ENVIRONMENTAL PRODUCT DECLARATION

as per *ISO 14025* and *EN 15804+A2*

Owner of the Declaration	Institut Feuerverzinken GmbH
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Hot-dip galvanized Structural Steel: Sections and merchant bars

bauforumstahl e.V. & Institut Feuerverzinken GmbH

Institut Bauen und Umwelt e.V.

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1. General Information

bauforumstahl e.V. & Institut Feuerverzinken GmbH

Programme holder

IBU – Institut Bauen und Umwelt e.V.
Hegelplatz 1
10117 Berlin
Germany

Declaration number

EPD-BFS-20240011-IBG1-EN

This declaration is based on the product category rules:

Structural steels, 01.08.2021
(PCR checked and approved by the SVR)

Issue date

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Valid to

28.04.2029

Dipl.-Ing. Hans Peters
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Hot-dip galvanized Structural Steel: Sections and merchant bars

Owner of the declaration

Institut Feuerverzinken GmbH
Mörsenbroicher Weg 200
40470 Düsseldorf
Germany

Declared product / declared unit

The declared unit is 1 t of hot-dip galvanized structural steel - sections and merchant bars.

Scope:

This environmental product declaration (EPD) covers hot-dip galvanized structural steel - sections and merchant bars that are 100% recycled from steel scrap. The Life Cycle Assessment refers to an average product and is based on data collected from 9 representative plants. The precursor products are rolled steel sections that are subsequently hot-dip galvanized. The hot rolled sections are produced by:

- ArcelorMittal, operating sites at Differdange/Esch-Belval (Luxembourg), Hunedoara (Romania), Olaberria/Bergara (Spain)
- Peiner Träger (Germany)
- Stahlwerk Thüringen (Germany)

The products are hot-dip galvanized under subcontracting agreements and by the member companies and partners of the German Association for Hot-Dip Galvanizing (Industrieverband Feuerverzinken e.V. IVF, see https://www.feuerverzinken.com/industrie/ mitglieder-und-partner). For the selection of the hot-dip galvanizing contractors for the purpose of data collection, the plant size, galvanizing capacity and product range were taken into account. With regard to the scope of the EPD, the data thus covers a representative sample.
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.

The EPD was created according to the specifications of EN 15804+A2. In the following, the standard will be simplified as *EN 15804*.

Verification

The standard EN 15804 serves as the core PCR
Independent verification of the declaration and data according to ISO 14025:2011
☐ internally ☒ externally

Dr.-Ing. Nikolay Minkov,
(Independent verifier)

2. Product

2.1 Product description/Product definition

This EPD applies to hot-dip galvanized structural steel sections and merchant bars that are 100% recycled from scrap. It covers steel products of the grades S235 to S500. For the placing on the market of the product in the European Union/European Free Trade Association (EU/EFTA) (with the exception of Switzerland) *Regulation (EU) No. 305/2011 (CPR)* applies. The product needs a Declaration of Performance taking into consideration
EN 10025-1:2004 Hot rolled products of structural steels – Part 1: General technical delivery conditions and the CE-marking. For the application and use the respective national provisions apply.

2.2 Application

Hot-dip galvanized 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 are:
• single-storey buildings (industrial and storage halls, etc.)
• multi-storey buildings (offices, residential buildings, shops, car parks, high rise, etc.)
• bridges (railway bridge, road bridge, pedestrian bridge, etc.)
• other structures (power plants, stadiums, convention centres, airports, stations, etc.)

2.3 Technical Data

This EPD is valid for sections and merchant bars of varied grades and different forms of delivery that have been hot-dip galvanized according to *EN ISO 1461* and *DASt Guideline 022*. Specific information on dimension tolerances, constructional data as well as mechanical and chemical properties can be found in the relevant literature and/or the standards.

Bautechnische Daten

Name	Value	Unit
Density	7850	kg/m^3
Modulus of elasticity	210000	N/mm^2
Coefficient of thermal expansion	12	$10^{-6}K^{-1}$
Thermal conductivity bei 20°C λ	48	W/(mK)
Melting point depending on the alloy proportions up to	1536	°C
Shear modulus	81000	N/mm²
Emissivity up to 500 °C / from 500 °C	0,35 / 0,7	

Performance data of the product is in accordance with the declaration of performance with respect to its essential characteristics according to *EN 10025 Hot rolled products of structural steels*. Further product standards are e.g.: *ASTMA36, A572, A588, A709,*
A913/A913M and *A992.*

2.4 Delivery status

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

2.5 Base materials/Ancillary materials

Structural steels are non-or low-alloy steel products whose carbon content is between 0 and 0.6 %. Iron is the main component of structural steel. The content of other elements is less than 2 %. The exact chemical composition varies depending on the steel grade.

Auxiliary materials:
For the production by electric arc furnace: lime aluminium, ferro alloys (ferro silicon, ferro manganese, ferro nickel, ferro niobium, ferro vanadium, ferro titanium)
The rates of these additives depend on the steel grade.
For hot-dip galvanizing: degreasing agent, hydrochloric acid, zinc and ammonium chloride, zinc alloy
The product for authorization contains substances on the *ECHA* list of substances of very high concern (SVHC) (14 July2021) above 0.1 % by mass: **No.**
The product contains further carcinogenic, mutagenic, reprotoxic (CMR) substances of category 1A or 1B that are not on the candidate list, exceeding 0.1 % mass in at least one subproduct: **No.**
Biocides have been added to the construction product, or the product has been treated with biocides (a treated product pursuant to the *Biocidal Product Regulation (EU) No.528/2012)*: **No.**

2.6 Manufacture

In the electric steel production route scrap is molten in an electric arc furnace to obtain liquid steel.
Refining (lowering of sulphur, phosphorous and other tramp elements) 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 in special cases, poured into ingot molds to form blocks.
The semi-product (beam-blank, slab, bloom or billet) is hot-rolled into the final product dimensions (H-shape, I-shape, U-shape, L-shape and other merchant bars).
Quality control: *ISO 9001* Monitoring according to the product standards, e.g. *EN 10025, Part 1*.

Subsequently, the products are hot-dip galvanized. For this purpose, they undergo a wet chemical surface cleaning, are covered by flux, dried and then dipped in a hot zinc bath and cooled *Peissker 2016*. Quality assurance: *ISO 9001* monitoring according to *DASt Guideline 022*.

2.7 Environment and health during manufacturing

No measures relating to safety, health and environment protection during the manufacturing process extending beyond national guidelines are required.

2.8 Product processing/Installation

Processing recommendations:
Planning, processing, implementation and intended use of section and merchant bar constructions have to be carried out depending on the respective applications according to the generally recognized rules of engineering and the manufacturer's recommendations.
The standards of *EN 1993* and *EN 1994 (EUROCODE EC3 and EC4)* apply to the design of steel structures and composite steel and concrete structures. They include the requirements regarding serviceability, bearing capacity, durability and fire resistance of steel structures *EC3* and composite steel and concrete structures *EC4*.
The Standard Parts 1+2 of *EN 1090* apply to the execution of steel structures and include the requirements for factory production control.
In addition, the european standards will work in connection with national amendments, national instructions, guidelines and publications, as well as legal provisions.
Regarding transport and storage of sections and merchant bars, 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 structural steel 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 merchant bars does not release substantial environmental pollutants. Particular measures to protect the environment are not required.

Residual material:
During processing residual pieces as well as turnings are separately collected. This scrap steel is entirely recycled by melting and producing new steel products.
The steel scrap can be nearly 100 % recycled by melting to produce new steel products, while the recovered zinc can be used again for hot-dip galvanizing.

2.9 Packaging

Hot-dip galvanized structural steels are normally shipped without packaging. To facilitate transportation, the material is generally made available in bundles.
For sea transport, special packaging to protect the goods while at sea might be used.

2.10 Condition of use

Structural steels are non- /low-alloyed steel products generated by alloying iron with other metals and non-metals (esp. carbon). Iron is the main component of steel sections and merchant bars. The components are listed under chapter 2.5 'Base materials'. During usage no changes in material composition shall occur.

2.11 Environment and health during use

The intended use of hot-dip galvanized structural steel does not pose a hazard to health or environment in any known way.

2.12 Reference service life

Hot-dip galvanizing allows for durable corrosion protection of steel components under atmospheric corrosion conditions. The protection normally lasts for several decades without any need for maintenance or repair.

Life to first maintenance for zinc coating systems according to DIN EN ISO 1461 in a range of corrosivity categories (excerpt from DIN EN ISO 14713-1, Table 2)

Minimum thickness [µm]	C3	C4
	Life min./max. (years) and durability class (VL, L, M, H, VH)	
85	40/>100; VH	20/40; VH
140	67/>100; VH	33/67; VH
200	95/>100; VH	48/95; VH

NOTE: The figures for life have been rounded to whole numbers. The allocation of the durability designation is based upon the average of the minimum and maximum of the calculated life to first maintenance, e.g. 85 µm zinc coating in corrosivity category C4 gives expected durability of 85/2.1 = 40.746 years (rounded to 40 years) and 85/4.2 = 20.238 years (rounded to 20 years). Average durability of (20 + 40)/2 = 30 years – designated "VH".
Abbreviations: VL = very low (life 0 to <2 years); L = low (life 2 to <5 years); M = medium (life 5 to <10 years); H = high (life 10 to <20 years); VH = very high (life ≥20 years)

Hot-dip galvanizing also provides adequate protection under maritime conditions and against deicing salts.
For more information regarding the reference service life of hot-dip galvanized structural steel, see *EN ISO 14713-1*.
Description of the influences on the ageing of the product when applied in accordance with the rules of technology.

2.13 Extraordinary effects

Fire

The product meets the requirements of building material safety class A1 (non-flammable according to *EN 13501*).
Given the significantly lower emissivity of hot-dip galvanized structural steel, and depending on the form factor, fire resistance class R30 can be achieved by hot-dip galvanizing alone and without any additional protective measures.
At temperatures above 650°C, the thin zinc coating evaporates quickly as zinc oxide (ZnO), causing fumes.
When inhaled for a prolonged period of time, ZnO fumes can cause metal fume fever (diarrhoea, fever, dry throat), whereby these symptoms normally disappear within 1 to 2 days after inhalation. The critical temperature (failure temperature of the component) depends primarily on the component load and the insulation of the component.

Fire safety

Name	Value
Building material class Classification according to DIN EN 13501-1	A1

Water

Hot-dip galvanized steel is stable to water, insoluble and does not emit substances in water.

Mechanical destruction

Due to the ductility of steel, steel-structures react resilient in the event of unforeseeable mechanical destruction: In case of tensile load necking will occur before cracking. In case of a lasting high compression load, components of steel may buckle or bulge. No splintering or breaking edges shall result.

2.14 Re-use phase

General:
After the service life of hot-dip galvanized structural steel constructions the material is collected as secondary material for recycling or reuse.

Recycling:
Hot-dip galvanized structural steel is 100 % recyclable to new products of similar or higher quality. Due to the magnetic properties even small amounts are regained after dismantling. On the European market 88 % of the products are used for closed-loop recycling.

Re-use:
Hot-dip galvanized structural steel elements can be reused. On the European market 11 % of the products are reused after dismantling. Data from industry estimates based on the following sources: *European Commission Technical Steel Research* and *German Ministry of Environmental Affairs*

2.15 Disposal

Due to its high value, steel scrap is not disposed of, but fed into a well-established endless cycle of reuse and recycling. However, in case of dumping due to collection loss no environmental impacts are expected.
Waste code according to European Waste Catalogue *EWC*: 17 04 05 - iron and steel

2.16 Further information

For more information on hot-dip galvanized structural steel and its use, visit www.bauforumstahl.de and www.feuerverzinken.com.

3. LCA: Calculation rules

3.1 Declared Unit

The reference unit is 1 ton of hot-dip galvanized structural steel sections and merchant bars.

Foreground data describing the on-site production are integrated into the *LCA FE Software* model for all sites under study. The LCI is assessed based on annual production data. Background data are taken from the *LCA FE Database*.

Declared unit

Name	Value	Unit
Declared unit	1	t
Specific weight	7850	kg/m³
Conversion factor to 1 kg	0.001	-

The average EPD is calculated considering a production volume-weighted approach and is representative for all steel products covered by the declared unit.

3.2 System boundary

Type of the EPD: cradle-to-gate - with modules C1-C4 and module D were considered.

Modules A1-A3 cover the production stage including the upstream burdens of purchased raw materials (structural steel sections, zinc, etc.), their transports and the manufacturing at the production sites under study. Material and energy flows for the hot-dip galvanizing are considered. Electricity consumption of the production of the steel sections is modelled via residual grid mix (production in Germany + imports - exports -certified "green" electricity). For the process of hot-dip galvanizing the German consumption grid mix is considered to account for the fact that 40-50 % is produced via green electricity. The zinc for hot-dip galvanizing is modelled via the special high grade zinc dataset from IZA (International Zinc Association), representing a conservative approach.

Modules C1-C4 consider the dismantling of the considered product (C1, *PhD Siebers*), the transportation of the dismantled components to their final EoL destination (C2), the waste processing for reuse, recovery or recycling (C3) as well as the disposal (C4).

Module D refers to the End-of-Life, including recycling and/or reuse.

3.3 Estimates and assumptions

All assumptions are documented in detail and represent the reality as best as possible, based on available data at the time of publishing.

3.4 Cut-off criteria

No cut-off criteria are applied in this study. All reported data were incorporated and modelled using the best available LCI data.
Packaging materials and their transportation, or the steel and plastic straps used to bundle the considered steel products for delivery, are neglected due to low contribution to the overall life cycle results.

3.5 Background data

Secondary data from the *LCA FE Database* (former *GaBi*) were used to model the background system in the LCA model.

3.6 Data quality

Technological: All primary and secondary data are modelled to be specific to the technologies or technology mixes under study. Where technology-specific data are unavailable, proxy data are used. The overall technological representativeness is considered to be good.

Geographical: All primary and secondary data are collected specific to the country / region under study. Where country/region-specific data are unavailable, proxy data are used. The overall geographical representativeness is considered to be good.

Temporal: All primary data are collected for the year 2022. All secondary data come from the *Sphera* LCA FE Databases and are representative of the years 2018-2023. As the study intended to compare the product systems for the reference year 2022, temporal representativeness is good.

3.7 Period under review

The data used for this LCA is based on up-to-date primary data collected by bauforumstahl e.V. (reference year 2018-2020) and Industrieverband Feuerverzinken e.V. (reference year (2022).

3.8 Geographic Representativeness

Land or region, in which the declared product system is manufactured, used or handled at the end of the product´s lifespan: Europe

3.9 Allocation

There is no allocation of the foreground data.

3.10 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. The *LCA FE Database* (CUP version 2023.2) was used to calculate the LCA.

4. LCA: Scenarios and additional technical information

Characteristic product properties of biogenic carbon

The declared product does not include biogenic carbon.
Note: 1 kg of biogenic carbon i sequivalent to 44/12 kg of CO_2.

End-of-Life Scenarios

The EPD covers four End-of-Life scenarios (*SteelConstruction-info; European Commission Technical Steel Research*):

- Scenario 0: 100 % Recycling
- Scenario 1: 100 % Reuse
- Scenario 2: 100 % Landfill /Lost
- Scenario 3: European average 88 % Recycling, 11 % Reuse and 1 % Loss

End-of-Life (C1-C4)

Name	Value	Unit
Landfilling - Scenario 0	0	kg
Landfilling - Scenario 1	0	kg
Landfilling - Scenario 2	1000	kg
Landfilling - Scenario 3	10	kg

Reuse, recovery and/or recycling potential (D)

Name	Value	Unit
Recycling - Scenario 0	1000	kg
Recycling - Scenario 1	0	kg
Recycling - Scenario 2	0	kg
Recycling - Scenario 3	880	kg
Reuse - Scenario 0	0	kg
Reuse - Scenario 1	1000	kg
Reuse - Scenario 2	0	kg
Reuse - Scenario 3	110	kg

5. LCA: Results

The following table contains the LCA results for a declared unit of 1 ton hot-dip galvanized structural steel - sections and merchant bars.

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE OR INDICATOR 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	X	X	X	X	X

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT according to EN 15804+A2: 1 ton hot-dip galvanized structural steel - sections and merchant bars

Parameter	Unit	A1-A3	C1	C2	C3	C3/1	C3/2	C3/3	C4	C4/1	C4/2	C4/3	D	D/1	D/2	D/3
GWP-total	kg CO_2 eq	7.89E+02	2.08E+01	3.01E+00	0	0	0	0	0	0	1.43E+01	1.43E-01	2.07E+02	-7.85E+02	1.93E+03	1.15E+02
GWP-fossil	kg CO_2 eq	7.87E+02	2.08E+01	3.02E+00	0	0	0	0	0	0	1.48E+01	1.48E-01	2.08E+02	-7.83E+02	1.95E+03	1.17E+02
GWP-biogenic	kg CO_2 eq	1.93E+00	-5.03E-02	-4.44E-02	0	0	0	0	0	0	-5.1E-01	-5.1E-03	-1.23E+00	-1.98E+00	-1.15E+01	-1.41E+00
GWP-luluc	kg CO_2 eq	1.88E-01	2.33E-02	2.79E-02	0	0	0	0	0	0	4.67E-02	4.67E-04	2.77E-02	-1.57E-01	2.59E-01	9.75E-03
ODP	kg CFC11 eq	3.1E-09	7.71E-12	3.92E-13	0	0	0	0	0	0	3.82E-11	3.82E-13	-2.8E-10	-3.1E-09	-2.61E-09	-6.13E-10
AP	mol H^+ eq	2.23E+00	1.92E-01	3.74E-03	0	0	0	0	0	0	1.07E-01	1.07E-03	5.09E-01	-2.22E+00	4.76E+00	2.51E-01
EP-freshwater	kg P eq	7.08E-04	1.02E-04	1.1E-05	0	0	0	0	0	0	3.02E-05	3.02E-07	4.85E-05	-6.96E-04	4.53E-04	-2.93E-05
EP-marine	kg N eq	5.74E-01	9.89E-02	1.25E-03	0	0	0	0	0	0	2.75E-02	2.75E-04	8.18E-02	-5.72E-01	7.64E-01	1.67E-02
EP-terrestrial	mol N eq	6.21E+00	1.08E+00	1.51E-02	0	0	0	0	0	0	3.03E-01	3.03E-03	7.33E-01	-6.2E+00	6.85E+00	3.24E-02
POCP	kg NMVOC eq	1.62E+00	2.68E-01	3.22E-03	0	0	0	0	0	0	8.31E-02	8.31E-04	3.32E-01	-1.62E+00	3.1E+00	1.45E-01
ADPE	kg Sb eq	3.04E-02	1.39E-06	1.99E-07	0	0	0	0	0	0	6.94E-07	6.94E-09	1.18E-03	-3.04E-02	1.1E-02	-2.19E-03
ADPF	MJ	1.29E+04	2.85E+02	4.1E+01	0	0	0	0	0	0	2E+02	2E+00	2.07E+03	-1.28E+04	1.93E+04	6.07E+02
WDP	m^3 world eq deprived	9.73E+01	1.26E+00	3.64E-02	0	0	0	0	0	0	1.65E+00	1.65E-02	1.4E+01	-9.72E+01	1.31E+02	2.98E+00

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; WDP = Water (user) deprivation potential)

RESULTS OF THE LCA - INDICATORS TO DESCRIBE RESOURCE USE according to EN 15804+A2: 1 ton hot-dip galvanized structural steel - sections and merchant bars

Parameter	Unit	A1-A3	C1	C2	C3	C3/1	C3/2	C3/3	C4	C4/1	C4/2	C4/3	D	D/1	D/2	D/3
PERE	MJ	1.84E+03	1.5E+01	2.98E+00	0	0	0	0	0	0	3.26E+01	3.26E-01	-8.17E+01	-1.84E+03	-7.63E+02	-2.82E+02
PERM	MJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PERT	MJ	1.84E+03	1.5E+01	2.98E+00	0	0	0	0	0	0	3.26E+01	3.26E-01	-8.17E+01	-1.84E+03	-7.63E+02	-2.82E+02
PENRE	MJ	1.29E+04	3.05E+02	4.11E+01	0	0	0	0	0	0	2E+02	2E+00	2.07E+03	-1.28E+04	1.93E+04	6.05E+02
PENRM	MJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PENRT	MJ	1.29E+04	3.05E+02	4.11E+01	0	0	0	0	0	0	2E+02	2E+00	2.07E+03	-1.28E+04	1.93E+04	6.05E+02
SM	kg	1.12E+03	0	0	0	0	0	0	0	0	0	0	-1.2E+02	0	-1.12E+03	-1.17E+02
RSF	MJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	4.22E+00	4.23E-02	3.27E-03	0	0	0	0	0	0	5.05E-02	5.05E-04	2.11E+01	-4.22E+00	1.97E+02	2E+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 = 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 – WASTE CATEGORIES AND OUTPUT FLOWS according to EN 15804+A2:
1 ton hot-dip galvanized structural steel - sections and merchant bars

Parameter	Unit	A1-A3	C1	C2	C3	C3/1	C3/2	C3/3	C4	C4/1	C4/2	C4/3	D	D/1	D/2	D/3
HWD	kg	1.56E-03	4.02E-10	1.27E-10	0	0	0	0	0	0	4.36E-09	4.36E-11	1.55E-05	-1.56E-03	1.45E-04	-1.57E-04
NHWD	kg	6.56E +01	3.04E-02	6.27E-03	0	0	0	0	0	0	1E+03	1E+01	-2.51E +01	-6.56E +01	-2.34E +02	-3.16E +01
RWD	kg	1.26E +00	1.77E-03	7.7E-05	0	0	0	0	0	0	2.28E-03	2.28E-05	-2.27E-04	-1.26E +00	-2.12E-03	-1.39E-01
CRU	kg	0	0	0	0	1E+03	0	1.1E+02	0	0	0	0	0	0	0	0
MFR	kg	0	0	0	1E+03	0	0	8.8E+02	0	0	0	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EET	MJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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; EET = Exported thermal energy

RESULTS OF THE LCA – additional impact categories according to EN 15804+A2-optional:
1 ton hot-dip galvanized structural steel - sections and merchant bars

Parameter	Unit	A1-A3	C1	C2	C3	C3/1	C3/2	C3/3	C4	C4/1	C4/2	C4/3	D	D/1	D/2	D/3
PM	Disease incidence	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
IR	kBq U235 eq	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ETP-fw	CTUe	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HTP-c	CTUh	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HTP-nc	CTUh	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SQP	SQP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

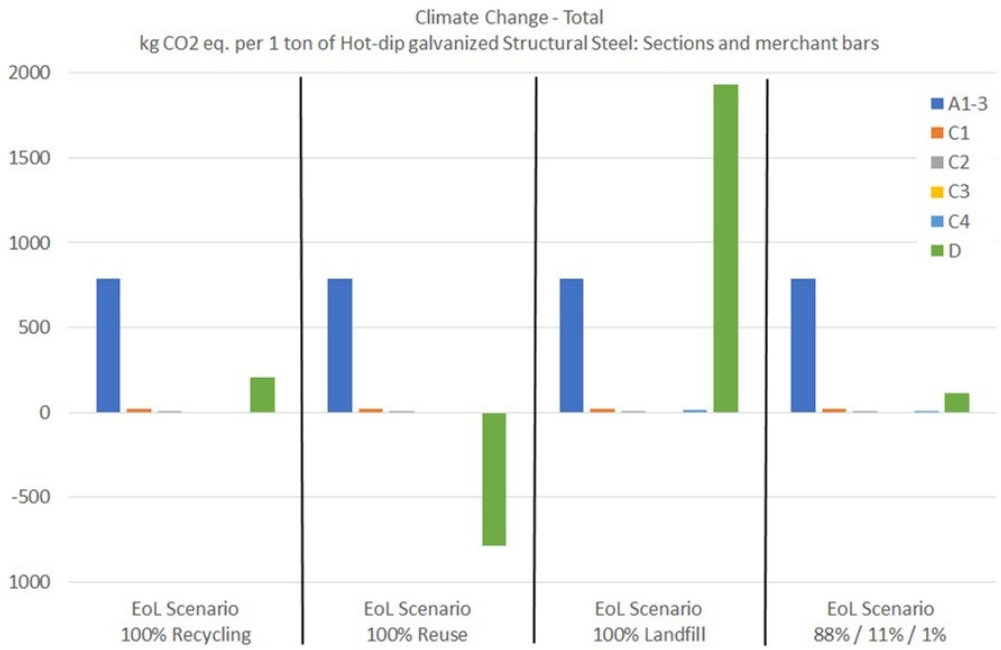
PM = Potential incidence of disease due to PM emissions; IR = Potential Human exposure efficiency relative to U235; ETP-fw = Potential comparative Toxic Unit for ecosystems; HTP-c = Potential comparative Toxic Unit for humans (cancerogenic); HTP-nc = Potential comparative Toxic Unit for humans (not cancerogenic); SQP = Potential soil quality index

Disclaimer 1 – for the indicator “Potential Human exposure efficiency relative to U235”. This impact category deals mainly with the eventual impact of low-dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure or radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, radon and from some construction materials is also not measured by this indicator.

Disclaimer 2 – for the indicators “abiotic depletion potential for non-fossil resources”, “abiotic depletion potential for fossil resources”, “water (user) deprivation potential, deprivation-weighted water consumption”, “potential comparative toxic unit for ecosystems”, “potential comparative toxic unit for humans – cancerogenic”, “Potential comparative toxic unit for humans - not cancerogenic”, “potential soil quality index”. The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high as there is limited experience with the indicator.

6. LCA: Interpretation

The following figure shows the results of the individual modules for all End-of-Life scenarios using the example of climate change.



It is visible that module D varies significantly depending on the considered End-of-Life scenario. The manufacturing phase (module A1-3) dominates the product system for all scenarios, except for the scenario with 100% landfill/lost at End-of-Life.

The following tables give a detailed evaluation of all LCIA results of the production phase (A1-A3):

	Auxiliaries	Disposal	Energy	Recovery	Steel	Water	Zinc
1. Environmental impact indicators							
01 EN15804+A2 Climate Change - total [kg CO2 eq.]			>15%		~70%		>15%
02 EN15804+A2 Climate Change, fossil [kg CO2 eq.]			>15%		~70%		>15%
03 EN15804+A2 Climate Change, biogenic [kg CO2 eq.]	<5%	<50%	~25%	>-5%	>10%		<15%
04 EN15804+A2 Climate Change, land use and land use change [kg CO2 eq.]	<5%		~10%	>-5%	<70%		>20%
05 EN15804+A2 Ozone depletion [kg CFC-11 eq.]	<5%		~25%	~-5%	<45%		>30%
06 EN15804+A2 Acidification [Mole of H+ eq.]			<10%	>-5%	<65%		>30%
07 EN15804+A2 Eutrophication, freshwater [kg P eq.]	~5%	>10%	>25%	<-5%	>20%		~40%
08 EN15804+A2 Eutrophication, marine [kg N eq.]			<15%	>-5%	~60%		~30%
09 EN15804+A2 Eutrophication, terrestrial [Mole of N eq.]			<15%	>-5%	~60%		<30%
10 EN15804+A2 Photochemical ozone formation, human health [kg NMVOC eq.]			<15%	>-5%	>60%		<30%
11 EN15804+A2 Resource use, mineral and metals [kg Sb eq.]				<-35%			~135%
12 EN15804+A2 Resource use, fossils [MJ]			>15%		>70%		<15%
13 EN15804+A2 Water use [m³ world equiv.]				<-5%	>55%	>5%	<45%
2. Ressource use indicators							
01 EN15804+A2 Use of renewable primary energy (PERE) [MJ]	<5%		~20%	<-5%	~35%		<50%
03 EN15804+A2 Total use of renewable primary energy resources (PERT) [MJ]	<5%		~20%	<-5%	~35%		<50%
04 EN15804+A2 Use of non-renewable primary energy (PENRE) [MJ]			>15%		>70%		<15%
06 EN15804+A2 Total use of non-renewable primary energy resources (PENRT) [MJ]			>15%		>70%		<15%
10 EN15804+A2 Use of net fresh water (FW) [m3]			<5%	<-5%	>55%	<5%	~45%

Most of the indicators are dominated by the provision of steel sections, followed by the supply chains of zinc, electricity and natural gas (including the consumption of natural gas during the hot-dip galvanization on-site).

For climate change the main contributors are the production of structural steel (~70 %), the supply chain of zinc (>15 %) as well as the consumption of electricity and thermal energy (>15 %).
Ozone depletion is dominated by the production of structural steel (<45 %), and the supply chain of zinc (>30 %) and electricity (>20 %).

Acidification is mainly caused by the production of structural steel (>60 %) and the supply chain of zinc (30 %).
Main contributors to eutrophication (freshwater) are the supply chains of zinc (>35 %) and electricity (~20 %) as well as the production of structural steel (~20 %).
Eutrophication (marine), eutrophication (terrestrial) and photochemical ozone depletion are mainly caused by the production of structural steel (~60 %), followed by the supply chain of zinc (>25 %) as well as electricity and thermal energy (>10 %).
Resource use (minerals & metals) is caused by the supply chain of zinc. Resource use (fossils) is dominated by the production of structural steel (>70 %), followed by the energy-related supply chains (~15 %) and zinc (<15 % zinc).

Water use is dominated by the production of structural steel (~55 %) and the supply chain of zinc (~45 %).

7. Requisite evidence

7.1 Chemical weathering

When exposed to the elements, the surfaces of hot-dip galvanized steel components become naturally covered in a protective layer known as patina. Patina is extremely durable and thus provides exceptionally effective protection against corrosion, lasting several decades.
At the same time, it protects the zinc coating, so that it remains intact for a long period of time.
The ever more stringent air quality improvement measures (in particular the desulphurisation of power plant and engine fuels) have a major positive impact on the reduction of chemical weathering of zinc coatings. *Schröder 2013* reports of zinc coating depletion rates of up to 4.7 µm/a observed in the 1970s in hot-dip galvanized steel crash barriers.
For complete chemical weathering, recent publications (see *Hullmann 2003*) quote corrosion rates for zinc of 3.0 g/m²*a (corresponding to approx. 0.5 µm/a). Recent studies (*BAST 2008* and *Schröder 2013*) examined hot-dip galvanized steel crash barriers along the German Federal Motorway BAB 4 and detected no measurable loss of thickness of the zinc coating due to chemical weathering after 10 years of exposure to the elements.
Chemical weathering can thus be assumed to be minimal and therefore negligible, even over several years and under increased corrosion stress such as along motorways (where deicing salt is used during the winter months).

8. References

Standards:

AISC 303-10
Code of Standard Practice for Steel Buildings and Bridges

ANSI/AISC 360-16
Specification for Structural Steel Buildings

ASTM A36-14
Standard specification for carbon structural steel

ASTM A283-18
Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

ASTM A514-14
Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel ISO 9001
Quality management systems - RequirementsPlate, Suitable for Welding

ASTM A572-15
Standard Specification for High-Strength Low-Alloy ColumbiumVanadium Structural Steel

ASTM A573-13
Standard Specification for Structural Carbon Steel Plates of Improved Toughness

ASTM A588-15
Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance

ASTM A633-18
Standard Specification for Normalized High-Strength Low-Alloy Structural Steel Plates

ASTM A709-13
Standard Specification for Structural Steel for Bridges

ASTM A913-15
Standard specification for high-strength low-alloy steel shapes of structural quality, produced by quenching and self-tempering process (QST)

ASTM A992-11(15)
Standard specification for structural steel shapes

ASTM A1066-11(15)
Standard Specification for High-Strength Low-Alloy Structural Steel Plate Produced by Thermo-Mechanical Controlled Process (TMCP)

AWS D1.1/D1.1M-15
Structural Welding Code – Steel

DAST Guideline 022
Hot-dip galvanizing of prefabricated loadbearing steel components, Deutscher Ausschuss für Stahlbau, Düsseldorf, 2016

EN 1090
Execution of steel structures and aluminium structures

EN ISO 1461
Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods

EN 1993 / Eurocode 3
Design of steel structures

EN 1994 / Eurocode 4
Design of composite steel and concrete structures

ISO 9001
Quality management systems - Requirements

EN ISO 9223
Corrosion of metals and alloys - Corrosivity of atmospheres - Classification, determination and estimation

EN 10025
Hot rolled products of structural steels

EN 10025-1:2004
Hot rolled products of structural steels

EN 13501-1
Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests

EN ISO 14713-1
Zinc coatings - Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 1: General principles of design and corrosion resistance

EN 15804+A2
Sustainability of construction works —Environmental Product Declarations — Core rules for the product category of construction products

ISO 12944-2
Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 2: Classification of environments

ISO 14001
Environmental management systems - Requirements with guidance for use

ISO 14025
Environmental labels and declarations — Type III environmental declarations —Principles and procedures

References:

BAST 2008
Bandverzinkte Schutzplankenholme, Bundesanstalt für Straßenwesen, Bergisch-Gladbach 2008

Biocidal Product Regulation (EU) No.528/2012)
Regulation (EU) No 528/2012 of the European Parliament and of the Council of 22 May 2012 concerning the making available on the market and use of biocidal products

CPR
Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC Text with EEA relevance

ECHA
European Chemicals Agency

European Commission Technical Steel Research
Sansom, M. and Meijer, J.: Life-cycle assessment (LCA) for steel construction, European Commission technical steel research, 2001-12

EWC
European Waste Catalogue

German Ministry of Environmental Affairs
"Instrumente zur Wiederverwendung von Bauteilen und hochwertigen Verwertung von Baustoffen"

Hullmann 2003
Hullmann, Heinz: Natürlich oxidierende Metalloberflächen; Umweltauswirkungen beim Einsatz von Kupfer und Zink in Gebäudehüllen; 2003, Stuttgart, Fraunhofer ISB-Verlag, ISBN: 3-8167-6218-2

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LCA for Experts Software System and Database for Life Cycle Engineering, Sphera Solution GmbH, Leinfelden-Echterdingen,CUP Version 2023.2 (https://www.gabisoftware.com/support/gabi)

PCR, Part A
Product Category Rules for Building-Related Products and Services, Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report. Institut Bauen und Umwelt e.V. (IBU), 2021, www.bau-umwelt.de, Version 1.2, 01/08/2021

PCR, Part B
Requirements on the EPD for Structural steels – Institut Bauen und Umwelt e.V., Königswinter (pub.): From the range of Environmental Product Declarations of Institute Construction and Environment e.V. (IBU), Version 4, 01/08/2021 (PCR checked and approved by the SVR)

PhD Siebers
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Peißker 2016
Peißker, P und Huckshold, M. (2016): Handbuch Feuerverzinken. 4. vollständig überarbeitete und erweiterte Auflage, Wiley-VCH, ISBN 978-3-527-33767-5

Schröder 2013
Schröder, M.: Korrosionsbeständigkeit von diskontinuierlich und kontinuierlich verzinkten Schutzplanken, Vortrag anlässlich EGGA-Assembly, 10.-13. Juni 2013, Dresden

The literature referred to in the Environmental Product Declaration must be listed in full.Standards already fully quoted in the EPD do not need to be listed here again.
The current version of PCR Part A and PCR Part B of the PCR document on which they are based must be referenced.

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