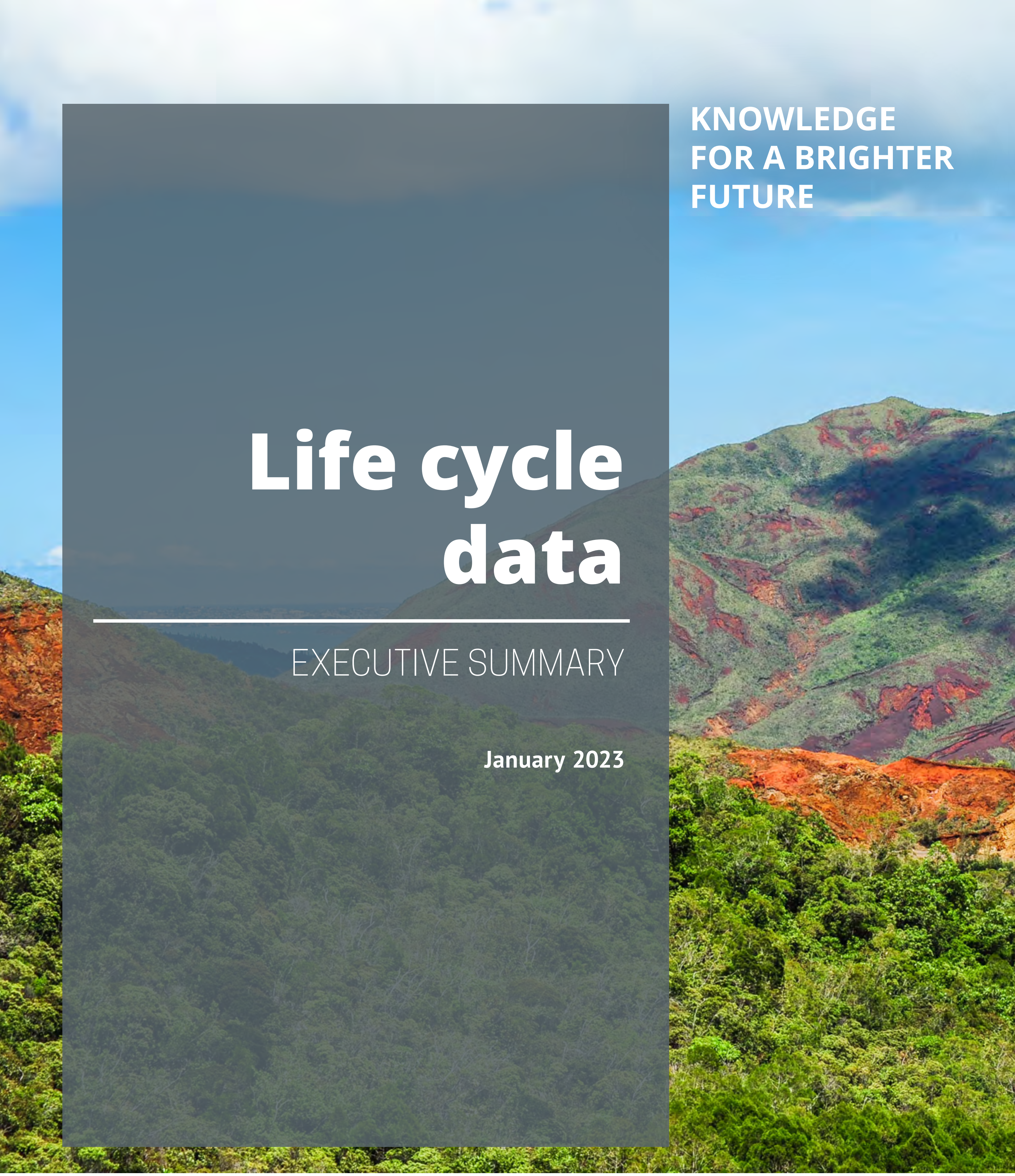


KNOWLEDGE FOR A BRIGHTER FUTURE

Life cycle data

EXECUTIVE SUMMARY

January 2023

sphera

Nickel INSTITUTE
knowledge for a brighter future

About 70% of global nickel production is used to manufacture stainless steels. As a result of changes in manufacturing technology, choice of raw materials, improved efficiencies and rationalisation, the global steel sector continues to update the LCI databases for both stainless and carbon steel products. This in turn require the need for rigorous LCI datasets for nickel metal and ferronickel as two major nickel products used in stainless steel production. Furthermore, in recent years the shift from internal combustion engines to electric vehicles, especially in the automotive industry, is expected to increase the consumption of nickel sulphate. There is already an extensive global growth observed for nickel sulphate and hence, there is currently a demand for a reliable and representative life cycle inventory dataset for this compound.

Between 2018 and 2019, the Nickel Institute conducted a Life Cycle Assessment (LCA) on nickel products (Class 1 nickel, ferronickel and nickel sulphate) in order to provide its stakeholders with up-to-date, reliable life cycle data. Based on the input from Nickel Institute members for the year 2017, representing 52% of the global production of Class 1 nickel; 47% of the global production of ferronickel and 15% of the global production of nickel sulphate, the study focused on quantifying the environmental impacts of the cradle to gate production of nickel products.

The following mass-based functional units and reference flows have been designated for this study:

- 1 kg of Class 1 nickel (>99.8%)
- 1 kg nickel in ferronickel (with a reference flow of 3.7 kg ferronickel based on 27% nickel content)
- 1 kg of nickel sulphate hexahydrate (nickel sulphate) (22% nickel content)

The target audience for this study incudes the Nickel Institute; nickel producers; first and end users (customers), legislators, academia, LCA practitioners, non-governmental organisations (NGOs), and in view of the growing public debate around energy and climate change financial stakeholders such as investors, the broad media landscape and the public.

A third party critical review of the study according to ISO 14040, ISO 14044 and ISO/TS 14071 was carried out by Professor Matthias Finkbeiner from Technical University Berlin (Germany).

In conclusion, this study provides improved data quality and representativeness in terms of technology for the potential life cycle impacts and life cycle inventory for the production of nickel products. The table below summarises the results of the assessed impact categories for the products in this study.

Table E-1 **Summary of results for nickel products**

Impact category	1 kg Class 1 Ni	1 kg Ni in FeNi (27% Ni in FeNi)	1 kg NiSO4
Global Warming Potential [kg CO_2 eq.]	13	45	4
Acidification Potential [kg SO_2 eq.]	1.4	0.17	0.26
Primary Energy Demand [MJ]	236	592	68
Eutrophication Potential [kg Phosphate eq.]	5.2E-03	0.016	1.5E-03
Photochemical Ozone Creation Potential [kg Ethene eq.]	0.055	0.010	0.010
Blue water consumption [kg]	106	924	49

The metallurgical processes are the major contributors to all nickel products. However, the sources of emissions differ depending on the technology used, and on the ore processed. In general, direct activities (e.g. smelting), mainly arising from the metallurgical processes, are the main contributors to most impact categories, as expected. The figures below give an overview of the contributing sources to the impact categories for nickel products considered in this study.

Figure E-1 **Contribution of various sources to impact categories for 1 kg Class 1 Nickel**

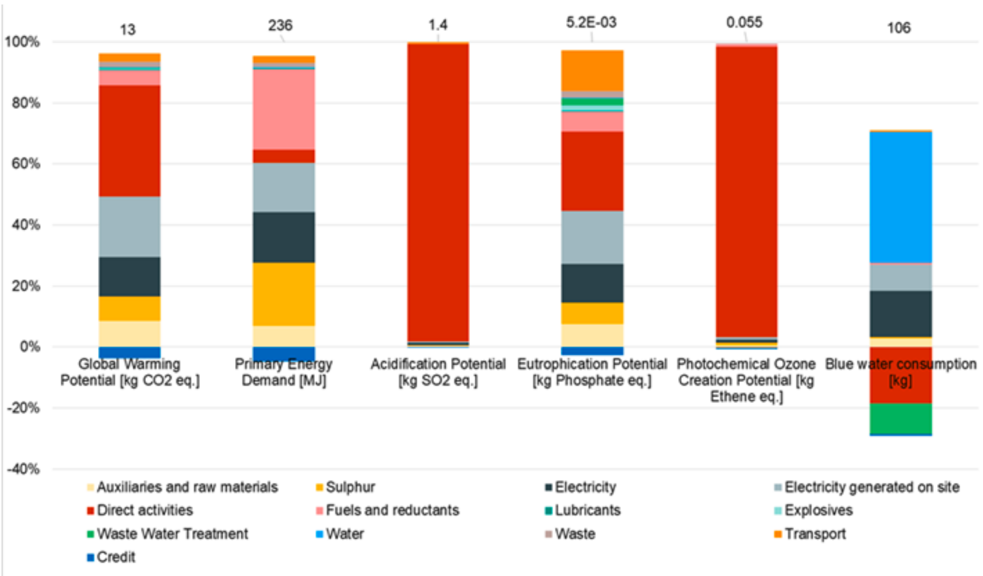


Figure E-2 **Contribution of various sources to impact categories for 1 kg Class 1 Nickel in Ferronickel**

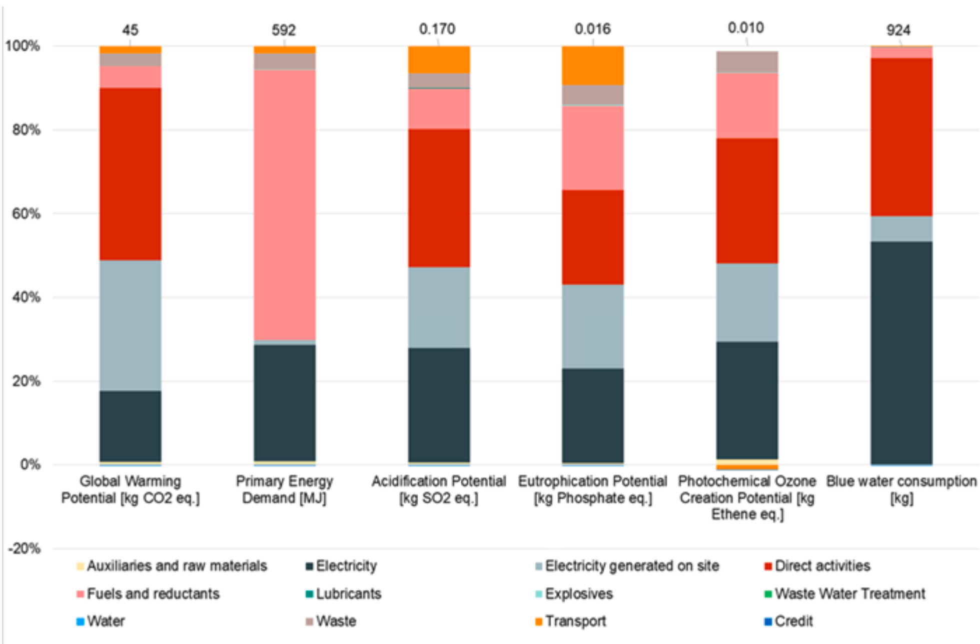
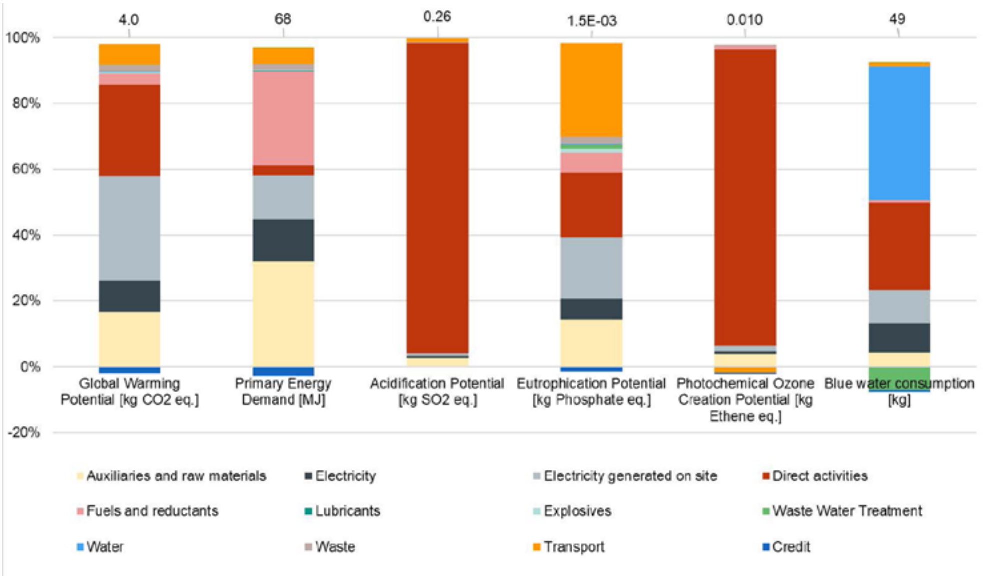


Figure E-3 **Contribution of various sources to impact categories for 1 kg Class 1 Nickel Sulphate**



In this study, Class 1 nickel and nickel sulphate are produced from both sulphidic and lateritic ore, and both pyrometallurgical and hydrometallurgical processing is used. It was found that the production volumes of Class 1 nickel is overrepresented in this study by lateritic nickel production compared to actual market situation. Ferronickel is only produced from lateritic ore using pyrometallurgical processing.

Whilst a trend in industry performance should be observable since the last and previous studies, key outcomes from this study showed that a clear and consistent result (trend) could not be established to understand the performance of the nickel industry since 2007. A detailed analysis of the different technologies showed that the environmental profile is highly dependent on the ore mineralogy and process technologies used for Class 1 nickel and nickel sulphate production.

Hence, the main recommendations from this study are to make the previous studies comparable to this study in terms of producers and–– technology in order to better understand trends in the performance of the nickel industry. As China represents about 31% of world nickel production, which is not covered in this study, a further recommendation is to assess the environmental profile of Chinese nickel production, taking into consideration the relevant production volumes, and production technologies for different nickel products applied in China.

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By Sphera for

Nickel Institute
communications@nickelinstitute.org
www.nickelinstitute.org
@NickelInstitute