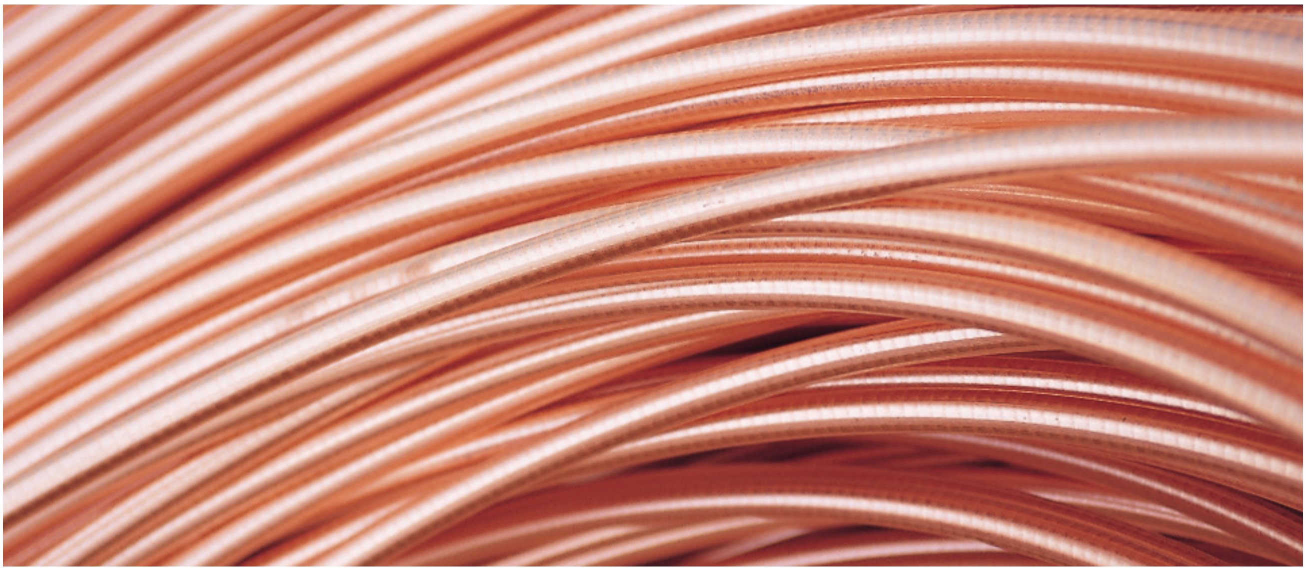
REPORT

Life Cycle Assessment of Oxygen-free Rod (Aurubis FOXROD)



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 oxygen-free copper rod (Aurubis FOXROD).

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.

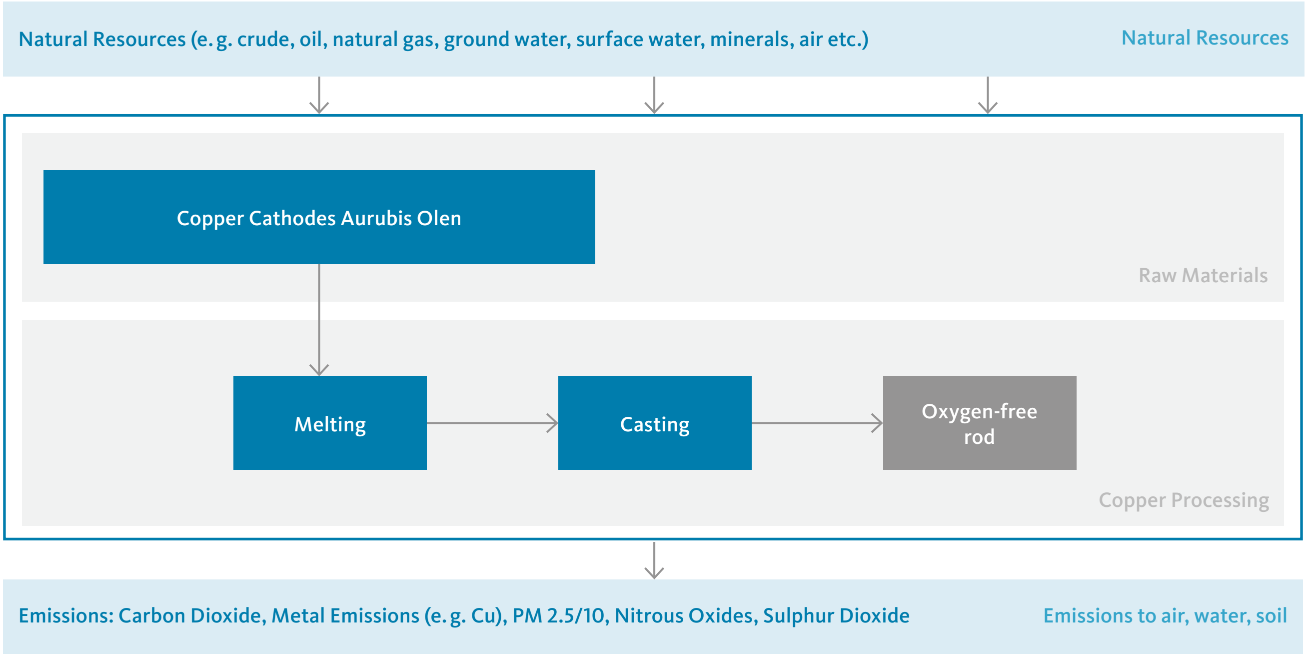
This study was performed with the help of Sphera.

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	Oxygen-free copper rod (Cu-OFE, Oxygen content: <4 ppm, Copper content: >99.99 %), 1 ton
Aurubis profile	Oxygen-free rod produced at the Aurubis plant in Olen, Belgium.
Considered production system (system boundaries)	Cradle-to-gate, production of copper wire rod
Time coverage	Reference calendar year 2022

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 copper wire rods. It does not include the manufacture of downstream products, use, end-of-life, or secondary copper-containing materials recovery schemes.



Process description

Aurubis FOXROD is produced from copper cathodes. Copper cathodes are fed into a melting furnace and melted by means of induction heating. In the casting furnace, the copper solidifies on a starter piece and is pulled upwards through water cooled tubes. Then the oxygen free wire rod is coiled in a set of coilers. The specificity of this installation is that throughout the process, there is no contact with the ambient air so the copper is not able to oxidise. In addition, the process does not involve any additional surface treatment with pickling and preservation agents or lubricants.

Life cycle inventory

The oxygen-free FOXROD production is located at a single site in Olen, Belgium

Specific primary data were collected for the Aurubis Olen production site. We used the data for 2022 for the processes associated with wire rod production:

- Melting
- Casting
- All related auxiliary processes

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
- Production and supply of electricity
- Production and supply of auxiliaries
- Transport of raw materials

[1] https://www.aurubis.com/en/responsibility/reporting-kpis-and-esg-ratings

Production and maintenance of capital goods is 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.

Aurubis FOXROD is produced from cathodes from Aurubis Olen site. Specific data were used for the cathodes produced in Olen for the reference year 2022.

Purchased electricity is assessed based on specific market-based CO_2 equivalent emission factor. The share of electricity produced on-site by windmills in Olen was considered carbon-free. Background processes e.g. upstream energy and auxiliary materials were modeled using LCA for Experts MLC database 2023.1 (former GaBi database)

The transport of copper cathode is not relevant as the cathodes are produced on site.

No lubricants and chemicals are used in the process. No direct CO_2 emissions occur from the process.

The nitrogen used in the process is included in the wire rod production because one storage tank for liquified nitrogen supplies both processes.

Water for indirect cooling is included in the water balance for the whole Olen site.

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

Treatment of CO products

No co-products are generated during oxygen-free copper rod production.

Sensitivity

No sensitivity checks were performed.

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 2023.1 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 sites have been collected from verified sources and measured data such as emission declarations, and technical and metal balances. The specific environmental profile of the Olen copper cathode was used.

Representativeness: Data for the most contributing process of cathode production were collected for the year 2022. For the melting and casting process primary data for the 2022 calendar year were used. All secondary data come from the MLC database 2023.1 and are representative of the years 2019-2023. 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 2023.1 provides the life cycle inventory data for all background data including materials and energy / electricity.

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 (3.0) is the most advanced impact assessment method adopted by the European Commission.

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 O3), 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 oxygen-free rod (Aurubis FOXROD) for the reference year 2022 are presented.

Figure 1: Results for 1 ton of Aurubis oxygen-free rod (2022), (Environmental footprint EF 3.0)

The results for all impact categories for the oxygen-free rod are presented below:

Table 2: Results for 1 ton of Aurubis oxygen-free rod (2022), (Environmental footprint EF 3.0)

Acidification	Mole of H+ eq./t oxygen-free rod	7.38E+00
Climate Change - total	kg CO_2 eq./t oxygen-free rod	1.148E+03
Climate Change, biogenic	kg CO_2 eq./t oxygen-free rod	3.16E+00
Climate Change, fossil	kg CO_2 eq./t oxygen-free rod	1.14E+03
Climate Change, land use and land use change	kg CO_2 eq./t oxygen-free rod	1.51E+01
Ecotoxicity, freshwater - total	CTUe/oxygen-free rod	1.11E+04
Ecotoxicity, freshwater inorganics	CTUe/t oxygen-free rod	8.28E+03
Ecotoxicity, freshwater metals	CTUe/t oxygen-free rod	2.66E+03
Ecotoxicity, freshwater organics	CTUe/t oxygen-free rod	1.23E+02
Eutrophication, freshwater	kg P eq./t oxygen-free rod	7.76E-03
Eutrophication, marine	kg N eq./t oxygen-free rod	2.54E+00
Eutrophication, terrestrial	Mole of N eq./t oxygen-free rod	2.75E+01
Human toxicity, cancer - total	CTUh/t oxygen-free rod	6.14E-07
Human toxicity, cancer inorganics	CTUh/t oxygen-free rod	5.11E-17
Human toxicity, cancer metals	CTUh/t oxygen-free rod	2.04E-07
Human toxicity, cancer organics	CTUh/t oxygen-free rod	4.10E-07
Human toxicity, non-cancer - total	CTUh/t oxygen-free rod	2.03E-05
Human toxicity, non-cancer inorganics	CTUh/t oxygen-free rod	1.52E-05
Human toxicity, non-cancer metals	CTUh/t oxygen-free rod	5.08E-06
Human toxicity, non-cancer organics	CTUh/t oxygen-free rod	1.28E-07
Ionising radiation, human health	kBq U235 eq./t oxygen-free rod	1.01E+02
Land Use	Pt/t oxygen-free rod	2.81E+03
Ozone depletion	kg CFC-11 eq./t oxygen-free rod	5.31E-09
Particulate matter	Disease incidences/t oxygen-free rod	1.17E-04
Photochemical ozone formation, human health	kg NMVOC eq./t oxygen-free rod	6.73E+00
Resource use, fossils	MJ/t oxygen-free rod	1.72E+04
Resource use, mineral and metals	kg Sb eq./t oxygen-free rod	-1.42E-01
Water use	m^3 world equiv./t oxygen-free rod	7.89E+02

Interpretation

The impact of the oxygen-free rod is dominated by the upstream copper cathode. Emissions associated with purchased electricity and grid mix also play an important role.

For the Carbon footprint/Global warming potential, the copper cathode production is the most contributing factor. Emissions from purchased electricity and transport also contribute.

For the Acidification potential, results are mainly driven by the copper cathode production, as well purchased electricity.

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

Results for Photochemical Ozone creation potential are mainly driven by SO_2 emissions from copper cathode production.

Water use is driven by the copper cathode production.

Conclusion

The goal of the study was to update the environmental profile of the oxygen-free rod and allow tracking of the progress and further improvement.

The operation in Olen site has taken continuous efforts for the reduction of direct emissions of pollutants such as dust as well as greenhouse gas emissions for the cathode production and copper processing. Measures were implemented to save energy and switch to renewable energies. Electricity is produced on site by wind turbines. These turbines yearly provide 14 million kWh of electricity, which is directly used at the site.

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 Aurubis FOXROD for fiscal year 2021/22 was 69 %

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.

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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 Oxygen-free Copper Rod“ (Vers. 3, 12/04/2023)

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: Production of Oxygen-free Copper Rod 12/04/2023) 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. 3536 1273-7

TÜV NORD CERT Prüf- und Umweltgutachtergesellschaft mbH

Hannover, 2023-12-05

Mr. Dr. Hirtz
Environmental verifier