LCA Study Report

Life Cycle Assessment:

Aluminium alloy bar Eural Gnutti S.p.A.

EURAL GNUTTI S.p.A.

Index

1. General Aspects

1.1 Definition of Life Cycle Assessment (LCA)

The LCA method is a standardised procedure that makes it possible to record, quantify and assess the environmental damage associated with a product, procedure or service, within a well-defined context. This study can be understood as 'integral' in that it also considers all the steps preceding and following the procedure under consideration. First, the objective and scope of the investigation must be defined; next, the so-called 'inventory analysis' must be constructed: in this step, the material and energy flows of the different steps of the procedure under investigation are noted. In a third step, after completing all the balances, it is possible to begin the environmental impact assessment: this estimate serves to identify and quantify the potential environmental effects of the analysed systems and provides essential information for the subsequent interpretations, which are carried out in the fourth step. At this point, the results obtained and the risk assessment are summarised, discussed and evaluated in relation to the previously set objective.

The basic idea of the LCA method is the recording of all material and energy flows associated with a product, process or service. The entire life of a compound or system is considered 'from cradle to grave'. This means that not only the environmental effects at the level of the production plant are taken into account, but the entire process leading to a product, starting from the sourcing of raw materials, through use and consumption to disposal. This wide-ranging approach is very important because if one were to consider too narrow a view, one could arrive at distorted conclusions as to advantages or disadvantages; in this way, on the other hand, it is possible to push optimisation as far as the real scientific minimum of the subject of the investigation.

Alternatively, a *cradle-to-gate* analysis is also permissible. Life cycle assessments (LCAs) that follow the cradle-to-gate approach measure the environmental footprint of a product up to the point where it leaves the factory gate. This means that the environmental footprint results do not include the footprint of the product's use by customers and end-of-life processes.

This is useful in some situations, as one does not always have data on what happens after the products leave the factory.

Life Cycle Assessment (LCA) is regulated by the internationally approved ISO 14040/14044 standards, in force since 1997.

From a consumer perspective, the study of product environmental impact is an essential tool for the development of sustainable consumption. Selective consumer pressure' can therefore be an important factor in stimulating innovation in companies, promoting sustainable consumption and improving environmental performance.

1.2 Customer

EY S.p.a. provided support for this LCA study on behalf of Eural Gnutti S.p.A., the world's leading manufacturer of cold-drawn aluminium alloy bars for machining. Extruded bars, solid and hollow extruded profiles complete the product range.

Eural Gnutti has developed lead-free aluminium alloys with high recycled aluminium content and high performance in terms of strength and machinability. The alloys are particularly popular in the automotive, aerospace, defence and general engineering industries.

Eural Gnutti's production is 100% Made in Italy, with future-oriented products of uncompromisingly high quality.

In addition to the Italian sites of Rovato (extrusion) and Pontevico (foundry), Eural Gnutti wholly owns a trading company in the United States 'Eural USA Inc.' and a sales brokerage company in Germany 'Eural Deutschland GmBH'; it also cooperates with several Italian and foreign sales agents.

Most of the production is in the form of machining bars, whose main characteristics include machinability, uniformity and high mechanical properties.

The bars are obtained through extrusion presses at the Rovato (BS) production site, using billets produced at the Pontevico (BS) foundry.

1.3 Timing of Report Development

The report was developed between February and October 2024

1.4 Legal references

The reference standards for conducting the study, as well as reporting the results of the LCA, are:

- UNI EN ISO 14040:2021, Environmental management - Life cycle assessment - Principles and framework.
- UNI EN ISO 14044:2021, Environmental management - Life cycle assessment - Requirements and guidelines

2. Objective of the study

The objective of the LCA study is to assess and quantify the environmental impact of a product, service or process during its entire life cycle, expressed in the form of different parameters and aspects.

2.1 Reasons for the study

The study, aimed at carrying out an LCA analysis for two aluminium bars of two different alloys, was initiated by Eural Gnutti Spa with the main objective of responding to a request from the ASI standard, according to which the company is certifying itself.

The other objectives that led to an LCA analysis can therefore be traced back to those determined by this standard, namely:

- Meeting customers' expectations of good practices and improving one's reputation;
- Strengthen internal management systems on environmental issues;
- Ensuring transparency in supply chains and managing supply chain risks;
- Communicate best practices and evidence of positive impacts that will affect its stakeholders.

This is also in line with the principles of the company, which aims to bring to market products that have less and less impact on the environment (Lead Free aluminium alloys) and to encourage the reuse of material through a circular economy system, which leads to the use of pre or post consumer recovered aluminium.

2.2 Planned applications and target group of the study

The LCA study will be used by the Customer to develop communication tools to be provided to its customers (actual and potential) indicating the environmental performance of the analysed products. The study is NOT intended to be used to support comparative assertions for public dissemination and therefore no specific expert review was conducted.

3. Scope of the study

3.1 The function of the analysed product

The product analysed is extruded and drawn aluminium bar. Specifically, two bars were analysed, respectively of alloy 2033 and 6026LF.

They are drawn semi-finished products made of highly machinable *Lead Free* aluminium alloys and are therefore particularly suitable for all applications related to machine tool machining.

The products under analysis are mostly used in the following sectors:

- Alloy bar 2033
    - Solenoid valves
    - Gas valves
    - Automotive - shock absorbers (e.g. tailgate)
    - Mechanical industry in general
- Alloy bar 6026LF
    - Automotive - brake systems (e.g. Master Cylinder pistons)
    - Mechanical industry in general

LED FREE ALLOY	PROPERTIES	APPLICATION SECTOR	COMPLIANCE
2033	Excellent machinability Small chips Longer tool life High mechanical properties Good anodizing	Automotive Electrical Electronic Defense Forging Screw, Bolts, Nuts Screwed parts Mechanical industry in general	2000/53/EC (ELV) 2011/65/EC (RoHSII) 2015/863/EC (RoHSIII) 2018/740/EC
6026LF	Hight speed machining Corrosion Resistance Mediun-High mechanical properties Attitude to decorative anodizing	Automotive Electrical Electronic Forging Screw, Bolts, Nuts Screwed parts Small parts Mechanical industry in general	2000/53/EC (ELV) 2011/65/EC (RoHSII) 2015/863/EC (RoHSIII) 2018/740/EC

Figure 1. Main characteristics of the alloys considered

This type of product and the alloys were chosen as the most representative of the entire family, as they are those most in demand and sold by Eural Gnutti. Moreover, this choice was also made with a view to the future, since these are lead-free alloys, a direction in which the sector in which the company operates is moving with increasing determination (also considering the mandatory regulations that will come into force in the next few years).

ANNO	TOTAL	2033	2077	6026LF
2016	0,03			0,03
2017	0,6	0,004		0,578
2018	1,9	0,027		1,868
2019	7,3	0,253		7,020
2020	10,1	0,843	0,003	9,240
2021	15,2	1,892	0,008	13,293
2022	17,1	3,341	0,003	13,757
2023	18,5	3,650	0,083	14,752

Figure 2. Sales trend *Lead Free* alloys

3.2 Functional Unit

1 kg of bar was defined as the functional/declared unit. This means that all material and energy flows were collected (and reported in the balance sheets) by reference to the set quantity.

3.3 System boundaries

The system boundaries are closely linked to the product system. A product system has a series of unit processes, elementary flows and product flows in the system boundaries.

The organisational boundaries of the system under consideration are those indicated in PCR UN CPC 4153 and can be represented as follows:

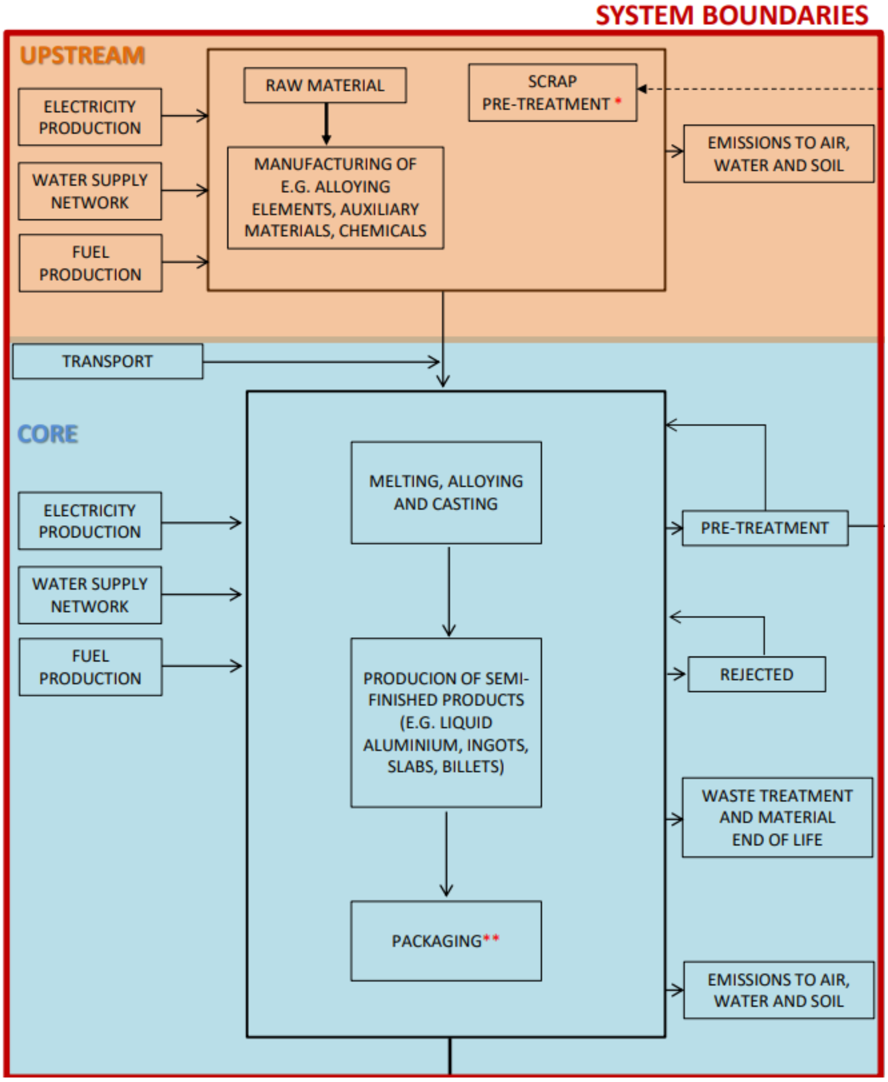

Figure 3 - Boundaries of the analysed system

Therefore, downstream processes of product use and end-of-life are excluded. In addition, waste and waste treatment aspects have not been considered in the analysis performed. This choice was dictated by the little relevance these represent for the product system analysed and by the fact that a large part of the output elements are part of the production cycle.

Upstream Processes include:

- extraction and processing of raw materials.

  The raw materials considered in the analysis are:

  - ✓ Crude
  - ✓ Scrap (post-consumer)
  - ✓ Scrap (pre-consumer)

- transport of raw materials from the supplier to the production site. As there are several suppliers, an average distance obtained from the ratio of total kilometres travelled to the number of trips made was taken as the distance travelled;
- production of alloying elements, chemicals and auxiliaries, such as

  - ✓ alloying elements. In order to protect industrial secrecy, alligators have all been reduced to a single type, namely silicon;

- ✓ salts (e.g. discouraging and detaching agents);
- ✓ water treatment materials (e.g. softening salts);
- ✓ auxiliary materials for the plant (e.g. argon, soda ash, oxygen);

- transport of auxiliary materials from the supplier to the production site. The kilometres between the supplier and Eural Gnutti's production site (Pontevico or Rovato, depending on the materials considered) were considered here. In the case of several suppliers, the greatest distance was considered;
- production of spare parts (e.g. refractories) and all material required for frequent maintenance operations;
- production of packaging for distribution;
- consumption of electricity and fuels and other energy carriers used in upstream processes.

The following processes, however, were not included:

- maintenance of machinery and other operations carried out occasionally (i.e. frequently > 3 years) or in emergency situations;
- packaging of raw and auxiliary materials used in the production of aluminium, as they are considered irrelevant.

Core Processes include:

- transport of materials and components from the billet production site (Pontevico) to the bar conversion site (Rovato);
- manufacturing processes of aluminium and aluminium alloys, from casting to drawing;
- direct emissions generated in the main processes (e.g. CO, NOx, SOx, heavy metals);
- consumption of electricity and fuels and other energy carriers used in core processes;
- co-products, such as slag, chips, oxides;
- packaging of the bar produced.

The following processes, however, were not included:

- manufacture of production equipment, buildings and other capital goods;
- maintenance of machinery and other operations carried out occasionally (i.e. frequently > 3 years) or in emergency situations;
- staff business trips;
- movement of personnel to and from the workplace;
- research and development activities, including the production and manufacture of laboratory equipment.

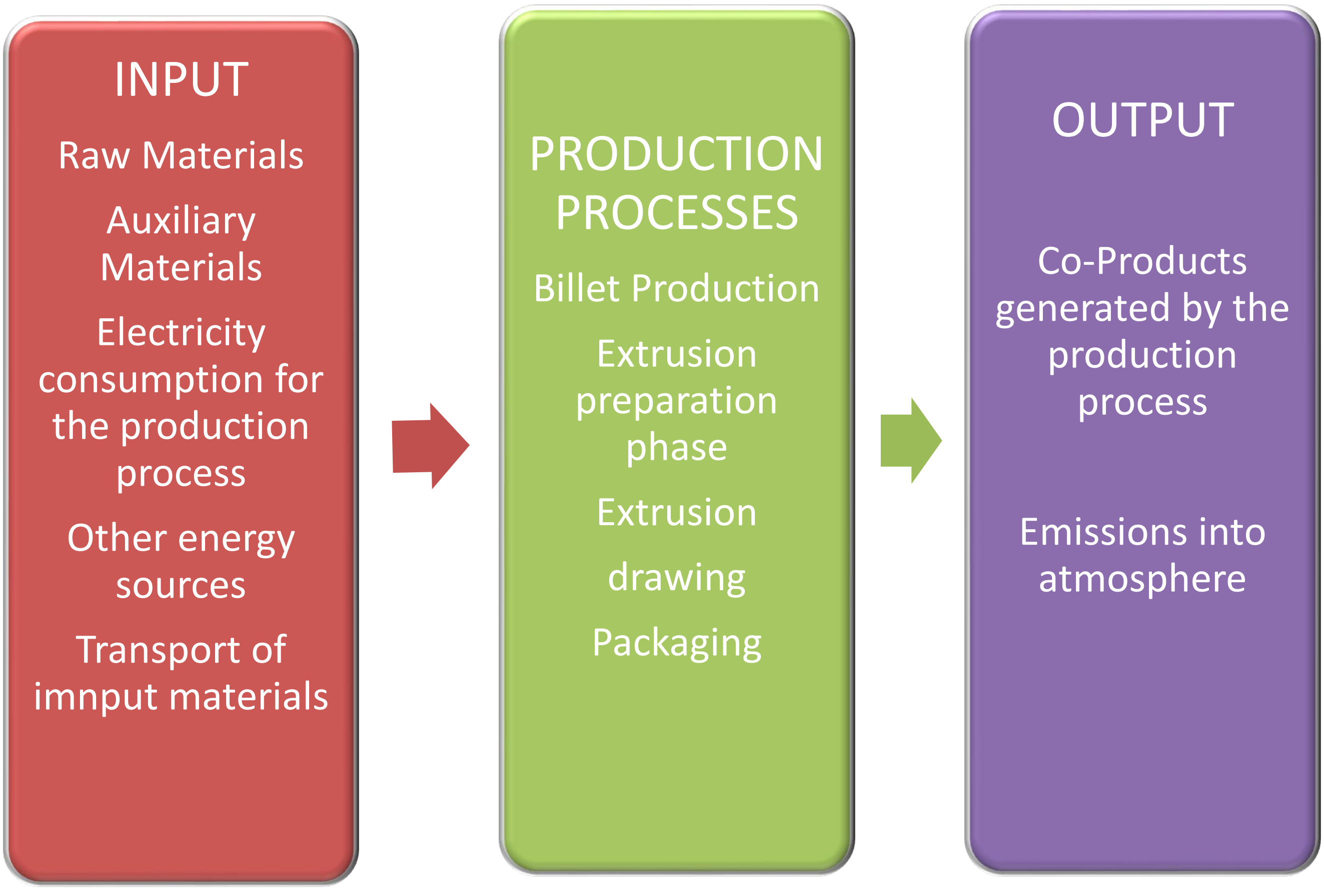

Figure 4. Elements considered in the analysis

3.4 Exclusion Criteria

In the present study, no cut-off criteria were adopted: all flows needed for the investigation were considered in their entirety, as defined in the previous section, provided there were sufficient data.

4. Life cycle inventory analysis

Life cycle inventory (*LCI*) analysis is a phase of *life cycle assessment* (*LCA*) that includes the compilation and quantification of inputs and outputs related to the product under consideration, throughout its entire life cycle. This phase consists of the following steps.

4.1 Data Collection Processes

Qualitative and quantitative data for LCI were collected for the identified unit processes included in the system boundaries. The data collected (measured, calculated or estimated) were used to quantify the inputs and outputs of a unit process.

The most important material and energy flows of the analysed processes were collected in order to construct what can be considered the heart of the LCA method, the 'inventory analysis'. After the input and output data of the various processes had been derived and processed, the results were calculated and recorded.

Inputs

Impacts in this phase of the life cycle come from the sources divided as follows:

- Raw material production
- Material transport from supplier to production site
- Production of other auxiliary input materials/substances used in the production process and their transport from suppliers to the production site
- Energy consumption

The main sources relating to the production of the bar are:

Source	Primary data	Secondary data
Raw material production	✓ Type of material ✓ Material weight per product	✓ Impact factor from production by material type
Transport of raw materials	✓ Distance to supplier ✓ Quantity of material transported ✓ Vehicle type ✓ Type of fuel consumed	✓ Activity-based impact factor (tkm)
Electricity consumption for production processes	✓ Total electricity consumption ✓ Electricity consumption per product	✓ Impact factor for the national network
Consumption of other energy sources	✓ Overall consumption ✓ Consumption per product	✓ Impact factor per source type
Production of other input materials	✓ Material weight ✓ Type of material	✓ Impact factor from production by material type
Transport of other input materials	✓ Distance to supplier ✓ Quantity of material transported ✓ Type of vehicle ✓ Type of fuel consumed	✓ Activity-based impact factor (tkm)

Outputs

The main sources for outputs are:

Source	Primary data	Secondary data
Atmospheric emissions from production process	✓ Type of pollutant ✓ Concentration of each type of pollutant	✓ Single pollutant impact factor

Table 1. Main sources on bar production

4.2 Qualitative and quantitative description of unit processes

Aluminium rods are produced using mostly secondary (pre- or post-consumer) aluminium and alligators. The content of the ingredients in relative terms is presented in Table 3.

Ingredients	% in 1 kg bar
Aluminium (primary)	20-30%
Aluminium (secondary - pre consumer)	20-30%
Aluminium (secondary - post consumer)	40-50%
Alligants	1-5%
Other materials	10-20%

Table 2. Composition of the analysed product

BAR PRODUCTION

FACTORY IN PONTEVICO (BS)

The Pontevico billet foundry has been in operation since 1985, and aluminium alloy casting is carried out at the site. In particular, the plant makes use of modern casting and casting technologies. The plant is able to guarantee compliance of billets with the class "A" requirements of the SAE AMS-STD-2154 standard on structural integrity.

The production cycle of the Pontevico plant can be summarised as follows:

- **Raw material reception, control and storage**
    - Reception of raw material first control and storage in dedicated areas
- **Yield verification and compacting**
    - The yield is checked and compacted if necessary
- **Furnace loading, melting and alligator**
    - Loading of material into the melting and waiting furnaces for alloying materials
- **Billet cooling**
    - The cast material is poured into the casting plate and the billets are cooled
- **Storage and quality control**
    - Billets are stored in the yard awaiting subsequent operations
- **Cutting and homogenisation**
    - Billets are cut at the start of casting
- **Shipping to Rovato**
    - Shipment of billets to Rovato by wheeled transport

FACTORY IN ROVATO (BS)

The Rovato plant was established in 1968, at the site the production of semi-finished products takes place, supplemented by subsequent cold working (drawing) with heat treatments. Eural Gnutti's production mainly consists of round, square, hexagonal and flat bars and profiles in aluminium alloys.

Once the billet reaches the Rovato plant, this process follows:

- **Billet storage in dedicated yards**
    - Billets received are stored waiting to be transported to the cutting department, or directly to the extrusion pre-heating oven

- **Transport to the extrusion departments for prior reheating of the material to extrusion temperature in special ovens heated directly with methane gas**
  - Transport by forklift, loading into the preheating oven and subsequent heating to extrusion temperature
- **Billet chiselling before introduction into the press**
  - Removal of the outer part of the billet before extrusion
- **Extrusion with hydraulic horizontal presses using preheated 'hot' special steel tooling,**
  - The billet after being cut to the appropriate length is extruded
- **Solubilisation treatment with cooling in water.**
  - Preheating of extruded rods to solution temperature and subsequent cooling in water
- **Ironing.**
  - Stretching of bars to eliminate stresses generated by hardening
- **Ageing**
  - Bars undergo artificial ageing treatment
- **Pickling**
  - Treatment in basic and acidic solutions to remove oxidation, and bar cleaning before drawing
- **Cold-drawing.**
  - Cold drawing of bars
- **Control**
  - Final conformity, surface, mechanical, macrographic and chemical analysis checks
- **Packaging and storage.**
  - Packaging and storage of bars in covered warehouse ready for shipment to customers

The process described above is summarised graphically in the diagram below.

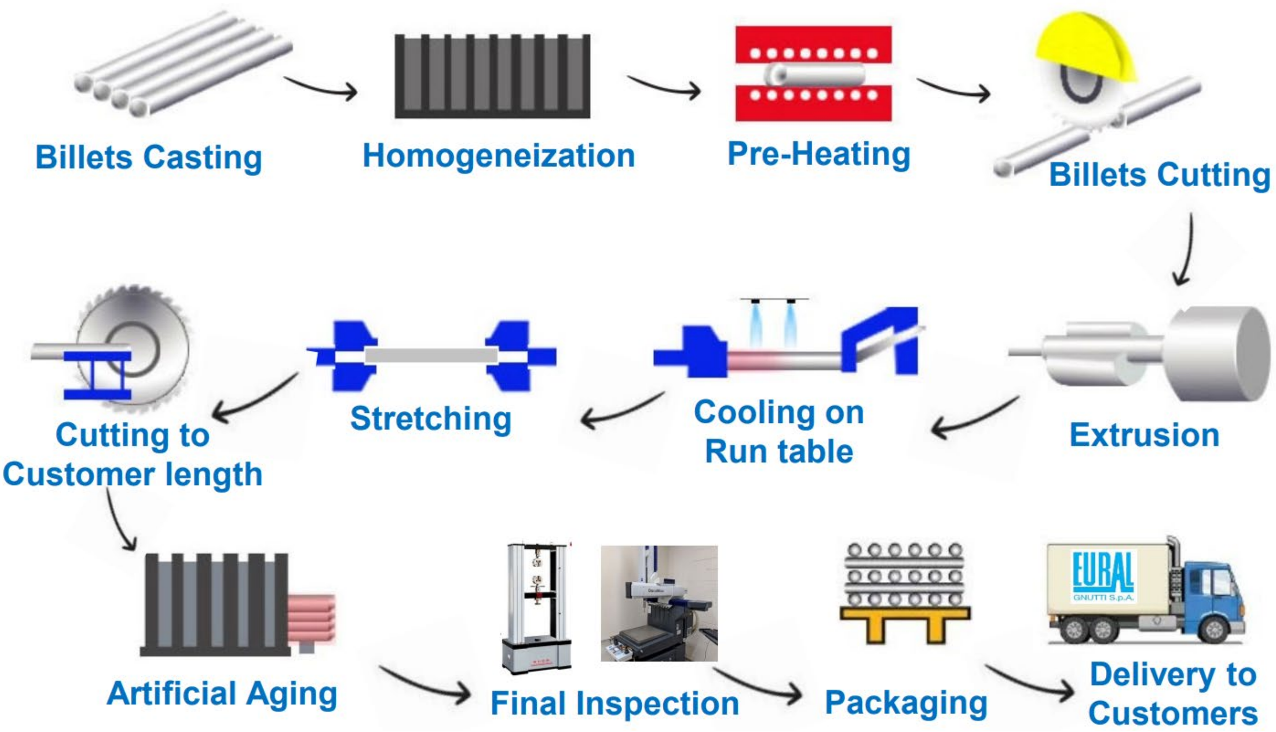

Figure 5. Stages of the production process at the Rovato plant

4.3 Sources of published literature

No literature sources were used to elaborate this study, with the exception of the databases considered.

4.4 Calculation Procedures

Once the data collection is complete, the next step is the calculation of the impact relative to the individual sources. The calculation is developed using OpenLCA software.

OpenLCA, is an opensource software, which is based on the creation of four elements:

- Flows: in this initial step, the flow is indicated, i.e. the object under consideration and the units of measurement that will be used for calculation. In this step, the properties and thus the units of measurement that will be taken into account are indicated;
- Processes: in this phase, inputs and outputs are indicated with their respective quantities and units of measurement. This part constitutes the inventory phase;
- Product system: In this phase, the graphical model is provided, i.e. the network of processes representing the product system is created;
- Projects: In this final phase, all data are organised into a single project, in which a report is created with the results obtained from the product systems and indicating the impact generated according to the chosen evaluation method.

With regard to the database to be used, a choice was made among the databases made available by OpenLCA Nexus. In particular, priority was given, for the most part, to the information made available within the Ecoinvent and EF database, which have a wealth of data with Italian/European geographical references.

The study therefore involved searching and analysing within the databases, the most appropriate information for the creation of the subsequent steps illustrated above.

Finally, the impact was calculated using the EF v.3.1 evaluation method.
The results thus obtained were then analysed, showing the data in the following chapter.

The steps described above were followed for both products under analysis.

4.5 Data Validation

During the data collection process, a data validity check was conducted to confirm and demonstrate that all data quality requirements were met. During data validation, the focus was on the primary, site-specific data, such as electricity consumption and product specifications, as well as transport data.

4.5.1 Data Quality Assessment

Considering the crucial importance of the reliability of the values of the LCA study, the ascertainment and reliability of the data collected constitutes an important preparatory phase, which allows time to be optimised in the subsequent phases of the study. It is therefore important at this stage to determine the degree of detail and the elements on which the accuracy of the analysis depends. There are two main types of data used to calculate the carbon footprint that can be classified as:

- Primary data - data collected directly in the field, from specific facilities owned or controlled by the reference company or a company within its supply chain

- Secondary data - derived data that can be obtained from literature or specially prepared databases (e.g. energy company in the country where the analysis is carried out, emissions from a truck used for transport, and so on). Generally, to be relevant, secondary data must reflect the typical conditions of the respective processes or services, and when using derived data, it is important to check and cite the sources, date of publication and all elements that allow for transparent handling.

The specific data for this study were collected by Eural Gnutti, for individual processes under the operational control of the organisation that conducted the LCA analysis.
In the life cycle assessment, secondary data from the most significant existing databases were used.
For secondary data, two databases were mainly used: Ecoinvent and PEF (Environmental Footprint). The choice was dictated by the completeness of the data contained within these two databases and the fact that they make available data predominantly referring to the European context.

Specific data were used for all considered processes of Eural Gnutti, based on the production year 2023. Secondary data, e.g. on transport and electricity production, came from Ecoinvent.

In order to reduce the level of uncertainty, the following was considered:

1. The specific data were evaluated by the company and, where possible, checked and documented;
2. In collecting the secondary data, the following principles were taken into account:
    i. data at national level
    ii. EU-wide data
    iii. data at international level, used only if the above-mentioned data are not available (IPCC, US EPA, etc.).

From the analysis that was made on the data used, the following can be stated:

- Temporal representativeness: the primary data were collected specifically for the elaboration of this study by Eural Gnutti; as for the secondary data, the databases used (Ecoinvent and PEF) are in the latest update available in OpenLCA.
- Geographical representativeness: the processes used in this study reflect the geography of the boundaries of the system (e.g. the energy mix used reflects, when known, the country of production, when not known the geographical area of reference: Europe or the World); the choices are however in line with the scope of the study.
- Technological representativeness: when choosing the data and modelling the different life cycle phases, it was taken into account that the technology described in the database was representative of the analysed system.
- Accuracy: data were collected accurately and validated through comparisons and verifications of mass and energy balances; in addition, an uncertainty analysis was carried out through Monte Carlo analysis.
- Reproducibility: The processes used for modelling and the data described in this report allow the results of the study to be reproduced, using the same database, methods and characterisation factors.
- Data sources: the data collection file used clearly reports all sources used

4.5.2 Treatment of missing data

Not all the necessary data turned out to be available. Furthermore, for some of the data to be considered (e.g. skimming) it was not possible to identify a suitable dataset within the databases used.

For these two types of data, it was decided not to include them in the analysis, in order to avoid diminishing their quality by including purely estimated data or data referring to poorly consistent types that were not the one sought.

For those not currently available, internal monitoring will be improved so that they can be integrated at a later stage of the analysis.

However, it is possible to consider the impact of these data as very small, since they do not belong to the most relevant macrocategories from the point of view of LCA analysis.

4.6 Sensitivity analysis to correct system boundaries

It was not necessary to change the boundaries of the system, but one of the sensitivity analyses took in

benefits are also taken into account. A description of the sensitivity analyses carried out can be found in section 6.1.

4.7 Allocation Principles and Procedures

Allocation consists of the allocation of inputs and outputs to the different process units. Each process unit can be divided into sub-processes.

In this phase, inputs and outputs are assigned to each process system.

In this particular case, detailed data is provided for almost every process step.

The effects of the primary production of reused materials are allocated to the main product in which the material was used.

No allocation criteria were applied, other than those already present in the Ecoinvent and PEF processes used.

5. Life Cycle Impact Assessment

In the *Life Cycle Impact Assessment (LCIA*) phase of the LCA study, the potential impact of each source, with reference to the categories listed in the next section, identified within the system boundaries was quantified. The calculation is developed by multiplying the activity data with the relevant impact factors, each for each criterion considered.

5.1 Models, impact categories and indicators considered

The impact categories that were considered in the LCA analysis are those suggested in the UN CPC 4153 PCR, among others:

Impact category	Indicator	Units of Measurement
Climate change	✓ Global Warming Potential (GWP)	✓ Kg CO_2 eq
Acidification	✓ Acidification potential (AP)	✓ mol H+ eq
Eutrophication, freshwater	✓ Fraction of nutrients reaching freshwater end compartment (P)	✓ Kg P eq
Eutrophication, terrestrial	✓ Accumulated exceedance (AE)	✓ mol N eq
Eutrophication, marine	✓ Fraction of nutrients reaching marine end compartment (N)	✓ Kg N eq
Photochemical formation of ozone	✓ Tropospheric ozone concentration increase	✓ kg NMVOC eq
Depletion of the ozone layer	✓ Ozone depletion potential (ODP)	✓ kg CFC 11 eq
Resource utilisation, minerals and metals	✓ Abiotic resource depletion (ADP)	✓ kg Sb eq
Resource utilisation, fossil	✓ Abiotic depletion potential (ADP) for fossil resources	✓ MJ
Use of water resources	✓ User deprivation potential	✓ m^3 water eq of deprived water

Table 3. Impact categories considered in the study

5.2 The results of the study

The life cycle impacts of aluminium bars produced by Eural Gnutti, result in:

1 kg aluminium alloy 2033 bar		
Impact category	**Value**	**Units of Measurement**
Climate change	4,444	Kg CO_2 eq
Acidification	0,023	mol H+ eq
Eutrophication, freshwater	0,002	Kg P eq
Eutrophication, terrestrial	0,043	mol N eq
Eutrophication, marine	0,004	Kg N eq
Photochemical formation of ozone	0,015	kg NMVOC eq
Depletion of the ozone layer	1,07E-7	kg CFC 11 eq
Resource utilisation, minerals and metals	8,47E-6	kg Sb eq
Resource utilisation, fossil	64,59	MJ
Use of water resources	12,043	m^3 water eq of deprived water

Table 4. Environmental impacts per production of 1 kg of alloy bar 2033

1 kg aluminium alloy bar 6026LF		
Impact category	**Value**	**Units of Measurement**
Climate change	3,131	Kg CO_2 eq
Acidification	0,018	mol H+ eq
Eutrophication, freshwater	0,001	Kg P eq
Eutrophication, terrestrial	0,032	mol N eq
Eutrophication, marine	0,003	Kg N eq
Photochemical formation of ozone	0,011	kg NMVOC eq
Depletion of the ozone layer	8,29E-8	kg CFC 11 eq
Resource utilisation, minerals and metals	5,79E-6	kg Sb eq
Resource utilisation, fossil	46,51	MJ
Use of water resources	7,65	m^3 water eq of deprived water

Table 5. Environmental impacts per production of 1 kg of 6026LF alloy bar

The environmental impacts for the different stages of the production cycle are as follows:

1 kg aluminium alloy 2033 bar					
Indicator	**Unit**	**Phases**			
		Billet production	Billet transport	Pre-extrusion	Extrusion and drawing
GWP	**Kg CO_2 eq**	4,238	0,02	0,041	0,2
AP	**mol H+ eq**	0,022	0,00003	0,0002	0,0012
P	**Kg P eq**	0,002	0	0,00001	0,00005
AE	**mol N eq**	0,039	0,00007	0,0007	0,004
N	**Kg N eq**	0,004	0,00001	0,00007	0,0004
Tropospheric ozone concentration increase	**kg NMVOC eq**	0,014	0,00004	0,0002	0,001
ODP	**kg CFC 11 eq**	8,7E-8	2,554E-10	3,353E-9	2,012E-8
ADP	**kg Sb eq**	8,127E-6	3,924E-8	4,062E-8	3,481E-7
ADP for fossil resources	**MJ**	61,15	0,18	0,7	3,44
User deprivation potential	**m^3 water eq of deprived water**	12,03	0,0009	0,0009	0,013

Table 6. Environmental impacts disaggregated by LCA stages (league 2033)

1 kg aluminium alloy bar 6026LF					
Indicator	Unit	Phases			
		Billet production	Billet transport	Pre-extrusion	Extrusion and drawing
GWP	**Kg CO_2 eq**	2,932	0,013	0,038	0,199
AP	**mol H+ eq**	0,017	0,00002	0,0001	0,001
P	**Kg P eq**	0,001	0	0	0,00005
AE	**mol N eq**	0,029	0,00007	0,0007	0,003
N	**Kg N eq**	0,003	0,00001	0,00007	0,0003
Tropospheric ozone concentration increase	**kg NMVOC eq**	0,01	0,00005	0,0002	0,001
ODP	**kg CFC 11 eq**	6,351E-8	2,547E-10	3E-9	1,936E-8
ADP	**kg Sb eq**	5,465E-6	3,914E-8	4,088E-8	3,278E-7
ADP for fossil resources	**MJ**	43,07	0,18	0,66	3,44
User deprivation potential	**m^3 water eq of deprived water**	7,635	0,0009	0,0009	0,013

Table 7. Environmental impacts disaggregated by LCA stages (alloy 6026LF

As expected, therefore, the process with the greatest impact on the total is that of billet production at the Pontevico plant.

The following tables show the influence of the different sources of environmental impact by macro-categories of life cycle phases. 1 Kg of aluminium bar alloy 2033					
Indicator	Unit	Phases			
		Raw material production	Production of other materials	Energy consumption	Transport
GWP	**Kg CO_2 eq**	3,836	0,031	0,263	0,313
AP	**mol H+ eq**	0,02	0,0006	0,002	0,0006
P	**Kg P eq**	0,002	1,93E-5	6,76E-5	2,10E-5
AE	**mol N eq**	0,032	0,003	0,006	0,002
N	**Kg N eq**	0,003	0,0003	0,0006	0,004
Tropospheric ozone concentration increase	**kg NMVOC eq**	0,012	0,0008	0,001	0,001
ODP	**kg CFC 11 eq**	7,19E-8	4,21E-10	2,86E-8	6,24E-9
ADP	**kg Sb eq**	7,10E-6	4,13E-7	1,68E-10	9,62E-7
ADP for fossil resources	**MJ**	55,034	0,592	4,594	4,37
User deprivation potential	**m3 water eq of deprived water**	11,994	0,027	0	0,022

Table 8. Environmental impacts related to input macrocategories (alloy 2033)

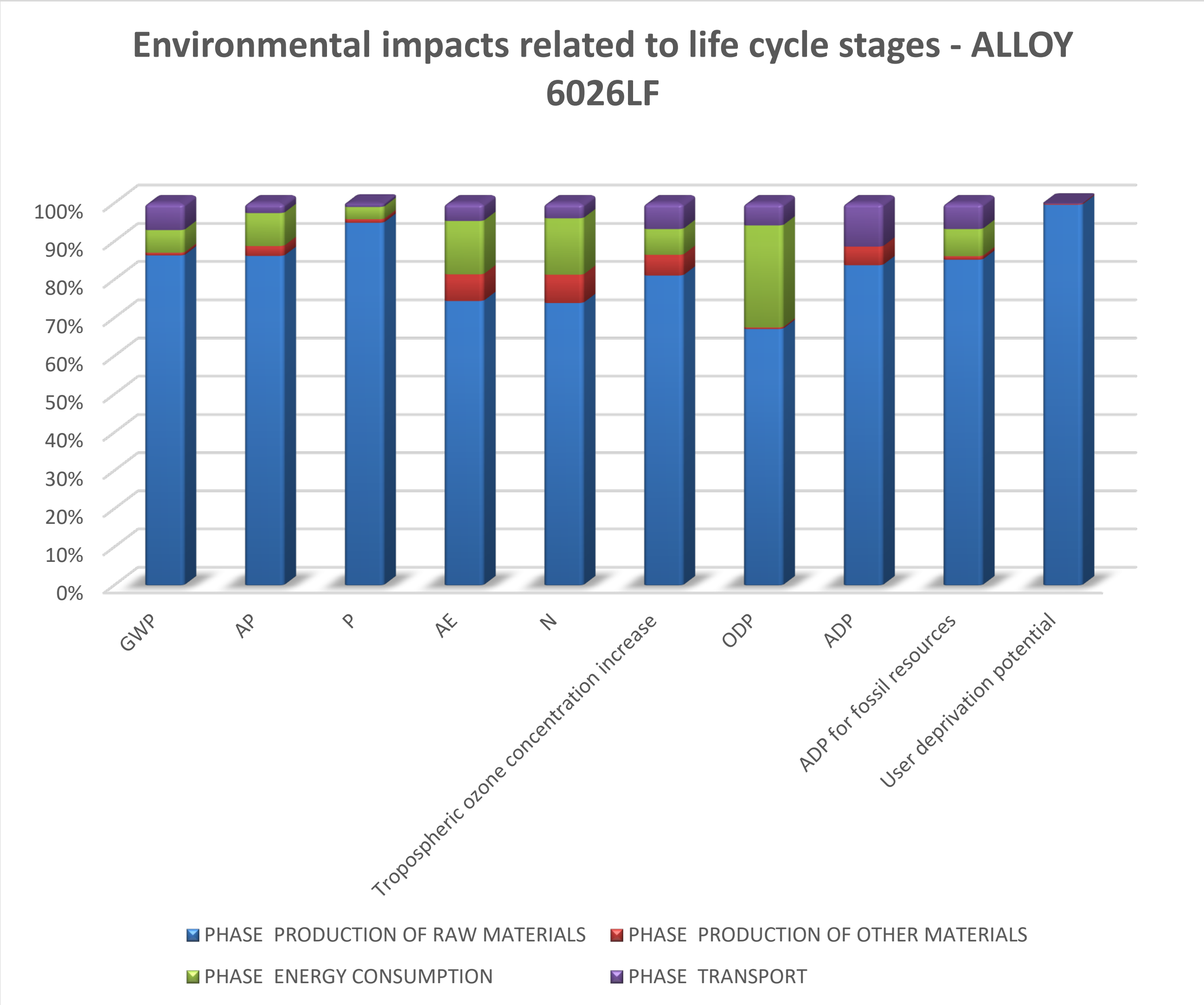

Figure 6. Histogram Graph of Environmental Impacts Related to Input Element Macrocategories (Alloy 2033)

1 kg aluminium alloy bar 6026LF					
Indicator	Unit	Phases			
		Raw material production	Production of other materials	Energy consumption	Transport
GWP	**Kg CO_2 eq**	2,74	0,037	0,284	0,07
AP	**mol H+ eq**	0,015	0,0008	0,002	0,0001
P	**Kg P eq**	0,001	2,72E-5	7,60E-5	4,74E-6
AE	**mol N eq**	0,023	0,004	0,006	0,0004
N	**Kg N eq**	0,002	0,0004	0,0006	3,55E-5
Tropospheric ozone concentration increase	**kg NMVOC eq**	0,009	0,0007	0,001	0,0002
ODP	**kg CFC 11 eq**	5,03E-8	7,09E-10	3,05E-8	1,41E-9
ADP	**kg Sb eq**	5,18E-6	3,93E-7	1,61E-10	2,17E-7
ADP for fossil resources	**MJ**	39,893	0,657	4,969	0,987
User deprivation potential	**m^3 water eq of deprived water**	7,613	0,03	0	0,005

Table 9. Environmental impacts related to macrocategories of input elements (alloy 6026LF)

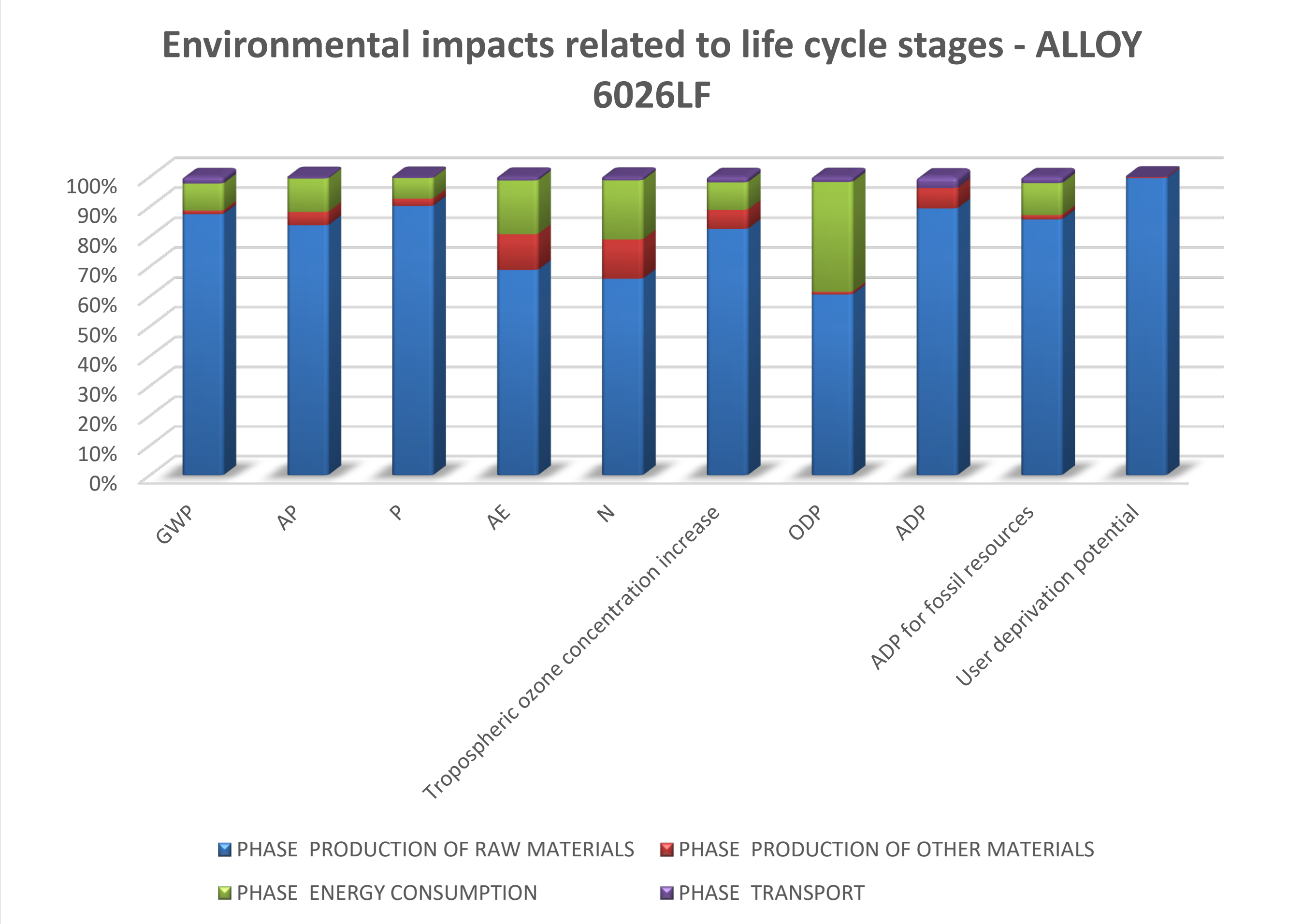

Figure 7. Histogram chart of environmental impacts related to macrocategories of input elements (alloy 6026LF)

The calculation of these emissions is divided into four main segments:

- **Raw material** production - production of the raw materials used to create the alloy. Included within or this category are: primary aluminium, secondary aluminium - pre consumer, secondary aluminium post consumer and alligators. These components come from different companies within the country and/or the EU. The data used are secondary data, combined with the amount of material required to produce 1 kg of aluminium bar.
- **Production of other** materials - production of auxiliary materials that enter the production process. The data used are secondary data, combined with the amount of material required to produce 1 kg of aluminium bar.
- **Transport of materials** - the calculation of environmental impacts related to this activity is based on the following primary data: type and quantity of material, distance to the supplier, type of vehicle and fuel used.

With regard to activity data for transport, both for raw materials and other input materials, the following were considered:

- Type of transport used: 16-32 tonne truck, diesel EURO6
- Distance travelled between the producer/supplier's site and the Eural Gnutti plant (Pontevico or Rovato): distances were taken from the calculator available on the Internet (google map) or, where more than one supplier was to be considered, the average distance was calculated by dividing the total kilometres travelled in the year by the number of trips made (in particular, for the transport of raw materials).

- **Energy consumption** - this data is available at company level, either as summary data or by specific product. The company consumes electricity and methane gas and the primary data regarding these sources are: type of fuel, origin of the electricity consumed and the consumption to produce 1 kg of bar.
The specific data for the declared unit was obtained, where possible, by measuring the machine's absorption; where this was not possible, the nameplate power was taken into account, related to the time of use (also estimated), or the total consumption was divided by the phase considered for annual production.

During the production of the bar, there are direct emissions into the environment from the following operations:

- Furnaces: The pollutants considered are Dust, PAH, Dioxins, PCB, CO, Nox, HF, HCl, Hg, Hazardous Metals, COT;
- Cutting and related operations: the pollutants considered are Dust and PAH;
- Extrusion: the pollutants considered are Dust and PAH;
- Pickling: the pollutant considered is sulphuric acid.

From the perspective of almost all impact categories analysed, the most important values come from the production of raw materials, which account for more than half of the impacts generated.
Next are the impacts from energy consumption, which includes electricity and methane.

5.3 Limitations of the Life Cycle Inventory Assessment (LCIA) results
There are no limitations in relation to the defined objective and scope of the LCA.

5.4 Results of the LCIA in relation to the objective and scope
The results of the LCIA are in line with the defined objective and scope of the LCA.

5.5 LCIA versus Life Cycle Inventory (LCI) results
LCIA results are in line with LCI results

6. Life Cycle Interpretation

The results of the quantification of environmental impacts, according to LCIA, were interpreted according to the objective and scope of this study. The interpretation includes:

- Quantitative and/or qualitative assessment of uncertainty,
- Sensitivity analysis
- Completeness check
- Consistency check
- Conclusions and recommendations

Uncertainty analysis

The uncertainty analysis of the total result was conducted with the Monte Carlo Method using the specific OpenLCA functionality. The analysis was performed on 100 runs using the Lognormal distribution for which the property applies that 95% of the possible values lie between: value/sigma^2 and value*sigma^2, where sigma represents the standard deviation of the distribution.

This analysis shows that the LCA study:

Indicator	Uncertainty - alloy bar 2033		
	Average value	Median	Standard deviation
Global Warming Potential (GWP)	12,04308147	12,04308147	8,92653E-15
Acidification potential (AP)	0,004446585	0,004446249	8,02082E-05
Fraction of nutrients reaching freshwater end compartment (P)	0,043380298	0,043382998	0,000857563
Accumulated exceedance (AE)	0,002050806	0,002035995	6,53512E-05
Fraction of nutrients reaching marine end compartment (N)	0,015487691	0,015471499	0,000238022
Tropospheric ozone concentration increase	1,046304529	0,96094516	0,351883256
Ozone depletion potential (ODP)	4,459618113	4,456624536	0,017867405
Abiotic resource depletion (ADP)	8,47496E-06	8,47495E-06	7,01218E-11
Abiotic depletion potential (ADP) for fossil resources	1,13875E-07	1,13813E-07	7,7232E-09
User deprivation potential	0,023365292	0,023350501	0,000201806

Table 10. Uncertainty analysis bar alloy 2033

Indicator	Uncertainty - alloy bar 6026LF		
	Average value	Median	Standard deviation
Global Warming Potential (GWP)	3,14426624	3,140589143	0,017015655
Acidification potential (AP)	0,018189641	0,018160036	0,000189279
Fraction of nutrients reaching freshwater end compartment (P)	0,001538045	0,001519879	7,16045E-05
Accumulated exceedance (AE)	0,033041697	0,032938276	0,000748375
Fraction of nutrients reaching marine end compartment (N)	0,003396348	0,003382593	6,90477E-05
Tropospheric ozone concentration increase	0,011654848	0,011633753	0,000197955
Ozone depletion potential (ODP)	8,99972E-08	8,84477E-08	9,92874E-09
Abiotic resource depletion (ADP)	46,84111503	46,72869059	0,608217766
Abiotic depletion potential (ADP) for fossil resources	5,79245E-06	5,79245E-06	6,81826E-11
User deprivation potential	7,64798109	7,64798109	7,14122E-15

Table 11. Uncertainty analysis bar alloy 6026LF

In both cases, a low level of uncertainty is expected.

Sensitivity analysis

The sensitivity analysis should present the influence of various significant inputs, outputs and methodological choices, including allocation methods, applied to the LCA results.

A sensitivity analysis of the data was conducted with respect to possible transport scenarios for the distribution of products from the producers' premises to the production sites of Eural Gnutti, to take into account the different distances in the transport phase.

Currently, the distances between the manufacturer's registered office and Eural Gnutti's production sites, as far as auxiliary materials are concerned, and the average kilometres per trip, as far as raw materials are concerned, have been taken into account.

Two scenarios were therefore assumed, one more conservative, the other more negative, in order to be able to analyse the impact of transport if the actual site where the raw materials are produced was taken into account.

Two scenarios were then defined, compared to the one taking into account the distances currently travelled, assuming, in one, that the product could be purchased from Italian companies all within 50 km (Scenario 1) of the bar production site, the other in which the products all come from distances greater than 700 km (Scenario 2), greater than the current maximum distance.

Transport impact per 1 kg alloy bar 2033										
	Kg CO_2 eq	mol H+ eq	Kg P eq	mol N eq	Kg N eq	kg NMVOC eq	kg CFC 11 eq	kg Sb eq	MJ	m^3 water
LCA study 2033	4.4435	0.023	0.0020	0.0427	0.0043	0.01526	1.07E-7	8.47E-6	64.5	12.043
LCA studio 6026LF	3.1312	0.017	0.0014	0.0324	0.0033	0.0114	8.29E-8	5.79E-6	46.5	7.65
Scenario 1										
Alloy bar 2033	4.6016	0.024	0.0020	0.0435	0.0044	0.0158	1.10E-7	8.96E-6	66.7	12.054
DIFFERENCE	**+3,6%**	**+4,3%**	**0**	**+1,9%**	**+2,3%**	**+3,5%**	**+2,8%**	**+5,8%**	**+3,4 %**	**+0,1%**
Alloy bar 6026LF	3.1094	0.017	0.0014	0.0323	0.0033	0.0113	8.24E-8	5.72E-6	46.2	7.6464
DIFFERENCE	**-0,7%**	**0**	**0**	**-0,3%**	**0**	**-0,9%**	**-0,6%**	**-1,2%**	**-0,6%**	**-0,04%**
Scenario 2										
Alloy bar 2033	10.565	0.035	0.0024	0.0758	0.0074	0.0364	2.29E-7	2.72E-5	149.9	12.465
DIFFERENCE	**+137%**	**+52,2 %**	**+20%**	**+77,5%**	**+72%**	**+138%**	**+114%**	**+221%**	**+132, 4%**	**+3,5%**
Alloy bar 6026LF	3.2292	0.018	0.0015	0.0329	0.0033	0.0117	8.48E-8	6.09E-6	47.8	7.6547
DIFFERENCE	**+3,1%**	**+5,9%**	**+7,1%**	**+1,5%**	**0**	**+2,6%**	**+2,3%**	**+5,2%**	**+2,8 %**	**+0,06%**

Table 12. Sensitivity analysis

The analysis shows that the transport phase can lead to a reduction of about 1% in the best case scenario, and an increase of more than 7% in the worst case scenario.

The results of the sensitivity analyses show that the differences, although rather marked, have a modest effect on the overall environmental impacts of the product, with the exception of the worst-case scenario for alloy 6026LF. The reason for this is that most of the emissions come from the production of raw materials. Therefore, it can be said that, even with a high level of assumptions, the calculation represents a reliable analysis of the impact of the product throughout its life cycle.

Completeness check

The completeness check qualitatively assesses the information and data used in the different phases of the LCA study to ensure their completeness with respect to the defined objectives, scope, system boundaries and quality criteria. This check is useful to ensure that all major aspects of the life cycle have been considered and all available data analysed.

All processes within the individual life-cycle phases included in the system boundaries were modelled to represent each specific situation. All available data for each process unit were checked. Below is the table used as a guide for the check, which includes an assessment of the need or otherwise for data integration.

Input/Output	Alloy 2033	Complete?	Action required	Alloy 6026LF	Complete?	Action required	General completeness of data
Raw material production	X	YES	-	X	YES	-	Excellent
Transport of raw materials	X	YES	-	X	YES	-	Excellent
Electricity consumption for production processes	X	NO	Improved monitoring	X	NO	Improved monitoring	Excellent
Consumption of other energy sources	X	NO	Improved monitoring	X	NO	Improved monitoring	Excellent
Production of other input materials	X	NO	Other available databases will also be evaluated	X	NO	Other available databases will also be evaluated	Excellent
Transport of other input materials	X	YES		X	YES	-	Excellent
Waste/product production	X	NO	Improved monitoring Other available databases will also be evaluated	X	NO	Improved monitoring Other available databases will also be evaluated	Good
Atmospheric emissions from production process	X	YES	-	X	YES	-	Excellent

Table 13. Completeness analysis

Consistency check

The consistency check ensures that the data quality, assumptions and methods used were consistent with the objective and scope of the study. This was done by following the method indicated in IOS 14044 (see table).

Consistency check	
Data quality and accuracy	It is considered sufficient
Choice of method	The methodological choices made are consistent with the ISO 14040 and 14044 and ISO 14067 standards taken as reference in this study.
Age of data	The data refer to 2023
Technology coverage	State of the art
Time coverage	Recent
Geographical coverage	Italy/Europe
Evaluation of inconsistencies	Analyses of results, input and output flows, and outcome networks revealed no inconsistencies

Table 14. Consistency analysis

Conclusions, limitations and recommendations

The LCA Study shows that the greatest impacts come from the input processes, with raw material production clearly predominating, accounting for more than 80 per cent for almost all categories considered. The calculation made for these emission sources is based on the type and quantity of material required to produce 1 kg of aluminium bar.

On the other hand, the various *core* stages of the bar production process have an impact of between 10 and 20 per cent. The contribution of energy consumption on ozone layer depletion appears particularly relevant. However, the analysis made confirms that the activities connected with the actual production carried out by Eural Gnutti within its factory are relatively impactful in the product life cycle.

The other sources included in the system boundaries, represented by transport and auxiliary material production. as the analysis shows, are much lower, with little individual impact.

However, since this is the first study of this type carried out by Eural Gnutti, it is possible that not all input and output elements, for the various production stages, have been fully considered. At a more mature stage, a more precise and detailed analysis will be possible, going further into auxiliary processes, in addition to the *core* processes considered.

Considering the assumptions made above, it may also be worthwhile to try to obtain primary activity data directly from the raw material producers, so that the use of literature data can be avoided. To date, given the difficulty of obtaining data directly from producers of raw materials or other materials required for bar production, it has been decided to proceed via literature data.

Ultimately, the LCA methodology also has limitations inherent in the method itself, e.g. the availability of accurate and complete data, complexity of the study, timeframes and the costs involved for resources and information. One of the most significant issues that may be encountered concerns the possibility of dealing with the lack of information based on sound science, due to the lack or even absence of previous studies.
This brings the risk of defining the inventory with data that is assumed and inferred or not always so precise and complete .