TATA STEEL

Structural hollow sections

Environmental Product Declaration

CONTENTS

Structural hollow sections
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-2022-016
Date of Issue: 8th June 2022
Valid until: 7th June 2027

Owner of the Declaration: Tata Steel Europe
Programme Operator: Tata Steel UK Limited, 18 Grosvenor Place, London, SW1X 7HS

The CEN standard EN 15804:2012+A2:2019 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: Chris Foster, Eugeos Ltd.

1 General information

Owner of EPD	Tata Steel UK
Product	Structural hollow sections
Manufacturer	Tata Steel Europe
Manufacturing sites	Corby, Hartlepool and Port Talbot (UK), and Maastricht, Zwijndrecht, and IJmuiden (Netherlands)
Product applications	Construction and infrastructure, lifting and excavating equipment, offshore structures, mechanical related applications such as wind bracing and machinery
Declared unit	1 tonne of steel product
Date of issue	8th June 2022
Valid until	7th June 2027

This Environmental Product Declaration (EPD) is for all structural hollow steel sections manufactured by Tata Steel in the UK and Netherlands. The environmental indicators are average values for hot finished and cold formed structural hollow sections from Corby, Hartlepool, Maastricht and Zwijndrecht, with feedstock supplied from Port Talbot and IJmuiden.

The information in this Environmental Product Declaration is based on production data from 2016 and 2017.

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

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2 Product information

2.1 Product Description

Hybox® cold formed and Celsius® hot finished structural hollow sections (sometimes referred to as 'tubes'), are manufactured in a range of circular, square, rectangular and elliptical shaped tubes. They are manufactured to standard grades in a range of sizes from 21.3 to 508mm, with wall thicknesses from 2 to 16mm. The full range of Tata Steel's structural hollow sections are included in this EPD.

Cold formed tubes are made from fully killed steel, which is critical to formability and weldability, and the dimensions and corner radii are controlled to tight tolerances. They are strong, light, cost-effective and aesthetically appealing structural steel hollow sections that provide reliable formability and toughness. They can be used in a wide range of structural and engineering applications, including those where specific properties and compliance with design codes are required, and are suitable for galvanising.

Hot finished structural hollow sections are manufactured from normalised fine grain steel and combine high yield strength with lower carbon content for improved weldability and fabrication. Their applications include large-scale construction and building projects where the product's strength and weldability is suitable for both internal and external structural use, including multi-storey columns, space frames, and lattice beams. The sections can also be used in the offshore industry for both primary and secondary applications, and for industrial and 'off-highway' vehicles, such as cranes, excavators, bulldozers and dumper trucks.

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
Corby	Structural hollow sections	Tata Steel	UK
Hartlepool	Structural hollow sections	Tata Steel	UK
IJmuiden	Hot rolled coil	Tata Steel	NL
Maastricht	Structural hollow sections	Tata Steel	NL
Zwijndrecht	Structural hollow sections	Tata Steel	NL

The process of hollow section manufacture at Tata Steel begins with sinter and/or pellet 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 primary feedstock of the hollow section manufacturing process. The hot rolled coils are transported by rail, from Port Talbot to either the Corby or Hartlepool tube manufacturing sites, and by inland waterway, from IJmuiden to either Maastricht or Zwijndrecht. An overview of the process from raw materials to hot rolled coil is shown in Figure 1.

The tube making process begins with the uncoiling, levelling and slitting (except Hartlepool) of the hot rolled coil, which is then passed through a series of shaped rolls that gradually form the flat strip into a circular section. The two strip edges, now adjacent to one another, are welded using a high frequency induction process. Both external and internal weld beads are trimmed in-line and a further set of rolls effect the final shaping and sizing of the tube. 100% non-destructive testing is performed in-line on the weld-seam to ensure integrity and the tubes are cut to length prior to hot finishing or despatch. An overview of the process from hot rolled coil to cold formed structural hollow section is shown in Figure 2.

The subsequent hot finishing process comprises a reheating operation, and with the section at a normalising temperature of approximately 900ºC, a further shaping and sizing operation imparts the product's final dimensions and properties. This process is shown in Figure 3 from the non-destructive testing stage onwards.

Process data for the manufacture of hot rolled coil at Port Talbot and IJmuiden were gathered as part of the latest data collection on behalf of worldsteel. For both Port Talbot and IJmuiden, and for the tube making sites, the data collection was not only organised by site, but also by each process within each site. In this way it was possible to attribute resource use and emissions to each process, and using processed tonnage data, also attribute resources and emissions to specific products.

Figure 1 Process overview from raw materials to hot rolled coil

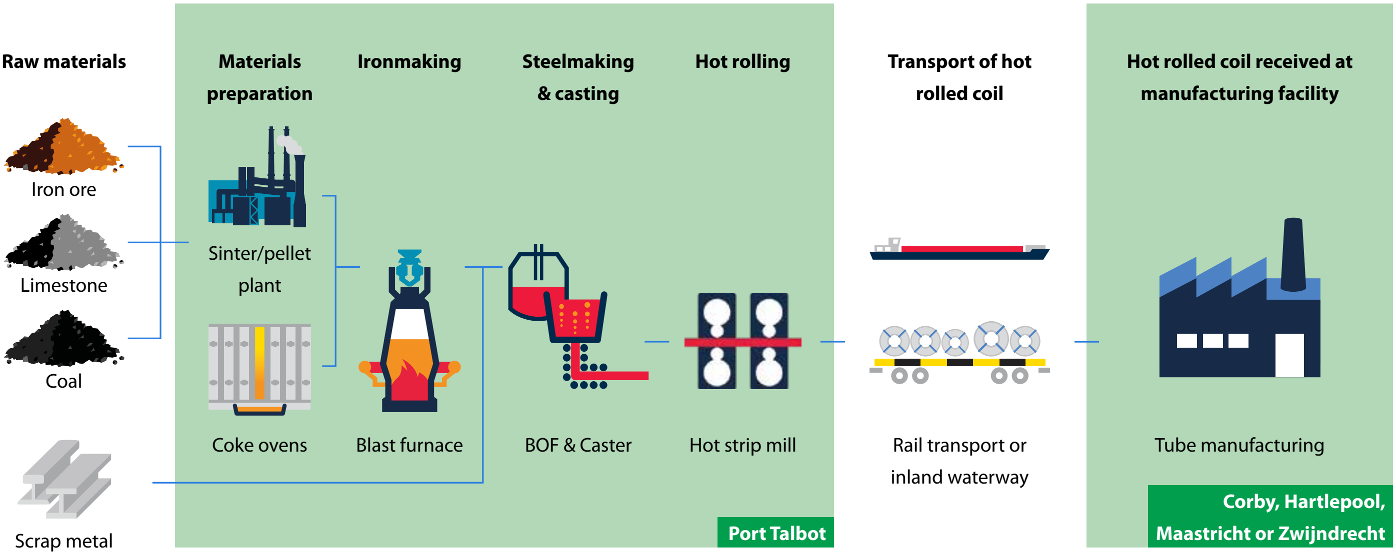


Figure 2 Process overview from hot rolled coil to cold formed structural hollow section

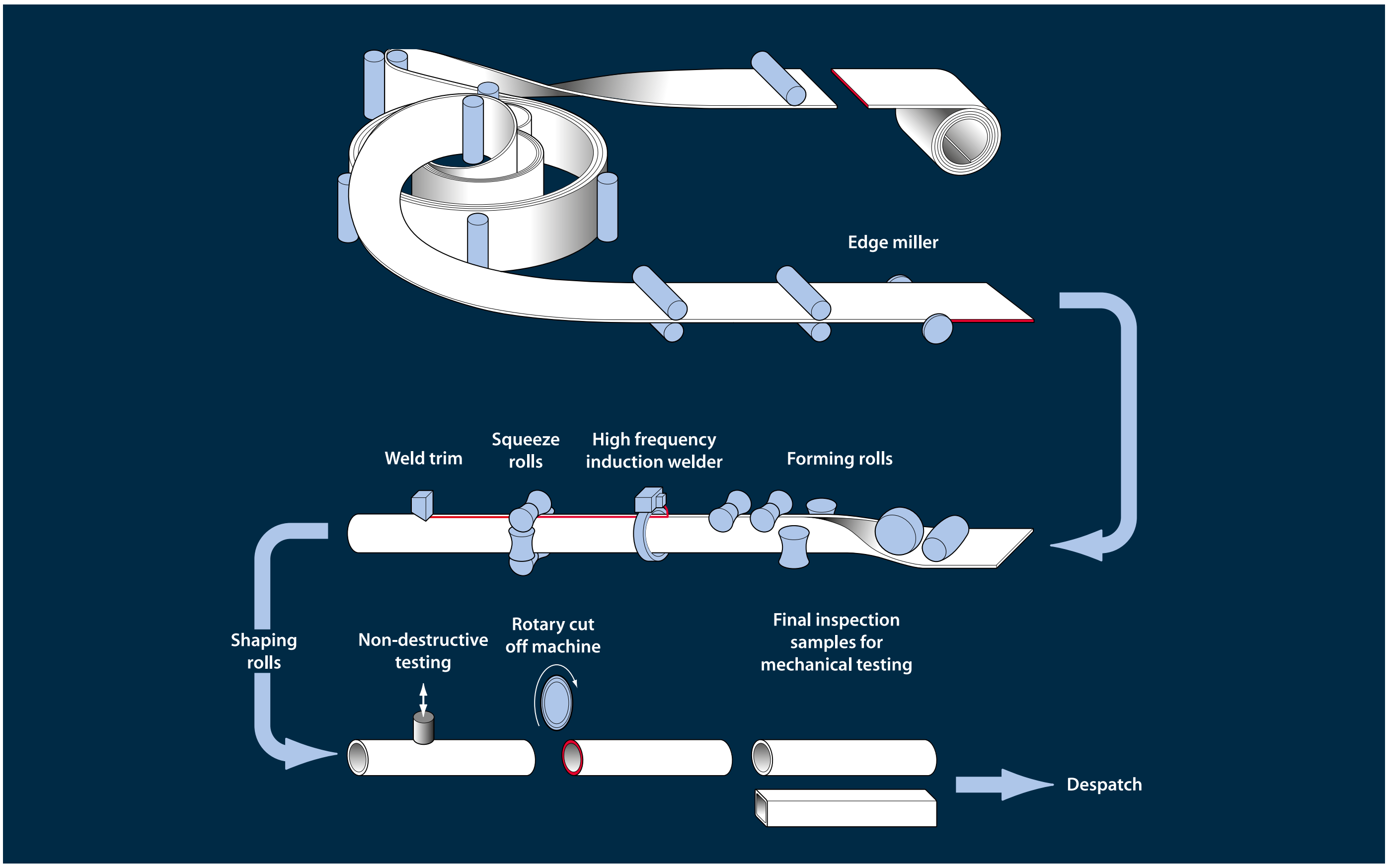
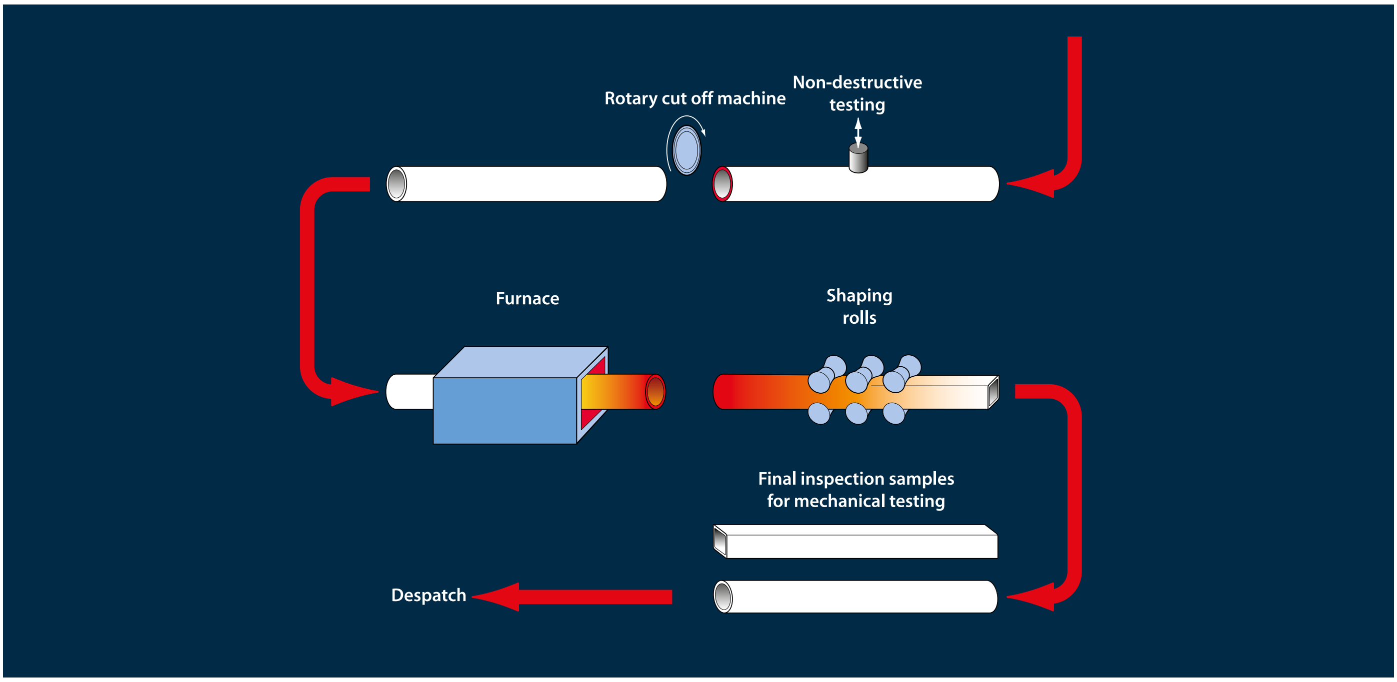


Figure 3 Hot finishing of cold formed structural hollow sections



2.3 Technical data and specifications

The general properties of structural hollow sections are shown in Table 2, and the technical specifications of both cold formed and hot finished structural hollow sections are presented in Table 3. The relevant European standard for cold formed structural hollow sections is EN 10219 [8,9,10]. The relevant European standard for hot finished structural hollow sections is EN 10210 [11,12,13], and there are additional standards for weldable structural steels for specific applications [14,15].

Table 2 General properties of structural hollow sections

	Structural hollow sections
Density (kg/m³)	7850
Modulus of Elasticity (N/mm²)	210000
Coefficient of thermal expansion (10-6 /K)	12
Thermal Conductivity (W/mK)	48
Melting Point (°C)	1520
Electrical Conductivity at 20°C (/Ωm)	3.9

Table 3 Technical specification of structural hollow sections

	Cold formed structural hollow sections
Specification	EN 10219 S355 J2H
Yield Strength (N/mm²)	355 minimum
Tensile Strength (N/mm²)	470 - 630
Elongation	20%
Impact Strength (Joules)	27 at -20°C
Carbon equivalent (max)	0.45
Certification	Product certification 3.1 [16] Applicable to Tata Steel's Corby, Hartlepool, Maastricht and Zwijndrecht sites; ISO 9001 [17], ISO 14001 [18], BES 6001 [19]

	Hot finished structural hollow sections
Specification	EN 10210 S355 NH
Yield Strength (N/mm²)	355 minimum
Tensile Strength (N/mm²)	470 - 630
Elongation	22%
Impact Strength (Joules)	40 at -20°C
Carbon equivalent (max)	0.43
Certification	Product certification 3.1 [16] Applicable to Tata Steel's Corby and Hartlepool sites; ISO 9001 [17], ISO 14001 [18], BES 6001 [19]

2.4 Packaging

Structural hollow sections are not normally painted or galvanised at the tube manufacturing sites as this is usually carried out after fabrication, and prior to this, the sections would be pickled or blast cleaned. Therefore the normal despatch from the tube mills merely consists of sheeting the load or enclosing in covered trailers. The tubes are secured for transport using steel banding and clips, timbers and anti-slip mats. The mass of this packaging is 0.9kg/tonne for steel banding and clips, 2.7kg/tonne for timber, and 0.2kg/tonne for anti-slip mats. A small amount of polyethylene film and card/paper packaging (approximately 0.006kg/tonne in total) is used at the Netherlands sites.

2.5 Reference service life

A reference service life for structural hollow sections is not declared because they can be used in a variety of different forms of construction, and the final construction application is not defined. To determine the full service life of structural hollow sections, all factors would need to be included such as location and environment, corrosion protection, and fire protection. Corrosion and fire protection are usually applied during installation on site. Under 'normal' conditions, structural hollow sections would not need to be replaced over the life of the building or structure.

Structural hollow steel sections can be recovered and re-used or recycled repeatedly without loss of quality as a building material and they comply with the requirements of construction product class A1 (non-combustible). Tata Steel's structural hollow sections are supplied with full certification, declaration of performance (DoP) & factory production control (FPC) ensuring full traceability during and after the original service life.

2.6 Biogenic Carbon content

There are no biogenic carbon containing materials in the product. The biogenic carbon content of the packaging materials is shown in Table 4.

Table 4 Biogenic carbon content at the factory gate

	Hybox® structural hollow sections
Biogenic carbon content (product) (kg C)	0
Biogenic carbon content (packaging) (kg C)	1.35

Note: 1kg biogenic carbon is equivalent to 44/12 kg of CO_2

3 Life Cycle Assessment (LCA) methodology

3.1 Declared unit
The unit being declared is 1 tonne of steel structural hollow section.

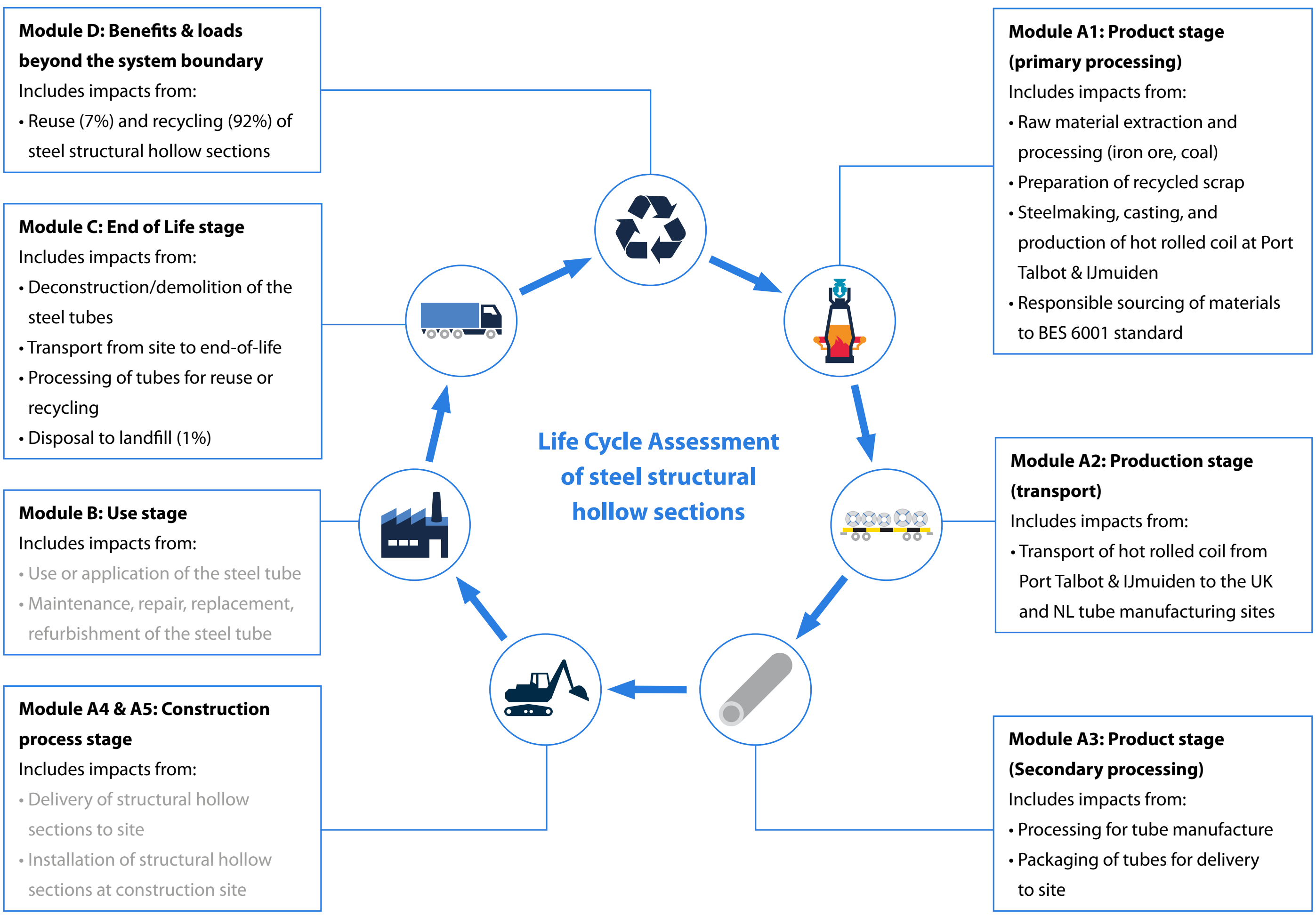
3.2 Scope
This EPD can be regarded as Cradle-to-Gate with modules C and D and the specific modules considered in the LCA are;

A1-A3: Production stage (raw material supply, transport to production site, manufacturing)
C1-C4: End-of-life (demolition/deconstruction, transport, processing for recycling and disposal)
D: Reuse, recycling and recovery

The life cycle stages are explained in more detail in Figure 4, but where the text is in light grey, the impacts from this part of the life cycle are not considered.

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 steel structural hollow sections have been omitted. On this basis, there is no evidence to suggest that inputs 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 4 Life Cycle Assessment of structural hollow sections



3.4 Background data

For life cycle modelling of steel structural hollow sections, the GaBi Software System for Life Cycle Engineering is used [20]. The GaBi database contains consistent and documented datasets which can be viewed in the online GaBi documentation [21].

Specific data derived from Tata Steel's own production processes at Port Talbot, IJmuiden and the tube manufacturing sites, 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 2016 and 2017, 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 datasets took place less than 10 years ago. An assessment of the quality of data used in this study, has been made using the scheme provided in the UN Environment Global Guidance on LCA database development, referenced in EN 15804. The study is considered to be based on good 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 [22].
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 IJmuiden, 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 [23]. 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 5. The end-of-life percentages are taken from a Tata Steel/ EUROFER recycling and re-use survey of UK demolition contractors carried out in 2012 [24].

For all indicators the characterisation factors from the EC-JRC are applied, identified by the name EN_15804, and based upon the EF Reference Package 3.0 [25]. In GaBi, the corresponding impact assessment is used, denoted by 'EN 15804+A2'.

The values presented in the LCA results tables of section 4 are tonnage weighted average values for steel structural hollow sections across the four manufacturing sites at Corby, Hartlepool, Maastricht and Zwijndrecht.

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/infrastructure assessment, in order to capture any differences in other aspects of the building or infrastructure 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 or infrastructure, or, a higher strength product may require less material for the same function.

Table 5 Main scenario assumptions

Module	Scenario assumptions
A1 to A3 – Product stage	Manufacturing data from Tata Steel's sites at Port Talbot, Corby and Hartlepool (UK) and IJmuiden, Maastricht and Zwijndrecht (Netherlands) are used
A2 – Transport to the tube manufacturing site	In the UK, the hot rolled coils are transported from Port Talbot to Corby a distance of 476km and from Port Talbot to Hartlepool a distance of 721km, on a 726t load capacity diesel/electric train. A load capacity utilisation of 0.45 is assumed to allow for empty returns and the proportion of the journeys powered by diesel and by electricity, are approximately 50% for each. In the Netherlands, the hot rolled coils are transported from IJmuiden to Maastricht a distance of 274km, and from IJmuiden to Zwijndrecht a distance of 168km, on a 1500t load capacity barge. A load capacity utilisation of 0.45 is assumed to allow for empty returns
C1 – Deconstruction and demolition	Energy consumption estimated based upon published data for the dismantling of steel constructions in Germany [26]
C2 – Transport for recycling, reuse, and disposal	In the UK, a distance of 250km is assumed from the installation site to both recycling and reuse, on a 25t load capacity truck. In the Netherlands, this distance is assumed to be 150km. For both the UK and Netherlands, a distance of 100km is assumed from the installation site to landfill. A load capacity utilisation of 0.45 is assumed to allow for empty returns.
C3 – Waste processing for reuse, recovery and/ or recycling	This considers the energy associated with cutting the tubes for recycling and is based upon the same data as C1
C4 - Disposal	At end of life, 1% of product is disposed to landfill
D – Reuse, recycling, and energy recovery	At end of life, 92% of product is recycled and 7% is re-used

Please note that in the GaBi software, an empty return journey is accounted for by halving the load capacity utilisation of the outbound journey.

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	ND	ND	ND	ND	ND	ND	ND	ND	ND	X	X	X	X	X

X = Included in LCA; ND = module not declared

Environmental impact:

1 tonne of structural hollow section

Parameter	Unit	A1 – A3	C1	C2	C3	C4	D
GWP-total	kg CO_2 eq	2.59E+03	4.53E+00	1.79E+01	1.02E+00	1.45E-01	-1.61E+03
GWP-fossil	kg CO_2 eq	2.59E+03	5.62E+00	1.81E+01	1.02E+00	1.49E-01	-1.61E+03
GWP-biogenic	kg CO_2 eq	2.23E+00	-1.24E+00	-1.67E-01	4.75E-03	-4.42E-03	-9.84E-01
GWP-luluc	kg CO_2 eq	5.21E-01	1.57E-01	2.58E-04	5.92E-05	2.75E-04	-6.22E-02
ODP	kg CFC11 eq	7.30E-10	1.24E-11	2.27E-12	5.05E-12	3.51E-13	-5.36E-11
AP	mol H^+ eq	7.33E+00	2.01E-02	5.96E-02	1.43E-03	1.06E-03	-3.02E+00
EP-freshwater	kg PO_4 eq	6.57E-04	8.52E-05	3.71E-06	1.05E-06	2.53E-07	-3.56E-04
EP-marine	kg N eq	1.67E+00	4.85E-03	2.83E-02	4.39E-04	2.71E-04	-5.99E-01
EP-terrestrial	mol N eq	1.76E+01	6.08E-02	3.11E-01	4.77E-03	2.97E-03	-6.09E+00
POCP	kg NMVOC eq	5.92E+00	1.62E-02	5.56E-02	1.38E-03	8.22E-04	-2.58E+00
ADP-minerals&metals	kg Sb eq	2.51E-04	2.55E-06	1.07E-06	1.05E-07	1.53E-08	-3.65E-03
ADP-fossil	MJ net calorific value	2.65E+04	3.37E+02	2.37E+02	1.51E+01	1.95E+00	-1.59E+04
WDP	m^3 world eq deprived	5.69E+02	3.19E-01	2.30E-02	4.33E-02	1.64E-02	-4.02E+03
PM	Disease incidence	ND	ND	ND	ND	ND	ND
IRP	kBq U235 eq	ND	ND	ND	ND	ND	ND
ETP-fw	CTUe	ND	ND	ND	ND	ND	ND
HTP-c	CTUh	ND	ND	ND	ND	ND	ND
HTP-nc	CTUh	ND	ND	ND	ND	ND	ND
SQP		ND	ND	ND	ND	ND	ND

GWP-total = Global Warming Potential total
GWP-fossil = Global Warming Potential fossil fuels
GWP-biogenic = Global Warming Potential biogenic
GWP-luluc = Global Warming Potential land use and land use change
ODP = Depletion potential of stratospheric ozone layer
AP = Acidification potential, Accumulated Exceedance
EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment
EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment
EP-terrestrial = Eutrophication potential, Accumulated Exceedance
POCP = Formation potential of tropospheric ozone
ADP-minerals&metals = Abiotic depletion potential for non-fossil resources
ADP-fossil = Abiotic depletion potential for fossil resources
WDP = Water (user) deprivation potential, deprivation-weighted water consumption
PM = Potential incidence of disease due to PM emissions
IRP = Potential Human exposure efficiency relative to U235
ETP-fw = Potential Comparative Toxic Unit for ecosystems
HTP-c = Potential Comparative Toxic Unit for humans
HTP-nc = Potential Comparative Toxic Unit for humans
SQP = Potential soil quality index
The following indicators should be used with care as the uncertainties on these results are high or as there is limited experience with the indicator : ADP-minerals&metals, ADP-fossil, and WDP.

Resource use:

1 tonne of structural hollow section

Parameter	Unit	A1 – A3	C1	C2	C3	C4	D
PERE	MJ	9.83E+02	2.78E+01	1.05E+01	3.33E+00	2.93E-01	8.39E+02
PERM	MJ	2.99E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-2.09E+00
PERT	MJ	1.01E+03	2.78E+01	1.05E+01	3.33E+00	2.93E-01	8.37E+02
PENRE	MJ	2.65E+04	3.38E+02	2.39E+02	1.51E+01	1.96E+00	-1.59E+04
PENRM	MJ	2.27E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.59E-01
PENRT	MJ	2.65E+04	3.38E+02	2.39E+02	1.51E+01	1.96E+00	-1.59E+04
SM	kg	6.16E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-2.02E+00
RSF	MJ	0.00E+00	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	0.00E+00
FW	m^3	1.42E+01	2.86E-02	1.37E-03	2.37E-03	4.97E-04	-9.38E+01

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 = Input 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 structural hollow section

Parameter	Unit	A1 – A3	C1	C2	C3	C4	D
HWD	kg	1.12E-05	2.88E-09	5.86E-10	6.20E-10	1.00E-10	2.48E-06
NHWD	kg	1.67E+02	6.58E-02	2.04E-02	7.52E-03	1.24E+01	1.73E+02
RWD	kg	8.68E-02	1.82E-03	3.33E-04	7.19E-04	2.17E-05	-4.39E-03
CRU	kg	0.00E+00	0.00E+00	0.00E+00	1.67E+01	5.33E+01	0.00E+00
MFR	kg	0.00E+00	0.00E+00	0.00E+00	2.19E+02	7.01E+02	0.00E+00
MER	kg	7.49E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-5.25E-01
EEE	MJ	1.58E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.11E-01
EET	MJ	1.68E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	-1.17E-01

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 selected environmental impact categories for 1 tonne of Tata Steel's structural hollow section 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 the impact categories are A1-A3 (burdens) and D (benefits beyond the system boundary). The manufacture of hot rolled coil during stage A1-A3 is responsible for over 90% of each impact in all of the categories, specifically, the conversion of iron ore into liquid steel which is the most energy intensive part of the overall tube manufacturing process.

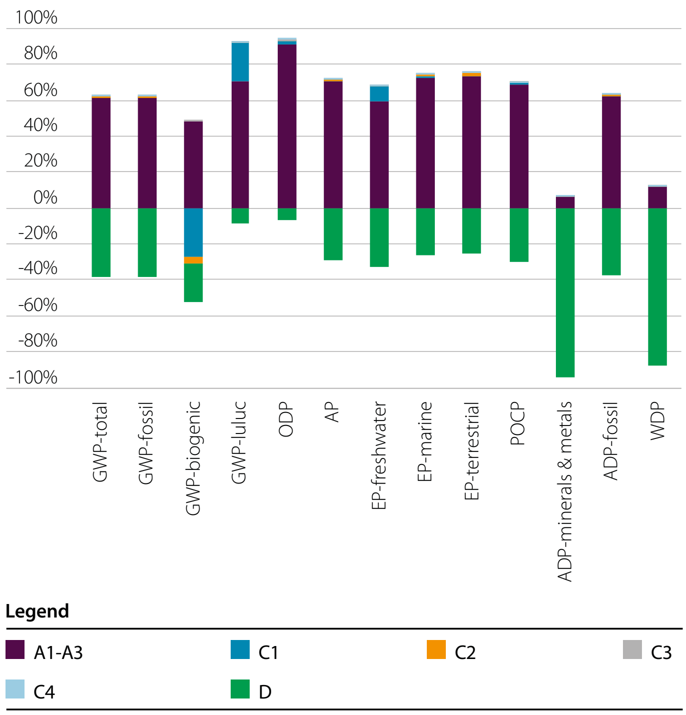
The primary site emissions come from the use of coal and coke in the blast furnace, and from the injection of oxygen into the basic oxygen furnace, as well as combustion of the process gases. These processes give rise to emissions of CO_2, which contributes 89% of the Global Warming Potential (GWP), and sulphur oxides, which are responsible for 60% of the impact in the Acidification Potential (AP) category. In addition, oxides of nitrogen are emitted which contribute 40% of the A1-A3 Acidification Potential, and over 90% of the Eutrophication Potentials (EP-marine and EP-terrestrial), and the combined emissions of nitrogen oxides (67%) together with sulphur oxides, carbon monoxide and methane, 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 the end-of-life stages C1 to C4. The exceptions are the contribution of C1 to the GWP-biogenic and GWP-luluc indicators. The contribution to GWP-biogenic comes from the biotic carbon component in the diesel mix used in the deconstruction process, and this impacts land use because of the requirement of land for the production of biodiesel.

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 pipe 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 [23]. The specific emissions that represent the burden in A1-A3, are essentially the same as those responsible for this Module D credit. It is important that the life cycle of the steel product is considered here, because in most cases, the Module D credit provides significant benefits in terms of reducing the whole life environmental impacts.

It is worth noting that for the ADP-minerals & metals indicator, the benefit in Module D is much greater than the manufacturing impact in A1-A3. This is a feature of the worldsteel 'value of scrap' calculation being based upon many steel plants worldwide. The tube making process does not consume zinc, so this burden is small when compared with the 'value of scrap' which features significant recovery of zinc from recycling in electric arc furnaces.

Figure 4 LCA results for steel structural hollow sections



Referring to the LCA results, the impact in Module D for the Use of Renewable Primary Energy indicator (PERT) is also different to the 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.

There is some variation of environmental impacts between the four tube manufacturing sites. This is highlighted in Table 6, which shows that the variations are mostly within 35% of the declared values and originate from the both location of the primary HRC steel supply and the product type (hot finished versus cold formed).

Table 6 Variation in A1-A3 impact by tube manufacturing site

	A1-A3 declared value	Maximum difference from declared value (by site) (%)
GWP total [kg CO_2 eq]	2590	10
ODP [kg CFC11 eq]	7.30E-10	45
AP [mol H^+ eq]	7.33	34
EP-freshwater [kg P eq]	6.57E-04	17
EP-marine [kg N eq]	1.67	20
EP-terrestrial [mol N eq]	17.6	24
POCP [kg NMVOC eq]	5.92	34
ADP fossil [MJ]	26500	19

6 References and product standards

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8. EN 10219-1:2006, Cold formed welded structural hollow sections of non-alloy and fine grain steels – Technical delivery requirements

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25. EC-JRC, EN 15804 Reference Package, https://eplca.jrc.ec.europa.eu/ LCDN/EN15804.xhtml

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