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Investigation of Standardization Needs Related to the Steel Industry's Climate Transition

A project within the framework of Vinnova's call for "Climate-focused standardization for increased innovation and competitiveness". Vinnova's diary number: 2022-00656

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Summary

The transition to a low-carbon economy in the steel industry is highly prioritized by various decision-makers worldwide. The steel industry, responsible for 7-9% of global greenhouse gas emissions, needs to significantly reduce its carbon emissions to contribute to the global goal of achieving "net-zero" emissions by 2050. The transition is underway, and currently, Sweden and the Swedish steel industry hold a leading position in the global shift towards fossil-free steel production.

In the project "Investigation of Standardization Needs Related to the Steel Industry's Climate Transition," known as URSTARK, several components were involved. These components include the mapping of relevant standards and initiatives, a stakeholder analysis, discussions and analysis of project results, and finally, the compilation of conclusions and a set of proposed actions.

There is a significant number of **standards** relevant to the steel industry and its climate impact at the organizational level, facility level (production site), and product level. More than 30 standards have been studied in the project, covering most aspects of the steel value chain that are relevant from a climate perspective. For products, there are standards and methods for calculating life cycle-based environmental footprints or carbon footprints. However, the product category rules for such environmental footprints often differ, making the results not entirely comparable. An area that has not yet been standardized but could be relevant is improved scrap sorting and recycling of alloys in steel scrap. Meanwhile, standardization continues in areas such as life cycle assessment, environmental communication, climate neutrality, traceability, and information transfer in the value chain and circular economy. A new initiative has been launched within CEN on "Requirements and guidelines for sectoral transition plans."

Numerous **initiatives** have been launched by various actors aiming to support different sectors in the global climate transition, some of which specifically focus on the steel industry. Some of these initiatives aim to evaluate steel using simplified methods as a basis for procurement. Around 40 different initiatives have been analyzed in the project. The purpose and scope of various initiatives have been mapped out. Some initiatives have tried to address the fact that the global supply of scrap is insufficient to meet the global demand for steel. Therefore, they have proposed criteria for "near-zero steel" based on the proportion of ore and scrap used in steel production. However, there is a difference of opinion within the steel industry regarding these proposed classifications of steel and their relevance to the climate transition, with some questioning these classifications mainly based on the risk of distorted competition.

Three initiatives, Responsible Steel's standard, worldsteel's method for collecting and calculating the climate intensity for production sites, and the SBTi Steel guide proposal, have been studied in a case study. The case study clearly shows that the scope of what is included in the method is crucial for the results.

An overview of measures contributing to climate transition throughout the value chain shows that the calculation methods that best estimate reduced greenhouse gas emissions are those that include a complete life cycle analysis for the product. By only considering production up to casting or rolling, you miss measures that may require more energy in the manufacturing phase but increase the functionality and lifespan of the final product, thereby reducing total

emissions. Therefore, the role of life cycle analysis in the assessment of steel production should be strengthened.

A **stakeholder analysis** has been conducted through interviews with 28 companies throughout the value chain, three investors, and five authorities. The stakeholder analysis shows that all stakeholders in the value chain demand information about companies' or products' carbon footprints and prefer reporting on goals and measures planned to reduce the footprint of each company. In some sectors, specific questions about climate information are asked, with references to particular methods or standards. This occurs, for example, in the construction sector and the automotive industry. Some customer companies, in addition to needing climate information, also have an interest in information about the proportion of secondary raw materials (scrap) used in steel production. Standards for life cycle assessment and environmental declarations are considered credible, as are some global initiatives, particularly the Greenhouse Gas Protocol and Science-Based Targets initiative. Some stakeholders, both steel companies and customers, have engaged in some of the steel-specific initiatives developed. Investors also highlight other tools. There is consensus throughout the entire steel value chain that uniform methods enabling fair comparability are valuable. Comparisons should also be made at the product level and preferably for products as delivered to the customer. Simplified methods can, of course, serve a purpose, but often these methods entail a risk, as simplified results can also be applied to analyses or decisions where they are no longer relevant. Therefore, it can be concluded that transparency regarding the purpose of the methods and their calculation models is very important. It can be difficult for different stakeholders to understand the difference between various reported values for climate-related emissions from a company, a production facility, or the carbon footprint of steel products.

Throughout the project, several conclusions have been drawn from the analysis of standards and initiatives, as well as the stakeholder analysis and conducted workshops. Several proposed actions are presented in the report. These actions primarily revolve around advocating for a common method for calculating the carbon footprint of steel and steel products, as a basis for establishing possible procurement criteria as incentives for driving the climate transition in the steel industry. An analysis of the consequences for market actors of the potential introduction of such criteria is needed. Additionally, participation in relevant international standardization, monitoring and influencing the implementation of relevant EU frameworks, including the development of Product Environment Footprint Category Rules (PEFCR) for various steel types, and the need for continued collaboration within the steel value chain are suggested.

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Preface

The project "Investigation of standardization needs related to the climate transition of the steel industry," with Vinnova's reference number 2022-00656 and the short name URSTARK, has been conducted within the framework of Vinnova's call for "Climate-focused standardization for increased innovation and competitiveness".

Following persons and companies have participated:

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The work has been carried out during the period of April 15, 2022, to January 30, 2023, with additional updates thereafter.

The project has collaborated with the Council for Innovative and Climate-Focused Standardization and its Working Group 2 "Fossil-Free Steel," led by the Swedish National Board of Trade (Kommerskollegium).

1 Introduction

1.1 Ground for the URSTARK Project

The background of the URSTARK project is the ongoing green transition, especially in Sweden, aimed at transforming the steel industry and significantly reducing its carbon dioxide emissions to contribute to the global goal of achieving "net-zero" greenhouse gas emissions by 2050. It is essential that the changes made result in real emissions reductions. It must also be possible to communicate these improvements in a way that rewards companies and steel producers contributing to actual emissions reductions while maintaining fair competition conditions in the global steel market. Hence, there is a need to map the standards and initiatives emerging in the market, identify how these affect companies' efforts to reduce emissions, and evaluate the current market conditions. Subsequently, it is important to assess the need for potential additional standards to complement and streamline regulations and national policy efforts.

1.2 Background - Activities in the Steel Value Chain

The combined emissions from the steel industry account for approximately 7-9% of global greenhouse gas emissions. Steel is also one of the world's most important and widely used construction materials, used in various applications such as buildings, infrastructure, transportation, energy production, industrial manufacturing, food production, healthcare, and numerous consumer products. Steel can be recycled repeatedly while retaining its technical properties, making it the most recycled material globally. Steel is a sustainable material used for a relatively long period before it is finally scrapped and sent for recycling. Global demand for steel is increasing due to population growth and improved living standards in various parts of the world. Therefore, scrap quantities are insufficient, even with enhanced sorting and recycling of scrap. Iron ore will continue to be required as a raw material for the foreseeable future. The majority of greenhouse gas emissions from the steel industry stem from the ore-based production of steel in blast furnaces, where iron ore is reduced to iron using coal. Given the collective emissions from the steel industry and the time the industry has taken for climate transition, it is a clear focal point for developing new regulations and initiatives to expedite the green transition.

In Sweden, measures are being taken and planned in both ore-based and scrap-based steel production to reduce emissions of carbon dioxide from fossil sources. Significant technological shifts are planned for ore-based steel production in Sweden, primarily by transitioning to direct-reduced iron sponge (DRI) where hydrogen or biogenic synthesis gas is used as a reducing agent. The iron sponge can then be melted in the same way as scrap to produce steel. For the ore-based production of iron powder, experiments are being conducted with biogas and biochar as substitutes for fossil natural gas and coal. For processing steps common to both production methods, efforts are underway to reduce greenhouse gas emissions, such as transitioning from fossil-based propane or natural gas to electricity, hydrogen, or biogas in various heating processes.

At the same time, steel product properties are continuously developed to achieve higher strength, increased durability, reduced maintenance needs, and longer lifespans, all contributing to reduced emissions in the final application. Reducing the carbon footprint of the final product is a top priority throughout the steel value chain, including the steel industry itself, its raw material suppliers, distributors, customers, and investors.

The Swedish steel industry's work on climate transition has been described in the "Steel Industry Climate Transition Plan"[1] from 2018, with a follow-up in 2020. For further information on how steel production is carried out in different process steps and its climate impact, please see Appendix 1, "Steel Production, Possible Measures, and Alloys."

There are several methods for calculating and assessing the carbon footprint. Calculations are performed at the national level, by company or corporation, sometimes for production sites, processes, or activities, and both for intermediate products and final products. There are official standards for developing and analyzing the climate impact of the final product from a life cycle perspective. There are also regulations related to marketing and procurement principles.

Coordinating and creating clarity on definitions and methods for tracking the climate impact in a value chain in a transparent, understandable, and fair manner are central, and standardization can play a significant role in this regard. However, it is important to note that different methods and definitions in various documents may have different purposes. In cases where the purpose is the same, the methods should be harmonized to the greatest extent possible. To interpret and use the results from different methods, it is necessary to understand what is included in each method; how much of the life cycle or value chain's contribution to climate impact is considered, whether and how potential emissions reductions during the product's use phase and when it is finally decommissioned and made available for disassembly, reuse, or recycling are considered. In-house developed methods and designations outside officially standardized definitions and methods place high demands on transparency. In most cases, they risk creating confusion in markets related to the steel value chain and, in the worst case, promoting greenwashing.

Currently, Sweden and the Swedish steel industry have a leading position in the global transition toward fossil-free steel production. This position has been achieved relatively quickly and is now driven by market expectations for steel products produced with low carbon dioxide emissions.

Examples include:

- Projects where iron ore reduction is carried out using hydrogen for steel production at SSAB and H2 Green Steel.
- Use of hydrogen as fuel for steel heating at Ovako.
- Reduction of ore for powder production with biochar and biogas at Höganäs.
- Electrification and the use of biogas for heat treatment processes at Uddeholm.

The low carbon footprint in the Swedish electricity mix also means that Swedish steelworks have a very low climate impact in international comparison from the electricity they use. Well-functioning assessment systems based on standards and other initiatives are of central importance and should enhance Swedish competitiveness in export markets for both ore-based and scrap-based iron and steel works, contributing to a reduction in global greenhouse gas emissions.

[1] https://www.jernkontoret.se/sv/publicerat/stal-och-stalindustri/klimatfardplan/ (2023-09-15)

In this project, the majority of Swedish iron and steel companies, along with representatives from raw materials and customers, have evaluated existing initiatives and standards relevant to the climate transition in the steel industry and drawn several conclusions.

1.3 Purpose

The purpose of the URSTARK project has been to:

- Increase knowledge about the opportunities and challenges of presenting the climate impact of steel with existing methods to contribute to standardization and increased harmonization of voluntary initiatives used to drive the green transition in the production and use of steel.
- Develop a plan for how it is practically possible to develop relevant standards in line with the call's purpose.
- Through ongoing monitoring, present the needs and conditions for the project's results in a national, European, and international context.

The project highlights factors and presents concrete approaches that can form the basis for decisions on future standard design projects. The goal has been to:

- Create conditions for collaboration on common standards for industrial interoperability (using information and/or functionality from another system or process) that contribute to increased climate benefit.
- Conduct and present case studies to enhance understanding of the consequences and business benefits of standardization and harmonize definitions and methods used in voluntary initiatives.
- Investigate how standards can promote innovation for increased climate benefit and competitiveness.

1.4 Implementation

The URSTARK project has included the following components:

- An inventory of standards and climate initiatives of significance for the climate transition of the steel value chain.
- A stakeholder analysis based on survey questions and interviews regarding the use of standards and methods from various climate initiatives and what might be missing to support the climate work.
- A review of where efforts can be made in the steel value chain and the recycling stage to reduce the climate impact of steel and a link to the potential need for additional standardization.

In the project, a workshop and two seminars, along with numerous project meetings, have been held. These have been crucial for acquiring knowledge and for anchoring and disseminating the results.

1.5 Limitations

Today, legislators, producers, customers, investors, and other decision-makers primarily focus on the carbon footprint, but other environmental impact categories are also important, as well as biodiversity and the use of mineral and metals. The standards and initiatives examined in the project often include multiple impact factors, and in such cases, this is reported even though the project's focus is on the climate impact.

2 Standards Relevant to the Climate Transition of the Steel Industry

There is a vast array of standards relevant to the steel industry and its climate impact at the organizational, facility (production site), and product levels, with over 30 standards studied in the project, see Annex 2 and Table 1 below. These standards cover most of the climate-relevant aspects in the steel value chain.
Standardization can contribute to consistency and transparency, for example, in how to:

- Lead climate efforts in an organization,
- Calculate greenhouse gas emissions from organizations and facilities,
- Inventory and analyze the climate and environmental impact of different products throughout their lifecycle,
- Transfer information in a value chain,
- Communicate climate and environmental claims,
- Verify the information.

The standards themselves do not evaluate the results obtained from standardized calculations and methods; instead, the evaluation of the results is done by stakeholders affected by the outcome (customers, financiers, owners, etc.).
Standardization is carried out within standardization bodies, where consensus is an important part of the process. This means that standards reach the level of ambition that participants in the standardization process can agree upon.

2.1 Standards

To develop a life cycle-based carbon footprint for a steel product, general standards for life cycle assessments (LCA) are needed initially (*ISO 14040* and *ISO 14044*). There is also an ISO standard for life cycle inventory data for a steel product (*ISO 20915*) that can be used. The results of a life cycle assessment can be communicated in the form of a self-declared environmental claim type II according to *ISO 14021* or a third-party verified environmental declaration type III according to *ISO 14025*.
In cases where a type III environmental declaration, often called EPD (Environmental Product Declaration), is chosen for communication between companies and customers, it should be third-party verified and available at the time of purchase. To develop a type III environmental declaration, PCR (Product Category Rules) for the specific product type, established by a program operator in collaboration with stakeholders for the specific product, are required. PCR provides detailed instructions on what should be included and what types of data should be used to develop this environmental declaration (EPD). After the life cycle assessment is conducted according to the designated PCR, an approved reviewer is hired to ensure the life cycle assessment is correct (third-party verification). After this third party review is completed, the environmental declaration is published by the program operator, and in most cases, also by the company manufacturing the product. The environmental declaration is typically valid for 5 years.

In the construction sector, there is a global standard *ISO 21930 - Sustainability in building construction - Environmental declaration of building products and building services*. It is an international basic standard with rules for the development of LCAs for building materials. In the EU, there is a standard *CEN- 15804 – Sustainability in building construction - Environmental declaration - Product category rules*, which can be used in parallel with the international ISO standard. For building products in the EU, a large number of EPDs are developed according to *EN 15804* and underlying, clarifying PCR documents. For steel and

aluminum products, a European overarching supplementary standard (c-PCR) *prEN 17662* is under development and is expected to be published in 2024.

It is not self-evident that delimitations and specifications are exactly the same for steel products among all program operators. Therefore, it is not entirely straightforward to compare EPDs for steel developed by different program operators. Since they fundamentally rely on the same ISO standards for LCA, they are usually reasonably related. There is also international work within ISO on "mutual recognition of EPD" between different program operators to facilitate customers' comparison and informed choices regarding the life cycle-based environmental impact of products. There is also an international standard that only calculates the life cycle-based climate impact from a product in a "single issue environmental declaration," *ISO 14067 Carbon footprint*.

There are also standards for calculating an organization's greenhouse gas emissions and calculating site-specific greenhouse gas emissions from energy-intensive industries and from the steel industry.

Figure 1. Overview description of the relationships between various standards relevant to the climate impact of steel production and steel products

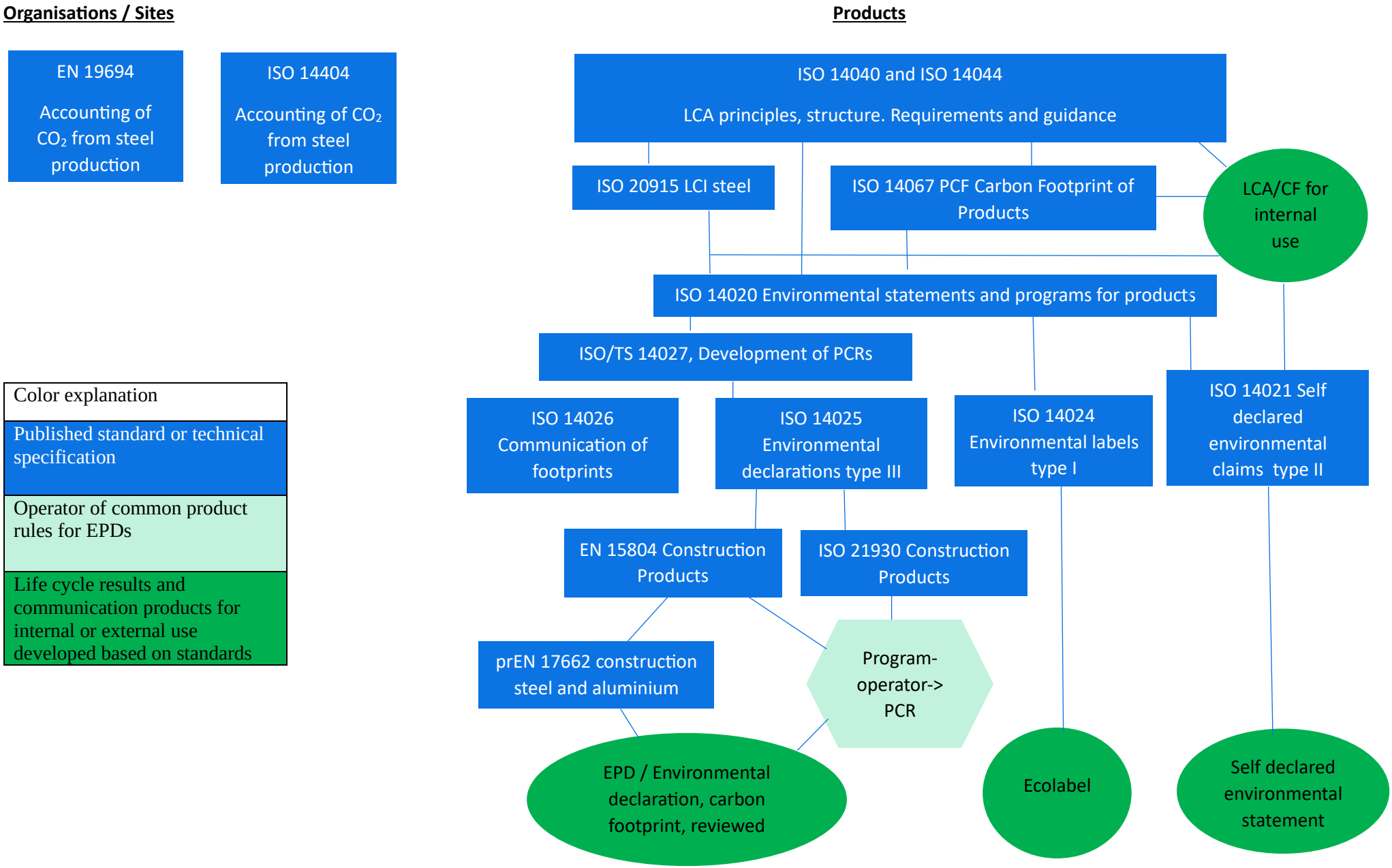


Table 1. Relevant standards for steel companies and steel products related to climate impact and recycling (not exhaustive)

Product LCA/EPD/PCR and product Standards	
ISO 14040:2006	General LCA - Principles and framework
ISO 14044:2006	General LCA - Requirements and guidelines
ISO 14045:2021	Eco-efficiency assessment of production systems
ISO 14020:2022	Environmental statements and programs for products – principles and general requirements
ISO 14021:2017	Environmental labels and declarations - Self-declared environmental claims (type II)
ISO 14024:2018	Environmental labels and declarations – Environmental labeling (type I)
ISO 14025:2006	Environmental labels and declarations - Environmental declarations (type III)
ISO 14026:2017	Principles, requirements, and guidelines for communication of footprint information
ISO 14027:2018	Environmental labels and declarations – Development of product category rules
ISO 21930:2017	Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services
EN 15804:2012+A2:2019	Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products
prEN 17662	EPD - Product category rules complementary to EN 15804 for Steel, Iron and Aluminium structural products for use in construction works
ISO 20915:2018	Life cycle inventory calculation methodology for steel products (closely aligned to the worldsteel methodology for LCI calculation)
ISO 14067:2018	GHG - Carbon footprint of products - Requirements and guidelines for quantification
EN 45557:2020	Recycled content in energy related products
EN 45555:2020	Recyclability and recoverability of energy-related products
Organisation or site greenhouse gas emissions, GHG, Quantification and Reporting	
ISO 14064-1:2018	Specification with guidance at the organization level for quantification and reporting of GHG emissions and removals
ISO/TR 14069:2013	Guidance for the application of ISO 14064-1
ISO 14064-2:2019	Specification with guidance at the project level for quantification, monitoring and reporting of GHG emission reductions or removal enhancements
ISO 14064-3:2019	Specification with guidance for the verification and validation of GHG statements
ISO 14694-1:2021	Stationary source emissions – Determination of GHG emissions in energy-intensive industries. Part 1. General aspects
SS-EN 19694-1:2016	Stationary source emissions – Determination of GHG emissions in energy-intensive industries. Part 1. General aspects
SS-EN 19694-2:2016	Stationary source emissions – Determination of GHG emissions in energy-intensive industries. Part 2 Iron and steel industry
ISO 14404-1:2013	Calculation method of carbon dioxide emission intensity from iron and steel production - Part 1: Steel plant with blast furnace (BF-BOF)
ISO 14404-2:2013	Calculation method of carbon dioxide emission intensity from iron and steel production - Part 2: Steel plant with electric arc furnace (EAF)
ISO 14404-3:2017	Calculation method of carbon dioxide emission intensity from iron and steel production - Part 3: Steel plant with electric arc furnace and coal-based or gas-based direct reduction iron (EAF-DRI)
ISO 14404-4:2020	Guidance for using the ISO 14404 series
General standards supporting decarbonisation	
ISO 14097:2021	GHG management and related activities — Framework including principles and requirements for assessing and reporting investments and financing activities related to climate change
ISO 14080:2018	GHG management and related activities -- Framework and principles for methodologies on climate actions
ISO/DIS 14068	GHG management and climate change management and related activities - Carbon Neutrality
ISO 14030-1:2021	Environmental performance evaluation — Green debt instruments — Part 1: Process for green bonds
ISO 14030-2:2021	Environmental performance evaluation — Green debt instruments — Part 2: Process for green loans
ISO14030-3:2022	Environmental performance evaluation — Green debt instruments — Part 3: Taxonomy
ISO 14030-4:2021	Environmental performance evaluation — Green debt instruments — Part 4: Verification programme requirements
CEN NWIP 2023	Requirements and guidelines for sectoral transition plans
IWA 42:2022	Net Zero Guiding Principles

The international standardization is advancing in the areas of LCA, environmental communication, carbon footprint, climate neutrality, traceability, and information transfer in the value chain, as well as within the circular economy. A new initiative has also been launched within CEN regarding "Requirements and guidelines for sectoral transition plans." All these areas are crucial for the transition of the steel value chain. An area related to the climate impact in the steel value chain where there are trade rules but no standards, and which could potentially be relevant for a standardization initiative, is the content of alloys and other substances in scrap.

2.2 EU's Method for Environmental Footprint of Products

Within the EU, the European Commission has developed a life cycle-based method fundamentally based on ISO standards 14044, 14067, 14020, and 14025 to calculate the environmental impact of products, services, and companies, known as environmental footprints. A guide for the environmental footprint of products (Product Environmental Footprint – PEF) has been developed and revised in 2021. It provides guidance and defines some requirements for conducting a PEF study. It also includes specific requirements for the development of Product Environmental Footprint Category Rules (PEFCR). The PEF guide itself does not aim to directly compare products, for example, to communicate in an environmental statement that one product has a lower environmental footprint than another. To make comparisons within a product group, it is necessary to have or develop PEFCR for the relevant product group. PEFCR complements the general PEF guide with additional harmonization of methods, relevance, and reproducibility for the specific product group. PEFCR also supports prioritizing the environmental impact factors that are most significant in the analysis, which is expected to reduce the time and costs of conducting a PEF study. The requirements described in the PEF guide have been developed after considering recommendations in similar, widely recognized environmental reporting methods and guidance documents. In the PEF guide, there are general requirements for goals and scope, and the study should include:

- Analysis unit and reference flow,
- System boundaries,
- Environmental impacts factors,
- Assumptions and limitations

The analysis unit for a PEF study should be defined based on the following aspects:

- The function/service provided, “what”
- The extent of the function/service “how much”
- The expected quality level, “how good”
- The product’s durability/lifespan, “how long”
- NACE code(s)

The PEF guide includes specific requirements regarding:

- Data quality
- Analysis rules, such as analysis unit, study scope, resource use and emission profiles, allocation rules, environmental footprint analysis, and other information requirements
- Procedure rules for creating and reviewing PEFCR

These requirements are often more specific or clearer than in many PCRs. The purpose is, among other things, to harmonize the implementation of PEF studies and to make the results easier to compare within a product group.

EUROFER's PEF Work

Within Eurofer (the European steel industry's trade association), a feasibility study is underway to prepare the development of PEFCR for several steel products. In this work, in accordance with the PEF guide, they have reviewed already existing relevant documents and PCR:s from various program operators.

Table 2: List of existing PCR:s and PEFCR:s for steel products, based on Table 1 in Interim report "Eurofer preparatory background study for potential legislative requirements related to environmental footprint information for steel products", by VITO, November 2022

PCR/PEFCR
The International EPD® System - Basic iron or steel products & special steels, except construction products PCR
The International EPD® System - Fabricated steel products, except construction products, machinery and equipment PCR
prEN 17662 EPD - Product category rules complementary to EN 15804 for Steel, Iron and Aluminium structural products for use in construction works
IBU - Part B: Requirements on the EPD for Thin-walled profiles and profiled panels of metal
IBU - Part B: Requirements on the EPD for Structural steels
IBU - Part B: Requirements on the EPD for Reinforcing Steel
KIWA Product Category Rules for steel construction products
SCS Global Services - North American PCR for Designated Steel Construction Products
UL: PCR Guidance for Building- Part B: Designated Steel Construction Product EPD Requirements
AENOR GLOBAL EPD - PCR 001 Long Steel products of non-alloy steel hot rolled from electric furnace, for construction products
EPD NORGE - NPCR 013 Steel as Construction Material
PEFCR for Metal Sheets for various applications

Review of the above PCRs in Eurofer's Feasibility Study Confirms that the Rules of the PEF Guide Are More Specific and Clearer Than Described in Many PCRs. In addition, certain parts of the LCA analyses are performed differently than required by the PEF guide:

- The number of environmental impact categories to be reported in PEF, e.g., changes in land use.
- Cut-off rules may vary.
- Allocation rules differ.
- PEF specifies certain requirements regarding the modeling of, for example, electricity, transportation, capital goods, storage, and distribution.
- End of-life modeling: PEF has a Circular Footprint Formula (CFC), while End of life, e.g., recycling according to EN15804, should be reported in module D.
- Normalization and weighting are included in PEF.
- Some requirements for additional information are specified in PEF.
- Benchmarking is described in PEF but not in PCR:s.

3 Initiatives relevant to the climate transition of the Steel industry

3.1 Mapping of various initiatives

A mapping of recent initiatives relevant to the climate transition of the steel industry towards the production of steel with very low greenhouse gas emissions has been conducted, see Annex 2 and Table 3 below. The focus has been primarily on initiatives developing in parallel with standards developed by international standardization bodies. The initiatives are either generic for various industries or specific to the steel industry. The purpose of this section has been to identify existing methods, tools, policies, and platforms for low-emission steel products that can be used by manufacturers, customers, investors, and decision-makers alongside or in conjunction with standards developed by ISO and CEN or regulations developed by the European Commission. Another purpose has been to identify obstacles and gaps in initiatives to create a global adaptation of the steel market for "near-zero steel." The goal of the mapping has been to see similarities and differences and create an understanding of how they impact the rules for steel companies in the future.

3.1.1. Key Players

In Annex 2 "Initiatives and standards for the transition to near zero steel production," a mapping and analysis of about 40 existing or ongoing initiatives relevant to the climate transition of the steel industry are presented. The initiatives are applicable at the company level, facility/production site level, or product/material level. They apply at the national, regional, or global level. There are also different key players for different initiatives. These can be summarized as:

a) Member organizations for states/countries
b) Member organizations for companies
c) Research organizations
d) Ad hoc organizations and various partnerships.

3.1.2 Purposes and Focus Areas of Initiatives

During the mapping, the initiatives have been categorized based on the purposes or focus areas of the various initiatives. Since the nature of the initiatives varies widely, the classification is approximate:

- **Roadmap:** These initiatives focus on roadmaps, providing an overview of the current state of the steel sector and a range of possible strategies to reduce emissions to achieve net-zero emissions (Ro).
- **Collaboration:** Coordination and exchange of existing information and development status between stakeholders, countries, research institutes, and companies. Collaborations can result in, for example, an interactive database, dialogue, or alliance with different actors (Co).
- **Demand:** Coalition of companies and governments worldwide. Uses its purchasing power to create an early demand market for "near-zero steel" in both the public and private sectors (De).
- **Tool:** Tools that support companies in assessing and communicating climate impact but where the purpose is only to facilitate the work (To).
- **Finance:** Develops financing mechanisms such as grants, loans, interest to support the development of technology and infrastructure for steel production and the use of steel with low greenhouse gas emissions (Fi).
- **Policy:** Developed statements to governments in areas with steel production and/or steel consumption. The documents contain a coherent set of policy positions reflecting international challenges (Po).
- **Framework:** Description of inventory and methodology for reporting greenhouse gas emissions from products (Prod) or an organization (Org). (Fw)

The initiatives with methods have also been categorized according to **the level at which climate impact is specified**: **company (C),** facility or **production site (S),** or **product (P)**. The organizations behind the initiatives/methods are also specified.

The initiatives have also been divided into two groups. Group 1 consists of initiatives with methods aimed at reporting the carbon footprint for possible certification or labeling of steel in relation to specific threshold values. Group 2 consists of general initiatives where some of them also propose reporting methods without the possibility of certification or labeling in relation to threshold values. In both groups, several initiatives have been selected for a deeper analysis. The choice has been made based on the project participants' interest in various initiatives and awareness that they are already used by relevant stakeholders or proposed to be implemented in various ways, such as a basis for public procurement.

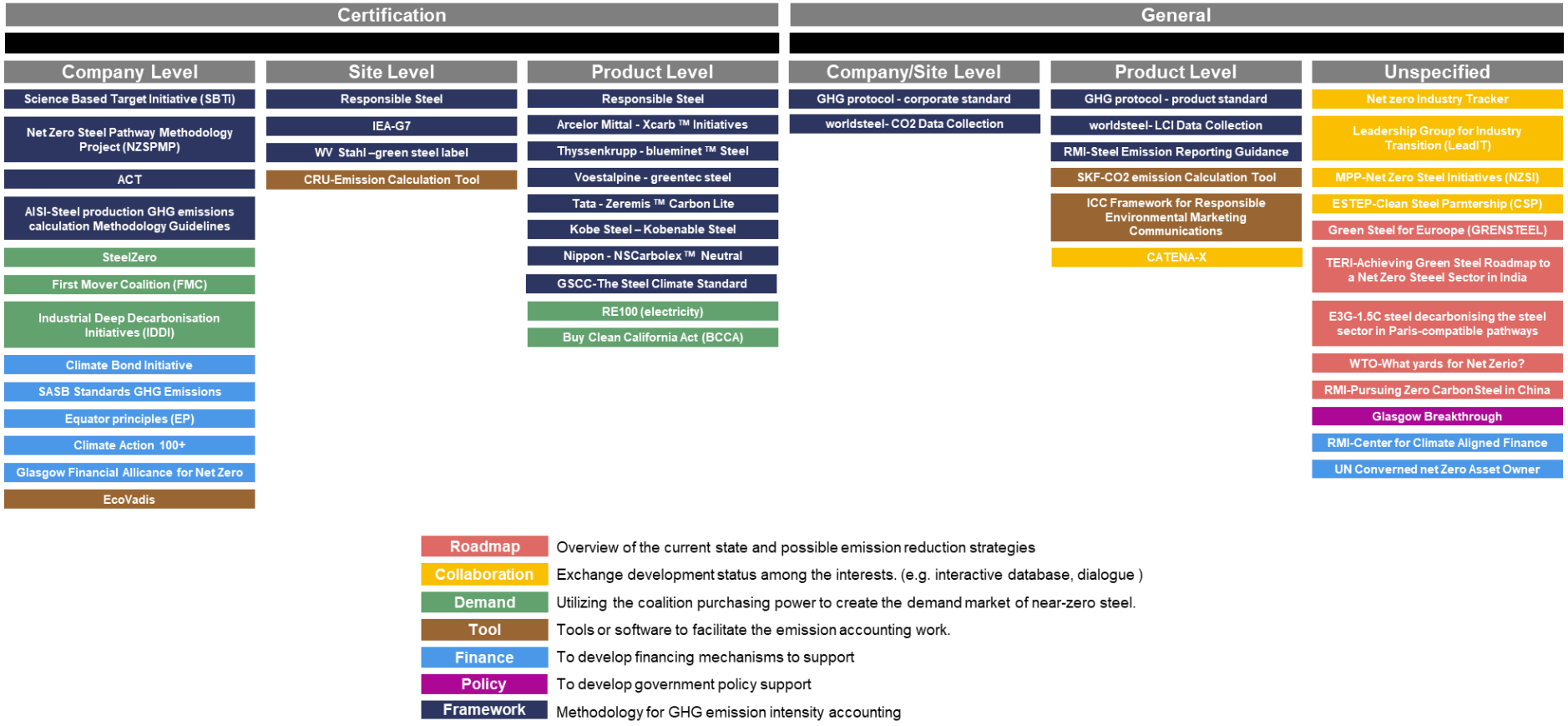


Table 3. Overview of initiatives for steel with a very low carbon footprint

3.1.3 Initiatives aimed at climate reporting for certification or labelling

These initiatives offer certification or labeling of a product, production site, or "near-zero production technology." The certification or labeling system is typically developed with the help of existing rules and standards. The initiatives aiming to provide certification or labeling are summarized in Table 4. Additional information is also available in the appendix to Annex 2.

Table 4. Initiatives with methods aimed at certification or labeling in relation to specific threshold values. Initiatives in bold have undergone an in-depth analysis.

Initiative	Web	Organization behind the initiative	Level	Focus area
Achieving Net Zero Heavy Industry Sectors in G7 Members	Link	IEA	S	Fw
Responsible Steel	Link	Company rep. and independent advisors	S, P	Fw
Science Based Targets Initiative (SBTi)	Link	WRI &WWF &CDP& UNGC	C	Fw
Net Zero Steel Pathway Methodology Project (NZSPMP)	Link	SBTi & Partners	C	Fw
A label system for green lead markets	Link	WV Stahl	S	Fw
Industrial Deep Decarbonisation Initiative (IDDI)	Link	UNIDO, CEM, UK etc.	C	De
SteelZero	Link	Climate Group/ResponsibleSteel	C	De
Assessing low-Carbon Transition Initiative (ACT)	Link	UNFCCC, CDP, ADEME	C	Fw
First Mover Coalition (FMC)	Link	World Economic Forum	C	De
GSCC-The Steel Climate Standard	Link	GSCC	P	Fw
AISI- Steel production GHG Emissions Calculation Methodology Guidelines	Link	AISI	C	Fw
RE100	Link	Climate Group, CDP	P	De
EcoVadis	Link	EcoVadis	C	To
CRU	Link	CRU/RMI/ ResponsibleSteel	S	To
Climate Bonds Initiative	Link	-	C	Fi
SASB Standards GHG Emissions	Link	International Sustainability Standards Board (ISSB)	C	Fi
Equator principles (EP)	Link	International Finance Corporation	C	Fi
Buy Clean California Act (BCCA)	Link	Department of General Services (DGS), the California Air Resources Board (CARB)	P	De
Climate Action 100+	Link	5 global investor representatives.	C	Fi
Glasgow Financial Alliance for Net Zero (GFANZ)	Link	UN Special Envoy, UNFCCC Race to Zero	C	Fi
Mass balance and Book and claim Proprietary certifications (examples)				
Xcarb ™ Initiatives	Link	Arcelor Mittal	P	Fw
bluemint™ Steel	Link	thyssenkrupp Steel Europe	P	Fw
greentec steel	Link	voestalpine	P	Fw
Zeremis™ Carbon Lite	Link	Tata Steel IJmuiden	P	Fw
Kobenable Steel	Link	Kobe Steel	P	Fw
NSCarbolex™ Neutral	Link	Nippon Steel Corp	P	Fw

Level**:* C-company; S-site; P-product; ***Focus area: Fw – Framework – Ramverk, De – Demand, To – Tool, Fi – Financing mechanism; Links from 2023-09-29

Achieving Net Zero Heavy Industry Sectors: This report, commissioned by Germany during its G7 presidency, is from the International Energy Agency (IEA). It provides G7 members with a toolbox of policies and financing mechanisms and includes recommendations to accelerate the climate transition of heavy industries such as cement and steel. The report

also includes a definition of "near zero" and "low emission" for steel production based on emission intensity in the relation to the share of scrap material. The report is based on IEA's "Net Zero by 2050: A Roadmap for the Global Energy Sector" published in 2022.

ResponsibleSteel™ Standard: Introduced in November 2019, ResponsibleSteel™ Standard is the first global multi-stakeholder standard and certification program for the steel industry. Covering environmental, social, and governance aspects, the latest version (Version 2, published in September 2022) has clarified requirements related to climate impact. Expected to be finalized in 2023, Version 2 will allow the certification of both steel production facilities and the steel produced at those facilities. The reporting framework currently does not apply to high-alloy and stainless steels, but technical specifications and threshold values for greenhouse gas intensity from these materials are under development (ResponsibleSteel, 2022).

The Science Based Targets initiative (SBTi): A collaboration between CDP, UN Global Compact, World Resource Institute (WSI), and WWF, SBTi helps companies develop emission reduction goals aligned with the climate targets of the Paris Agreement. Science-based targets are defined as a company's relative emission reductions over time based on their baseline emissions and activities. SBTi uses a Sectoral Decarbonization Approach (SDA) to guide different sectors, including the steel industry. A draft guide for the steel sector was published in November 2022 and was under public consultation until January 2023. The final sector guide for steel is expected to be published in 2023 (SBTi, 2022).

- **Net Zero Steel Pathway Methodology Project (NZSPMP):** A collaborative project with SBTi, NZSPMP aimed to develop a clear sectoral guide (SDA) for the steel industry to use when setting science-based targets (SBT). The project proposed a set of key principles to help companies measure and set goals for greenhouse gas reduction. The steering group for NZSPMP included ArcelorMittal, Blue Scope, GFG Alliance, Tata Steel, worldsteel, and ResponsibleSteel. The final project report was published in July 2021 (NZSPMP, 2021).

Assessing low-Carbon Transition Initiative (ACT): ACT is a project aiming to develop criteria and methodology for different sectors. It helps companies in evaluating their practices and actions to meet the 2°C target. Based on the Sectoral Decarbonisation Approach (SDA) developed by the Science-Based Targets initiative (SBTi), it applies to various types of steel companies. A few criteria exist and are used to assess companies' climate transition measures with different scores. The criteria and their weighting vary depending on the type of company and include emissions from raw materials used. The method is therefor also applicable to companies that produce high-alloy and stainless steel. The approach promotes companies' scrap recycling. The latest ACT methodology document for the iron and steel sector is version 2, published in March 2022. The ACT steering committee consists of representatives from ADEME and CDP. (ACT, 2022).

Industrial Deep Decarbonisation Initiative (IDDI): Launched in 2021 by UNIDO and Clean Energy Ministerial, IDDI is a coalition of governments and the private sector working to reduce carbon dioxide emissions from heavy industries (steel and cement). It does so by promoting demand for low-carbon materials through green public procurement. IDDI is led by the UK, India, and current members include Canada, Germany, the United Arab Emirates, Saudi Arabia, the US, Japan, and Sweden (UNIDO, 2022).

A Labelling System for Green Lead Market: Proposed by the German Steel Federation (WV Stahl), this classification system defines categories based on virtual reference facilities producing quality steel. It calculates emissions up to hot rolling, credits emissions for blast furnace slag, and considers the proportion of recycled raw materials (scrap). The system focuses on demand mechanisms and is still under development. A rulebook with key specifications has been completed, but further details are needed for implementation, such as a description of what to measure and a list of emission factors, etc. (WV Stahl, 2022):

SteelZero: An initiative by the Climate Group in partnership with ResponsibleSteel, SteelZero commits member companies to publicly purchase 100% "net-zero steel" by 2050 and a commitment to 50% of their steel needs by 2030, meeting one of the following criteria (Climate Group, 2023):

- Steel certified according to ResponsibleSteel
- Steel from production facilities following science-based targets approved by SBTi (Science-Based Targets initiative)
- “Low Embodied Carbon Steel" defined on a sliding scale depending on the proportion of scrap used as raw material.

First Mover Coalition (FMC): Formed by a group of leading global companies, FMC aims to leverage its purchasing power to unlock the untapped potential of new, clean energy technologies in sectors challenging to reduce emissions, including steel. FMC's steel commitment requires members to buy at least 10% "near-zero emissions steel" by 2030. The criteria for "near-zero emissions steel" should adhere to one of the following (World Economic Forum, 2022):

- Raw steel from "near-zero CO_2 technology" production units.
- Emitting <0.4 t (with 0% scrap) to <0.1 t (with 100% scrap) of CO_2 /t raw steel (including only scope 1 and scope 2 in production).

FMC supports the development and use of two key technologies: Direct Reduced Iron (DRI) production and Electric Arc Furnaces (EAF). The commitment aims to catalyze investments in low-carbon emissions steel production by creating demand for "near-zero steel”.

The Global Steel Climate Council (GSCC): An international association of steel companies and stakeholders, GSCC has proposed a technology-neutral standard, "The Steel Climate Standard," to measure and report greenhouse gas emissions from steel production. The standard focuses on reducing greenhouse gases from the global steel industry in line with the Paris Agreement, using a science-based sliding scale to decrease emissions over time. The method covers all relevant emissions from Scope 1, 2, and 3 up to hot rolling. Assessment criteria linked to the sliding scale are available for two different product groups (flat and long products). Emission values for the product can be certified according to the method, with emissions reporting third-party reviewed every three years and limitation goals at least every five years (Global Steel Climate Council, 2023).

All the above initiatives are further analyzed in Chapter 3 in Annex 2.

3.1.4 General initiatives aimed at supporting climate transition

These initiatives do not aim for certification or labeling. Some provide guidelines for reporting emission intensities and suggest possible strategies for reducing greenhouse gas emissions. Other initiatives focus on building networks among key players (companies, stakeholders, etc.).

Table 5. Reporting methods, proposals, etc., without the possibility of certification or labeling in relation to threshold values. Initiatives in bold have undergone an in-depth analysis

Initiative	Web	Organization behind the initiative	Level	Focus area
GHG protocol corporate standard	Link	WRI/WBCSD	C	Fw
GHG protocol-product standard	Link	WRI/WBCSD	P	Fw
worldsteel CO_2 emissions data collection	Link	worldsteel	S	Fw
worldsteel LCI data collection	Link	worldsteel	P	Fw
CATENA-X (Automotive data network)	Link	German Federal Ministry for Economic Affairs and Energy'	P	Co
RMI-Steel Emission Reporting Guidance	Link	RMI	P	Fw
The Center for Climate Aligned Finance (CCAF)	Link	RMI	-	Fi
Leadership Group for Industry Transition (LeadIT)	Link	Representatives from Sweden, India, and the World Economic Forum.	-	Co
Net Zero Steel Initiative (NZSI)	Link	The Mission Possible Partnership (MPP)	-	Co
Green Steel for Europe (GRENSTEEL)	Link	EU	-	Ro
Clean Steel Partnership (CSP)	Link	European Steel Technology Platform (ESTEP)	-	Co
Achieving Green Steel Roadmap to a Net Zero Steel Sector in India	Link	TERI (India)	-	Ro
1.5°C Steel decarbonising the steel sector in Paris-compatible pathways	Link	E3G	-	Ro
What yardstick for Net Zero?	Link	WTO	-	Ro
RMI-Pursuing Zero-Carbon Steel in China	Link	RMI	-	Ro
Glasgow Breakthroughs	Link	Race to Zero	-	Po
CO_2 emission Calculation Tool	Link	SKF	P	To
UN Convened Net Zero Asset Owner	Link	UN	-	Fi
Net Zero Industry Tracker	Link	WEF-Accenture	-	Co
ICC Framework for Responsible Environmental Marketing Communications	Link	ICC	P	To

Nivå: C-company ; S-site; P-product; ***Focus area***: Ro – Roadmap, Co – Collaboration, To – Tool, Fi – Financing mechanism, Po – Policy, Fw – Framework. Links from 2023-09-29

Greenhouse Gas Protocol (GHG Protocol) is an initiative developed by two organizations: the **World Business Council for Sustainable Development (WBCSD)** and the **World Resources Institute (WRI)**. The GHG Protocol has established the following global standards for both the private and public sectors:

- *GHG Protocol Corporate Accounting and reporting Standard (2004)* (GHGP, 2015): A standardized accounting method for reporting corporate GHG emissions. Also referred to as "Corporate Standard". It has been widely used by businesses, NGOs, and governments around the world as the International Standards for developing and reporting a company-level GHG inventory. The Corporate standard has firstly defined a company's direct and indirect GHG emissions into three scopes. It is obligated for companies to report all scope 1 emissions (i.e., direct emissions from owned sources) and all scope 2 emissions (i.e., indirect emissions from the generation of purchased

electricity). Scope 3 emissions (other indirect emissions) is an optional reporting category.

- *Corporate Value Chain (Scope 3) Accounting and Reporting Standard (2011)* (GHGP, 2013): a supplement to the Corporate Standard, referred to as "Scope 3 Standard". Aiming to assist companies to understand and report indirect emissions from the value chain.
- *Product Life Cycle Accounting and Reporting Standard (2011)* (GHGP, 2011): A Guidance document for companies to report life cycle GHG emissions for a specific product. Also referred to as "Product Standard".

The GHG Protocol has also developed a tool (Excel spreadsheet) to assist companies in calculating greenhouse gas emissions. The Iron and Steel tool (version 2, 2007) enables the calculation of CO_2 and CH_4 emissions from major greenhouse gas sources in the steel manufacturing process chain, whether the process steps are within the company's facility or external. The methods and standard emission factors in the tool refer to the IPCC guidelines from 2006.

The Climate Action Data Collection Programme was launched in 2008 by **The World Steel Association**, worldsteel. Currently, worldsteel conducts two annual data collections. One is the **CO_2 Data Collection**, and the other is the **LCI (Life Cycle Inventory) Data Collection**.

CO_2 Data Collection (worldsteel, 2008) aims to create global average CO_2 intensity. CO_2 emissions intensity of crude steel production is reported through an online tool by its members. It provides the common methodology to ensure the sites' reported emissions are calculated with the same boundaries and parameters. The methodology of data collection is based on the international standard *ISO 14404:2013-Calculation method of carbon dioxide emission intensity from iron and steel production*.

LCI Data Collection (worldsteel, 2021) gathers underlying LCI (Life Cycle Inventory) data for the environmental impact of 16 long and flat carbon steel products, such as strips, reinforcing bars, wire, sheets, rings, etc. The LCA method follows the ISO 14040:2006 and ISO 14044:2006 standards. LCI data is collected annually, ensuring that no data is older than five years, and is reported as averages both globally and regionally. The LCI data can be used in LCA studies by various stakeholders, and the dataset is freely available. The system boundary for LCI data is from cradle to gate, including net credits for end-of-life scrap. The dataset collects primary data from 24 separate steel manufacturing process steps, along with some other supporting processes and raw material transport. The data represents approximately 26% of global crude steel production in 28 countries. The highest represented region is Europe.

3.2 Differences in scope among various initiatives

Initiative with different calculation methods often have varying system boundaries, influenced by the distinct purposes they serve to meet the needs of different stakeholders. These differences in system boundaries can mean that different sections of a product's life cycle are covered by the initiatives and their calculation methods. Environmental impacts from raw materials and electricity may be handled differently (included or excluded), and general versus specific data may be utilized to different extents in various initiatives.

The table below outlines differences in the selected initiatives that have been examined more closely regarding the system boundaries for the calculation/reporting of greenhouse gas emissions. From the table, it is evident that the initiatives have different reporting levels (company C, facility/production site S, or product P). Regarding the greenhouse gases included, several initiatives only encompass CO_2 emissions, most calculate emissions for all greenhouse gases and report them as CO_2 equivalents, and one initiative calculates CO_2 and methane. Mining emissions are not included in all frameworks. Allocation to by-products is included only in certain frameworks. There are also differences in whether emissions from transportation should be included or not. Therefore, it is evident that when the system boundaries are not the same, the results are not comparable.

Table 6. The comparison of the different GHG emission reporting framework

Initiative	Level	Steel	Scope	Transport	Mining	Alloy	Product	Source	Near Zero Steel kg CO_2/t	Allocation	Biogenic emissions	CCUS	Carbon offset
Description in section	**-**	**-**	**3.3**	**3.3.3**	**3.3.3**	**3.3.3**	**3.1**	**3.2**	**3.6**	**3.4**	**3.3.1**	**3.3.1**	**3.3.1**
GHG Protocol (Corporate Standard)	C	All	1+2+3 (L)					CO_2 eq.		Electricity:2	CH_4, N_2O :3 CO_2 :2	TBD	TBD
GHG Protocol (Product Standard)	P	All	1+2+3	✓	✓	✓	SP	CO_2 eq.		Co-product:1 Recycling:1	2	TBD	2
worldsteel (CO_2 data methodology)	S	All	1+2+3 (P)	X	X	✓	SP	CO_2		1	1	2	2
worldsteel (LCI data methodology)	P	LA	1+2+3	✓	✓	✓	SP	CO_2 eq.		1	2	2	2
ResponsibleSteel	S	LA	1+2+3	✓	✓	✓	CS	CO_2 eq.	100% ore<400; 100%Scrap<50	Intermediate product:1 Process gas:1 Co-products (slag):2	3	1	2
IEA-G7	S	LA	1+2+3 (P)	O	✓	X	CS	CO_2, CH_4	100% ore<400; 100%Scrap<50	Electricity:2	1	1	2
SBTi	C	All	1+2+3 (O)	O	X	O	HRS	CO_2 eq.		2	2	TBD	1
NZSPMP	C	All	1+2+3 (L)	X	X	✓	CS	CO_2 eq.		1	3	2	NS
WV Stahl	S	LA	1+2+3	✓	X	✓	HRS	CO_2 eq.	100% ore<482; 100%Scrap<344	Slag/off gas: 1 Electricity/semi-product:2	NS	TBD	TBD
ACT	C	All	1+2+3 (L)		X	✓	SP	CO_2		1	1	TBD	NS
SteelZero	C	All	1+2+3	TBD	TBD	TBD	CS	CO_2 eq.	TBD	TBD	TBD	NS	1
FMC	C	LA	1+2	X	X	X	CS	CO_2	100% ore<400; 100%Scrap<100	NS	NS	NS	NS
GSCC	P	LA	1+2+3	✓	✓	✓	HRS	CO_2 eq.	<120	2	1 or 3	2	2

Level: C-company; S-site; P-product; ***Steel***: LA-low alloy; ***Scope***: P: partial; L: limited; O: optional; ***Product***: SP-steel product; CS-crude steel; HRS-hot rolled steel

Transport/Mining/Alloy: ✓: included in accounting; X: excluded from boundary; O: optional in accounting; TBD: to be developed;

Allocation: 1: emission reduction from exported materials or energy is considered; 2: The site should bear full burden of the emissions for exported material or energy.

Biogenic Emissions: 1. The biogenic emissions are NOT included in accounting; 2. The biogenic emissions reported separately in accounting. 3. The biogenic emissions are included in accounting

CCUS: Carbon Capture Utilization Storage. 1- The emission reduction due to CCUS is considered in accounting. 2- The emission reduction due to CCUS is NOT considered in accounting

Carbon Offset: 1-Carbon offset is PARTIALLY considered in accounting, 2-Carbon offset is NOT considered in accounting

3.2.1 System boundaries in various initiatives

The system boundary in a Life Cycle Assessment (LCA) specifies which processes should be included in the study. For a consistent reporting of greenhouse gas emissions, the boundary must be well-defined and consistent across studies to enable comparisons. The system boundary should also encompass a significant portion of emissions from steel production. A typical process flow for steel production within the system boundary "cradle to gate" includes raw material mining, iron manufacturing, transportation, steel manufacturing with potential alloy additions, casting, machining, heat treatment, coating, and other metal processing. If "cradle to grave" is used as the system boundary, it should also include the use of steel products and processes for handling end-of-life products.

System boundary ending at cast steel

The downstream boundary for **ResponsibleSteel**, **SteelZero**, **FMC**, and **IEA-G7** has been set after casting, excluding additional semi-finishing, and finishing processes such as hot rolling, cold rolling, coating, etc., due to the variations in these processes between facilities producing different products.

System boundary ending after hot rolling

The Iron & Steel core SDA boundary used in **SBTi**, **WV Stahl's Green Steel Label** and **GSCC** suggest defining the system as the production of hot-rolled steel instead of crude steel. The reasons of extending the boundary to include hot rolling step can be summarized as following:

- 95% steel production will go through hot rolling.
- Hot rolling consumes large amount of fuel for heating and therefore GHG emissions cannot be neglected.
- The inclusion of hot rolling may simplify the emissions reporting from integrated plants.

System boundary depending on ownership

In **GHG Protocol**, **NZSPMP**, **worldsteel,** and **ACT**, the ownership of the steel company has been considered. The additional processing such as rolling, annealing, pickling, galvanizing, heat treating, coating, and forging should all be included in the boundary for accounting if the process is owned by company.

Upstream boundary

The upstream boundary for **worldsteel**, **SBTi**, **ACT**, and **WV Stahl's Green Steel Label** excludes the mining process since the emission from this activity is considered as low impact compared with iron and steelmaking process.

SBTi's proposal for SDA from November 2022 also does not include so-called secondary metallurgy that takes place in ladle furnaces, vacuum induction melting, etc.

3.2.2 GHG gases

The GHG emissions includes consideration of the emissions of carbon dioxide (CO_2), methane (CH_4), nitrogen trifluoride (NF_3), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) etc. Each emission of a greenhouse gas is converted to its warming potential (GWP) relative to CO_2 (CO_2e) using a 100-year time

horizon, as published in the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 6.

In the reporting framework of **worldsteel CO_2 collection**, **IEA-G7**, and **ACT**, this process has been simplified due to the fact that the primary greenhouse gas emissions from the iron and steel sector come from CO_2. This simplification also facilitates data collection from companies, as there is often a lack of data for emissions of other greenhouse gases.

Table 7. GHG emissions included

Initiative	GHG emissions
GHG Protocol (Corporate Standard)	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3 (7)
GHG Protocol (Product Standard)	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 (6)
worldsteel (CO_2 data methodology)	CO_2
worldsteel (LCI data methodology)	All GHG gases
ResponsibleSteel	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3 (7)
IEA-G7	CO_2, (CH_4)
SBTi	CO_2, CH_4 and N_2O
NZSPMP	All GHG gases
WV Stahl (Green steel label)	All GHG gases
ACT	CO_2
SteelZero	CO_2-eq
FMC	CO_2
GSCC	All GHG gases

3.2.3 Emission Scope

The emissions are normally categorized as scope 1, scope 2 and scope 3 based on GHG protocol. The frameworks of **IEA-G7**, **FMC** and **NZSPMP** focus on the inclusion and exclusion of core emission process, rather than the definition of scope 1, 2 and 3. By doing this it can solve following two issues:

- The disclosure of emissions at the corporate level may differ based on the extent of vertical integration. In certain cases, vertical integration may encompass emissions-intensive upstream processes like sintering and coke production. If these processes are operated and owned by a steelmaker, the emissions will be classified as scope 1 (as per the GHG Protocol). However, for non-integrated operators, these same emissions would fall under scope 3 and may not be reported, posing challenges when comparing GHG emissions across the sector.
- Over time, the boundaries of scope 1, 2, and 3 are likely to become more flexible, further limiting comparability. For instance, with the increasing use of direct reduced iron (DRI) to facilitate a transition to hydrogen-based steelmaking, emissions could be categorized as scope 1 when DRI is produced using hydrogen generated on-site. The detailed variance of emission scope is further described in the subsequent sessions.

When accounting the GHG emissions, the data quality can be classified as following:

Primary data, refers to information collected directly from original sources specifically for the purpose of measuring and monitoring GHG emissions. It involves conducting surveys, measurements, and direct observations. Primary data collection methods are often more resource-intensive but provide specific and site-specific information.

Secondary data, refers to information that has been collected by someone else or for another purpose but can be used for reporting greenhouse gas emissions. This means gathering

existing data from published reports, databases, research articles, or public publications. Standard emission factors are sometimes used when primary data collection is challenging. Secondary data sources provide broader and more general data for estimating emissions.

Verification refers to all the collected data should be verified by the third party.

3.2.3.1 Scope 1/ Direct emissions

Scope 1 emissions are direct greenhouse gas emissions from assets owned by the company, such as industrial facilities, transportation, buildings, and electricity production. In addition to the use of fossil fuels, scope 1 emissions can also be influenced by the combustion of bioenergy, such as biochar, biocoal, charcoal, and biogas, as well as activities related to CCUS (carbon capture, utilization, and storage) and carbon offsetting. Reporting requirements may vary within different frameworks, as outlined below.

Table 8. Scope 1, Biogenic emission, CCUS, Carbon offset and Data Quality

	Biogenic emissions	CCUS	Carbon offset	Data Quality
GHG Protocol (Corporate Standard)	CH_4, N_2O: 3 CO_2: 2	TBD	TBD	P
GHG Protocol (Product Standard)	2	TBD	2	P
worldsteel (CO_2 data collection)	1	2	2	P>S
worldsteel (LCI data collection)	2	2	2	P>S
ResponsibleSteel	3	1	2	P>S or D
IEA-G7	1	1	2	NS
SBTi	2	TBD	1	P>S
NZSPMP	3	2	NS	NS
WV Stahl – Green steel label	NS	TBD	TBD	P>S
ACT	1	TBD	NS	P
SteelZero	NS	NS	1	NS
FMC	NS	NS	NS	NS
GSCC	-Certified (1) -Non-certified (3)	2	2	V

TBD: to be developed, CCUS: carbon capture and utilization storage; NS not specified

Biogenic Emission: 1. The biogenic emissions are NOT included in accounting, considered as 0, 2. The biogenic emissions reported separately in accounting. 3. The biogenic emissions are included in accounting, reported the same as fossil emissions

CCUS: 1- The emission reduction due to CCUS is considered in accounting. 2- The emission reduction due to CCUS is NOT considered in accounting

Carbon offset: 1-Carbon offset is PARTIALLY considered in accounting, 2-Carbon offset is NOT considered in accounting

Data Quality: P-primary data, S-secondary data, D-default value; V-verification from third party

worldsteel-CO_2 data collection, **IEA-G7**, and **ACT** are considering the use of bioenergy as carbon-neutral. It means that the direct emissions from burning biogenic sources are not included in accounting or considered as 0. **GHG Protocol-Product Standard, SBTi**, and **worldsteel-LCI** says that direct biogenic emissions should be reported separately. In **GHG Protocol-Corporate Standard**, direct biogenic CO_2 emissions are not included in the accounting but reported. CH_4 and N_2O emissions from biomass should be included in scope 1.

ResponsibleSteel, and **IEA-G7** considers the emission reduction from CCUS technology, while **worldsteel-CO_2 collection**, **worldsteel-LCI**, and **GSCC** are excluding the CCUS from its framework. **SBTi** and **GHG Protocol** are now under discussion for the accounting rules in

relation with CCUS. In **GHG protocol**, a new standards and guidance for companies to report emission inventory from activities related with carbon removals/ storage and bioenergy are under development. The publication of this guidance is expected in early 2023.

SBTi and **SteelZero** state that carbon offset should not be considered in the short-term emission target because it may create multiple problems like land use, fairness, and climate justice. However, when the direct operational emissions reach zero, one can consider carbon offsetting for any remaining emissions to achieve the target of near zero steel.

GHG Protocol-Product, **worldsteel-CO_2 collection**, **worldsteel-LCI**, **ResponsibleSteel**, **IEA-G7**, and **GSCC** does not include carbon offset in its accounting framework.

The preferred data collection regarding scope 1 or direct emissions are prior to primary data. Here are some examples of primary data sources.

- On-site measurements: This involves using equipment and instruments to directly measure emissions from various sources, such as power plants, industrial facilities, or vehicles.
- Fuel consumption records: Gathering data on fuel consumption from records, invoices, or meter readings to calculate associated GHG emissions. This can include direct fuel combustion or indirect emissions from electricity consumption.
- Process data: Collecting information about production processes, including raw material inputs, chemical reactions, and energy consumption, to estimate emissions associated with specific activities.
- Emission factors: Conducting specific measurements to determine emission factors for different sources or activities. Emission factors represent the amount of emissions produced per unit of activity (e.g., kilograms of CO_2 per liter of fuel burned).

If primary data from Scope 1 is not available, secondary data may also be acceptable, like in **worldsteel-CO_2 collection**, **worldsteel-LCI**, **ResponsibleSteel**, **SBTi**, and **WV Stahl**. For **GSCC**, all collected data should be verified by the third party.

3.2.3.2 Scope 2/ Energy-related indirect emissions

Scope 2 emissions are energy-related indirect emissions, i.e., electricity-related emissions and other energy-related emissions. Emission factors for electricity exist in two types: location-based average emission factors and market-based (contract-specific) emission factors.

Table 9. Details of Scope 2/energy related indirect emissions

	Purchased Energy Source					Data Quality
	Electricity	Steam	Heat	Cooling	H2	
GHG Protocol (Corporate Standard)	√	√	√	√		M+L
GHG Protocol (Product Standard)	√	√	√	√		
worldsteel (CO_2 data collection)	√	√				NS
worldsteel (LCI data collection)	√	√	√	√		
ResponsibleSteel	√	√	√	√		NS
IEA-G7	√		√		√	NS
SBTi	√	√	√	√		NS
NZSPMP	√					M or L
WV Stahl -Green steel label	√					NS
ACT	√	√	√	√		L>M
SteelZero	√	√	√	√		Same as GHG protocol
FMC	√					NS
GSCC	√	√	√	√		M>L

✓: Included in accounting; NS: not specified. 1-High priority; L: location-based, M: market-based

3.2.3.3 Scope 3U/ Other indirect emissions

Scope 3 emissions are other indirect emissions such as emissions from upstream activities like material extraction, processing, and transportation. The requirements for which upstream emissions to include vary significantly in different frameworks. Upstream emission sources mainly include the following categories, as found in the table below:

1) Mining of iron ore
2) Mining of others (coke, limestone etc)
3) Production of pellets, iron products,
4) Production of lime
5) Production of coke
6) Production of ferroalloys
7) Production of hydrogen, biofuels
8) Sorting and collection of scrap
9) Production of other fossil fuel such as natural gas
10) Production of electrodes
11) Production of other slag formers such as dolomite
12) Production of oxygen gas
13) Production of other process gases such as Ar, N_2
14) Transport of materials

Table 10. Details of Scope 3/ indirect emissions

Emission Source	1	2	3	4	5	6	7	8	9	10	11	12	13	14
GHG Protocol [2] (Corporate Standard)			✓	✓	✓									
GHG Protocol (Product Standard)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
worldsteel (CO_2 data collection)	X	X	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	X
worldsteel (LCI data collection)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ResponsibleSteel	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
IEA-G7	✓	✓	✓	✓	✓	X	✓		✓	X	X			O
SBTi	O	O	✓	✓	✓	O	O	O	O					O
NZSPMP	X	X	✓	✓	✓	✓	✓	X	X					X
WV Stahl -Green steel label	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ACT	X	X	✓	✓	✓	✓	✓	X	X					
SteelZero	(TBD)													
FMC	X	X	X	X	X	X	X	X	X	X	X	X	X	X
GSCC	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓

✓: Included in accounting; X: not included in accounting; O: Optional, (blank): not specified.

One of the significant differences in how initiatives consider indirect upstream emissions is alloy production, which constitutes significant greenhouse gas emissions for certain steel companies. Alloy production processes fall within the boundaries of the **GHG Protocol**, **ResponsibleSteel**, **NZSPMP**, **both methods of worldsteel**, **ACT**, **WV Stahl Green Steel label**, and **GSCC** but are excluded in other initiatives. In **SBTi**, the production of ferroalloys is excluded from the SDA system boundary for low-alloy steel production. However, it is recommended to include these upstream emissions in the production of high-alloy and stainless-steel production.

In the framework of **SBTi**, **worldsteel**, **ACT**, and **NZSPMP**, the mining and upstream transport of raw materials have been considered as low emissions and can be excluded from the reporting boundary. **IEA-G7** include the emissions associated with the extraction, beneficiation and transportation of iron ore and limestone in the indirect emissions.

The use of hydrogen, biogas or syngas in iron and steelmaking are modern decarbonization technologies. They are partially or fully covered in the accounting boundary for most initiatives.

FMC doesn't include emissions from scope 3 in the accounting.

3.2.3.4 Scope 3D/ indirect downstream emissions

Scope 3D, or downstream indirect emissions, are defined as greenhouse gas emissions occurring downstream from a company's own operations.

In the **GHG Protocol Product Standard**, if it is a "cradle-to-grave" defined boundary, it may also include use, end-of-life phase other than material acquisition & pre-processing and production.

[2] GHG-Protocol Corporate refer to the Calculation sheet from iron and steel sector

ResponsibleSteel only includes the GHG emissions associated with the storage or disposal waste, and residual materials both on and off-site.

3.4 Emission Allocation

ISO 14040/44 standard has suggested a few methods when accounting emission intensity within a multi-product system. Typical methods for allocating the burden of greenhouse gas emissions include:

- Avoid allocation and use System expansion: assign emission credits for a delivered by-product, such as process gas, equivalent to the emissions of a comparable product (e.g., natural gas)
- Physical allocation: Distribute the greenhouse gas burden among different products based on physical relationships, such as weight or energy content.
- Economic allocation: Allocate CO_2 emissions among different products based on their economic value.

In **GHG Protocol-corporate standard**, if a company sells surplus electricity, it should report all direct emissions for co-generation under scope 1. Indirect emissions from generation of surplus electricity are reported separately in scope 3. The company that purchases the electricity should report it in its scope 2 indirect emissions. Thus, no credit is assigned for exported electricity.

In **worldsteel-CO_2 data collection**, slag credit can be calculated but do not need to be reported. Credits are given to exported process gases, energy, coal tar and benzole etc. **worldsteel-LCI data collection** selected system expansion to best show all steel industry products and co-products and their environmental impacts.

ResponsibleSteel and **SBTi** states that there is no reduction of GHG emissions for the site due to the production of by-products and co-products. It means the steel site should take full burden.

IEA-G7 states that no credit is given for exported electricity. The handling of by-products is not clearly specified in the report.

WV Stahl-Green steel label allows consideration of credits only for slag used in cement production and the use of blast furnace gases for generation of electricity and heat outside the plant.

Table 11. Burden allocation of exported electricity, intermediate products, co-product, recycling, and process gas

	Electricity	Intermediate product	Co-products	Recycling	Process gas
GHG Protocol (Corporate Standard)	2	NS	NS	NS	NS
GHG Protocol (Product Standard)	NS	NS	1 (SE, P, E)	1	NS
worldsteel (CO_2 data methodology)	1	1	1 (slag)	NS	1
worldsteel (LCI data methodology)	1	1	1 (SE)	1	1
ResponsibleSteel	NS	1	2	NS	1
IEA-G7	2	NS	NS	NS	NS
SBTi	2	2	2	NS	2
NZSPMP	1	1	1	NS	1
WV Stahl (Green steel label)	2	2	1 (slag)	NS	1 (BFG)
ACT	1	NS	1 (slag)	NS	1
GSCC	2	2	2	NS	2

NS: not specified;

1: emission reduction due to exported materials or energy is considered;

2: The site should bear the full burden of the emissions for exported material or energy.

3: Associated emissions reported separately

SE: system expansion method, physical allocation method, E: economic allocation method

3.3 Near Zero Steel Thresholds

Several initiatives include methods for establishing threshold values for "low-emission steel," "near-zero steel," or "low embodied steel." One rationale for these proposed methods is to facilitate the choice of steel materials with a lower carbon footprint for steel purchasers. By doing so, steel buyers could contribute to creating an early demand market for "near-zero steel," potentially leading to a faster rate of investment within the steel industry to reduce greenhouse gas emissions.

3.3.1 Initiative with sliding scale as a function of scrap ratio

ResponsibleSteel, **IEA-G7**, **WV Stahl Green label**, and **FMC** propose methods for calculating the carbon intensity of "near-zero steel," described as a function dependent on the proportion of secondary raw material in the form of scrap in relation to the total iron metal raw material used in steel production. With current manufacturing processes, emissions decrease with a higher proportion of secondary raw material (scrap). However, since scrap alone is not sufficient as raw material to meet the total demand for steel, other measures must be taken, especially in ore-based steel production. This is the reason for these proposed criteria for low-emission steel that consider the relationships between primary and secondary iron raw material. Increased scrap incorporation as a measure to reduce emissions is thus neutralized. The principle is proposed to set emission intensity levels for steel that are independent of the process route but still consider that ore-based production requires extensive measures.

ResponsibleSteel and **IEA-G7** propose the same principles for "near-zero steel" (raw steel), based on the IEA's modeling of future technological developments in the steel industry and the evolution of the energy system. While the IEA describes the system boundaries for the data foundation, it does not provide a detailed method for data collection. The methods also propose different levels of low-emission steel that are above the “near-zero” level. The goal is

to establish procurement requirements that tighten over time, set as multiples of the near-zero level in the IEA's proposal. **FMC** uses a definition of “near-zero steel” (crude steel) that considers the proportion of scrap. Only scope 1 and 2 emissions are included, and the basis for the definition is not explicitly stated. **WV Stahl Green label** follows the same principle but is based on specific technology combinations and calculates emission levels up to the hot-rolled product for “near-zero steel”, with levels of low-emission steel in between, up to the current state-of-the-art.

SBTi has proposed a method in its draft sectoral guidance that includes a sliding scale accounting for the proportion of scrap. This method is intended for use when a steel company sets its science-based emission reduction targets. However, it is not intended to be used for classifying or certifying steel.

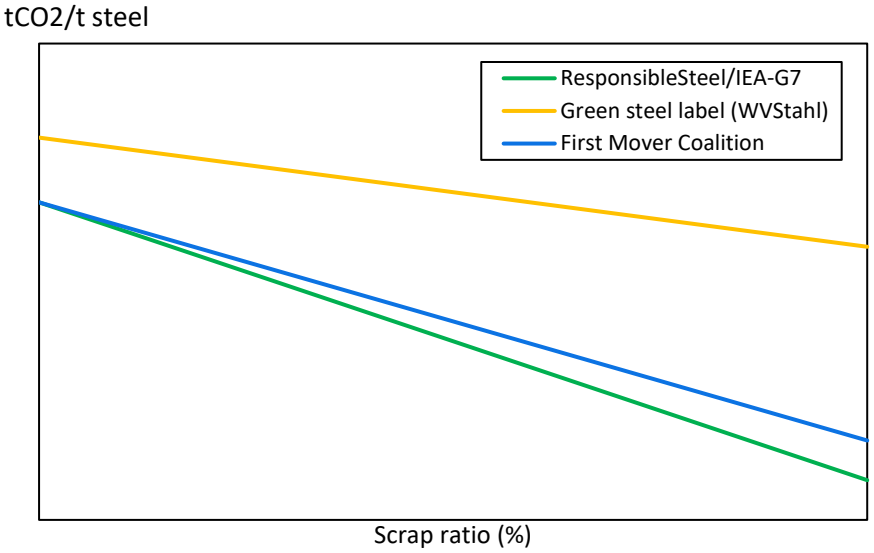


Figure 2. Threshold levels for near-zero carbon steel in three alternatives, considering the proportion of primary and secondary iron raw materials (scrap) in steel production

The proportion of secondary iron raw material (scrap) is a crucial variable in several methods, some of which specify threshold values for "near-zero steel." The levels for these threshold values depend on both system boundaries and assumptions about future emission reductions. Definitions exist for various types of scrap:

- ”Internal scrap”: scrap from crudes steel making unit then recycled within the same process
- ”Home scrap”: scrap from downstream steel production process within steelworks (e.g., rolling)
- ”Prompt scrap” or ”manufacturing scrap”, generated during the manufacture of steel products by customer, before the final products reach the market.
- ”End of life scrap” or ”post-consumer scrap”: scrap collected after final products have reached rhe end of their useful life and have been collected for recycling.
- ”Non-ferrous metal scrap”: scrap consisting of non-iron metals

ResponsibleSteel does not include the internal scrap while **SBTi** excludes non-ferrous metal scrap when calculating the scrap ratio. The scrap fraction is calculated as follows: all scrap as defined by the method entering the smelter / total amount of steel produced.

There is no clear definition of what is included in scrap in **IEA-G7**, **FMC** and **WV Stahl Green label**. However, there will be a rulebook under development with additional details for the **WV Stahl Green label**.

3.3.2 Initiative with sliding scale as a function of time

There are also proposals where the carbon footprint of the product is compared with general emission levels that decrease over time, aligning with global emission goals outlined in the Paris Agreement. In these cases, steel products are compared regardless of manufacturing methods and raw materials. **The Global Steel Climate Council (GSCC)** is an example of such an initiative.

It is technically challenging to produce flat products and long products with the same CO_2 intensities (kg CO_2-eqv/kg steel). Flat products tend to have higher CO_2 intensity compared to other forms. GSCC distinguishes the intensity standard between long products and flat products for allowing more accurate comparison of product producing companies. The company's accounted GHG emissions intensity for the specified product should be annually calculated and compared with this GSCC standard. The objective for "near zero steel" is 0.12 tCO_2-eq/t hot-rolled steel.

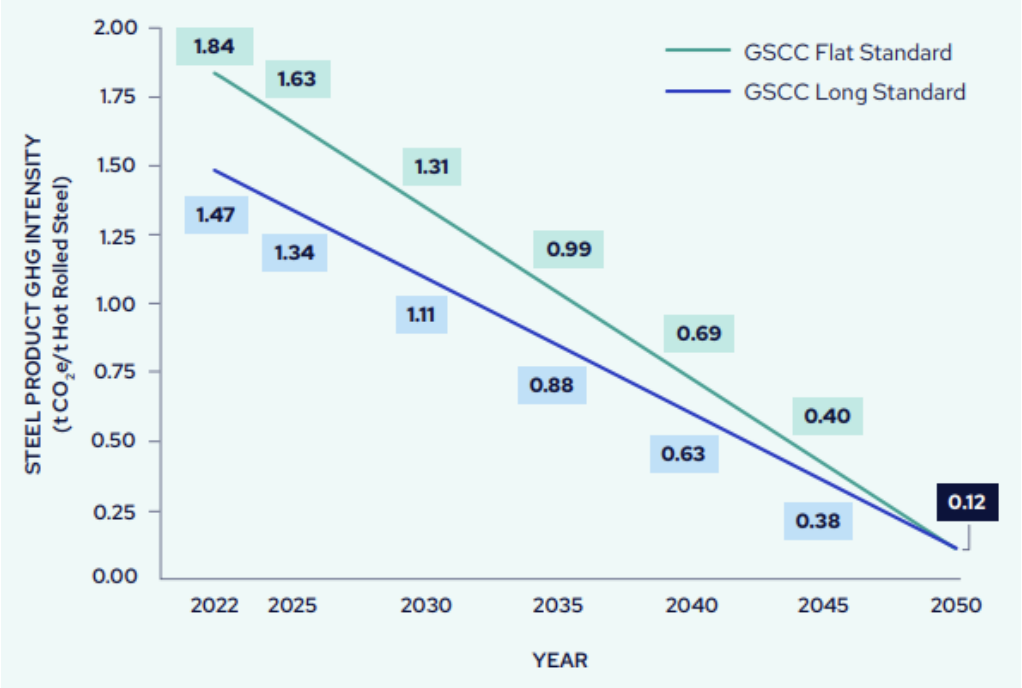


Figure 3. GSCC Flat and Long Steel Product Standards

3.4 Initiatives by the European Commission Affecting Climate Actions in the Iron and Steel Industry

The European Commission uses directives and regulations as tools. A regulation is a binding legal act that must be applied in all EU countries, while a directive serves as a framework that all member countries must achieve, implemented in their national legislations. Other tools used by the EU Commission include various frameworks and initiatives, such as those within the EU's Green Deal. Examples of relevant product-related EU initiatives impacting the steel industry's climate transition include:

Product Environmental Footprint, (PEF), is an LCA (Life Cycle Assessment) method following ISO 14044, relating to the EU Commission's work on **substantiating green claims.**

Organisational Environmental Footprint, (OEF), is developed in parallel with PEF, and is used for organizational environmental footprints.

The ILCD Database, provides LCI (Life Cycle Inventory) data that is freely available for use in developing PEF or OEF.

Ecodesign for Sustainable Products Regulation, ESPR, from March 30, 2022, as part of the EU's Green Deal, aims to regulate the sustainability of products throughout their life cycle. The proposal suggests expanding the Eco-design Directive to cover all products not regulated by other product legislation, introducing new requirements for information (digital product passport), and environmental performance (e.g., reparability, recyclability, and energy/resource efficiency). Specific requirements for a particular product group and methods to follow them will be outlined in delegated acts.

Construction Products Regulation (CPR). A proposal for a new regulation was presented on March 30, 2022. It broadens the definition of construction products, aligning with EU climate goals and protecting people and the environment. It allows for setting requirements for function, safety, and environmental performance. Life cycle properties must be declared for products covered by a harmonized technical specification, based initially on EN 15804 Sustainability of construction works - Environmental product declarations - Product category rules (initially for climate impact).

Corporate Sustainability Reporting Directive (CSRD), is the EU's new directive for corporate sustainability reporting. Effective from January 1, 2024, it expands coverage to more companies and standardizes reporting. Requirements extend to all large companies and all listed companies in the EU. Parent companies in a large group must prepare a sustainability report for the group. The rules will apply to listed small and medium-sized enterprises, considering their specific characteristics. More comprehensive and detailed reporting requirements are introduced, following mandatory EU standards currently being developed. These standards will be adopted by the Commission as delegated acts, specifying the information to be provided, covering environmental, social, and corporate governance issues. It will also be mandatory for sustainability reporting to be audited by a third party. The CSRD will now be implemented in national law.

Table 12. EU regulations, directives, and initiative

Directives and initiatives	Type	Web	Level
Product Environmental Footprint PEF	Other	Link	Product
Organisational Environmental Footprint, OEF	Other	Link	Company
ILCD Database	Other	Link	Product
Initiative on substantiating green claims	Directive	Link	Product
Green Steel for Europe	Project	Link	Company
EU Taxonomy	Regulation	Link	Company
Construction Products Regulation, CPR	Regulation	Link	Product
Ecodesign for Sustainable Product Regulation ESPR	Regulation	Link	Product
Net-Zero Industry Act	Plan	Link	Company
Corporate Sustainability Reporting Directive CSRD	Directive	Link	Company

Links from 2023-09-29

4 Illustrative examples of climate impacts for some initiatives

4.1 Case Study

A case study has been conducted on three initiatives:

- **worldsteel CO_2 data collection** method to gather intensity data from steel production facilities/sites.
- **ResponsibleSteel´s standard**, which has a method for calculating a steel facility's greenhouse gas emissions and the facility's CO_2 intensity for the production of raw steel,
- **SBTi**'s proposed method in the sectoral guide for steel, which can be used when a steel company sets its science-based targets.

These three initiatives all have methods for calculating the climate intensity of steel from a production site. The methods in these three initiatives have not been developed for the same purposes, but the case study clearly demonstrates and explains why different results are obtained based on methods and delineation for the calculations.

Three case studies have been conducted for the following steel manufacturing process:

1. EAF-LF: Electric arc furnace (remelting scrap) and ladle furnace (quality adjustment)
2. DR-EAF-LF: Reduction shaft furnace (direct reduction iron production) + EAF (melting mixes of DRI and scrap) + LF (adjustment)
3. EAF-AOD: EAF (Remelting scrap/alloy) +AOD (decarburization, reduction and refining). Applied specially for stainless steel production.

The following two steel types have been selected to illustrate differences between different calculation methods:

- Carbon steel (CS): EN 1.0503, 0.5% Mn, 0.5%C. For tempering and quenching, normally used for mechanical engineering and automotive components.
- Stainless steel 304 (SS): EN 1.4301, 18%Cr, 8%Ni, 1.4% Mn, 0.03%C. It is good corrosion resistance and widely used in household appliances, food, and beverage industry etc.

Table 13. Information about the case studies

Case	Steel	Process	Scrap ratio
1	CS	EAF-LF	100 %
2	CS	EAF-LF	20 %
3	SS	EAF-AOD	80 % (SS)

4.2 Inventory and assumptions

The inventory for steel production in the studied cases has been generated from RawMatMix, a web-based material optimization tool. The assumption is based on the raw material's chemistry and product specifications, along with certain standard parameter values such as operating temperature and metal distribution factors. These data were selected as typical values from previous work at Kobolde & Partners. The assumptions and assumptions are not verified, which introduces some uncertainty in the results. However, the purpose of the case

study is to compare the reported greenhouse gas emissions under different reporting frameworks. Therefore, the results should be viewed as indicative rather than definitive.

To simplify the calculations and facilitate the comparison of differences between the various frameworks, the following assumptions were made:

- The calculation is based on 100 tons of liquid steel production before casting. Inventory data for processes such as casting and hot rolling are estimated. No metal loss during casting and hot rolling is assumed.
- Emission factors are from worldsteel 2022. This may differ compared to sources that include other greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O). The facility is assumed to be Europe-based, and the electricity used is assumed to be from the EU electricity mix.
- The scrap used in the production are 100% from end-of-life scrap which is purchased from external actor.
- Site waste disposal, material recovery is not included.
- Transport distance for solid raw materials (e.g., scrap, limestone, and coke) to the steel plant is assumed to be 100 km.
- No losses via dustformation occur.

4.3 GHG emissions of 1 ton of steel production for different reporting framework

Example 1

The GHGE emissions are calculated for carbon steel production with 100% scrap use. The main differences are described below:

- Scope 1: ResponsibleSteel shows the lowest value (77kgCO_2/t) due to the exclusion of hot rolling in the calculation. SBTi has lower Scope 1 emissions than worldsteel because SBTi excludes secondary metallurgy (i.e., corrections made after the electric arc furnace based on analysis and temperature).
- Scope 2: ResponsibleSteel shows the lowest value because the electricity used in hot rolling is not calculated because hot rolling is outside the method's system boundary.
- Scope 3: scope 3 emissions in SBTi are not included if, collectively they are less than 40% of the total emissions. worldsteel has lower scope 3 value than ResponsibleSteel because mining is beyond the system boundary in worldsteel's reporting framework.
- Total Greenhouse gases: SBTi<ResponsibleSteel<worldsteel.

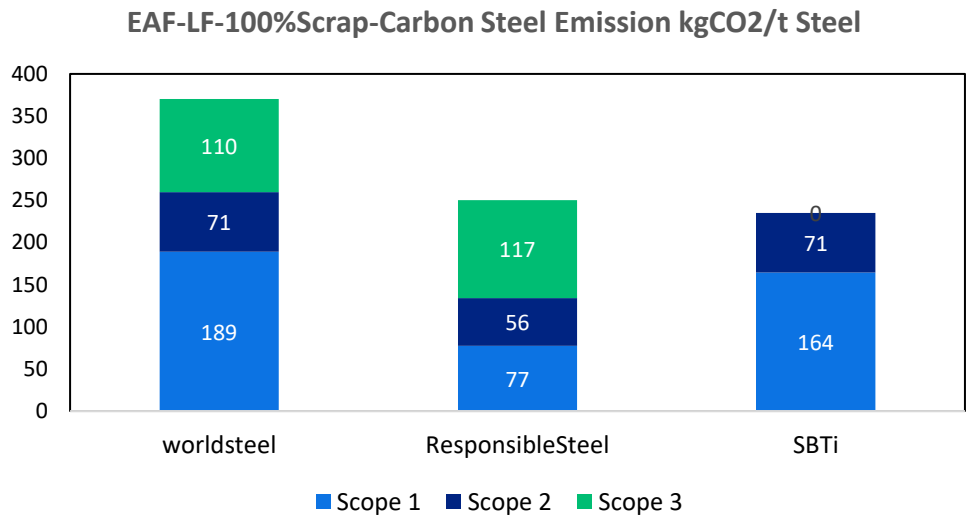


Figure 4.1. GHG emissions of carbon steel produced from EAF-LF process with 100% scrap

Example 2

Direct Reduced Iron (DRI) is another typical iron material used in the process when scrap is lacking, or the quality of scrap is low. The study presents results for carbon steel produced with a mixture of scrap and DRI, with an assumed scrap content of approximately 20%. The main differences are:

- Scope 1: ResponsibleSteel shows the lowest value (59 $kgCO_2/t$) due to the exclusion of hot rolling in the calculation. SBTi has lower Scope 1 emissions than worldsteel based on the exclusion of secondary metallurgy.
- Scope 2: ResponsibleSteel shows the lowest value because the electricity used in hot rolling is not calculated since hot rolling is beyond the system boundary.
- Scope 3: Compared to the production scenario (100% scrap) in figure 4.1, the increased use of DRI results in an increased addition of slag-forming substances. This leads to a high value of scope 3 emissions in general due to greenhouse gas emissions from the production of lime, dolomite, and magnesite. Scope 3 emissions are included in this scenario in SBTi because the total Scope 3 emissions are higher than 40% of the total emissions. Among the three reporting methods, worldsteel shows the lowest emission levels due to the exclusion of mining.
- Total Greenhouse Gases: ResponsibleSteel < worldsteel < SBTi

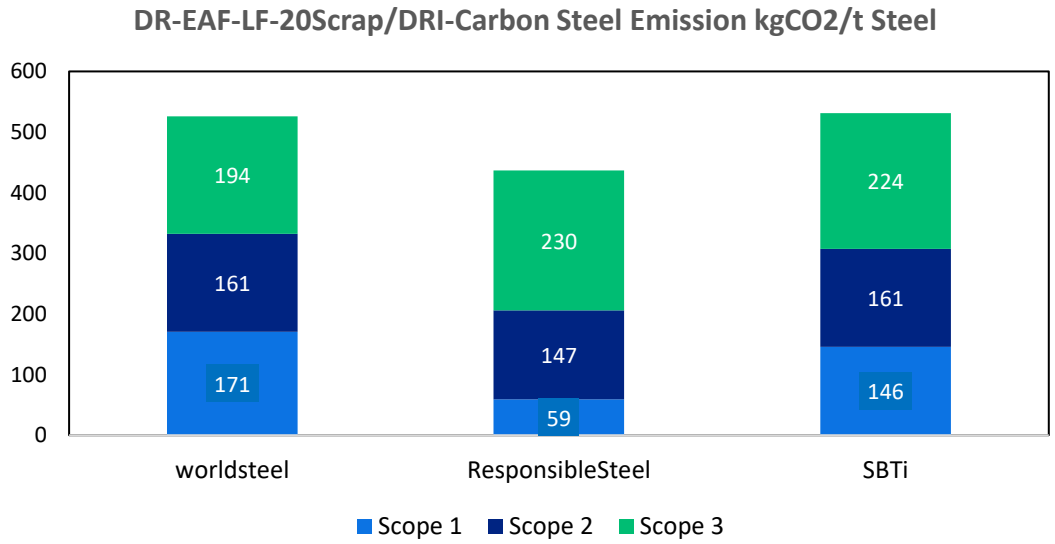


Figure 4.2. GHG emissions of carbon steel produced from DRI-EAF-LF process with 20% scrap+DRI

Example 3

When it comes to reporting the CO_2 intensity for stainless steel, there are currently not many frameworks covering this due to the high alloy content. For instance, ResponsibleSteel is currently applied only for steel with an alloy content lower than 8%. Therefore, there are no results for ResponsibleSteel in this example. The major difference in greenhouse gas emissions when using the worldsteel and SBTi methods to calculate CO_2 intensity for stainless steel is:

- Scope 1: SBTi has lower Scope 1 emissions than worldsteel due to the exclusion of secondary metallurgy in the SBTi method.
- Scope 2: No difference.
- Scope 3: SBTi shows lower scope 3 emissions due to the exclusion of secondary metallurgy where primary alloys are added to adjust the stainless steel grades.

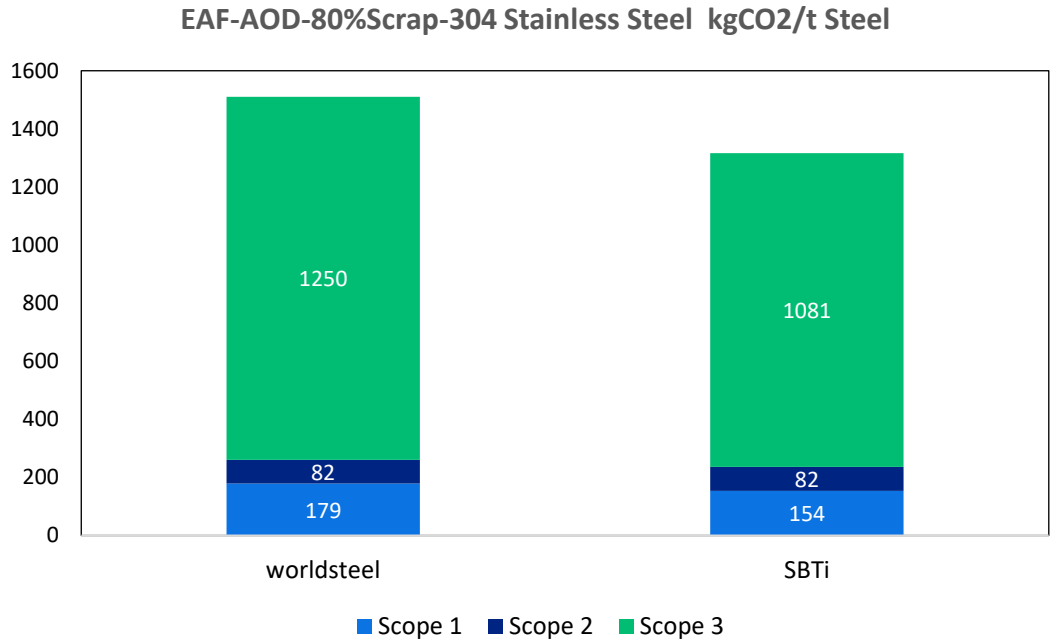


Figure 4.3 GHG emissions of 304 steel produced from EAF-LF process with 80% scrap

5. Stakeholder analysis

5.1 Implementation

Jernkontoret has gathered information through a series of interviews, conducted either as in-depth verbal interviews or through the distribution of surveys. Respondents represent the entire value chain of the steel industry, including raw material suppliers, steel companies, steel distributors, and end customers. Additionally, representatives from several Swedish authorities and some investment companies participated. Questions were designed to illuminate stakeholders' perspectives on the needs and conditions for standardization in the area of "near-zero steel." In total, seven raw material suppliers (iron ore, alloys, scrap, and lime), nine steel companies operating in Sweden, and twelve steel distributors and customers contributed interview responses. Trafikverket, Boverket, Upphandlingsmyndigheten, Försvarets Materielverk, Energimyndigheten, and three investment companies also responded to surveys.

In the interviews, questions were posed regarding the initiatives and standards related to carbon footprint from companies, facilities/projects, or products that various stakeholders request or use for their external communication regarding carbon footprint. Stakeholders have highlighted methods that work well and should be utilized. They have indicated types of assessments and communication regarding carbon footprint that are not satisfactory and how they would like initiatives and standards to be developed to support the steel industry's efforts towards reducing greenhouse gas emissions.

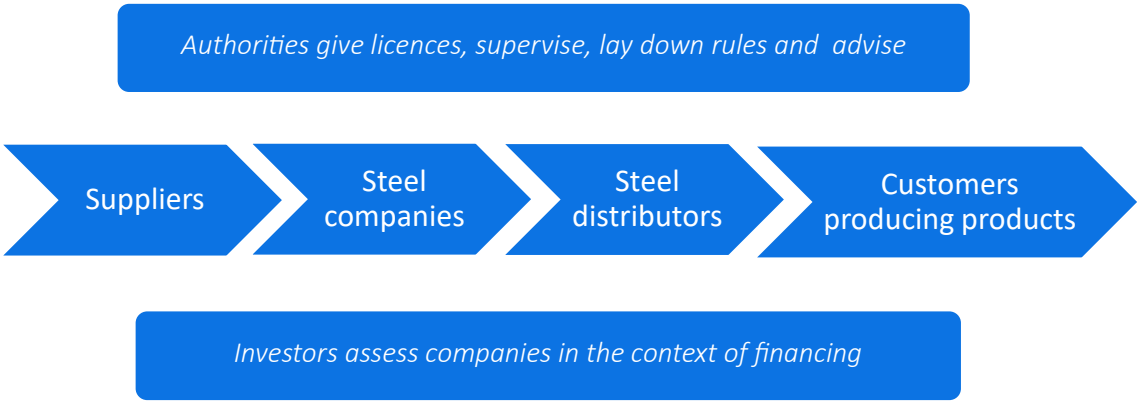
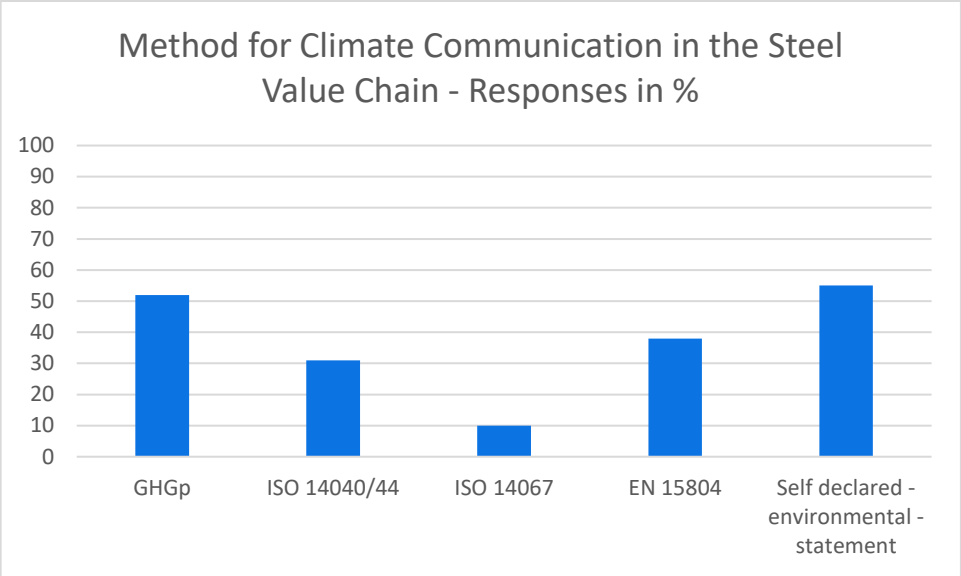
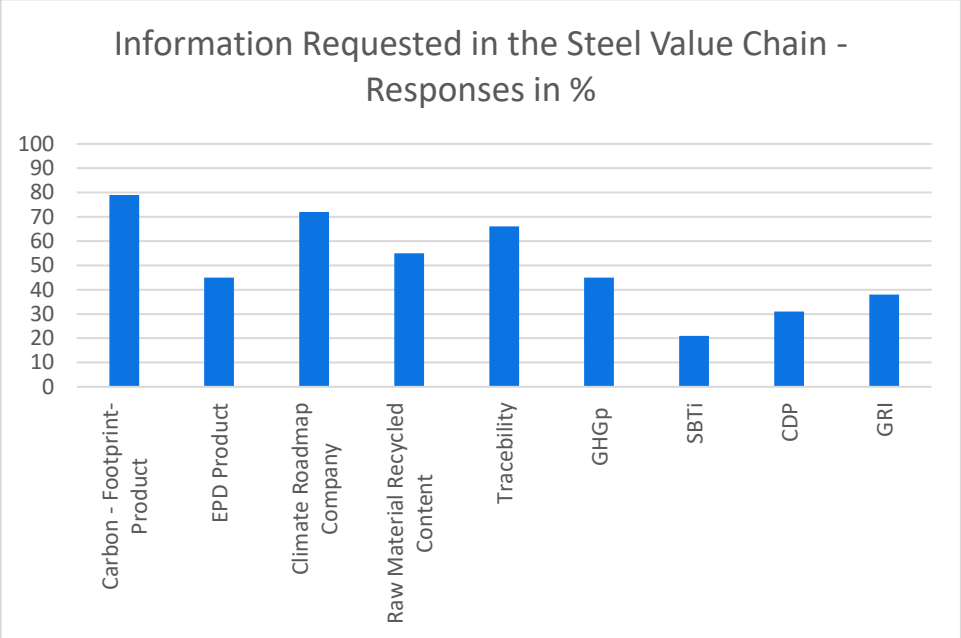


Figure 6. Stakeholders in the steel value chain

In the two diagrams below, all respondents' answers are summarized regarding the methods used to communicate the carbon footprint in the steel value chain and the type of information sought regarding the company's climate impact or the carbon footprint of products.





5.2 Raw Material Suppliers

Below are examples of opinions from seven different suppliers of ore, alloys, scrap, and lime.

5.2.1 Ore and Alloy Suppliers

Greenhouse Gas Protocol (GHGp) for reporting a company's climate impact and Carbon Footprint according to *ISO 14067 Carbon Footprint of Products* are useful and good methods. At the same time, there are many different initiatives and labels with climate classifications that are not comparable. Flexibility and compliance with the rapid development in climate work are demanded. A common and clear labeling/classification system is desirable.

An alloy supplier states that for them to become CO_2-neutral, they need to:

1. replace parts of the fossil reducing agent with fossil-free alternatives,
2. explore alternative production processes, and
3. evaluate the possibility of CCS (carbon capture and storage).

Close collaboration with the steel industry is needed, as the chosen path may affect both the chemical and physical properties of the alloy.

5.2.2 Scrap Supplier

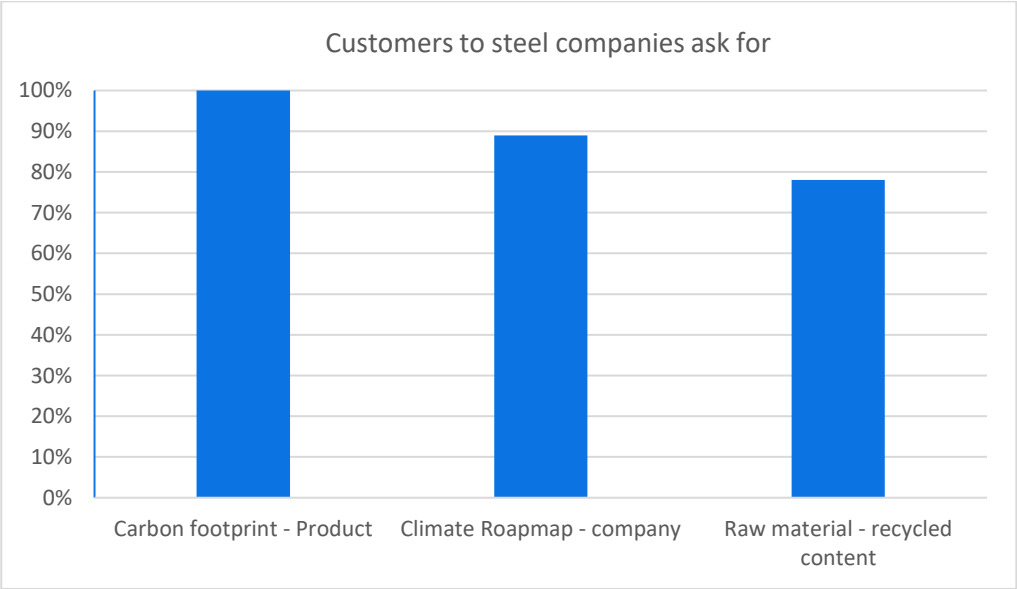
Coordinated optimization of scrap supply for Swedish steel companies in terms of quality and logistics essentially always means a reduced carbon footprint. Optimal sorting of scrap qualities is needed to achieve as much value preservation as possible in the metallic material that is scrapped.
One recycling company has its own digital calculation model where, to its industrial customers, such as manufacturing companies, parallel to quantities of collected scrap and costs, it can also report the carbon footprint from the collection, sorting, treatment, and transport of the industrial customer's scrap, performed by the recycling company.

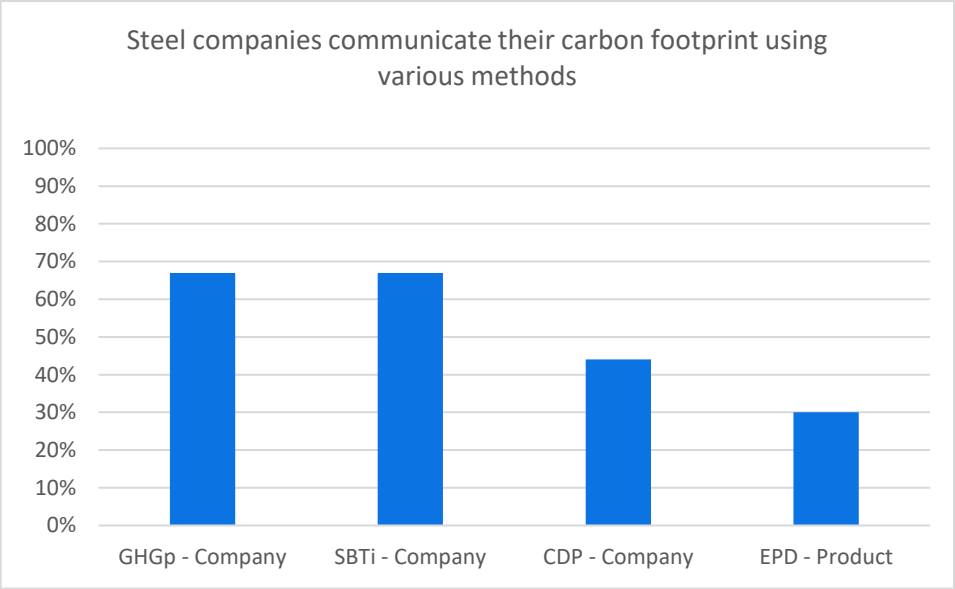
5.2.3 Lime Suppliers

Two lime suppliers have responded to the survey. They argue that there are too many initiatives, standards, and methods that are similar but still not comparable, depending on when specific data are used or not. In standardization, it should also be clarified whether compensation via offsets is allowed or not when calculating a carbon footprint for a material or product. Allocation principles for the environmental impact assigned to different materials and whether they should be considered primary products or by-products are also important.

5.3 Steel Companies

The following two diagrams show what steel companies perceive customers to be interested in for information and how they themselves report climate impact at the company or product level.





The following is a summary of the responses from nine Swedish steel companies.

5.3.1 Effective Methods Currently in Use

Steel companies highlight several global initiatives for company-level reporting, such as the GRI standard for sustainability reporting, GHGp, Sustainability Accounting Standards Board (SASB) for the American market, and The Customer Data Platform (CDP - formerly Carbon Disclosure Project). Most steel companies have, or are in the process of making commitments and approved goals according to the Science Based Targets initiative (SBTi) or plan to make such commitments. Reference is also made to joining the Global Compact. To communicate the carbon footprint of steel products, steel companies believe that ISO and EN standards for life cycle assessments (e.g., *ISO 14040* and *ISO 14044*) and environmental declarations (e.g., *ISO 14025* and *EN 15804*) are generally good. These standards describe how third party reviewed environmental declarations, known as EPDs (Environmental Product Declaration), are developed. The European Commission's Product Environmental Footprint (PEF) method with a circular footprint formula is also mentioned. Steel companies prefer methods with clear descriptions of how calculations are made, transparent reporting of results, and the use of specific data with high quality to the greatest extent possible.

5.3.2 Methods Under Development

ResponsibleSteel, and several follow-up initiatives, propose methods based on a sliding scale with threshold values for how steel can be classified as having low climate impact emissions depending on the proportion of scrap in steel production, see also section 3. Some find these methods valuable for driving the green transition broadly within the steel industry, even if the main purpose is considered to manage the transition from ore-based steel production. However, scrap-based steel companies often consider methods with this type of sliding scale to be disadvantageous and unfair. According to scrap-based steel companies, there is a risk that these methods may cause scrap-based steel to lose market share to ore-based steel, despite scrap-based steel having significantly lower carbon footprint today. They also believe that depending on the levels chosen for the sliding scales, there is a risk that scrap-based steel will be classified in a way that may distort competition.

5.3.3 Example of Less Effective Methods

Regarding examples of less effective methods, Swedish steel companies agree that average methods where overall improvements resulting in a reduction in carbon dioxide emissions are allocated to a certain part of the production volume are not good. Classifying that part as "greener" than the remaining production volume from the same facility is misleading and complicates the market (for both steel manufacturers and their customers), such as when purchasing steel based on carbon footprint. The method is considered to carry an obvious risk of being perceived as greenwashing that can spill over to other communication. Steel companies also agree that it is difficult for some stakeholders to understand the difference between steel companies' communication of the company's carbon footprint, the climate intensity of a production process, and the carbon footprint of steel products. Furthermore, it is highlighted that it is not consistent when to use specific or generic emission data, and making product comparisons is difficult when definitions and terminology are not clearly stated.

5.3.4 Steel Companies' Wishes for the Future

Steel companies have raised several problem areas that need to be addressed:

The multitude of initiatives and methods to report carbon footprints for companies, projects, or processes and, finally, for products make it difficult for different stakeholders to understand what the various reported figures include and mean. For example, methods for calculating and assessing emission reductions within countries/production facilities are not the same as methods related to a product's climate impact, such as the use of Environmental Product Declarations (EPDs) or Product Environmental Footprint (PEF). The purpose of the method and the method's boundaries are crucial for interpreting the results correctly.

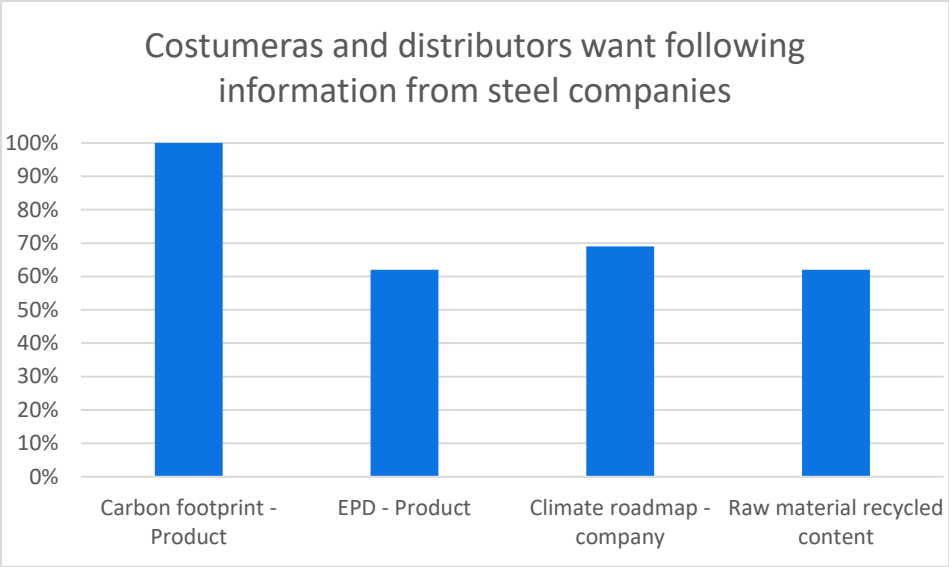
Many methods for reporting and assessing a steel product's carbon footprint do not consider the qualitative differences between different steel grades and products and thus the function they contribute to during the usage phase.

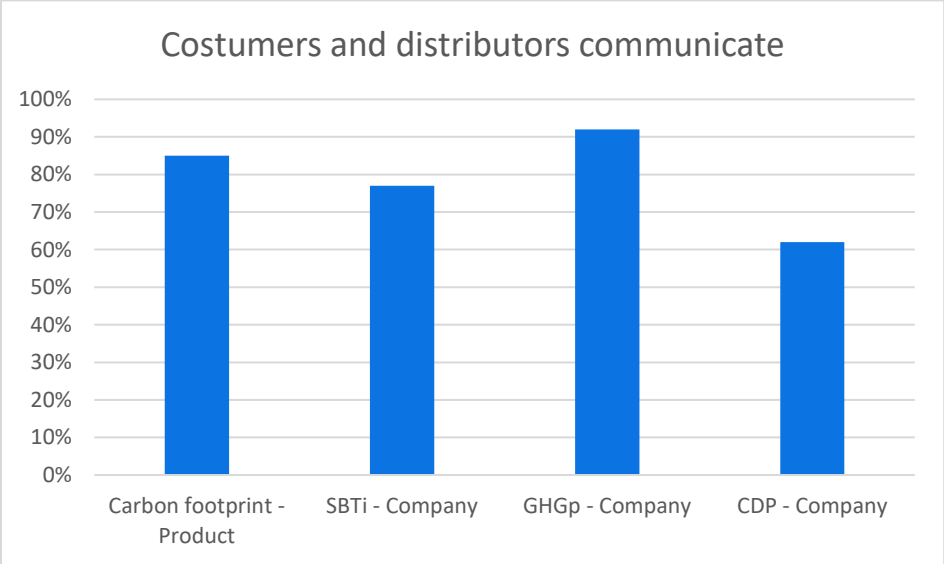
Measures to reduce greenhouse gas emissions are taken in the entire steel value chain. The use of the terms scope 1, scope 2, and scope 3 in different reports is not as clear as reporting which steps in the steel life cycle are included in a method aimed at calculating carbon footprints from products.

5.4 Customers and Distributors

Eleven customers and two steel distributors have either been interviewed or responded to a survey about the information they demand from steel suppliers, the methods they use to communicate their climate work and the carbon footprint of their products, and how they view harmonization and standards. Customers represent primarily the automotive and transport sectors and the construction sector, but representatives from the manufacturing industry and furniture companies have also provided input.

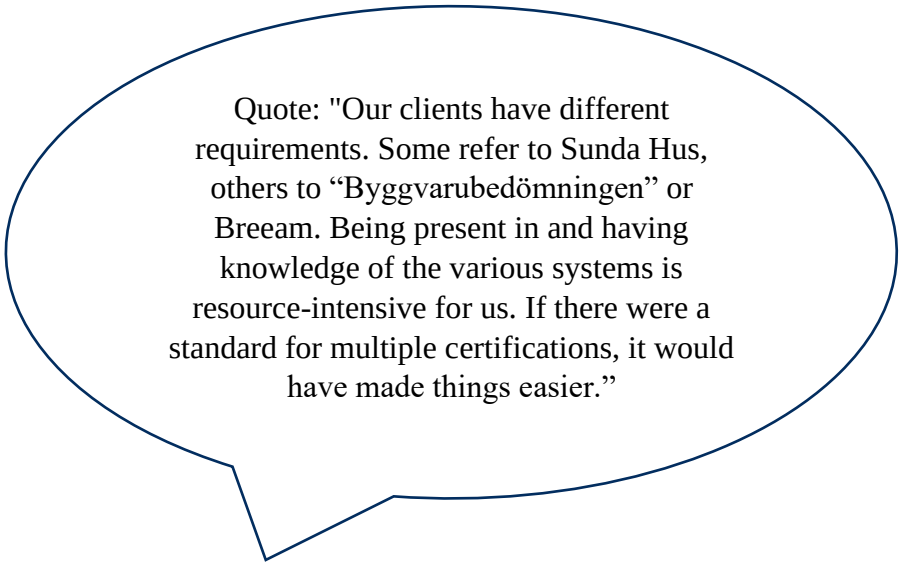
Responses from the group of customers and distributors are summarized in the two diagrams below.


Costumeras and distributors want following information from steel companies
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Carbon footprint - Product
EPD - Product
Climate roadmap - company
Raw material recycled content


Costumers and distributors communicate
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Carbon footprint - Product
SBTi - Company
GHGp - Company
CDP - Company

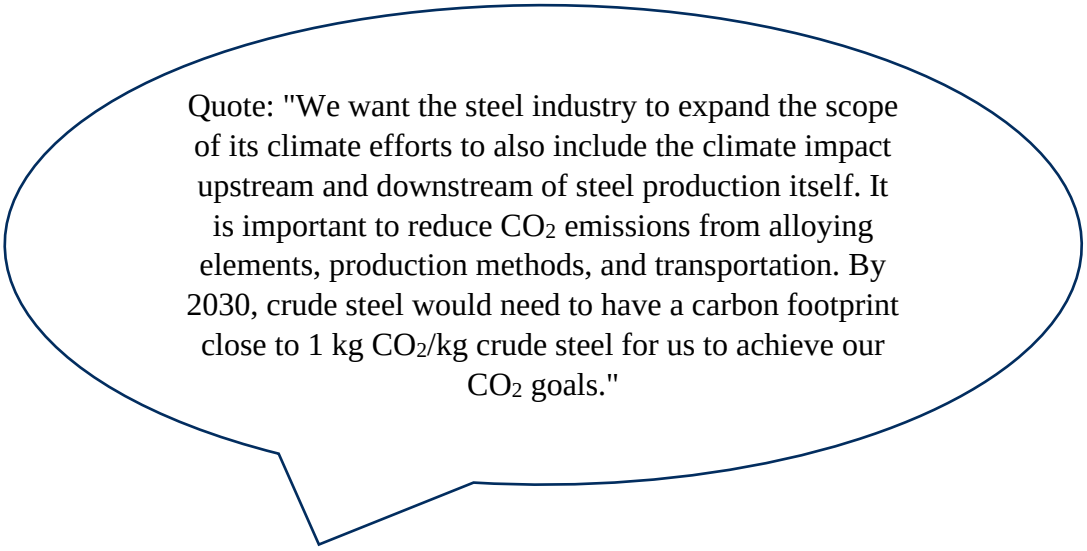
5.4.1 Construction Sector

Representatives from the construction sector largely rely on EPDs (Environmental Product Declarations) according to the standard *EN 15804 "Sustainability of construction works - Environmental product declarations - Product category rules"* to obtain information about the various climate impacts of building materials. This approach aims to limit the climate impact of buildings throughout their lifespan. Within the construction sector, there are also several different rating systems that one can adhere to or certify newly constructed buildings against. These systems assess the environmental performance of the building in various areas, including climate impact.



5.4.2 Automotive and transportation

The automotive and transportation sector is a major user of steel. With the transition to the electrification of vehicles and transportation, there is an increasing focus on the carbon footprint of incoming materials. Specific life cycle assessment (LCA) data is frequently requested, with a particular emphasis on the carbon footprint. Some companies in the automotive industry also have an ambition to incorporate an increasing proportion of recycled raw materials in their vehicles.



5.4.3 Others

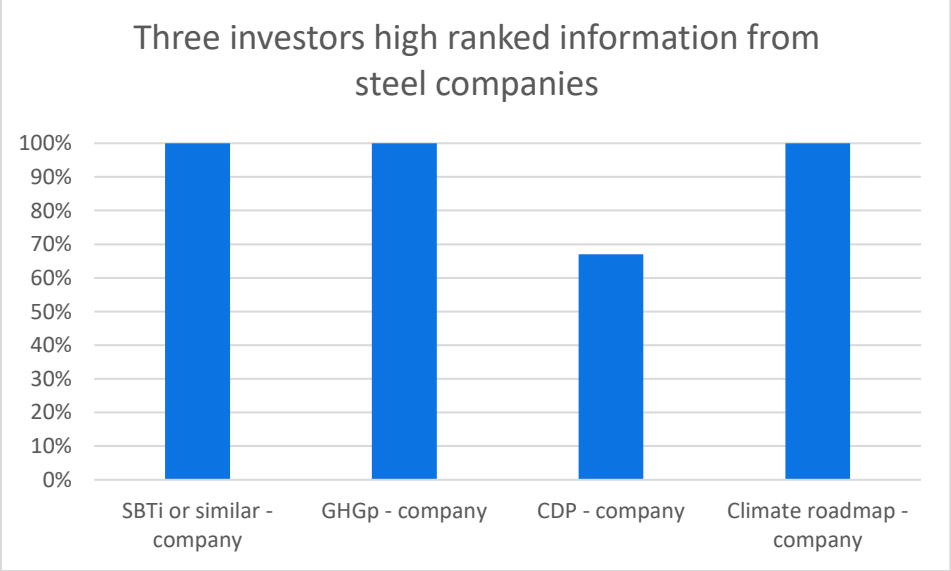
Representatives from the engineering industry, which in several cases supplies components to the automotive industry, are calling for increased access to steel with a very low carbon footprint while maintaining product quality. They seek access to verified specific CO_2 emissions throughout the value chain. One company has set its own criteria, in line with major initiatives like SBTi, that at least 50% of their steel suppliers should meet by 2030.

Steel distributors call for calculation standards that provide comparable results (EPDs should be more standardized) and transparent results where compensation measures are not included in the product's carbon footprint. It is also challenging to compare different steel materials as they do not have the same quality or meet the same functional requirements for the final use.

The furniture company highlights the problem of various, not clearly defined terms such as "near zero steel," "fossil-free steel," "green energy," etc. They believe it is important to realize that we are on a journey, and new knowledge and methods will emerge to calculate and evaluate measures for limited climate impact.

5.5 Investors

Three investors have been invited to provide feedback for the project. Below are selected parts of their responses.



5.5.1 Examples of Good Methods from Investors

The UN Convened Net Zero Asset Owner Alliance (NZAOA) is a member-led initiative for institutional investors committed to reducing the climate impact of their investment portfolios in line with the Paris Agreement. *Climate Action 100+* and the Net Zero Company Benchmark, aimed at helping investors influence companies with the highest greenhouse gas emissions globally, are other tools highlighted in the survey responses. *SBTi* is developing a calculation method for the steel industry. It is crucial that it becomes robust and scientifically grounded since SBTi sectoral guidelines are tools used by many investors. An investor suggests that ongoing development and reporting of emissions from purchased raw materials/materials should drive demand for steel with a very low carbon footprint. Especially now, as there are also expanded requirements for investors to report scope 3 (company's

purchases of raw materials) under SFDR (*EU's Sustainable Finance Disclosure Regulation*) from 2023.

5.6 Government Agencies

The following government agencies have responded to the survey: Trafikverket (Swedish Transport Administration), Boverket (Swedish National Board of Housing, Building, and Planning), Upphandlingsmyndigheten (Swedish Agency for Public Procurement), Försvarets Materielverk (Swedish Defence Materiel Administration), and Energimyndigheten (Swedish Energy Agency).

Among the agencies providing information, **Trafikverket** (Swedish Transport Administration) is currently the only one directly requesting information on the carbon footprint from material suppliers, to be presented in an EPD according to *EN 15804 Sustainability of construction works - Environmental product declarations - Product category rules for type III environmental declarations*. These EPDs can be used in Trafikverket's overall incentive model, where Trafikverket, in accordance with the agency's guiding document *TDOK 2015:0007, Climate Calculation - infrastructure maintenance energy use and climate impact in a life cycle perspective*, rewards climate-saving measures in material production in connection with major infrastructure investments.

Boverket (Swedish National Board of Housing, Building, and Planning), as support for developers who are required by law to register a climate declaration, has developed a climate database containing conservative values for various building materials that can be used as a basis for the climate declaration. For instance, for several steel products. If the developer wants to use specific data, these data must come from a third party reviewed environmental declaration (EPD) according to the *EN 15804 standard*. Boverket does not take a position on which methods are most suitable but refers to the work done at the EU level in the revision of the Construction Product Regulation and the ongoing review of the harmonized standards for construction products.

Upphandlingsmyndigheten (Swedish Agency for Public Procurement) responds that there are currently no specific requirements for carbon footprints in procurement. However, based on the EU Procurement Directive, it is conceivable that requirements for carbon footprints, content of certain substances, conflict minerals, and traceability may be imposed. Upphandlingsmyndigheten has developed several sustainability criteria that can be used in procurement, such as to achieve reduced climate impact in the total contract for major construction projects. Proposed requirements for climate calculations during the contract period are described, aiming to reduce the project's negative climate impact from a life cycle perspective. Life cycle perspective refers to a perspective on the life cycle following the standards *EN 15978 Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method* and *EN 15804*.

Försvarets Materielverk (Swedish Defence Materiel Administration) currently does not normally impose requirements for carbon footprints in its procurement. However, the information is desirable, and requirements in the field may be applied in the future.

5.6.1 Examples of Good Methods from Government Agencies

Both Trafikverket and Boverket refer to the standard *EN 15804 Sustainability of construction works - Environmental product declarations - Product category rules* and the third party

verified EPDs produced according to that standard. However, Boverket also refers to the review of technical specifications for construction products currently taking place within the EU. Upphandlingsmyndigheten highlights traceability and possible certificates or certifications for the proportion of recycled material after consumer use and environmental and climate impact (including biogenic sources but separately stated) shown with a standardized third party-reviewed environmental declaration, for example, in an EPD.

5.6.2 Examples of Less Favorable Methods from Government

Trafikverket argues that there are problems with differences in PCR (Product Category Rules) in different EPD programs, which can make it problematic to compare results from different EPDs. Trafikverket also does not consider the allocation system called Mass Balance Approach for biomass used for calculations in some EPD programs as a good method. Trafikverket also sees a problem with its incentive model used to reward climate performance specifically when it comes to steel, as the demand for steel scrap is higher than the supply. Requirements for lower emissions for steel currently risk only affecting the amount of used scrap-based steel in construction work since it has a lower carbon footprint in an EPD, not changes in the steel manufacturing process.

Upphandlingsmyndigheten raises the following problems:

- Non- traceable or non-verifiable self-claims.
- Assuming net-zero climate impact from biogenic sources.
- Claims about climate compensations that are non-traceable, non-verifiable, and not third-party-reviewed and do not compensate for the caused impact, where additional measures, i.e., compensation genuinely contributing to an action. Climate offsets are generally challenging to verify.

6 Discussion

6.1 Purposes of Various Calculations, Communication, and Evaluation of Carbon Footprints

Different stakeholders have varying information needs regarding greenhouse gas emissions in the steel value chain. This means that the purposes of different harmonized calculation methods, standards, or other initiatives may vary.

Investors

To monitor a company's climate impact and sustainability goals in relation to financial decisions so they can prioritize which businesses to invest in. They aim is to attract financial actors and demonstrate that their operations support sustainable development through their sustainability efforts. Corporate roadmaps and tools like SBTi goals are essential.

Customers

Customers want to know the greenhouse gas emissions associated with the products they purchase. Based on credible information, such as an EPD, they can choose suppliers to influence their own upstream scope 3 goals and obtain data for communicating their own environmental or carbon footprint for the final product. Some customers, often smaller businesses, prefer straightforward information to facilitate the selection of steel with lower climate impact. EPDs, carbon footprints, and procurement criteria are crucial tools.

Politicians, States

Politicians and states aim to drive or support climate transition through various means, including research support, investment support, public procurement, stricter legislation, and guidance to citizens. Tools include international standardization or other voluntary initiatives such as roadmaps, research projects, and procurement criteria.

Steel Companies

Steel companies want to demonstrate a reduction in greenhouse gas emissions to be attractive to investors, employees, the public, and public decision-makers. Roadmaps, sustainability reporting, GRI, SBTi, and GHG protocols are suitable tools. They also want to position themselves in the market, show customers they are better than competitors, demonstrate progress, and get paid for products with lower carbon footprints. Suitable tools include EPDs, PEF, sustainability reports, and roadmaps. They may also seek support for their transition plans, where roadmaps can be a suitable tool.

6.2 Key Issues for the Climate Transition and Standardization of the Steel Industry

6.2.1 Corporate-Level Carbon Footprints

Companies report and are assessed based on both their direct emissions and indirect emissions from purchased electricity, raw materials, and inputs, as well as the transportation required from cradle to gate. Reporting often follows GRI in sustainability reports, covering sustainability indicators and, for climate-related impact, the Greenhouse Gas Protocol (GHGp). The new EU directive, the Corporate Sustainability Reporting Directive (CSRD), introduces more detailed reporting requirements for sustainability reports and mandates reporting according to mandatory EU standards, which are under development.

Many stakeholders, including investors, owners, customers, and states, seek information on companies' plans and commitments to achieve net-zero greenhouse gas emissions by 2050, as outlined in the Paris Agreement. These are often referred to as corporate climate action plans. Many companies join the Science Based Targets initiative (SBTi) to credibly report and inform about their climate action plans. SBTi is developing a sector-specific guide for the steel industry on how goals should be set. A new ISO standard for a company to be called carbon neutral is being developed, expected to be completed in 2023. An international guide, "Net zero guidelines," has been developed within ISO in 2022, intended as a tool for decision-makers and those working toward net-zero greenhouse gas emissions for their operations, group of operations, region, or country.

These various standards and methods aim to enable companies and organizations to report their goals and progress in reducing greenhouse gas emissions in line with the Paris Agreement, allowing stakeholders to assess or consider these efforts.

6.2.2 Climate Intensity Levels for Steel

Due to the slow pace of global steel industry transition, several initiatives have developed climate intensity levels for steel to be used by customers and other stakeholders to drive the industry's transition. Various initiatives propose criteria for classifying steel expressed as CO_2 equivalents (CO_2-eq) per ton of steel for certain parts of the manufacturing processes (criteria for "near-zero emission production" and "low emission production"), considering the amount of scrap/raw material used in production. The sliding scales presented in different initiatives such as ResponsibleSteel, IEA-G7, WV Stahl, and SteelZero are examples of this. The criteria in different initiatives do not always have the same scope; for example, they are proposed for crude steel or hot-rolled steel. The sliding scales in different initiatives also do not have the same levels for different classifications of low-emission steel, and the criterion for "near-zero steel" is set lower for steel produced with 100% secondary raw material (scrap) than steel produced with 100% primary raw material (ore). These methods, still under development, are currently limited to general low-alloy steel products.

The proposed criteria in these methods are intended to serve as threshold values for "near-zero steel" or "low-emission steel" regardless of the manufacturing method but considering iron raw material use. The motivation behind these proposals is the expected shortage of scrap to cover the steel demand for the foreseeable future. Other solutions than increased scrap share in steel production must be applied to meet the entire steel sector's climate transition. This remains a fact even if market prices for scrap contribute to improved sorting and recycling of scrap. The threshold values are expected to be ambitiously set for both production methods

used today to involve the entire steel sector in the transition and the journey towards net-zero by 2050. It can be added that the current division between ore-based and scrap-based steel companies may not be as clear in the future, as the share of primary iron raw material in the form of iron sponge is expected to increase in today's scrap-based plants.

There are other initiatives, such as the Global Steel Climate Council (GSCC), proposing that the carbon footprint, regardless of raw material, should be compared on a scale where emission levels decrease over time without differentiating levels based on the type of iron raw material. The ultimate goal of achieving global climate targets by 2050 remains the same. Initially, this would drive towards more scrap usage and thus increased costs for scrap, which could, in turn, help drive the transition in ore-based production.

These initiatives demonstrate a significant interest in achieving a harmonized definition or standard for production that results in near-zero CO_2 emissions within the steel industry, making such production facilities competitive. It also shows that there are different views on how this should be done. Transparent reporting of near-zero production emissions or low-emission steel according to a harmonized definition aims to ensure that different companies report the same thing, facilitating comparisons for customers and other stakeholders. However, the methods of these initiatives imply that it is not the final steel products that are classified but the production of crude steel or a slightly longer part of the manufacturing chain, i.e., the classification of the initial production of steel material.

Several of these initiatives also express a clear ambition for these methods to be the basis for procurement and drive demand for steel produced with low greenhouse gas emissions.

6.2.3 Carbon Footprint for Products

There have long been standards and methods for conducting life cycle assessments for products, calculating various environmental impact categories, including climate impact, and then communicating this information in the form of an environmental declaration with multiple environmental impact categories or as a "single-issue declaration" in the form of a carbon footprint. This is often done in collaboration with a program operator who then publishes third party-reviewed environmental declarations (EPDs).

To calculate the climate impact of products, data is needed for the raw materials and inputs used in production, energy consumption, emissions, and other losses during manufacturing processes, as well as the impact from handling and transportation. As more climate-conscious actors aim to reduce their carbon footprints, information about the climate impact associated with acquired raw materials, inputs, or products becomes increasingly important. Specific life cycle-based data from suppliers are therefore increasingly requested. In some cases, general data available in databases can also be used. To coordinate what must be included when creating an environmental declaration for a product, product category rules (PCRs) are first developed for that type of products.

In summary, methods, and standards for developing and communicating life cycle-based environmental declarations or carbon footprints for products are relatively well-developed. However, it can still be challenging to compare the results for one steel product with another. This is due, for example, to how product category rules are designed; specifically, the extent to which specific data or general data is used, how the allocation of climate impact occurs between a primary product and a by-product, how environmental and climate impact is

distributed between recycling scrap as raw material and the recyclability of materials when the product is finally scrapped, etc. There is a need for further clarification of methods in existing standards to facilitate and enable fair comparisons between different materials and products.

A complete Life Cycle Assessment (LCA) can be conducted for various types of steel and steel products with different technical properties and qualities that constitute the material's function during its use. The customer can consider the functionality of the chosen steel product in the use phase of the final product/application, where properties such as corrosion resistance, strength, lifespan, reduced maintenance needs during the use phase, etc., are relevant to the full life cycle of the final application. An environmental declaration according to established international standards always includes emissions and impacts throughout the life cycle of the steel product, at least from cradle to gate, ensuring that requested information on upstream impacts of steel production is always included. This is also something that the vast majority of stakeholders want to see in a reported carbon footprint for a product.

6.2.4 Allocation Method Mass Balance Used in Communication of Steel Carbon Footprint

Some companies use average methods where overall improvements leading to reduced carbon dioxide emissions within the company or facility are allocated to a limited part of the production volume. The method/calculation can be third party-reviewed and then communicated as delivering "greener" products. However, the reported climate impact from products, linked to the selected part of the production volume, can be misleading and complicate the market's ability to make climate-conscious choices when purchasing. The risk of misunderstandings is significant, which is why it is crucial for the method underlying the calculation to be transparently and clearly disclosed so that customers truly understand what the reported figure for carbon footprint represents. This way of reporting is called "mass balance to attribute the low/zero carbon footprint property to the part of the production volume that the improvement covers" and is now proposed for approval as a method in an ISO standard on "Mass balance" within "Chain of custody" currently under development. These distributions of emission reductions linked to implemented measures should be distinguished from when mass balance is used as a method to allocate energy types such as fossil-free electricity or biogas.

6.2.5 Scope Concepts

The scope 1, scope 2, and scope 3 concepts defined in the Greenhouse Gas Protocol are valuable in a company's reporting of its direct and indirect carbon footprint, aiming to identify areas suitable for improvement measures. However, it is less suitable to use these concepts when discussing what is included in a carbon footprint for a finished steel product or what is included in a figure for climate intensity from parts of steel production because the extent to which specific processes are part of the company and which parts are purchased from other actors varies between companies. In some cases, emissions may be classified as direct scope 1 emissions, and in other cases as indirect scope 3 emissions, depending on who is reporting.

6.2.6 Biogenic Emissions or Uptake of Greenhouse Gases

How emissions or uptake of greenhouse gases with biogenic origin should be reported is regulated in various standards, such as "*ISO 14067 GHG - Carbon footprint of products – Requirements and guidelines for quantification*" and "*EN 15804 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products.*"

In summary, these two standards states that emissions of both fossil greenhouse gases and biogenic greenhouse gases should be reported separately when developing a carbon footprint or reporting an EPD. For biogenic raw materials, such as wood products, it is assumed that the forest's uptake of CO_2 corresponds to minus 1 kg CO_2e/kg CO_2 biogenic carbon, and the actual emission when using wood products, for example, in combustion, contributes plus 1 kg CO_2e/kg CO_2 biogenic carbon to the atmosphere. In this way, uptake and emissions of CO_2 essentially offset each other over the life cycle (excluding biogenic methane), and biogenic raw materials do not contribute to an increased carbon footprint, given sustainably managed bioresources. Fossil CO_2 emissions, on the other hand, cannot be offset against any uptake and therefore contribute to the net emissions of CO_2e in a reported EPD or carbon footprint.

6.2.7 Scrap and Alloys in Scrap as Steel Raw Material

Using steel scrap as raw material in steel production is an effective way to recycle a valuable metallic material and manufacture new steel with equal or higher technical performance. Since the reduction of iron oxide from iron ore occurred in previous life cycles (ore-based steel production in blast furnaces), greenhouse gas emissions are significantly lower in the production of scrap-based steel in an electric arc furnace, mostly depending on how the electricity used in the electric arc furnace is produced. Using steel scrap as raw material for new steel is therefore good for both resource and climate reasons. To better utilize the metal content in scrap, improved sorting of scrap based on alloy content is needed. The ability to sort different materials cost-effectively is a key issue throughout the entire steel product life cycle.

7 Conclusions and Recommendations

Below are the conclusions and positions developed within the project to contribute to increased harmonization of methods and definitions, as well as transparent reporting of carbon footprints. The ultimate goal is to avoid misunderstandings and incorrect interpretation of different results. In the end, methods, standards, and tools should facilitate the communication of real improvements in a way that rewards companies and steels contributing to actual emissions reductions while maintaining fair competition on the global steel market. Both scrap-based and ore-based steel production will be needed in the foreseeable future, but the transformation of the entire steel industry and different production methods to achieve net-zero can occur in various ways.

7.1 Different Standards and Initiatives

7.1.1 Conclusions

Despite many international standards, carbon footprints for steel products are not always comparable. There is a lack of a global standard/method with product category rules for steel products.

- The multitude of ways to report climate-related emissions is problematic, leading to increased costs for companies and potential confusion for customers. It is challenging for different stakeholders to understand the difference between various reported values for climate-related emissions from a company, a production facility, or the carbon footprint of steel products. Therefore, clear purposes for each method and reporting form are crucial—who is the reporting intended for, and what is its use? For each climate reporting purpose, it is beneficial to have as few methods and systems as possible.
- Calculation methods should be clear regarding system boundaries, scope, and data quality, and this should be transparently and easily accessible so that customers and other stakeholders understand what the reported carbon footprint figure represents.
- It is essential to distinguish between actual emission reductions, capture/use of CO_2 (CCS/CCU), and compensation measures (offsets), and it should be clear how these are handled in different methods.
- High-Quality data/specific and primary data should always be used first when available, especially for emissions that are significant for the company, production unit, or product.
- Demand for data and information on climate impact exists throughout the steel value chain. Different sectors and actors demand reporting in different formats and tailored in different ways. Coordination of methods and reporting approaches would facilitate meeting the demand for information on carbon footprints from various customer segments more cost-effectively.

7.2 Reporting and Assessment at Company Level

7.2.1 Conclusion

- It is crucial for the purpose and scope of reported climate impact from a company to be clear in the reporting. For example, whether it describes the previous year's performance or goals adopted and planned changes going forward.
- The Greenhouse Gas Protocol serves a good function for global harmonization of organizations' reporting of greenhouse gas emissions.

- The Science-Based Targets initiative is a relevant tool that supports companies in setting climate goals in line with scientific models developed within the Intergovernmental Panel on Climate Change (IPCC). The initiative primarily targets companies that have not yet transitioned their operations.
- Conclusion about the carbon footprint of a company's specific products cannot be straightforwardly drawn from corporate reports. For a company with multiple steel grades and different steel products, it is challenging to allocate the company's combined direct and indirect climate-related emissions to the various products. Life cycle inventories for the products are needed in such cases.

7.3 Climate Intensity Levels for Steel

7.3.1 Conclusions

- There is a lack of a common standardized method for climate intensity and the definition of "near-zero steel".
- When assessment criteria are proposed as the basis for procurement and expressed as CO_2 equivalents per ton of steel for a specific part of the manufacturing processes, there is a risk that these levels will be compared with or perceived as product-specific carbon footprints reported using life cycle-based methods. Therefore, it is essential that the method/classification only pertains to part of the life cycle. When used in procurement, it should be combined with a life cycle-based carbon footprint.
- There are differing opinions within the steel industry regarding the value of proposed methods with sliding scales to classify the climate intensity of steel from a specific part of steel production and based on the proportion of primary and secondary iron raw material (ore or scrap). The opinions differ primarily between ore-based steel companies and scrap-based companies. Even among steel industry customers, opinions differ on whether the introduction of such classifications of "near-zero steel" or "low-emission steel" would facilitate their ability to make knowledge-based decisions in their efforts to reduce the carbon footprints of their final products.
- Pros: Ore-based iron and steel companies believe that assessment methods with threshold values for steel can be a tool for countries to fulfill commitments to reach their climate goals. It provides a basis for distinguishing steel from steel at an overarching level—creating an opportunity to build a market for "near-zero steel" or "low-emission steel" and clarity on which processes need to change to reduce the total emissions from the steel industry. A sliding scale that includes both ore-based and scrap-based steel production includes the entire industry instead of excluding scrap-based manufacturing, which accounts for approximately 25% of the world's steel production. Overall, this aims to accelerate the green transition where the entire steel industry needs to set ambitious goals regardless of the starting point. These sliding scales are not considered to hinder procurement at the product level, for example, through requirements for environmental product declarations (EPDs) or requirements for the carbon footprint of the product delivered to the customers.
- Cons: Scrap-based steel companies believe that a definition of "near-zero steel" based on a sliding scale is inappropriate, especially since it treats similar properties differently based on the steel's production method. The threshold values in the sliding scales mean that scrap-based steel is assigned a poorer classification than ore-based, even when the carbon footprint is significantly lower for scrap-based steel and the properties of scrap-based and ore-based steel may be the same. If the levels were

applied as minimum requirements in procurement, there is a risk that ore-based steel with higher climate intensity gains an advantage and competes out scrap-based steel with lower climate intensity, even though the steel products have the same quality.

- The project’s opinion is that the emission level requirements for scrap-based steel production (on the right side of the sliding scales) may be too low in several of the proposals analyzed in the project. The level for "near-zero steel" (i.e., the lowest level in the sliding scales) should be the same regardless of the iron raw material used in production. In other words, the goal for "near-zero production" is the same regardless of technology choice and raw material.
- Several methods for assessing "near-zero steel" are not applicable to "special steel" manufactured to achieve entirely different technical and functional properties than "simpler carbon steel”.
- When describing methods and criteria for calculating the climate intensity from one or more steel production stages, it must be clear which production stages should be included so that it is possible to critically assess the comparability of the results.
- According to the project's experience, there is a lack of analysis of the market consequences of using criteria for "near-zero production steel" or "low-emission steel" based on different scales in procurement and its compatibility with procurement law principles, such as the principle of equal treatment and non-discrimination in the Public Procurement Act and EU Directive 2024/24/EU.
- When using criteria for "near-zero steel" or "low-emission steel" according to simplified methods in procurement, a life cycle-based carbon footprint for the steel product should also be requested. This is to assess the carbon footprint in relation to the steel product delivered to the customer. Such a carbon footprint should be reviewed by a third party.

7.3.2 Proposed Actions

- The first step must be for the steel industry to agree on a common method for reporting emissions for steel products at the international level. The same methodology should be applicable for reporting emissions for intermediate products, such as crude steel. Based on a unified method and relevant data derived from current/real emission factors, potential levels for "low-emission" and "near-zero" steel can be established.
- Before deciding on the possible introduction of procurement criteria based on different classifications of "low-emission" and "near-zero steel" according to the "sliding scale" principle (with different levels of emission intensity based on the proportion of primary and secondary iron raw material in steel production), a thorough review and impact analysis are necessary. Stakeholders from the steel industry should participate in such an analysis. The analysis should cover the procurement legal conditions when introducing procurement criteria with different requirements for steel depending on the proportion of secondary iron raw material (scrap), even if the functionality of the steel is deemed equivalent.
- An analysis should also be conducted to determine the starting and ending points for these scales before potential implementation. The requirements for ore-based steel and scrap-based steel must be reasonably fair while still encouraging emission-reducing measures in different steel production methods. The long-term goal for greenhouse gas

emissions from steel production, regardless of raw material and process route, should be the same.

7.4 Carbon Footprint of Steel Products

7.4.1 Conclusions

- Calculation of a product's carbon footprint should be based on life cycle-based data that has been inventoried and evaluated according to current standards and accepted methods.
- Communication of a product's carbon footprint should adhere to applicable international standards, such as those for developing environmental declarations (EPD) or Product Environmental Footprints (PEF). It should also comply with marketing laws and any other relevant methods.
- Existing life cycle-based standards and methods for reporting a product's carbon footprint need to become more uniform to ensure a fair comparison between different materials and products. This includes determining when general data should be used, how the environmental benefits of recycling should be allocated based on the products' content of recycled scrap or their recyclability when scrapped, and rules for allocation between primary product and by-product, etc. Allocation issues in standards for LCA (*ISO 14000 series*) and sustainable construction (*ISO 21930* and *EN 15804*) are particularly important, as well as mass balance as a method for traceability and information transfer in the supply chain (*ISO 22095 series chain of custody*).
- There is no harmonized global PCR (Product Category Rules) for steel, but if developed, it would eliminate the differences in today's PCRs for steel from different program operators.
- The steel grade and its functional properties must be considered in comparisons of carbon footprints.
- When reporting a product's carbon footprint, offset measures should not be included. If offset measures are applied, they should be clearly described and reported separately.
- Allocating general emission reductions from production to a certain part of the production volume (proposed as a mass balance method according to *ISO 22095 Chain of Custody*) to classify certain steels as green or near-zero steels is problematic. The results can be difficult to understand and may be perceived as misleading in the market. If used, transparent and clear reporting is necessary.
- Allocation purchased energy based on certificates for renewable electricity or biogas according to *ISO 22095* is seen as less problematic, although transparency requirements are crucial here as well. However, it is not always allowed, for example, in the rules of various program operators for EPD.

7.4.2 Proposed Actions

- SIS should, with the support of the Swedish steel industry, work to elevate *prEN 17662 EPD - Product category rules complementary to EN 15804 for Steel, Iron and Aluminium structural products* for use in construction works to a global PCR standard for steel products.
- Stakeholders in the Swedish steel value chain and relevant authorities should engage in continued standardization of life cycle analyses, environmental product declarations, and product carbon footprints. This includes information transfer in the

value chain for increased transparency, agreement on method choices, and the possibility of fair comparability within and between material types, for example, through "SIS TK 605, Traceability and Information Transfer in the Value Chain" and "SIS TK 207 Environmental Management".

- The Swedish steel industry should follow and participate in CEN's New Working Item Proposal work "Requirements and guidelines for sectoral transition plans".
- Active participation from Swedish steel companies and Jernkontoret in Eurofer's work on developing PEFCRs to enable the development of PEF for steel products within the EU.
- Swedish authorities and the Government Offices are encouraged to actively participate in EU collaborations on relevant regulations such as the Construction Product Regulation, ESPR, Green Claims, including PEF, Green Public Procurement, etc., to assess, mandate, and communicate the climate impact of products based on robust, scientific, and life cycle-based methods. The Swedish steel industry wants to actively contribute knowledge, constructive proposals, and ideas in this work.
- The Swedish steel industry should work towards internationally harmonized regulations in the area between the EU and the rest of the world by developing an action plan for:
    - Enhanced Swedish participation in international standardization.
    - Enhanced Swedish participation in EU standardization.
    - Enhanced collaboration with relevant authorities.

7.5 Scope Definitions

7.5.1 Conclusions

- When describing methods and criteria for calculating the climate intensity from one or more production stages in steel manufacturing, it must be clear what should be included to determine the comparability of results. Simply referring to Scope 1, Scope 2, and Scope 3 can become unclear, as it varies what is included in a steel company's own operations and what is not.

7.6 Biogenic Carbon and Fossil Carbon

7.6.1 Conclusions

- It must be possible to use biogenic raw materials and energy in the steel industry and distinguish it from fossil sources.
- When fossil CO_2 emissions in steel production are replaced by emissions from sustainably produced biogenic raw materials, the sequestration of carbon dioxide by these materials must be considered in the net result. However, the emissions should be reported separately and not included in the net carbon footprint of the product.

7.7 Value of Scrap and Alloys in Scrap as Steel Raw Material

7.7.1 Conclusions

- Proper management of scrap makes a difference, enabling better utilization of alloying metals in subsequent life cycles, reducing the need for primary alloying metals. Improved sorting and classification of scrap with increased knowledge of content contribute to increasing the purity of different scrap classes and reducing the proportion of substances that constitute technical impurities in steel production, such as copper.
- Imposing requirements on the proportion of scrap in steel production does not automatically reduce the climate impact of global steel production, as the availability of scrap is far less than the demand for steel worldwide. Therefore, ore-based steel production will be necessary in the foreseeable future. Only when the collection and sorting of scrap of demanded qualities match the demand for steel will the significance of primary raw materials cease.

7.7.2 Proposed Actions

- Examine the interest in Sweden in developing a proposal for a new standardization initiative for a standard or technical report on sorting techniques and classification/verification of alloys and impurities in scrap. This would contribute to increased recycling of alloy content in steel scrap and reduce the proportion of technical impurities.

7.8 Miscellaneous

7.8.1 Conclusions

- Collaboration in the steel value chain needs to continue. Learning together and facilitating the transparent and credible sharing of information between stakeholders are valuable. Making the knowledge gathered in the project available to various stakeholders, especially different types of requirements setters (legislators, procurers, initiators, authorities, etc.), is also important.
- The steel market is global and highly competitive. Initiatives and policy impacts on the market are very sensitive.
- Requirements in public procurement may risk distorting the market unfavorably if decision bases are not reliable. The Swedish steel industry is highly dependent on exports, making this especially important to maintain fair competitive conditions in the market. This is crucial while requirements in public procurement are essential for driving the transition.

7.8.2 Proposed Actions

- Jernkontoret will continue to coordinate collaboration within the Swedish steel industry's value chain regarding the transition to the production of "near-zero steel" and possible collaboration with authorities and decision-makers regarding the potential impact of various policy instruments on the market.

8 Contributions to the Objectives of the Call

8.1 Project Purpose – Fulfilment

Purpose: Provide knowledge about methods for the climate impact of steel and contribute to standardization and increased harmonization in the production and use of steel. Plan for the development of standards. Monitor the environment and disseminate results.

Outcomes: Dissemination of knowledge at the final seminar and in the final report with proposals for standardization.

8.2 Project Goals – Fulfilment

Goal 1: Create conditions for collaboration on common standards for industrial interoperability that contribute to increased climate benefits.

Fulfilment: Representatives from various parts of the steel value chain (raw material suppliers, steel producers, and customers) participated in the project. Understanding of different stakeholders' needs for standardized and harmonized information about the carbon footprint has been strengthened during the project. Various requests have been identified from different stakeholders.

Goal 2: Conduct and present case studies for increased understanding of the consequences of and business benefits of standardization, as well as harmonize definitions and methods used in voluntary initiatives.

Fulfilment: A case study has been conducted for three different initiatives. The study clearly shows that what is included in calculations according to different methods affects the value of climate intensity expressed as kg CO_2eq / kg steel.

Goal 3: Investigate how standards can promote innovation for increased climate benefits and competitiveness.

A survey of existing and ongoing standards relevant to the carbon footprint of steel has been conducted. Differences between what is described in standards and in other types of initiatives have been examined. Standards usually address management processes, methods for calculation, or verification of data but do not specify desirable levels for, e.g., carbon footprint. Other initiatives aim to influence the market to support the transition, especially for ore-based steel production where reduction of iron oxide occurs with coal. Well-designed standardized methods for calculating and comparing carbon footprints can promote climate innovation and increase competitiveness for the Swedish steel industry.

8.3 Results and Expected Outcomes

A wide range of actors within the steel value chain have participated and gained deeper insights into the relationship between standards in the climate area and other initiatives focusing on the carbon footprint of organizations and products, as well as accelerating climate transition. The objectives and limitations and their effects on different market actors have been discussed. The results are in a comprehensive reference document. This is expected to lead to increased engagement in standardization work and, ultimately, more purposeful standards for steel with a very low carbon footprint.

9 Utilization of Results and Continued Work

The results of the project have been compiled in this final report, along with an underlying technical report. A final seminar was organized on January 19, inviting relevant stakeholders from academia, authorities, companies, industry representatives, and other stakeholders. The information presented at the final seminar has been documented for further dissemination if needed. Throughout the project, there has been regular information exchange between the project "Investigation of standardization needs related to the steel industry's climate transition" and the "Working Group for Fossil-Free Steel," which was tasked by the Swedish National Board of Trade's Council for Innovative and Climate-Focused Standardization to examine fossil-free steel and the need for standardization. This collaboration aimed to maximize knowledge about fossil-free steel and standardization, leverage the work of both groups, and avoid duplication of efforts.

10 References

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The Swedish Iron and Steel Producers' Association

Since its foundation in 1747, Jernkontoret has been owned jointly by the Swedish iron and steel companies. Jernkontoret represents Sweden's iron and steel industry on issues that relate to trade policy, research and education, standardisation, energy, the environment and sustainability as well as transportation issues. Jernkontoret also manages the joint Nordic research on steel. In addition, Jernkontoret draws up statistical information relating to the industry and carries out research into the history of mining and metallurgy.

Jernkontoret