Environmental Product Declaration (EPD)
According to ISO 14025 and EN 15804+A2:2019

BOFS - Basic Oxygen Furnace Slag

Registration number:	EPD-Kiwa-EE-191090-EN
Issue date:	21-08-2025
Valid until:	21-08-2030
Declaration owner:	Hüttenwerke Krupp Mannesmann GmbH
Publisher:	Kiwa-Ecobility Experts
Programme operator:	Kiwa-Ecobility Experts
Status:	verified

1 General information

1.1 PRODUCT

BOFS - Basic Oxygen Furnace Slag

1.2 REGISTRATION NUMBER

EPD-Kiwa-EE-191090-EN

1.3 VALIDITY

Issue date: 21-08-2025

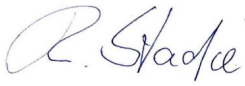
Valid until: 21-08-2030

1.4 PROGRAMME OPERATOR

Kiwa-Ecobility Experts
Wattstraße 11-13
13355 Berlin
DE

Raoul Mancke

(Head of programme operations, Kiwa-Ecobility Experts)



Dr. Ronny Stadie

(Verification body, Kiwa-Ecobility Experts)

1.5 OWNER OF THE DECLARATION

Declaration owner: Hüttenwerke Krupp Mannesmann GmbH

Address: Ehinger Straße 200, 47259 Duisburg, Germany

E-mail: marten.sprecher@hkm.de

Website: https://www.hkm.de

Production location: Duisburg

Address production location: Ehinger Straße 299, 47259 Duisburg, Germany

1.6 VERIFICATION OF THE DECLARATION

The independent verification is in accordance with the ISO 14025:2011. The LCA is in compliance with ISO 14040:2006 and ISO 14044:2006. The EN 15804+A2:2019 serves as the core PCR.

☐ Internal ☒ External

Gaurav Das, Freelancer

1.7 STATEMENTS

The owner of this EPD shall be liable for the underlying information and evidence. The programme operator Kiwa-Ecobility Experts shall not be liable with respect to manufacturer data, life cycle assessment data and evidence.

1.8 PRODUCT CATEGORY RULES

Kiwa-Ecobility Experts, General Programme Instructions “Product Level”, SOP EE 1203_R. 3.0 (27.02.2025)

Kiwa-Ecobility Experts, General Programme Instructions “Product Level” – Annex B1 Environmental Information Programme according to EN 15804 / ISO 21930, SOP EE 1203_R. 3.0 (27.02.2025)

1 General information

1.9 COMPARABILITY

In principle, a comparison or assessment of the environmental impacts of different products is only possible if they have been prepared in accordance with EN 15804+A2:2019. For the evaluation of the comparability, the following aspects have to be considered in particular: PCR used, functional or declared unit, geographical reference, the definition of the system boundary, declared modules, data selection (primary or secondary data, background database, data quality), scenarios used for use and disposal phases, and the life cycle inventory (data collection, calculation methods, allocations, validity period). PCRs and general program instructions of different EPD program operators may differ. Comparability needs to be evaluated. For further guidance, see EN 15804+A2:2019 and ISO 14025.

1.10 CALCULATION BASIS

LCA method R<THINK: Ecobility Experts | EN15804+A2

LCA software*: Simapro 9.6

Characterization method: RETHINK characterization method (see references for more details)

LCA database profiles: ecoinvent (for version see references)

Version database: v3.19 (20250306)

** Simapro is used for calculating the characterized results of the Environmental profiles within R<THINK.*

1.11 LCA BACKGROUND REPORT

This EPD is generated on the basis of the LCA background report 'BOFS - Basic Oxygen Furnace Slag' with the calculation identifier ReTHiNK-91090.

2 Product

2.1 PRODUCT DESCRIPTION

This specific EPD covers Linz-Donawitz process slag (BOFS), a by-product generated during the conversion of pig iron into crude steel. As a metallurgically inherent material, BOFS is an unavoidable part of the steelmaking process.

Due to its defined chemical composition—primarily consisting of iron oxide, calcium oxide, and silicon dioxide—BOFS is particularly well-suited as a high-quality secondary raw material for road construction.

When used as aggregate in various construction applications, BOFS is processed under quality-controlled conditions in accordance with the requirements of the relevant harmonized European standards:

- EN 13043 – Aggregates for bituminous mixtures and surface treatments for roads, airfields, and other trafficked areas
- EN 13242 – Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
- EN 13383 - Armourstones

The specific use of the product is subject to the respective national legal regulations at the place of use, particularly with regard to environmental compatibility, installation classes, and approval procedures.

2.2 REFERENCE SERVICE LIFE

RSL PRODUCT

The RSL is filled in because the R<THINK system requires it. The RSL is not relevant for this study. It was added only for technical reasons and does not affect the results.

USED RSL (YR) IN THIS LCA CALCULATION:

50

2.3 TECHNICAL DATA

BOFS consists predominantly of oxidic components, particularly iron oxide (Fe_2O_3), calcium oxide (CaO), and silicon dioxide (SiO_2). These are complemented by smaller proportions of aluminium oxide (Al_2O_3), magnesium oxide (MgO), and other trace elements.
The composition results from the metallurgical process in the LD converter and is characterized by a crystalline structure with high mechanical strength.

BOFS can be recycled and reused for the same purpose after excavation, crushing and screening.

According to the German Substitute Building Materials Ordinance (EBV), BOFS is classified as SWS 1.

- pH value: 9–13
- Electrical conductivity (µS/cm): < 10,000
- F (mg/l): < 1.1
- Cr (µg/l): < 110
- Mo (µg/l): < 55
- V (µg/l): < 180

Chemical compound	Average Value [%]
Fe total	19
CaO	47
SiO_2	12
MgO	2
Al_2O_3	1.6

2.4 SUBSTANCES OF VERY HIGH CONCERN

According to Regulation (EC) No. 1907/2006 (REACH),
LD slag does not contain any substances listed on the Candidate List of Substances of Very High Concern (SVHC) published by the European Chemicals Agency (ECHA) in quantities requiring declaration.

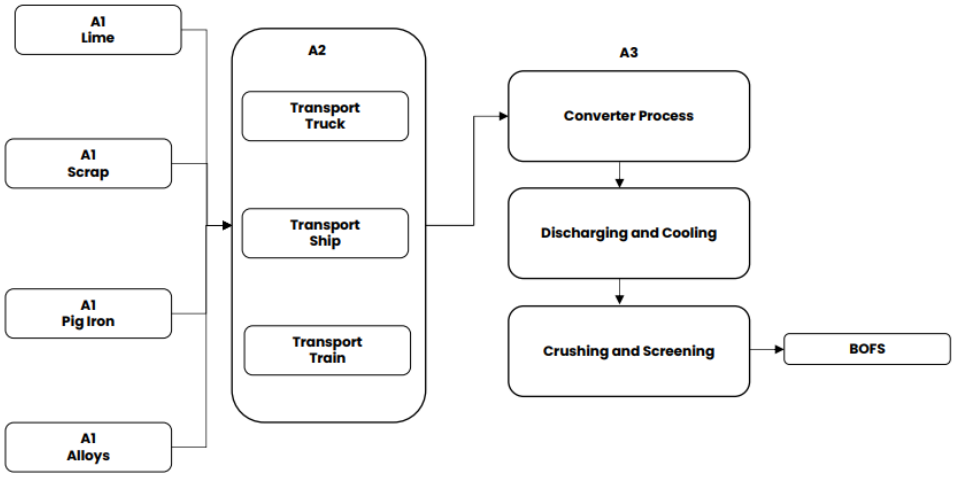
- EINECS No.: 294-409-3
- CAS No.: 91722-09-7
- Substance name: Slags, steelmaking, converter

2.5 DESCRIPTION PRODUCTION PROCESS

In the LD process, molten pig iron is converted into crude steel in the converter. During this process, BOFS continuously forms as a separate liquid phase, which is separated from the steel.

After separation, the slag is cooled and processed. The resulting material is primarily used in the field of road construction.

2 Product


A1
Lime
A1
Scrap
A1
Pig Iron
A1
Alloys
A2
Transport
Truck
Transport
Ship
Transport
Train
A3
Converter Process
Discharging and Cooling
Crushing and Screening
BOFS

3 Calculation rules

3.1 DECLARED UNIT

1 tonne (t)

The declared unit is 1 tonne of basic oxygen furnace slag (BOFS) at the factory gate, generated during the production of crude steel.
This is a specific EPD, reflecting average production data and conditions.

Reference unit: ton (ton)

3.2 CONVERSION FACTORS

Description	Value	Unit
Reference unit	1	ton
Weight per reference unit	1000.000	kg
Conversion factor to 1 kg	0.001000	ton

3.3 SCOPE OF DECLARATION AND SYSTEM BOUNDARIES

This is a Cradle to gate EPD. The life cycle stages included are as shown below:

(X = module included, ND = module not declared)

A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

The modules of the EN 15804 contain the following:

Module A1 = Raw material supply	Module B5 = Refurbishment
Module A2 = Transport	Module B6 = Operational energy use
Module A3 = Manufacturing	Module B7 = Operational water use
Module A4 = Transport	Module C1 = De-construction / Demolition
Module A5 = Construction - Installation process	Module C2 = Transport
Module B1 = Use	Module C3 = Waste Processing
Module B2 = Maintenance	Module C4 = Disposal
Module B3 = Repair	Module D = Benefits and loads beyond the product system boundaries
Module B4 = Replacement	

3.4 REPRESENTATIVENESS

This EPD is specific for BOFS, a product of HKM. The results of this EPD are representative for Germany.

3.5 CUT-OFF CRITERIA

Product stage (A1-A3)

All input flows (e.g. raw materials, transportation, energy use, packaging, etc.) and output flows (e.g. production waste) are considered in this LCA. The total neglected input flows do therefore not exceed the limit of 5% of energy use and mass.

3 Calculation rules

3.6 ALLOCATION

This EPD is based on the same production process as the EPD for crude steel (see EPD-Kiwa-EE-211782-EN). The environmental impacts were allocated based on economic value. The share attributed to the slag amounts to 0.0046% of the market value, based on the average market prices at HKM for the year 2023.

3.7 DATA COLLECTION & REFERENCE PERIOD

All primary data were collected during the accounting period (01.01.2023 – 31.12.2023).

All secondary data were selected with a geographical reference to Germany whenever possible.

If datasets with a reference to Germany were not available, datasets were chosen based on the following geographical scope, in descending order: Europe, Global.

3.8 ESTIMATES AND ASSUMPTIONS

For BOFS, only modules A1–A3 are declared since the material is integrated into other construction products (e.g., cement, concrete) and cannot be physically separated or identified at end of life.

3.9 DATA QUALITY

The primary data represent iron and steel production in Germany.

The quality level of geographical representativity can be considered “good,” the quality level of technical representativity can be considered “good,” and the temporal representativity can also be considered “good.” Therefore, the overall data quality for this EPD can be classified as “good.”

To ensure comparability of results, only consistent background data from the ecoinvent database version 3.9.1 was used in the life cycle assessment (e.g. datasets for energy, transport, auxiliary and operating materials), which refer to the reference year 2022. The database is regularly reviewed and thus meets the requirements of EN 15804 (background data not older than 10 years). All consistent datasets contained in the ecoinvent database are documented and can be accessed in the ecoinvent online documentation.

3.10 POWER MIX

The electricity used in the production process is generated on-site from process gases and natural gas. Since emissions from these fuels are directly included in the LCA model, electricity is not modeled as a separate input. As such, no standalone emission factor is assigned to electricity within the life cycle model. A calculated average emission factor of 0.35 kg CO_2e/kWh, based on internal fuel use and power generation, is documented in the background report for information purposes only.

4 Scenarios and additional technical information

5 Results

For the impact assessment long-term emissions (>100 years) are not considered. The results of the impact assessment are only relative statements that do not make any statements about end-points of the impact categories, exceedance of threshold values, safety margins or risks. The following tables show the results of the indicators of the impact assessment, of the use of resources as well as of waste and other output flows.

5.1 ENVIRONMENTAL IMPACT INDICATORS PER TON

CORE ENVIRONMENTAL IMPACT INDICATORS EN 15804+A2

Abbr.	Unit	A1	A2	A3	A1-A3
GWP-total	kg CO_2 eq.	2.17E-2	1.15E-2	2.45E+0	2.48E+0
GWP-f	kg CO_2 eq.	2.17E-2	1.15E-2	2.45E+0	2.48E+0
GWP-b	kg CO_2 eq.	1.04E-5	3.48E-6	5.46E-4	5.60E-4
GWP-luluc	kg CO_2 eq.	9.79E-6	1.40E-5	3.09E-4	3.33E-4
ODP	kg CFC 11 eq.	2.58E-10	1.76E-10	2.73E-8	2.78E-8
AP	mol H+ eq.	1.11E-4	2.71E-4	6.48E-3	6.86E-3
EP-fw	kg P eq.	1.26E-6	7.46E-8	1.20E-4	1.21E-4
EP-m	kg N eq.	2.88E-5	6.47E-5	1.26E-3	1.35E-3
EP-T	mol N eq.	3.33E-4	7.16E-4	1.46E-2	1.57E-2
POCP	kg NMVOC eq.	1.08E-4	1.99E-4	4.45E-3	4.75E-3
ADP-mm	kg Sb-eq.	8.69E-8	1.54E-8	1.28E-5	1.29E-5
ADP-f	MJ	8.56E-1	1.43E-1	3.69E+1	3.79E+1
WDP	m3 world eq.	6.22E-4	4.55E-4	1.36E-1	1.37E-1

GWP-total=Global Warming Potential total (GWP-total) | **GWP-f**=Global Warming Potential fossil fuels (GWP-fossil) | **GWP-b**=Global Warming Potential biogenic (GWP-biogenic) | **GWP-luluc**=Global Warming Potential land use and land use change (GWP-luluc) | **ODP**=Depletion potential of the stratosperic ozon layer (ODP) | **AP**=Acidification potential, Accumulated Exceedance (AP) | **EP-fw**=Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater) | **EP-m**=Eutrophication potential, fraction of nutrients reaching marine end compartment (EP-marine) | **EP-T**=Eutrophication potential, Accumulated Exceedance (EP-terrestrial) | **POCP**=Formation potential of tropospheric ozone (POCP) | **ADP-mm**=Abiotic depletion potential for non fossil resources (ADP mm) | **ADP-f**=Abiotic depletion for fossil resources potential (ADP fossil) | **WDP**=Water (user) deprication potential, deprivation-weighted water consumption (WDP)

5 Results

ADDITIONAL ENVIRONMENTAL IMPACT INDICATORS EN 15804+A2

Abbr.	Unit	A1	A2	A3	A1-A3
PM	disease incidence	9.83E-10	3.88E-10	2.23E-8	2.37E-8
IR	kBq U235 eq.	1.95E-4	6.02E-5	1.06E-1	1.07E-1
ETP-fw	CTUe	2.45E-1	7.18E-2	6.02E+0	6.34E+0
HTP-c	CTUh	1.74E-10	5.94E-12	5.98E-10	7.78E-10
HTP-nc	CTUh	1.09E-10	4.98E-11	2.98E-8	3.00E-8
SQP	Pt	1.13E-1	2.70E-2	3.15E+0	3.29E+0

PM=Potential incidence of disease due to PM emissions (PM) | **IR**=Potential Human exposure efficiency relative to U235 (IRP) | **ETP-fw**=Potential Comparative Toxic Unit for ecosystems (ETP-fw) | **HTP-c**=Potential Comparative Toxic Unit for humans (HTP-c) | **HTP-nc**=Potential Comparative Toxic Unit for humans (HTP-nc) | **SQP**=Potential soil quality idex (SQP)

CLASSIFICATION OF DISCLAIMERS TO THE DECLARATION OF CORE AND ADDITIONAL ENVIRONMENTAL IMPACT INDICATORS

ILCD classification	Indicator	Disclaimer
ILCD type / level 1	Global warming potential (GWP)	None
	Depletion potential of the stratospheric ozone layer (ODP)	None
	Potential incidence of disease due to PM emissions (PM)	None
ILCD type / level 2	Acidification potential, Accumulated Exceedance (AP)	None
	Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)	None
	Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	None
	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	None
	Formation potential of tropospheric ozone (POCP)	None
	Potential Human exposure efficiency relative to U235 (IRP)	1
ILCD type / level 3	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
	Abiotic depletion potential for fossil resources (ADP-fossil)	2
	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
	Potential Comparative Toxic Unit for humans (HTP-c)	2
	Potential Comparative Toxic Unit for humans (HTP-nc)	2

5 Results

ILCD classification	Indicator	Disclaimer
	Potential Soil quality index (SQP)	2

Disclaimer 1 – 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 due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.

Disclaimer 2 – 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 experienced with the indicator.

5.2 INDICATORS DESCRIBING RESOURCE USE AND ENVIRONMENTAL INFORMATION BASED ON LIFE CYCLE INVENTORY (LCI)

PARAMETERS DESCRIBING RESOURCE USE

Abbr.	Unit	A1	A2	A3	A1-A3
PERE	MJ	1.60E-2	1.90E-3	3.08E-1	3.26E-1
PERM	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
PERT	MJ	1.60E-2	1.90E-3	3.08E-1	3.26E-1
PENRE	MJ	8.56E-1	1.43E-1	3.69E+1	3.79E+1
PENRM	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
PENRT	MJ	8.56E-1	1.43E-1	3.69E+1	3.79E+1
SM	Kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
RSF	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
NRSF	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
FW	m^3	4.67E-5	1.72E-5	2.40E-2	2.41E-2

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**=Net use of fresh water

5 Results

OTHER ENVIRONMENTAL INFORMATION DESCRIBING WASTE CATEGORIES

Abbr.	Unit	A1	A2	A3	A1-A3
HWD	Kg	1.00E+3	7.32E-7	4.65E-5	1.00E+3
NHWD	Kg	9.31E-3	9.81E-4	1.06E-1	1.16E-1
RWD	Kg	1.34E-7	3.91E-8	1.42E-4	1.42E-4

HWD=Hazardous waste disposed | **NHWD**=Non-hazardous waste disposed | **RWD**=Radioactive waste disposed

ENVIRONMENTAL INFORMATION DESCRIBING OUTPUT FLOWS

Abbr.	Unit	A1	A2	A3	A1-A3
CRU	Kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
MFR	Kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
MER	Kg	0.00E+0	0.00E+0	0.00E+0	0.00E+0
EET	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0
EEE	MJ	0.00E+0	0.00E+0	0.00E+0	0.00E+0

CRU=Components for re-use | **MFR**=Materials for recycling | **MER**=Materials for energy recovery | **EET**=Exported Energy, Thermic | **EEE**=Exported Energy, Electric

5 Results

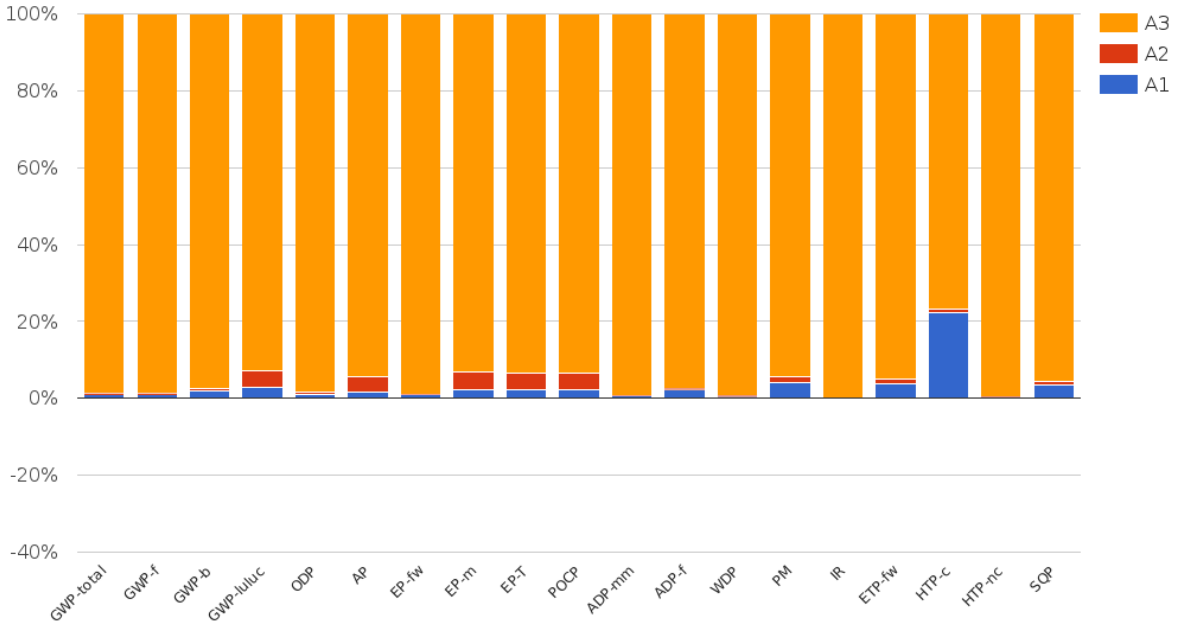
5.3 INFORMATION ON BIOGENIC CARBON CONTENT PER TON

BIOGENIC CARBON CONTENT

The following Information describes the biogenic carbon content in (the main parts of) the product at the factory gate per ton:

Biogenic carbon content	Amount	Unit
Biogenic carbon content in the product	0	kg C
Biogenic carbon content in accompanying packaging	0	kg C

6 Interpretation of results



The manufacturing stage (A3) is the most impactful, contributing approximately 97% of the total global warming potential (GWP). This is primarily due to the electricity demand used for granulation.

The total GWP (A1–A3) is 2.481 kg CO_2-equivalents, with nearly all of it attributable to energy use during manufacturing.

7 References

ISO 14040
ISO 14040:2006-10, Environmental management - Life cycle assessment - Principles and framework; EN ISO 14040:2006

ISO 14044
ISO 14044:2006-10, Environmental management - Life cycle assessment - Requirements and guidelines; EN ISO 14044:2006

ISO 14025
ISO 14025:2011-10, Environmental labels and declarations — Type III environmental declarations — Principles and procedures

EN 15804+A2
EN 15804:2012+A2:2019/AC:2021, Sustainability of Buildings - Environmental Product Declarations - Framework Development Rules by Product Category

Kiwa-EE GPI R.3.0
Kiwa-Ecobility Experts, General Programme Instructions “Product Level”, SOP EE 1203_R. 2.0 (27.02.2025)

Kiwa-EE GPI R.3.0 Annex B1
Kiwa-Ecobility Experts, General Programme Instructions “Product Level” – Annex B1 Environmental Information Programme according to EN 15804 / ISO 21930, SOP EE 1203_R. 2.0 (27.02.2025)

Ecoinvent
ecoinvent Version 3.9.1 (December 2022)

R<THINK characterization method
ecoinvent 3.9.1: EN 15804+A1 indicators (CML-IA Baseline v3.09), EN 15804+A2 indicators (EF 3.1)

EN 13043
DIN EN 13043:2002-12, Aggregates for bituminous mixtures and surface treatments for roads, airfields, and other trafficked areas

EN 13242
DIN EN 13242:2008-03, Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction

EN 13383
DIN EN 13383:2013-12, Armourstone – Part 1: Specifications

8 Contact information

Publisher	Operator	Owner of declaration

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