

LIFE CYCLE INVENTORY DATA AND ENVIRONMENTAL METRICS FOR THE PRIMARY ALUMINIUM INDUSTRY - 2019 DATA

Critical Review Report

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for the International Aluminium Institute

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1 Subject of review, procedure

The life cycle assessment work "LIFE CYCLE INVENTORY DATA AND ENVIRONMENTAL METRICS FOR THE PRIMARY ALUMINIUM INDUSTRY - 2019 DATA" (Available at: <https://international-aluminium.org/re-resources/lifecycle/>), performed by the *International Aluminium Institute* (IAI) was subject to a critical review by a panel of three independent, external experts according to the ISO standard 14040 and 14044, Clause 6.3 (International Organization for Standardization (ISO) 2006a, b). IAI commissioned the critical review panel on 30 April 2021. The critical review panel was able to accompany the study from its very beginning.

The review panel members had access to the following documents:

- PFC001 - Version2018.xlsx (June 2021)
- PFC 2019 data_for review.xlsx (June 2021)
- IAI Smelter Anode Energy Survey form.xlsx (June 2021)
- IAI Form ES011 (Blank).xlsx (June 2021)
- Casting Energy 2019 data for review.xlsx (June 2021)
- Aluminium Energy 2019 data_for review.xlsx (June 2021)
- Alumina Energy 2019 data_for review.xlsx (June 2021)
- LCA Report 2019 draft for review v1.docx (May 2022)
- LCA Report 2019 draft for review v3.1.docx.docx (August 2022)

Discussions have taken place bilaterally and all questions of the reviewers were answered and addressed sufficiently. Upon the reviewer's request revisions had taken place concerning LCI data and in particular regarding the systematic treatment of zero and non-reported values and the calculation of average values. During LCI data review only very few data errors were identified, which were corrected in the revised versions.

The critical review process took place in an open and constructive atmosphere.

All comments of the reviewers given in the earlier stages of the review process are well reflected in the study report and the LCI dataset.

The present final version of the review report takes into account the revisions made by the *International Aluminium Institute* (IAI) after submitting individual feedbacks on earlier versions of the report circulated in May 2022 and August 2022.

2 Purpose of the critical review

According to the ISO standard 14044, Clause 6.1 "the critical review process shall ensure that:

- the methods used to carry out the LCA are consistent with this International Standard,
- the methods used to carry out the LCA are scientifically and technically valid,
- the data used are appropriate and reasonable in relation to the goal of the study,
- the interpretations reflect the limitations identified and the goal of the study, and
- the study report is transparent and consistent."

The following sections contain the statements of the critical review panel on the five aspects mentioned above.

3 Consistency of the methods with the ISO standards

The LCI dataset on the global and regional aluminium supply chains is state-of-the-art.

The inventory analysis methods applied are consistent with the ISO standards 14040 and 14044. The extensive Excel workbooks are well structured and facilitated an in-depth review of the data provided by the individual sites.

The declared unit and reference flow are 1'000 kg of product and 1'000 kg of primary aluminium ingots. This is considered appropriate for the goal and scope of this study and the reference units are used consistently along the aluminium supply chain.

Main modelling choices were made in a conservative manner, i.e. rather resulting in overestimated mass and energy flows. Non-reporting and zero values are treated consistently and systematically. There were neither critical nor decisive allocation issues to be dealt with.

The impact assessment methods chosen are in line with the ISO 14044 standards. They are critically discussed, emphasising weaknesses and shortcomings as far as existing. The indicators chosen facilitate the comparison with the 2015 LCI dataset on world aluminium. For future updates it is recommended to consider using more of the globally recommended indicators published in Frischknecht & Joliet (2016, 2019).

4 Scientific and technical validity of the methods applied

The life cycle inventories are established with an attributional approach. This choice is appropriate and all models and data are in line with this approach. The derivation of average unit processes from raw data and information, and the inventory models are scientifically and technically valid.

The impact category indicators (Acidification potential, Depletion of fossil energy resources, Eutrophication potential, Global warming potential, Ozone depletion potential, Photo-oxidant creation potential) addressed are the same as in the predecessor Environmental Metrics Report (LCI Data 2015). The Water scarcity footprint is quantified with the AWARE method, the method recommended by the Life Cycle Initiative of UN Environment. However, this choice does not allow a comparison of the environmental performance of the aluminium supply chains between 2015 and 2019. It would have been beneficial to assess the 2015 data with AWARE too. The impact category indicators are considered relevant with the exception of Ozone depletion potential, to which the aluminium supply chain contributes only marginally.

Toxicity and land use related impact category indicators are not used. It is recommended to address these topics in the next regular update of the LCI data of the aluminium supply chain. UN Environment published recommended methods and characterisation factors of biodiversity losses caused by land use and on human and eco-toxicity.

5 Appropriateness of data

Data used in the foreground are solid, quality checked, reasonable and as complete as possible. The lack of primary data on Chinese mines, smelters and refiners is bridged with sensible and conservative assumptions. IAI was able to establish regional averages of each step of the aluminium supply chain. For the first time two regional datasets (South America, Oceania) are provided for bauxite mining, plus, energy data was available for individual Chinese facilities (instead of the aggregated totals). And the number of reporting sites of nearly all production steps and reporting item increased, partly substantially. These increases contribute to higher representativeness and better quality of the inventory data.

It is recommended to add a section on production and supply of primary aluminium, alumina and bauxite. This would help in better understanding the trade movements and supply chains.

The reviewers had access to the detailed and complete *Microsoft Excel* workbooks, in which all single reporting units are documented and the regional and global averages are calculated. All calculations were accessible and were randomly checked for correctness and appropriateness. Only a few errors were detected, which are considered a proof for the exceptionally high quality of data inquiry and data processing at IAI. It was recommended to include information (data) about the current market mixes of Bauxite, Alumina, Aluminium and Aluminium Ingots from the perspective of the “user markets” such as Europe, USA, China or Japan.

The transfer from the original primary information to the Excel workbooks was not reviewed (not part of the scope of review work).

6 Assessment of the interpretation in view of limitations and goal and scope

The report includes thorough analyses of the life cycle inventories of bauxite mining, alumina production, anode production, aluminium electrolysis and ingot casting and of the environmental impacts caused by one global and four different dedicated archetypical scenarios of aluminium supply chains.

The interpretation includes a description of the major deviations from the LCI data and results presented in the previous survey (2015 data), distinguishing between the two main reasons namely technical improvements (performance driven changes) as well as sample size and error issues (data driven changes).

The environmental impacts of the global and four archetypical scenarios are assessed in detail with further materiality analyses related to greenhouse gas emissions. The results are discussed critically highlighting significant issues and limitations. The conclusions reflect these significant issues as well as the major limitations.

Limitations are well described. In addition, it should be mentioned that the GHG emissions for electricity from hydropower are estimated to be zero. However, in some regions methane emissions of barrier lakes have been determined (in particular in tropical regions) which should be considered.

The AWaRe characterization factors for the background processes submitted via GaBi, were based on regional averages instead on local data. This has been corrected only for hydropower which provided data which were one order of magnitude lower. For other sources of electricity, e.g. coal energy, lower values could also be obtained. This might lead to significantly lower WSFP parameters, if indirect processes are considered.

7 Transparency and consistency of dataset and report

The report is clearly structured and well-readable. It includes all parts required in an LCA report. All necessary information was given to the reviewers, if not included into the report.

The confidentiality of plant specific data does not affect reading and understanding of the report because full transparency is provided with horizontally averaged unit processes per life cycle stage.

The Chapter on life cycle impact assessment helps the reader to better understand the life cycle inventory data and provides guidance on how to link the life cycle inventory data with background data and with life cycle impact assessment methods.

The report successfully continues the long-term tradition of the aluminium industry to provide relevant life cycle inventory data on a unit process level. It would deserve a section on the global aluminium industry's plans and commitments to help countries in reducing their greenhouse gas emissions to net zero by 2050 or even earlier and by that contribute to the 1.5°C target of the Paris Agreement.

8 Recommendations for future updates

The LCI report document could be considered as a living document, with possible updates due to significant changes in inventory data and due to methodological improvements. The LCI data survey with aluminium plants should continue to take place every five years.

The update of the life cycle inventory data 2019 of the global aluminium supply chain was used to consolidate significant improvements achieved in 2015 and partly to go beyond. The LCI data inquiry on water withdrawal, use and discharge was combined with information on the location of the sites to allow for a regionalised assessment of the water footprint with the UN Environment recommended AWARE method.

As results of the impact assessment, the indicator results, ideally, should be presented for the different regions and for the different processes, i.e. bauxite mining, alumina refining and primary aluminium smelting. The data should include background processes but not the aluminium related upstream process.

In this report, archetypal supply scenarios have been selected for the smelters in China, for the countries of the Gulf Cooperation Council, for Europe and for Canada. This is a pragmatic approach which avoids time-consuming calculations. However, future activities should include the calculation of indicator results for real market supply situations of all regions, including North America, South America, Oceania, other Asia, Global and Global without China.

It should be avoided that global indicator results are used by practitioners for primary aluminium which is supplied to a specific region, because the data of global aluminium are dominated by China where a high percentage of coal energy is used for the electrolysis, and a substantial share of Chinese Aluminium is used domestically.

For future updates it is recommended to continue trying to increase the data coverage of Chinese production sites and of mining sites. In particular, the provision of regionalised datasets of bauxite mining would be highly beneficial. It is recommended including the treatment of red mud into the life cycle inventory, quantifying the energy and material requirements as well as resource demand (land use) and emissions from red mud storage and disposal.

It is also recommended to revisit the selection of environmental impact category indicators in view of the scientific progress and the progress made in international harmonisation activities led by the *United Nations Environment Programme* ([UNEP-SETAC Life Cycle Initiative](#)). The progress made in indicators describing biodiversity impacts due to land use as well as human and eco toxicity should allow addressing these environmental impacts in the next update. If needed the relevant data provider should be asked to update their impact assessment methods data.

It is recommended that the next regular update of the LCI data of the aluminium supply chain also includes normalization as described in ISO 14044, i.e. a comparison of the determined indicator results with global reference flow data.


9 Conclusions

Collecting and evaluating relevant LCA (LCI and LCIA) data in regular intervals belongs to the greatest services industry associations can provide for the industry concerned as well as to the scientific, environmental and political associations. This service has been provided by IAI on a global basis for many years and exemplarily. The interval of 5 years is well chosen and also used by [European Aluminium](#).

The reviewed LCI and LCA study fully complies with the requirements of the ISO standards 14040 and 14044. The LCI of global primary aluminium supply is comprehensive and thorough. The goal and scope are appropriately defined. The methods used are scientifically and technically valid. The environmental impact category indicators are reasonable. Some relevant environmental impacts such as biodiversity losses and toxicity are recommended to be addressed with the next update. The data compiled and processed are appropriate and reasonable in view of the goal and scope of the study and form a solid foundation for any future LCA of products containing primary aluminium. The report is complete, clearly structured and well-readable. The presentation of unit process dataset representing the different steps of the supply chain of primary aluminium production is highly appreciated and is a lighthouse for other industry associations. Conclusions and recommendations are based on the results of the analyses, respecting the limitations and the goal and scope.

We recommend publishing the entire LCI dataset as well as the report including this review report.

Uster, 17 November 2022


Dr. Rolf Frischknecht
on behalf of the critical review panel

10 References

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