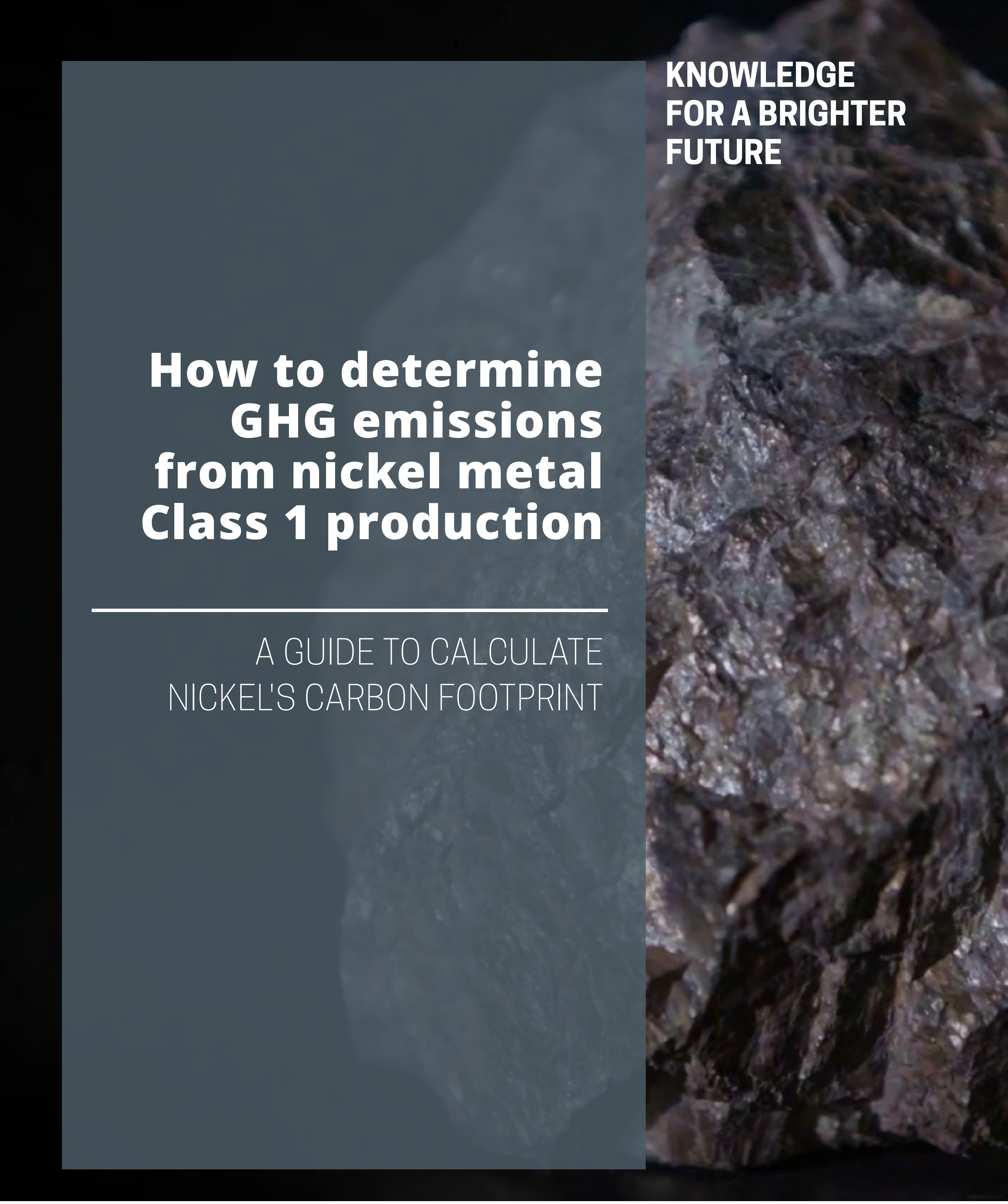

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How to determine GHG emissions from nickel metal Class 1 production

A GUIDE TO CALCULATE NICKEL'S CARBON FOOTPRINT

Nickel INSTITUTE
knowledge for a brighter future

How to determine GHG emissions from nickel metal Class 1 production

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The document reflects the current state of discussion in the nickel industry and wider LCA community concerning the calculation of GHG emissions for Class 1 nickel. Discussions within the wider industry and LCA community on calculating GHG emissions are ongoing; methods and underlying parameters experience updates and are aligned with regulatory initiatives. The Nickel Institute therefore plans to review and update the guidance in the future on a regular basis to ensure its alignment with the latest methods, newest data and regulatory requirements.

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How to determine GHG emissions from nickel metal Class 1 production

1. Introduction

Climate change is the major challenge for societies globally. Efforts at global and regional level aim at mitigating the impacts from the globally observed temperature increase. Greenhouse gas (GHG) emissions are the major driver for climate change. The measurement of GHG emissions is therefore an important step in understanding total emissions affecting climate change; identifying hot spots where significant GHG emissions occur; demonstrating and measuring efforts in reducing GHG emissions and determining their contribution to climate change mitigation.

Metals production and associated mining processes are estimated to account for 8-10% of all GHG emissions globally[1]. Due to produced tonnages and energy intensity, carbon steel is the major contributor to metals production GHG emissions, followed by aluminium and copper. Thanks to its comparatively low production levels, nickel is a relatively small contributor with roughly 0.27%, according to Nickel Institute estimates. Nonetheless, the nickel industry is also in the focus of climate change mitigation measures, and companies are working towards reducing their GHG emissions.

The most common, globally accepted tool to measure climate change potential at product level, as well as other environmental impacts, are environmental life cycle assessments (LCAs). LCAs provide data and information on in total 15 environmental impact categories. This guidance addresses the “climate change” life cycle environmental impact category. It specifies the principles, requirements and methodologies for quantifying and communicating GHG emissions from refined nickel metal (traded as so-called Class 1 nickel) production processes and the associated cradle-to-gate carbon footprints of their products and precursors (nickel ores from mining, nickel concentrates from beneficiation and ore preparation, nickel intermediates from primary extraction from both lateritic and sulfidic nickel metal production).

This guidance is based on ISO 14044 standard on environmental management - life cycle assessments – requirements and guidelines. Due to the generic nature of ISO 14044, the guidance shows the specific approaches applied to the production of refined nickel (traded as Class 1 nickel metal with a nickel content of >99.8%). It also is aligned with the *GHG protocol Product Life Cycle Accounting and Reporting Standard*[2].

The application of this guidance allows producers of nickel ores and concentrates, nickel intermediates and nickel metal producers as well as their customers and other stakeholders to calculate the climate change impact of Class 1 nickel metal production, which is also known as the "carbon footprint" of Class 1 nickel metal.

2. Goal and scope

The climate change impact of a product is the summation of all greenhouse gas emissions over the production stages of the relevant product. The impact is expressed as CO_2 equivalents (CO_2eq)/kg metal and includes, besides carbon dioxide (CO_2), other so-called "climate relevant gases" (i.e., gases contributing to climate change).

The goal of this guidance is to provide LCA practitioners and their stakeholders with a standardized approach on how to calculate the climate change impact for all relevant GHG emissions (expressed in CO_2eq) of refined nickel metal. It also covers associated precursor products, including sulfidic and lateritic nickel ores, nickel concentrates, and nickel intermediates from primary Ni production (including those resulting from the pyro- and hydrometallurgical treatment of lateritic and sulfidic ores).

The guidance is an addition to and precision of ISO 14044 *Environmental management — Life cycle assessment — Requirements and guidelines* as this does not provide sufficient detail on the application for the nickel industry and its characteristics. The globally accepted and applied ISO 14044 standard only provides general guidance on how to conduct a life cycle assessment. This specific guidance harmonizes the calculation of greenhouse gas emissions for refined nickel metal (Class 1 nickel). It ensures that data communicated by nickel metal Class 1 producers are coherent and based on the same calculations, methods, and parameters.

3. System boundaries

The system boundaries include the four relevant major unit processes as well as - in some cases - several sub-processes:

- mining (both open pit and underground)
- ore preparation (for lateritic ores) and beneficiation (for sulfidic ores)
- primary extraction (comprising both hydro- and pyrometallurgical processes for both lateritic and sulfidic ores and secondary raw materials)
- metal refining.

It also includes :

- the transport of raw materials into and between the processes
- electricity generation (on- and offsite)
- wastewater treatment and waste processing.

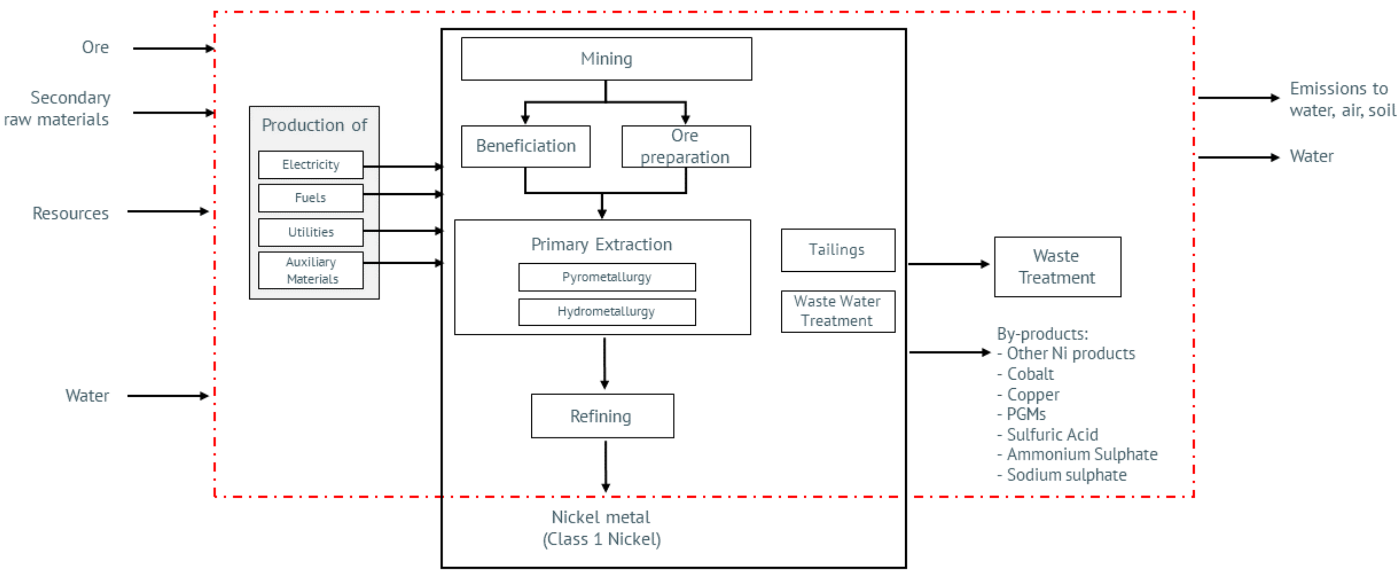
It also comprises the production of fuels, utilities and auxiliary materials which are required throughout the production process of refined nickel metal (Class 1 nickel). By-products which might occur during production are also considered. Their inclusion into the calculation is further explained in Section 6.1.

Nickel is mainly used as an alloying element in stainless steel and alloy steel production. Most nickel recycling therefore takes place outside the nickel industry on an alloy level; notably in stainless steel mills. For environmental and economic reasons, the nickel-containing alloys are recycled into stainless steel or other nickel-containing alloys.

A growing amount of nickel is expected to be recycled within the nickel industry due to the increasing relevance of nickel in other end uses such as emerging EV battery technologies. The recycling of nickel is either integrated into the primary production process or conducted in recycling installations where metal scraps containing a wide range of different metals are treated. The nickel-containing scrap material follows similar pyro- and hydrometallurgical processes as in primary extraction, followed by refining.

The system boundaries are shown in a simplified flowchart in Figure 1.

Figure 1 **System boundary of nickel metal (Class 1 nickel) production showing the processes, in- and outputs in scope. System boundary is shown in red.**



Several processes are excluded from the system boundaries, such as the refining processes associated with further treatment of by-products, the transport of fuel, materials and human resources to the site, transport of the refined nickel metal to the customer, waste transport and emissions associated with business administration.

The inclusion and exclusion of processes is related to applicable cut-off criteria. Processes which contribute less than 1% to the total GHG emissions of nickel metal production can be excluded, where the amount of excluded processes does not exceed 3% of the total GHG emissions. The approach is aligned with the EU *Product Environmental Footprint Guidance.* [4]

The processes included within and excluded from the system boundaries are shown in Table 1. They are based on experience of the collection and update of life cycle data for nickel metal Class 1 production. [5,6] The processes excluded from the system boundaries have shown to be below the above-mentioned cut-off criteria.

Table 1 **Processes included and excluded from the system boundaries**

Included	Excluded
Mining (i.e., open pit and underground, including the removal of overburden and waste rock) of nickel ore	Refining processes associated with further treatment of by-products such as e.g., cobalt, copper and PGMs
Ore beneficiation (sulfidic ore) and ore preparation (lateritic ore)	Secondary Effect of potential volume of acid mine drainage from waste rock
Primary extraction (all pyro- and hydrometallurgical processes applied) to convert nickel containing intermediates such as e.g., concentrates into nickel matte, mixed sulphides and oxides including processes such as leaching, separation, calcination, smelting, converting	Transport of fuels, ancillary / auxiliary material to site
Refining to nickel metal including processes such as leaching, electro-leaching, volatizing	Transport to customer
Transport of ore, concentrates, matte and other nickel intermediates	Transport of waste
Ancillary / auxiliary materials used on site	Production of capital equipment and infrastructure
All relevant water inputs and outputs	Transport of raw materials, human resources and business administration
Onsite (direct) emission to air	

Table 2 **GWP Values for most relevant Greenhouse Gases[8]**

Greenhouse Gas Name	Chemical formula	GWP values for 100 year time horizon
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265
Chlorofluorocarbons (CFCs)		2-13.900
Hydrofluorocarbons (HFCs)		4-12.400
Perfluorinated Compounds		6.630-23.500
Fluorinated Ethers		1-12.400
Perfluoropolyethers		9.710
Hydrocarbon and others		9-376

4. Greenhouse Gas Emissions

The mechanism of the greenhouse effect can be observed on a small scale in a greenhouse; incoming solar energy is trapped, causing the internal temperature to rise. This effect also occurs on a global scale. When short-wave ultraviolet radiation from the sun meets the earth's surface some energy is re-emitted as longer wave infrared radiation. Instead of directly heading back out to space, some of this infrared radiation is absorbed by greenhouse gases in the troposphere and re-radiated in all directions, including back to earth. This results in a warming effect at the earth's surface. In addition to the natural mechanism, the greenhouse effect is enhanced by human activities.

Several gases contribute to the global warming potential. The predominant greenhouse gas emitted is carbon dioxide (CO_2). It enters the atmosphere through the combustion of fuels (coal, natural gas, oil), waste or other carbon-containing materials such as biomass. It also can result from chemical processes such as the manufacture of cement.

Other relevant gases contributing to the global warming potential are methane (CH_4) which is emitted during the production and transport of coal, natural gas and oil. It might also be emitted from livestock and other agricultural practices. Nitrous oxide (N_2O) and fluorinated gases are other climate relevant gases contributing to climate change[7].

The Intergovernmental Panel on Climate Change (IPCC) published the values of the 100- year global warming potential (GWP) for different greenhouse gases. These values are recommended to be used to convert life cycle inventory results to an indicator of climate change impact (kg CO_2eq).

An overview on the most relevant greenhouse gases and their global warming potential is shown in Table 2. IPCC updates the GWP values for the most relevant greenhouse gases on a regular basis. It is therefore recommended to check for the latest available IPCC data and to use those.

The predominant greenhouse gas emitted from refined nickel metal production is carbon dioxide (CO_2). Other gases relevant to the global warming potential are also or have the potential to be released during the various steps of nickel mining, ore preparation, primary extraction, and refining such as methane or nitrous oxide.

According to the GHG Protocol; GHG emissions are categorized into three main types (scope 1, scope 2 and scope 3 emissions). The approach of the GHG Protocol is in the meantime commonly used to demonstrate whether the emissions occur onsite, are related to indirect offsite processes, or associated with upstream processes. The definition of the scope 1-3 emissions is as follows[9]:

- Scope 1: *"Direct GHG emissions occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment".*
- Scope 2: *"Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated".*
- Scope 3: "*Scope 3 emissions are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services".*

The GHG Protocol definitions are based on ownership and control over emissions by companies while ISO 14044 refers to the metal production processes assessed. In order to maintain data consistency and comparability across the industry, the classification according to the GHG Protocol into Scope 1,2 and 3 emissions is recommended to be done based on the production process.

In some countries and regions, the allocation of GHG emissions to the above-mentioned categorized types might have to follow agreed country- or region-specific standards. According to the US EPA, "*Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling.*" [10]

Scope 3 emissions as defined in the GHG Protocol can cover a wide range of upstream and downstream activities, such as distribution, processing and use of sold products, business travel, as well as end of life treatment. For determining the GHG emissions from products, only upstream scope 3 emissions are included. For nickel production, this means that scope 3 emissions are limited to input materials (e.g., fuel, auxiliaries, sulphur, reductant, explosives, lubricants), upstream water production and wastewater treatment as well as transport taking place within or in between production sites.

An overview of the emissions included into the scope and assessed is shown in Table 3.

Table 3 **GHG emissions in nickel production according to the GHG Protocol**

Process step	Description	Scope emission
Direct activities	Combustion emissions associated with fuels, reductants and other process emissions (air and water emissions).	Scope 1
Electricity onsite	Emissions associated with electricity generated on site	Scope 1
Electricity	Electricity from the national or local electricity grid	Scope 2
Raw materials	Nickel containing raw materials sourced from third parties (e.g., ore concentrates, nickel matte, MSP, MHP, black mass)	Scope 3
Auxiliaries	GHG emissions associated with production of auxiliary raw materials such as e.g., chemicals	Scope 3
Sulphur	Production of sulphur used in the process	Scope 3
Fuels, reductants	Production of fuels and reductants used in the process	Scope 3
Lubricants	Production of lubricants used in the process	Scope 3
Explosives	Production of explosives used in the process	Scope 3
Waste-water	Municipal waste-water treatment. The emissions associated with onsite water treatment fall under direct activities	Scope 3
Water	The upstream production of tap water	Scope 3
Transport	Includes the fuel for transport (the production thereof) , transport of raw materials, human resources and combustion of associated fuels	Scope 3
Credit	Impact associated with the credit of by-product assuming the conventional production route of respective by-product	Scope 3

5. Life Cycle Impact Assessment

According to ISO 14040[11] and 14044, the life cycle impact assessment builds on the life cycle inventory where process in- and outputs are determined.

The production processes and associated substances which have been considered as GHG emissions and the selected characterization factors shall be reported. The globally agreed characterization factors for global warming potential are shown in Table 2.

The potential climate change impact of each GHG emitted and removed by the system under study (in our case nickel metal Class 1 production) shall be calculated by multiplying the mass of GHG released or removed with the 100-year global warming potential given by the IPCC for the particular gas in units of kg CO_2eq per kg emission. The total carbon footprint of the system under study is the sum of these calculated impacts.

When comparing impacts across time, the characterization factors applied to emission inventories should be the same for all periods under study.

The carbon footprint data of refined nickel (Class 1 nickel) should be updated at least every five years or whenever a significant change occurs in the production process or any other parameters affecting the emission intensity of nickel. The five-year update rhythm is in line with requirements formulated by e.g., the European Commission in their Product Environmental Footprint[12].

The following situations, as mentioned in the GHG Protocol, will trigger a significant change:

1. Structural changes in nickel production, including significant process change in operation, technology advancement, raw material, or energy.
2. Changes in calculation methodology or improvements in the accuracy of emission factors or activity data or inclusion of new types of sources that result in a significant impact on the emissions data.
3. Discovery of significant errors, or cumulative errors that are collectively significant.

Frequency of inventory data collection should be informed by the frequency of significant change in emissions intensity of the process(es) under study. These may be different for different emission sources. All inventory data shall refer to a one-year period.

6. Modeling parameters

6.1. Allocation of by-products

According to ISO 14044, the inputs and outputs shall be allocated to the different products according to clearly stated procedures. ISO proposes a stepwise procedure:

- Step 1: where possible allocation is to be avoided by either dividing the unit process into two or more subprocesses or expanding the product system to include the additional functional units related to the by-products
- Step2: where allocation cannot be avoided, the in- and outputs shall be partitioned between its different products reflecting the underlying physical relationships
- Step 3: where allocation cannot be avoided and no physical relationships can be established, in- and outputs shall be allocated in a way that reflect other relationships between the product and by-products, such as e.g. economic value

They shall be documented and explained together with the allocation procedure. The sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation. Whenever several alternative allocation procedures could be applicable, a sensitivity analysis shall be conducted to illustrate the consequences of the departure from the selected approach. The analysis shall be transparently presented, explained and justify the allocation approach used.

Multi-output allocation generally follows the requirements of ISO 14044 with the allocation rule most suitable for the respective process step applied within the process. Multi-input allocation shall be applied for waste processes including energy recovery, landfill, and wastewater treatment. When allocation becomes necessary during the data collection phase, the most suitable allocation rule for the respective process steps shall be applied and documented.

The production of refined nickel metal typically results in several other products being produced:

- Base metals are nonferrous metals (such as e.g., Cu or Co) that are neither precious nor noble metals.
- Platinum group metals (PGMs) and other noble metals such as e.g., gold or silver which belong to the group of precious metals. They may also occur and are produced as a by-product. On the other hand, nickel itself can occur as a by-product in other metals production processes such as e.g., in Cu, Co or PGM production.
- Moreover, certain non-metallic by-products can be produced, such as sulphuric acid which results from the removal of oxidized sulfur during the smelting of sulfidic nickel concentrates. Ammonium and sodium sulphate occurr in the refining process.

These base metals, precious metals, and non-metal products are treated by means of an allocation.

Different allocation methods are available and applied in industries in general where a range of different products occur together. The most common allocation methods are economic allocation (by value) or mass allocation (by weight). There are pros and cons associated with the different allocation methods which need to be considered. They can be found in a recommendation made by the metals and minerals industry in a peer-reviewed article.[13]

System expansion considers the existence of an alternative route to produce the by-product(s). The principle of system expansion is based on the fact that the by-product saves or avoids another product with equivalent function. It requires that this inventory (of the by-product) will be included into the system boundaries and inverted (i.e., subtracted from the analyzed system). This results in an environmental credit for the system analyzed according to the amount of by-product produced. System expansion is not used in the case of the metal by-products since the primary production of valuable metals such as copper, cobalt and PGMs could also yield small amounts of nickel. If this process is provided with credits, not only would it negate the production of copper, but also of small amounts of nickel. This would unreasonably and unfavorably affect the overall LCA for nickel.

In the case of nickel, a combination of economic value and mass allocation is generally used for metallic by-products:

- Where exclusively base metals occur together, a mass allocation is used to define the environmental profile. Typically, there is not a vast physical and economic difference. This allocation method is considered the best approach
- Economic allocation is used where base metals and precious metals occur together. They have vastly different economic values and production volumes (e.g., platinum [low production volume, high market value] versus copper [high production volume and lower market value]). Therefore, a mass allocation would not represent the value of the products and the rationale for producing the different metals. The prices used in this assessment are averaged over 10 years. Available public sources[15,16] shall be documented.
- There are specific cases where (in the case of a combination of base and precious metals occurring together) mass allocation in mining and beneficiation and economic allocation in smelting and refining might be applied. Such a combination of mass and economic allocation can be applied where e.g., assay data for mining and smelting are not available and an economic allocation therefore not possible. Such specific cases need to be highlighted, explained and justified.

As recommended by the agreed guidance in the metals industry[17], system expansion is applied for non-metallic by-products such as e.g., sulphuric acid, ammonium sulphate and sodium sulphate. It requires that the inventory of the non-metallic by-products is included into the system boundaries and subtracted from the analyzed system. This results in an environmental credit for the system analyzed according to the amount of by-product produced. The GHG calculation has to transparently disclose the credits and what kind of credits, i.e. , what is the conventional method for producing the by-product that has been considered.

The origin of the dataset used for the conventional production method and its reference year needs to declared and should be a reliable, globally accepted data source.

As recommended by ISO 14044:2006, the choice of the allocation method must be explained and justified and ideally accompanied by a sensitivity analysis.

6.2. Electricity

Electricity is a major energy source in nickel metal production processes. The emissions related to the production of electricity consumed in the nickel production processes, waste and wastewater treatment, ancillary processes and any other processes included in the system boundaries shall be included in the inventory. GHG emissions of electricity supply can vary significantly, depending on the specific electricity power generation technology applied by a company onsite or by the upstream electricity supplier.

Electricity shall be included according to the requirements formulated in ISO 14067 and the EU PEF Guidance. The following hierarchical approach is to be followed:

a. Supplier-specific electricity product shall be used if, for a country, there is a 100% tracking system in place, or if
   i. available, and
   ii. the set of minimum criteria to ensure the contractual instruments are reliable is met.

b. The supplier-specific total electricity mix shall be used if:
   i. available, and
   ii. the set of minimum criteria to ensure the contractual instruments are reliable is met.

c. The 'country-specific residual grid mix, consumption mix' shall be used. Country-specific means the country in which the life cycle stage or activity occurs. This may be an EU or non-EU country. The residual grid mix prevents double counting with the use of supplier-specific electricity mixes in a. and b..

d. As a last option, the average EU residual grid mix, consumption mix (EU+EFTA), or region representative residual grid mix, consumption mix, shall be used.

For a. and b. the contractual instruments used for electricity modeling shall meet the criteria as described in GHG Protocol Scope 2 Guidance. For companies operating outside the EU, a national residual grid mix might not be available. In order to allow data comparability, companies operating within the EU shall also be allowed to report their GHG emissions with the national grid mix.

GHG emission factors for countries globally as well as for different electricity generation technologies can be found in life cycle databases or in available publications such as the IEA[18].

As defined in the GHG Protocol Corporate Accounting and Reporting standard[18] companies shall be allowed to report their scope 2 GHG emissions by using the country-specific grid mix and using the supplier-specific electricity product / mix or – in absence of a supplier-specific electricity product / mix – the national residual grid mix.

Further guidance on the modeling of the "country-specific residual grid mix, consumption mix" can be found in ISO 14067and the EU PEF guidance[4].

Electricity generated onsite is considered as scope 1 emission (direct onsite). The emissions from generation of the electricity onsite are calculated based on the fuels combusted.

Further guidance on the modeling of the onsite electricity production can be found in ISO 14067 and the EU PEF guidance.

6.3. Fuel combustion

The greenhouse gas emissions which are related to the combustion of fuels consumed during the production process shall be calculated by using default emission factors which are published by the International Panel on Climate Change in their 2006 report[20]. If emission factors from other sources are used (e.g., national inventories), they shall be mentioned in the summary report.

6.4. Secondary data

Several auxiliary materials are used in the nickel production processes for which the nickel producer might not obtain primary data from its supplier, such as lubricants, sulfur, explosives, reduction agents or any other materials used in the production process and not falling into the system boundaries. For those materials, secondary data which can be commonly found in public and / or commercial databases shall be used. An overview on commercial and public databases can be found on the GHG Protocol website. [21]

7. Communication, third party verification

Transparent communication and interpretation of the results is of critical importance.

GHG emission calculations must always be presented with an overview on the methods and modeling parameters used, distribution of emissions from different scopes and credits, as well as a sensitivity analysis. This is in line with the requirements formulated in the International EPD system containing specific climate declarations based on ISO-14067[22].

The GHG Protocol Product Life Cycle Accounting and Reporting Standard formulates several requirements when results are presented. The GHG accounting and reporting of a product inventory shall follow the principles of relevance, accuracy, completeness, consistency, and transparency. This shall also be applied for the communication of the nickel metal GHG emissions to third parties.

The results of the total greenhouse gas emissions from nickel metal production shall be reported by the product manufacturer. In case the calculations were done by a third party, it shall be declared in the report.

The report shall inform on the cradle-to-gate GHG emissions of 1kg of nickel metal (Class 1 nickel). It shall include

- all relevant parameters chosen as listed in this guide
- the allocation method applied together with a justification and explanation
- the electricity mix underlying the calculations
- the parameters used for fuel combustion
- a distinction of primary and secondary data used
- a statement of the system boundaries applied. Define exclusions and estimated proportion of total GHG emissions for comparison with the EU Product Environmental Footprint Guidance.

Credits included in the footprint of the unit should be disclosed in such way that the reader can easily calculate the footprint both with and without the inclusion of credits in the footprint.

The report shall indicate the reference year for which the data were collected.

The reported data shall be accompanied by a certificate conducted by an independent third party confirming that the GHG data calculations were done according to those guidelines.

Glossary

Abbreviations

CFC	Chlorofluorocarbons
Co	Cobalt
CO_2eq	Carbon Dioxide equivalents
Cu	Copper
EN	European Norm
EPD	Environmental Product Declaration
GHG	Greenhouse gas emissions
GWP	Global Warming Potential
HFC	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standardisation Organization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
MHP	Mixed Hydroxide Product
MSP	Mixed Sulfide Product
Ni	Nickel
NI	Nickel Institute
PEF	Product Environmental Footprint
PGM	Platinum Group Metals
US EPA	United States Environmental Protection Agency

Terminology

- Black mass: Product of recycled battery materials that can be interned in the nickel metallurgical process. Reduction of end-of-life lithium-ion batteries, resulting in a powder substance that contains critical battery materials, including lithium, cobalt, nickel, and manganese, as well as copper, aluminum, and graphite.
- By-products: Products occuring together with the main product. Products that are not the main purpose of the production process
- Characterization factor : Quantitative representation of the relative importance of a specific intervention. Here: GWP of climate relevant gases
- Class 1 nickel: Nickel with a metal content >99.8%
- Emission factor: Factor of CO_2 eq per unit of fuels consumed, such as e.g., oil, gas, coal
- Nickel matte: An intermediate of the nickel metallurgical process having nickel content which varies from 30 to 60%
- Primary data: Life cycle data based on in-and output data of a specific company
- Secondary data: Aggregated life cycle data averaged over several producers, as found in public and commercial databases

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