REPORT

Life Cycle Assessment of Copper Shapes (Aurubis SHAPES)

What is Life Cycle Assessment?

LCA is a decision-making tool used to identify environmental burdens and evaluate the potential environmental impacts of goods or services over their life cycle.

The benefit of using an LCA approach means that negative impacts can be identified and possibly minimized while avoiding the transfer of these impacts from one life cycle stage to another. When applied to product design, production processes, and a decision-making aid, LCA is a meaningful tool for implementing effective sustainability strategies.

Goal

To evaluate our environmental performance and contribution to sustainable development, we carried out a life cycle assessment (LCA) for the copper shapes (billets and cakes) or Aurubis SHAPES.

This study helps in tracking the improvement progress and identifying opportunities for further improving our environmental performance. The results are intended to be published and disclosed to the public.

The target audience includes stakeholders interested in the life cycle environmental impacts of copper shapes such as customers, investors, governmental authorities, non-governmental organizations.

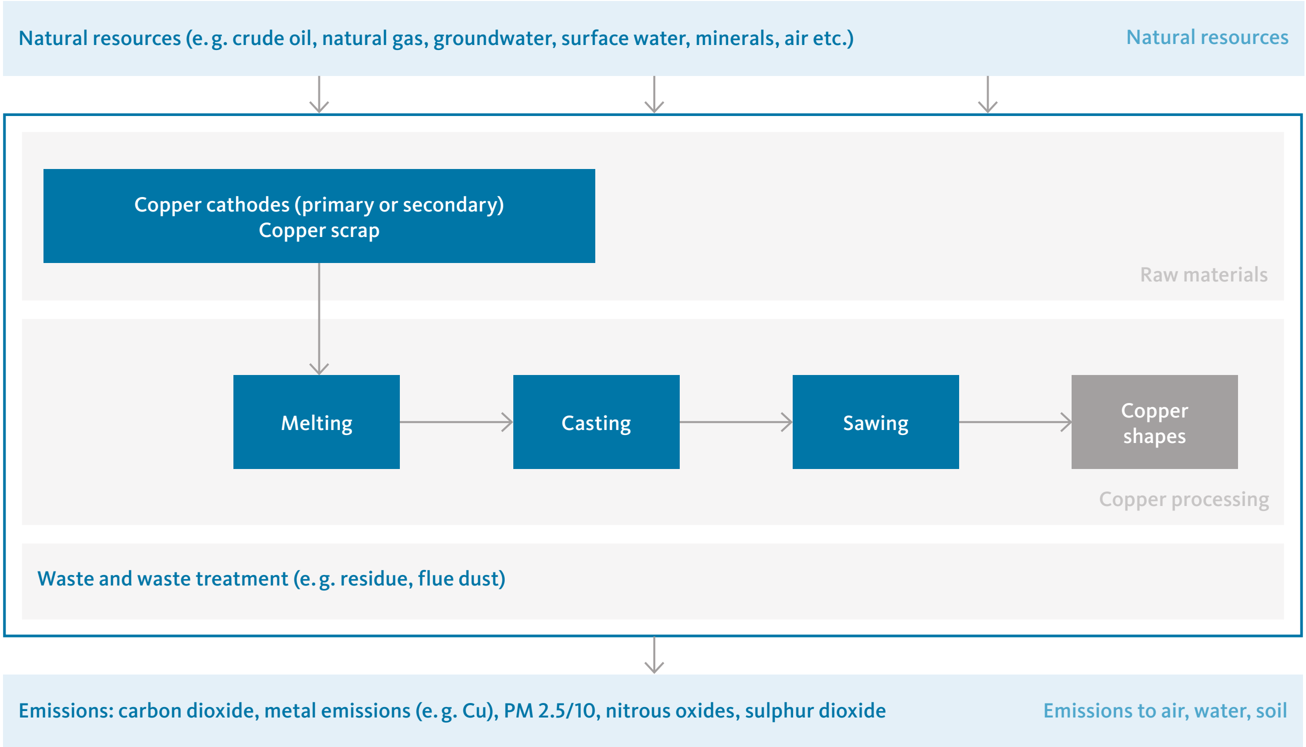
This study was performed with the help of Sphera.

Scope

The study was conducted in conformance with the standards ISO 14040 (ISO 14040:2021 Environmental management — Life cycle assessment —Principles and framework) and ISO 14044 (ISO 14044:2021 Environmental management — Life cycle assessment —Requirements and guidelines) on LCA.

Product and declared unit	Copper Shapes (Billets and Cakes) (ETP, low alloyed), 1 ton
Aurubis profile	Shapes produced at the Aurubis plant in Hamburg
Considered production system (system boundaries)	Cradle-to-gate, production of copper shapes
Time coverage	Reference calendar year 2023

The system boundary of the study included a cradle-to-gate life cycle inventory from the extraction of the copper ore at the mine, the production of copper cathode to the production of the copper shapes. It does not include the manufacture of downstream products, use, end-of-life, or secondary copper-containing materials recovery schemes.



Process description

Copper shapes (billets and cakes) are manufactured from high-purity copper cathodes, copper scrap, or low-alloyed copper in an installation for continuous casting. Billets and cakes are produced in different copper specifications depending on the final application. Typical specifications are: ETP copper, phosphorized copper, low oxygen or oxygen-free copper, low alloyed copper.

The installation includes shaft melting furnaces, holding induction furnaces, and multi-strand continuous casters for billet and cake casting. Cathode and copper scrap are charged by elevator bins to the shaft furnaces. The molten copper is transferred by launder from the shaft to the holding furnace. From the holding furnace, the copper is dosed into the casting molds of the vertical continuous casters. The solidified copper, leaving the casting mould, forms a continuous cake or billet strand which is cut to length by a flying saw as the cast strands come down. The cast strand is cooled with water. The water is partly re-circulated, the bleed is discharged after settling and separation of solids.

Life cycle inventory

Aurubis produces shapes (billets and cakes) via continuous casting.

Specific primary data were collected for the Aurubis shapes production site in Hamburg. We used data for 2023 for the processes associated with the production of the shape:

- Melting
- Casting
- Sawing
- All related auxiliary processes: On-site wastewater treatment, Gas cleaning systems (for primary and secondary off-gases)

The data included all known inputs and outputs for the processes. Inputs are the use of energy (fuels, electricity, steam), water, primary and secondary raw materials, fluxes, reagents, etc. Outputs are the products, intermediates, emissions to air and water, and waste.

The upstream processes include:

- Production of raw materials: copper cathode, scrap
- Production and supply of fuels
- Production and supply of electricity
- Production and supply of chemicals, auxiliaries
- Transport of raw materials

Production and maintenance of capital goods are excluded from the study. It is expected that these impacts are negligible compared to the impacts associated with running the equipment over its operational lifetime. Packaging is also excluded. As this is a cradle-to-gate study, transport to the customer is outside the system boundary.

For the processing of Aurubis copper cathodes, specific data were used for all cathode-producing sites for the reference year 2023. The modelling considered the actual origin of copper cathodes from different Aurubis sites.

For the input of copper cathodes purchased from third parties, no specific data were available, therefore the global average data set from the International Copper Association was used, with the reference year 2019[1].

Purchased electricity is assessed based on specific electricity mix and market -based CO_2 equivalent emission factors. Steam is assessed based on background data for steam production with natural gas. Background processes e.g. fuels, and auxiliary materials were modelled using the LCA for Experts MLC database 2024.1 (former GaBi database).

For the transport of copper cathode and scrap materials, primary activity data were collected for delivered raw materials during the calendar year 2023, including mode of transport (truck, ship, rail cars), region /country, and approximated distance. Secondary data sets for truck, rail, and container ship carriers from the MLC database 2024.1 were used.

Data for fuels and auxiliary materials such as lubricants, chemicals, etc. were obtained from the MLC database 2024.1. The direct CO_2 emissions from the combustion of fuels and carbon present in the raw materials are calculated based on specific information about fuel consumption by source, net calorific value and emission factor (in accordance with reports on greenhouse gas emissions pursuant to Directive 2003/87).

The Life cycle inventory is not included in the report due to confidentiality reasons.

[1] copperalliance.org/wp-content/uploads/2023/05/ICA-LCI-GlobalSummary-202305-F.pdf

Treatment of CO products

Filter dust and copper scale generated during shapes production leave the product system. They are further processed for copper recovery in the copper smelter and therefore cut-off approach was applied.

Sensitivity

The study by the International Copper Association on the raw material cathode copper (ref. year 2013[2]) performed sensitivity checks on key methodological choices. No additional sensitivity check was performed in the 2023 study. It is deemed that the conclusions from the sensitivity analyses conducted in the previous study remain valid for this study.

Data quality

Data quality is judged by its completeness, reliability, consistency, and representativeness. To cover these requirements and to ensure reliable results, specific primary data in combination with consistent background LCA information from the MLC database 2024.1 were used.

Completeness: Data has been collected for all relevant processes. To ensure data consistency, all primary data were collected with the same level of detail. Each unit process was checked for mass balance and completeness of the emission inventory.

Reliability: All gate-to-gate data for the Aurubis production site in Hamburg have been collected from verified sources and measured data such as emission declarations, and technical and metal balances. The environmental profile of the global copper cathode was obtained from the most recent and reliable dataset from the International Copper Association.

Representativeness: Data for the most contributing process of cathode production were collected for the year 2023. For the melting, casting, and sawing process primary data for the 2023 calendar year were used. All secondary data come from the MLC database 2024.1. The data represented the technological and geographical location of the operations. All primary and secondary data were collected specifically for the countries or regions under study and were modelled to be specific to the technologies under study. Where country/region-specific or technology-specific data were unavailable, proxy data were used.

The LCA model was created using the LCA For Expert Software system for Life Cycle Assessment, developed by Sphera Solutions GmbH. The MLC database 2024.1 provides the life cycle inventory data for all background data including materials and energy/electricity.

[2] copperalliance.org/wp-content/uploads/2021/07/ICA-EnvironmentalProfileHESD-201803-FINAL-LOWRES-1.pdf

Life Cycle Impact Assessment

The key environmental aspects were assessed with the Environmental Footprint impact assessment method (3.0) along 16 impact categories.

The Environmental footprint method is the most advanced impact assessment method adopted by the European Commission. The Environmental Footprint impact assessment method (3.0) is applied to ensure consistency and comparability with studies by the International Copper Association. The characterization method from the Centre for Environmental Studies (CML) at Leiden University in the Netherlands is considered outdated.

The following key impact categories were selected because they represent a broad range of relevant environmental impacts and are each determined by a well-established scientific approach: Global warming potential, Acidification potential, Eutrophication potential, Photochemical Ozone creation potential, Resource use fossil, and Water use.

Results for all 16 indicators are included in the report. However, it is important to note that “abiotic depletion potential” and “toxicity” impacts are not sufficiently robust and accurate to be used for metals.

Table 1: Life Cycle Assessment Impact Categories

Impact Category	Description
Global Warming Potential	A measure of greenhouse gas emissions, such as CO_2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health and material welfare.
Eutrophication Potential	Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.
Acidification Potential	A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule’s capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.
Photochemical Ozone Formation	A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O_3), produced by the reaction of VOC and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be injurious to human health and ecosystems and may also damage crops.
Ressource use, fossil	A measure of the total amount fossil resources non-renewable (e.g., petroleum, natural gas, etc.) extracted from the earth used for the primary energy production.
Water use	Deprivation water consumption.

Study Results

The life cycle impact results for the key impact categories for copper shapes (Aurubis SHAPES) for the reference year 2023 (right bar) are presented below and compared to results for the year 2021 and 2022 (left bars).

Figure 1: Results for 1 ton of Aurubis copper shapes (2021), (2022) and (2023), (Environmental footprint EF 3.0)[3]

[3] The results for water use for 2021 are not comparable because of different modeling of rain water and application of regionalized flows.

The impacts are also split to analyse the contribution from direct emissions, copper cathode production, upstream energy, transports, purchased electricity, and others (auxiliary materials, water input, waste).

The results for all impact categories for the copper cathode are presented below:

Table 2: Results for 1 ton of Aurubis average copper shapes (2023), (Environmental footprint EF 3.0)

Acidification	Mole of H+ eq./t	1.49E+01
Climate Change – total	kg CO_2 eq./t	1.80E+03
Climate Change, biogenic	kg CO_2 eq./t	3.35E+00
Climate Change, fossil	kg CO_2 eq./t	1.78E+03
Climate Change, land use and land use change	kg CO_2 eq./t	2.32E+01
Ecotoxicity, freshwater – total	CTUe/t	9.01E+03
Ecotoxicity, freshwater inorganics	CTUe/t	6.57E+03
Ecotoxicity, freshwater metals	CTUe/t	2.25E+03
Ecotoxicity, freshwater organics	CTUe/t	1.87E+02
Eutrophication, freshwater	kg P eq./t	1.07E-02
Eutrophication, marine	kg N eq./t	3.08E+00
Eutrophication, terrestrial	Mole of N eq./t	3.33E+01
Human toxicity, cancer – total	CTUh/t	1.27E-06
Human toxicity, cancer inorganics	CTUh/t	9.13E-18
Human toxicity, cancer metals	CTUh/t	6.01E-07
Human toxicity, cancer organics	CTUh/t	6.72E-07
Human toxicity, non-cancer - total	CTUh/t	4.33E-05
Human toxicity, non-cancer inorganics	CTUh/t	8.59E-06
Human toxicity, non-cancer metals	CTUh/t	3.47E-05
Human toxicity, non-cancer organics	CTUh /t	2.42E-07
Ionising radiation, human health	kBq U235 eq./t	4.34E+01
Land Use	Pt/t	4.23E+03
Ozone depletion	kg CFC-11 eq./t	1.72E-09
Particulate matter	Disease incidences/t	2.04E-04
Photochemical ozone formation, human health	kg NMVOC eq./t	8.96E+00
Resource use, fossils	MJ/t	2.58E+04
Resource use, mineral and metals	kg Sb eq./t	9.30E-01
Water use	m^3 world eq./t	1.16E+03

Interpretation

The impact of the copper shapes is dominated by the upstream copper cathode. Emissions associated with upstream energy also play a role.

For the Carbon footprint/Global warming potential, the copper cathode production is the most contributing factor. Emissions from upstream energy also contribute.

For the Acidification potential, results are mainly driven by the copper cathode production.

Results for Eutrophication potential are driven by NO_x emissions associated with copper cathode production.

Results for Photochemical Ozone creation potential are mainly driven by SO_2 emissions from copper cathode production. Direct emissions have a small contribution.

Water use is driven by the copper cathode production.

Conclusion

The goal of the study was to update the environmental profile of the copper shapes and allow tracking of the progress and further improvement.

The updated environmental impact of Aurubis SHAPES is lower than the profile from 2021 for almost all the impact categories such as Acidification, Climate Change and Eutrophication. This is mainly due to improved profile of Aurubis Hamburg cathode and higher recycled content.

The operations have taken continuous efforts for the reduction of direct emissions of pollutants such as dust as well as greenhouse gas emissions. We also invested in energy-efficient technologies at all sites across Aurubis Group.

The results for water use for 2023 cannot be compared with the 2021 results because of different modeling of rain water and application of regionalized flows. The water use impacts improved in 2023 compared to 2022 due to improved profile of the Hamburg copper cathodes used.

The results for Resource use, fossil are higher for 2023, mainly related to the environmental impacts of the upstream natural gas energy carrier (impact related to flaring and venting during natural gas production).

At the same time, our recycling as well as the efficiency of metal recovery has an important role in the results of our life cycle assessment.

The recycled content of the shapes, for the Aurubis Group for calendar year 2023 was 30%. The recycled content has been verified by TUEV Nord Cert on the basis on ISO 14021 and regulation EC 1221/2009.

TÜVNORD

CERTIFICATE OF VALIDITY

DIN EN ISO 14040:2021 / DIN EN ISO 14044:2021 (product-related life cycle assessment - LCA)

Evidence that the application conforms to the regulations was delivered, and is herewith certified according to the TÜV NORD CERT Prüf- und Umweltgutachtergesellschaft mbH - procedure for

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Aurubis

Range of application

Life Cycle Assessment „Production of Copper Shapes“

The requirements of the above-mentioned standards were evidently fulfilled by a critical review with regard to

- the scientifically justified and technically valid methods used in carrying out the LCA;
- the appropriateness of the data used in relation to the objective of the study;
- the consideration of the objective of the LCA and the identified limitations in the interpretations.

The LCA report (Ref: 35383293-3, 23.09.2024) is transparent and self-consistent.

This declaration of validity refers exclusively to the functional unit at point in time of the LCA report.

Report No. 3538 3293-3

TÜV NORD CERT Prüf- und Umweltgutachtergesellschaft mbH

Hannover, 2024-11-05

Mr. Dr. Hirtz
Environmental verifier

Alejandro Ibanez Cuesy
Environmental expert

TÜVNORD

VERIFICATION

of group-wide harmonised Recycling-Quota (RQ)
for input materials, metals and copper products

on the basis of
DIN EN ISO 14021:2021 and the
Regulation (EC) No 1221/2009 as amended on 25 November 2009

As result of the review on the basis of the Standard and the Regulation, we hereby confirm in respect of

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and
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as well as the associated locations to the annex

that

- **the data and the method of determination of Recycling-Quota in the „Report of the verification of group-wide harmonised Recycling-Quota (RQ) for input materials, metals and copper products" from August 22nd, 2024, reliably and credibly reflect the process relevant facts at the mentioned locations.**

Hamburg, 2024-11-21

Rainer Winter
Environmental Verifier
DE-V-0265

Critical review

An independent, external auditor reviewed the methodology, data quality, and modelling aspects of the study.

Name and contact information of the auditor:

Dr. Winfried Hirtz
Alejandro Ibanez Cuesy

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The review was performed according to ISO 14040 (2021) and ISO 14044 (2021).

Note:
The Certificate of Validity can be found as an Annex to this document.

Aurubis AG
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