Environmental Product Declaration

Graphite Electrode

Manufactured by Resonac Graphite Austria GmbH

EPD®
THE INTERNATIONAL EPD® SYSTEM

Under PCR 2023:02 Graphite products; Version 1.0.1; 2023-04-27 PRODUCT CATEGORY CLASSIFICATION: UN CPC 3795, 3799, 4695, in accordance with ISO 14025:2006	
Program:	The International EPD® System www.environdec.com
Program operator:	EPD International AB
EPD registration number:	EPD-IES-0025507:001
Issue date:	2025-09-19
Validity date:	2030-09-18 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
Geographical scope:	Global

Presentation

This declaration contains the environmental performance of the production of Graphite Electrodes (GE) manufactured by

- **Resonac Graphite Austria GmbH** in the plant located in Elektrodenwerkplatz 1, 4822 Bad Goisern am Hallstaettersee, Austria.

This EPD has been conducted according to the International EPD System regulation. This regulation is a system for the international use of Type III Environmental Declarations, according to ISO 14025:2010. Not only the system but also its applications are described in the General Programme Instructions (GPI 4.0). The report has been made following the specifications given in the Product Category Rule PCR 2023:02 Graphite products Version 1.0.1 with date: 2023-04-27.

The assessed life cycle includes all the stages from cradle to grave.

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

EPDs within the same product category but from different programs may not be comparable.

General Information

About the manufacturer

Manufacturer	RESONAC GRAPHITE AUSTRIA GMBH
Central offices address	Elektrodenwerkplatz 1, 4822 Bad Goisern am Hallstaettersee, Austria
Email	graphite_info@resonac.com
Telephone	Tel +43 6135 8641
Website	www.graphite.resonac.com

About the product

Product name	GRAPHITE ELECTRODE
Other name(s)	-
Manufacturing plant location	Bad Goisern am Hallstaettersee, Austria
CPC code	3795, 3799, 4695

About programme operator

Product name	EPD INTERNATIONAL AB
Other name(s)	Box 210 60, SE-100 31 Stockholm, Sweden
Manufacturing plant location	support@environdec.com
CPC code	www.environdec.com

About this EPD

Product Category Rules (PCR)

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

Product Category Rules (PCR):
PCR 2023:02 Graphite products; Version 1.0.1; 2023-04-27
PRODUCT CATEGORY CLASSIFICATION: UN CPC 3795, 3799, 4695.

PCR review conducted by:
PCR review was conducted by the Technical Committee of the International EPD® System. A full list of members is available at www.environdec.com. The review panel may be contacted via info@environdec.com. Review chair: Lars-Gunnar Lindfors

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
☐ EPD verification through an EPD Process Certification*
☐ EPD verification through a pre-verified LCA/EPD tool

Third party verifier:
Marcel Gómez, Marcel Gómez Consultoría Ambiental S.L. – info@marcelgomez.com
Approved by: The International EPD System

*EPD Process Certification involves an accredited certification body certifying and periodically auditing the EPD process and conducting external and independent verification of EPDs that are regularly published. More information can be found in the General Programme Instructions on www.envrondec.com. International EPD System

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

EPD owner

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EPDs within the same product category but from different 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 more information on comparability, see ISO 14025.

The owner of this EPD, RESONAC GRAPHITE AUSTRIA GMBH has the sole ownership, liability and responsibility on this EDP.

Company Information

Product provider

As an active participant in a **collaborative chemical company**, Resonac Graphite Business Unit (RGBU) is committed to developing technologies and processes that align with the needs of the times - harnessing the transformative power of chemistry responsibly.

Therefore, **Resonac Graphite Austria GmbH**, one of the production sites of RGBU, in which sustainability has an important role in the productivity process. Hence, Resonac Graphite Austria, complies with Quality certificates that endorse its commitment to the continuous improvement of its processes:

- ISO 9001: 2015 Quality Management System
- ISO 50001: 2018 Energy Management System
- ISO 14001: 2015 Environmental Management System
- ISO 45001: 2018 Health and Safety Management System

Product Information

Product identification

The system analyzed in this Declaration comprises the life cycle of the production of the Graphite Electrode manufactured by Resonac Graphite Austria GmbH located in Bad Goisern am Hallstaettersee, Steeg (Austria).

Information about the product

The product analyzed in this EPD is a synthetic graphite electrode with a carbon content > 99% with the CPC code 3795, 3799, 4695.

Graphite electrodes are primarily used in the production and recycling of steel. During the process, steel scrap is melted in a large crucible (furnace) by an electric arc. This is the genesis of the name “Electric Arc Furnace” (EAF). The arc is a channel of ionized air through which electric current passes from the electrode into the steel scrap. A similar phenomenon occurs during a thunderstorm with the rapid discharge of electricity that we know as lightning.

In the steel mill, the furnace is loaded with steel scrap. Then, one column (direct current furnace) or three columns (alternating current furnace) consisting of multiple graphite electrodes screwed on top of each other, is introduced and the arc is ignited. The arc is maintained for a few minutes so that a generated temperature of around 3500 degrees Celsius can rapidly melt the scrap in the furnace. The molten steel is then poured off for further processing. This procedure is known as tapping. Typical cycle times, i.e., the time between two taps, are between 45 and 90 minutes. During the process, between 1 and 2 kg of graphite are generally consumed for each ton of liquid steel. The diameter of the electrodes can vary between 350 and 800 mm and the lengths range from 1500 - 3600 mm with a weight of between 0.3 and 3.2 t for each electrode. These measures depend on furnace and customer requirements.

Composition

The Graphite Electrode is composed >99% of graphite with a carbon content of 99.9%. Each Electrode is distributed with a Pin, which is a necessary part for its operation that connects the electrode to the electric arc furnace. This Pin is also made of 100% graphite and is produced by Resonac Graphite Japan Corporation. Additionally, the final product, ready for distribution, has packaging made of various materials specified in Table 1 and Table 2. This packaging is referring to the distribution packaging which constituting, with its content, a sales unit for the final user or consumer at the point of retail (ISO 21067-1:2016, Section 2.2.7).

STEEG				
Component	Weight, kg	Post-consumer recycled material, weight%	Biogenic material, mass-% of product	Biogenic material, kg C/FU
Graphite	1	0%	0%	0

Table 1. Final product components for 1 kg Graphite Electrode

Packaging Material	Weight, kg	Weight % per DU	Biogenic material, mass-% of product	Biogenic material, kg C/FU
Styrofoam - packaging Steel non renewable - packaging Wood	1.08E-03 5.95E-04 1.54E-02	1.08 E-01 % 5.95 E-02 % 1.54 %	0% 0% 1.54%	0 0 7.70 E-03
TOTAL	1.70E-02	1.70%	1.54%	7.70 E-03

Table 2. Packaging materials for 1 kg of Graphite Electrode.

The content declaration does not apply to proprietary materials and substances covered by exclusive legal rights including patent and trademarks. In general, an indication that a product is “free” of a specific hazardous material or substance should be done with caution and only when relevant, following the rules in ISO 14021 on self-declared environmental claims.

Information on the hazardous properties of materials and chemical substances should follow the requirements given in the latest revision of the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), 9 issued by the United Nations or national or regional applications of the GHS.

LCA Information

Declared Unit

EPDs based on this PCR (Graphite products; Version 1.0.1; 2023-04-27) shall use a declared unit. The declared unit shall be 1 (one) kg of graphite product ready for delivery (if packaging is included, its weight shall not be included in the 1 kg declared unit).

Time representativeness and geographical scope

This assessment has been done using the production data of 2023 and the geographical scope of the EPD is global.

System boundaries

The system boundaries were considered under a perspective of “cradle to grave”. So, this EPD covers all product stages: upstream processes, core processes and downstream processes according to the PCR 2023:02 Graphite products. Figure 1 shows the life cycle processes described in the PCR.

Synthetic - Graphite for Eledctrodes

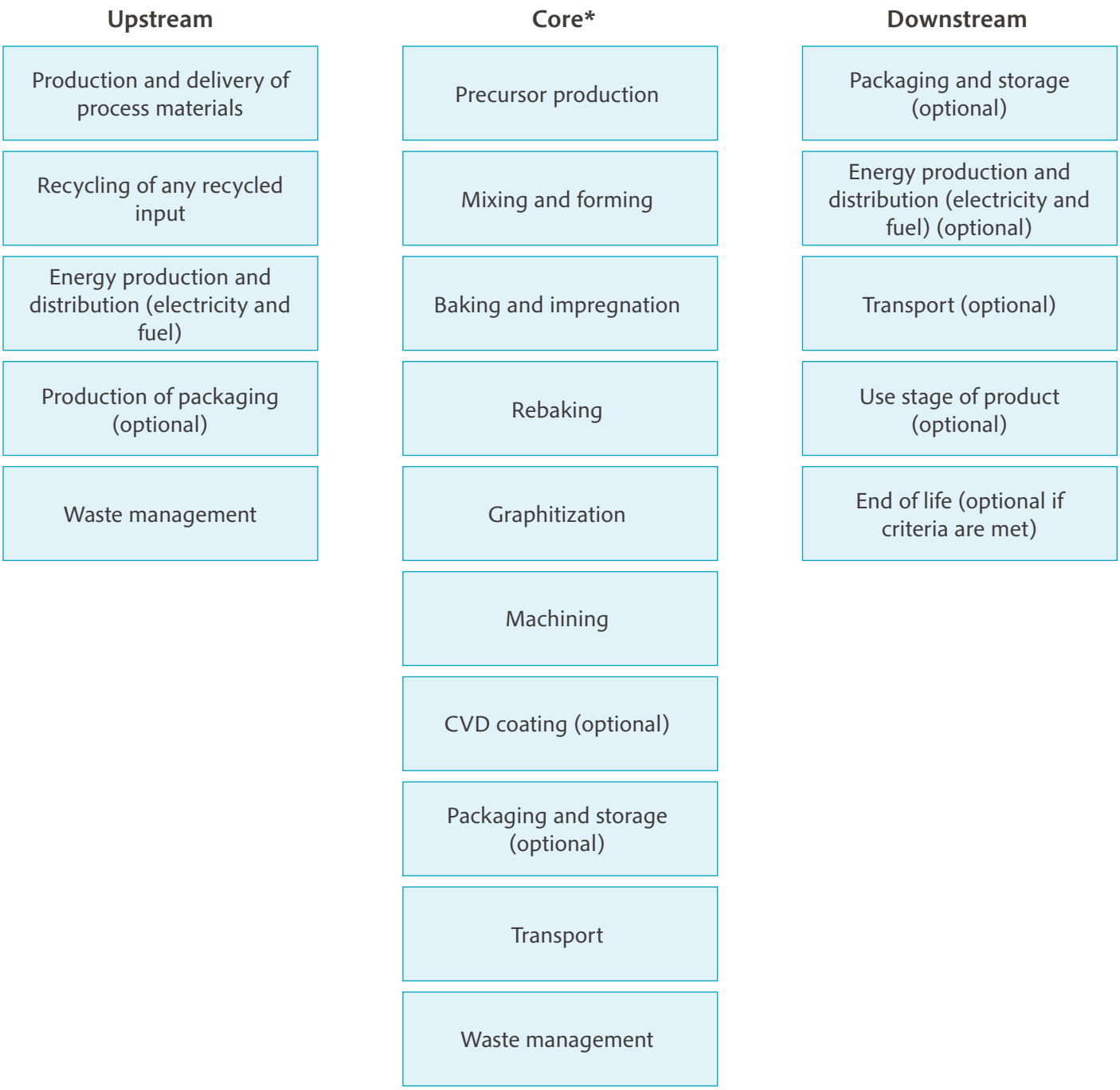

Figure 1. Life cycle specific processes included in the PCR 2023:02 Graphite products for Graphite Electrodes.

Therefore, the processes considered in the life cycle inventory were:

Upstream processes:

- Raw materials production: extraction and production processes of the needle coke, pitch and packing media.

Core processes:

- Transportation of raw materials.
- Processes of the Graphite Electrodes production: green shop, Baking/Rebaking, Pitch impregnation, Graphitization and Machining. With the emissions derived from this process.
- Energy production and fuels production for the energy requirements for the process and the combustion of the fuels. Energy sources considered were electricity from Austria grid, and part of this electricity comes from green electricity. Fuels for stationary energy sources: petrol and natural gas. Fuels for mobile energy for own fleet: petrol and diesel. Other energy sources: district heating (from renewable biomass) and other self-generated energy (like thermal).
- Production of the connecting Pin and its transportation to Steeg.
- Production of packaging.
- Management of waste and wastewater generated.
- Direct emissions from the production process: nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), carbon dioxide (CO2), total organic carbon (TOC), particles (PM2.5-PM10) and polycyclic aromatic hydrocarbons (PAHs).
- Water intake (electricity consumption of pumping)
-

Downstream processes:

- Distribution to the customers
- Waste treatment of packaging

The LCI includes, in accordance with PCR, a minimum of 95% of the total input flows (mass and energy). Table 3 shows the modules or stages declared and its geographical scope. Additionally, the tables shows that the percentage of total specific data analyzed was 41.9%.

	UPSTREAM	CORE	DOWNSTREAM
Modules declared	X	X	X
Geographical scope	Global	Austria	Global
Specific data used	0%	36.9%	5.0%
Variation – products	0%	0%	0%
Variation - sites	0%	0%	0%

Table 3. Stages or modules declared, geographical scope and variations.

This means that all processes up to the output gate of the manufacturer are included, from quarry works and components manufacturing, to transports of materials and fuels, factory process and final preparation. All direct and indirect environmental impacts have been calculated and are reported in this document.

Within the downstream processes, **Resonac Graphite Austria GmbH**, has no control over the processes within the use stage or the end-of-life stage of the Graphite Electrodes as well as the packaging materials. Thus, some life cycle steps concerning of the downstream process which were optional accordingly to PCR were not considered into the analysis.

1. Waste management of the packaging materials. The management of this type of waste generally depends on each country and even each municipality. As the electrodes are distributed across several countries, the traceability of these packaging products is lost, so estimates must be made on their management as waste. For this reason, the most conservative scenario with regard to the treatment of packagaing waste was considered to be sanitary landfill.

2. Use stage of product. Graphite Electrodes are used in electric arc furnaces to produce steel. An electric charge passes through them, melting the steel, causing part of the electrode to be consumed, the carbon of which reacts with oxygen in the air and is released as CO2. Each use of the electrode causes a deterioration of part of its mass. This electrode wear depends on several factors, such as the electric charge, the dimensions of the electrode, the use made of it, etc. As Resonac Graphite Austria GmbH has no control over most of these factors, certain estimates should be assumed, which would increase the uncertainty of the calculation. As this stage of the life cycle according to PCR is optional in the analysis, it has been decided to exclude it.

3. End of life of the Graphite Electrodes. It has been assumed that Graphite Electrodes are used and reused until the electrode is completely consumed.

Technical Information

Calculation Methodology

This EPD represents Type III Environmental Declarations according to ISO 14025 2010. The inherent Life Cycle Assessment (LCA) has been developed according to ISO 14040 and ISO 14044 International Standards and following the International EPD System General Programme Instruction (GPI 4.0), the PCR 2023:02 Graphite products; Version 1.0.1; 2023-04-27.

Version 3.19 of software Air.e LCA™ with Ecoinvent™ 3.11 database has been used for LCA modelling and impacts calculations.

PCR impact categories were assessed according to the EF 3.1 method.

All processes related to the product have been included in the assessment.

All transportation and components have been included in this LCA, considering real loads and distances traveled by the materials used between January 2023 and December 2023. The main means of transportation have been included for the purchase of fuel and external raw materials. Operations in the port have been excluded.
The distances by road and sea have been mainly provided by Resonac Graphite Austria GmbH according to its own records.

Allocations have been avoided where possible. On the other hand, some allocations had to be considered with respect to co-products. In this case, the co-products generated are steam and packing media used from the process. The allocation was calculated economically from the value of the by-products with respect to the total turnover, which was 4.2 %. So, in environmental terms, the co-product was allocated 4.2 % of the 100 % of the calculated environmental impact.

Cut-off rules: more than 95% of the total input flows (mass and energy) per module (e.g. Upstream, Core or Downstream) have been included following the indications of the PCR.

The calculation of the environmental impacts associated with the electricity mix of Steeg was calculated considering that the electricity produced source was 100 % renewable. In this way, the electricity production was modeled considering the specific electricity mix of the ecoinvent 3.11 dataset for Austria and taking into account the electricity production mix in 2023[1] in Austria and using only renewable energy sources. The resulting emission factor to produce 1 kWh of electricity is 52.2178 g CO2e.

[1]https://www.statista.com/statistics/1234896/austria-distribution-of-electricity-production-by-source/

Emission Factors and Tools

The emission factors and environmental impacts of the elements in the life cycles that are not controlled by **Resonac Graphite Austria GmbH**, or direct emissions that has not measured or calculated, come from Ecoinvent database, version 3.11, using the cut-off criteria of that database.

The LCA has been developed using the software Air.e LCA v3.19.

The environmental impacts of the production of the Pin were estimated from its carbon footprint data of 6.23 tonnes CO2e/tonne PIN. Considering that the Pin is made of the same material as the GE and the production process is similar, the ratio of the CF between the Pin and the GE (not counting the impacts associated with the Pin) was calculated, and the same ratio was applied for the rest of the environmental impacts.

Data quality

According to the environmental footprint product category rules quality data criteria, and considering that the data used for the processes is representative of the geography scope declared, that there was no need to significantly modify technical aspects and that the data is from the last complete year, the data quality is considered as **high.**

Environmental Performance

The following tables present the results of totalized potential environmental impacts and for each stage of the life cycle of one kilogram of Graphite Electrode manufactured by Resonac Graphite Austria GmbH in Steeg (Austria). The estimated impact results are only relative statements that do not indicate the end points of the impact categories exceeding threshold values, safety margins or risks.

Potential Environmental Impact

The results obtained in this analysis are shown in Table 4:

		UPSTREAM	CORE	DOWNSTREAM	**TOTAL**
Global Warming Potential (GWP100) (kg of CO2 equivalent)	Total	8.16E-01	1.64E+00	1.63E-01	2.62E+00
	Fossil	8.16E-01	1.66E+00	1.34E-01	2.61E+00
	Biogenic	0.00E+00	-2.85E-02	2.85E-02	0.00E+00
	LULUC	1.32E-04	6.14E-04	4.94E-05	7.96E-04
Ozone depletion (kg of CFC11 equivalent)		8.33E-08	4.62E-08	2.87E-09	1.32E-07
Acidification (mol of H+ equivalent)		3.52E-03	5.15E-03	7.87E-04	9.46E-03
Eutrophication fresh water (kg of P equivalent)		3.03E-05	2.27E-04	1.05E-05	2.68E-04
Eutrophication marine water (kg of N equivalent)		5.56E-04	1.28E-03	3.05E-04	2.14E-03
Eutrophication terrestrial (mol of N equivalent)		5.59E-03	1.35E-02	3.00E-03	2.21E-02
Photochemical ozone creation (kg of NMVOC equivalent)		7.45E-03	4.31E-03	1.02E-03	1.28E-02
Depletion of abiotic resources (elements) (kg of Sb equivalent)		3.24E-07	1.73E-05	4.19E-07	1.80E-05
Depletion of abiotic resources (fossil fuels) (MJ net calorific value)		4.92E+01	1.33E+01	1.91E+00	6.44E+01
Water depletion (m3 world equivalent)		4.57E-02	4.37E-01	6.94E-03	4.90E-01

Table 4. Results for each environmental impact indicator.

Use of resources

Additionally, according to the PCR, indicators "Use of resources" had been calculated and they are shown in Table 5 and Table 6.

MJ, net calorific value	UPSTREAM	CORE	DOWNSTREAM	TOTAL
Use of RENEWABLE primary energy resources used as energy carrier (PERE)	1.24E-01	4.02E-01	-1.25E-01	**4.01E-01**
Use of RENEWABLE primary energy resources used as raw materials (PERM)	0.00E+00	4.98E-01	1.56E-01	**6.54E-01**
Total use of RENEWABLE primary energy resources (PERT)	1.24E-01	9.00E-01	3.15E-02	**1.06E+00**

Table 5. Use of renewable primary energy.

MJ, net calorific value	UPSTREAM	CORE	DOWNSTREAM	TOTAL
Used of NON-RENEWABLE primary energy resources used as energy carrier (PENRE)	8.61E+00	9.09E+00	1.81E+00	**1.95E+01**
Use of NON-RENEWABLE primary energy resources used as raw materials (PENRM)	4.06E+01	1.69E+00	1.02E-01	**4.23E+01**
Total use of NON-RENEWABLE primary energy resources (PENRT)	4.92E+01	1.08E+01	1.91E+00	**6.18E+01**

Table 6. Use of non-renewable primary energy.

Indicator – Use of Resources	UPSTREAM	CORE	DOWNSTREAM	TOTAL
Secondary material (SM) kg	3.43E-03	2.33E-03	8.62E-04	**6.61E-03**
Renewable secondary fuels (RSF) MJ	5.98E-06	1.39E-05	1.04E-05	**3.03E-05**
Non-renewable secondary fuels (NRSF) MJ	0.00E+00	5.53E+00	0.00E+00	**5.53E+00**
Net use of fresh water (FW) m3	1.11E-03	2.04E-02	1.76E-04	**2.17E-02**

Table 7. Indicators describing use of resources.

Waste and Output flows

Table 8 shows the indicators describing wastes and output flows.

Waste indictors	UPSTREAM	CORE	DOWNSTREAM	TOTAL
Hazardous waste disposed – kg	1.22E-02	1.42E-02	2.79E-03	**2.92E-02**
Non-hazardous waste disposed – kg	1.79E-01	4.49E-02	1.05E-01	**3.28E-01**
Radioactive waste disposed – kg	2.45E-06	0.00E+00	5.79E-07	**3.03E-06**

Output flows indicators	UPSTREAM	CORE	DOWNSTREAM	TOTAL
Components for reuse – kg	0.00E+00	1.39E-05	0.00E+00	**1.39E-05**
Material for recycling – kg	1.13E-04	2.49E-02	1.33E-04	**2.51E-02**
Material for energy recovery – kg	2.71E-07	0.00E+00	9.06E-08	**3.61E-07**
Exported energy, electricity – MJ	1.56E-03	0.00E+00	3.69E-04	**1.93E-03**
Exported energy, termal - MJ	2.31E-04	4.82E-04	7.74E-04	**1.49E-03**

Table 8. Indicators describing wastes and output flows.

Interpretation

In Figure 2 shows the relative impacts per stage for each indicator. Thus, it can be observed that most of the environmental impacts occur during the CORE stage. This is due mainly to the energy required in the production process.

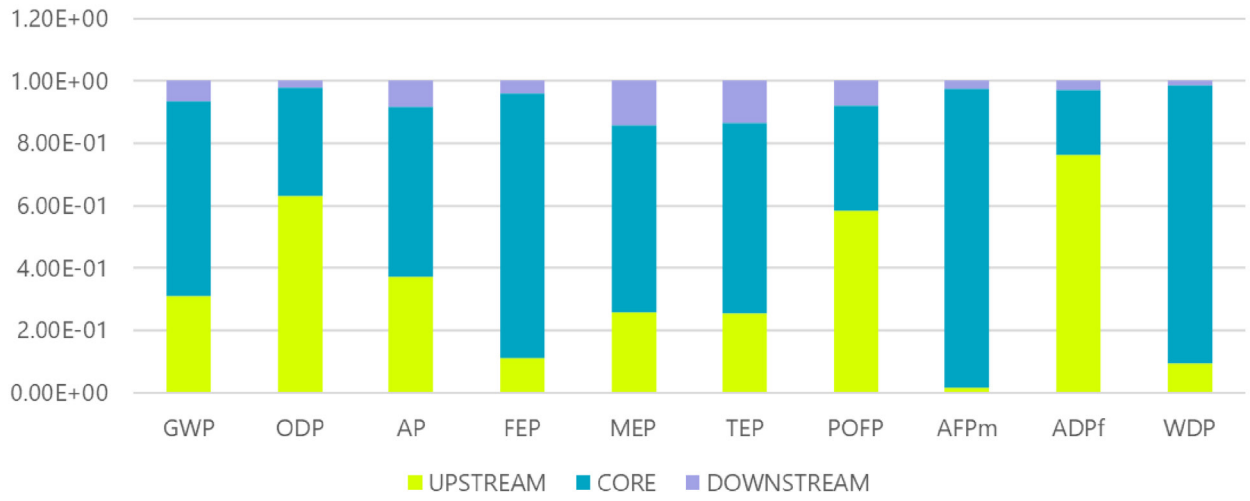

Figure 2. Relative impacts per stage for each indicator.

Figure 3 shows the processes of the CORE stage and those indicators in which this stage has had a major contribution. In most of the environmental impacts, electricity production has the most relative contribution. Moreover, direct emissions (or emissions to air) and stationary energy requirements (natural gas consumption), has also a significant contribution in the impacts regarding to the Core stage.

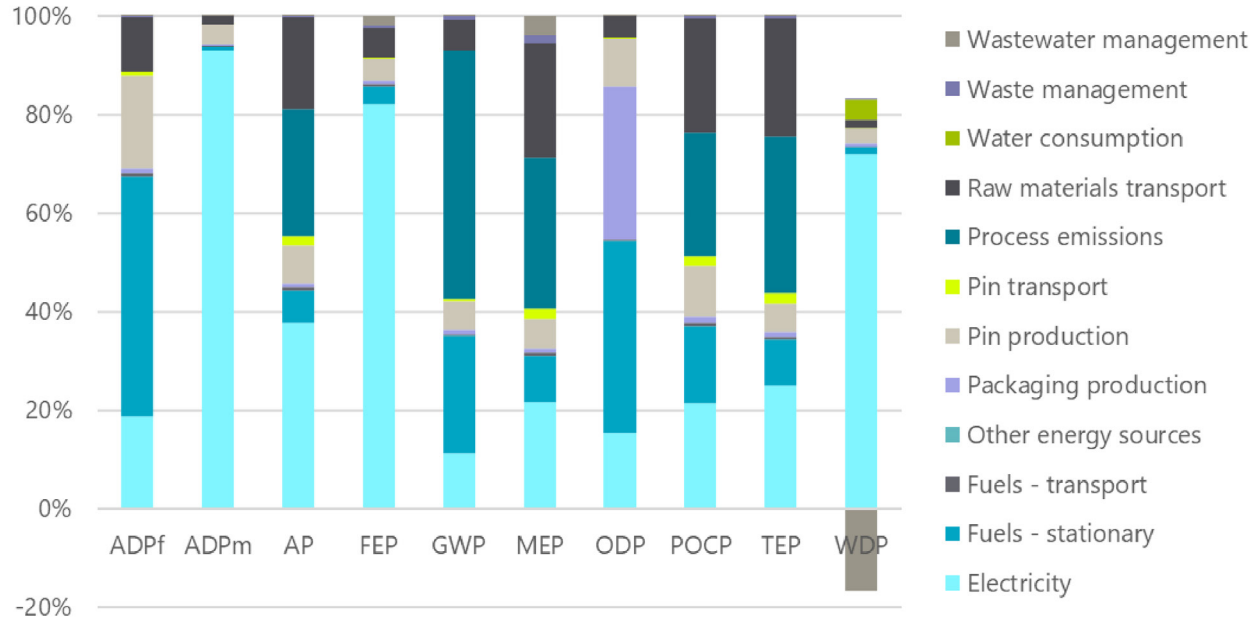

Figure 3. Relative impacts of the core processes.

References

This declaration has been developed according to the General Programme Instructions of the International EPD® System. Version 4.0.

PCR 2023:02 Graphite products Version 1.0.1 2023-04-27.

ISO 14040:2006 Environmental management - Life Cycle Assessment - Principles and framework.

ISO 14044:2006 Environmental management - Life Cycle Assessment - Requirements and guidelines.

ISO 14020:2000 Environmental statements and programmes for products - Principles and general requirements.

ISO 14025:2006 Environmental labels and declarations - Type III environmental declarations - Principles and procedures.

Registro Estatal de Emisiones y Fuentes Contaminantes (prtr-es.es).

Resonac Graphite Business Unit (https://www.graphite.resonac.com/)

Software: Air.e LCA rev. 3.19 (www.solidforest.com).

LCA detailed inventory report Report version 1, August 2025.

Main database: Ecoinvent 3.11 (www.ecoinvent.org).

Geographical scope of the EPD: Global.

The environmental information and calculations used for the calculation of the environmental impacts arising from the production of the Pin are specified in the LCA detailed inventory report.

Note: Environmental declarations published within the same product category, though originating from different programs, 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 PCR or fully aligned PCR versions; cover products with identical functions, technical performance and use (e.g. identical declared/functional units); have equivalent system limits and data descriptions; apply equivalent data quality requirements, data collection methods, and allocation methods; apply identical cut-off rules and impact assessment methods (including the same version of characterization factors); have equivalent content statements; and be valid at the time of comparison. For more information on comparability, see EN 15804 and ISO 14025.