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EXECUTIVE SUMMARY

This deliverable reports the principles of LCA and the data needed for the environmental sustainability indicators that enables near-online LCA for the steel and copper cases. The connection to the KPIs is explained. The sustainability indicators in COCOP are divided into KPIs and LCA indicators. Both of them are supposed to be based on online measurements as much as possible. The LCA indicators take into account the value chain from raw material extraction to the end of the production process, and the KPIs (including resource efficiency indicators) focus on efficiency at the production site.

ABBREVIATIONS

DMA	Disclosure on Management Approach
eq	equivalent
FSF	Flash Smelting Furnace
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
IRMA	Initiative for Responsible Mining Assurance
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
PSC	Peirce-Smith Converter
REI	Resource Efficiency Indicator
AF	Anode Furnace

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1 Introduction

1.1 Aim and background

Developing processes and technologies which enable a lower carbon footprint along the value chain and which facilitate a more circular economy, are core business [1]. Business needs to be proactive in resource efficiency in order to manage environmental challenges. Businesses need to take a step forward to become more resource efficient to reach environmental responsibility and trust within the stakeholders, and encourage the development and implementation of more resource efficient technologies. Resource efficiency is not only a key factor for minimising negative impacts on environment, but also for sustaining competitiveness. The European Union has taken action by issuing a roadmap to become a more efficient resource use in Europe. The Roadmap to a Resource Efficient Europe defines resource efficiency targets to the European Union and a plan to achieve them. [2]

The environmental objective of COCOP is to increase the sustainability of the process industry i.e. reduction of pollution, greenhouse gas emissions and energy/raw materials consumption as well as being better prepared to meet existing and emerging regulatory mandates in terms of environment, quality or safety aspects. Resource efficiency is not limited to company's boundaries like process and plant management. Instead the basic principle is to measure inputs of materials and energy relative to the physical outputs (more from less – thinking). The aim in COCOP is to integrate Life cycle Assessment (LCA) calculations into the coordinative-level optimisation in the form of sustainability indices. This will be done by processing and combining the real-time data that is available in the control systems to LCAs, providing model-based decision support to plant operator and managers. Online environmental indicators which can be calculated from direct process measurements and models to predict the environmental effects of the plants operational level will be defined. The concept of online or near-online LCA will enable daily process optimisation in terms of environmental impacts.

According to the International Energy Agency, the iron and steel industry are one of the biggest sources of CO_2 emissions globally [3]. Copper smelter sites are big SO_2 emission sources. Both manufacturing industries have potential to reduce their total CO_2 and SO_2 emissions by optimising their sub-processes. In the COCOP project new possibilities to enhance proactive process operator work will be developed. The operator should be more aware of the functioning of the whole plant, instead of being restricted to the sub-process for which they are responsible.

This deliverable reports the principles of LCA and the data needed for the environmental sustainability indicators that enables near-online LCA for the steel and copper cases. The connection to the KPIs is explained.

1.2 Introducing EU MORE

A key performance indicator (KPI) is a type of performance measurement that evaluates the success of an activity. Often KPI relate inputs and outputs and are either intensities, when stated as inputs per unit of product output [4], or efficiencies which are the reciprocals of intensities [5]:

“KPIs represent a set of measures focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization.”

For different purposes a number of KPIs exist. Most companies monitor their energetic and material efficiency and report KPI normally in retrospect over extended periods of time (e.g. per business year). KPI reflect the choice of raw materials, the plant technology used and the operational performance, without distinguishing between the different influences. As such, they cannot support decision making processes in daily plant operations. With real-time Resource Efficiency Indicators (REI), the effects of technical improvements and of operational policies can be measured and actions can be derived for real-time or near real-time plant performance improvements. The EU MORE project (Real-time Monitoring and Optimization of Resource Efficiency in Integrated Processing Plants) was aimed at monitoring and improving resource efficiency during daily operations of large chemical production plants by developing and implementing real-time REIs. Real-time REIs are different from REIs or KPIs obtained from historic analysis, because they allow online monitoring and rapid intervention to improve resource efficiency.

In the EU MORE project, the REIs were divided into generic and specific indicators. Generic indicators can be applied to every plant and can be aggregated bottom up, whereas specific indicators measure unit specific effects and provide more detailed information on key production steps, such as reaction and purification steps that strongly influence the efficiency of the plant. One outcome of the EU MORE-project was a list of REIs recommended as a basis for REI selection and development in process industries. These indicators include a few main generic REIs, providing the basis for a number of other REIs derived out of these. The list of recommended REIs can be found on the MORE website [6].

1.3 Key Performance Indicators in COCOP

KPIs used in COCOP project are based on ISO 22400-2 [11]. Each KPI is defined as quantifiable and strategic measurements that reflect the plant’s critical success factor.

COCOP Delivery 2.2. introduces the indicators relevant to COCOP cases copper and steel. Some of the KPIs applied in COCOP can be used for real-time monitoring and optimization of resource efficiency, and they are extendable to Life Cycle Assessment (LCA).

The KPI's and associated online indicators to be controlled along the project will be:

Copper case

KPI Copper case	Title Online Indicator/ real-time monitoring	Description/ Requirement
KPI-T1C: Equipment load ratio: Feed rate FSF TUTCOCOPDEV-107To Do	Already measured	-
KPI-T2C: Stability Feed Rate FSF TUTCOCOPDEV-108To Do	Online indicator savings due to improved stability Feed rate FSF	The system SHOULD present an online indicator for savings due to improved stability Feed rate FSF. Savings such as Reduction of CO_2 and less emission - (no oil used or less oil).
KPI-T3C: Copper content waste slag relative to baseline TUTCOCOPDEV-109To Do	Online indicator recovery of copper FSF and PSC	The system SHOULD present an online indicator for recovery of copper in FSF and PSC.
KPI-T4C: Equipment load ratio: Acid plant TUTCOCOPDEV-110To Do	Online indicator SO_2 emissions Acid plant	The system SHOULD present an online indicator for estimated SO_2 emissions Acid Plant.
KPI-T5C: Stability Acid plant TUTCOCOPDEV-111To Do	Online indicator energy usage Acid plant (fan) due to stability	The system SHOULD present an online indicator representing energy energy usage Acid plant (fan) due to stability.
KPI-T6C: Wear of bricklining (velocity) relative to produced bilister TUTCOCOPDEV-112To Do	N.A (weekly measurement)	
KPI-T7C: Wear of bricklining (velocity) TUTCOCOPDEV-113To Do	N.A (weekly measurement)	
KPI-T8C: Propan usage relative to produced copper TUTCOCOPDEV-114To Do	Online indicator propan usage relative to produced copper	The system SHOULD present an online indicator for propan usage relative to produced copper in AF.

KPI-T9C: Amount of produced converter slag compared to optimal estimate from FSF matte analysis. TUTCOCOPDEV-115To Do	Online indicator Amount of produced converter slag compared to optimal estimate from FSF matte analysis	The system SHOULD present an online indicator for Amount of produced converter slag compared to optimal estimate from FSF matte analysis and the usage of SiO_2.
KPI-T10C: Stability Anode Composition TUTCOCOPDEV-116To Do	N.A	
KPI-T11C: Scrap usage ratio TUTCOCOPDEV-117To Do	Online indicator scrap usage ratio	The system SHOULD present an online indicator for scrap usage ratio in AF and PSC.
KPI-T12C: Oil usage in the anode furnaces and FSF TUTCOCOPDEV-118To Do	Online indicator for emissions due to Oil usage in FSF and AF.	The system SHOULD present an online indicator for emissions due to Oil usage in FSF and AF.

Steel case

KPI Steel case	**Title Online Indicator/ real-time monitoring**	**Description/ Requirement**
KPI-T1S: Percentage of rejection (kilograms) on the finishing line TUTCOCOPDEV-120To Do	Online indicator for emissions due to rejections on the finishing line	The system SHOULD present an online indicator for emissions due to rejections on the finishing line such as Energy usage and CO_2.
KPI-T2S: Percentage of reworking (number of bars) on the finishing line TUTCOCOPDEV-121To Do	Online indicator for losses due to reworking (number of bars) on the finishing line	The system SHOULD present an online indicator for productivity decrease at the Finishing Shop due to reworking (number of bars) on the finishing line.
KPI-T3S: Percentage of rejection (kilograms) after Continuous Casting due to process parameters TUTCOCOPDEV-122To Do	Online indicator for emissions due to rejection (kilograms) after Continuous Casting	The system SHOULD present an online indicator for emissions due to rejection (kilograms) after Continuous Casting such as Energy usage and CO_2.

Each KPI may contribute to one or several impacts (= impact dependencies):

- Productivity (better yield)

- Energy usage (per tonne)
- CO_2 emission (per tonne)
- SO_2 emissions (per tonne)
- Dust emission (per tonne)
- Decrease of resource consumption raw material
- Generation of waste material and its potential in the reuse/recycling path

1.4 Principles of LCA

LCA is a standardised method (ISO 14040-44) to assess the overall environmental impacts through the value chain. LCA includes measuring the individual ingoing resources both process and site levels. Upstream and downstream effects from raw material acquisition, production and use to the end of life cycle stages are taken into account. LCA as a tool is most commonly used in process and product benchmarking and development, strategic decision-making, and environmental reporting and communication. Data for LCA is typically average data collected on yearly basis. The novelty of developing online LCA indicators is to develop a system for real-time life cycle management, i.e. the outcome of D4.4 is real-time data that is available on the control systems and can be integrated to LCA. So far, no such attempt has been successfully implemented into plant-wide optimisation and control systems.

The LCA framework consists of four phases, which are gone through during an LCA study. The phases are goal and scope definition, inventory analysis, impact assessment, and interpretation (Figure 1). Goal and scope definition is the starting point where the aims and boundaries of the study are defined. The data for the system is collected in inventory analysis, and the inventory is then utilised in impact assessment. Interpretation is an on-going process during the study and describes the iterative nature of LCA where the results from each phase are evaluated and reflected to the previous work done in other phases. This may lead to redefining the focus points of the study and more accurate results.

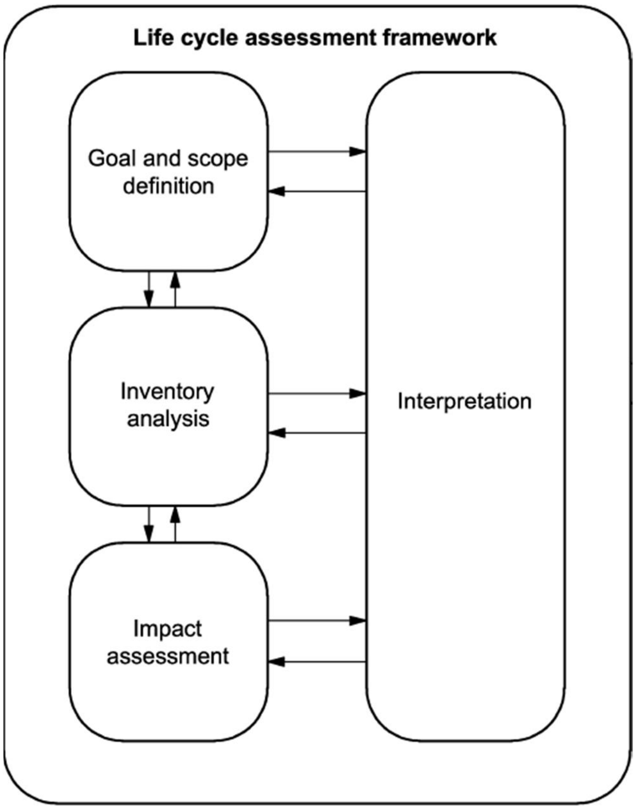

Figure 1. The four phases of LCA.

2 Environmental reporting

Current environmental management systems, such as the EU-EMAS Regulation or the ISO 14001 (ISO standard on environmental management systems) require an explicit commitment for continuous improvement of environmental performance but not the use of indicators per se. Indicators are, however, of great importance when environmental targets are defined and comprehensive environmental reports prepared. In addition to an environmental management system, there are several voluntary reporting options that organisations can use, such as Global Reporting Initiative (GRI).

2.1 Mining and Metals Sector Disclosure and Boliden GRI Report

The Mining and Metals Sector Disclosure document is based on the 'GRI Mining and Metals Sector Supplement'. This Sector Supplement was issued in 2010 and developed based on the G3 Guidelines (2006). Following the launch of the G4 Guidelines in May 2013, the complete Sector Supplement content is now presented in the 'Mining and Metals Sector Disclosures' document, in a new format, to facilitate its use in combination with the G4 Guidelines. The Mining and Metals Sector Disclosures document contains a set of disclosures for use by all organizations in the Mining and Metals sector. The disclosures cover key aspects of sustainability performance that are meaningful and relevant to the Mining and Metals sector and which are not sufficiently covered in the G4 Guidelines.

Boliden's environmental strategy is based on three component parts - Environmental impact, Resource efficiency, and Credibility. These elements address the most important environmental areas for Boliden´s license to operate and our long-term competitiveness. The ambition is to go beyond legislative and regulatory requirements.

Boliden Group's sustainability reporting is prepared in accordance with the G4 Sustainability Reporting Guidelines, including the Mining & Metals Sector Supplement [7].

Table 1. Environmental targets for 2014-2018.

METAL DISCHARGES TO WATER	Metal discharges to water, shall decrease by 25%
METAL EMISSIONS TO AIR	Emissions of metals to air, shall decrease by 10%
SULPHUR DIOXIDE EMISSIONS	Sulphur dioxide emissions to air, shall decrease by 10%

CARBON DIOXIDE EMISSIONS	The carbon dioxide intensity shall be max 0.77 tonne CO□/tonne metal
ENVIROMENTAL ACCIDENTS	Boliden shall have zero environmental accidents every month (Accidents classified as level A incidents and/or incidents when limit values were exceeded. Events which could cause considerable impact to the environment.)

The more detailed results of the environmental targets are shown in the GRI report (e.g. as tonnes CO_2/tonne metal, or metal discharges to water as tonnes Me-eq.)

Boliden has changed the reporting of metal emissions to air and discharges to water in order to improve the way how the environmental impacts are measured. Under the new method, the various elements are allocated a factor, depending on how toxic they are to the aquatic environment (discharges to water) and to humans exposed to them (air emissions). The new measure, Metal Equivalents, is a better metric for monitoring over time than the combined weight of emissions, because the weight concept did not convey the fact that, for exam-ple, the metals arsenic and mercury have a greater environmental impact than copper and zinc.

Boliden’s complete list of 2015 GRI index is in accordance with Global Reporting Initiative’s G4 standard. The aspects included the Category Environmental are the following:

Table 2. Complete list of GRI indices.

Aspect: Materials		
G4-EN1	Materials used by weight or volume	GRI 19
G4-EN2	Percentage of materials used that are recycled input materials	GRI 19
Aspect: Energy		
G4-DMA	Aspect Specific DMA	GRI 19
G4-EN3	Energy consumption within the organisation	GRI 20
G4-EN5	Energy intensity	GRI 20
G4-EN6	Reduction of energy consumption	GRI 20

Aspect: Water		
G4-EN8	Total water withdrawal by source	GRI 21
G4-EN10	Percentage and total volume of water recycled and reused	GRI 21
Aspect: Biodiversity		
G4-DMA	Aspect Specific DMA	GRI 21
G4-EN11	Operational sites owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas	GRI 22
G4-EN13	Habitats protected or restored	GRI 22
MM1	Amount of land disturbed or rehabilitated	GRI 22
Aspect: Emissions		
G4-DMA	Aspect Specific DMA	GRI 23
G4-EN15	Direct greenhouse gas (GHG) emissions (Scope 1)	GRI 23
G4-EN16	Energy indirect greenhouse gas (GHG) emissions (Scope 2)	GRI 23
G4-EN18	Greenhouse gas (GHG) emissions intensity	GRI 23
G4-EN19	Reduction of greenhouse gas (GHG) emissions	GRI 24
G4-EN21	NO_x, SO_x, and other significant air emissions	GRI 24
Aspect: Effluents and Waste		
G4-EN22	Total water discharge by quality and destination	GRI 25
G4-EN23	Total weight of waste by type and disposal method	GRI 25

G4-EN24	Total number and volume of significant spills	GRI 26
MM3	Total amount of overburden, rock, tailings etc	GRI 25
Aspect: Compliance		
G4-EN29	Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with environmental laws and regulations	GRI 26
Aspect: Transport		
G4-EN30	Significant environmental impacts of transporting products and other goods and materials for the organisation's operations, and transporting members of the workforce	GRI 27
Aspect: Supplier Environmental Assessment		
G4-DMA	Aspect Specific DMA	GRI 27
G4-EN32	Percentage of new suppliers that were screened using environmental criteria	GRI 27
Aspect: Environmental Grievance Mechanisms		
G4-DMA	Aspect Specific DMA	GRI 27
G4-EN34	Number of grievances about environmental impacts filed, addressed, and resolved through formal grievance mechanisms	GRI 27

DMA = Disclosure on Management Approach

3 Case copper

3.1 Process description

The copper case study is an example from a copper-smelting plant. The potential for improvement comes from increased production and reduced emissions related to more precise timing of operations. Especially, the value of the production increase is significant. Since the copper smelter utilises the ingenious chemical energy of Cu-concentrate, the energy savings and CO_2 emissions are minor. On the other hand, optimised process operation can further reduce CO_2 emissions per ton of concentrate and significantly reduce the amounts of SO_2 released to the atmosphere through, for example, reduction of process variations or improved response to abnormal process conditions. When the process variations are in control the acid plant which processes SO_2 to sulfuric acid is able to capture the SO_2 produced in the different production stages. The yield of Cu, purity of end product, and reducing emissions (dust, SO_2 and CO_2) are also included in the objectives.

A copper smelter consists of several unit processes and questionnaires were sent to Boliden Harjavalta in order to define what are the relevant emissions from each unit process.

Overall objectives in Harjavalta are in copper production:

- Increasing the capacity of the smelter
- Increasing the recovery of copper
- Decreasing the emissions per ton produced anode copper (SO2, CO2)
- Decreasing the use of fossil fuels and raw materials producing CO_2
- Better control of impurities in anode copper.

If the acid plant capacity is exceeded, SO_2 emissions to the surrounding environment can occur. The current control system of pressures at the acid plant, flash smelting furnace (FSF) and Peirce-Smith converters (PSC) operates in such a way that under-pressure at converter hood may no longer reach its set point resulting in converter off-gas leaking to the atmosphere. This is noticed by the converter operator and the correcting actions that are taken can typically be 1) stopping the converter blow and/or 2) lowering the FSF feed fate.

3.2 System description for the life cycle assessment of the copper pilot case

As described in Chapter 1.4, life cycle assessment consists of four phases. Goal and scope definition sets the boundaries and defines the aims of the assessment work. In this case, the goal is to provide real-time environmental impact data to support decision making when running the process. The system boundaries follow mainly the framework described in Deliverable 4.1 (Figure 1, p. 5), but in addition, the life cycle perspective has been taken into account by considering impacts in the value chain. However, the system ends after the anode furnace, and thus, the production of copper products and their end-of-life have not been considered. The boundaries of this cradle-to-gate system are presented in Figure 2.

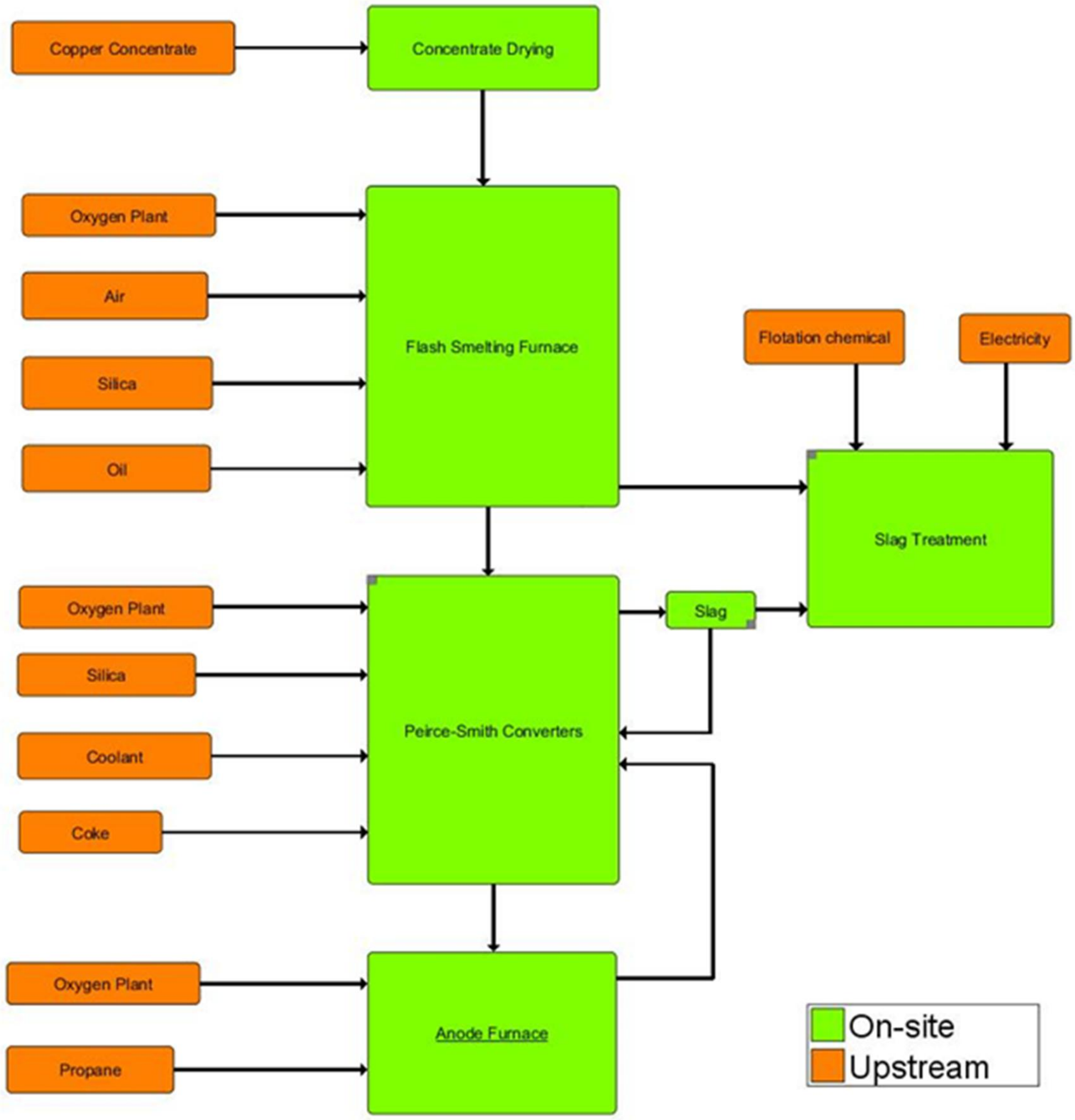

Figure 2. System boundaries of the LCA for Copper pilot case. The green on-site processes describe the unit processes at the production site, and the orange upstream processes describe the related actions in the value chain.

The functional unit of the LCA is one tonne of copper anode produced in the anode furnace. This means that the LCA software scales all the input and output flows in the flowsheet to meet the demands of the production of one tonne of copper anode. This enables the comparison of the environmental impacts to previous results and ignores the effects due to changes in production volume.

Usually, LCA studies are based on average data from past years, and collecting the life cycle inventory (LCI) is the most time-consuming part of the study. In this case, the data collection occurs automatically by the process control system, which enables the online LCA calculations in real-time. However, the input and output flows for each unit process have to be defined in the LCI phase and included in the LCA model because the system needs to know which parameters are connected to the LCA calculation. The online measurements can be utilised only for the on-site operations, and thus, general database data is needed for the upstream processes. In practice, this means that general datasets are used, for example, for electricity and copper concentrate production. The datasets cover a cradle-to-gate system, which ends to the gate of the production site. The EcoInvent 3.3 database [10] is used as the source for database data. In order to cover the whole value chain, the raw material transportations to the copper smelter have to be included, as well.

4 Case steel

4.1 Process description

The aim of the project is to optimise the main Steel production sub-processes that affect to the generation of surface defects, and the main aspects to be taken into account are:

- Productivity of the plant
- Reduction of energy use
- Reduction of CO_2 emissions
- Economic impact

In the sustainability point of view, the most important aspect is the reduction of CO_2 emissions. However, the optimisation aims at increasing productivity, which usually means minimising waste, reducing energy use, and avoiding disturbances, which all benefit in the environmental impact calculations eventually.

The steel production process has been divided into three sub-processes: secondary metallurgy, continuous casting, and hot rolling. All of the sub-processes consume energy in the form of electricity and heat, and a large part of the energy is produced with fossil fuels. This means that the carbon dioxide emissions from energy production have to be considered carefully. In addition to energy, there are also other inputs to the processes, which have to be taken into account, such as alloy materials and slag formers.

4.2 System description for the life cycle assessment of the steel pilot case

The LCA for the steel case is similar to the copper case. The goal is to create a real-time system, which utilises measurement data from the processes to assess the environmental impacts. The system boundaries are based on the framework described in Deliverable 4.1 (Figure 4, p. 32) but are expanded to cover a cradle-to-gate system, which starts from raw material extraction and ends to the production site. The functional unit is one tonne of steel billet produced in the rolling mill sub-process. The life cycle inventory is collected online from the sub-processes on-site, and a database is used for the upstream processes. The steel case system is illustrated in Figure 3.

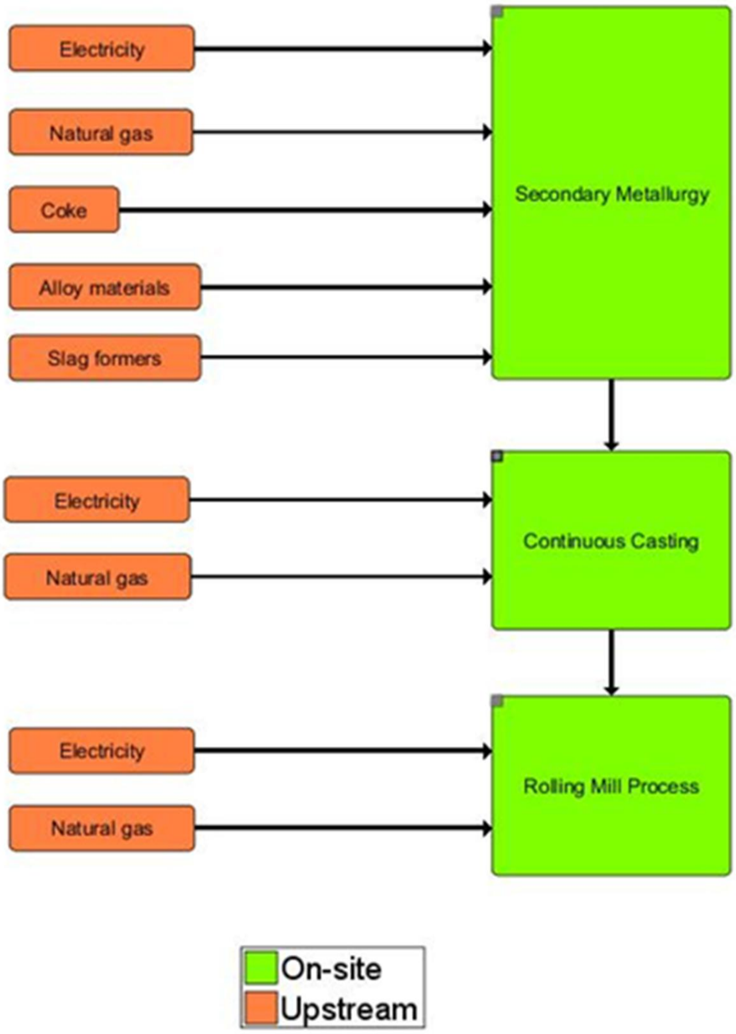

Figure 3. System boundaries of the LCA for Steel pilot case. The green on-site processes describe the unit processes at the production site, and the orange upstream processes describe the related actions in the value chain.

5 Near-online LCA indicators

The near-online LCA indicators have been selected based on their significance and available data. The steel and copper industries are large sources of CO_2 and SO_2 emissions, which is why these emissions have been in focus in the companies' sustainability work. In COCOP, the sustainability of the processes is assessed by means of LCA and the indicators are the LCA impact categories.

5.1 LCA indicators

The LCA impact category results are the outcome of the life cycle impact assessment (LCIA). LCIA is the phase where the LCI results are converted into potential environmental impacts. This is done by means of an impact assessment methodology. In this case, the CML2001 [9] methodology was selected. CML2001 covers a wide array of impact categories, but it is not reasonable to include all of them in the study since it would need a huge amount of data which is not available. The LCA focuses on two impact categories, global warming and acidification, due to their relevance to the production processes. The results from the calculations are kg CO_2-equivalents (CO_2-eq) and kg SO_2-equivalents (SO_2-eq) per one tonne of product for global warming and acidification, respectively.

The main emissions contributing to global warming are carbon dioxide (CO_2), methane (CH_4), and dinitrogen monoxide (N_2O), and the most important acidifying emissions are sulphur dioxide (SO_2), nitrogen oxides (NO_x), and ammonia (NH_3). All of these gases are included in the Ecoinvent datasets used for the upstream modelling. The main emissions formed in the on-site production processes are CO_2 and SO_2, thus these emissions are the main output flows and should be either measured or calculated from each unit process in order to provide a comprehensive impact assessment. Naturally, all the available emission data will be utilised in the assessments if applicable. From the input side, all the raw material and energy flows should be measured. The input flows are linked to the Ecoinvent datasets and the quantities define the impacts from the upstream operations. The data needs for the copper and the steel case are presented in Figure 3 and Figure 4, respectively.

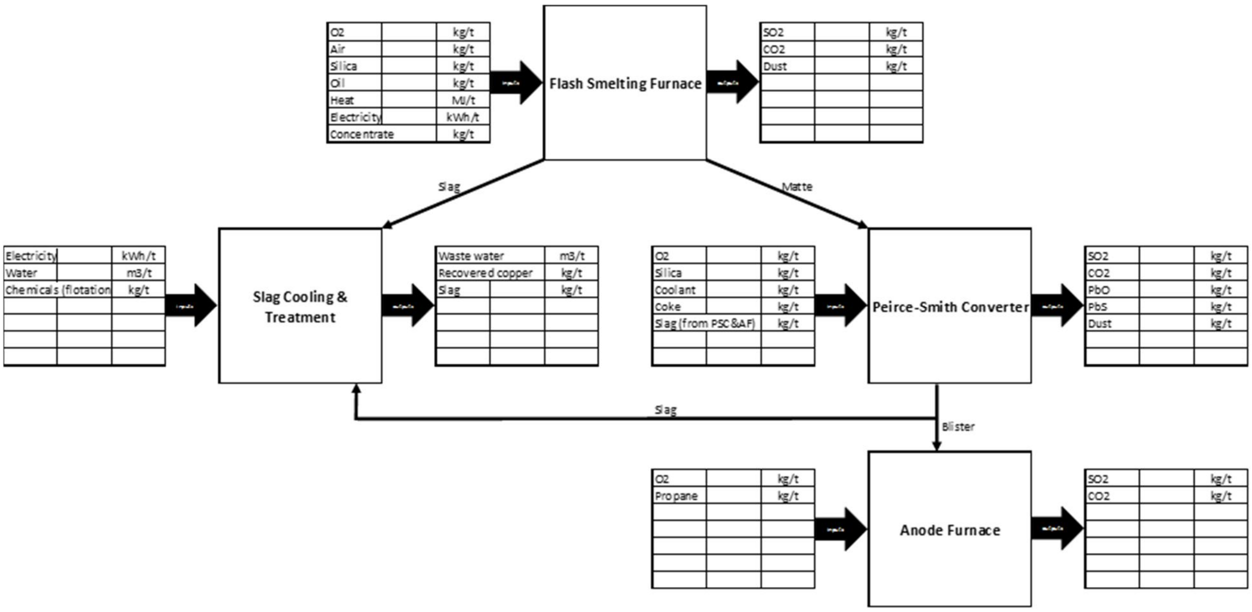

Figure 4. The data needs from the copper case.

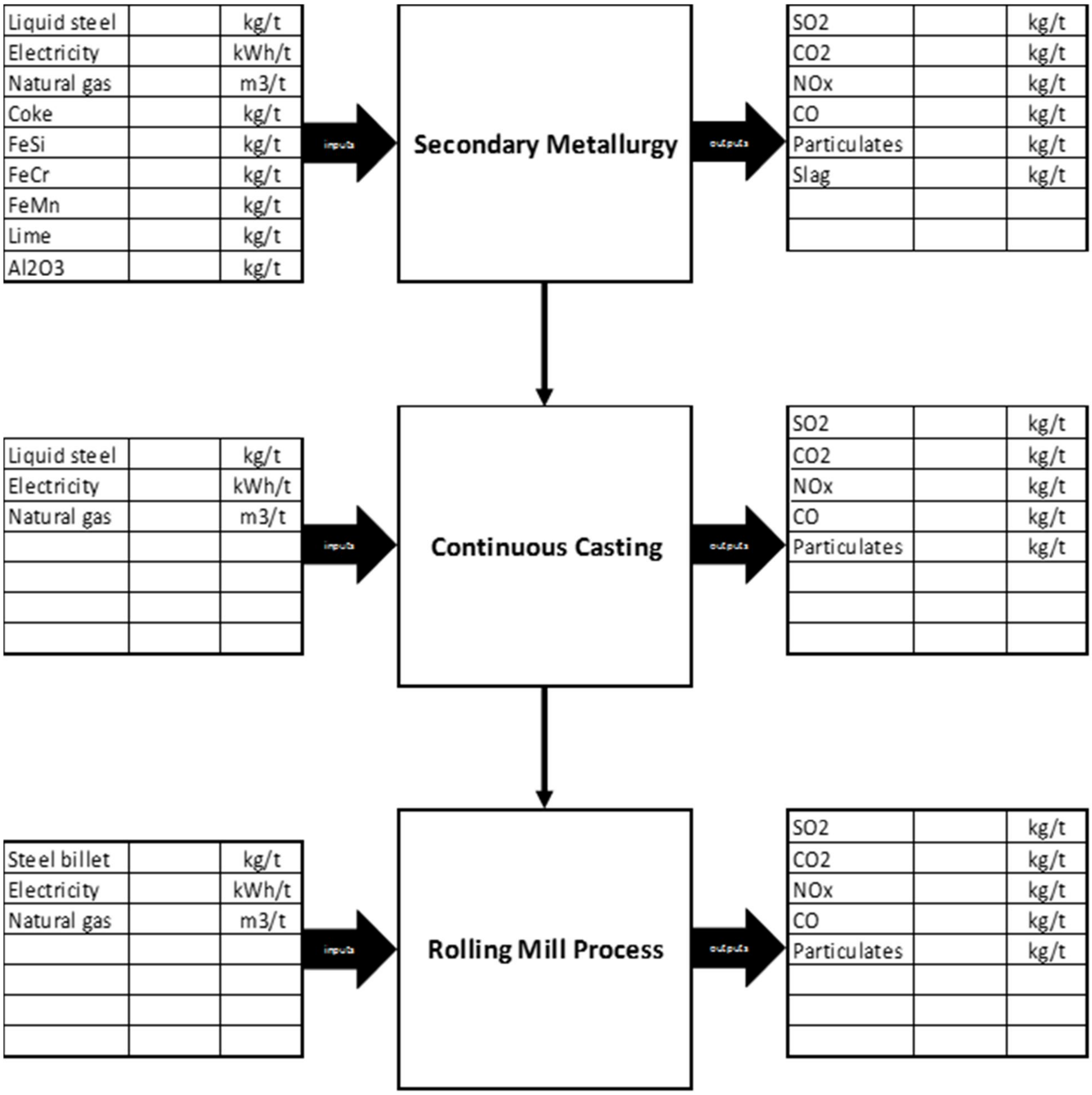

Figure 5. Data needs for the steel case.

The generic requirements to the COCOP system related to LCA are defined in Table 3. Also other requirements are related to LCA, but they are not specific to LCA only.

Table 3 Generic requirements related to LCA

General requirement	Description
REQ-G-LCA-010 LCA models	The system MUST be able to run LCA models.

REQ-G-LCA-020 Input from the process to LCA	The LCA models MUST have access to near online data. Some data can be accessed from the DCS system of the process (see TUTCOCOPDEV-76), but some data will be entered by other means. Such data can be, e.g., laboratory measurements that are done only monthly.
REQ-G-LCA-030 LCA model linking to other models	LCA models MUST have read access to data from unit models to be able to provide forecasts for LCA indicators.
REQ-G-UI-150 - Sustainability aspects to UI	Sustainability aspects, like · indicators · any effect the optimisation system supports SHOULD be visualised if possible

6 Critical summary

The sustainability indicators in COCOP are divided into KPIs and LCA indicators. Both of them are supposed to be based on online measurements as much as possible. The LCA indicators take into account the value chain from raw material extraction to the end of the production process, and the KPIs (including resource efficiency indicators) focus on efficiency at the production site. The current situation of defining the LCA indicators and discussion about the next steps are summarised in Table 4.

Table 4. Summary of the current situation related to the sustainability indicators in COCOP.

Issue	Current situation	Remarks
KPIs in relation to LCA indicators	KPIs and LCA utilizes partly same data from the processes and complement each other by providing important information about the process performance.	Many of the KPIs follow the CO_2 and SO_2 emissions which are also of interest in LCA.
Available data for LCA	Based on the information gained from the production sites, the available data is applicable for calculating the impact categories global warming (kg CO_2-eq/t) and acidification (kg SO_2-eq/t). The main data is CO_2 and SO_2 emissions, and the raw material and energy input flows. Transportations may be a significant emission source and the emission data should be included to cover the whole value chain. The amount and treatment of solid waste is also one aspect to be taken into account.	Taking into account the impacts to water systems would require expanding the scope to cover the wastewater discharges from the production sites. Heavy metal emissions are a risk for human health and the environment, and could be included in the assessment. However, the current toxicity impact categories are not as reliable as the global warming category, for example. The transportations and solid waste treatments can be calculated based on average data if primary data is not available.
Applicability of the LCA	The LCA will cover the sub-processes, which are in the focus of the project, and the related raw material and energy value chains. Thus, the whole production sites are not modelled and the possible by-products are not taken into account at the demonstration stage. The model is extendable to cover the whole site.	The LCA results are applicable in comparing the performance to previous results or a target value. The global warming result (kg CO_2-eq/t) cannot be considered as a carbon footprint result (including all the production stages of a final product), but can be used as a valid contribution to it.

Applying online data in LCA	Some of the measurements are continuous, some of them are measured heat by heat, and some data is measured as a monthly basis. How to deal with different kind of data inputs?	Using heat by heat averages would be optimal.

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