Impact Assessment of Common Construction Materials using EN 15804+A1:2013 and Draft EN15804:2018

On behalf of British Precast

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On behalf of thinkstep AG and its subsidiaries

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1. Goal of the Study

The goal of this study is to provide an independent assessment of the changes in impact in moving from the current Life Cycle Impact Assessment categories used in EN 15804:2012+A1:2013 and those suggested in the proposed amendment to this standard currently out for enquiry, Draft EN 15804/prA:2018.

British Precast intend to use the report to understand the potential differences in impact and to use this information to comment on the draft through the enquiry.

The main target audience for the report is British Precast staff and their members who wish to understand the implications of the proposed amendment.

The report calculates the impact using both approaches for three products which have been chosen to reflect the broad scope of construction materials generally used:

- 1 m^2 of Hollowcore precast concrete flooring, as modelled in the British Precast IBU EPD, EPD-BPC-20160005-CCD1-EN, issued in 2017.
- 1 kg of Steel hot rolled coil (DE) (EN 15804) as described in documentation located at http://gabi-documentation-2018.gabi-software.com/xml-data/processes/4672623a-fdf6-41ce-b838-d723d5d89280.xml,
- 1 kg of Cross Laminated Timber (CLT), as modelled in the Wood First LCA Database and described at http://woodforgood.com/assets/Downloads/CLT_v1.2_2014-03-18.pdf.

All the models have been updated to the GaBi 2018 database, meaning that the latest electricity grid mix and other secondary data has been used for the modelling. For example, the GaBi 2018 Database has remodelled the use and emission of halogenated substances: since the use of certain halogenated substances was banned following the implementation of the Montreal Protocol, the following emissions are not present any longer in the updated thinkstep datasets: Halon (1301), R 11 (trichlorofluoromethane), R 114 (dichlorotetrafluoroethane) and R 12 (dichlorodifluoromethane). This has consequently reduced the impact factors for Ozone Depletion Potential for many datasets in the GaBi 2018 database.

The study has used typical end of life scenarios and modelled the life cycle stages A1-A3, C3, C4 and Module D. In addition, for precast concrete, the carbonation of concrete during demolition has been considered in B1 and C3.

These modules have been chosen because they show the principal impacts (and benefits in Module D) for the three chosen products.

2. Products modelled

2.1. 1 m² British Precast Hollowcore Flooring

The British Precast EPD Tool GaBi model was updated to use GaBi 2018 datasets. The parameters used for the 2017 IBU EPD were input into the model.

Following the initial assessment, the modelling was revised so that the uptake of carbon dioxide during carbonation, which occurs at various points in the model, was changed from an uptake of carbon dioxide as a renewable resource, to a “negative” emission of inorganic carbon dioxide. This was done as the PEF methodology has a GWP of zero for uptake of carbon dioxide as a renewable resource, and for emissions of biogenic carbon dioxide. It is clear from the text in the proposed amendment to EN 15804 that carbonation should be considered and we believe this change in modelling should be included in a note in the standard to ensure that carbonation is correctly assessed.

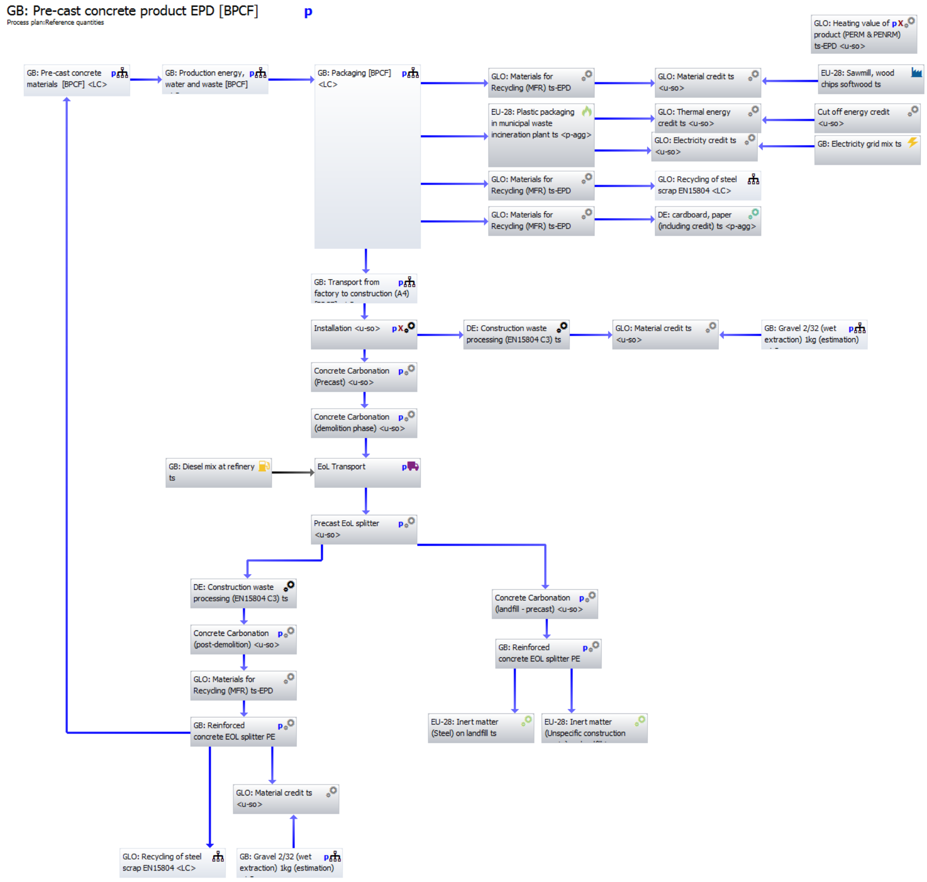

Figure 1: Overview of GaBi model for precast concrete

As in the EPD, the end of life (C3 and C4) was modelled as follows:

Recycling as aggregate: 90%

Landfill: 10%

In Module D, the recycled aggregate was credited with virgin gravel. As the steel rebar is assumed to be made of recycled steel, there is no net output of steel scrap and therefore no credit in Module D for recycling of steel; instead, using a worst case interpretation of EN 15804, the net input flow of steel scrap is shown in Module D as a burden due to the need to “top up” the system with primary steel..

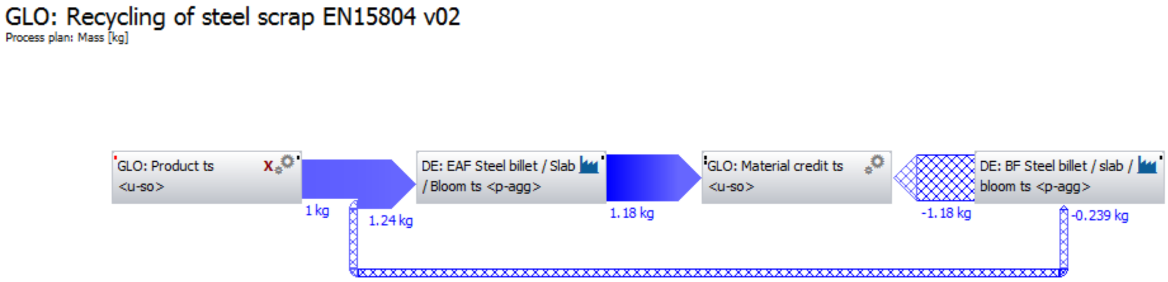

Figure 2: Modelling of net scrap approach for steel

2.2. 1 kg Steel Hot Rolled Coil (DE)

For steel, a hot rolled coil dataset was used as this is manufactured using the blast furnace and basic oxygen furnace route and the BPCF were keen to understand the effect of different impact assessment methods on this type of virgin steel production. This type of steel has a recycled input, in this case approximately 19%. The documentation for this dataset is provided in http://gabi-documentation-2018.gabi-software.com/xml-data/processes/4672623a-fdf6-41ce-b838-d723d5d89280.xml.

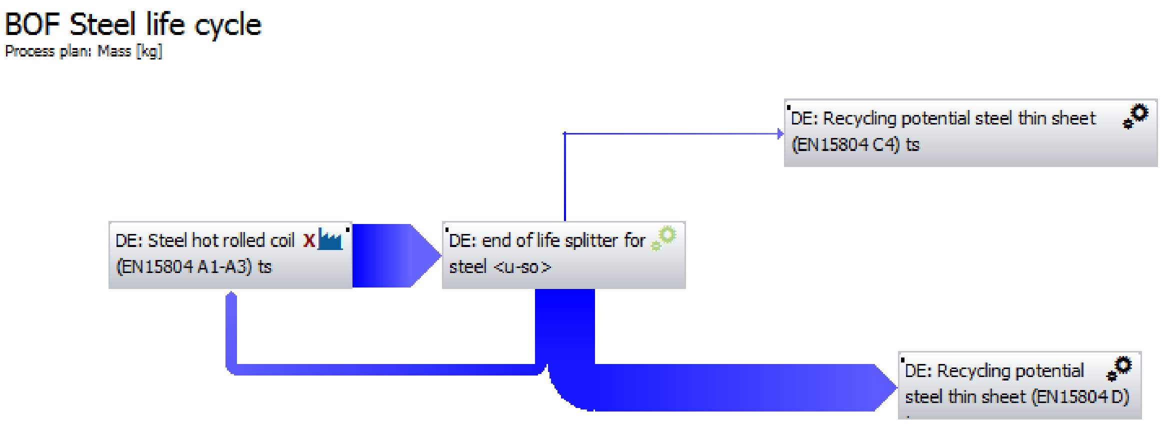

Figure 3: GaBi model of BOF steel life cycle

At end of life (C3 and C4), the following was modelled:

95% recycling (in C3 there is no impact as the scrap reaches End of Waste state in C1.)

5% to landfill modelled using GaBi dataset “Recycling potential steel thin sheet (EN15804 C4)” – documentation can be found at http://gabi-documentation-2018.gabi-software.com/xml-data/processes/761ac95a-3f5d-4792-ab00-6c01a55f32ec.xml.

In Module D, the net output flow (0.95 kg recovered output – 0.19 kg recycled input) is recycled using the EAF process, and the avoided benefit of recycling is shown using primary steel production. This used the GaBi Dataset, “Recycling potential steel thin sheet (EN15804 D)” – documentation can be found at http://gabi-documentation-2018.gabi-software.com/xml-data/processes/bcac2d2d-a1f0-4cb7-9354-fe519759d419.xml.

2.3. 1 kg Cross Laminated Timber (CLT)

Cross laminated timber was modelled using the model developed for the Wood First Database which is described at http://woodforgood.com/assets/Downloads/CLT_v1.2_2014-03-18.pdf. At end of life, we modelled 50% Energy Recovery (C3), 50% landfill (C4). No recycling options currently exist for CLT.

In module D, the benefits of avoided electricity and heat production were modelled for the outputs of energy arising from Energy Recovery.

Figure 4: Overview of GaBi model of CLT

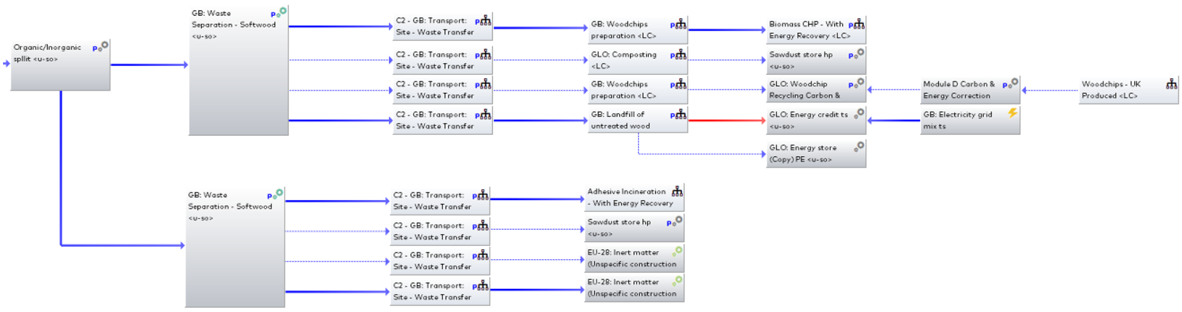

Figure 5: Overview of the End of Life model for CLT

3. Impact Assessment

Two approaches for impact assessment were used.

The first approach is based on the impact assessment categories proposed in Draft EN 15804/prA:2018, based on the latest version of the PEF (which has not yet been published), as described in Figure 6 and Figure 7.

Impact Category	Indicator	Unit	Model
Depletion of abiotic resources - mineral elements [a]	Abiotic depletion potential (ADP-elements) for non-fossil resources [a]	kg Sb eq.	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.
Depletion of abiotic resources - fossil fuels [a]	Abiotic depletion potential (ADP-fossil fuels) for fossil resources [a]	MJ, net calorific value	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.
Acidification	Accumulated Exceedance, Acidification potential AP;	mol H+ eq.	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Global Warming total [b]	Global Warming Potential (GWP100)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
GWP from fossil carbon, removals and emissions	GWP fossil	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
GWP from biogenic carbon	GWP biogenic	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
GWP from land use and land use change, removals and emissions	GWP land use and land use change	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Eutrophication terrestrial	Accumulated Exceedance, Eutrophication potential, EP terrestrial;	mol N eq.	Accumulated Exceedance (Seppälä et al. 2006, Posch et al
Eutrophication aquatic freshwater	Fraction of nutrients reaching freshwater end compartment Eutrophication potential, EP freshwater	kg PO_4 eq.	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Eutrophication aquatic marine	Fraction of nutrients reaching freshwater end compartment Eutrophication potential, EP marine	kg N eq.	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Ozone Depletion	Depletion potential of the stratospheric ozone layer, ODP;	kg CFC 11 eq.	Steady-state ODPs 2014 as in WMO assessment
Photochemical ozone creation	Formation potential of tropospheric ozone, POCP;	kg Ethene eq.	LOTOS-EUROS (Van Zelm et al, 2008) as applied in ReCiPe
Water scarcity	User deprivation potential	m^3 world	Available WAter REmaining (AWARE)

Figure 6: Proposed Mandatory Impact Assessment Methodologies from Draft EN 15804/prA:2018

Impact category	Indicator	Unit (expressed per functional unit or per declared unit)
Human toxicity, cancer effects	Potential Comparative Toxic Unit for humans	CTUh
Human toxicity, non-cancer effects	Potential Comparative Toxic Unit for humans	CTUh
Eco-toxicity (freshwater)	Potential Comparative Toxic Unit for ecosystems	CTUe
Land use related impacts/ Soil quality	Potential soil quality index	dimensionless
Particulate Matter emissions	Potential incidence of disease due to PM emissions	Incidence of disease
Ionizing radiation, human health	Potential Human exposure efficiency relative to U235	kBq U235 eq.

Figure 7: Proposed Optional Impact Assessment Methodologies from Draft EN 15804/prA:2018

For this thinkstep have used their Impact Assessment Environmental Quantities implemented as “EF 1.8” which has been developed for the PEF Pilots using the latest version of these methods.

The second approach is that provided in EN 15804:2012+A1:2013 based on CML 2002 as updated in 2012. This is described in Figure 9. For this thinkstep have used their Impact Assessment Environmental Quantities implemented as “ CML2001 - Jan. 2013”.

characterisation factors	LCIA models
GWP (100-years time horizon)	Global Warming Potential for a 100-year time horizon as in IPCC: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment. Report of the Intergovernmental Panel on Climate Change. [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]
POCP	Jenkin, M.E. & G.D. Hayman, 1999: Photochemical ozone creation potentials for oxygenated volatile organic compounds: sensitivity to variations in kinetic and mechanistic parameters. Atmospheric Environment 33: 1775-1293. Derwent, R.G., M.E. Jenkin, S.M. Saunders & M.J. Pilling, 1998. Photochemical ozone creation potentials for organic compounds in Northwest Europe calculated with a master chemical mechanism. Atmospheric Environment, 32. p 2429-2441.
ODP (steady state)	Ozone Depletion Potentials for Steady-state as in WMO (World Meteorological Organisation): Scientific assessment of ozone depletion. Global Ozone Research and Monitoring Project Reports. 2003
AP (average Europe total)	Acidification Potentials for average Europe total as in Huijbregts, M., 1999b: Life cycle impact assessment of acidifying and eutrophying air pollutants. Calculation of equivalency factors with RAINS-LCA. Interfaculty Department of Environmental Science, Faculty of Environmental Science, University of Amsterdam, The Netherlands.
EP	Heijungs, R., J. Guinée, G. Huppes, R.M. Lankreijer, H.A. Udo de Haes, A. Wegener Sleeswijk, A.M.M. Ansems, P.G. Eggels, R. van Duin, H.P. de Goede, 1992: Environmental Life Cycle
ADP (ultimate reserves)	Abiotic Resource Depletion Potentials for ultimate ultimate reserves as in Oers, L.F.C.M., van & Koning, A., de & Guinée, J.B. & Huppes, G., 2002. Abiotic resource depletion in LCA: improving characterisation factors for abiotic depletion as recommended in the new Dutch LCA Handbook. Delft: Ministry of Transport, Public Works and Water Management.

Figure 8: Impact Assessment Methodologies provided in EN 15804:2012+A1:2013

4. Results

The results are not intended to make a comparison between the impacts of the different products. Instead, the intention is to provide the results for each product using the two impact assessment methods so that any potential implications of moving from the methods used in EN 15804:2012+A1:2013 to those proposed in Draft EN 15804+A2:2018 can be considered.

The results are provided on the following pages.

4.1. Results for 1 kg[1] British Precast Hollowcore Flooring

Table 1: Results for concrete using Draft EN 15804+A2:2018

Impact Assessment Category	GB: Pre-cast concrete product EPD [BPCF] <LC>					
	A1-A3	**B1**	**C1**	**C3**	**C4**	**D**
Acidification terrestrial and freshwater [Mole of H+ eq.]	3.55E-04	0.00E+00	0.00E+00	2.28E-05	1.18E-05	5.71E-06
*Cancer human health effects [CTUh]	1.68E-10	0.00E+00	0.00E+00	2.07E-11	1.77E-11	5.97E-13
Climate Change [kg CO2 eq.]	1.69E-01	-9.51E-03	-4.20E-04	-9.27E-03	7.44E-04	4.35E-03
Climate Change (land use change) [kg CO2 eq.]	4.19E-05	0.00E+00	0.00E+00	9.45E-06	7.59E-06	-5.80E-06
*Ecotoxicity freshwater [CTUe]	3.26E-03	0.00E+00	0.00E+00	4.86E-04	2.35E-04	3.52E-04
Eutrophication freshwater [kg P eq.]	1.20E-07	0.00E+00	0.00E+00	8.45E-09	3.46E-08	-9.22E-09
Eutrophication marine [kg N eq.]	1.03E-04	0.00E+00	0.00E+00	1.12E-05	3.36E-06	-2.25E-06
Eutrophication terrestrial [Mole of N eq.]	1.11E-03	0.00E+00	0.00E+00	1.23E-04	3.51E-05	-2.36E-05
**Ionising radiation-human health [kBq U235 eq.]	4.83E-03	0.00E+00	0.00E+00	4.60E-05	3.17E-05	-3.71E-04
***Land Use [Pt]	2.71E-01	0.00E+00	0.00E+00	1.22E-02	4.04E-03	-2.18E-02
*Non-cancer human health effects [CTUh]	1.29E-08	0.00E+00	0.00E+00	1.82E-10	1.15E-09	-5.50E-10
Ozone depletion [kg CFC-11 eq.]	3.69E-14	0.00E+00	0.00E+00	3.62E-16	2.46E-16	-2.73E-15
Photochemical ozone formation - human health [kg NMVOC eq.]	2.98E-04	0.00E+00	0.00E+00	3.23E-05	9.53E-06	5.12E-07
Resource use, energy carriers [MJ]	8.87E-01	0.00E+00	0.00E+00	4.54E-02	2.13E-02	4.60E-03
Resource use, mineral and metals [kg Sb eq.]	2.29E-07	0.00E+00	0.00E+00	3.12E-09	6.57E-10	-1.29E-09
Respiratory inorganics [Incidence of Disease]	3.08E-09	0.00E+00	0.00E+00	5.30E-10	1.42E-10	7.69E-11
Water scarcity [m^3 world equiv.]	7.67E-03	0.00E+00	0.00E+00	4.12E-04	1.18E-04	-1.96E-04

*The results of the toxicity indicators shall be used with care as the uncertainties on these results may be high.

**Potential ionizing radiation from the soil, from radon and from some construction materials is not measured by this indicator.

***The results of the land use related impact shall be used with care due to the limited experience with this indicator.

Table 2: Results for concrete using EN 15804:2012+A1:2013

Impact Assessment Category	GB: Pre-cast concrete product EPD [BPCF] <LC>					
	A1-A3	**B1**	**C1**	**C3**	**C4**	**D**
Acidification potential (AP) [kg SO2 eq.]	2.91E-04	0.00E+00	0.00E+00	1.58E-05	9.42E-06	5.67E-06
Global warming potential (GWP) [kg CO2 eq.]	1.73E-01	-9.51E-03	-4.20E-04	-9.37E-03	7.08E-04	8.94E-03
Eutrophication potential (EP) [kg Phosphate eq.]	3.64E-05	0.00E+00	0.00E+00	3.86E-06	1.30E-06	-8.22E-07
Ozone Depletion Potential (ODP) [kg R11 eq.]	5.44E-14	0.00E+00	0.00E+00	5.31E-16	3.60E-16	-4.00E-15
Photochemical Ozone Creation Potential (POCP) [kg Ethene eq.]	1.95E-05	0.00E+00	0.00E+00	1.73E-06	7.44E-07	4.54E-06
Abiotic depletion potential for fossil resources (ADPF) [MJ]	7.74E-01	0.00E+00	0.00E+00	4.42E-02	2.06E-02	1.35E-02
Abiotic depletion potential for non-fossil resources (ADPE) [kg Sb eq.]	2.29E-07	0.00E+00	0.00E+00	3.14E-09	6.11E-10	-1.32E-09

[1] Results for 1 m2 of hollowcore flooring have been divided by 300 to give the results for 1 kg.

4.2. Results for 1 kg Steel Hot Rolled Coil (DE)

Table 3: Results for steel using Draft EN 15804+A2:2018

Impact Assessment	BOF Steel life cycle <LC>		
	A1-A3	C4	D
Acidification terrestrial and freshwater [Mole of H+ eq.]	0.00610	5.91E-06	-4.23E-03
*Cancer human health effects [CTUh]	3.69E-09	8.87E-12	-2.33E-09
Climate Change [kg CO2 eq.]	2.21	0.000814	-1.46
Climate Change (land use change) [kg CO2 eq.]	0.000514	3.79E-06	0.000228
*Ecotoxicity freshwater [CTUe]	0.141	0.000118	-0.099
Eutrophication freshwater [kg P eq.]	2.47E-06	1.73E-08	-8.70E-07
Eutrophication marine [kg N eq.]	0.00134	1.68E-06	-0.00087
Eutrophication terrestrial [Mole of N eq.]	0.0145	1.75E-05	-0.00952
**Ionising radiation - human health [kBq U235 eq.]	0.0114	1.58E-05	0.0268
***Land Use [Pt]	0.883	0.00202	0.832
*Non-cancer human health effects [CTUh]	6.78E-08	5.77E-10	-1.20E-08
Ozone depletion [kg CFC-11 eq.]	1.08E-13	1.23E-16	1.94E-13
Photochemical ozone formation - human health [kg NMVOC eq.]	0.00445	4.77E-06	-0.00293
Resource use, energy carriers [MJ]	19.2	0.0107	-10.7
Resource use, mineral and metals [kg Sb eq.]	4.03E-08	3.28E-10	1.42E-07
Respiratory inorganics [Incidence of Disease]	6.41E-08	7.11E-11	-4.21E-08
Water scarcity [m³ world equiv.]****	0.0483	4.99E-05	-0.0238

*The results of the toxicity indicators shall be used with care as the uncertainties on these results may be high.

**Potential ionizing radiation from the soil, from radon and from some construction materials is not measured by this indicator.

***The results of the land use related impact shall be used with care due to the limited experience with this indicator.

**** This result has been generated using an earlier version of the steel model.

Table 4: Results for steel using EN 15804:2012+A1:2013

Impact Assessment Category	1 kg BOF Steel		
	A3	C4	D
Acidification potential (AP) [kg SO2 eq.]	5.04E-03	4.71E-06	-3.48E-03
Global warming potential (GWP) [kg CO2 eq.]	2.17E+00	7.96E-04	-1.44E+00
Eutrophication potential (EP) [kg Phosphate eq.]	4.85E-04	6.50E-07	-2.98E-04
Ozone Depletion Potential (ODP) [kg R11 eq.]	1.58E-13	1.80E-16	2.84E-13
Photochemical Ozone Creation Potential (POCP) [kg Ethene eq.]	6.89E-04	3.72E-07	-4.48E-04
Abiotic depletion potential for fossil resources (ADPF) [MJ]	1.90E+01	1.03E-02	-1.14E+01
Abiotic depletion potential for non fossil resources (ADPE) [kg Sb eq.]	3.88E-08	3.06E-10	1.48E-07

4.3. Results for 1 kg Cross Laminated Timber (CLT)

Table 5: Results for CLT using Draft EN 15804+A2:2018

Impact Assessment Category	Cross Laminated Timber (CLT) - Cradle-to-Grave (1m3) <LC>			
	A1-A3	C3	C4	D
Acidification terrestrial and freshwater [Mole of H+ eq.]	0.002164	0.001039	0.001654	-0.00155
*Cancer human health effects [CTUh]	1.94E-09	4.53E-11	1.79E-10	-3.4E-10
Climate Change [kg CO2 eq.]	0.601376	0.029394	1.038404	-0.62538
Climate Change (land use change) [kg CO2 eq.]	0.002479	2.3E-05	4.74E-05	-9.6E-05
*Ecotoxicity freshwater [CTUe]	0.034252	0.004946	0.002489	-0.01286
Eutrophication freshwater [kg P eq.]	5.34E-06	1.05E-08	2.39E-06	-2.7E-07
Eutrophication marine [kg N eq.]	0.000933	0.000455	7.94E-05	-0.00038
Eutrophication terrestrial [Mole of N eq.]	0.008582	0.004987	0.000626	-0.00408
**Ionising radiation - human health [kBq U235 eq.]	0.087476	0.000777	0.000687	-0.09398
***Land Use [Pt]	8.854517	0.011617	0.033359	-0.26199
*Non-cancer human health effects [CTUh]	9.13E-08	1.13E-09	1.07E-08	-1.5E-08
Ozone depletion [kg CFC-11 eq.]	4.74E-12	5.76E-15	5.15E-15	-7E-13
Photochemical ozone formation - human health [kg NMVOC eq.]	0.002158	0.001214	0.000533	-0.00106
Resource use, energy carriers [MJ]	8.64625	0.085458	0.512496	-10.5232
Resource use, mineral and metals [kg Sb eq.]	4.6E-07	2.35E-09	7.24E-09	-1E-07
Respiratory inorganics [Incidence of Disease]	5.45E-07	4.35E-09	1.19E-08	-1.2E-08
Water scarcity [m³ world equiv.]	0.099924	0.024995	-0.02045	-0.00933

*The results of the toxicity indicators shall be used with care as the uncertainties on these results may be high.

**Potential ionizing radiation from the soil, from radon and from some construction materials is not measured by this indicator.

***The results of the land use related impact shall be used with care due to the limited experience with this indicator.

Table 6: Results for CLT using EN 15804:2012+A1:2013

Impact Assessment Category	Cross Laminated Timber (CLT) - Cradle-to-Grave (1m3) <LC>			
	A1-A3	C3	C4	D
Acidification potential (AP) [kg SO2 eq.]	1.82E-03	4.66E-04	5.09E-05	1.29E-05
Global warming potential (GWP) [kg CO2 eq.]	-1.05E+00	8.87E-02	2.64E-02	5.07E-03
Eutrophication potential (EP) [kg Phosphate eq.]	3.76E-04	9.91E-05	7.82E-06	3.09E-06
Ozone Depletion Potential (ODP) [kg R11 eq.]	8.71E-12	2.30E-15	4.67E-16	8.80E-17
Photochemical Ozone Creation Potential (POCP) [kg Ethene eq.]	1.20E-04	-1.33E-04	4.51E-06	-5.02E-06
Abiotic depletion potential for fossil resources (ADPF) [MJ]	7.38E+00	1.20E+00	3.62E-01	6.82E-02
Abiotic depletion potential for non fossil resources (ADPE) [kg Sb eq.]	4.69E-07	6.34E-09	3.02E-10	7.73E-11

5. Limited Commentary on the Results

5.1. Acidification

The two methods use different indicators but are fundamentally both measuring acidity. However the EN 15804:2012+A1:2013 method includes a wider range of characterised emissions – for example emissions of hydrogen chloride, bromide, fluoride and sulphide, nitric acid, phosphoric acid and sulphuric acid. It is likely the differences in these emissions and the difference in indicator which accounts for the differences in acidification impacts.

In future, it is intended to implement the "regionalisation" of characterisation factors for acidification and the underlying inventory, but this has not yet taken place within the PEF indicators implemented for the pilots or in GaBi EF 1.8.

5.2. Cancer – human health effects

The results for 1 kg of concrete about 10 times smaller than for 1 kg of CLT, which has half the impact of 1k steel.(Note that these quantities are not comparable in function).

5.3. Global Warming Potential

The key differences between the two methods are the use of higher GWP for methane and some changes to other GHG GWP in the IPCC 5th Assessment Report GWP characterisation factors used in the Draft EN 15804+A2:2018/EF 1.8 factors, and the use of a "zero" characterisation factor for biogenic emissions (uptake or release) within the Draft EN 15804+A2:2018/EF 1.8 factors. This has the biggest impact for CLT which is no longer shows the uptake of biogenic carbon in A1-A3, or the release of biogenic carbon at the end of life.

We also note that it will be important to include the uptake of carbon dioxide during carbonation as a negative emission of inorganic Carbon dioxide rather than an uptake of renewable carbon dioxide resource as has previously been modelled, if the "benefit" of carbonation is to be shown in the EPD.

Land use change impacts appear to be small, even for timber.

5.4. Ecotoxicity

Results for 1 kg steel appear to be significantly higher than for 1 kg CLT, which again are considerably higher than for 1 kg concrete. (Note that these quantities are not comparable in function).

5.5. Eutrophication

The new indicators for eutrophication do not use any of the same units as the previous indicator so it is difficult to make comparisons. Steel appears to have slightly higher impacts per kg than CLT and both have higher impacts per kg than concrete for all three new indicators. (Note that these quantities are not comparable in function).

5.6. Ionising Radiation

CLT appears to have slightly more impact per kg than steel, which has slightly more impact than concrete per kg. (Note that these quantities are not comparable in function).

It should be noted that this indicator does not account of any ionising radiation which may be emitted from construction materials themselves, such as granite or gypsum, or emissions of radon from the ground, or other sources of natural radiation such as cosmic rays, all of which are likely to have a much higher impact on human health resulting from ionising radiation than the emissions from nuclear power stations which is what this impact indicator measures.

5.7. Land Use

CLT appears to have significantly more impact than steel per kg, which has slightly more impact than concrete per kg. (Note that these quantities are not comparable in function).

5.8. Non-cancer human health effects

Steel appears to have slightly higher impacts per kg than CLT or concrete. (Note that these quantities are not comparable in function).

5.9. Ozone depletion

All ozone depletion impacts have reduced considerably since the release of GaBi 2018 because the underlying models have all been adapted to account for the discontinued use of halons and other ozone depleting gases.

Both models are based on WMO characterisation factors, the Draft EN 15804+A2:2018/EF 1.8 impacts are based on WMO 2014 report values and are all higher than those reported for EN 15804:2012+A1:2013 which are based on WMO 2003 Report values.

5.10. Photochemical ozone formation - human health

The indicator has changed so the results of the two indicators are not directly comparable.

Steel has slightly higher impacts than CLT per kg with the new indicator, and concrete has lower impacts per kg than both. (Note that these quantities are not comparable in function).

5.11. Resource use, energy carriers

The difference between these indicators is broadly that uranium is included in the draft EN 15804+A2:2018/EF 1.8 methodology but not the EN 15804:2012+A1:2013 methodology (which considers it within ADPE).

5.12. Resource use, mineral and metals

Using the new indicator, the result for BOF steel is lower per kg than for CLT, with concrete having a slightly higher impact per kg. The results using the older indicator are similar.

5.13. Respiratory inorganics

This impact category relates to particulate emissions, and is currently using the impact unit, “Deaths” in PEF which is equivalent to the unit “incidence of disease”.

Per kilogram, CLT has the highest impact, significantly higher than both steel and concrete. (Note that these quantities are not comparable in function).

On this basis (assessing A1-A3, C3 and C4), 1 death from particulates would be caused by the use of 1,800 tonnes CLT, 34,000 tonnes BOF steel or 260,000 tonnes concrete.

5.14. Water scarcity

Steel originally had a negative water scarcity for A1-A3, suggesting a problem with the modelling of water flows in the current version of the model. The model from an earlier version of GaBi has been used for this report. CLT has a higher water scarcity per kg than steel, and both have higher water scarcity than concrete per kg. (Note that these quantities are not comparable in function).