ENVIRONMENTAL PRODUCT DECLARATION

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

Owner of the Declaration	
Programme holder	Institut Bauen und Umwelt e.V. (IBU)
Publisher	Institut Bauen und Umwelt e.V. (IBU)
Declaration number	EPD-ZIN-20210262-IBG1-EN
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Valid to	21.03.2027

duroZINQ® hot-dip galvanized steel

ZINQ Technologie GmbH

Institut Bauen und Umwelt e.V.

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ECO PLATFORM EPD EN 15804 VERIFIED

1. General Information

ZINQ Technologie GmbH	duroZINQ® hot-dip galvanized steel
Programme holder IBU – Institut Bauen und Umwelt e.V. Panoramastr. 1 10178 Berlin Germany	**Owner of the declaration** ZINQ Technologie GmbH An den Schleusen 6 45881 Gelsenkirchen Deutschland
Declaration number EPD-ZIN-20210262-IBG1-EN	**Declared product / declared unit** 1 t of duroZINQ® hot-dip galvanized structural steel
This declaration is based on the product category rules: Structural steels, 11.2017 (PCR checked and approved by the SVR)	**Scope:** This EPD refers to 1t of duroZINQ® hot-dip galvanized steel galvanized at facilities of the ZINQ® group (see www.zinq.com/standorte). Representative foreground data from five duroZINQ® hot-dip galvanizing plants collected by ZINQ Technologie GmbH and background data from the GaBi database was used to conduct the LCA study. The data were weighted according to the yearly production and the galvanized surface area of the products.
Issue date 22.03.2022	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*.
Valid to 21.03.2027	**Verification** The standard *EN 15804* serves as the core PCR Independent verification of the declaration and data according to *ISO 14025:2010* ☐ internally ☒ externally
Dipl. Ing. Hans Peters (chairman of Institut Bauen und Umwelt e.V.)	Matthias Klingler (Independent verifier)
Dr. Alexander Röder (Managing Director Institut Bauen und Umwelt e.V.))	

2. Product

2.1 Product description/Product definition

This EPD applies to 1 t (1000 kg) of duroZINQ® hot-dip galvanized structural steel which are products of ZINQ Technologie GmbH and applied for the purpose of corrosion protection of said steel components. Characteristics are:

- Hot-dip zinc coating according to *DIN EN ISO 1461* consisting of a zinc layer and intermetallic zinc-iron-phases as a result of the hot-dip galvanizing process
- Applied on steel components, e.g. hot-rolled sections or structures welded from heavy plates; a typical surface of such steel components per ton is 15 – 80 m², the average value resulting from the data gathered for this background reports is 40 m² per ton of product
- Typical zinc coating thickness is 60 – 200 µm, the average value resulting from the data gathered for this background report is 115.7 µm

The EPD covers steel products of the grades S235 to S960 rolled out to structural sections, merchant bars and heavy plates with the aforementioned zinc coating. The steel products are manufactured via Blast Furnace with Basic Oxygen Furnace (BF+BOF) and Electric Arc Furnace (EAF) routes according to the *EPD of Structural steel: Sections and plates*.

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: 2005* Hot rolled products of structural steels – Part 1: General technical delivery conditions and *EN ISO 1461:2009* Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods and the CE-marking.

For the application and use the respective national provisions apply.

2.2 Application

Structural steels are intended for bolted, welded or otherwise connected constructions of buildings or other load-bearing (support) structures but also for infrastructure components, commercial vehicle components and other structures. The zinc coatings applied to steel structures serve in particular the purpose of protecting these against corrosive and/or mechanical loading during the use phase. They thus are applied in steel applications where relevant corrosive loadings occur and appropriate protection against these is required to extend the service life of the steel components and ensure their functionality. Zinc coatings also serve additional purposes, such as optical design and improved fire protection.
Examples of hot-dip galvanized steel applications include:

- Single story buildings like industrial and storage halls
- Multi-storey buildings like offices, residential buildings, car parks and shops
- Bridges for different modes of transport like railway or roads
- Sub-structure of solar panels, scaffoldings or shelving systems
- crash barriers, sign posts and sign bridges

2.3 Technical Data

This EPD is valid for steel products of varied grades and different forms of delivery according to the *EPD of Structural steel: Sections and plates*.

Technical Data

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	48 - 58	W/(mK)
Melting point depending on the alloy up to	1536	°C

Performance data of the product 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: *ASTM A36, ASTM A283, ASTM A514, ASTM A572, ASTM A573, ASTM A588, ASTM A633, ASTM A709, ASTM A913, ASTM A992* and *ASTM A1066*.For the execution of steel structures *EN 1090* has to be taken into consideration. For hot-dip galvanizing *EN ISO 1461*, Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods has to be taken into consideration. Further relevant standards*: EN ISO 14713-1, EN ISO 14713-2, ASTM A123, ASTM A143, ASTM A153, ASTM A384, ASTM A385.*

2.4 Delivery status

The dimensions of the products declared in this EPD may vary depending on the intended application.

2.5 Base materials/Ancillary materials

One ton of the hot-dip galvanized structural steels covered in this EPD consist of 966.94 kg of structural steel according to the *EPD of Structural steel: Sections and plates* and 33.06 kg of protective zinc coating. The masses are based on the declared unit (40 m2 surface, 115.7 µm coating thickness).

Materials (zinc & auxiliaries) of the coating process:

- Primary and secondary (remelted) zinc and zinc alloys
- Industrial cleaner
- Degreaser
- Acid degreasing additives
- Wetting agents
- Pickling additives
- Hydrochloric acid
- Hydrogen peroxide
- Flux (Zinc chloride and Ammonium chloride)
- Passivation
- Binding wire

Hot-dip galvanized steel is not a substance or mixture under the chemical law (*REACH*). Nethertheless, the following declaration are given for duroZINQ hot-dip galvanized steel:

- This product/article/at least one partial article contains substances listed in the candidate list (date: 18.12.2019) exceeding 0.1 percentage by mass: no
- This product/article/at least one partial article contains other CMR substances in categories 1A or 1B which are not on the candidate list, exceeding 0.1 percentage by mass**:** no.
- Biocide products were added to this construction product or it has been treated with biocide products (this then concerns a treated product as defined by the (EU) Ordinance on Biocide Products No. 528/2012): no.

2.6 Manufacture

The manufacturing of structural steel refers to the *EPD of Structural steel: Sections and plates*.

In hot-dip galvanizing, the fully or semi-fabricated steel components are first cleaned using a wet-chemical pre-treatment and then coated by dipping them into the molten liquid zinc melt. This includes the use of natural gas to fire the molten zinc to ~450°C, ensuring a constant temperature and compensating for thermal losses, as well as the drying furnace. Electrical energy is used for the extraction system at the galvanizing kettel and for the cranes that move the galvanizing material through the process. For this purpose, racks, hooks, chains, wires and traverses are used in addition as auxiliary equipment.

2.7 Environment and health during manufacturing

During production, there are no special requirements for safety, environmental protection and health beyond

the legal requirements. Compliance with these requirements is verified in the course of duroZINQ® hot-dip galvanizing using management systems (*ISO 14001*, *ISO 45001* and *ISO 50001*). In addition, a complete assessment of all substances used in the process and duroZINQ® product, including an ABC-X analysis, was carried out as part of the *Cradle-to-Cradle certification* process (certification has been valid continuously since 2013).

2.8 Product processing/Installation

Processing recommendations:
Planning, processing, implementation and intended use of duroZINQ® hot-dip galvanized 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 *EN 1993* and *EN 1994* 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 *EN 1993* and composite steel and concrete structures *EN 1994*.
EN 1090-1 and *EN 1090-2* apply to the execution of steel structures and include the requirements for factory production control. In addition, these European Standards will work in connection with national amendments, national instructions, guidelines and publications, as well as legal provisions.
Regarding transport and storage of duroZINQ® hot-dip galvanized 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 e.g. regarding welding, bolting, hot and cold forming or assembly are to be observed in every case.

Occupational safety/Environmental protection:
When processing/using duroZINQ® hot-dip galvanized 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 duroZINQ® hot-dip galvanized steel sections and plates pursuant to the generally recognized rules of engineering does not release substantial environmental pollutants. Particular measures to protect the environment are not required.

Residual material:
During duroZINQ® hot-dip galvanizing as well as during processing of duroZINQ® hot-dip galvanized steel residual pieces as well as turnings are to be separately collected. Zinc-rich waste from the duroZINQ® hot-dip galvanizing process is treated and returned to the zinc cycle. duroZINQ® hot-dip galvanized scrap steel is entirely recycled by melting and producing new steel products.
Optionally, duroZINQ® hot-dip galvanized steel can be returned at its end of life to the ZINQ facility, where the duroZINQ® coating is removed and the zinc is reintroduced into the zinc cycle.

2.9 Packaging

No additional packaging is necessary since the duroZINQ® coating provides the protecting function of a package.

2.10 Condition of use

duroZINQ® hot-dip galvanized steel products are non-/low-alloyed steel products with a protective coating, which results from hot-dip galvanizing in a zinc melt of at least 98 mass% zinc, the rest being amounts of minor alloying elements such as aluminium or bismuth.
During use the zinc coatings undergo permanent reactions with its atmosphere, building a very resistant zinc carbonate layer (carbonisation). Under ongoing corrosive loading of the zinc coating the zinc corrodes and the layer becomes thinner over time. This process of zinc consumption or zinc loss takes place very slowly at a zinc corrosion rate. For an average corrosive atmosphere, the corrosion rate could be assumed to 1.3 µm/year according to *EN ISO 12944-2*.

2.11 Environment and health during use

The protective layer of the zinc coating (zinc carbonate, patina) formed naturally under the influence of air and moisture is very stable and not soluble in water (see 2.10) under consideration of today's strongly reduced air pollution (here especially the SO_2 concentration in the air) and proper application (no water drainage permanently provided by the design). The zinc ion runoff significantly depends on the load of "acidic" air pollutants, especially SO_2. As the SO_2 concentration in the air has decreased to one-fifth of previous levels over the past 30 years, there has also been a corresponding decrease in the zinc runoff and thus of the zinc concentration in precipitation water. The legal limits for the total concentration of zinc in drinking water are undercut. In water systems, only a small portion of the total zinc concentration is available to an organism; this amount is called the biologically available amount. It is related to the physicochemical conditions of the receiving water body. For example, bioavailability is affected by the amount of zinc that is organically or inorganically bound, bound to particles, or competing with other ions.
There are no known adverse effects on health when steel hot-dip galvanized with duroZINQ® is used as intended. Like iron, zinc is one of the metals essential for life. Zinc is not accumulated in the body. The zinc intake recommendation of the *German Nutrition Society (DGE)* is 15 mg daily.

2.12 Reference service life

Structural steel products are supposed to serve at least the lifetime of a building which is 50 years according to *EN 15978*. The technical service life of a galvanized steel product is determined by the time the protecting zinc coating stays on the steel to protect it from corrosion. At a rate of 1.3 µm per year (section 2.10) this leads to a technical service life of at least 89 years and therefore exceeds the 50 years lifetime of buildings.

2.13 Extraordinary effects

Fire
The material is class A1, i.e. not flammable per *EN 13501*.
Under fire load, the zinc coating has a positive effect on the steel structure in that it slows down its heating, which ensures the load-bearing capacity of the structure for a longer period of time compared to ungalvanized, unprotected steel.

When heated above 650°C, the thin zinc coating evaporates briefly as zinc oxide (ZnO), producing smoke. The ZnO smoke, inhaled over a longer period of time, can cause "zinc fever" (diarrhoea, fever, dry throat), which, however, disappears completely some days after inhalation.

Brandschutz

Name	Value
Building material class	A1

Water
Under the influence of water, no negative effects on the functional capability of duroZINQ hot-dip galvanized steel within the intended service life are to be expected - provided that it is used as intended.

Mechanical destruction
Due to the ductility of steel and the high mechanical resistance of the duroZINQ® hot-dip zinc coating, duroZINQ® hot-dip steel structures react resiliently in the event of unforeseeable mechanical destruction. In case of tensile load necking will occur before cracking. In case of lasting high compression load, components of duroZINQ® hot-dip galvanized steel may buckle or bulge. No splintering or breaking edges shall result.

2.14 Re-use phase
Steel sections and plates made of duroZINQ® hot-dip galvanized steels are recyclable to 100 % *EPD of Structural Steel: Sections and Plates*. Re-use takes place for around 11 % of the products while 88 % are recycled in a closed loop. Around 1 % can not be regained due to occurring losses. The zinc coating is carbonized over the lifetime of the steel structure.

2.15 Disposal
Due to its high value as a raw material, hot-dip galvanized steel scrap is not disposed of but recycled in a long-established cycle. Reaction products of the zinc coating with the atmosphere (zinc carbonate resulting from carbonization) are removed from the surface in very low concentrations over the lifespan of the steel product, but without known harm to the environment.
Waste code according to European Waste Catalogue *EWC*:
17 04 05 - iron and steel

2.16 Further information
Further information on duroZINQ® products can be obtained from www.zinq.com.

3. LCA: Calculation rules

3.1 Declared Unit
The declared unit is 1t (1000 kg) of hot-dip galvanized structural steel. Data from 5 representative duroZINQ® hot-dip galvanizing sites of the ZINQ® group (see www.zinq.com/standorte) has been used to declare a representative product (40 m^2 surface, 115.7 µm coating thickness), the total production in 2019 from the 5 sites has been weighted according to the galvanized surface and corrected by a factor to account for typical products of the respective site.

Declared Unit

Name	Value	Unit
Declared unit	1	t
Conversion factor to 1 kg (mass in kg per declared unit)	1000	-

3.2 System boundary
Type of the EPD: Cradle to gate with options, modules C1–C4, and module D.
Modules A1-A4, B1-B7, C1-C4 and D have been considered.

Module A1-A4 consider the following:
- Production of structural steel according to the *EPD of Structural Steel: Sections and Plates*,
- production of zinc and zinc alloy components,
- transport of the structural steel to the manufacturing sites,
- the galvanizing process, including all auxiliaries and the use of electricity and thermal energy,
- transport from the manufacturing sites to the construction site.

For the electricity consumption of the galvanizing process a renewable energy grid mix has been taken into account. The electricity usage of the production of steel, as well as module D refers to to the *EPD of Structural Steel: Sections and Plates*. Electricity credits of energy recovery inside the system boundaries have been accounted for using a German average grid mix. The proportion of green electricity demand for the galvanizing process is 100%. Therefore, no residual grid mix has been considered.

Module B1-B7 consider the following:
- Carbonisation of the Zinc coating during use of the product. This serves as a carbon dioxide sink. The calculation is based on the stoichiometric ratio lowered by an amount to account for real conditions,
- during intended use over the considered lifetime of hot-dip galvanized structural steels, no maintenance, replacement or refurbishment is needed. The products do not use energy or water.

Module C1-C4 consider the following:
- Deconstruction of structural steel,
- transport to the end-of-life,
- processing and disposal according to the *EPD of Structural Steel: Sections and Plates*.

Due to carbonisation, no remaining zinc must be considered.

Module D considers benefits and loads beyond the system boundary according to the *EPD of Structural Steel: Sections and Plates*.

3.3 Estimates and assumptions

Primary data was used to model all on-site processes of the hot-dip galvanizing process. Data were cross-checked to identify and eliminate data gaps. High-quality secondary data from the *GaBi database* was used to model upstream material and energy flows. Secondary data was as technologically and geographically representative as possible. Zn/Al master alloys, alloying elements and auxiliaries are considered using their material weights. Instead of primary data collection from suppliers to reflect specific brand products, datasets from the *GaBi database* for standard processing chemicals have been used.
For sludges, a solid waste content was assumed. This solid waste content is handled as hazardous waste with the respective treatment. Waste water and water content of the sludges are assumed to be treated in municipal waste water treatment. Other wastes are treated as commercial waste in a municipal waste incineration plant.

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. Data for the sites were cross-checked with one another to identify potential data gaps. No processes, materials or emissions that are known to make a significant contribution to the environmental impact of the products studied have been omitted. On this basis, there is no evidence to suggest that input or outputs contributing more than 1 % to the overall mass or energy of the system or that are environmentally significant have been omitted. It can be assumed, that all excluded flows contribute less than 5 % to the impact assessment categories.
Production of capital equipment, facilities and infrastructure required for manufacture are outside the scope of this assessment.
Transport of base materials with low shares in the composition are neglected.

3.5 Background data

The LCA model is created using the *GaBi Software* system for life cycle engineering, developed by Sphera Solutions GmbH. The *GaBi database* provides the life cycle inventory data for several of the raw and process materials obtained from the background system. The most recent of the database was 2020.

3.6 Data quality

The foreground data collected by ZINQ Technologie GmbH are based on yearly production amounts in productions plants.
All relevant background datasets are taken from the *GaBi database*. The study is based on high quality data.

3.7 Period under review

The foreground data collected by ZINQ Technologie GmbH are based on yearly production amounts in productions plants. The production data refer to an average of the year 2019.

3.8 Allocation

Allocation for the structural steel is done according to the *EPD of Structural Steel: Sections and Plates*. The hot-dip galvanizing process does not deliver any co-products. The applied model does not contain any allocation.

3.9 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 *GaBi database* provides the life cycle inventory data for several of the raw and process materials obtained from the background system. The most recent of the database was 2020.

4. LCA: Scenarios and additional technical information

Characteristic product properties
Information on biogenic Carbon

The production of the steel refers to the *EPD of Structural Steel: Sections and Plates*.
Information for the scenario used is given in the following tables. Information regarding the service life is given in section 2.12.

Transport to Construction site (A4)

Name	Value	Unit
Transport distance	100	km
Capacity utilisation (including empty runs)	61	%

Ende des Lebenswegs (C1-C4)

Name	Value	Unit
Reuse	106	kg
Recycling	851	kg
Energy recovery	0	kg
Landfilling	9.67	kg

5. LCA: Results

In Table 1 "Description of the system boundary", all declared modules shall be indicated with an "X"; all modules that are not declared shall be indicated with "MND" (As default the modules B3, B4, B5 are marked as MNR – module not relevant). In the following tables, columns can be deleted for modules that are not declared. Indicator values should be declared with three valid digits (eventually using exponential form (e.g. 1,23E-5 = 0,0000123). A uniform format should be used for all values of one indicator.
If several modules are not declared and therefore have been deleted from the table, the abbreviations for the indicators can be replaced by the complete names, while the readability and clear arrangement should be maintained; the legends can then be deleted.
If due to relevant data gaps, an indicator cannot be declared in a robust way, then the abbreviation “IND” (indicator not declared) should be used for this indicator.

- 0 – calculated value is 0
- 0 – value falls under the cut-off
- 0 – assumption which exclude any flows (e.g. exported electricity A1-A3)
- IND – in cases where the inventory does not support the methodological approach or the calculation of the specific indicator IND shall be used.

If no reference service life is declared (see chapter 2.13 "Reference Service Life"), the LCA results of the modules B1-B2 and B6-B7 shall refer to a period of one year. This shall then be indicated as an explanatory text below the tables. In addition, the formula for the quantification of such B-modules over the total life cycle shall be provided.

Disclaimer:
EP-freshwater: This indicator has been calculated as “kg P eq” as required in the characterization model (EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe; http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml).

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; ND = 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	X	ND	X	X	X	X	X	X	X	X	X	X	X	X

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT according to EN 15804+A2: 1 t duroZINQ® hot-dip galvanized steel

Core Indicator	Unit	A1	A2	A3	A4	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
GWP-total	[kg CO_2-Eq.]	1.26E+3	2.91E+1	8.12E+1	6.03E+0	-7.39E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.09E+1	2.91E+0	1.73E+0	0.00E+0	-3.68E+2
GWP-fossil	[kg CO_2-Eq.]	1.25E+3	2.90E+1	8.07E+1	5.99E+0	-7.39E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.08E+1	2.90E+0	1.74E+0	0.00E+0	-3.67E+2
GWP-biogenic	[kg CO_2-Eq.]	6.78E+0	0.00E+0	4.41E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	3.60E-2	0.00E+0	-1.35E-2	0.00E+0	-3.59E-1
GWP-luluc	[kg CO_2-Eq.]	3.51E-1	2.35E-1	3.01E-2	4.86E-2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.57E-2	2.35E-2	3.13E-3	0.00E+0	-2.93E-2
ODP	[kg CFC11-Eq.]	-3.46E-7	3.49E-15	5.25E-8	7.21E-16	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.38E-13	3.49E-16	3.22E-14	0.00E+0	2.74E-13
AP	[mol H^+-Eq.]	3.73E+0	2.98E-2	-3.25E-2	6.16E-3	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.39E-2	2.98E-3	4.97E-3	0.00E+0	-8.46E-1
EP-freshwater	[kg P-Eq.]	6.66E-4	8.82E-5	6.57E-5	1.82E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.89E-5	8.82E-6	4.42E-6	0.00E+0	-1.87E-4
EP-marine	[kg N-Eq.]	9.47E-1	8.67E-3	-1.39E-2	1.79E-3	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	5.30E-3	8.67E-4	1.32E-3	0.00E+0	-1.69E-1
EP-terrestrial	[mol N-Eq.]	1.03E+1	1.04E-1	-1.38E-1	2.16E-2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	5.57E-2	1.04E-2	1.42E-2	0.00E+0	-1.77E+0
POCP	[kg NMVOC-Eq.]	3.00E+0	2.41E-2	7.89E-2	4.98E-3	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.45E-2	2.41E-3	3.73E-3	0.00E+0	-6.48E-1
ADPE	[kg Sb-Eq.]	1.80E-2	2.08E-6	-2.54E-3	4.30E-7	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	3.13E-6	2.08E-7	4.42E-7	0.00E+0	-3.94E-3
ADPF	[MJ]	1.33E+4	3.86E+2	1.31E+3	7.99E+1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.90E+2	3.86E+1	2.92E+1	0.00E+0	-3.42E+3
WDP	[m^3 world-Eq deprived]	1.38E+3	2.59E-1	-1.85E+2	5.37E-2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.36E+0	2.59E-2	3.29E-1	0.00E+0	-3.27E+1

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

RESULTS OF THE LCA - INDICATORS TO DESCRIBE RESOURCE USE according to EN 15804+A2: 1 t duroZINQ® hot-dip galvanized steel

Indicator	Unit	A1	A2	A3	A4	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
PERE	[MJ]	1550.00	21.70	399.00	4.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	84.30	2.17	11.60	0.00	37.30
PERM	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PERT	[MJ]	1550.00	21.70	399.00	4.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	84.30	2.17	11.60	0.00	37.30
PENRE	[MJ]	13300.00	387.00	1310.00	80.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	190.00	38.70	29.20	0.00	-3420.00
PENRM	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PENRT	[MJ]	13300.00	387.00	1310.00	80.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	190.00	38.70	29.20	0.00	-3420.00
SM	[kg]	800.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FW	[m^3]	32.50	0.03	-4.22	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.01	0.00	-0.80

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

RESULTS OF THE LCA – WASTE CATEGORIES AND OUTPUT FLOWS according to EN 15804+A2: 1 t duroZINQ® hot-dip galvanized steel

Indicator	Unit	A1	A2	A3	A4	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
HWD	[kg]	3.52E-4	1.80E-5	-3.31E-5	3.72E-6	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	7.87E-8	1.80E-6	1.14E-7	0.00E+0	-2.67E-4
NHWD	[kg]	17.50	0.06	0.52	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.01	9.70	0.00	24.40
RWD	[kg]	6.36E-1	4.79E-4	-6.39E-3	9.90E-5	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.88E-2	4.79E-5	3.86E-3	0.00E+0	-5.85E-2
CRU	[kg]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	106.00	0.00	0.00
MFR	[kg]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	851.00	0.00	0.00
MER	[kg]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EEE	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EET	[MJ]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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

RESULTS OF THE LCA – additional impact categories according to EN 15804+A2-optional: 1 t duroZINQ® hot-dip galvanized steel

Indicator	Unit	A1	A2	A3	A4	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
PM	[Disease Incidence]	4.19E-5	1.77E-7	-1.41E-6	3.67E-8	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.00E-7	1.77E-8	4.87E-8	0.00E+0	-1.10E-5
IRP	[kBq U235-Eq.]	1.13E+2	6.92E-2	-9.85E-1	1.43E-2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	4.73E+0	6.92E-3	6.32E-1	0.00E+0	-6.61E+0
ETP-fw	[CTUe]	2.14E+4	2.73E+2	-2.49E+3	5.65E+1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	8.13E+1	2.73E+1	1.36E+1	0.00E+0	-3.04E+2
HTP-c	[CTUh]	7.45E-7	5.72E-9	-7.31E-8	1.18E-9	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	2.25E-9	5.72E-10	5.01E-10	0.00E+0	6.45E-8
HTP-nc	[CTUh]	4.65E-5	2.95E-7	-1.00E-6	6.10E-8	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	8.27E-8	2.95E-8	3.10E-8	0.00E+0	-4.22E-6
SQP	[-]	8.04E+2	1.36E+2	7.06E+1	2.80E+1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	6.05E+1	1.36E+1	9.08E+0	0.00E+0	-3.22E+1

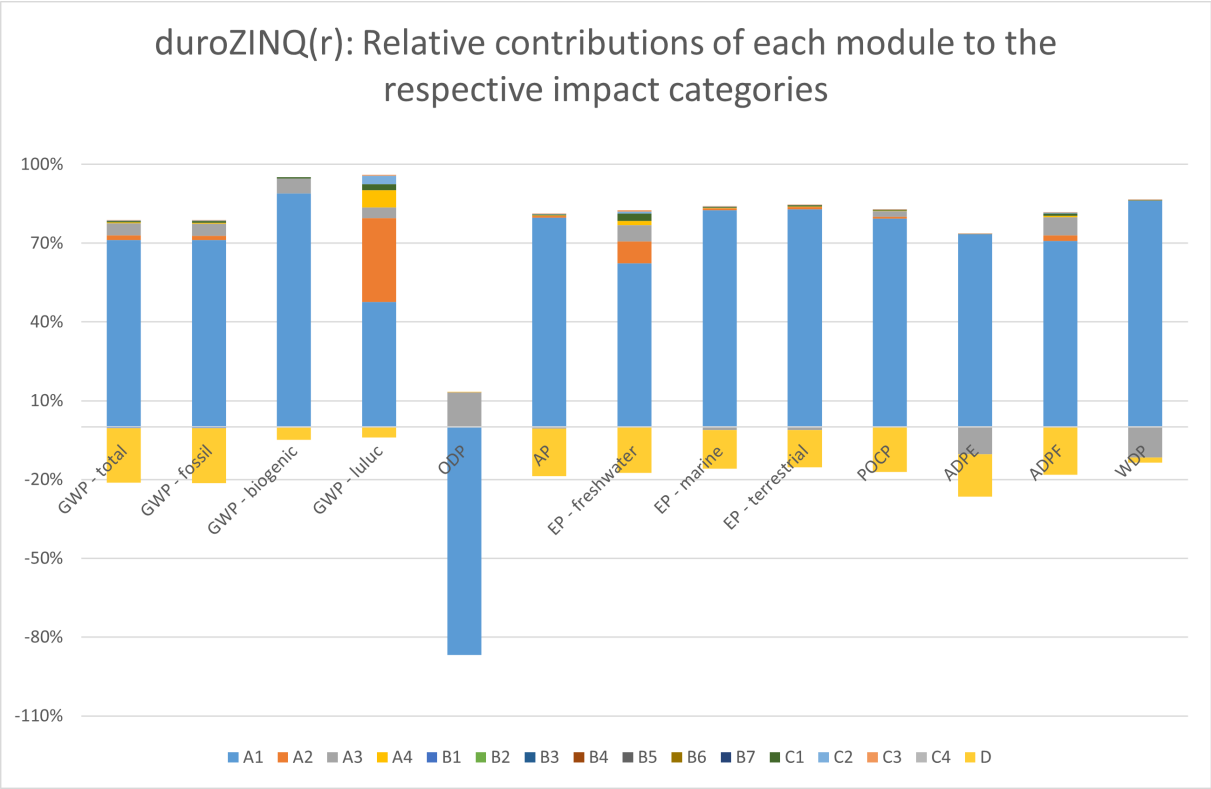
Caption	PM = Potential incidence of disease due to PM emissions; IR = Potential Human exposure efficiency relative to U235; ETP-fw = Potential comparative Toxic Unit for ecosystems; HTP-c = Potential comparative Toxic Unit for humans (cancerogenic); HTP-nc = Potential comparative Toxic Unit for humans (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 nor 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 fossil resources”, “abiotic depletion potential for non-fossil resources”, “water (user) deprivation potential”, “deprivation-weighted water consumption”, “potential comparative toxic unit for ecosystems”, “potential comparative toxic unit for humans - cancer effects”, “potential comparative toxic unit for humans – non-cancer effects”, “potential soil quality index”.
The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

6. LCA: Interpretation

The interpretation of this EPD highlights the contribution of the hot-dip galvanizing process in the environmental impact of 1 t of duroZINQ® hot-dip galvanized steel. While the highest share of impacts as for a hot-dip galvanized product is related to the production of the structural steel as part of Module A1, this refers to the *EPD of Structural Steel: Sections and Plates*. The potential benefits in module D are exclusively attributable to the steel. Additionally, the use phase serves as a sink for CO_2 due to carbonization of the zinc coating. The following graph shows the relative contribution of each module for the different impact categories.
Negative contributions of module A3 (the hot-dip galvanizing process) for ADPE and WDP are linked to the recovery of high-value zinc, a sulphidic ore, using a rotary kiln while the upstream of zinc is part of module A1. This results in a net negative value of module A3 for impact categories linked to the mining of zinc.
The results show a similar trend to GWP for most of the impact categories Module A1 is linked to the highest impacts and module D offers benefits to reuse and recycling of the structural steel.



7. Requisite evidence

7.1 Weathering performance
The corrosion rate of zinc depends on the position of the component and the conditions of the surrounding atmosphere (corrosivity categories according to *EN ISO 12944-2*). For corrosivity category C3, which according to this standard is characteristic of an urban and industrial atmosphere with moderate sulfur dioxide load and a coastal atmosphere with low salt load and thus corresponds to the typical corrosive load of steel structures, the corrosion rate is assumed to be 1.3 µm/year.

8. References

Standards

ASTM A36
ASTM A36 / A36M: 2019 Standard Specification for Carbon Structural Steel

ASTM A123
ASTM A123 / A123M: 2017 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A143
ASTM A143 / A143M: 2020 Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

ASTM A153
ASTM A153 / A153M: 2016 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A283
ASTM A283 / A283M: 2018 Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

ASTM A384
ASTM A384 / A384M: 2019 Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies

ASTM A385
ASTM A385 / A385M: 2020 Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)

ASTM A514
ASTM A514 / A514M: 2018 Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate

ASTM A572
ASTM A572 / A572M: 2021 Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

ASTM A573
ASTM A573 / A573M: 2020 Standard Specification for Structural Carbon Steel Plates

ASTM A588
ASTM A588 / A588M: 2019 Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance

ASTM A633
ASTM A633 / A633M: 2018 Standard Specification for Normalized High-Strength Low-Alloy Structural Steel Plates

ASTM A709
ASTM A709 / A709M: 2018 Standard Specification for Structural Steel for Bridges

ASTM A913
ASTM A913 / A913M: 2019 Standard Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)

ASTM A992
ASTM A992 / A992M: 2020 Standard Specification for Structural Steel Shapes

ASTM A1066
ASTM A1066 / A1066M: 2015 Standard Specification for High-Strength Low-Alloy Structural Steel Plate Produced by Thermo-Mechanical Controlled Process (TMCP)

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

EN 1090-1
EN 1090-1:2012 Execution of steel structures and aluminium structures - Part 1: Requirements for conformity assessment of structural components

EN 1090-2
EN 1090-2:2018 Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures

EN ISO 1461
EN ISO 1461:2009 Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods

EN 1993
EN 1993 Eurocode 3 - Design of steel structures

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

EN 10025
EN 10025 Hot rolled products of structural steel

EN 10025-1
EN 10025-1: 2005 Hot rolled products of structural steels – Part 1: General technical delivery conditions

EN 13501
BS EN 13501-1:2018 Fire classification of construction products and building elements Classification using data from reaction to fire tests

EN 14025
DIN EN ISO 14025:2010 Environmental labels and declarations. Type III environmental declarations. Principles and procedures

EN ISO 14713-1
EN ISO 14713-1: 2017 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 ISO 14713-2
EN ISO 14713-2:2020 Zinc coatings - Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 2: Hot dip galvanizing

EN 15804
EN 15804+A2 Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products

EN 15978
DIN EN 15978
Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method

ISO 14001
ISO 14001:2015 Environmental management systems - Requirements with guidance for use

ISO 45001
ISO 45001: 2018 Occupational health and safety management systems - Requirements with guidance for use

ISO 50001
ISO 5001:2018 Energy management systems - Requirements with guidance for use

Further references

CPR
Regulation (EU) No 305/2011: Harmonised conditions for the marketing of construction products, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32011R0305

Cradle-to-Cradle Certification
Guidance for the Cradle to Cradle Certified™ Product Standard, Cradle to Cradle Products Innovation Institute www.c2ccertified.com

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German Nutrition Society / Deutsche Gesellschaft für Ernäherung e.V. (DGE), reference values for Nutrient intake, www.dge.de

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Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report according to EN 15804+A2:2. *Institut Bauen und Umwelt e.V.* (IBU). November 2021. www.ibu-epd.com

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