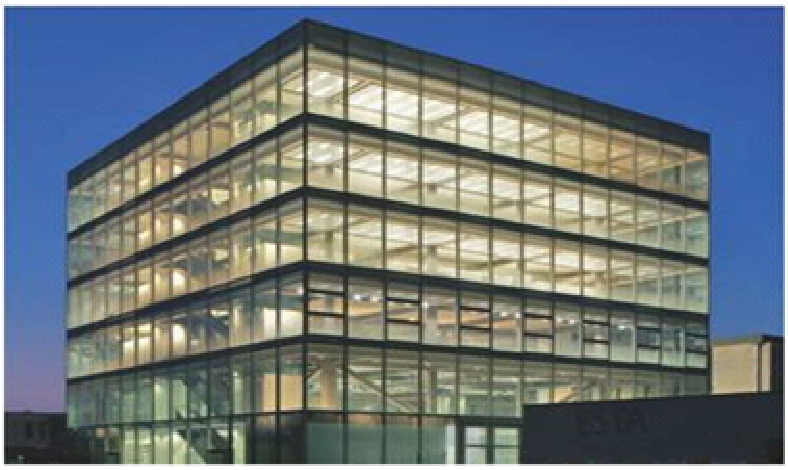
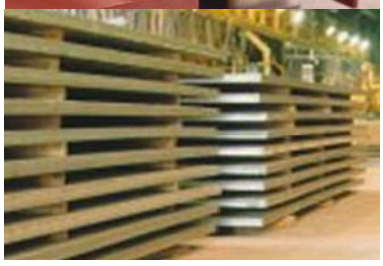



Environmental Product Declaration

According to ISO 14025

Structural Steel: Sections and Plates

>>bauforumstahl

Declaration number
EPD-BFS-2010111-E

Institut Bauen und Umwelt e.V.
www.bau-umwelt.com

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und Umwelt e.V.

Summary

Environmental Product-Declaration

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Institute Construction and Environment

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Program holder

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Declaration holder

EPD-BFS-20100111-E

Declaration number

Structural steel: Sections and Plates

This declaration is an environmental product declaration according to ISO 14025 and describes the specific environmental impacts of the mentioned construction materials. It is supposed to support the sustainable development of environmental and health friendly construction. All relevant environmental data is contained in this validated declaration.

The declaration is based on the PCR document „Construction steel“, 09-2010.

Declared Building Products

This validated declaration entitles the usage of the label of the Institute for Construction and Environment. This exclusively applies to the mentioned products, three years from the date of issue. The declaration holder is liable for the basic information and verifications.

Validity

The **declaration** is complete and contains in detailed form:

- Product definition and information about building physics
- Information about material characteristics and the material’s origin
- Description of the product’s manufacturing
- Indication of product processing
- Information about the in-use conditions, extraordinary impacts and end-of use phase
- Life cycle assessment results

Content of the declaration

6th October 2010

Date of Issue

Prof. Dr.-Ing. Horst J. Bossenmayer (President of the Institute Construction and Environment)

Signatures

This declaration, and the rules on which it is based, have been verified by the independent Advisory Board (SVA) according to ISO 14025.

Verification of the Declaration

Prof. Dr.-Ing. Hans-Wolf Reinhardt (chairman of the SVA)

Dr. Frank Werner (tester appointed by the SVA)

Signatures

Summary

Environmental Product-Declaration

Product description

This EPD applies to 1 kg of structural steel (section and plate). It covers steel products rolled out to structural sections, merchant bars and heavy plates, intended for bolting, welding or connecting.

Applications

Structural steels are intended for bolted, welded or otherwise connected constructions of buildings, bridges and other structures, or in composite steel and concrete structures.

Examples:

- single storey buildings (industrial and storage halls, etc.)
- multistorey buildings (offices, residential, shops, car parks, high rise, etc.)
- bridges (railway bridge, road bridge, pedestrian bridge, etc.)
- other structures (power plants, stadiums, convention centers, airports, stations, etc.)

Scope of the LCA

The LCA is performed according to ISO 14040 ff. corresponding to the requirements of the guidelines concerning Type III declarations of the Institute for Construction and Environment. Specific industrial data as well as data from the data base „GaBi 4" is used as data basis. The LCA comprises raw material and energy consumption, raw material transports and the actual production phase of structural steel as well as its recycling at the end of the life cycle whilst considering the recycling potential. The LCA applies to structural sections, merchant bars and heavy plates for several structural applications.

Results of the LCA

Structural steel: Sections and Plates

Parameter	Unit per kg	Production	End-of-Life*	Total
Primary energy, non-renewable	[MJ]	19.48	-7.70	**11.78**
Primary energy, renewable	[MJ]	0.65	-0.08	**0.57**
Global Warming Potential (GWP 100 years)	[kg CO_2-eqv.]	1.68	-0.88	**0.80**
Ozone Depletion Potential (ODP)	[kg R11-eqv.]	3.19E-08	1.04E-08	**4.23E-08**
Acidification Potential (AP)	[kg SO_2-eqv.]	3.47E-03	-1.68E-03	**1.79E-03**
Eutrophication Potential (EP)	[kg PO_4^{3-}-eqv.]	2.89E-04	-1.31E-04	**1.58E-04**
Photochemical Ozone Creation Potential (POCP)	[kg C_2H_4-eqv.]	7.55E-04	-4.57E-04	**2.98E-04**

* In this EPD 100% recovery, 11% reuse and 1% loss are assumed.

Issued by: PE INTERNATIONAL, Leinfelden-Echterdingen
In cooperation with >>bauforumstahl

Evidence and verifications

No testings and verifications required

Scope of validity

This environmental product declaration covers steel products rolled out to structural sections, merchant bars and heavy plates, intended for bolted, welded or otherwise connected constructions of buildings, bridges and other structures.

This environmental product declaration is valid for products of the participating companies ArcelorMittal with the sites in Dabrowa, Differdange, Esch-Beval and Ostrava, as well as Dillinger Hütte GTS, Ilsenburger Grobblech GmbH, Peiner Träger GmbH and Stahlwerk Thüringen GmbH.

1 Product definition

Product definition

The production process is using the two following routes:

1. Blast Furnace with Basic Oxygen Furnace (BF + BOF)
2. Electric Arc Furnace (EAF)

The construction products are:
- hot rolled structural sections, including merchant bars
- heavy plates

The steel grades (strength levels) are:
- S235 to S960

Application

Structural steels are intended for bolted, welded or otherwise connected constructions of buildings, bridges and other structures, or in composite steel structures.

Examples:
- single storey buildings (industrial and storage halls, etc.)
- multistorey buildings (offices, residential, shops, car parks, high rise, etc.)
- bridges (railway bridge, road bridge, pedestrian bridge)
- other structures (power plants, stadiums, convention centers, airports, stations, etc.)

Placing on the market/ Codes of practice

Product standards: DIN EN 10025, ASTM A36, A572, A992, A913, A/SA283, A514, A573, A588, A633 and A709
Fabrication standards: DIN EN 1090, AISC, AWS
Application standards: Eurocodes, AISC

Quality control

CE mark, Ü-Zeichen, ISO 9001, ISO 14000

Delivery status, characteristics

The dimensions of the declared products may vary according to the intended use case.

Constructional data

Essential product characteristics according to DIN EN 10025-1:2004 Annex ZA
Tolerances on dimensions and shapes:

- For plates: EN 10029
- For sections and merchant bars: DIN EN 10034 / DIN EN 10024 / DIN EN 10279 / DIN EN 10056

Elongation: DIN EN 10025 relevant to the steel grade

Tensile strength: DIN EN 10025 relevant to the steel grade

Yield strength: DIN EN 10025 relevant to the steel grade

Impact strength: DIN EN 10025 relevant to the steel grade

Weldability (chemical composition): DIN EN 10025 relevant to the steel grade

Durability (no performance determined)

Table 1: Material properties

Material property	Unit	Value
Unit mass ρ_a	kg/m³	7850
Modulus of elasticity E_a	MPa	210000
Shear modulus G_a	MPa	81000
Modulus of linear thermal expansion a_a	K^{-1}	$12*10^{-6}$
Thermal conductivity at 20°C λ	W/(m*K)	48-58
Fire Safety	Material Class A1, i.e. not flammable to EN 13501-1	

2 Basic materials

Base materials primary products

A. For the production route “Blast Furnace with Basic Oxygen Furnace”:
At least 65% iron ore and up to 35% scrap

B. For the production route “Electric Arc Furnace”:
100% scrap (= pre-consumer, post-consumer and internal)

Auxiliary substances / additives

A. For the production route “Blast Furnace with Basic Oxygen Furnace”:
Coking coal, coal, lime

B. For the production route “Electric Arc Furnace”:
Lime

For routes A and B:

Ferroalloys: Ferro-silicium, Ferro-manganese, Ferro-nickel, Ferro-niobium, Ferro-vanadium, Ferro-titanium

Aluminium

The rates of these additives are depending on the steel grade.

Material explanation

Iron ore and coal are natural raw materials which are available in a large number of qualities depending on their natural composition and structure. Lime and alloys are also from natural sources, partly pre-processed for their use in the steelmaking process, alloys may also be from recycled material. Steel scrap is a secondary raw material traded in several well defined qualities depending on composition (Fe-content) and origin-related characteristics (e.g. plates and sections, galvanized sheet, shreddings and turnings).

Raw material extraction and origin

Iron ore, coal, alloys and lime as natural raw materials are extracted from the soil usually in surface and underground mines. Scrap and alloys to some extent are collected from demolition and shredderings sites and other end of use origins (post-consumer), from steel processing and manufacturing of steel products (pre-consumer), and internal recovery during steel making.

Availability of raw materials

1. World’s iron ore reserves are infinite as iron (chemical element: Fe) is one of the most frequent elements on earth.
2. The world has large reserves of coal.
3. Steel scrap (=used steel) is very abundant. Europe is a net exporter of scrap.

3 Product manufacturing

Manufacturing the building product

In the integrated steel production route iron ore (Ferro-oxides) is mixed with coal and sintered as preparation for being fed into the blast furnace together with coking coal, the reducing agent. Pellets may also be used. The pig iron produced in the blast furnace is transferred into the basic oxygen furnace. In this vessel, the iron is converted into steel by lowering the carbon content of the iron through an exothermic reaction, by blowing oxygen into the melt. For temperature control, scrap (up to 35%) is added to the melt.

In the electric steel production route scrap is molten in an electric arc furnace to obtain liquid steel.

Refining (lowering of sulphur and phosphorous) and alloying (e.g. about 1 % Mn, 0.2% Si) and / or micro-alloying (e.g. about 0.01% V) is applied to give the requested characteristics to the steel.

At the end of the steelmaking process, the liquid steel is transformed into a semi-finished product in a continuous casting machine or ingot casting is practiced.

For the hot rolling process the semi-product (slab, beam-blank, bloom or billet) is rolled into the final product dimensions (heavy plate, wide flats, H-shape, I-shape, U-shape, L- shape and other merchant bars).

Health protection Production

Occupational health and safety management (OHSM) in accordance with OHSAS 18001.

Environmental protection
Production

Environmental management (EM) in accordance with ISO 14001.

4 Product processing

Processing recommendations

Planning, processing, implementation and intended use of section and plate constructions have to be carried out depending on the respective applications according to the generally recognized rules of engineering and manufacturer's recommendations.

The standards of DIN EN 1993 and DIN EN 1994 (= EUROCODE EC3 and EC4) apply to the design of steel and composite steel and concrete structures. They include the requirements regarding serviceability, bearing capacity, durability and fire resistance of steel structures.

The standard DIN EN 1090 covers fabrication and erection of steel structures and contains the requirements for conformity assessment of structural components.

In addition, the European Standards will work in connection with national amendments, national instructions, guidelines and publications, legal provisions as well as pertinent technical literature.

Regarding transport and storage of sections and plates, the generally accepted requirements for securing loads have to be observed.

Instruction details of the manufacturer based on verified standards and guidelines regarding welding, galvanizing as well as hot and cold forming are to be observed in every case.

Occupational safety/ Environmental Protection

When processing/using of steel sections and plates pursuant to the generally recognized rules of engineering there are no measures to be taken which are going beyond the public occupational health and safety.

The processing/using of steel sections and plates pursuant to the generally recognized rules of engineering do not trigger the release of substantial environmental pollutants. Particular measures taken to protect the environment are not required.

Residual material

During processing residual pieces as well as turnings are separated from other materials and collected. This scrap steel is entirely recycled by melting and producing as new steel products.

Packaging

Sections and plates are delivered unpacked.

5 Condition when in use

Constituent parts

Structural steels are non-alloyed / low-alloyed steel products that have developed by alloying iron with carbon and other metals. Iron is the main component of steel sections and plates. The components are listed under chapter 2 “Basic materials”.

Effects on environment and health

The designated and relevant use of sections and plates does not carry any known adverse health effects as there is no incorporation given for the described uses.

Hazards effecting water, air/atmosphere and ground do not occur from the intended use of steel sections and plates.

Utilization phase

Requirements on use and maintenance do not occur from the described products but from their specific fabrication and application. No change in material composition occurs.

Iron and Oxygen form bivalent and trivalent oxides. As these oxides do not form protective layers, exposed surface areas of sections and plates may oxidise while in contact with the atmosphere.

If required, the surfaces of fabricated structural components are protected with anti-corrosion material in order to prevent any direct contact with the atmosphere.

In case of unprotected use the rusting rates of unalloyed steel are depending on the conditions of the surrounding atmosphere.

6 Extraordinary impacts

Fire

Fire Safety:
The material is class A1, i.e. not flammable per DIN EN 13501
The material is not fumes emitting.
The critical temperature for the integrity of the structure is substantially depending on member loading and member restraining conditions.

Water

Steel is stable to water, not soluble and is not emitting substances in water. In case of flooding no impacts are expected.

7 End of Life phase

Structural steel: Sections and plates are 100% recyclable. Around 1% is lost during material recovery.

Reuse

Sections and plates can be reused after dismantling. Currently, around 11% of the products are re-used after dismantling [industry estimate based on the following (internal) sources: /European Commission Technical Steel Research/, /“Declaration

Environnementale et Sanitaire Conforme a la Norme NF P 01-010“, Pourtrelle en acier, Décembre 2007/, /“Steel Recycling Rates at a Glance“, Steel Recycling Institute, 2007/]

Reutilisation None

Recycling Section and plates can be recycled without any problems after dismantling. Currently, around 88% of the products are used for closed loop recycling of the material.

Reclamation None

Disposal Due to its high value as a resource, steel scrap is not disposed of, but instead in a well established cycle fed to reuse or recycling. However, in case of dumping no environmental impacts result.

8 Life cycle assessment

8.1 Information on system definition and modelling of the life cycle

Declared Unit This EPD applies to 1 kg product structural steel (section and plate; average values of the participating members as described in the scope of validity).

System boundaries The analysis of this study covers the following steps:

- Production of raw materials and energy
- Production / Manufacture of the product
- Waste water treatment
- End-of-Life (Reuse of the product structural steel, recycling; remelting of steel scrap)

Principally the inventory data include material, energy, auxiliary as well as water consumption and waste productions (foreground data). The foreground data derive from the participating firms. Further, they include LCA data sets (cradle to gate) for raw materials, energies, and other auxiliaries linked to the foreground data of various stages of the life cycle (background data). The background data are provided by PE INTERNATIONAL.

Assumptions and estimations No assumptions and estimations were necessary for the LCA.

Cut-off criteria On the input side all flows entering the system and contributing to more than 1% in total mass or primary energy are considered. It can therefore be assumed that the demands of the IBU are fulfilled.

Background data like material and energy production are taken from the GaBi 4 database (/GaBi 4 2006/). Respective cut-off criteria (system boundaries) are given in the documentation of the data sets (/GaBi 4 2006/).

Transports Transports distances are included in all background data sets.

Period under consideration Modelling is based on production data from 2007/2008. Background data refer from 2002 to 2008 (/GaBi 4 2006/).

Background data	Background data like material and energy production are taken from the GaBi 4 database (/GaBi 4 2006/).
Data quality	The production is modelled based on averaged volume production data of the contributing companies. Amounts for the input and output of energy and materials have been directly derived from annual production data of 2007/2008.
Allocation	During the production phase of the sections and plates different by-products are produced which can be further used and therefore credits for this materials are modelled and balanced. The by-product slag (EAF or BF slag) is modelled as a mixture of cement and gravel (based on specific provided company data). Material credits are given for the by-products benzene, sulphur and tar. Energy consumption for machines is measured directly throughout the production. Therefore electricity consumption in the production sites can be directly broken down to the declared product. Steel scrap from production is directly reused in the furnace process. Site external steel scrap (from other sources) is calculated as being used in the electric arc furnace process. The internal produced process gases CO gas, BF gas and BOF gas are used as internal energy carriers for different processes. If there is a surplus of process gases which are not needed for the production an incineration of those process gases is modelled. The thermal energy is calculated as converted into electrical power and then this amount displays the credit for the substituted electrical power.
End-of-Life Scenario	The End-of-Life scenario considers the re-use and the recycling of sections and the plate production. In the End-of-Life phase a collection rate factor of 100 % is modelled. This means that after the utilization 100% of the products are still available and can be used for End-of-Life. Additionally a loss of 1% is assumed. 11% of the dismantled products are directly reused. The remaining share of 88% of steel scrap (after subtraction of the steel scrap needed for the production of the structural steel; in the case of this EPD, slightly more than 50% secondary material used in the production process) is available for the recycling potential of the structural steel. The so-called recycling potential means the avoidance of primary structural steel production.
Credits	Credits for the recycled metals (net consideration) are calculated through the correspondent primary production under consideration of the expenditure throughout the recycling process. The substitution approach is used for the power generation through process gases. The amount of generated power is set off through the process DE: Power. This represents the savings of fossil fuels and their respective emissions, which would have occurred otherwise.

8.2 Description of the assessment results and analysis

Life Cycle Inventory	The following chapter determines material and energy flows along the manufacture and the End-of-Life of the considered products.
Primary energy	The average primary energy consumption of the production and recycling of 1 kg structural steel is shown in Table 2.

Table 2: Average primary consumption of 1 kg structural steel (production and EOL[1] (=recycling))

Average volume production	Unit	Production [1 kg]	End-of-Life [1 kg]
Primary Energy from Resources	**MJ**	**19,48**	**- 7,70**
Primary Energy from Crude oil	MJ	1,55	- 0,94
Primary Energy from Hard coal	MJ	10,54	- 7,11
Primary Energy from Lignite	MJ	1,10	0,06
Primary Energy from Natural Gas	MJ	5,03	- 0,10
Primary Energy from Uranium	MJ	1,26	0,40
Primary Energy from Renewable Raw Materials	**MJ**	**0,65**	**- 0,08**

The primary energy demand is depending on the kind of product (plate or section production) and the type of steel making (BOF or EAF).

The recycling credit results from the avoided production of primary steel slab due to the recycling potential. Therefore the primary energy demand in the production phase can be minimized.

There is no net-credit for the end-of-life of the energy carriers uranium and lignite. This is due to the power consumption (and the correspondent consumption of energetic resources) throughout the recycling process in the electric furnace.

Considering the different primary energy carriers during the production phase the hard coal has the highest influence (52 %) due to the coke resp. coal usage during the coke making process and in the blast furnace process. It follows with 25 % the energy carrier natural gas and the remaining ones are below 10 %.

Uranium is only used in the extraction of power in nuclear power plants.

[1] In the further course of this document, EoL stands for End-of-Life and refers to the Post-Utilisation Phase.

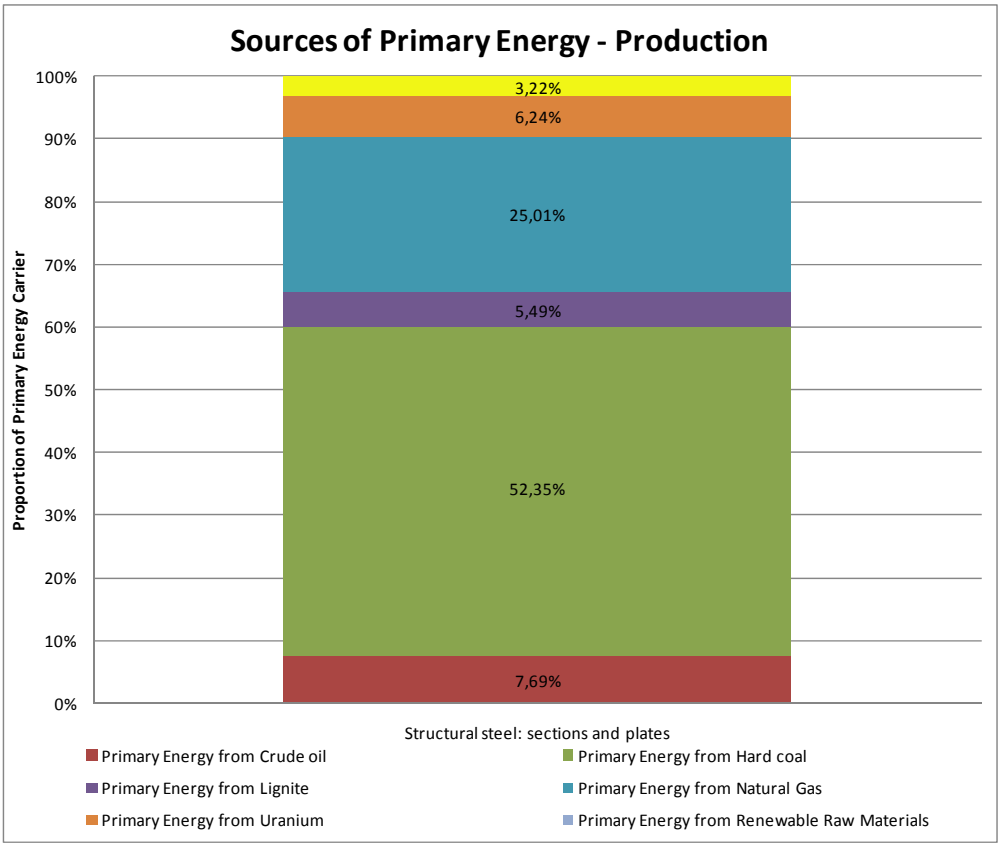

Figure 1: Sources of Primary Energy in the production stage

Water utilisation

The following table shows the water consumption of one kg structural steel (production and EoL (= recycling) phase). It shows that the water consumption is divided in different categories. In the End-of-Life phase credit for water consumption is reached. Therefore the total amount of water consumption of one kg structural steel is 1,88 kg. Mills operate mainly with a closed-loop water system.

Table 3: Water consumption of 1 kg structural steel (production and EOL (= recycling))

Average volume production	Unit	Production [1 kg]	End-of-Life [1 kg]
Water Consumption (Total)	**kg**	**6,75**	**-4,87**
Fresh Water	kg	3,011	-2,966
Ground Water	kg	1,363	-0,429
Origin not Specified	kg	6,56	-2,671
River Water	kg	-4,209	1,226
Sea Water	kg	0,02	-0,028

Wastes

The following aggregated values of the life cycle inventory analysis, referring to waste production, represent one kg structural steel (production and EoL (=recycling) phase).

Stockpile goods are dominated by overburden (> 96% contribution). Overburden is mainly generated by coal extraction (coal for power generation and iron making).

The gained credit of the End-of-Life phase is also depending on the overburden (stockpile goods). The recycling potential (avoiding of primary steel slab production)

gives credit for the stockpile goods and dangerous waste and therefore the total amount of waste can be reduced.

Table 4: Waste of 1 kg structural steel (production and EOL (= recycling))

Average volume production	Unit	Production [1 kg]	End-of-Life [1 kg]
Waste (Total)	**kg**	**4,52**	**-2,35**
Stockpile Goods	kg	4,51	-2,36
Consumer Waste	kg	4,25E-04	0,01
Dangerous Waste	kg	0,003	-1,79E-03
Radioactive Waste	kg	4,3E-04	9,90E-05
Hazardous Waste	kg	0,003	-1,89E-03

Impact assessment

For the evaluation of the potential environmental impact of the structural steel the CML-methodology (CML = Center voor Milieukunde at Leiden) with the characterization factors of 2007 (December) is applied.

- Abiotic Resource Depletion (ADP)
- Global Warming Potential (GWP)
- Ozone Layer Depletion Potential (ODP)
- Acidification Potential (AP)
- Eutrophication Potential (EP)
- Photochemical Ozone Creation Potential (POCP)

The following impact assessment indicators represent 1 kg structural steel (production and EoL (=recycling) phase).

Considering the influence of the two phases it can be seen that the share of the production phase is nearly for all categories the same. It ranges from 62 % to 75 %.

For all considered impact categories, besides ODP, a credit can be given for the End-of-Life phase. There is no credit for ODP due to the fact that EAF process in the End-of-Life phase is based on power consumption.

Table 5: Impact assessment indicators of 1 kg structural steel (production and EOL (= recycling))

		Unit	Production [1 kg]	End-of-Life [1 kg]
Abiotic Resource Depletion	ADP	kg Sb-Equiv.	8.77E-03	-3.89E-03
Global Warming Potential	GWP	kg CO_2-Equiv.	1.68	-0.88
Ozone Layer Depletion Potential	ODP	kg R11-Equiv.	3.19E-08	1.04E-08
Acidification Potential	AP	kg SO_2-Equiv.	3.47E-03	-1.68E-03
Eutrophication Potential	EP	kg PO_4-Equiv.	2.89E-04	-1.31E-04
Photochemical Ozone Creation Potential	POCP	kg Ethene-Equiv.	7.55E-04	-4.57E-04

Depending on the type of product (section or plate) and the type of production process (BOF or EAF making) the influence of the process steps differs per considered impact category.

While BOF route is dominated through the coke and coal input through the coke production process and in the blast furnace, the EAF route is mainly dominated through the power consumption in its environmental profile.

Global Warming Potential is dominated by the carbon dioxide emissions. The

savings in the end-of-life phase are confronting the contribution of the production and remelting within the recycling to the GWP. In total, the GWP for the complete life-cycle is 0.8 kg CO2eq.

9 Proof

Not relevant for these products.

10 PCR-document and verification

This declaration is based on the Product Category „Construction steel“, 09-2009.

PCR review, was conducted by: Advisory board IBU: Prof. Dr.-Ing. Hans-Wolf Reinhardt (Universität Stuttgart, IWB)
Independent verification of the declaration according to ISO 14025: ☐ internal ☒ external
Validation of the declaration: *Dr. Frank Werner*

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