ENVIRONMENTAL PRODUCT DECLARATION

Aluminium Billet, **VERDEX**

Sistem Alüminyum Sanayi ve Ticaret A.Ş.

In accordance with ISO 14025 and EN 15804:2012+A2:2019/AC:2021

PROGRAMME

The International EPD® System, www.environdec.com

PROGRAMME OPERATOR

EPD International AB

LICENSEE

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Product not yet on the market – Results of this EPD shall be used with care as the LCI data is not yet based on 1 year of production which may result in increased uncertainty”

Programme Information

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Information about standards and reference PCR

CEN standard EN 15804 serves as the core Product Category Rules (PCR)

Product Category Rules (PCR):

PCR 2019:14 Construction products, version 1.3.4, Construction EN 15804:2012+A2:2019/AC:2021, Sustainability of Construction Works

UN CPC Code: 41532

Aluminium and aluminium alloy bars, rods, and profiles.

PCR review was conducted by: The Technical Committee of the International EPD® System. Review chair: Claudia A. Peña, University of Concepción, Chile. The review panel may be contacted via the Secretariat, www.environdec.com/contact.

EPDs within the same product category but registered in different EPD programmes may not be comparable. For two EPDs to be comparable, they must be based on the same PCR (including the same version number) or be based on fully-aligned PCRs or versions of PCRs; cover products with identical functions, technical performances and use (e.g. identical declared/functional units); have equivalent system boundaries and descriptions of data; apply equivalent data quality requirements, methods of data collection, and allocation methods; apply identical cut-off rules and impact assessment methods (including the same version of characterisation factors); have equivalent content declarations; and be valid at the time of comparison.

Verification

External and independent ('third-party') verification of the declaration and data, according to ISO 14025:2006, via

EPD verification through an individual EPD verification

Third party individual verifier: Vijay Thakur

Approved by: The International EPD® System

Procedure for follow-up of data during EPD validity involves third party verifier:

☑ Yes ☐ No

LCA Study & EPD Design

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www.metsims.com

LCA practitioners of the study: Yıldıray Yılmaz & Orhan Atacan, Metsims Sustainability Consulting

The EPD owner has the sole ownership, liability, and responsibility for the EPD.

Company Information

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With 30 years of experience and an innovative vision, Sistem Alüminyum is a fully integrated facility that includes foundry – aluminum billet, extrusion lines, electrostatic powder coating and anodizing facilities, a wood coating department, a mechanical processing facility, and composite panel production lines, starting from mold production. The facilities are established on an area of 330,000 square meters, 120,000 square meters of which is closed space, in Ergene, Tekirdağ.

At Sistem Alüminyum, production is carried out in two main product groups: aluminum extrusion profiles used in architectural and industrial sectors and aluminum composite panels for facade applications. In addition to these, as of 2021, the forging aluminum facility has also commenced operations. Sistem Alüminyum, which won the first prize in 2018, 2019, 2020, and 2022, and the second prize in 2023 at the İDDMİB 'Metallic Stars of Export' award ceremonies in the 'Aluminum Rods and Profiles' category with its export sales figures, exports to more than 75 countries across 4 continents. Ranked 247th in the Turkey's Top 500 Industrial Companies 2023 list compiled by the Istanbul Chamber of Industry (ISO), Sistem Alüminyum develops products and services for sectors such as construction, aviation, marine, automotive, white goods, electricity, and energy in its facilities with an annual production capacity of 103,000 tons of aluminum profiles.

Sistem Alüminyum, which holds certifications such as CE, TSE, QUALICOAT for electrostatic powder coating applications, and QUALANOD for anodizing applications, was included in the Turquality Brand Support program, a state-sponsored branding program, in 2024.

Additionally, the company holds prestigious certifications such as IATF 16949 (Automotive Quality Management System), AS9100 (Aviation, Space, and Defense Quality Management System), ISO 9001, ISO 14001, ISO 45001, ISO/IEC 27001 (Information Security Management System), and ISO 50001 (Energy Management System).

Product Information

Product Name:

Aluminium Billet, **VERDEX**

Production Location:

Ergene-1 OSB, Vakıflar OSB Mh. D100 Cd.No:13/1, 59930

Ergene/Tekirdağ/Türkiye

Aluminium Billet Production

The production of aluminium billets involves several key steps that utilize recycled aluminium scrap instead of primary aluminium derived from bauxite. This process is more energy-efficient and environmentally sustainable, as it significantly reduces the energy demand compared to primary production.

The process begins with the collection and sorting of aluminium scrap from various sources, such as industrial waste, discarded vehicle parts, and used packaging materials. The scrap is classified based on its alloy composition to ensure the final billet meets the required specifications. Contaminants like iron, plastic, and coatings are removed through mechanical and chemical separation techniques to improve the purity of the material.

Once sorted, the aluminium scrap is melted in a furnace, typically a reverberatory or rotary furnace, at temperatures between 660°C and 750°C. Fluxes may be added to remove impurities and oxides, ensuring a cleaner melt. A degassing process is also carried out to eliminate dissolved hydrogen, which could otherwise lead to porosity in the final billet.

After melting and refining, the molten aluminium is cast into billets using either a continuous casting process. Following casting, the billets undergo homogenization heat treatment to improve their mechanical properties and ensure consistency in composition. After cooling, they are cut to the required length and either stored for later use or sent for extrusion to be formed into various aluminium products.

VERDEX

VERDEX is a specialised type of aluminium billet designed to achieve a significantly lower environmental impact compared to conventional secondary aluminium billets. The key distinction lies in its material composition, as VERDEX billets incorporate a much higher proportion of post-consumer scrap aluminium, reducing the reliance on newly processed secondary aluminium. Additionally, the process integrates low-carbon primary materials, ensuring that any virgin aluminium used has minimal associated carbon emissions. By optimising the scrap sorting, refining, and melting processes, VERDEX achieves a lower carbon footprint while maintaining high mechanical performance and quality standards. This approach not only enhances resource efficiency but also aligns with circular economy principles, making it a preferred choice for industries prioritising sustainability, such as construction, automotive, and consumer goods manufacturing.

Product Information

Main technical and chemical specifications of the product are listed below.

Alloy	Diameter	Length	Ultrasonic Control	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
EN AW-6060	5", 6", 7", 8", 9", 10"	7000 mm	100%	0.3 - 0.6	0.1 - 0.3	0.1	0.1	0.35 - 0.6	0.05	0.15	0.1

This EPD is specific to VERDEX, a newly developed aluminium billet product by Sistem Alüminyum. Unlike conventional secondary billets, VERDEX stands out due to its exceptionally high use of post-consumer aluminium scrap and the incorporation of low-carbon primary aluminium, significantly lowering its environmental impact. VERDEX is not a mass-produced item; instead, it is manufactured exclusively based on demand, making it a specialized product within Sistem Alüminyum's portfolio. Consequently, this EPD is valid for one year, reflecting the product's unique production approach. The estimated annual production capacity for VERDEX is 15,000 tons.

The production process follows a similar approach to conventional secondary billet manufacturing, with key material inputs including aluminium ingots, scrap metals, and alloying elements. However, what differentiates VERDEX is its high proportion of post-consumer scrap, which constitutes approximately 86-87% of the furnace charge. This scrap is sourced from multiple suppliers and meets strict quality specifications, allowing it to be fed directly into the furnace without the need for additional processing. The environmental impacts associated with the remelting of post-consumer scrap are fully accounted for in this analysis.

While maximizing recycled content is a priority, technical constraints and the stringent requirements for billets used in extrusion processes prevent the use of 100% post-consumer scrap. To maintain the necessary material properties and performance, around 11% of the furnace charge consists of primary aluminium, such as ingots. Sistem Alüminyum carefully selects and monitors its primary aluminium suppliers, ensuring that the sourced materials align with its sustainability objectives and contribute to an overall lower carbon footprint.

It should be noted that the produced billets are intermediate products for profile manufacturing and are directly fed into the extrusion lines. As they require no packaging input, packaging is not declared.

Material	Weight (%)	Post-consumer material weight (%)	Biogenic material kg C / declared unit
Post consumer secondary ingots	86 - 87	100	0
Primary ingots	11 - 12	0	0
Alloying elements	1.5 - 2	0	0
Sum	**100**	**86 - 87**	**0**

LCA Information

Declared Unit

1 kg of aluminium billet, VERDEX.

System Boundary

Cradle to gate with options, modules C1–C4 and module D.

Cut-off Rules

The criteria for exclusion were set so that individual input flows less than 1% of the total, with a cumulative limit of less than 5%, could be omitted. This was contingent upon confirming that these excluded flows did not significantly alter the reported data, with "significant" defined as affecting the total by less than 5%.

REACH Regulation

No substances included in the Candidate List of Substances of Very High Concern for authorization under the REACH regulations are present in this product either above the threshold for registration with the European Chemicals Agency or above 0.1% (wt/wt).

Background Data

For all LCA modelling and calculation, Ecoinvent database (v3.10, EN15804 Method) and SimaPro (v9.6) LCA software were used. Characterization factors of EN 15804 reference package based on EF 3.1 are utilized. Impact of infrastructure and capital goods are excluded from the analysis. Relatively high values for waste outputs (HWD, NHWD) are mainly due to the use of Ecoinvent EN15804 method, which takes all the upstream wastes into consideration.

Period Under Review

The data used for the LCA study concerns the period between July 2024 to January 2025.

Source of Electricity

The modelled electricity data for the production of VERDEX is sourced from the ecoinvent 3.10 database, representing medium voltage electricity consumption with a carbon intensity of 0.575 kg CO_2 eq./kWh. The selected dataset reflects an electricity mix consisting of approximately 35% from hard coal and lignite, 29.2% from hydropower, 19.4% from natural gas, 9.4% from wind, 3.5% from geothermal, 1.2% from natural gas co-generation, 1.1% from biogas, and around 1.2% from various other sources

Allocations

The allocation is made in accordance with the directives of EN 15804+A2. Energy and resources are allocated to the aluminium billet production based on the mass. In addition, hazardous and non-hazardous waste amounts were also allocated from the total waste generation in 2023. For end of life calculation, Annex C version 2.1 (May 2020) of JRC report is utilized to determine the final fate (recycling, landfilling, incineration etc.) of materials and their percentages. Post-consumer scrap is a main input to the product system and its allocation is conducted based on the real data provided. In cases, where real data was not possible to obtain, conservation estimates are used.

Post-consumer scrap

The GWP-GHG intensity of the post-consumer scrap is 567 kg CO_2 eq./tonne.

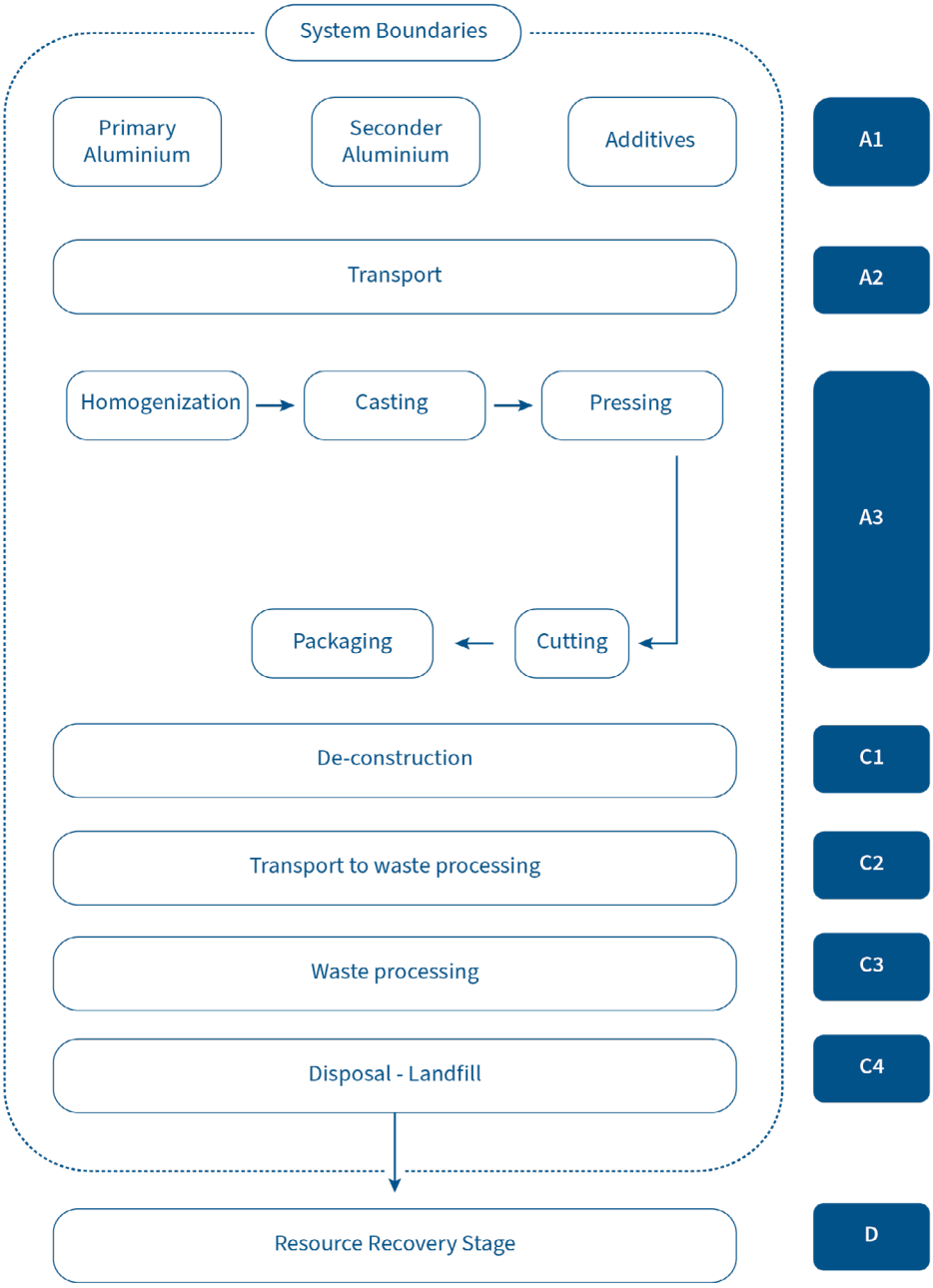
Assumptions

Upstream and downstream road transportation are assumed to be carried out with Euro5 motor vehicles with a size class of > 32 metric tonnes where distances acquired through Google Maps. In addition, 100 km distance for the waste transport at C2 stage is assumed.

	PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS & LOADS
	Raw Material Supply	Transport	Manufacturing	Transport	Construction Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	De-construction demolition	Transport	Waste Processing	Disposal	Recycling Potential
MODULES	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Modules Declared	X	X	X	ND	ND	ND	ND	ND	ND	ND	ND	ND	X	X	X	X	X
Geography	GLO	GLO	TR	-	-	-	-	-	-	-	-	-	GLO	GLO	GLO	GLO	GLO
Specific Data Used	17%			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Variation - Products	0%			-	-	-	-	-	-	-	-	-	-	-	-	-	-
Variation - Sites	0%			-	-	-	-	-	-	-	-	-	-	-	-	-	-

X = Module declared, ND = Not declared, TR = Türkiye, GLO = Global

System Diagram



System Diagram

A1 Raw Material Supply

This stage includes the sourcing and processing of raw materials used in billet production. The primary inputs consist of post-consumer scraps, supplemented by primary aluminium such as ingots. Scrap materials are collected, sorted, and prepared for remelting. The environmental impacts of raw material extraction, refining, and any necessary pre-treatment are accounted for in this stage.

A2 Transport

This phase covers the transportation of raw materials from suppliers to Sistem Alüminyum's production facility. Various transport modes, such as road and sea freight, are considered based on actual supplier locations. The analysis includes fuel consumption, emissions, and any associated logistics impacts.

A3 Manufacturing

The manufacturing stage includes the remelting, alloying, casting, and homogenization of aluminium billets. The scrap aluminium and primary materials are melted in a furnace, refined, and cast into billet form using direct-chill (DC) casting. The process is optimised to maximise post-consumer scrap use and reduce energy consumption. Electricity and natural gas consumption, process emissions, and auxiliary material usage (such as fluxes and degassing agents) are considered in this stage.

C1 Deconstruction/Demolition

The product is an intermediate material that is exclusively used for the production of aluminum profiles through extrusion. As a semi-finished product, it does not undergo any direct assembly or disassembly in its supplied form. This stage is highly dependent on project-specific conditions, including manual or mechanical dismantling methods, the type of structure, and the tools used for the end-product (profile). Therefore, a generic calculation following the JRC Technical Report of the European Commission is used.

C2 Transport

Following deconstruction, the aluminum components are transported to scrap collection and recycling facilities. The transportation process aligns with typical industry practices, with road transport as the primary mode. Fuel consumption and emissions for this phase are accounted for, based on an assumed transport distance of 100 km using a Euro 5 lorry.

C3 Waste Processing

At this stage, collected aluminum scraps undergo sorting, cleaning, and pre-treatment before re-entering the recycling loop. Due to aluminum's high recyclability without significant quality degradation, the majority of the material is expected to be re-melted and reused in secondary aluminum production. The environmental impacts of these recycling processes, including energy consumption and emissions, are accounted for in this phase. In line with the latest PEF Guidance of European Commission, 95% of the collected scraps—primarily sourced from buildings, such as doors and windows—are assumed to be recycled.

C4 Disposal

Due to mechanical separation losses, corrosion, contamination, and collection inefficiencies, 5% of the material is assumed to be lost during the end-of-life phase. This portion is considered non-recoverable and is ultimately disposed of as inert material in a landfill. The environmental impacts associated with this disposal are accounted for in this stage.

D Future reuse, recycling or energy recovery potentials

At the end of life, 95% of the aluminum is assumed to be collected and recycled. However, around 85 - 86% of the product already consists of post-consumer recycled content, only the remaining represents a net environmental benefit in Module D. This benefit is calculated based on the avoided environmental impact of producing primary aluminum, ensuring that double counting is avoided in accordance with EN 15804+A2 guidelines.

LCA Results

The estimated impact results are only relative statements, which do not indicate the endpoints of the impact categories, exceeding threshold values, safety margins and/or risks. The results of this EPD should not be used without the consideration of Module C.

Core environmental impact indicators (Mandatory)

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
GWP - Total	kg CO_2 eq.	2.88E+00	3.24E-02	1.96E-02	1.94E-01	2.56E-02	-7.63E-01
GWP - Fossil	kg CO_2 eq.	2.88E+00	3.24E-02	1.96E-02	1.92E-01	2.55E-02	-7.40E-01
GWP - Biogenic	kg CO_2 eq.	2.14E-03	3.50E-06	3.31E-06	1.34E-03	7.47E-05	-3.67E-03
GWP - Luluc	kg CO_2 eq.	1.93E-03	2.81E-06	7.77E-06	7.29E-05	3.17E-05	-1.87E-02
ODP	kg CFC-11 eq.	5.30E-08	4.95E-10	2.73E-10	6.52E-10	4.64E-10	-1.27E-08
AP	mol H+ eq.	1.15E-02	2.92E-04	6.52E-05	5.30E-04	1.47E-04	-4.93E-03
EP - Freshwater	kg P eq.	4.80E-04	9.43E-07	1.53E-06	3.65E-05	4.04E-06	-4.33E-04
EP - Marine	kg N eq.	1.85E-03	1.35E-04	2.11E-05	8.37E-05	6.29E-05	-6.26E-04
EP - Terrestrial	mol N eq.	1.94E-02	1.48E-03	2.30E-04	8.91E-04	5.56E-04	-6.03E-03
POCP	kg NMVOC	9.01E-03	4.42E-04	9.07E-05	2.87E-04	1.74E-04	-2.65E-03
*ADPE	kg Sb eq.	1.30E-05	1.13E-08	6.26E-08	2.50E-06	6.58E-08	-1.33E-06
*ADPF	MJ	3.72E+01	4.23E-01	2.74E-01	9.89E-01	4.31E-01	-1.16E+01
*WDP	m3 depriv.	7.19E-01	1.24E-03	1.50E-03	2.12E-02	-1.64E-01	-1.42E+00

Additional environmental impact indicators (Mandatory)

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
**GWP-GHG	kg CO_2 eq.	2.88E+00	3.24E-02	1.96E-02	1.94E-01	2.56E-02	-7.63E-01

Acronyms

GWP-total: Climate change, **GWP-fossil**: Climate change- fossil, **GWP-biogenic:** Climate change - biogenic, **GWP-luluc:** Climate change - land use and transformation, **ODP:** Ozone layer depletion, **AP:** Acidification terrestrial and freshwater, **EPfreshwater:** Eutrophication freshwater, **EP-marine:** Eutrophication marine, **EP-terrestrial:** Eutrophication terrestrial, **POCP:** Photochemical oxidation, **ADPE:** Abiotic depletion - elements, **ADPF:** Abiotic depletion - fossil resources, **WDP:** Water scarcity.

Legend

A1: Raw Material Supply, **A2**: Transport, **A3:** Manufacturing, **C1:** Demolition, **C2:** Waste Transport, **C3:** Waste Processing, **C4:** Disposal, **D:** Future reuse, recycling or energy recovery potentials.

LCA Results

Additional environmental impact indicators (Optional)

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
PM	disease inc.	1.22E-07	8.30E-09	1.55E-09	1.24E-08	2.70E-09	-5.90E-08
***IR	kBq U-235 eq.	2.99E-02	1.89E-04	2.25E-04	4.76E-03	9.48E-04	-2.14E-01
*ETP-FW	CTUe	7.21E+00	6.00E-02	7.31E-02	7.50E-01	1.76E+02	-2.40E+00
*HTP - C	CTUh	8.90E-09	1.26E-10	1.01E-10	6.95E-10	1.32E-10	-3.70E-09
*HTP - NC	CTUh	1.99E-08	5.74E-11	1.76E-10	2.42E-09	4.04E-09	-1.04E-08
*SQP	Pt	3.00E+00	2.97E-02	1.64E-01	2.66E-01	6.61E-01	-5.99E-01

Acronyms

PM: Respiratory inorganics - particulate matter, **IR:** Ionising radiation, **ETP-FW:** Ecotoxicity freshwater, **HTP-c:** Cancer human health effects, **HTP-nc:** Non-cancer human health effects, **SQP:** Land use related impacts, soil quality.

Indicators describing resource use (Mandatory)

Indicator	Unit	A1-A3	C1	C2	C3	C4	D
PERE	MJ	1.41E+00	2.59E-03	3.60E-03	1.04E-01	1.28E-02	-4.91E+00
PERM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	1.41E+00	2.59E-03	3.60E-03	1.04E-01	1.28E-02	-4.91E+00
PENRE	MJ	3.72E+01	4.23E-01	2.74E-01	9.92E-01	4.31E-01	-1.16E+01
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	3.72E+01	4.23E-01	2.74E-01	9.92E-01	4.31E-01	-1.16E+01
SM	kg	8.69E-01	1.76E-04	1.23E-04	5.10E-04	1.71E-04	-1.85E-03
RSF	MJ	6.44E-05	4.59E-07	1.57E-06	6.94E-06	2.37E-06	-1.43E-05
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	1.73E-02	3.03E-05	3.67E-05	5.33E-04	-3.82E-03	-3.43E-02

Acronyms

PERE: Use of renewable primary energy excluding resources used as raw materials, **PERM:** Use of renewable primary energy resources used as raw materials, **PERT:** Total use of renewable primary energy, **PENRE:** Use of non-renewable primary energy excluding 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, **SM:** Secondary material, **RSF:** Renewable secondary fuels, **NRSF:** Non-renewable secondary fuels, **FW:** Net use of fresh water

LCA Results

Environmental information describing waste categories (Mandatory)							
Indicator	**Unit**	**A1-A3**	**C1**	**C2**	**C3**	**C4**	**D**
HWD	kg	3.84E-01	4.73E-04	4.81E-04	1.33E-02	3.26E-03	-2.06E-01
NHWD	kg	2.53E+00	6.46E-03	9.03E-03	3.64E-01	5.47E+00	-1.99E+00
RWD	kg	7.29E-06	4.65E-08	5.52E-08	1.16E-06	2.32E-07	-5.67E-05

Environmental information describing output flow (Mandatory)							
Indicator	**Unit**	**A1-A3**	**C1**	**C2**	**C3**	**C4**	**D**
CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	7.40E-01	1.14E-06	2.02E-06	8.13E-01	7.22E-06	-4.80E-04
MER	kg	1.81E-06	5.80E-09	1.77E-08	4.29E-07	3.12E-08	-1.63E-07
EE (Electric)	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE (Thermal)	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Acronyms

HWD: Hazardous waste disposed, **NHWD:** Non-hazardous waste disposed, **RWD:** Radioactive waste disposed, **CRU:** Components for reuse, **MFR:** Material for recycling, **MER:** Materials for energy recovery, **EE (Electrical)**: Exported energy electrical, **EE (Thermal)**: Exported energy thermal.

*Disclaimer 1: 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.

**Disclaimer 2: GWP-GHG = Global Warming Potential total excl. biogenic carbon following IPCC AR5 methodology. The indicator includes all greenhouse gases included in GWP-total but excludes biogenic carbon dioxide uptake and emissions and biogenic carbon stored in the product. The GWP-GHG indicator is identical to GWP-total except that the characterisation factor (CF) for biogenic CO_2 is set to zero.

***Disclaimer 3: 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.

References

ISO 9001:2015 Quality Management Systems

ISO 50001:2018 Energy Management Systems

GPI General Programme Instructions of the International EPD® System. Version 4.0.

ISO 14020:2000 Environmental Labels and Declarations — General principles

EN 15804:2012+A2:2019/AC:2021 Sustainability of construction works - Environmental Product Declarations — Core rules for the product category of construction products

ISO 14025/ DIN EN ISO 14025:2009-11 Environmental labels and declarations - Type III environmental declarations — Principles and procedures

ISO 14040/44/ DIN EN ISO 14040:2006-10 Environmental management - Life cycle assessment - Principles and framework (ISO14040:2006) and Requirements and guidelines (ISO 14044:2006)

PCR for Construction Products and Construction Services/ Prepared by IVL Swedish Environmental Research Institute, Swedish environmental Protection Agency, SP Trä, Swedish Wood Preservation Institute, Swedisol, SCDA, Svenskt Limträ AB, SSAB, The International EPD System, 2019:14 Version 1.3.4.

The International EPD® System The International EPD® System is a programme for type III environmental declarations, maintaining a system to verify and register EPD®s as well as keeping a library of EPD®s and PCRs in accordance with ISO 14025. www.environdec.com

C1 Calculation Dos Santos Gervasio, H. and Dimova, S., Model for Life Cycle Assessment (LCA) of buildings , EUR 29123 EN, Publications Office of the European Union, 2018, ISBN 978-92-79-79974-7 (print),978-92-79-79973-0 (pdf), doi:10.2760/10016 (online),10.2760/789069 (print), JRC110082.

Ecoinvent Ecoinvent Centre, www.ecoinvent.org

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