Environmental Product Declaration

for:

Pig iron

from

Citygusa Siderurgia Ltda.

Programme:	The International EPD® System EPD registered through the fully aligned regional programme: Hub EPD Brasil. More information at www.environdec.com
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An EPD should provide current information and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com

THE INTERNATIONAL EPD® SYSTEM

Programme information

Programme:	The International EPD® System		**Brazilan Hub:**	EPD BRASIL Fundação Vanzolini
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Accountabilities for PCR, LCA and independent, third-party verification

Product Category Rules (PCR): PCR: 2015:03 Basic iron or steel products, except construction products (CPC 412) version 2.1.1 (2025-03-27)

PCR review was conducted by: Hudai Kara

Life Cycle Assessment (LCA) accountability: Vinícius G. Maciel, Edivan Cherubini, Guilherme Zanghelini; EnCiclo Soluções Sustentáveis

Independent third-party verification of the declaration and data, according to ISO 14025:2006, via:
☒ EPD verification by individual verifier

Third-party verifier: Claudia A. Peña
Director of PINDA LCT SpA.
email: pinda.lct@gmail.com
Approved by: The International EPD® System

Procedure for follow-up of data during EPD validity involves third-party verifier:
☐ Yes ☒ No

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

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. For further information about comparability, see ISO 14025. We also discourage the use of this EPD for B2C communication since the EoL results are not included in the EPD.

Company information

Owner of the EPD:	Citygusa Siderurgia Ltda.
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About Citygusa

Citygusa Siderurgia Ltda, located on Pedro Leopoldo, Minas Gerais, Brazil, and has been in the market for 26 years. The company expertise lies in the production and distribution of pig iron, a crucial component derived from the fusion and refinement of iron ore within a high-capacity blast furnace. This transformation yields a remarkably ferrous liquid, constituting a vital element within the thriving MG steel industry. Citygusa adheres to a sustainable industrial model, harnessing cutting-edge technology driven by cultivated biomass. This commitment reflects the company's dedication to responsible production practices. Since its establishment in 1997, the company's focus on modernization and technical improvement has been the pillars of its identity. The dynamic team comprises approximately 150 dedicated direct employees, supported by an impressive network of 3 000.00 indirect cooperators. Citygusa operates in the domestic and international markets, mainly exporting to North America. The company's journey is characterized by an ongoing pursuit of excellence, driven by innovation and fortified by a dedication to both local and global partnerships.

Certifications:

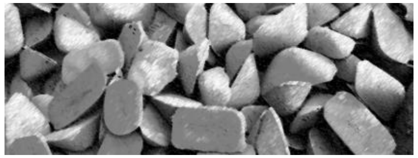
The company also has its GHG inventory certified by a third-party company

GHG INVENTORY VERIFICATION
ISO 14064-1
SGS

Product information

Product name: Pig iron (ingot)

Product identification:
The results in this EPD are a production average of pig iron in 2021. Averages are obtained through the total production, total consumption of raw materials and total generation of waste and emissions in Citygusa facility.



Pig iron ingot

Product description:
Pig iron ingot produced in a blast furnace using charcoal as the primary source of carbon. The main components of the ingot are iron and carbon. The function of this product is to serve as raw material to the several sectors (e.g., building sector, automotive industry, among others), since pig iron ingots are used for steel production, automotive manufacturing, construction, machinery, among others.

UN CPC code: 412 - Products of iron or steel

Geographical scope: Brazil

Packaging: The product is sold without packaging, in bulk conditions

Recycled material: Provenience of recycled materials (pre-consumer or post-consumer) in the product: the product uses scrap pig iron (pre-consumer) and scrap steel (post-consumer) for its process. Neither credits associated with upstream burdens of the scrap used in the ironmaking process nor credits associated with EoL recycling of the semi-finished steel product were included. According to the PCR (EPD, 2023), this methodological choice has been set according to the polluter pays principle (PPP) and the rationale of the book-keeping LCA approach (Attributional LCA).

Substances of very high concern (SVHC): This product contains no substances of very high concern (SVHC) on the REACH Candidate List published by the European Chemicals Agency

Content declaration

Product

Product components	%
Iron	93.20-95.38%
Carbon	4.20-4.50%
Silicon	0.001-1.00%
Manganese	0.001-1.00%
Phosphorus	0.001-0.16%
Sulphur	0.001-0.05%
Others	0.001-0.10%

LCA information

Declared unit:

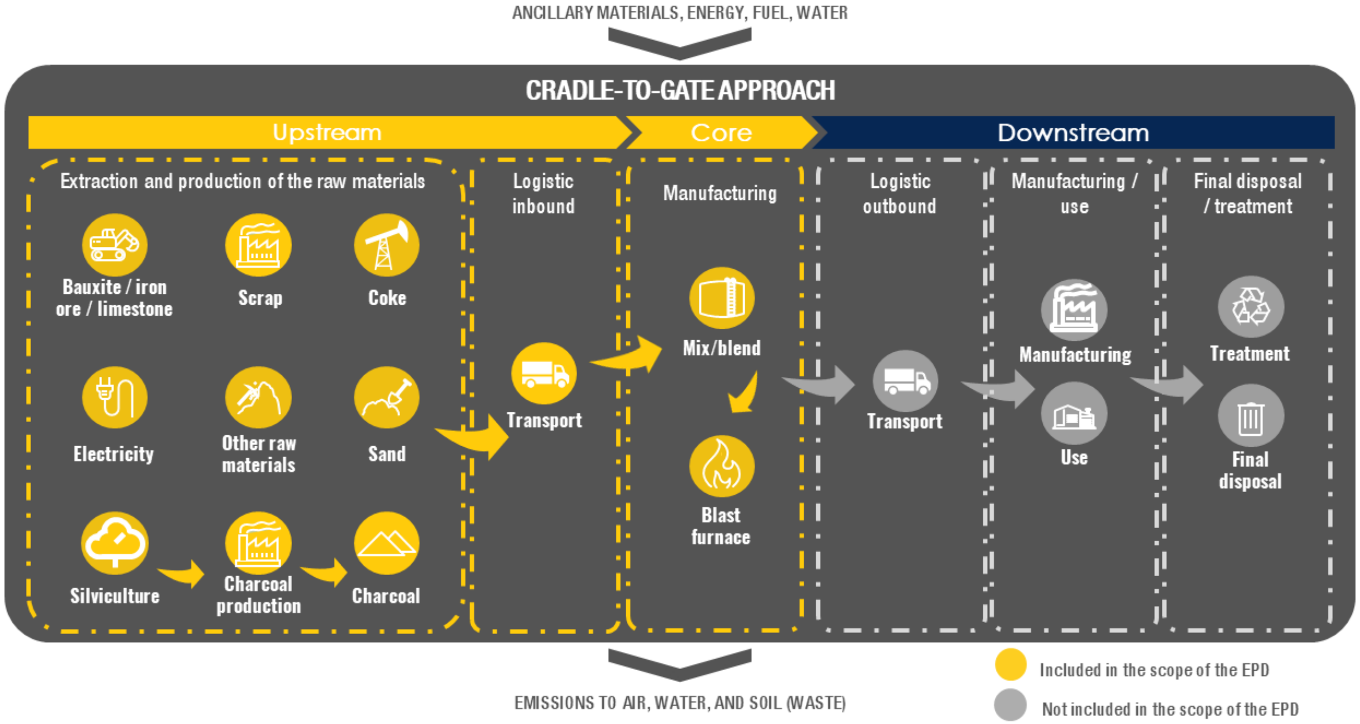
1 tonne (1 000 kg) of pig iron (ingot).

Time representativeness:

January 2021 to December 2021. We selected the year 2021 for this analysis because the project has commenced in October 2022 and continued throughout the entirety of 2023.

System boundaries:

The system boundaries employed in this EPD is “Cradle-to-gate” with upstream and core modules. Therefore, there are no processes excluded (except of those at EoL stage).



Description of system boundaries:

Upstream processes – Raw materials extraction and production & Transport to Citygusa:

This module assesses the impact of the raw materials' supply chain, including inbound transport from suppliers to Citygusa Siderurgia. In the production of pig iron, mineral resources are used, with iron ore being the primary resource along with its impurities (silica, alumina, manganese, phosphorus, and others), limestone, sand, graphitic shale, and bauxite. Iron ore serves as the primary source of iron in pig iron production. Extracted from open-pit mines, iron ore undergoes a reduction process in a blast furnace. Bauxite is an alumina input used in the process to assist in dealing with the impurities present in iron ore, aiding in the formation of slag. Limestone, a sedimentary rock primarily composed of calcium carbonate, is a crucial fluxing agent in the pig iron production process. When added to the furnace, limestone helps remove impurities by forming slag, which is separated from the iron. This process ensures the production of high-quality pig iron. Sand is used in the preparation of channels lined with it due to its heat-resistant properties. Graphitic shale serves as a release agent, aiding in the removal of pig iron ingots.

The extraction of sand, iron ore, bauxite, limestone, and graphite shale involve distinct processes and plays integral roles in various industries. Charcoal is obtained through the burning of wood, where carbonization occurs, and it is used as a reducing agent in the charcoal blast furnace. The high carbon content contributes to providing sufficient energy for the process. Charcoal is produced by wood sourced from planted forests and sustainably managed plants.

Core – Pig iron manufacturing:

Pig iron, an intermediate product produced from smelting iron ore, is the initial result of melting iron ore within a blast furnace. Continuous raw material charging at the furnace's apex drives the smelting process, ultimately yielding pig iron. Reduction of iron ore occurs by combining carbon sources (coke and charcoal) and limestone at elevated temperatures. This reaction produces carbon monoxide, which effectively reduces iron oxide to form pig iron. Coproducts such as crude slag iron and granulated slag may also be generated. Crude slag iron is a residue remaining after molten pig iron is cast, containing impurities from iron ore and furnace-introduced fluxes. Granulated slag, on the other hand, emerges from rapidly cooling crude slag iron with water. Sand and graphite are used to demold pig iron ingots, which are also cooled with water, generating sludge. The cooling process breaks slag into small granules, later ground into fine powder. Valuable as a coproduct, granulated slag substitutes cement in construction and acts as a feedstock for cement production, a soil conditioner, and a component in glass manufacturing. Pig iron production at Citygusa involves transporting raw materials from storage to aggregate bays using heavy equipment. Subsequently, raw materials are mixed and dedusted before being charged. The mix combines iron ore, charcoal, coke, bauxite, limestone, and scrap metal. Dust and fine particles generated during handling can negatively impact smelting efficiency, product quality, and pose environmental and health risks. Removing dust and particulates from raw materials reduces these issues. Excess waste is sold to other companies for reuse. The pig iron production starts with the blend preparation. At Citygusa, pig iron is not part of an integrated steel plant. The use of charcoal as a carbon source distinguishes "pig iron" production, offering a simpler, low-CO_2 emissions alternative to traditional carbon sources like fossil fuels. Biogenic charcoal, derived from renewable organic materials, serves as a sustainable carbon alternative in iron production. Therefore, this module (core) comprehensively considers all atmospheric emissions associated with pig iron manufacturing. This includes emissions from the blast furnace, such as CO_2 released during limestone calcination, combustion of charcoal and coke, and the combustion of Diesel B11 in generators. Additionally, it addresses environmental burdens related to waste transport from Citygusa to its final disposal or reuse

destinations (e.g., coprocessing, reuse, landfill). The module also takes into account the impacts of diesel production and consumption, as well as emissions during product transportation.
Furthermore, it assesses environmental burdens related to internal transport of raw materials, residues, and water sprinkler usage. The impacts from diesel production and consumption, along with emissions during product transportation, are considered in this process. The module also evaluates environmental burdens linked to generators, factoring in impacts from diesel production and consumption, as well as emissions during electricity generation.
Moreover, it includes an assessment of the impacts of electricity production used in pig iron manufacturing, noting that the electricity is sourced from the Brazilian electricity grid. Finally, the module accounts for the environmental impacts of sludge treatment at landfills..

Downstream processes – Uses of pig iron and End-of-life (EoL):

Not included in the system boundaries. Downstream processes (from gate-to-grave) are not applied since this EPD covers a semi-finished or intermediate iron that will be further processed to become a finished consumer product.

Database(s) and LCA software used:

SimaPro® software, version 9.5.0.2. The ecoinvent® database version 3.9.1 provided the life cycle background data for product system modelling

Cut-off criteria:

The cut-off criteria are applied to justify possible flows dismissed on data collection and product system modelling. The criteria generally applied is based on:

- Mass: when the flow mass is less than 1% of the cumulative mass of all the inputs and outputs of the life cycle inventory (LCI) model, exception to flows with high environmental relevance (e.g., mercury). The sum of the excluded flows shall not exceed 1% of the declared environmental impacts;
- Energy: when the flow energy is less than 1% of the cumulative energy of all the inputs and outputs of the LCI model. The sum of the excluded flows shall not exceed 1% of the declared environmental impacts;
- Environmental relevance: the neglected flows shall not have significant environmental impact.

Allocation:

Allocation can be defined as the impact factors distribution between the reference product and the coproducts, when they are simultaneous and dependent. There two types of situations where allocation may be required: in multi-output processes and in end-of-life processes (i.e., the recycling).ISO 14044 provides a stepwise procedure (section 4.3.4.2) to recommend the choice of an allocation approach for the foreground processes. For the background datasets (unit process) from ecoinvent® database it was assumed the default allocation based on the economic value for the multi-output processes. More information on the allocation procedures by ecoinvent® database can be found on Weidema et al. (2013). Regarding to the foreground model, the products that are classified as non-conforming and part of the processing losses are internally recycled by Citygusa Siderurgia to produce new pig iron. Therefore, there is no need to apply an allocation for these flows since this is a closed-loop system. Based on the PCR 2015:03 (EPD, 2020), for the process and co-products not listed on the PCR, the most suitable allocation procedure shall be used. Analysing the production processes of Citygusa, it is not possible to avoid allocation by dividing the unit process into sub-processes nor to apply physical relationships between the inputs and the outcomes of each process. The allocation based on the mass of each co-product relative to the reference product is also not advisable due to the higher weight of some co-products with relative lower economic value. Due to these beforementioned reasons, the economic allocation is the most suitable approach to deal with the multi-functional processes on the core/manufacturing stage of the product system for this LCA. The economic values used to estimate the allocation factors applied to our product system are showed in the Table below:

Product/by-product	Economic allocation (in %)
Dust charcoal	0.95%
Iron ore dust	0.68%
Dust coke	0.00%
Crude slag	0.02%
Granulated slag	0.10%
Pig iron (ingot)	98.25%

Source: primary data from Citygusa Siderurgia

Results of the environmental performance indicators per declared unit

Impact[1] category indicators (EN 15804+A2 based on EF 3.1 Package)

PARAMETER		UNIT	Upstream	Core	TOTAL
Global warming potential (GWP)	Fossil	kg CO_2 eq.	4.36E+02	1.63E+02	5.99E+02
	Biogenic	kg CO_2 eq.	3.52E+02	7.41E+00	3.59E+02
	Land use and land transformation	kg CO2 eq.	-9.87E+01**	1.74E+00	-9.70E+01
	TOTAL	**kg CO_2 eq.**	**6.89E+02**	**1.72E+02**	**8.62E+02**
Ozone depletion potential (ODP)		kg CFC 11 eq.	3.58E-06	5.05E-07	4.08E-06
Acidification potential (AP)		mol H^+ eq.	1.72E+00	2.83E-01	2.01E+00
Eutrophication potential (EP)	Aquatic freshwater	kg P eq.	2.00E-02	8.79E-04	2.09E-02
	Aquatic marine	kg N eq.	7.10E-01	5.04E-02	7.60E-01
	terrestrial	mol N eq.	6.83E+00	4.82E-01	7.31E+00
Photochemical ozone creation potential (POCP)		kg NMVOC eq.	5.41E+00	1.46E-01	5.55E+00
Abiotic depletion potential (ADP)*	Metals and minerals (non- fossil resources)	kg Sb eq.	3.61E-04	5.91E-05	4.20E-04
	Fossil resources	MJ, net calorific value	2.15E+03	3.40E+02	2.49E+03
Water deprivation potential (WDP)*		m3 world eq. deprived	6.50E+01	3.44E+01	9.94E+01

* Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator.
** Negative values accounts for positive impacts due to soil carbon sequestration/uptake from the charcoal upstream chain.

[1] The estimated impact results are only relative statements which do not indicate the end points of the impact categories, exceeding threshold values, safety margins or risks.

Results of the environmental performance indicators per declared unit

Resource use indicators

PARAMETER		UNIT	Upstream	Core	TOTAL
Primary energy resources – Renewable	Use as energy carrier	MJ, net calorific value	2.42E+04	3.27E+02	2.46E+04
	Used as raw materials	MJ, net calorific value	1.90E+04	0,00E+00	1.90E+04
	TOTAL	**MJ, net calorific value**	4.32E+04	3.27E+02	4.35E+04
Primary energy resources – Non-renewable	Use as energy carrier	MJ, net calorific value	2.19E+03	3.42E+02	2.54E+03
	Used as raw materials	MJ, net calorific value	1.46E+02	0.00E+00	1.46E+02
	TOTAL	**MJ, net calorific value**	2.34E+03	3.42E+02	2.68E+03
Secondary material (optional)		kg	0.00E+00	0.00E+00	1.64E+02
Renewable secondary fuels (optional)		MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00
Non-renewable secondary fuels (optional)		MJ, net calorific value	0.00E+00	0.00E+00	0.00E+00
Net use of fresh water (optional)		m^3	1.48E+01	3.05E+00	1.79E+01

Results of the environmental performance indicators per declared unit

Waste indicators (optional)

PARAMETER	UNIT	Upstream	Core	TOTAL
Hazardous waste disposed	kg	0.00E+00	0.00E+00	INA
Non-hazardous waste disposed	kg	0.00E+00	1.03E+02	1.03E+02
Radioactive waste disposed	kg	0.00E+00	0.00E+00	INA

Output flow indicators (optional)

PARAMETER	UNIT	Upstream	Core	TOTAL
Components for reuse	kg	0.00E+00	5.97E+02	5.97E+02
Material for recycling	kg	0.00E+00	0.00E+00	INA
Materials for energy recovery	kg	0.00E+00	0.00E+00	INA
Exported energy, electricity	MJ per energy carrier	0.00E+00	0.00E+00	INA
Exported energy, thermal	MJ per energy carrier	0.00E+00	0.00E+00	INA

References

EPD (2021) General programme instructions for the International EPD® System. Version 3.01

EPD (2024) Product Category Rules. PCR2015:03 version 2.1.1. Basic iron or steel products & special steels, except construction steel products. Product Category Classification: UN CPC 4112 AND 412. EPD International AB.

ISO (2006a) 14040: Environmental Management - Life Cycle Assessment - Principles and Framework.

ISO (2006b) 14044: Environmental Management - Life Cycle Assessment - Requirements and guidelines.

Life Cycle Assessment of the pig iron. Prepared by EnCiclo Soluções Sustentaveis for Citygusa Siderurgia Ltda. Final report version 1.9 (2024-February-28)

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