impact products
	Foamed in Place	0.65	2	6	ft2-R5.68*	2	Values estimated from EC3 assuming EPD bias to lower impact products
	Blown	0.14	0.19	0.7	ft2-R5.68*	2	Values estimated from EC3 assuming EPD bias to lower impact products

*SI declared unit for insulation is 1 m2 at thickness to attain Rsi=1. Inch-pound / USA unit for insulation is currently 1 ft2 at R-5.68 (approximately equivalent to Rsi=1). In the future, the EC3 inch-pound / USA unit for insulation will be 1 ft2 at R-1.

The SI unit values are the formal and originally established baselines. The inch-pound/USA unit baseline values are provided in this document for reference and are appropriate for simple analysis and order-of-magnitude estimates.

See *Appendix: Baseline value differences due to unit conversion and rounding* in this document for further information.

Appendix: Baseline value differences due to unit conversion and rounding

The SI unit values are the formal and originally established baselines. The inch-pound/USA unit baseline values are provided in this document for reference and are appropriate for simple analysis and order-of-magnitude estimates.

For any thorough analysis, the Carbon Leadership Forum recommends using the SI versions (or precise conversions from these, such as the 'calculate values' provided in this appendix). The EC3 tool uses the SI versions, and automatically converts as needed to inch-pound/USA units with appropriate precision.

The reported inch-pound / USA baseline values are rounded to the same number of significant digits as the SI versions. Therefore, the baseline values in SI vs. inch-pound units are considered reasonably close, but not equivalent. The difference due to rounding when converting from SI to inch-pound units is displayed below for each reported baseline value, where: % dif = (reported_value - calculated_value) / calculated_value, and where *calculated_value* refers to the inch-pound value as converted from the formal SI value to four or five significant digits, and *reported_value* refers to the rounded inch-pound value displayed in the baseline table.

		CLF BETA BASELINES (kg CO2e per declared unit)									
		Low			Ave			High			
Category	Subtype	**calculated value**	**reported value**	**% dif**	**calculated value**	**reported value**	**% dif**	**calculated value**	**reported value**	**% dif**	**Declared unit**
Steel											
Rebar		0.3354	0.3	-10.6%	0.4441	0.44	-0.9%	0.9072	0.91	0.3%	lb
Wire & Mesh		0.6804	0.68	-0.1%	1.0297	1.0	-2.9%	1.3608	1.4	2.9%	lb
PT Tendon		0.6804	0.68	-0.1%	1.0297	1.0	-2.9%	1.3608	1.4	2.9%	lb
Plate		0.4468	0.45	0.7%	0.6668	0.67	0.5%	1.3608	1.4	2.9%	lb
Structural Steel	HSS	0.6804	0.68	-0.1%	1.0841	1.1	1.5%	1.1340	1.1	-3.0%	lb
Structural Steel	Rolled Shapes	0.3175	0.3	-5.5%	0.5262	0.53	0.7%	1.1340	1.1	-3.0%	lb
Cold Formed Steel	Framing	0.6804	0.68	-0.1%	1.0342	1.0	-3.3%	1.3608	1.4	2.9%	lb
Open Web Steel Joists	Not yet in EC3 tool	0.3175	0.3	-5.5%	0.6260	0.63	0.6%	1.1340	1.1	-3.0%	lb
Wood											
Dimensional Lumber		38.23	40	4.6%	68.810	70	1.7%	76.46	80	4.6%	yd3
Engineered lumber	GLB/LVL/PSL/CLT	175.85	180	2.4%	298.18	300	0.6%	305.82	310	1.4%	yd3
	I Joist	0.3048	0.30	-1.6%	0.6096	0.61	0.1%	1.8288	2	9.4%	ft
	PLY/OSB	152.91	150	-1.9%	237.01	240	1.3%	305.82	310	1.4%	yd3
Concrete											
Backfill/Slurry								458.73	460	0.3%	yd3
Shotcrete	Match Ready Mixed										
Ready Mixed Concrete	2500psi	175.85	180	2.4%	221.72	220	-0.8%	290.53	290	-0.2%	yd3
	3000psi	198.78	200	0.6%	244.66	240	-1.9%	321.11	320	-0.3%	yd3
	4000psi	237.01	240	1.3%	298.18	300	0.6%	397.57	400	0.6%	yd3
	5000psi	290.53	290	-0.2%	374.63	370	-1.2%	489.31	490	0.1%	yd3
	6000psi	305.82	310	1.4%	389.92	390	0.0%	512.25	510	-0.4%	yd3
	8000psi	359.34	360	0.2%	474.02	470	-0.8%	604.00	600	-0.7%	yd3
Gypsum Board											
	All	TBD	TBD		TBD	TBD		418.06	420	0.5%	1000 ft2
Carpet											
	All	0.5574	0.6	7.6%	1.0219	1.0	-2.1%	3.2516	3.3	1.5%	ft2
Ceilings											
	All	0.7432	0.7	-5.8%	TBD	TBD		2.7871	2.8	0.5%	ft2
Aluminium											
	Cast Ingot	3.0459	3	-1.5%	5.9421	5.9	-0.7%	7.9782	8.0	0.3%	lb
Glazing											
	Glass (kg material)	0.5346	0.53	-0.9%	0.6518	0.65	-0.3%	1.5876	1.6	0.8%	lb
Insulation											
Insulation by form	Board	0.3716	0.37	-0.4%	6.5032	7	7.6%	9.2903	9	-3.1%	ft2R5.68*
	Blanket	0.0279	0.03	0.5%	0.0836	0.08	-4.3%	0.7432	0.7	-5.8%	ft2R5.68*
	Foamed in Place	0.6503	0.65	0.0%	1.8581	2	7.6%	5.5742	6	7.6%	ft2R5.68*
	Blown	0.1394	0.14	0.5%	0.1858	0.19	2.3%	0.7432	0.7	-5.8%	ft2R5.68*