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LIGHT GAUGE STEEL FRAMING

Supplier Environmental Product Declaration Contents

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BRITISH STEEL

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LIGHT GAUGE STEEL FRAMING

Steel Rails and Sections

(including semi-finished long products)

Environmental Product Declaration

Owner of the Declaration: British Steel, Brigg Road, Scunthorpe, North Lincolnshire, DN16 1BP
Programme Operator: Tata Steel UK Limited, 30 Millbank, London, SW1P 4WY

CONTENTS

British Steel Rails and Sections (including semi-finished long products)
Environmental Product Declaration
(in accordance with ISO 14025 and EN 15804)

This EPD is representative and valid for the specified (named) products

Declaration Number: EPD-TS-2020-003
Date of Issue: 24th January 2020
Valid until: 23rd January 2025

Owner of the Declaration: British Steel, Brigg Road, Scunthorpe, North Lincolnshire, DN16 1BP
Programme Operator: Tata Steel UK Limited, 30 Millbank, London, SW1P 4WY

The CEN standard EN 15804:2012+A1:2013 serves as the core Product Category Rules (PCR) supported by Tata Steel's EN 15804 verified EPD PCR documents

Independent verification of the declaration and data, according to ISO 14025

Internal ☐ External ☒

Author of the Life Cycle Assessment: Tata Steel UK
Third party verifier: Olivier Muller, PricewaterhouseCoopers, Paris

1 General information

Owner of EPD	British Steel
Product	Steel rails and sections (including semi-finished long products)
Manufacturer	British Steel
Manufacturing sites	Scunthorpe, Teesside and Hayange
Product applications	Steel sections used in construction and infrastructure, steel rails for mainline and urban transport railway networks, and semi-finished long products for subsequent downstream re-rolling and forging
Declared unit	1 tonne of steel sections
Date of issue	24th January 2020
Valid until	23rd January 2025

This Environmental Product Declaration (EPD) is for steel rails, sections and semi-finished long products manufactured by British Steel in the UK and France. The environmental indicators are for products manufactured at Scunthorpe, Teesside and Hayange with feedstock supplied from Scunthorpe.

The information in the Environmental Product Declaration is based on production data from 2016.

EN 15804 serves as the core PCR, supported by Tata Steel's EN 15804 verified EPD programme Product Category Rules documents, and this declaration has been independently verified according to ISO 14025 [1,2,3,4,5,6,7].

Third party verifier

Olivier Muller, PwC Stratégie - Développement Durable, PricewaterhouseCoopers Advisory, 63, rue de Villiers, 92208 Neuilly-sur-Seine, France

2 Product information

2.1 Product Description

Steel sections are supplied in the as-rolled or thermomechanical rolled condition from British Steel rolling mills in Scunthorpe and Teesside. These hot rolled sections can also be supplied in the shot-blasted or shot-blasted and primed conditions. They include universal beams and columns, equal and un-equal angles and parallel flange channels in a range of external dimensions from less than 100mm to over 1000mm, and product weights from less than 20kg/m to over 1000kg/m. Mechanical properties of these products range from those for mild steel grades through to high strength steel grade variants.

Steel rails are supplied in either the as-rolled condition or the heat treated head hardened condition from British Steel rolling mills in Scunthorpe and Hayange. Over 80 different rail profiles are produced, with section weights from 27kg/m to just over 75kg/m, for both rail wheel support and guidance, and third rail electrification requirements.

Steel semi-finished long products (rolled billets) are supplied in the as-rolled condition from the British Steel rolling mill in Scunthorpe for subsequent downstream re-rolling and forging applications. The current size range for these products is 75mm to 160mm square sections, and a range of rectangles including 160mm x 70mm for cathode collector bar applications. Mechanical properties of these products range from those for mild steel grades through to ultra-high strength steel grade variants. Rolling of billet allows for a far wider range of product dimensions than available from direct cast material. Rolled billet provide the highest levels of surface quality and high through process reduction ratios necessary for the most demanding product applications.

2.2 Manufacturing

The manufacturing sites included in the EPD are listed in Table 1 below.

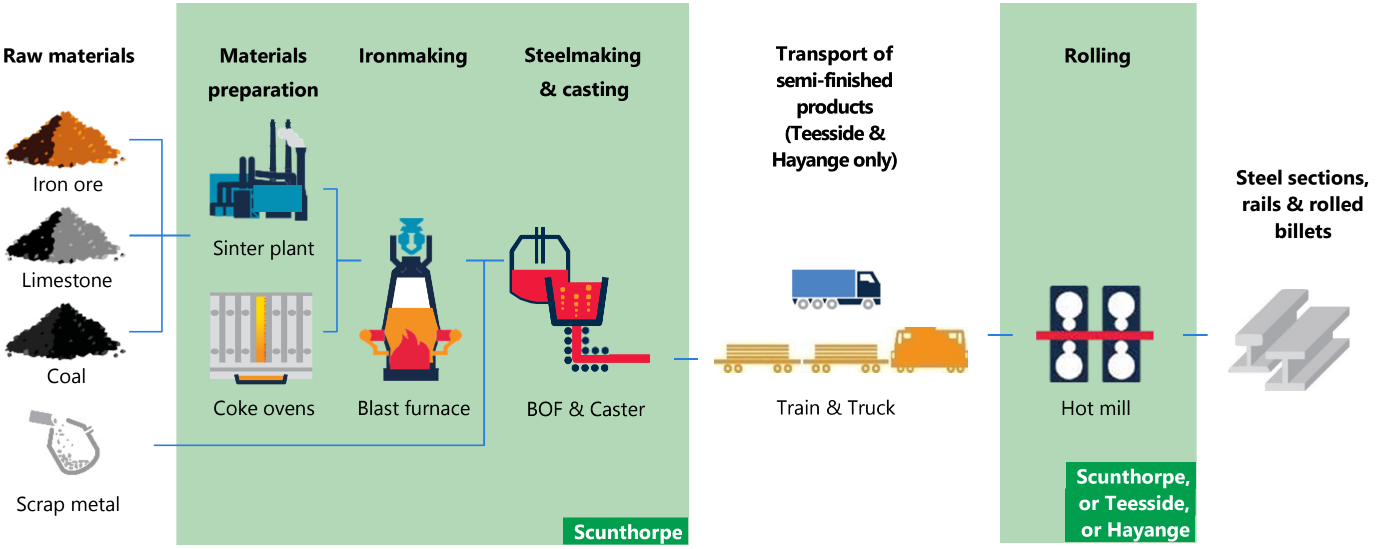
Table 1 Participating sites

Site name	Product	Manufacturer	Country
Scunthorpe	Semi-finished products	British Steel	UK
Scunthorpe	Sections, rails & rolled billets	British Steel	UK
Teesside	Sections	British Steel	UK
Hayange	Rails	British Steel	France

The steel manufacturing process at British Steel begins at Scunthorpe integrated steelworks where sinter is produced from iron ore and limestone, and together with coke from coal, are reduced in a blast furnace to produce liquid iron. Steel scrap is added to the liquid iron and oxygen is blown through the mixture to convert it into liquid steel in the basic oxygen furnace. Gases evolved from these processes are recycled and used to power reheating furnaces and also to generate electricity. Alloys are added to the liquid steel before it is continuously cast into rectangular sections. Discrete blooms, billets and slabs are cut from the continuously cast solid steel strands, and these semi-finished products are subsequently reheated and hot rolled in to a section or rail to make the final product. Blooms are also rolled to produce billet sized sections to meet customer specifications. Some of the semi-finished products are transported from Scunthorpe to Teesside and Hayange by road and rail, and are reheated and hot rolled in a section or rail mill. The process is shown in Figure 1.

Process data for the manufacture of steel long products at Scunthorpe, Teesside and Hayange was gathered as part of the latest worldsteel data collection. This was done for the 2016 calendar year for all three sites.

Figure 1 Process overview from raw materials to steel sections



2.3 Technical data and specifications

The technical specifications of the product are shown in Table 2.

2.4 Packaging

Sections and rail products are supplied singly or in tie wired product bundles to meet customer order requirements, and packaging is an absolute minimum. Steel is delivered to customer premises or directly to site, in lengths ranging from less than 6m to individual rails 216m long. Individual bars or bundles are separated by re-usable timbers or bespoke multi-use spacers, and loads are securely fixed to the railway wagon or truck by re-usable strapping. If required, loads can be sheeted although this is generally not necessary for steel rails and sections.

2.5 Reference service life

A reference service life for steel rails and sections is not declared because the construction or infrastructure application of these products is not part of this LCA study. To determine the full service life of steel rails and sections, all factors would need to be included, such as details of the final product application, and its location and environment.

Steel sections are supplied in a vast range of dimension and product property combinations, to allow maximum design efficiencies to be achieved. Construction and infrastructure projects range from re-usable temporary installations, to permanent structures designed to be serviceable for many decades.

Rail steel grades have been developed to resist the key degradation mechanisms of wear, fatigue and corrosion, and to facilitate simple on-site repairs to provide the maximum possible safe in-service life. Typically, the life of installed rail ranges from many years to decades, with rails often cascaded to lower category track through their serviceable life.

Table 2 Technical specification of the steel products

		British Steel sections, rails & rolled billets
Scope/Product	**Attributes**	**Applicable standards (typical)**
Manufacturing facilities	Quality systems and factory production control	ISO 9001 [8], NHSS 3B [9], CPR [10]
Sections	Dimensions	EN 10365 [11], ASTM A6 [12]
	Mechanical properties	EN 10025 [13], EN 10225 [14], ASTM A572 [15], ASTM A992 [16]
Rails	Dimensions	ISO 5003 [17], ISO 22055 [18], EN 13674 [19],
	Mechanical properties	EN 14811 [20], BS 11 [21], BS 500 [22], BS 7865 [23] Customer/network specific rail standards
Rolled billet	Dimensions	Customer specific – dimensions, chemistry
	Mechanical properties	and mechanical properties designed to achieve final product requirements

3 LCA methodology

3.1 Declared unit

The unit being declared is 1 tonne of steel sections, rails and rolled billet.

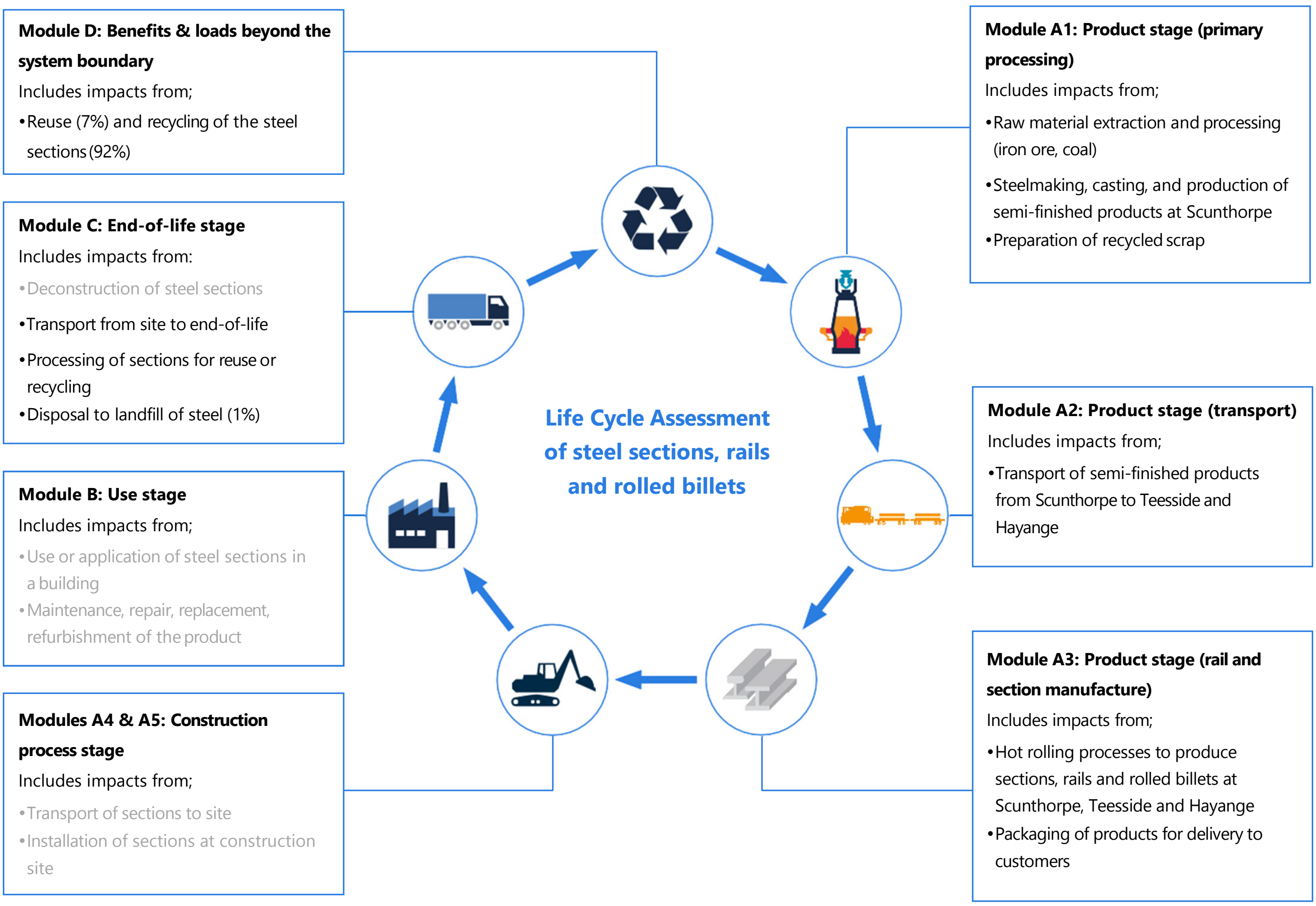
3.2 Scope

This EPD can be regarded as Cradle-to-Gate (with options) and the modules considered in the LCA are;

A1-3: Production stage (Raw material supply, transport to production site, manufacturing)
C2-4: End-of-life (Transport to EoL, processing for recycling & reuse and disposal)
D: Reuse, recycling and recovery

The life cycle stages are explained in more detail in Figure 2.

Figure 2 Life Cycle Assessment of steel sections, rails and rolled billets



3.3 Cut-off criteria

All information from the data collection process has been considered, covering all used and registered materials, and all fuel and energy consumption. On-site emissions were measured and those emissions have been considered. Data for all relevant sites were thoroughly checked and also cross-checked with one another to identify potential data gaps. No processes, materials or emissions that are known to make a significant contribution to the environmental impact of the sections, rails and rolled billets have been omitted. On this basis, there is no evidence to suggest that input or outputs contributing more than 1% to the overall mass or energy of the system, or that are environmentally significant, have been omitted. It is estimated that the sum of any excluded flows contribute less than 5% to the impact assessment categories. The manufacturing of required machinery and other infrastructure is not considered in the LCA.

3.4 Background data

For life cycle modelling of the steel products, the GaBi Software System for Life Cycle Engineering is used [24]. The GaBi database contains consistent and documented datasets which can be viewed in the online GaBi documentation [25].

Where possible, specific data derived from British Steel's own production processes were the first choice to use where available.

To ensure comparability of results in the LCA, the basic data of the GaBi database were used for energy, transportation and auxiliary materials.

3.5 Data quality

The data from the British Steel production processes are from 2016, and the technologies on which these processes were based during that period, are those used at the date of publication of this EPD. All relevant background datasets are taken from the GaBi software database, and the last revision of these data sets took place less than 10 years ago. Therefore, the study is considered to be based on high quality data.

3.6 Allocation

To align with the requirements of EN 15804, a methodology is applied to assign impacts to the production of slag and hot metal from the blast furnace (co-products from steel manufacture), that was developed by the World Steel Association and EUROFER [26]. This methodology is based on physical and chemical partitioning of the manufacturing process, and therefore avoids the need to use allocation methods, which are based on relationships such as mass or economic value. It takes account of the manner in which changes in inputs and outputs affect the production of co-products and also takes account of material flows that carry specific inherent properties. This method is deemed to provide the most representative method to account for the production of blast furnace slag as a co-product.

Economic allocation was considered, as slag is designated as a low value co-product under EN 15804. However, as neither hot metal nor slag are tradable products upon leaving the blast furnace, economic allocation would most likely be based on estimates. Similarly BOF slag must undergo processing before being used as a clinker or cement substitute. The World Steel Association and EUROFER also highlight that companies purchasing and processing slag work on long term contracts which do not follow regular market dynamics of supply and demand.

Process gases arise from the production of the semi-finished products at Scunthorpe and are accounted for using the system expansion method. This method is also referenced in the same EUROFER document and the impacts of co-product allocation, during manufacture, are accounted for in the product stage (Module A1).

End-of-life assumptions for recovered steel and steel recycling are accounted for as per the current methodology from the World Steel Association 2017 Life Cycle Assessment methodology report [27]. A net scrap approach is used to avoid double accounting, and the net impacts are reported as benefits and loads beyond the system boundary (Module D).

3.7 Additional technical information

The main scenario assumptions used in the LCA are detailed in Table 3. The end-of-life percentages are based upon a Tata Steel/ EUROFER recycling and reuse survey of UK demolition contractors carried out in 2014 [28].

The environmental impacts presented in the 'LCA Results' section (4) are expressed with the impact category parameters of Life Cycle Impact Assessment (LCIA) using characterisation factors. The LCIA method used is CML 2001-April 2013 [29].

3.8 Comparability

Care must be taken when comparing EPDs from different sources. EPDs may not be comparable if they do not have the same functional unit or scope (for example, whether they include installation allowances in the building), or if they do not follow the same standard such as EN 15804. The use of different generic datasets for upstream or downstream processes that form part of the product system may also mean that EPDs are not comparable.

Comparisons should ideally be integrated into a whole building assessment, in order to capture any differences in other aspects of the building design that may result from specifying different products. For example, a more durable product would require less maintenance and reduce the number of replacements and associated impacts over the life of the building.

Table 3 Main scenario assumptions

Module	Scenario assumptions
A1 to A3 – Product stage	Manufacturing data from British Steel's sites at Scunthorpe, Teesside and Hayange are used
A2 – Transport of semi-finished products to Teesside and Hayange	The semi-finished products are transported to Teesside and Hayange by road and rail from Scunthorpe. A utilisation factor of 45% was assumed to allow for empty returns and the distances travelled are 336km to Teesside (by rail) and 866km (by road and rail) to Hayange
C2 – Transport for recycling, reuse, and disposal	A transport distance of 100km to landfill or to a recycling site is assumed, while a distance of 250km is assumed for reuse. Transport is by road on a 27 tonne load capacity lorry with 40% utilisation to account for empty returns
C3 – Waste processing for reuse, recovery and/or recycling	There is no additional processing of material for recycling or reuse
C4 - Disposal	At end-of-life, 1% of the steel is disposed to landfill, in accordance with the findings of an NFDC survey
D – Reuse, recycling, and energy recovery	At end-of-life, 92% of the steel is recycled and 7% is reused, in accordance with the findings of an NFDC survey

4 Results of the LCA

Description of the system boundary

Product stage			Construction stage		Use stage							End of life stage				Benefits and loads beyond the system boundary
Raw material supply	Transport	Manufacturing	Transport	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse Recovery Recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X	X	X	X

X = Included in LCA; MND = module not declared

Environmental impact:

1 tonne of steel sections, rails and rolled billet

Parameter	Unit	A1 – A3	C2	C3	C4	D
GWP	kg CO_2 eq	2.45E+03	8.98E+00	0.00E+00	1.49E-01	-1.60E+03
ODP	kg CFC11 eq	3.59E-12	1.48E-15	0.00E+00	8.64E-16	4.09E-12
AP	kg SO_2 eq	6.05E+00	7.94E-03	0.00E+00	8.92E-04	-3.18E+00
EP	Kg PO_4^{3-} eq	4.68E-01	1.83E-03	0.00E+00	1.01E-04	-2.24E-01
POCP	kg Ethene eq	1.54E+00	-1.35E-04	0.00E+00	6.96E-05	-7.74E-01
ADPE	kg Sb eq	7.84E-04	6.90E-07	0.00E+00	5.47E-08	-2.41E-02
ADPF	MJ	2.45E+04	1.21E+02	0.00E+00	2.08E+00	-1.51E+04

GWP = Global warming potential

ODP = Depletion potential of stratospheric ozone layer

AP = Acidification potential of land &water

EP = Eutrophication potential

POCP = Formation potential of tropospheric ozone photochemical oxidants

ADPE = Abiotic depletion potential for non-fossil resources

ADPF = Abiotic depletion potential for fossil resources

Resource use:

1 tonne of steel sections, rails and rolled billet

Parameter	Unit	A1 – A3	C2	C3	C4	D
PERE	MJ	6.26E+02	7.06E+00	0.00E+00	2.73E-01	9.52E+02
PERM	MJ	8.11E+00	0.00E+00	0.00E+00	0.00E+00	-5.68E-01
PERT	MJ	6.34E+02	7.06E+00	0.00E+00	2.73E-01	9.51E+02
PENRE	MJ	2.66E+04	1.31E+02	0.00E+00	2.32E+00	-1.51E+04
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	2.66E+04	1.31E+02	0.00E+00	2.32E+00	-1.51E+04
SM	kg	6.72E+01	0.00E+00	0.00E+00	0.00E+00	-4.70E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	1.43E+00	1.36E-01	0.00E+00	1.29E-02	-5.45E+00

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials

PERM = Use of renewable primary energy resources used as raw materials

PERT = Total use of renewable primary energy resources

PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials

PENRM = Use of non-renewable primary energy resources used as raw materials

PENRT = Total use of non-renewable primary energy resources

SM = Use of secondary material

RSF = Use of renewable secondary fuels

NRSF = Use of non-renewable secondary fuels

FW = Use of net fresh water

Output flows and waste categories:

1 tonne of steel sections, rails and rolled billet

Parameter	Unit	A1 – A3	C2	C3	C4	D
HWD	kg	6.96E-05	0.00E+00	0.00E+00	0.00E+00	-4.87E-06
NHWD	kg	1.31E+02	0.00E+00	0.00E+00	1.00E+01	-9.20E+00
RWD	kg	1.09E-02	1.65E-04	0.00E+00	2.89E-05	-3.10E-04
CRU	kg	0.00E+00	0.00E+00	7.00E+01	0.00E+00	0.00E+00
MFR	kg	0.00E+00	0.00E+00	9.20E+02	0.00E+00	0.00E+00
MER	kg	3.12E-01	0.00E+00	0.00E+00	0.00E+00	-2.18E-02
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

HWD = Hazardous waste disposed

NHWD = Non-hazardous waste disposed

RWD = Radioactive waste disposed

CRU = Components for reuse

MFR = Materials for recycling

MER = Materials for energy recovery

EEE = Exported electrical energy

EET = Exported thermal energy

5 Interpretation of results

Figure 3 shows the relative contribution per life cycle stage for each of the seven environmental impact categories for 1 tonne of steel sections, rails and rolled billet. Each column represents 100% of the total impact score, which is why all the columns have been set with the same length. A burden is shown as positive (above the 0% axis) and a benefit is shown as negative (below the 0% axis). The main contributors across all impact categories are A1-A3 (burdens) and D (benefits beyond the system boundary).

The manufacturing stage A1-A3 is responsible for almost 100% of the burden in most of the categories, specifically, the conversion of iron ore into liquid steel which is the most energy intensive part of the manufacturing process.

The primary site emissions come from the use of coal and coke in the blast furnace, and from the injection of oxygen into the basic oxygen furnace, as well as combustion of the process gases. These processes give rise to emissions of CO_2, which contribute 95% of the Global Warming Potential (GWP), and sulphur oxides, which are responsible for around 70% of the impact in the Acidification Potential (AP) category. In addition, oxides of nitrogen are emitted which contribute just over 25% of the A1-A3 Acidification Potential, over 90% of the Eutrophication Potential (EP). The combined emissions of sulphur and nitrogen oxides also contribute to the Photochemical Ozone indication (POCP) category, but the largest contributor to this indicator is actually carbon monoxide at more than 75%.

Figure 3 clearly indicates the relatively small contribution to each impact from the other life cycle stages, C2 through to C4. Of these stages, the most significant contributions are from C2, to the Eutrophication Potential, mainly the result of nitrogen oxides emissions from the combustion of diesel fuel used in road transport.

Module D values are largely derived using worldsteel's value of scrap methodology which is based upon many steel plants worldwide, including both BF/BOF and EAF steel production routes. At end-of- life, the recovered steel is modelled with a credit given as if it were re-melted in an Electric Arc Furnace and substituted by the same amount of steel produced in a Blast Furnace [27]. This contributes a significant reduction to most of the environmental impact category results, but the Module D impact for the ODP indicator is a positive value and does not contribute a reduction to the total. In other words, for ODP, the recycling impact is larger than the impact of primary manufacture, and this burden comes from the way that the scrap credit is modelled.

Figure 3 LCA results for the steel sections, rails and rolled billet

For the ADPE indicator, the benefit in Module D is much greater than the impact from manufacturing in A1-A3 and this results from the worldsteel 'value of scrap' calculation being based on many steel plants worldwide. In the case of ADPE, the Module D benefit is greater than the steel manufacturing burden because the Scunthorpe liquid steel production process is more efficient than the average (the Module D benefit being a reflection of the world-wide steel plant average).

Referring to the LCA results, the impact in Module D for the Use of Renewable Primary Energy indicator (PERT) is different to other impact categories, being a burden or load rather than a benefit. Renewable energy consumption is strongly related to the use of electricity, during manufacture, and as the recycling (EAF) process uses significantly more electricity than primary manufacture (BF/BOS), there is a positive value for renewable energy consumption in Module D but a negative value for non-renewable energy consumption.

For use of net fresh water, Module D is a benefit, but the magnitude of this benefit is greater than the impact from Modules A1-A3. Once again, this is a result of the way Module D is calculated. Scunthorpe is a relatively modest user of fresh water, and the worldwide average calculation for Module D includes many sites with considerably greater fresh water use in A1-A3 than Scunthorpe.

6 References and product standards

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7. EN 15804:2012+A1:2013, Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products

8. ISO 9001: 2015, Quality management systems

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29. CML LCA methodology, Institute of Environmental Sciences (CML), Faculty of Science, University of Leiden, Netherlands

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ArcelorMittal

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LIGHT GAUGE STEEL FRAMING

ENVIRONMENTAL PRODUCT DECLARATION

as per *ISO 14025* and *EN 15804*

Owner of the Declaration	ArcelorMittal Europe - Flat Products
Programme holder	Institut Bauen und Umwelt e.V. (IBU)
Publisher	Institut Bauen und Umwelt e.V. (IBU)
Declaration number	EPD-ARC-20200027-CBD1-EN
ECO EPD Ref. No.	00001269
Issue date	10/07/2020
Valid to	09/07/2025

Cold Rolled Steel Coils

ArcelorMittal Europe

www.ibu-epd.com | https://epd-online.com

General Information

ArcelorMittal Europe	Cold Rolled Steel Coils
Programme holder IBU – Institut Bauen und Umwelt e.V. Panoramastr. 1 10178 Berlin Germany	**Owner of the declaration** ArcelorMittal Europe – Flat Products 24-26 Boulevard d'Avranches L-1160 Luxembourg Luxembourg
Declaration number EPD-ARC-20200027-CBD1-EN	**Declared product / declared unit** The declaration applies to 1 ton of cold rolled steel coil.
This declaration is based on the product category rules: Structural steels, 07.2014 (PCR checked and approved by the SVR)	**Scope:** The Life Cycle Assessment is based on data collected from the ArcelorMittal plants producing Cold Rolled Coils, representing 95 % of the annual production from 2015.
Issue date 10/07/2020	The owner of the declaration shall be liable for the underlying information and evidence; the IBU shall not be liable with respect to manufacturer information, life cycle assessment data and evidences.
Valid to 09/07/2025	**Verification** The standard *EN 15804* serves as the core PCR Independent verification of the declaration and data according to *ISO 14025:2010* ☐ internally ☒ externally
Dipl. Ing. Hans Peters (chairman of Institut Bauen und Umwelt e.V.)	
Dr. Alexander Röder (Managing Director Institut Bauen und Umwelt e.V.))	Mr Carl-Otto Neven (Independent verifier appointed by SVR)

Product

Product description/Product definition
This Environmental Product Declaration refers to Cold Rolled Steel Coil, Slit Coil and Sheet including Indaten® weathering steel, consisting of carbon steel. The EPD results reflect the volume weighted average of these products.

Cold Rolled Coils are produced in ArcelorMittal cold rolling mill in which Hot Rolled Steel coils are continuously rolled between a series of stands of rotating cylinders, and then annealed, either on a continuous annealing line or on batch annealing facilities. Alloy composition and process parameters are set to guarantee the required grade. The coils are then delivered to manufacturers for shaping into end products to be included in building works, generally to precise dimensions, thereby avoiding losses on the construction site.

Mean thickness value is at 1.5 mm but the declaration covers the whole range from 0.4 mm up to 3 mm. Width range is from 30 mm up to 1880 mm.

For the use and application, the product has a performance taking into consideration *EN 10130:2006* - Cold rolled low carbon steel flat products for cold forming - Technical delivery conditions or *EN 10268+A1:2013* - Cold rolled steel flat products with high yield strength for cold forming - Technical delivery conditions. For the application and use the respective national provisions apply.

Indaten® cold rolled steel offers improved resistance to atmospheric corrosion. Despite not being covered by a specific European standard, it is a thin gauge version of the hot rolled steel defined in the *EN 10025-5:2019* - Hot rolled products of structural steels - Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance for Indaten®.

It is a fine-grain, high-strength structural steel that has been optimised to give improved processing and in-service performance.

Application
Cold Rolled Coils can be used in various construction applications, such as:

- Construction: façade & cladding, roofing, sun screens & shades.
- Road equipment: safety barriers, protection equipment, sound insulation wall panels.
- Art sculpture & Other industrial applications: Containers & filters, etc.

Cold-rolled coils and Indaten® coils are delivered in wide coils, slit coils or sheets. It can be processed by all conventional processing operations used for cold rolled: cutting, slitting, bending, drawing, clinching, profiling, stamping, welding etc.

Indaten® Weathering steels offer improved resistance to corrosion thanks to the addition of copper during manufacture.

Additional alloying elements and specific thermal treatments during annealing can be used to increase the steel's tensile strength or make forming processes easier.

Technical Data
ArcelorMittal Europe Flat products is producing Cold Rolled Steel Coils in 6 mills. The EPD covers 95 % of the total production in 2015.

ArcelorMittal offers a full range of grades in compliance with the *EN 10130* to meet different applications.

ArcelorMittal has also created Indaten® weathering steel grade to meet different applications.

Constructional data

Name	Value	Unit
Density	7850	kg/m^3
Modulus of elasticity	210000	MPa
Coefficient of thermal expansion	12	$10^{-6}K^{-1}$
Thermal conductivity	48	W/(mK)
Melting point	1650	°C
Minimum yield strength	180 - 850	MPa

Performance data of the product with respect to its characteristics in accordance with the relevant technical provision from standards *EN 10130* or *EN 10268* (no CE-marking).

Voluntary data: ArcelorMittal product catalogue – document centre: https://industry.arcelormittal.com/productdocumentcentre

Base materials/Ancillary materials
The chemical composition is in accordance with *EN 10130* or *EN 10268*. High strength low alloyed (HSLA) carbon steel has a carbon content lower than 0.2 %. Yield strengths from 180 MPa up to 850 MPa are available.

Steel is mainly iron and carbon, with small amounts of alloying elements. These elements modify the chemical and physical properties of steel such as strength, durability and corrosion resistance. High strength low alloyed (HSLA) carbon steel has a carbon content lower than 0.2 %.
The metallurgical composition of weathering steels includes less than 0.2 % carbon. Alloying elements (mainly copper, chromium, nickel, phosphorus, silicon, and manganese) typically comprise less than 5 % of the steel.

Weathering steels are known as corrosion resistant steels. Like standard carbon steels, weathering steels oxidise when exposed to the atmosphere. Due to their specific chemistry, the corrosion rate of weathering steels is generally much lower than that of standard carbon steel. To obtain the weathering features, those steel grades are including some alloys like Cu, Cr, Ni, P & Mo in quantities defined by the standards. The possible chemical composition is defined in European standard. Weathering steels can be classified into two categories: those with limited phosphorous content (typically less than 0.035 %); and those with a higher phosphorous content. Weathering steels with a phosphorous content of between 0.06 and 0.15 % are identified by the letter P at the end of the product name.

High levels of phosphorous improves the corrosion resistance of weathering steels. Phosphorous is not used in heavy plate for structural uses as it can form iron phosphide (FeP3) during welding. This can hamper weldability and cause the weld zone to become brittle. For this reason, phosphorous weathering steels are usually only available in thicknesses lower than 12 mm.

This product contains substances listed in the candidate list (date: 26.2.2020) exceeding 0.1 percentage by mass: no

Reference service life
A reference service life for cold rolled steel coil is not declared. Cold rolled coil products are construction products with many different application purposes. The lifetime therefore will be limited by the application as well as the service life of the work.

First structural steel projects using weathering steel were completed 50 years ago in Europe and have demonstrated a very low maintenance level and no need for painting.

At the end of life, weathering steel products could be recovered, recycled and sent to the steel mill.

LCA: Calculation rules

Declared Unit
This Environmental Product Declaration refers to Cold Rolled Steel Coil, Slit Coil and Sheet including Indaten® weathering steel, consisting of carbon steel, as specified in Part B requirements on the EPD for Structural Steels.

Declared unit

Name	Value	Unit
Declared unit	1000	kg
Conversion factor to 1 kg	0.001	-
Density	7850	kg/m3

System boundary
Type of the EPD: cradle-to-gate - with options. Module A1-A3, Module C3 and module D were considered.

Modules A1-A3 of the Cold Rolled Steel Coil, Slit Coil and Sheet including Indaten® weathering steel production include the following:
· The provision of resources, additives, and energy
· Transport of resources and additives to the production site
· Production processes on-site including energy, production of additives, disposal of production residues, and consideration of related emissions
· Recycling of production/manufacturing scrap. Steel scrap is assumed to reach the end-of-waste status once it is shredded and sorted, thus becomes input to the product system in the inventory.

Module C3 takes into account the sorting and shredding of after-use steel that is recycled, as well as the non-recovered scrap due to sorting efficiency which is landfilled. A conservative value of 2 % landfill is considered.

Module D refers to the End-of-Life of the steel coil, including reuse and recycling.

Comparability
Basically, a comparison or an evaluation of EPD data is only possible if all the data sets to be compared were created according to *EN 15804* and the building context, respectively the product-specific characteristics of performance, are taken into account.

Gabi version 9.2 was used with Gabi Database SP35 version 8.7 to calculate this EPD.

LCA: Scenarios and additional technical information

Current practice for the average Cold Rolled Steel Coil consist of 98 % recycling and 2 % landfill according to the /European Commission Technical Steel Research/.

End of life (C3)

Name	Value	Unit
Landfilling	2	%

Reuse, recovery and/or recycling potentials (D), relevant scenario information

Name	Value	Unit
Recycling	98	%

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LCA: Results

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED; MNR = MODULE NOT RELEVANT)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MNR	MNR	MNR	MND	MND	MND	MND	X	MND	X

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: 1 ton of cold rolled steel coil

Parameter	Unit	A1-A3	C3	D
Global warming potential	[kg CO_2-Eq.]	2.38E+3	2.00E+0	-1.65E+3
Depletion potential of the stratospheric ozone layer	[kg CFC11-Eq.]	4.82E-9	6.89E-12	3.24E-10
Acidification potential of land and water	[kg SO_2-Eq.]	4.12E+0	6.78E-3	-3.98E+0
Eutrophication potential	[kg $(PO_4)^{3-}$-Eq.]	4.18E-1	7.99E-4	-3.41E-1
Formation potential of tropospheric ozone photochemical oxidants	[kg ethene-Eq.]	7.04E-1	4.75E-4	-5.12E-1
Abiotic depletion potential for non-fossil resources	[kg Sb-Eq.]	1.02E-4	9.53E-7	1.70E-4
Abiotic depletion potential for fossil resources	[MJ]	2.06E+4	2.25E+1	-1.31E+4

RESULTS OF THE LCA - RESOURCE USE: 1 ton of cold rolled steel coil

Parameter	Unit	A1-A3	C3	D
Renewable primary energy as energy carrier	[MJ]	6.16E+2	1.12E+1	1.20E+3
Renewable primary energy resources as material utilization	[MJ]	0.00E+0	0.00E+0	0.00E+0
Total use of renewable primary energy resources	[MJ]	6.16E+2	1.12E+1	1.20E+3
Non-renewable primary energy as energy carrier	[MJ]	2.06E+4	3.43E+1	-1.23E+4
Non-renewable primary energy as material utilization	[MJ]	0.00E+0	0.00E+0	0.00E+0
Total use of non-renewable primary energy resources	[MJ]	2.06E+4	3.43E+1	-1.23E+4
Use of secondary material	[kg]	1.13E+2	0.00E+0	0.00E+0
Use of renewable secondary fuels	[MJ]	0.00E+0	0.00E+0	0.00E+0
Use of non-renewable secondary fuels	[MJ]	0.00E+0	0.00E+0	0.00E+0
Use of net fresh water	[m^3]	4.59E+0	1.53E-2	5.79E-1

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: 1 ton of cold rolled steel coil

Parameter	Unit	A1-A3	C3	D
Hazardous waste disposed	[kg]	1.37E-5	2.18E-7	-8.67E-6
Non-hazardous waste disposed	[kg]	4.21E+0	2.01E+1	-2.63E+1
Radioactive waste disposed	[kg]	-2.71E-3	4.70E-3	2.94E-1
Components for re-use	[kg]	0.00E+0	0.00E+0	0.00E+0
Materials for recycling	[kg]	0.00E+0	9.80E+2	0.00E+0
Materials for energy recovery	[kg]	0.00E+0	0.00E+0	0.00E+0
Exported electrical energy	[MJ]	0.00E+0	0.00E+0	0.00E+0
Exported thermal energy	[MJ]	0.00E+0	0.00E+0	0.00E+0

References

EN 10025
EN 10025-5:2019 **-** Hot rolled products of structural steels - Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance

EN 10130
EN 10130:2006 - Cold rolled low carbon steel flat products for cold forming - Technical delivery conditions

EN 10268
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ArcelorMittal

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GaBi ts Software
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http://documentation.gabi-software.com

REACH
Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
https://echa.europa.eu/regulations/reach/legislation

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3

TATA STEEL

RoofDek D35 0.9mm steel structural roof deck

Environmental Product Declaration

CONTENTS

RoofDek D35 0.9mm steel structural roof deck
Environmental Product Declaration
(in accordance with ISO 14025 and EN 15804).

This EPD is representative and valid for the specified (named) product

Declaration Number: EPD-TS-2018-010
Date of Issue: 1st December 2018
Valid until: 30th November 2023

Owner of the Declaration: Tata Steel Europe
Programme Operator: Tata Steel UK Limited, 30 Millbank, London, SW1P 4WY

The CEN standard EN 15804:2012+A1:2013 serves as the core Product Category Rules (PCR) supported by Tata Steel's EN 15804 verified EPD PCR documents

Independent verification of the declaration and data, according to ISO 14025

Internal ☐ External ☒

Author of the Life Cycle Assessment: Tata Steel UK
Third party verifier: Olivier Muller, PricewaterhouseCoopers, Paris

1 General information

Owner of EPD	Tata Steel Europe
Product & module	RoofDek D35 0.9mm steel structural roof deck
Manufacturer	Tata Steel Europe
Manufacturing sites	Port Talbot, Llanwern, and Shotton
Product applications	Construction
Declared unit	1m^2 of steel structural roof deck
Date of issue	1st December 2018
Valid until	30th November 2023

This environmental product declaration is for RoofDek D35 steel structural roof deck manufactured by Tata Steel in the UK. The environmental indicators are for products manufactured at Shotton, with feedstock supplied from Port Talbot and Llanwern.

The information in the environmental product declaration is based on production data from 2013 and 2016.

EN 15804 serves as the core PCR, supported by Tata Steel's EN 15804 verified EPD programme Product Category Rules documents, and this declaration has been independently verified according to ISO 14025 [1,2,3,4,5,6,7].

Third party verifier

Olivier Muller, PwC Stratégie - Développement Durable, PricewaterhouseCoopers Advisory, 63, rue de Villiers, 92208 Neuilly-sur-Seine, France

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2 Product information

2.1 Product description

The RoofDek family of products consists of ten steel roof profiles which are designed to support all types of insulated roof systems. RoofDek D35 has a relatively shallow profile depth of 35mm and a cover width of 900mm, to meet the designers needs for efficiency, aesthetics, and structural performance. It is manufactured from Galvatite® hot dip zinc coated steel with a guaranteed minimum yield stress of 280N/mm^2, and has a fire rating of Class A1 to EN 13501-1[8].

RoofDek D35 is shown in Figure 1 and is an ideal choice of roof deck profile when securing to purlins, typically spanning 1.5m to 2.5m. The D35 product has a 150mm profile pitch, which fits perfectly with most single ply membrane manufacturers guidelines for mechanical fixing of their membrane to a deck which require fasteners at 150mm centres. Furthermore, the D35 profile has a 75mm crown, which provides a 50% surface area and is more than sufficient for most adhesive systems when bonding to the deck. For those looking for additional architectural features, the D35 profile can be supplied factory crimp curved, right down to a 400mm radius.

Figure 1 RoofDek D35 profile

2.2 Manufacturing

The manufacturing sites included in the EPD are listed in Table 1 below.

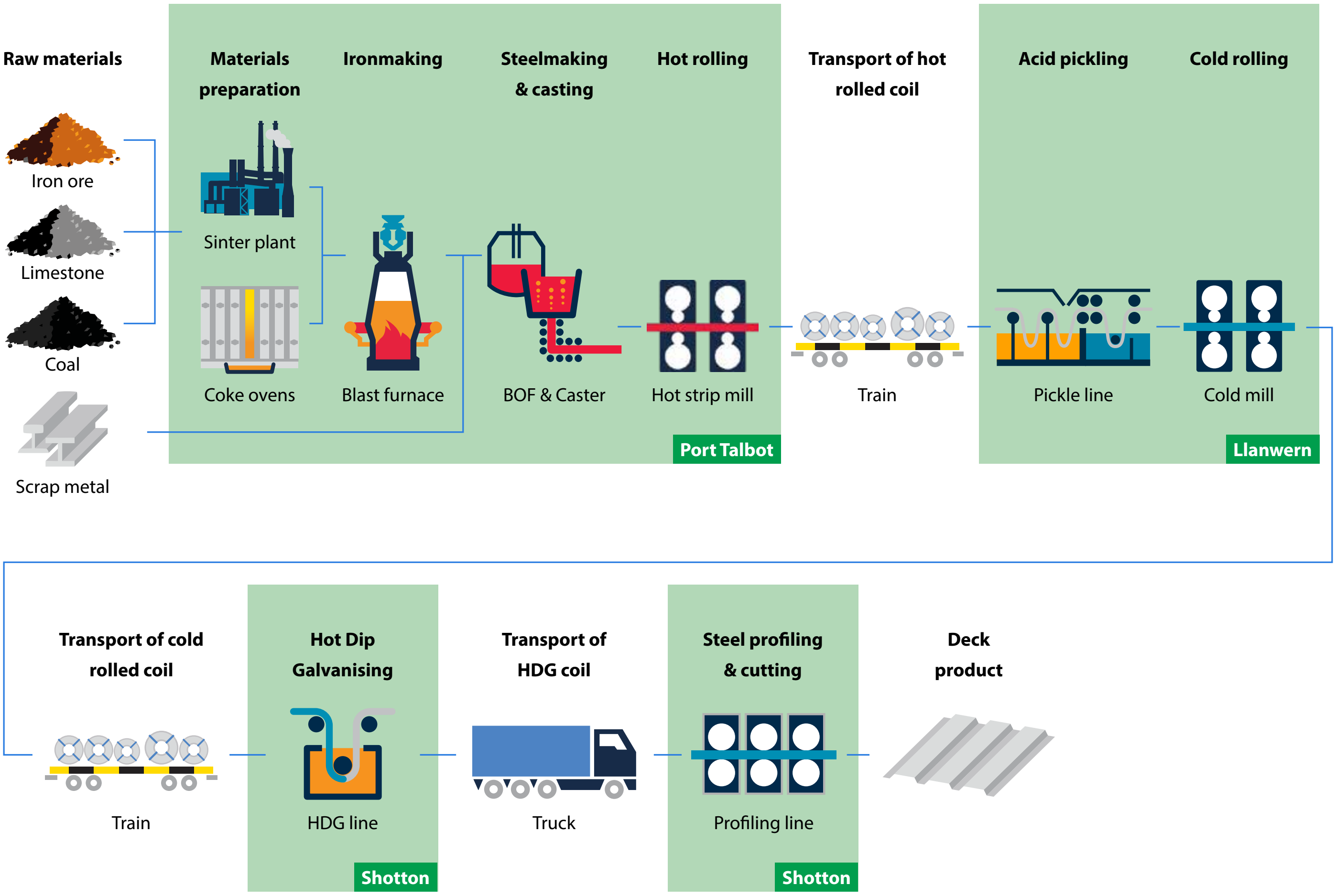
Table 1 Participating sites

Site name	Product	Manufacturer	Country
Port Talbot	Hot rolled coil	Tata Steel	UK
Llanwern	Cold rolled coil	Tata Steel	UK
Shotton	Hot dip galvanised coil	Tata Steel	UK
Shotton	Roof deck	Tata Steel	UK

The process of steel coil manufacture at Tata Steel begins with sinter being produced from iron ore and limestone, and together with coke from coal, reduced in a blast furnace to produce iron. Steel scrap is added to the liquid iron and oxygen is blown through the mixture to convert it into liquid steel in the basic oxygen furnace. The liquid steel is continuously cast into discrete slabs, which are subsequently reheated and rolled in a hot strip mill to produce steel coil. The hot rolled coils are transported by rail, from Port Talbot to Llanwern where they are pickled and cold rolled. Following, cold rolling the coil is transported by train to Shotton where the strip is galvanised.

The hot dip galvanised coils are transported from Shotton by road to the RoofDek manufacturing facility elsewhere on the Shotton site. The zinc coated steel is then profiled and cut into suitable lengths on a dedicated process line. An overview of the process from raw materials to manufacture of the steel roof deck product, is shown in Figure 2.

Figure 2 Process overview from raw materials to deck product



Process data for the manufacture of hot and cold rolled coil at Port Talbot and Llanwern was gathered as part of the latest worldsteel data collection. For Port Talbot and Llanwern, and hot dip galvanising at Shotton, the data collection was not only organised by site, but also by each process line within the site. In this way it was possible to attribute resource use and emissions to each process line, and using processed tonnage data for that line, also attribute resources and emissions to specific products. For the manufacture of the roof deck, process data was also collected from the profiling lines at Shotton.

2.3 Technical data and specifications

The general properties of the product are shown in Table 2.

Table 2 General characteristics and specification of the roof deck

	RoofDek D35 roof deck
Thickness of decking (mm)	0.9
Cover width (mm)	900
Standard maximum single span (mm)	2114
Standard maximum double span (mm)	2835
Profile weight (kg/m^2)	9.42
CE marking	DoP spec to EN 1090-1 [9]
Certification	Certifications applicable to Tata Steel's Shotton site are; ISO 9001[10], ISO 14001[11], OHSAS 18001[12] BES 6001 certification[13], EN10346[14]

2.4 Packaging

The deck profiles are packaged using wood base supports and plastic strapping in order to protect them during delivery to site and prior to installation.

2.5 Reference service life

A reference service life for structural deck is not declared because the steel profiles are part of a composite roofing system that also comprises an insulating roofing material such as slate or tiles, or felt, and the final construction application of the composite roof deck is not defined. To determine the full service life of steel structural deck, all factors would need to be included such as the type of roof material used, and the location and environment.

The indicative design working life of a structure is classed in accordance with EN 1990[15], clause 2.3. The design life ranges from category 1 at 10 years, to category 5 at 100 years. Common building structures are classed as category 4 at 50 years. In accordance with EN 1994-1-1[16], clause 4.2, the exposed surface of the steel decking shall be adequately protected to resist the particular atmospheric conditions. A zinc coating mass of 275g/m^2 (including both sides) is sufficient for the internal roof underside in a non-aggressive environment. Under 'normal' conditions, steel deck would not need to be replaced over the life of the building and structure.

3 LCA methodology

3.1 Declared unit

The unit being declared is 1m² of steel structural deck.

3.2 Scope

This EPD can be regarded as Cradle-to-Gate (with options) and the modules considered in the LCA are;

A1-A3: Production stage (Raw material supply, transport to production site, manufacturing)
C2, C3 & C4: End-of-life (transport, processing for recycling and disposal)
D: Reuse, recycling and recovery

All of the life cycle stages are explained in more detail in Figure 3, but where the text is in light grey, the impacts from this part of the life cycle are not considered for this particular product.

3.3 Cut-off criteria

All information from the data collection process has been considered, covering all used and registered materials, and all fuel and energy consumption. On-site emissions were measured and those emissions have been considered. Data for all relevant sites were thoroughly checked and also cross-checked with one another to identify potential data gaps. No processes, materials or emissions that are known to make a significant contribution to the environmental impact of the steel deck have been omitted. On this basis, there is no evidence to suggest that input or outputs contributing more than 1% to the overall mass or energy of the system, or that are environmentally significant, have been omitted. It is estimated that the sum of any excluded flows contribute less than 5% to the impact assessment categories. The manufacturing of required machinery and other infrastructure is not considered in the LCA.

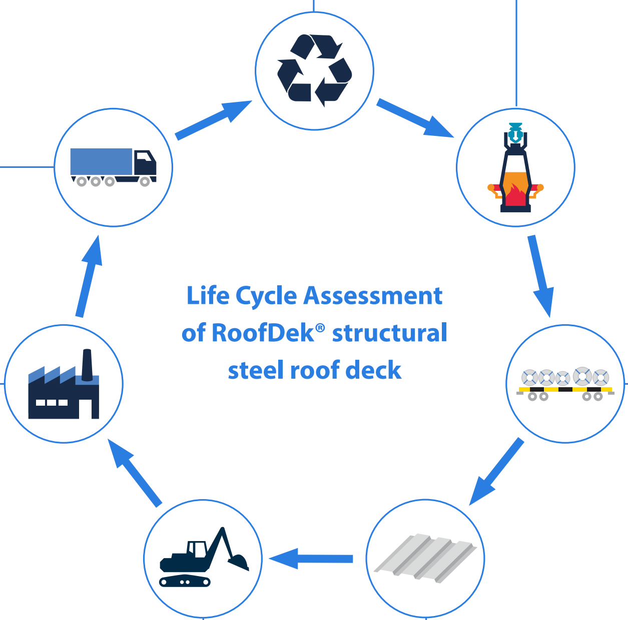
Figure 3 Life Cycle Assessment of steel deck

Module D: Benefits & loads beyond the system boundary
Includes impacts from;
- Deck reuse (0%) and recycling of the steel component (85%)

Module C: End-of-life stage
Includes impacts from:
- Deconstruction of composite deck system
- Transport from site to end-of-life
- Processing of deck system for reuse or recycling
- Disposal to landfill of steel (15%) and other system components

Module B: Use stage
Includes impacts from;
- Use or application of the composite deck in a building
- Maintenance, repair, replacement, refurbishment of the system

Modules A4 & A5: Construction process stage
Includes impacts from;
- Delivery of steel decks and other components to site
- Installation of composite deck system at construction site



Module A1: Product stage (primary processing)
Includes impacts from;
- Raw material extraction and processing (iron ore, coal)
- Steelmaking, casting, and production of cold rolled coil at Port Talbot & Llanwern
- Preparation of recycled scrap
- Hot dip metallic coating at Shotton
- Responsible sourcing of materials to BES 6001 standard

Module A2: Product stage (transport)
Includes impacts from;
- Transport of hot dip galvanised steel coils from Shotton to deck manufacturing site

Module A3: Product stage (deck manufacture)
Includes impacts from;
- Profiling and cutting of hot dip galvanised steel
- Packaging of decks for delivery to site

3.4 Background data

For life cycle modelling of steel deck, the GaBi Software System for Life Cycle Engineering is used [17]. The GaBi database contains consistent and documented datasets which can be viewed in the online GaBi documentation [18].

Where possible, specific data derived from Tata Steel's own production processes were the first choice to use where available.

To ensure comparability of results in the LCA, the basic data of the GaBi database were used for energy, transportation and auxiliary materials.

3.5 Data quality

The data from Tata Steel's own production processes are from 2013 and 2016, and the technologies on which these processes were based during that period, are those used at the date of publication of this EPD. All relevant background datasets are taken from the GaBi software database, and the last revision of all but two of these data sets took place less than 10 years ago. However, the contribution to impacts of these two datasets is small and relatively insignificant, and therefore, the study is considered to be based on high quality data.

3.6 Allocation

To align with the requirements of EN 15804, a methodology is applied to assign impacts to the production of slag and hot metal from the blast furnace (co-products from steel manufacture), that was developed by the World Steel Association and EUROFER [19]. This methodology is based on physical and chemical partitioning of the manufacturing process, and therefore avoids the need to use allocation methods, which are based on relationships such as mass or economic value. It takes account of the manner in which changes in inputs and outputs affect the production of co-products and also takes account of material flows that carry specific inherent properties. This method is deemed to provide the most representative method to account for the production of blast furnace slag as a co-product.

Economic allocation was considered, as slag is designated as a low value co-product under EN 15804. However, as neither hot metal nor slag are tradable products upon leaving the blast furnace, economic allocation would most likely be based on estimates. Similarly BOF slag must undergo processing before being used as a clinker or cement substitute. The World Steel Association and EUROFER also highlight that companies purchasing and processing slag work on long term contracts which do not follow regular market dynamics of supply and demand.

Process gases arise from the production of the continuously cast steel slabs at Port Talbot and are accounted for using the system expansion method. This method is also referenced in the same EUROFER document and the impacts of co-product allocation, during manufacture, are accounted for in the product stage (Module A1).

End-of-life assumptions for recovered steel and steel recycling are accounted for as per the current methodology from the World Steel Association 2017 Life Cycle Assessment methodology report [20]. A net scrap approach is used to avoid double accounting, and the net impacts are reported as benefits and loads beyond the system boundary (Module D).

3.7 Additional technical information

The main scenario assumptions used in the LCA are detailed below in Table 3. The end-of-life percentages are based upon the results of a survey carried out by the Steel Construction Institute in 2000 [21].

The environmental impacts presented in the 'LCA Results' section (4) are expressed with the impact category parameters of Life Cycle Impact Assessment (LCIA) using characterisation factors. The LCIA method used is CML 2001-April 2013 [22].

3.8 Comparability

Care must be taken when comparing EPDs from different sources. EPDs may not be comparable if they do not have the same functional unit or scope (for example, whether they include installation allowances in the building), or if they do not follow the same standard such as EN 15804. The use of different generic data sets for upstream or downstream processes that form part of the product system may also mean that EPDs are not comparable.

Comparisons should ideally be integrated into a whole building assessment, in order to capture any differences in other aspects of the building design that may result from specifying different products. For example, a more durable product would require less maintenance and reduce the number of replacements and associated impacts over the life of the building.

Table 3 Main scenario assumptions

Module	Scenario assumptions
A1 to A3 – Product stage	Manufacturing data from Tata Steel's sites at Port Talbot, Llanwern, and Shotton are used
A2 – Transport to the deck manufacturing site	The RoofDek manufacturing facilities are located on the Shotton site. For transport to Shotton, the steel coils are taken 5km by road on a 25 tonne payload truck. A utilisation factor of 45% was assumed to account for empty returns
C2 – Transport for recycling, reuse, and disposal	A transport distance of 100km to landfill or to a recycling site is assumed. Transport is on a 25 tonne load capacity lorry with 15% utilisation to account for empty returns
C3 – Waste processing for reuse, recovery and/or recycling	Steel deck that is recycled is processed in a shredder
C4 – Disposal	At end-of-life, 15% of the steel is disposed in a landfill, based upon the findings of an SCI survey
D – Reuse, recycling, and energy recovery	At end-of-life, 85% of the steel is recycled based upon the findings of a SCI survey

4 Results of the LCA

Description of the system boundary

Product stage			Construction stage		Use stage							End-of-life stage				Benefits and loads beyond the system boundary
Raw material supply	Transport	Manufacturing	Transport	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse Recovery Recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X	X	X	X

X = Included in LCA; MND = module not declared

Environmental impact:

1m² of 0.9mm RoofDek D35

Parameter	Unit	A1 – A3	C2	C3	C4	D
GWP	kg CO_2 eq	2.56E+01	1.97E-01	9.37E-02	2.25E-02	-1.09E+01
ODP	kg CFC11 eq	2.24E-11	3.41E-15	4.05E-12	5.09E-15	6.07E-08
AP	kg SO_2 eq	5.37E-02	5.19E-04	2.78E-04	1.33E-04	-2.14E-02
EP	kg PO_4^{3-} eq	5.36E-03	1.25E-04	2.65E-05	1.84E-05	-1.60E-03
POCP	kg Ethene eq	9.38E-03	-2.03E-04	1.92E-05	1.05E-05	-5.03E-03
ADPE	kg Sb eq	1.82E-03	3.00E-09	3.84E-08	8.64E-09	-3.11E-05
ADPF	MJ	2.67E+02	2.65E+00	1.34E+00	2.91E-01	-1.04E+02

GWP = Global warming potential
ODP = Depletion potential of stratospheric ozone layer
AP = Acidification potential of land & water
EP = Eutrophication potential
POCP = Formation potential of tropospheric ozone photochemical oxidants
ADPE = Abiotic depletion potential for non-fossil resources
ADPF = Abiotic depletion potential for fossil resources

Resource use:

1m² of 0.9mm RoofDek D35

Parameter	Unit	A1 – A3	C2	C3	C4	D
PERE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERM	MJ	3.21E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	3.21E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRE	MJ	8.99E+00	6.39E-02	5.27E-02	8.11E-03	-4.20E+00
PENRM	MJ	4.47E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	9.44E+00	6.39E-02	5.27E-02	8.11E-03	-4.20E+00
SM	kg	1.24E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	2.13E-04	1.32E-30	0.00E+00	4.57E-24	-5.13E-05
NRSF	MJ	2.04E-03	2.00E-29	0.00E+00	5.37E-23	-4.05E-04
FW	m^3	4.03E-02	2.44E-04	1.21E-03	1.83E-03	-6.32E-02

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials

PERM = Use of renewable primary energy resources used as raw materials

PERT = Total use of renewable primary energy resources

PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials

PENRM = Use of non-renewable primary energy resources used as raw materials

PENRT = Total use of non-renewable primary energy resources

SM = Use of secondary material

RSF = Use of renewable secondary fuels

NRSF = Use of non-renewable secondary fuels

FW = Use of net fresh water

Output flows and waste categories:

1m² of 0.9mm RoofDek D35

Parameter	Unit	A1 – A3	C2	C3	C4	D
HWD	kg	2.41E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NHWD	kg	1.73E+00	0.00E+00	0.00E+00	1.41E+00	0.00E+00
RWD	kg	3.63E-03	0.00E+00	2.50E-04	0.00E+00	0.00E+00
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	1.24E-02	0.00E+00	6.77E+00	0.00E+00	0.00E+00
MER	kg	5.50E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EEE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EET	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

HWD = Hazardous waste disposed

NHWD = Non-hazardous waste disposed

RWD = Radioactive waste disposed

CRU = Components for reuse

MFR = Materials for recycling

MER = Materials for energy recovery

EEE = Exported electrical energy

EET = Exported thermal energy

5 Interpretation of results

Figure 4 shows the relative contribution per life cycle stage for each of the seven environmental impact categories for 1m^2 of Tata Steel's RoofDek D35 product. Each column represents 100% of the total impact score, which is why all the columns have been set with the same length. A burden is shown as positive (above the 0% axis) and a benefit is shown as negative (below the 0% axis). The main contributors across all but one of the impact categories are A1-A3 (burdens) and D (benefits beyond the system boundary).

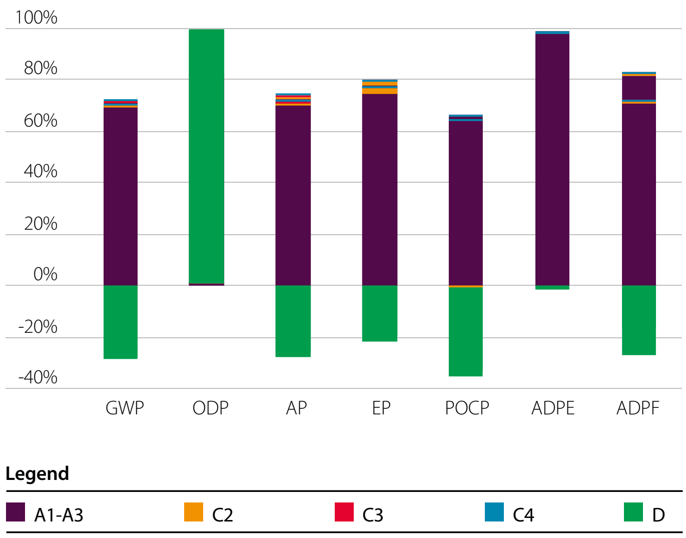
The manufacture of the cold rolled coil during stage A1-A3 is responsible for approximately 90% of each impact in most of the categories, specifically, the conversion of iron ore into liquid steel which is the most energy intensive part of the overall deck manufacturing process.

The primary site emissions come from the use of coal and coke in the blast and basic oxygen furnaces as well as combustion of the process gases. These processes give rise to emissions of CO^2, which contributes 94% of the Global Warming Potential (GWP), and sulphur oxides, which are responsible for almost two thirds of the impact in the Acidification Potential (AP) category. In addition, oxides of nitrogen are emitted which contribute one third of the A1-A3 Acidification Potential, and almost 90% of the Eutrophication Potential (EP), and the combined emissions of carbon monoxide (68%) together with sulphur and nitrogen oxides, contribute to the Photochemical Ozone indication (POCP).

Figure 4 clearly indicates the relatively small contribution to each impact from the other life cycle stages, which are transport of the decks to their end-of-life fate, processing of the steel scrap for recycling, and disposal to landfill.

Module D values are largely derived using worldsteel's value of scrap methodology which is based upon many steel plants worldwide, including both BF/BOF and EAF steel production routes. At end-of-life, the recovered steel deck is modelled with a credit given as if it were re-melted in an Electric Arc Furnace and substituted by the same amount of steel produced in a Blast Furnace [20]. This contributes a significant reduction to most of the environmental impact category results, with the specific emissions that represent the burden in A1-A3, essentially the same as those responsible for the impact reductions in Module D.

Figure 4 LCA results for the deck profile



The exception, with regard to the end-of-life credit given to steel scrap after the use stage in Module D, is the depletion potential of the stratospheric ozone layer (ODP) indicator. This particular impact score is a positive value and does not contribute a reduction to the total results as do the other listed impact categories. For ODP, the recycling of steel deck at end-of-life results in a relatively large burden when compared with that from the product stage, A1-A3. In other words, for ODP, the recycling impact is larger than the impact of primary manufacture. The very different energy sources (coal versus grid electricity mix) and technologies (BF/BOS versus EAF) are the main reasons why the recycling impact for ODP is larger than that of primary manufacture. The Module D burden comes from the allocation methodology used in the worldsteel model for calculating the 'value of scrap'.

For use of net fresh water, Module D is a benefit, but the magnitude of this benefit is greater than the impact from Modules A1-A3. This is explained by the Module D benefit for net use of fresh water being based upon a worldsteel calculation for many steel plants worldwide. Port Talbot, the biggest water user in this study, is a relatively modest user of fresh water as reported in A1-A3. The worldwide average calculation for Module D includes many sites with considerably greater fresh water use in A1-A3 than Port Talbot.

6 References and product standards

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2. Tata Steel's EN 15804 verified EPD programme, Product Category Rules Part 1, Version 1.0, January 2017

3. Tata Steel's EN 15804 verified EPD programme, Product Category Rules Part 2 – Steel Structural Deck, Version 1.0, October 2018

4. ISO 14044:2006, Environmental management - Life Cycle Assessment - Requirements and guidelines

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6. ISO 14040:2006, Environmental management - Life Cycle Assessment - Principles and framework

7. EN 15804:2012+A1:2013, Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products

8. EN 13501-1:2007+A1:2009, Fire classification of construction products and building elements. Classification using test data from reaction to fire tests

9. EN 1090-1, Requirements for conformity assessment for structural components

10. ISO 9001:2015, Quality management systems

11. ISO 14001:2015, Environmental management systems

12. BS OHSAS 18001:2007, Occupational health and safety management

13. BES 6001, Responsible sourcing of construction products

14. EN 10346:2015, Continuously hot-dip coated steel flat products for cold forming

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www.tatasteelconstruction.com

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4

Anthesis

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LIGHT GAUGE STEEL FRAMING

Environmental product declaration (EPD) report of fabricated steel products produced in the UK by Eco-Reinforcement members

FINAL REPORT

BRC Ltd

Report prepared by: Matt Fishwick and Katie Livesey

Report reviewed by: Alan Spray

Date of EPD: 20 March 2019 (5 year validity)

Anthesis

Environmental product declaration (EPD) report of fabricated steel products produced in the UK by Eco-Reinforcement members

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Date:

20 March 2019

1 Goal and scope

1.1 Background

Eco-Reinforcement are a consortium of reinforcing steel producers and fabricators who have developed a third-party certification scheme to access and recognise responsibly sourced reinforcing steel products.

Eco-Reinforcement are interested in better understanding the environmental profile of products manufactured by their member companies BRC Ltd, Express Reinforcements, ROM Group and Hy-Ten. To this end, life cycle assessment (LCA) can be used to generate quantitative environmental profiles for different products systems across their entire lifecycle. As Eco-Reinforcement were also very much interested in a study that allows a fair basis for comparison and communication results, an environmental product declaration (EPD) was performed using LCA as a basis for the underlying methodology.

Eco-Reinforcement members include the steel fabrications BRC Ltd, Express Reinforcements, ROM Group and Hy-Ten. This report is specific to BRC Ltd.

The following LCA practitioners from Anthesis were involved in this project:

- **Matt Fishwick** – Matt has over 10 years of experience in product carbon footprinting, LCA and waste. Past clients include E.ON, Land Securities, Lend Lease, HS2, Jotun and Masdar.
- **Alan Spray -** Alan leads the data analyst team at Anthesis. He has a PhD in engineering and a background in LCA, leading projects for EloPak, Reckitt Benckiser and Pepsico.

Life cycle assessment is a decision support tool that allows quantitative environmental profiles to be generated for different products systems. Environmental product declaration's and associated product category rules (PCRs) allow LCAs of similar products to be carried out using a consistent approach and communicated to interested stakeholders. This study and report has been performed in accordance with the requirements given in ISO 14025, EN 15804 and the International EPD programme's PCR for construction products and construction services (PCR 2012:01, v2.3, herein referred to as the construction products PCR). The methodology of this study is also underpinned by the international standards for LCA: ISO 14040:2006 and ISO 14044:2006.. Comparison of products will only be possible if the comparative product LCA/EPD is carried out using EN 15804 and the construction products PCR.

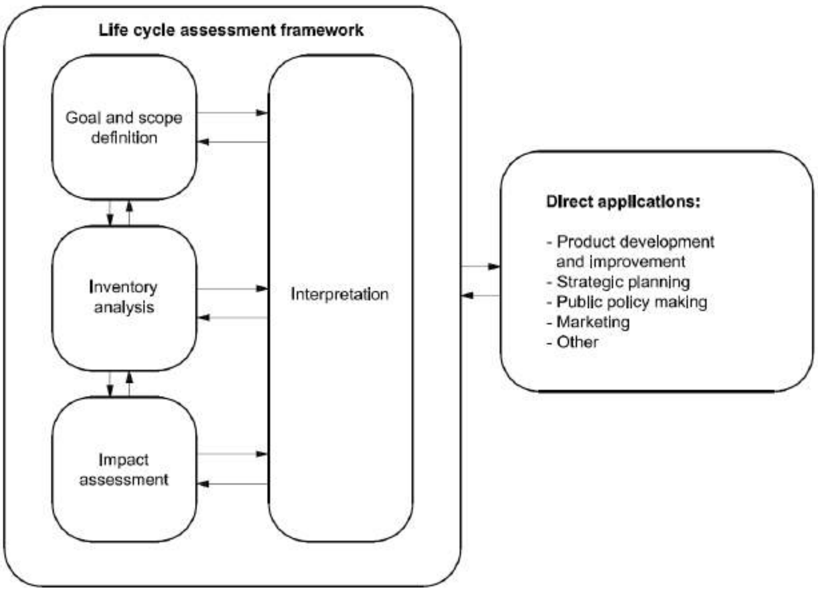

Figure 1 – The four stages of LCA as defined by ISO 14040.

The EPD followed a typical four-stage iterative process used in LCA: goal and scope definition, inventory analysis, impact assessment and interpretation (Figure 1). The whole process is usually iterative, with feedback loops between the interpretation and all other stages of the LCA, as was the case in this study. Following the definition of the goal and scope in this LCA project, the project involved the development of process flow diagrams (PFD) for each product system by both Anthesis and Eco-Reinforcement members jointly, in an iterative process. Then appropriate inventory data were gathered from both Eco-Reinforcement members and secondary sources to cover all unit processes within each product system. These inventory data were used to create a model, characterisation factors were applied, and results subsequently generated and interpreted.

1.2 Goal of the study

The goal of this study was to generate environmental profiles to be reported in an EPD of the following fabricated reinforcing steel products to better understand the associated lifecycle environmental impacts of each:

- **Cut and bent steel rebar product**; and
- **Cut and bent steel mesh product**.

This LCA study will allow BRC Ltd and Eco-Reinforcement to identify the relative contribution to environmental impact of all processes in the product lifecycles. Therefore, it will allow members to identify the relative contribution to environmental impact of all processes of the product systems under investigation and help identify 'hotspots' where mitigation measures can be targeted. Results from this study will be used to communicate the environmental performance of these product systems to customers and other stakeholders, in the form of an EPD. In each case, the intended use of this EPD is business-to-business communication, not business-to-consumer communication.

The main objectives of the study were to:

- Generate EPDs to communicate the environmental impact of the product systems;
- Identify significant contributions to the environmental impacts ("hotspots") across the product lifecycle; and
- Identify possible improvement areas of the studied systems that would be of interest for further analyses.

The intended applications are to:

- Understand the opportunities and risks of steel fabrication;
- Help inform opportunities for environmental impact reduction; and
- Inform BRC's environmental policy.

1.3 System boundaries

The system boundary of this LCA study was "**cradle-to-gate**", covering the following EN 15804 information modules: A1 raw material supply, A2 transport and A3 manufacturing (Figure 2). This includes the extraction and production of raw materials, manufacturing processes, all transportation stages and waste management through to the "gate" boundary. All other building life cycle stages are excluded.

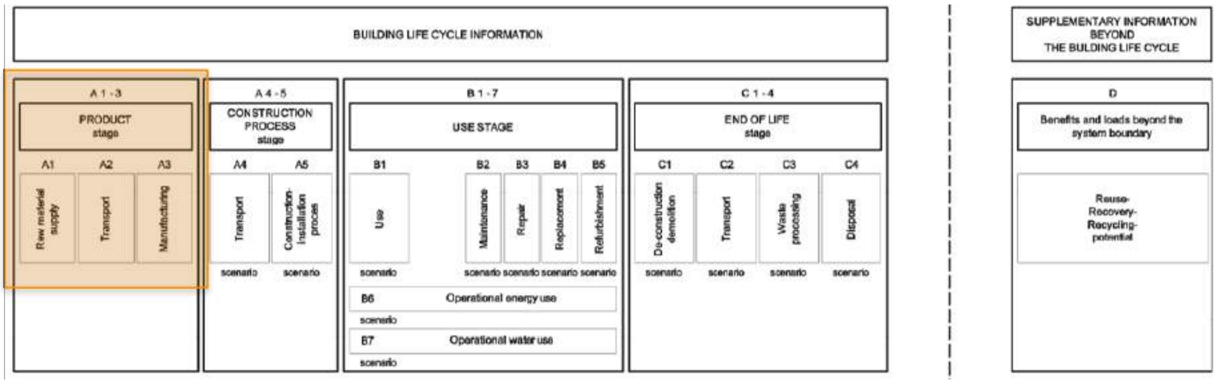

Figure 2 – EN 15804 building life cycle information modules

1.1 Declared unit

The general function of the product systems is, in each case, to provide reinforcement support for concrete used for a variety of purposes in buildings and infrastructure. However, the precise function of the product system at the building level is not stated here, due to the variety of possible uses of this construction product.

Instead, a declared unit was applied for this EPD. The declared unit provides a reference to which material flows of the construction product are normalised and serves as a basis of comparison between systems, it is therefore an important factor. The declared unit for this study was defined as:

"1 tonne of fabricated reinforced steel product produced in the UK"

1.2 Manufacturing sites

Data were collected from the following BRC Ltd manufacturing sites for the cut and bent steel rebar product system:

- **BRC Newhouse**: Block 14, Newhouse Industrial Estate, Newhouse, Motherwell, ML1 5SE;
- **BRC Newport**: Corporation Road, Newport, Gwent, NP19 4RD;
- **BRC Romsey**: Belbins Business Park, Cupernham Lane, Romsey, Hampshire SO51 7JF; and
- **BRC Mansfield**: Station Road, Sutton-in-Ashfield, NG17 5FY.

Data were collected from the following BRC Ltd manufacturing site for the cut and bent steel mesh product system:

- **BRC Barnsley**: Whaley Road, South Yorkshire Industrial Estate, Barugh, Barnsley, South Yorkshire, S75 1HT.

1.3 Material composition of product

The main material composition of the product is based on an EPD for rod/bar reinforcing steel published by one of BRC's main suppliers of this product (BREG EN EPD 000187; BRE, 2017). BRC's processes do not change the material composition of rod/bar reinforcing steel in any way.

- 95% iron; and
- 5% - FeSi, SiMn, CuSi, FeB, Al, FeV, C and other charge additives.

1.4 Product systems description

BRC Ltd produce cut and bent hot rolled ribbed steel reinforcement bar and mesh for use in the reinforcement of concrete. Both bar and mesh product systems have similar processes in their cradle-to-gate lifecycle, which are described below and presented in the PFD in Figure 3:

- **A1 raw materials supply:** scrap steel is added to an electric arc furnace to melt it and convert it into high quality steel before it is cast into billets. The production process for the first use of this scrap steel involved mining iron ore, extracting molten iron from the ore in a blast furnace and removing impurities to produce steel billets. Rod/bar reinforcing steel is produced by Celsa by heating steel billets, which are in turn pushed through a series of rolling stands with grooved cylindrical rolls, each with a smaller diameter than the previous. No other raw materials are considered in the product systems. Packaging materials were excluded based on immateriality.
- **A2 transport:** rod/bar reinforcing steel manufactured by Celsa in Cardiff is transported to BRC Ltd sites in the UK via road and rail.
- **A3 manufacturing:** rod/bar reinforcing steel is cut to the desired length and bent to the desired shape at BRC Ltd site.

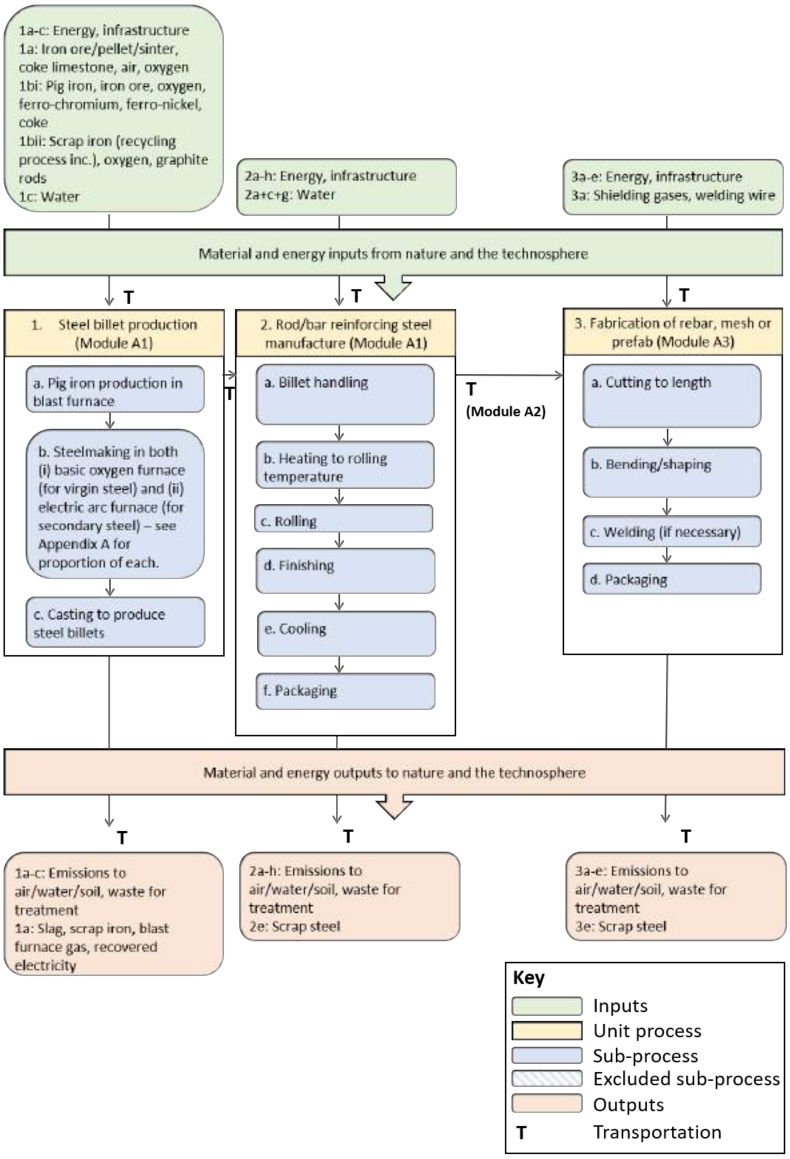

Figure 3 – Process flow diagram

1.5 Exclusions and cut-off criteria

In the process of building a life cycle inventory (LCI) it is typical to exclude items considered to have a negligible contribution to results. In order to do this in a consistent and robust manner there must be confidence that the exclusion is fair and reasonable. To this end, cut-off criteria are defined, which allow items to be neglected if they meet the criteria. In this study, exclusions could be made if they were expected to be within the below criteria:

- **Mass**: if a flow is anticipated to be less than 1% of the mass of the product it may be neglected;
- **Energy**: if a flow is anticipated to be less than 1% of the cumulative energy it may be neglected; and
- **Environmental significance**: if a flow is anticipated to be less than 1% of the key impact categories it may be excluded.

If an item meets one of the criteria but is expected to be significant for one of the other criteria it may not be neglected. For example, if a raw material is small in mass but is expected to have a notable contribution to the environmental results then it may not be excluded.

Lifecycle stages that have been omitted from the scope of the study include the following:

- Human energy inputs to processes;
- Production and disposal of the infrastructure (machines, transport vehicles, roads, etc.) and their maintenance;
- Environmental impacts related to storage phases;
- Losses of product at different points in the supply chain, for instance during handling and storage;
- Transport of employees to and from their normal place of work and business travel;
- Environmental impacts associated with support functions (e.g. R&D, marketing, finance, management etc.); and
- Primary, secondary and tertiary packaging of raw materials and finished products (estimated to be <0.1% of product by mass for finished products).

1.6 Data quality requirements

The general data quality requirements and characteristics that need to be addressed in this study are shown in Table 1.

Table 1 - Data quality requirements based on ISO 14044, EN 15804 or the construction products PCR

Aspect	Description	Requirement in this study
Time-related coverage	Desired age of data and the minimum length of time over which data should be collected	General data should represent the current situation of the date of study, or as close as possible. All data should be less than 10 years old and within the last 5 years for producer specific data. Producer specific data should be based on 1 year averaged data. Time period for inputs and outputs to and from the system should be

Aspect	Description	Requirement in this study
		100 years. Long term emissions (> 100 years) should be excluded.
Geographical coverage	Area from which data for unit processes should be collected	Data should be representative of the physical reality for the declared product.
Technology coverage	Type of technology (specific or average mix)	Data should be representative of the physical reality for the declared product.
Completeness	Assessment of whether all relevant input and output data are included for each data set.	Simple validation checks (e.g. mass or energy balances) will be performed.
Representativeness	Degree to which the data set reflects the true population of interest	The data should fulfil the defined time-related, geographical and technological scope.
Precision	Measure of the variability of the data values	Data that is as representative as possible will be used.
Reproducibility	Assessment of the method and data, and whether an independent practitioner will be able to reproduce the results	Information about the method and data (reference source) should be provided.
Sources of the data	Assessment of the data sources used.	Data will be derived from credible sources, and references will be provided.

1.7 Data quality indicators (DQIs)

To ensure the quality of data was sufficient data quality checks were completed on key data parameters. This was completed through the use of data quality indicators (DQIs).

Data quality indicators are applied to key data parameters to ensure that the data is fit for purpose. Key data parameters are assessed against a data quality matrix and assigned scores between 1 (best) and 5 (worst). The data quality matrix used in this study was adapted from Weidema et al. (2013) and is shown in Table 2. Data quality indicator scores for inventory data are provided in Appendix B.

Table 2 – Data Quality Indicator Matrix

Aspect	1	2	3	4	5
Reliability of the source	Verified data based on measurements	Verified data partly based on assumptions or non-verified	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate

Aspect	1	2	3	4	5
		data based on measurements			
Representative	Representative data from sufficient sample of sites over an adequate period to even out normal fluctuations	Representative data from a smaller number of sites but for adequate periods	Representative data from an adequate number of sites but from shorter periods	Representative data but from a smaller number of sites and shorter periods or incomplete data from an adequate number of sites and periods	Representativeness unknown or incomplete data from a smaller number of sites and/or from shorter periods
Temporal correlation	Less than three years of difference to year of study	Less than six years of difference	Less than 10 years of difference	Less than 15 years of difference	Age of data unknown or more than 15 years of difference
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown area or area with very different production conditions
Technological correlation	Data from enterprises, processes and materials under study	Data from processes and materials under study but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials but same technology	Data on related processes or materials but different technology
Reliability of the source	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate

1.8 Data collection procedures

Quantitative and qualitative primary and secondary data were collected for all processes within the system boundary (with the exception of exclusions described in Section 0) and these data were used to compile the LCI.

In this study, primary data were collected for all process likely to be under the operational control of BRC over the period of 01/01/2016 to 31/12/2016 and most other processes were modelled using secondary data. Primary data were collected from BRC using data collection sheets via an iterative process and comprised general site information including annual production masses, annual raw materials used, annual energy and fuel use, annual fugitive and process emissions, annual solid and liquid waste treatment. Further primary data came in the form of an EPD from one of BRC’s suppliers, Celsa Steel UK Ltd (BREG EN EPD No 000187).

Secondary data were collected primarily from extended version of the ecoinvent v3.4 database (EuGeos'15804-IA v3.0). All data sources are described in Appendix A.

A mass balance of materials for each site was performed and is summarised below:

- BRC Newhouse: 1.017 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.017 tonnes per tonne of product left as waste.
- BRC Newport : 1.017 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.017 tonnes per tonne of product left as waste.
- BRC Romsey: 1.027 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.027 tonnes per tonne of product left as waste.
- BRC Mansfield: 1.025 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.025 tonnes per tonne of product left as waste.
- BRC Barnsley: 1.009 tonnes of steel per tonne of product was bought to site, 1 tonne per tonne was used in products and 0.009 tonnes per tonne of product left as waste.

1.9 Life Cycle Impact assessment (LCIA) method

In LCA, the life cycle impact assessment (LCIA) stage is where characterisation factors are applied to life cycle inventory (LCI) data to generate environmental impact results. There are several LCIA methods that can be chosen, all with slightly different characterisation factors (both in terms of coverage and values) and different underlying characterisation models used to generate these factors. In this study, the LCIA methods prescribed in EN 15804 and the construction products PCR (CML-IA v4.1) were used.

The CML-IA impact assessment method transformed data gathered in the inventory phase to several indicator scores for various impact categories, giving a broad range coverage of environmental issues. These indicator scores express the relative severity on an environmental impact category and are represented here at the 'mid-point' stage. At the 'mid-point' stage, individual impact categories are shown, whereby a score is given for each in the appropriate reference unit.

A LCA model was built in Microsoft Excel for the product systems under investigation using primary and secondary inventory data. 'Mid-point' characterised results from the EuGeos EN 15804-IA database v2.1 were applied to LCI data in the LCA model. EuGeos EN 15804-IA is an extended version of ecoinvent v3.4 (cut-off) that allows for the calculation of all environmental indicators of CML-IA v4.1 in addition to other parameters required by EN 15804. Characterisation models and factors from CML-IA v4.1 were used unaltered and as provided and calculation of other EN 15804 parameters was carried out using EuGeos EN 15804-IA data and methods unaltered and as provided. Long term (> 100 years) emissions were excluded from this study. Note that estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks.

The CML-IA v4.1 mid-point environmental impact categories used in this study comprised the following:

- CML-IA v4.1, Global Warming Potential, GWP (kg CO_2 equivalent, eq);
- CML-IA v4.1, Depletion potential of the stratospheric ozone layer, ODP (kg CFC 11 eq);
- CML-IA v4.1, Acidification potential of soil and water, AP (kg SO_2 eq);
- CML-IA v4.1, Eutrophication potential, EP (kg $(PO_4)^{3-}$ eq);
- CML-IA v4.1, Formation potential of tropospheric ozone, POCP (kg C_2H_4 eq);
- CML-IA v4.1, Abiotic depletion potential for non-fossil resources, ADP-elements (kg Sb eq); and
- CML-IA v4.1, Abiotic depletion potential for fossil resources, ADP-fossil fuels (MJ, net calorific value).

Other EN 15804-IA parameters used in this study comprised the following:

- Parameters describing resource use, primary energy:
    - Use of renewable primary energy excluding renewable primary energy resources used as raw materials (MJ, net calorific value);
    - Use of renewable primary energy resources used as raw materials (MJ, net calorific value);
    - Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value);
    - Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials (MJ, net calorific value);
    - Use of non-renewable primary energy resources used as raw materials (MJ, net calorific value); and
    - Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value).
- Parameters describing resource use, secondary materials and fuels and use of water:
    - Use of secondary material (kg);
    - Use of renewable secondary fuels (MJ, net calorific value);
    - Use of non-renewable secondary fuels (MJ, net calorific value); and
    - Net use of fresh water (m^3).
- Parameters describing waste categories:
    - Hazardous waste disposed (kg);
    - Non-hazardous waste disposed (kg); and
    - Radioactive waste disposed (kg).
- Parameters describing outputs flows at the end of life:
    - Components for re-use (kg);
    - Materials for recycling (kg);
    - Materials for energy recovery (kg); and
    - Exported energy (MJ, net calorific value).

Average LCIA results for the product system were generated using individual per declared unit LCIA results from each BRC site and weighting them based on the mass of production output from each site.

1.10 General allocation procedures

For cases where there is more than one product in the system being studied, ISO 14040/44 prescribes the following procedure for the allocation of material and energy flows and environmental emissions:

- In the first instance, allocation should be avoided, by process sub-division.
- Expanding the product system to include the additional functions related to the co-products.
- Where these methods are not applicable, the ISO 14040/44 requires that allocation reflects the physical relationships of the different products or functions. Allocation based on physical relationships such as mass or energy is a practical interpretation of this and an approach often used in LCA.

- For some processes, allocation based on mass is not considered appropriate and, in these cases economic allocation is used.

In this study, allocation procedures for multi-product processes followed the ISO approach above. Site level allocation of primary data at the A3 manufacturing stage was not necessary as the product under investigation is the only product manufactured at each BRC site. In the case of secondary data, in most cases an extended version of the ecoinvent v3.4 database (EuGeos'15804-IA v3.0) was applied in this study. Where allocation of flows between multi-product processes was carried out in the EuGeos EN 15804-IA version of ecoinvent, an economic approach was used in most cases, with some mass-based allocation, where there was a direct physical relationship. The allocation approach of specific ecoinvent modules is documented on their website and method reports (see www.ecoinvent.org). See Appendix A for specific ecoinvent data used in this study.

1.11 End-of-life allocation procedures

In this study a cut-off method was applied to all cases of end-of-life allocation, including in the case of secondary data, where the EuGeos EN 15804-IA version of ecoinvent v3.4 with a cut-off by classification end of life allocation method was used. This was also used for the consumption of recycled materials at the start of life and for the sending of materials to recycling or material reuse at the end-of-life. In this approach the environmental burdens and benefits of recycled / reused materials are given to the product system consuming them, rather than the system providing them. This is known as the cut-off, recycled content or 100:0 approach. This is a common approach in LCA, follows the ISO standards on LCA and prescribed in EN 15804.

1.12 Demonstration of verification

CEN standard EN 15804 serves as the core product category rules
Independent verification of the declaration and data, according to EN ISO 14025:2010 ○ internal ○ **external**
Third party verifier: Jane Anderson, ConstructionLCA

1.13 Assumptions

During this LCA a number of assumptions were made, the most important of which are described below for transparency:

- Transportation of raw materials to BRC sites was based on the most logical route and transportation method from the supplier locations to site. A small proportion of steel was known to be transported by rail to some BRC sites, but detailed information on this was not available. Therefore, for simplicity all transport of steel from the supplier to BRC sites was modelled as being transported by road on the assumption that any difference in impact would be immaterial.
- Transportation of waste from BRC sites to materials recovery facilities was assumed to be a distance of 50 km by road.
- Average of refrigerant losses from other Eco-Reinforcement sites was used to estimate refrigerant losses from BRC sites.

2 Life cycle impact assessment (LCIA)

This section presents all LCIA results from this study for both product systems:

- **Cut and bent steel rebar product**; and
- **Cut and bent steel mesh product**.

Table 3 shows the cradle-to-gate LCIA results of 1 tonnes of BRC Ltd cut and bent steel rebar product. Results are broken down by life cycle information modules A1 raw materials, A2 transportation and A3 manufacturing and represented as a total of A1-3.

Table 3 – Cradle- to-gate LCIA results for 1 tonne of BRC Ltd cut and bent steel rebar product. For modules A4-5, B1-7, C1-4 and D, for all impact categories the notation Module Not Declared (MND) applies.

Impact category	Raw materials supply (A1)	Transport (A2)	Manufacturing (A3)	Total (A1-3)	A4-5, B1-7, C1-4 and D
Global warming potential, GWP (kg CO_2 eq)	659.7	16.9	7.3	684.0	MND
Depletion potential of the stratospheric ozone layer, ODP (kg CFC 11 eq)	4.6E-05	3.5E-06	6.8E-07	5.1E-05	MND
Acidification potential of soil and water, AP (kg SO_2 eq)	3.17	0.04	0.03	3.25	MND
Eutrophication potential, EP (kg $(PO_4)^{3-}$ eq)	0.80	0.01	0.00	0.81	MND
Formation potential of tropospheric ozone, POCP (kg C_2H_4 eq)	0.29	0.00	0.00	0.29	MND
Abiotic depletion potential for non-fossil resources, ADP-elements (kg Sb eq)	9.4E-04	1.1E-04	3.0E-05	1.1E-03	MND
Abiotic depletion potential for fossil resources, ADP-fossil fuels (MJ, net calorific value)	8,708	277	108	9,093	MND
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (MJ, net calorific value)	681.1	5.0	46.6	732.7	MND
Use of renewable primary energy resources used as raw materials (MJ, net calorific value)	1.1E-03	0.0E+00	3.3E-02	3.4E-02	MND
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)	681.1	5.0	46.6	732.8	MND
Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials (MJ, net calorific value)	10,808	286	123	11,217	MND
Use of non renewable primary energy resources used as raw materials (MJ, net calorific value)	0	0	4.8	4.8	MND
Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)	10,808	286	128	11,222	MND
Use of secondary material (kg)	1,173	0	0	1,173	MND
Use of renewable secondary fuels (MJ, net calorific value)	0	- 0.45	- 0.06	- 0.51	MND
Use of non renewable secondary fuels (MJ, net calorific value)	0	0	0	0	MND
Net use of fresh water (m^3)	17.74	0.06	0.03	17.84	MND

Impact category	Raw materials supply (A1)	Transport (A2)	Manufacturing (A3)	Total (A1-3)	A4-5, B1-7, C1-4 and D
Hazardous waste disposed (kg)	16.62	0.01	0.14	16.77	MND
Non hazardous waste disposed (kg)	44.7	24.8	0.9	70.3	MND
Radioactive waste disposed (kg)	5.6E-04	2.0E-03	5.7E-04	3.2E-03	MND
Components for re-use (kg)	169	0	0	169	MND
Materials for recycling (kg)	38.1	0.0	19.8	57.9	MND
Materials for energy recovery (kg)	0.0E+00	5.6E-12	8.2E-13	6.4E-12	MND
Exported energy (MJ, net calorific value)	0	0	0	0	MND

Table 4 shows the cradle-to-gate LCIA results of 1 tonnes of BRC Ltd cut and bent steel mesh product. Results are broken down by life cycle information modules A1, A2 and A3 and represented as a total of A1-3.

Table 4 – Cradle- to-gate LCIA results for 1 tonne of BRC Ltd cut and bent steel mesh product. For modules A4-5, B1-7, C1-4 and D, for all impact categories the notation Module Not Declared (MND) applies.

Impact category	Raw materials supply (A1)	Transport (A2)	Manufacturing (A3)	Total (A1-3)	A4-5, B1-7, C1-4 and D
Global warming potential, GWP (kg CO_2 eq)	653.0	16.7	24.5	694.2	MND
Depletion potential of the stratospheric ozone layer, ODP (kg CFC 11 eq)	4.6E-05	3.4E-06	2.3E-06	5.2E-05	MND
Acidification potential of soil and water, AP (kg SO_2 eq)	3.14	0.04	0.12	3.30	MND
Eutrophication potential, EP (kg $(PO_4)^{3-}$ eq)	0.80	0.01	0.01	0.81	MND
Formation potential of tropospheric ozone, POCP (kg C_2H_4 eq)	0.28	0.00	0.01	0.29	MND
Abiotic depletion potential for non-fossil resources, ADP-elements (kg Sb eq)	9.3E-04	1.1E-04	1.1E-04	1.2E-03	MND
Abiotic depletion potential for fossil resources, ADP-fossil fuels (MJ, net calorific value)	8,619	275	381	9,275	MND
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (MJ, net calorific value)	674.2	5.0	179.8	859.0	MND
Use of renewable primary energy resources used as raw materials (MJ, net calorific value)	1.1E-03	0.0E+00	9.9E-02	1.0E-01	MND
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)	674.2	5.0	179.9	859.1	MND
Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials (MJ, net calorific value)	10,698	283	444	11,425	MND
Use of non renewable primary energy resources used as raw materials (MJ, net calorific value)	0	0	14.4	14.4	MND
Total use of non renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value)	10,698	283	458	11,440	MND
Use of secondary material (kg)	1,161	0	0	1,161	MND
Use of renewable secondary fuels (MJ, net calorific value)	0	- 0.45	- 0.20	- 0.65	MND
Use of non renewable secondary fuels (MJ, net calorific value)	0	0	0	0	MND

Impact category	Raw materials supply (A1)	Transport (A2)	Manufacturing (A3)	Total (A1-3)	A4-5, B1-7, C1-4 and D
Net use of fresh water (m^3)	17.56	0.06	0.11	17.73	MND
Hazardous waste disposed (kg)	16.45	0.01	0.05	16.51	MND
Non hazardous waste disposed (kg)	44.2	24.5	1.6	70.3	MND
Radioactive waste disposed (kg)	5.6E-04	2.0E-03	2.1E-03	4.7E-03	MND
Components for re-use (kg)	168	0	0	168	MND
Materials for recycling (kg)	37.7	0.0	9.5	47.2	MND
Materials for energy recovery (kg)	0.0E+00	5.5E-12	2.9E-12	8.4E-12	MND
Exported energy (MJ, net calorific value)	0	0	0	0	MND

3 Interpretation

Figure 4 shows the cradle-to-gate LCIA hotspots for BRC Ltd cut and bent steel rebar product. Results are broken down by life cycle information modules A1 raw materials, A2 transportation and A3 manufacturing and represented as a total of A1-3.

For all impact categories the major hotspot is the production of raw materials (A1) and within this hotspot the production of steel billets is the major contributor, with impacts from fuel use and emissions to air from rolling and cutting processes also contributing. In the manufacture of steel billets, electricity use is the major hotspot for all impact categories, although lime production is notable for global warming and photochemical ozone creation impact categories. Transportation (A2) is notable for depletion of abiotic resources and ozone depletion, due to exhaust emissions, but immaterial for other impact categories. Manufacturing cut and bent steel rebar product (A3) is immaterial for all impact categories.

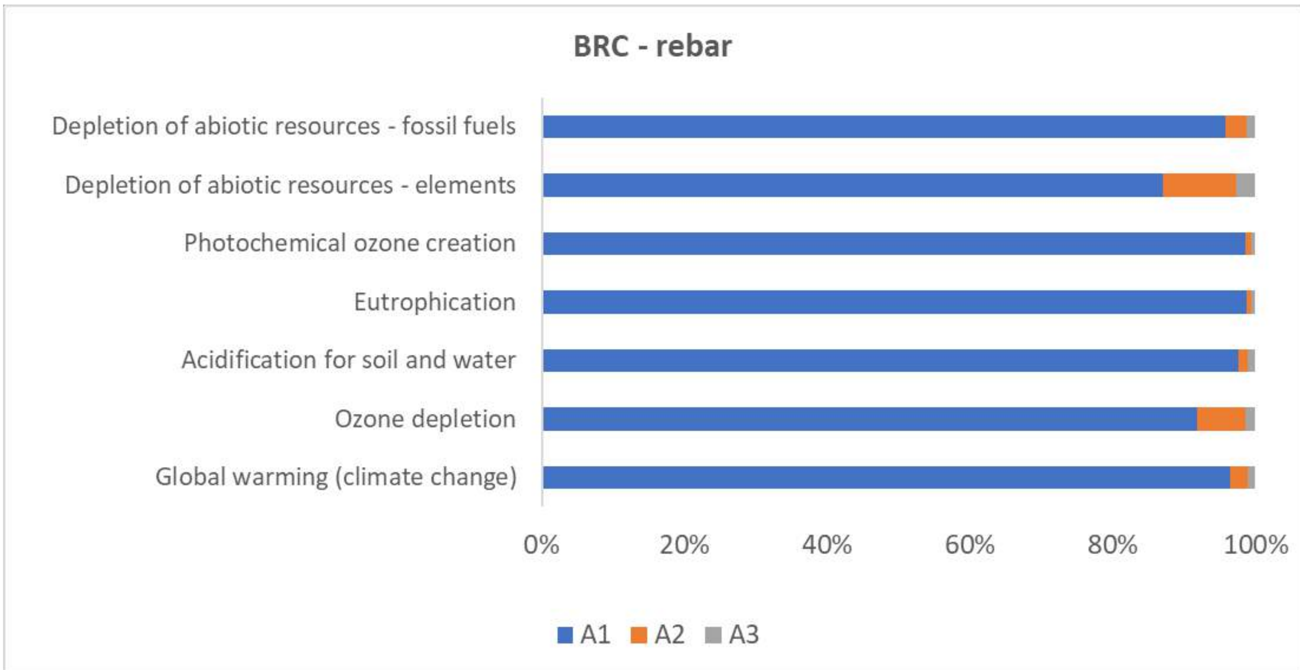

Figure 4 – Cradle- to-gate LCIA hotspots for BRC Ltd cut and bent steel rebar product

Figure 5 shows the cradle-to-gate LCIA hotspots for BRC Ltd cut and bent steel mesh product. Results are broken down by life cycle information modules A1, A2 and A3 and represented as a total of A1-3.

For all impact categories the major hotspot is the production of raw materials (A1) and within this hotspot the production of steel billets is the major contributor, with impacts from fuel use and emissions to air from rolling and cutting processes also contributing. Transportation (A2) is notable for depletion of abiotic resources and ozone depletion, due to exhaust emissions, but immaterial for other impact categories. Manufacturing cut and bent steel mesh product (A3) is immaterial for all impact categories except depletion of abiotic resources, where it is notable.

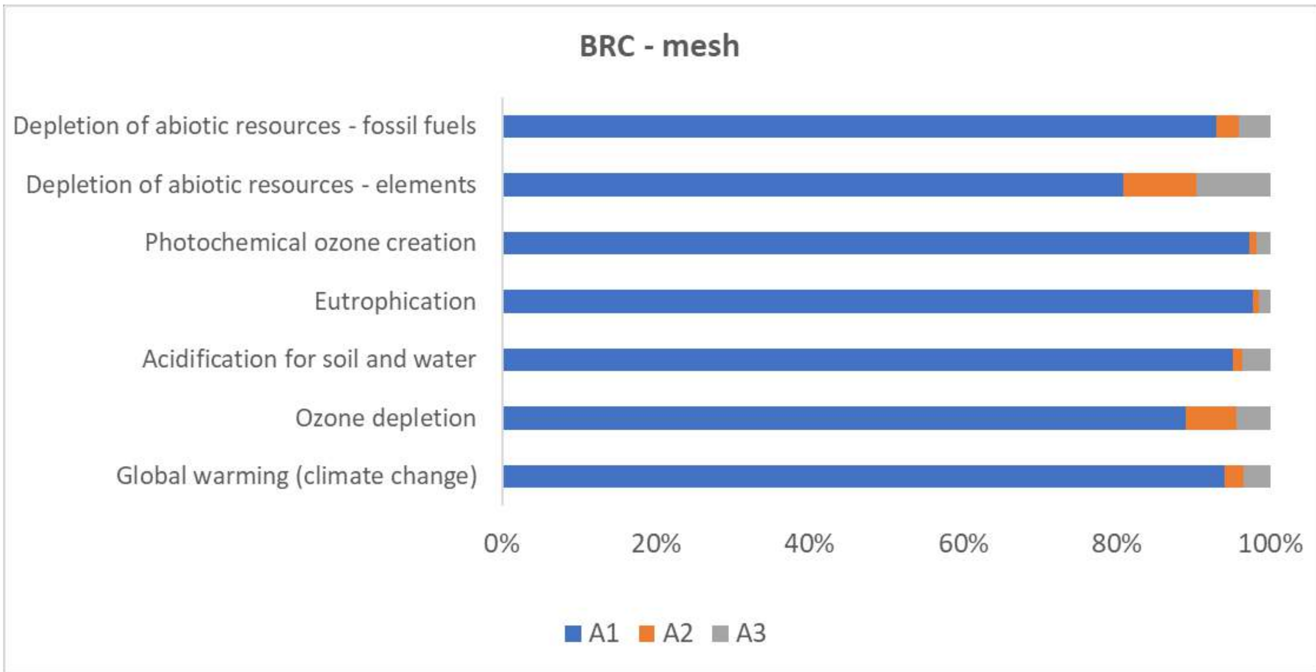

Figure 5 – Cradle- to-gate LCIA hotspots for BRC Ltd cut and bent steel mesh product

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These pages (Appendix A - Raw Data Sources) have been intentionally removed for data sensitivity purposes.

6 Appendix B – data quality assessment

Table 7 – Data Quality Indicator Matrix (replication of Table 2 for convenience)

Aspect	1	2	3	4	5
Reliability of the source	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate
Representative	Representative data from sufficient sample of sites over an adequate period to even out normal fluctuations	Representative data from a smaller number of sites but for adequate periods	Representative data from an adequate number of sites but from shorter periods	Representative data but from a smaller number of sites and shorter periods or incomplete data from an adequate number of sites and periods	Representativeness unknown or incomplete data from a smaller number of sites and/or from shorter periods
Temporal correlation	Less than three years of difference to year of study	Less than six years of difference	Less than 10 years of difference	Less than 15 years of difference	Age of data unknown or more than 15 years of difference
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown area or area with very different production conditions
Technological correlation	Data from enterprises, processes and materials under study	Data from processes and materials under study but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials but same technology	Data on related processes or materials but different technology
Reliability of the source	Verified data based on measurements	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate

Table 8 – Data Quality Indicator scores

Data	Reliability	Representative	Temporal correlation	Geographical correlation	Technological correlation
Annual mass of steel rod/bar from all suppliers used to produce cut and bent rebar	2	1	1	1	1
Annual mass of steel rod/bar from all suppliers used to produce cut and bent mesh	2	1	1	1	1
Production of steel billets and rod/bar reinforcing steel by Celsa	2	1	1	1	1
Annual mass of cut and bent steel rebar produced	2	1	1	1	1
Annual mass of cut and bent steel mesh produced	2	1	1	1	1
Annual grid electricity	2	1	1	1	1
Annual natural gas usage	2	1	1	1	1
Annual diesel usage	2	1	1	1	1
Annual fugitive emissions of refrigerants	4	5	1	1	1
Annual mass of general waste	2	1	1	1	1
Amount mass of scrap steel sent offsite	2	1	1	1	1
Annual mass of other waste sent for recycling	2	1	1	1	1
Annual mass of hazardous waste	2	1	1	1	1
Annual volumes of water use and treatment	2	1	1	1	1
Secondary data for transportation by road	2	2	1	2	2
Secondary data for imported grid electricity	2	2	1	1	2
Secondary data for natural gas	2	2	1	2	2
Secondary data for diesel use	2	2	1	2	2
Secondary data for refrigerant production and fugitive refrigerant emissions	2	2	1	2	3
Secondary data for water supply	2	2	1	2	2

Data	Reliability	Representative	Temporal correlation	Geographical correlation	Technological correlation
Secondary data for treatment of general waste	2	2	1	3	2
Secondary data for treatment of hazardous waste	2	2	1	2	2
Secondary data for treatment of waste water	2	2	1	2	2
Secondary data for waste transportation	2	2	1	3	2

ENVIRONMENTAL PRODUCT DECLARATION

as per /ISO 14025/ and /EN 15804/

Owner of the Declaration	British Ready-Mixed Concrete Association
Programme holder	Institut Bauen und Umwelt e.V. (IBU)
Publisher	Institut Bauen und Umwelt e.V. (IBU)
Declaration number	EPD-RMC-20180095-CBG1-EN
Issue date	24/08/2018
Valid to	23/08/2023

UK manufactured generic ready-mixed concrete

Produced by members of the British Ready-Mixed Concrete Association (BRMCA) part of the Mineral Products Association (MPA)

Institut Bauen und Umwelt e.V.

www.ibu-epd.com / https://epd-online.com

mpa essential materials sustainable solutions

brmca

General Information

British Ready-mixed Concrete Association	Generic Ready-Mixed Concrete
Programme holder IBU - Institut Bauen und Umwelt e.V. Panoramastr. 1 10178 Berlin Germany	**Owner of the Declaration** BRMCA Gillingham House, 38-44 Gillingham Street, London, SW1V 1HU
Declaration number EPD-RMC-20180095-CBG1-EN	**Declared product / Declared unit** 1m³ of generic ready-mixed concrete.
This Declaration is based on the Product Category Rules: Concrete components made of in-situ or ready-mixed concrete, 07.2014 (PCR tested and approved by the SVR) **Issue date** 24/08/2018 **Valid to** 23/08/2023	**Scope:** This is an association declaration which uses manufacturing data covering 93% of production from member companies of the British Ready-Mixed Concrete Association and a defined mix design to form an average 1m³ of generic ready-mixed concrete. It is based on data covering a period of 12 months (From January to December 2015). All data was collected from UK factories. The owner of the declaration shall be liable for the underlying information and evidence; the IBU shall not be liable with respect to manufacturer information, life cycle assessment data and evidences.
Prof. Dr.-Ing. Horst J. Bossenmayer (President of Institut Bauen und Umwelt e.V.)	**Verification** The CEN Norm /EN 15804/ serves as the core PCR Independent verification of the declaration according to /ISO 14025/ ☐ internally ☒ externally
Dipl. Ing. Hans Peters (Managing Director IBU)	Mr Carl-Otto Neven (Independent verifier appointed by SVR)

Product

Product description / Product definition
The product is a generic 1 m³ of ready-mixed concrete, where the constituent proportions are 310 kg of cementitious material, 1915 kg of natural aggregate, 137 litres of mains water, 2 litres of recycled water and 1.6 litres of a chemical admixture. The fresh wet density is a representative 2380 kg/m³. With many sources of cementitious materials and natural aggregates this generic concrete can be assumed to be at a consistence class not less than S3 and strength class not less than C30/37. Due to the wide variation of cements and natural aggregates available throughout the UK confirmation of consistence and strength class for any concrete should be confirmed by the producer before supply.

Ready-mixed concrete is made by mixing coarse and fine aggregates, cement and water in controlled proportions. Chemical admixtures are used to reduce water content and improve fresh and hardened concrete properties. Delivered to site on a just-in-time basis, ready-mixed concrete may be cast into any conceivable shape with almost no limit on volume. When hardened, concrete can carry substantial compressive loads by itself, but is more frequently reinforced to substantially increase its tensile and flexural strength.

Concrete to /EN 206/ and /BS 8500/ is not covered by the EU Construction Products Regulation. For the use and application of the concrete in the UK refer to /BS 8500/ *Concrete – Complementary British Standard to /BS EN 206/*

Application
Nearly all foundations, floors and the majority of building structures are made of concrete. Concrete is also often key to the architecture of our buildings, contributing greatly to their energy efficiency and visual appeal.

Technical Data
Concrete is specified and supplied in accordance with /BS 8500-2/ and /BS EN 206/.

Constructional data

Name	Value	Unit
Thermal conductivity	1.6	W/(mK)
Gross density	2380	kg/m³
Characteristic compressive strength, cube/cylinder	30/37	MPa
Characteristic tensile strength	2.9	MPa
Modulus of elasticity	33	GPa

Concrete to /EN 206/ and /BS 8500/ is not covered by the EU Construction Products Regulation. Concrete is supplied in accordance with the project specification and the appropriate requirements of /EN 206/ and /BS 8500/. Third party product conformity certification is recommended but any requirement is at the discretion of the specifier. Concrete to /EN 206/ and /BS 8500/ is not subject to CE Marking.

Base materials / Ancillary materials
The concrete constituent proportions used to generate this EPD are:
CEM I - 200kg
GGBS - 95kg
Fly Ash - 15kg
Natural aggregate - 1915kg
Water – 139 litres
Chemical admixture - 1.55kg
These values represent a generic factory produced ready mixed concrete. The composition of products complying with the EPD will vary depending on client specification and application. More detailed information is available in the respective manufacturer's documentation (e.g. product data sheets).
No /REACH/ substances of very high concern are included.

Reference service life
For most common applications and with suitable design and execution the service life of concrete is normally assumed to be not less than fifty years but may be 100 years or more. Requirements for durability in the UK, for either not less than 50 or not less than 100 years, are set out in /BS 8500-1/ Annex A.

The reference service life is declared as 100 years.

Packaging

Ready-mixed concrete is supplied without packaging.

LCA: Calculation rules

Declared Unit
The product is a generic 1 m³ of ready-mixed concrete, comprising 310 kg of cementitious material, 1915 kg of natural aggregate, 137 litres of mains water, 2 litres of recycled water and 1.6 litres (1.55 kg) of chemical admixture. The fresh wet density is a representative 2380 kg/m³.

Declared unit

Name	Value	Unit
Density (mean value)	2380	kg/m³
Declared unit	1	m³
Declared unit	2.38	t

System boundary
Type of EPD: Cradle to Gate with all options declared. The modules considered in the Life Cycle Assessment are modules A1-C4 inclusive.

Environment and health during manufacturing
Members of the BRMCA have formal Environmental Management Systems to put in place environmental protection measures which extend beyond national guidelines.

Cut-off criteria
/EN 15804/ requires that where there are data gaps or insufficient input data for a unit process the cut-off criteria shall be 1% of renewable and non-renewable primary energy usage and 1% of the total mass of this unit process. The total neglected flows from a product stage must be no more than 5% of product inputs by mass or 5% of primary energy contribution.
In this assessment, all information gathered from data collection for the production of concrete has been modelled, i.e. all raw materials used, the electrical energy and other fuels used, use of ancillary materials and all direct production waste. Transport data on input and output flows are also considered. Scenarios have been developed to account for downstream processes such as fabrication, installation, demolition and waste treatment. No cut-offs have been made. Hence this study complies with the cut-off criteria defined in the /PCR/.

Background data
Background data is based primarily on a generic dataset /GaBi ts 2014 software database/ integrated into the IBU verified bespoke British Precast Envision EPD tool. The background data also includes UK specific cement data supplied by members of the Mineral Products Association (MPA). (Tool Verified 07/03/17).

Allocation
All allocation is performed according to the /PCR/. As no co-products are produced, the flow of materials and energy and also the associated release of substances and energy into the environment are related exclusively to the concrete produced.

Comparability
Basically, a comparison or an evaluation of EPD data is only possible if all the data sets to be compared were created according to /EN 15804/ and the building context, respectively the product-specific characteristics of performance, are taken into account.
.

LCA: Scenarios and additional technical information

The following information supports the declaration of modules A1-B1 and C1-C4 inclusive.

Transport to the building site (A4)

Name	Value	Unit
Transport distance	12	km
Capacity utilisation (including empty runs)	50	%

Installation into the building (A5)

Name	Value	Unit
Material loss	3	%

This EPD contains an allowance of 3% to represent the average difference between ready mixed concrete delivered and that accounted for in the permanent works. This difference may be due to the reliability of measurement, the use of surplus concrete as extra blinding or fill, or comprise inert material recovered from chute washing and invariably incorporated somewhere into the works. This material is not waste but it may be colloquially identified as wastage by the contractor.

Use or application of the installed product (B1)
In practice, given the nature of the product and its application in the structure of the building, no impacts are associated with the use stage of concrete over the lifetime of the building. However, carbonation of concrete will occur during the lifetime of the building and is included in module B1. Carbonation is calculated using the approach recommended by the Mineral Products Association and BPCF and follows the methodology developed by Pommer et al. /Pommer 2005/, with reference to the work of Engelsen and Justnes /Engelsen 2014/, who have made further refinements related to the amount of CaO that can carbonate and the carbonation of slag.

For concrete carbonation factors based on MPA research and expert judgement have been used. The depth of carbonation on each surface has been modelled as 1.59mm based on average conditions for a concrete element. The surface area is assumed to be 2 m^2.
The study period is assumed to be 100 years (the RSL).

Modules B2 - B7 (Maintenance, Repair, Replacement, Refurbishment, Operational Energy Use, Operational Water Use)

It is assumed that the concrete covered by this EPD does not require maintenance, repair, replacement or refurbishment during its lifetime. Consequently, the impacts associated with these lifecycle stages are zero. There is no operational energy or operational water requirement associated with the product, however, it is acknowledged that any building material choice will have an impact on the operational energy and, in some cases, the operational water demand of the final building.

In case a **reference service life** according to applicable ISO standards is declared then the assumptions and in-use conditions underlying the determined RSL shall be declared. The same holds for a service life declared by the manufacturer.

Reference service life

Name	Value	Unit
Reference service life	100	a

End of life (C1-C4)

Name	Value	Unit
Recycling	90	%
Landfilling	10	%

LCA: Results

In Table 1 "Description of the system boundary", all declared modules are indicated with an "X"; Module D which is not declared is indicated with "MND". Indicator values are declared to three valid digits.

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	MND

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: 1m3 Generic Ready-mixed Concrete

Parameter	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
GWP	[kg CO_2-Eq.]	246.00	2.01	0.19	-19.90	0.00	0.00	0.00	0.00	0.00	0.00	-0.84	8.27	-18.90	1.98
ODP	[kg CFC11-Eq.]	1.69E-6	2.37E-13	2.00E-13	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	9.73E-13	6.01E-12	3.90E-12
AP	[kg SO_2-Eq.]	3.98E-1	8.39E-3	1.28E-3	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	3.45E-2	3.85E-2	2.27E-2
EP	[kg $(PO_4)^{3-}$-Eq.]	4.90E-2	2.02E-3	3.07E-4	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	8.29E-3	9.21E-3	3.09E-3
POCP	[kg ethene-Eq.]	1.18E-1	-3.20E-3	1.39E-4	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	-1.32E-2	4.16E-3	1.79E-3
ADPE	[kg Sb-Eq.]	4.54E-4	3.26E-8	3.36E-7	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.34E-7	1.01E-5	1.38E-6
ADPF	[MJ]	1.52E+3	2.76E+1	3.57E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.14E+2	1.07E+2	4.97E+1

Caption	GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources

RESULTS OF THE LCA - RESOURCE USE: 1m3 Generic Ready-mixed Concrete

Parameter	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
PERE	[MJ]	76.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PERM	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PERT	[MJ]	76.90	0.68	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78	8.49	6.00
PENRE	[MJ]	1.65E+3	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
PENRM	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PENRT	[MJ]	1.65E+3	2.77E+1	3.65E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.14E+2	1.10E+2	5.14E+1
SM	[kg]	30.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	[MJ]	41.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	[MJ]	258.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FW	[m^3]	3.85E-1	2.37E-4	9.81E-4	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	9.73E-4	2.94E-2	9.79E-3

Caption	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: 1m3 Generic Ready-mixed Concrete

Parameter	Unit	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
HWD	[kg]	6.98E-2	1.13E-7	1.29E-7	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	4.66E-7	3.86E-6	8.13E-7
NHWD	[kg]	8.62E+1	3.03E-4	1.68E-3	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.24E-3	5.05E-2	2.38E+2
RWD	[kg]	5.22E-2	3.03E-5	3.42E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.25E-4	1.02E-3	7.03E-4
CRU	[kg]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MFR	[kg]	0.00E+0	0.00E+0	7.14E+1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.08E+3	0.00E+0
MER	[kg]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EEE	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EET	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Caption	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EEE = Exported thermal energy

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