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Research Report

PROJECT RP3.006

MAPPING EMBEDDED EMISSIONS ACCOUNTING FRAMEWORKS FOR HEAVY INDUSTRY LOW-CARBON TRANSITION: THE CASE OF IRON AND STEEL

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Liberty Steel

BlueScope

Grange Resources

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1. INTRODUCTION

Decarbonising the iron and steel sector is a global priority, given its significant contribution to greenhouse gas emissions. The steel industry alone accounts for approximately 7–9% of global carbon dioxide (CO2) emissions. As demand for steel is projected to rise in the coming decades (Xuan and Yue, 2016), achieving deep decarbonisation in this sector is critical to meeting the Paris Agreement's objective of net-zero global emissions by 2050 (UNFCCC, 2015). The International Energy Agency (IEA) highlights that, under its Sustainable Development Scenario, the CO2 intensity of crude steel must decline by an average of 2.5% annually between 2018 and 2030 to align with these global targets.

A variety of public and private standards, certification and verification schemes have emerged to support the transition to low-carbon production in the iron and steel sector. Many of these rely on data regarding embedded emissions within supply chains and products. Consequently, a growing array of embedded emissions accounting frameworks (EEFs) has been developed specifically for iron and steel products based on these standards, methodologies embedded within policies, regulations, certification schemes, and reporting initiatives.

However, the proliferation of these schemes and frameworks presents challenges for the industry. Producers often struggle to navigate these frameworks, uncertain about their reliability and accuracy. Inconsistencies in methodological approaches, scope, and boundaries across EEFs create additional difficulties in achieving accurate and verifiable greenhouse gas emissions data at specific supply chain stages. This fragmentation risks increasing costs for producers, complicating market access, and raising concerns about greenwashing. Furthermore, the lack of interoperability among EEFs undermines efforts to ensure comparability and trust in emissions data.

To address these challenges, **HILT Project 3.006** is working to support industry partners in navigating this complex landscape of EEFs. As a foundational step, the Australian National University (ANU) research team has mapped 106 certification and verification schemes relevant to the iron and steel sector: **Section 3: Landscape of EEFs for Iron & Steel**, detailing each EEF's name, lead and participating organisations, year of establishment, scope and boundary coverage, sectoral focus, and type.

Additionally, this report provides the technical assessment of major EEFs in relation to regulatory and market considerations identified in report D1. **Section 4: Technical Assessment of Major EEFs**, benchmarking standards, certifications, verification schemes along with the scope and relevance.

2. OTHER LITERATURE AND CONTRIBUTION OF THIS REPORT

In recent years, various organisations have made significant strides in supporting the transition to net-zero emissions for industries, particularly in green steel production. Notable reports include:

- The International Energy Association (IEA, 2023) emissions measurement principles and pathways, offers a comparative assessment of different emissions measurement methodologies, evaluating their strengths, weaknesses, and differences. It various methods used to calculate greenhouse gas emissions across different sectors, including energy, industrial production, and specifically steel. Key areas of comparison include methodological approaches for measuring direct emissions, data quality, accuracy, and transparency in reporting emissions, as well as how these methods align with global climate targets. The report also highlights the differences in boundaries (such as organisational vs. product boundaries) and how methodologies account for indirect emissions (from supply chains, for instance).
- Similarly, the World Steel Association (World Steel Association, 2024) provides a detailed mapping of different greenhouse gas (GHG) protocol standards used in the steel industry. It specifically evaluates the differences in boundaries, allocation methods, and conformity assessments in GHG protocols.
- The World Economic Forum (WEF), through its Green Steel Tracker report 2023 and 2024, and the World Resources Institute (WRI) has highlighted green procurement initiatives focus more on identifying emission reduction policies and relevant targets for the steel industry. The WEF Green Steel Tracker monitors the global landscape of green steel initiatives, identifying the policy targets that various nations and companies have set to reduce emissions in the steel sector, such as carbon pricing and procurement policies. It tracks key developments in the green steel space, providing a high-level overview of efforts to promote green procurement and the adoption of low-carbon steel. Together, both focus on the broader policy landscape and the necessary market shifts for reducing emissions in steel production.

In contrast to these aforementioned, broader policy mapping exercises (also being reported in HILT P3.008), this project report fills a critical gap by providing a targeted assessment tailored specifically to the iron and steel sector, offering a deep dive into **embedded emissions accounting frameworks (EEFs)**[1], covering both domestic and international, public and private sector initiatives. It consolidates information into a specialised knowledge base of guidelines, methodologies, procurement policies, and tools which are directly underpinned by EEFs. This approach establishes clear connections to critical regulatory developments, such as the European Union's CBAM regulations and Australia's GO (Guarantee of Origin) scheme, which rely heavily on product-level emissions accounting

Firstly, this report responds to the growing complexity of decarbonisation initiatives and the proliferation of diverse EEFs by mapping more than 100 resources for the iron and steel. Furthermore, the accompanying social network analysis provides insights into the relationships between various EEFs, helping to navigate the complexities of certification, verification, and emissions reporting.

By identifying and analysing these EEFs, the report highlights not only the advantages but also the potential challenges in ensuring interoperability and comparability across frameworks. The proliferation of methodological diversity, differing boundaries, and measurement approaches can lead to greenwashing risks and increased costs for producers. This situation underscores the need for a clearer, more unified approach to emissions accounting, which this report aims to address. It serves as a key resource for companies and policymakers to navigate the evolving landscape of decarbonisation regulations and methodologies, with a clear emphasis on ensuring accurate, verified emissions calculations across product supply chains.

[1] Please refer to P3.006: Industry brief #1 *What are embedded emissions accounting frameworks (EEFS)?*

3. GLOBAL LANDSCAPE OF EMBEDDED EMISSIONS ACCOUNTING FRAMEWORKS (EEFS)

3.1 BACKGROUND AND APPROACH

The global landscape of Embedded Emissions Accounting Frameworks (EEFs) for the iron and steel sector is complex and rapidly evolving as industry seeks to meet stringent carbon reduction targets and align with international climate policies. EEFs are essential tools and standards that provide methodologies for quantifying, verifying, and reporting the emissions embedded in steel products. These frameworks not only support many public and private decarbonisation initiatives (see HILT CRC report Policies and regulatory drivers of embedded emissions accounting for Australian heavy industry low-carbon transition: The case of the iron and steel sector), but also provide transparency which helps solve "information failures" which can otherwise inhibit investment and market development for low carbon products.

This report offers a structured overview of key EEFs identified through a detailed stocktaking exercise, which involved extensive research across a variety of literature sources, reports, and existing frameworks. This process began with gathering publicly available and industry-specific documents that outline the Embedded Emissions Accounting Frameworks (EEFs) relevant to the iron and steel sector. Sources included policy reports, emissions measurement guidelines, certification schemes. The data from these sources was systematically reviewed and organised in an Excel spreadsheet to build a comprehensive database. Each EEF was analysed in terms of their:

Name of Resource/EEF: The title or identifier of the embedded emissions framework or resource, providing clarity on the framework being referenced.

Lead Organisation: This column identifies the primary organisation responsible for the development or management of the EEF, whether it be a government body, non-governmental organisation, or industry consortium.

Year of Establishment: The year the EEF was introduced or implemented, allowing users to understand the timeline of its development and potential updates.

Scope Coverage: This column specifies the scope and coverage of emissions in terms of scopes 1, 2 and 3 emissions.

Sectors Covered: This identifies the sectors or industries to which the EEF applies the sectors producing the product and/or the ones using it., coded in line with the International Standard Industrial Classification (ISIC) codes,

Type of EEF: This column classifies the EEF based on its nature:

Standards: Standards are established norms or requirements that provide a framework for consistent practices, processes, or products. They are typically developed and maintained by recognised bodies (e.g., ISO, ASTM) to ensure quality, safety, efficiency, and interoperability across industries or sectors.

Protocol: Protocols are detailed plans or procedures for how to carry out specific tasks or processes. They outline step-by-step instructions to ensure consistency in implementation, often within the scope of a standard or policy.

Initiatives: Initiatives are broad strategic organised efforts, often driven by organisations, governments, or coalitions, aimed at achieving a particular goal or set of goals. They may involve multiple actions, programs and activities such as setting new standards, promoting best practices, reporting or driving policy changes. E.g.

Policy: Policies are formal principles or rules that guide decision-making and actions within an organisation, government, or institution. E.g. EU CBAM

Tool/methods: Tools or methods are specific techniques, instruments, or software used to implement standards, protocols, policies, or initiatives. They provide practical means to achieve the desired outcomes. E.g. LCA, EPD, PEF

Mandatory: applies to Government's mandated ones, which is required by national, regional and international agreements and laws under specific regulatory regimes.

Voluntary: is a type of optional compliance and reporting, and not necessarily directed by Governments. Some "voluntary" certifications may become *de facto* mandatory in markets due to customer demand, regulatory pressure, or corporate sustainability goals.

The methodology used for compiling table A1 (Appendix) involved systematically identifying all relevant frameworks and organising them based on the above attributes, providing a clear, organised, and up-to-date reference for stakeholders in the industry, making it easier to navigate the increasingly complex landscape of EEFs.

3.2 LANDSCAPE OF GLOBAL EEFS AND RELATED GUIDELINES AND STANDARDS

Over the past couple of decades, there has been a noticeable surge in initiatives, encompassing regulations, policies, schemes, and frameworks aimed at establishing best practices, rules, or laws governing the decarbonisation of iron and steel industry and the transition to net zero emissions. The key challenge lies in defining “green steel” within the context of low-carbon or low-emission steel, particularly when emissions intensity thresholds differ. A critical priority is fostering trust in “green steel” standards and labels, with a shared focus on building confidence and clarity around low-emissions steel to mitigate false claims and greenwashing. Recent discussions led by G20 countries, the IEA[2], and WTO have underscored the importance of interoperability and harmonisation of standards.

This report analyses an abundance of over 92 guidelines applicable to steel companies, potentially leading to confusion, increased costs, and greater regulatory pressures as they strive to remain competitive in the market. Various tools, methodologies, standards, certification schemes, frameworks, policies, and disclosure mechanisms have been developed to measure and report the embedded emissions of the products. They have been developed by various actors – both governmental and non-governmental organisations, private sector, industries and transnational organisations – at different administrative levels covering various scopes and using a range of regulatory strategies.

Among these, this report conducts an in-depth analysis of major EEFs to delve into the intricate evolution of systems, examining both trends in existing and emerging schemes and their governance structures. The remaining 53 outtakes mostly consisted of initiatives in their developmental stages, lacking sufficient clarity in their descriptions to be fully considered. The proliferation of these resources underpinning EEFs highlights the growing recognition of the need for standardised emissions accounting methods across various industries. Of the identified EEFs, 27 specifically focus on product certifications, 11 on organisational certifications, and 6 combine both product and organisational certifications. This segmentation underscores the diverse approaches being taken to account for emissions at different levels of the supply chain, ranging from individual products to entire organisations.

Identification of major EEFs

This overview explores the prevalent and influential EEFs for the steel industry, highlighting their roles in fostering a more sustainable and responsible steel manufacturing landscape. The complete list of the schemes and guidelines is provided in the Appendix Table A1. An overview of a few EEFs are listed as:

- Responsible Steel Standard, version 2.0

The ‘Responsible Steel’ Standard encompasses a comprehensive array of sustainability principles governing the sourcing and production of steel. It addresses various aspects, including corporate leadership; environmental, social, and governance (ESG) management systems; occupational health and safety; labour and human rights; stakeholder engagement; local communities; climate change and greenhouse gas (GHG); noise; emissions; waste management; water conservation; biodiversity; and decommissioning. Version 2.0 specifically incorporates guidance for measuring and benchmarking GHG emissions during crude steel production.

- World Steel CO_2 Methodology update- provides a common basis of measurement of environmental and efficiency performance of steel products around the world. It outlines a steel specific standard based on ISO 14040: 20062 and ISO 14044: 2006, internationally agreed and universally applicable, to quantify resource use, energy and environmental

[2] www.iea.org/commentaries/collaboration-on-steel-and-cement-standards-is-crucial-for-global-markets

emissions associated with the manufacture of steel industry products, from the extraction of raw materials in the ground through to the point at which they are ready to be shipped from the steelworks (steel factory gate).

- Greenhouse Gas Protocol

The GHG Protocol, established by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), represent an inclusive initiative aiming to offer widely accepted GHG accounting standards and templates applicable across various industries. Within the GHG Protocol framework, the following relevant frameworks are explored:

1. Corporate Accounting and Reporting Standard (Corporate Standard): This standard presents fundamental carbon accounting principles under the GHG Protocol, designed for companies, non-governmental organisations (NGOs), government agencies, and other institutions developing an emissions inventory. The GHG Protocol, within these overarching guidelines, defines concepts like emissions scopes, widely adopted by other accounting methods.
2. GHG Emissions from Iron and Steel Production: This segment of the GHG Protocol provides industry-specific guidance for computing emissions related to iron and steel, extending beyond the scope of the general guidance provided in the Corporate Standard. The GHG Protocol's Iron and Steel guidance offers formulas for calculating emissions from industry-specific processes and instructions for managing unique accounting challenges, such as coproduct gas emissions.
3. Scope 2 Guidance: This guidance delivers updated recommendations for reporting indirect emissions stemming from energy and heat consumption, also known as scope 2 emissions within the parameters defined by the Corporate Standard. These guidelines serve to establish objectives, monitor emission reductions, and communicate progress to stakeholders.

- ISO 14404 Series

ISO 14404, released by the International Organization for Standardization (ISO), offers guidance on computing CO2 emissions from steel plants utilising diverse technologies and facility setups. ISO 14404-1 pertains to steel plants with blast furnaces, ISO 14404-2 addresses EAF steel plants, and ISO-14404-3 delves into EAF steel plants with coal or gas-based DRI facilities.

- Global GreenTag^{CertTM} GreenRate™ product certification

GreenRate™ stands as a thorough and comprehensive ecolabelling initiative, verified independently by a third party and designed in accordance with the ISO 14024 standard for environmental labels and declarations. In the certification process, pertinent BlueScope products undergo evaluation across multiple sustainability criteria. There are two separate ones for steel: COLORBOND® steel is manufactured to Australian Standards (AS 1397:2021 and AS/NZS 2728:2013). XLERPLATE® steel is typically used to manufacture structural sections for buildings, bridges, and stadiums and for other heavy industrial applications such as wind towers, pipelines, and storage tanks.

- ACRS (Australasian Certification Authority for Reinforcing and Structural Steels)

The ACRS Steel Certification Scheme is a program specifically developed to evaluate and certify the quality and performance of reinforcing and structural steels used in construction within Australasia. It is a 2-stage certification scheme conducting 8 areas of review and decision making on the conformity of steel products to one of more of 9 applicable standards (product requirements). The standards work as a benchmark and assurance mechanism, ensuring that the steel used in construction meets the necessary criteria for safety, reliability, and performance in compliance with regional standards.

- The Global steel Climate Council (GSCC)

The Global Steel Climate Council (GSCC) has introduced a technology-neutral global “Steel Climate standard” designed to measure and disclose carbon emissions specific to steel production. Aligned with a science-based trajectory aiming for a 1.5°C scenario by 2050, this standard sets a clear pathway for reducing emissions in the steel sector. To ensure credibility and accuracy, it mandates third-party verification of emissions data and requires the establishment of science-based targets.

- The Product Environmental Footprint (PEF)

The EU-PEF is indeed an initiative by the European Commission. It is designed to assess and quantify the environmental impact of a product throughout its entire life cycle, encompassing raw material extraction, production, distribution, use, and disposal. The goal of PEF is to create a standardised method for companies to measure and communicate the environmental performance of their products in a consistent and transparent manner. By utilising life cycle assessment (LCA) methodologies, PEF aims to provide a comprehensive understanding of a product's environmental impact, considering factors like carbon footprint, water usage, resource depletion, and other relevant indicators.

Evolution of EEFs

The increase in certifications, especially for steel products, has been substantial since the 1990s, with a notable surge in recent years. One of the earliest certifications examined, the Green Building Rating System (BREEAM), Environment Product Declarations (EPDs) has been a pioneer in assessing sustainability throughout the built environment lifecycle. However, more recent certifications, such as the GHG Protocol and the Science-Based Targets initiative (SBTi), World Steel Association Climate Action Data Provider Certificate, Responsible Steel, Pathfinder framework, Global Steel Climate Council (GSCC) Steel Climate Standard are specifically tailored to emissions reductions within the steel industry. Notably, the Responsible Steel Standard stands out, encompassing comprehensive principles covering various aspects of steel sourcing and production. These new frameworks are critical as they provide the sector with much-needed tools for setting targets and reporting progress in alignment with global climate goals, which is increasingly important as the steel industry contributes significantly to global carbon emissions.

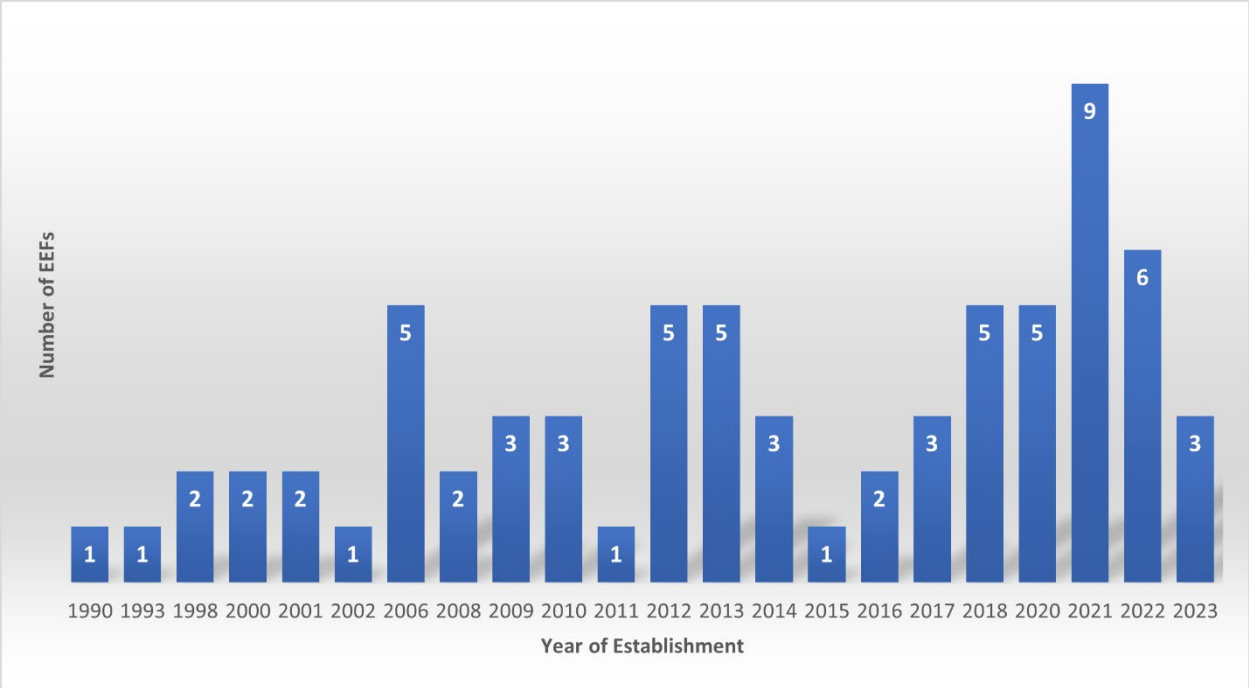

Figure 3.1 Evolution of steel EEFs: number EEFs by years

Sectoral focus

Notably, most of the frameworks analysed are concentrated in the construction and manufacturing sectors. This is not surprising, as these sectors are major consumers of steel and other heavy materials, and thus face immense pressure to reduce their carbon footprints. These sectors also present complex requirements for emissions accounting due to their broad supply chains and heavy reliance on industrial processes that emit large quantities of greenhouse gases (GHGs).

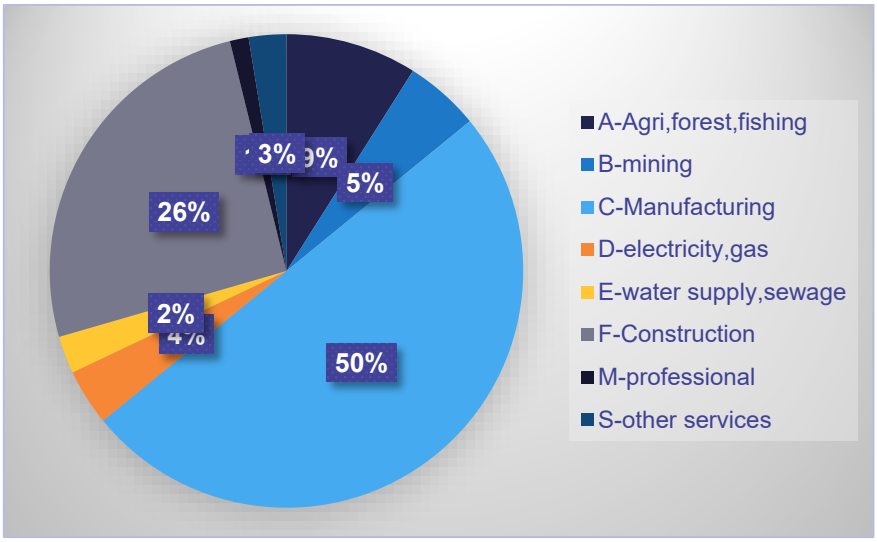

Figure 3.2 Sectoral focus of EEFs

Scope coverage

Another key finding is that most EEFs primarily focus on Scope 1 and Scope 2 emissions, which refer to direct emissions from owned or controlled sources and indirect emissions from purchased electricity, steam, and heating. Around 34% of the EEFs cover scope 1, 2 and partially scope 3, 19% on all scopes (1, 2 & 3) and 30% on lifecycle/footprint. There is, however, some attention given to Scope 3 emissions (only 6%), which encompass all other indirect emissions in a company's value chain, such as those from the production of raw materials or transportation. Scope 3 emissions are particularly challenging to quantify due to the complexity and variability of supply chain activities, which is why most frameworks treat them as optional or report them in more flexible terms. This treatment reflects the difficulty in achieving consistent and comparable reporting across organisations, especially when methodologies and boundary definitions vary widely. Moreover, there are different terminologies and metrics to present emissions accounting in the context of scope 1, 2 and 3 emissions, and direct and indirect emissions, with the use of different carbon accounting languages. For example, the EU OEF, GHG protocol and ISO use different terminologies which are inconsistent with schemes like Science-Based Targets (SBTs), carbon neutrality, climate neutrality and absolute zero[3]. This also highlights the need for better understanding to be developed in the context of emission accounting needs at the product, organisation, sector, and national levels. In addition, there are sector specific metrics with relevant to specific operational emissions, embedded emissions, financial investments and avoided emissions, which requires an agreement on metrics to be contextualised to show progress against the net zero targets. Science-based Targets initiative (SBTi) may allow such work for setting these appropriate metrics but does not get the information from countries where there is missing information on levels of emission reduction required. The reporting of scope 3 emissions remains optional in most standards, with no mandatory minimum level of reporting required for measuring and reporting the indirect emissions and allow flexibility for users to determine. On another side, only the GHG Protocol Corporate Value Chain Standard provides detailed guidance on accounting for Scope 3 (both upstream and downstream indirect emissions). However, limits the quantification of actual scope 3 emissions by allowing the openness of methodologies used to calculate these emissions. This particularly limits the comparability of emission inventories between the organisations and results are compromised with an absence of a consistent approach to doing the calculations and emissions accounting.

Compliance and reporting

The analysis also reveals that most of the EEFs are led by the private sector or industry organisations, with an increasing trend toward making these frameworks mandatory, for instance public procurement programs (e.g., US Buy Clean initiatives). Initially, many of these standards were voluntary, designed to guide businesses toward more sustainable practices. However, as the demand for emissions transparency and accountability grows, many of these initiatives are transitioning into mandatory requirements, particularly as stakeholders including governments, consumers, and investors demand more robust emissions

[3] HVMC. A review of carbon accounting tools and databases for consistent emissions accounting in the UK. 2022.

data. For example, the EU OEF/PEF frameworks are not yet universally mandatory but are gaining traction in regulatory discussions. This transition is critical for industries like steel, where emissions reporting is necessary not only for regulatory compliance but also for achieving climate goals such as carbon neutrality or net-zero emissions.

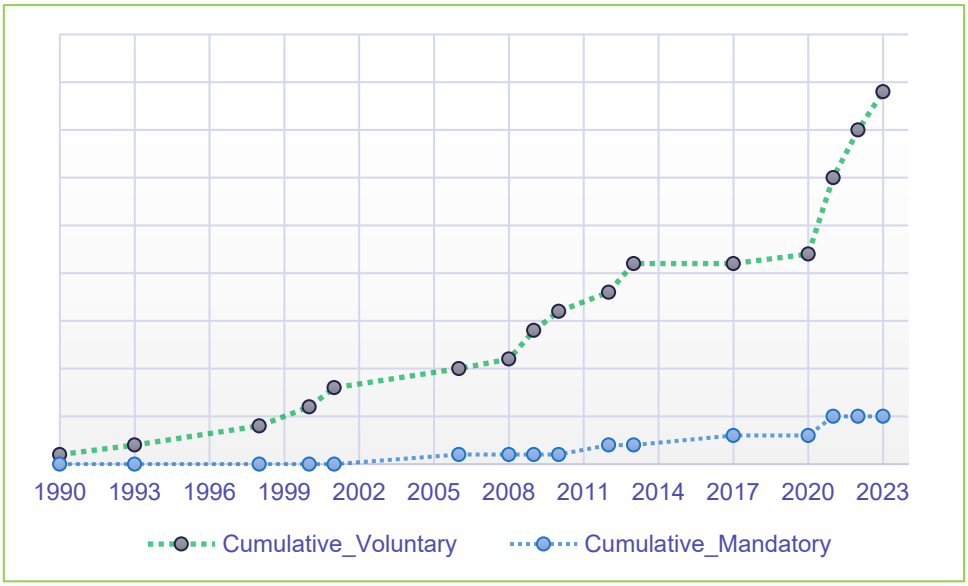

Figure 3.3 Trend of voluntary vs mandatory EEFs by year

The emphasis on mandatory reporting in recent years reflects broader market trends, where transparency in emissions accounting is becoming a competitive advantage for businesses. As such, the transition from voluntary to mandatory certifications is a significant step toward ensuring that all players in the steel sector, and beyond, are accountable for their emissions and are contributing to global decarbonisation goals. The shift toward mandatory reporting is also crucial in enhancing the consistency and comparability of emissions data across sectors and industries, which is essential for aligning with international climate agreements and achieving meaningful progress on emissions reductions

4. COMPARATIVE ANALYSIS OF MAJOR EEFS AND RELATED GUIDELINES AND STANDARDS

This section provides an in-depth analysis of the system boundaries, allocation principles, and scope coverage inherent in various embedded emissions frameworks (EEFs), identified through SNA. These were further evaluated based on key indicators:

- **System Boundaries:** defines the scope of emissions that is considered and how different methodologies define the physical or conceptual limits for assessing emissions (e.g., cradle-to-gate vs. cradle-to-grave) and their implications for accuracy and comparability.
- **Allocation Principles:** Examines the rules for distributing emissions among co-products, intermediates, or downstream applications, highlighting differences in fairness and transparency.
- **Scope Coverage**: Compares the treatment of emissions scopes (e.g., Scope 1, 2, and 3), including how comprehensively upstream and downstream activities are captured across frameworks. For example, in US taxonomy, in-facility energy is considered scope 1, and considered scope 2 in EU.

This approach provides a comprehensive understanding of the interplay between these key methodological elements and their implications for emissions accounting and policy design. Detailed analysis has been provided in Appendix Table A2.

4.1 MAJOR FINDINGS FROM COMPARATIVE ANALYSIS OF MAJOR EEFS

The analysis of embedded emissions accounting frameworks (EEFs) reveals several critical findings that highlight significant challenges in achieving consistent and comparable emissions reporting, particularly within the steel industry. These challenges primarily stem from variation in accounting methodologies, differences in system boundaries, and discrepancies in emission intensities.

- A central challenge identified in the landscape analysis is the inconsistency in emissions accounting methodologies across the various frameworks. These differences are particularly evident in the terminology used to classify emissions and the metrics employed to measure them. This is illustrated using a case study approach comparing various Embedded Emissions Frameworks (EEFs) applied to steel production, highlighting the variability in reported emissions from a single steel plant (appendix B).
- Inconsistent system boundary definitions across emissions accounting frameworks significantly hinder the comparability of emissions data across industries. The scope of included activities, such as transportation, supply chain emissions, or end-of-life processes, varies widely, leading to discrepancies in reported emissions. For example, some frameworks consider emissions from raw material extraction within the "cradle," while others exclude them entirely. Similarly, there is often a lack of clarity in defining boundaries, particularly in accounting for coproducts or byproducts, focus narrowly on direct emissions (Scope 1 and 2), others extend to include indirect upstream and downstream emissions (Scope 3). However, inconsistent methodologies for Scope 3 reporting further reduce reliability and comparability. These inconsistencies create barriers to establishing accurate and comprehensive emissions inventories, increasing the risk of double-counting emissions (e.g., overlapping upstream and downstream reports) or omitting critical activities (e.g., raw material extraction).
- Different emission intensity levels across frameworks create several challenges for emissions accounting, particularly for industries like steel, where production processes are energy-intensive and emissions vary significantly based on technology, energy sources, and material inputs

5. CONCLUSION

The current landscape of Embedded Emissions Frameworks (EEFs) is characterised by the proliferation of numerous methodologies, each with differing thresholds, emission intensity levels, and system boundaries. differences in how system boundaries are defined, and emissions are calculated result in inconsistent reporting of emissions volumes. This diversity has led to significant variability in emissions reporting, making it difficult to achieve consistency and comparability across industries and regions. Such fragmentation not only undermines transparency but also reduces the ability of stakeholders to make informed decisions based on standardised metrics.

Adding to this complexity is the unregulated nature of verification and certification schemes for EEFs. The absence of a harmonised regulatory framework has created uncertainty about the credibility and effectiveness of these frameworks. Without robust oversight, the potential for discrepancies and misuse increases, weakening the trust of industries, policymakers, and consumers in emissions accounting practices.

The challenges are particularly pronounced for internationally traded products, where the interoperability of EEFs is critical but largely lacking. Differing standards and accounting practices across borders make it harder for businesses to comply with emissions regulations and accurately account for embedded emissions in global supply chains. This misalignment complicates efforts to harmonise emissions accounting at a global level and places additional administrative burdens on industries operating in multiple jurisdictions.

Furthermore, the uneven regulatory burden along supply chains is evident in the vast differences in the completeness, accuracy, and compliance requirements for emissions accounting. While some stakeholders face stringent regulatory obligations, others operate with minimal accountability, creating an inequitable playing field. This disparity can discourage broad-based participation in emissions reduction efforts, limiting the overall effectiveness of decarbonisation initiatives.

Current EEFs also tend to focus heavily on energy-related emissions, providing limited incentives to explore decarbonisation pathways beyond energy. Key strategies, such as integrating circular economy practices and addressing material efficiency, remain underutilised. This narrow focus overlooks the critical role that circularity can play in reducing embedded emissions, particularly through material reuse and recycling. The lack of standards and alignment for circular economy emissions further exacerbates this issue, leaving circularity-related emissions unaccounted for in most frameworks.

Addressing these gaps requires a coordinated effort to integrate Embedded Emissions Accounting principles[4], establish robust verification and certification schemes, and develop standardised methodologies that can support a fair and effective transition to a low-carbon economy.

[4] White, Lee V., Emma Aisbett, Oscar Pearce, and Wenting Cheng. "Principles for embedded emissions accounting to support trade-related climate policy." *Climate Policy* (2024): 1-17.

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7. APPENDIX

TABLE A1: COMPREHENSIVE LANDSCAPE OF GLOBAL EEFS RELEVANT TO IRON AND/OR STEEL PRODUCTS

Name	Lead(s) (in bold) + participating organisations	Year of establishment	Scope/boundary coverage	Sectors covered (codes provided in the appendix)	Type: standards, protocol, certification, initiative, policy, tool/method
DGNB System	**DGNB- Deutsche Gesellschaft für Nachhaltiges Bauen- German Sustainability building council**	1990	Lifecycle/Footprint	F	
Australasian Certification Authority for Reinforcing and Structural Steels (ACRS) Sustainability Certification	ACRS	1998	Scope 1, Scope 2, Scope 3	F	Certification
Environmental Product Declaration	EPD International	1998	Lifecycle/Footprint	C, F	Tools/methods
Global Reporting Initiative (GRI) Standards	founded by **CERES and the Tellus Institute, with involvement of the UN Environment Programme.**	2000	Scope 1, Scope 2, Partial Scope 3	A, B,C, M, S	Standards, Protocol, initiative, tools/methods
GHG Protocol/product lifecycle/steel guideline/corporate standard	**World Resource Institute (WRI)**, World Business Council for Sustainable Development (WBCSD)	2001	Scope 1, Scope 2, Scope 3	A, B, C, M, S	Standards and protocols
Global GreenTag GreenRate Certification	Global GreenTag	2002	Lifecycle/Footprint	C, E, F, G	Certification
Bilan Carbone	**ADEME (Agence de l'environnement et de la maîtrise de l'énergie),** Manicore Consulting Firm, Groupe Caisse d'Epargne	2004	Lifecycle/Footprint	C, S	Tool/method
ISO 14067:2018 - Carbon Footprints of Products	ISO	2006	Scope 1, Scope 2, Partial Scope 3	A, B, C, D, E, F, G, H, I, R, T	Standard, tools/method
ISO 14064 Series	ISO	2006	Scope 1, Scope 2, Partial Scope 3	C	Standard, tools/method
CARES Sustainable Construction Steel (SCS) Scheme	Certification Authority for Reinforcing Steels (CARES)	2008	Lifecycle/Footprint	C, F	Certification

Industrial Deep Decarbonisation	**World Resources Institute (WRI)**, **United Nations Industrial Development Organization (UNIDO)** and the **International Organization for Standardization (ISO),** the Climate group, CDP, World Economic Forum (WEF), The Ellen MacArthur Foundation,	2009	Scope 3	C, F	Initiative
Kloeckner Metals Green Steel Definitions	Kloeckner Metals	2009	Scope 1, Scope 2, Scope 3	C, F	Standard, certification
Leadership in Energy and Environmental Design (LEED)	U.S. Green Building Council	2010	Lifecycle/Footprint	F	Standard
Responsible Steel International Standard and Certification	RESPONSIBLE STEEL	2010	Scope 1, Scope 2, Scope 3	C	Certification, Initiative
Green Star Green Building Rating Scheme	Global GreenTag	2010	Scope 1, Scope 2, Partial Scope 3	F	Certification
Xcarb Green Steel Certificates	**A**rcelorMittal	2012	Scope 3	C	Standard, Certification
India GHG Program	**WRI,** Indian federation	2012	Scope 1, Scope 2, Scope 3	A, B, C, M, S	Protocol, initiative
Ovako Environmental Product Declarations	**Ovako**, a prominent steel producer	2012	cradle-to-gate scopes, including raw material extraction, manufacturing processes, and delivery to the point of sale.	tools/methods, Protocol	Ovako Environmental Product Declarations
EU Product Environmental Footprint (PEF) Methodology	EU	2013	Lifecycle/Footprint	A, D, F, H, I, S	Tool/method
Carbon Disclosure Project (CDP)	**CDP Worldwide Group**, CDP Europe AISBL and CDP North America, Inc.	2013	Scope 1, Scope 2, Partial Scope 3	A, C, S	Standards, Protocol, initiative, tools/methods
ISO 14404 Series - Plant Level CO2 Emissions Intensity from Iron and Steel Production	International Organization for Standardization (ISO)	2013	Scope 1, Scope 2, Partial Scope 3	C	Standard, tools/method
American Iron and Steel Institute Steel Production Greenhouse Gas Emissions Calculation Methodology Guidelines	American Iron and Steel Institute	2017	Scope 1, Scope 2, Partial Scope 3	C	Protocol, tools/methods
OECD Guidance on Steel Products and Emission Measurement	Organisation for Economic Co-operation and Development (OECD)	2017			Policy, tools/methods,

Société Générale de Surveillance (SGS) Certification	SGS	2020	Lifecycle/Footprint	C,F	Certification
THE COALITION ON MATERIALS EMISSIONS TRANSPARENCY (COMET)	**Rocky Mountain Institute (RMI), MIT's sustainable supply chain initiative, Columbia centre on sustainable investment (CCSI), UN Climate Change**	2020	Scope 1, Scope 2, Scope 3	C, F	Protocol, initiative
Climate active-	Australian Government's certification program Department of Industry, Science, Energy and Resources.	2020	Scope 1, 2, and 3 Emissions	Across all industries.	Standard, certification, tools/method, initiative
Steel zero Initiative	Responsible Steel	2020	Scope 1, 2, and 3 Emissions		Initiative
Posco Greenate Certified Steel	POSCO steel manufacturers	2020	Scope 1, 2, and 3	C	certification
Bluemint Steel Certification	TATA Steel	2020	Scope 1, 2, and 3	C	certification
BlueScope's CarbonNeutral® Steel	BlueScope Steel	2021	Scope 1, 2, and 3	C	certification
EU Organisational Environmental Footprint (OEF) Method	**European Union (EU)**	2021	Scope 1, Scope 2, Partial Scope 3	A, B, C, S	Tool/method
Steel Sustainability Australia (SSA) Verified Supplier Certificate	Australian Steel Institute	2021	Lifecycle/Footprint	C, F	Certification
California Buy Clean Program – CALGreen California Green buildings standard code	California Department of General Services	2021	Lifecycle	C	Policy
Green Building Rating System BREEAM	**Building Research Establishment (BRE)**	2021	Lifecycle/Footprint	F	Standard
EU Green Public Procurement Standards	**EU**	2021	Scope 1, Scope 2, Scope 3	C, D, G, I, J, S	Policy
Climate Action 100+ for Steel Initiative	Climate Action 100+	2021	Scope 1, Scope 2	C	Initiative
United States Federal Buy Clean Initiative	U.S. Office of the Federal Chief Sustainability Officer	2021	Scope 1, Scope 2, Partial Scope 3	C, D, E, F	Policy
B Corporation Certification	B Corporation	2021	Scope 1, Scope 2	A, B, C, E, G, H, I, R, S	Certification
Infrastructure Sustainability Council (ISC) IS Rating Scheme	Infrastructure Sustainability Council (IS Council) for Australia and New Zealand	2021	Lifecycle/Footprint	F	Standard, certification
Climate Bonds Initiative's Criteria for Climate Bonds for the Steel Industry	The climate Bond (CBI)	2021	Scope 1, Scope 2, Partial Scope 3	C	Standard, certification, tools/method, initiative

European Union-United States Steel/Aluminum Embodied Carbon in Trade Negotiation	European Union (EU) and the United States (US)	2021	focus on the **cradle-to-gate** boundary.	Policy	
Mission Possible Partnership's Net Zero Steel Initiative	**The Energy Transitions Commission (ETC), We Mean Business Coalition, The World Economic Forum (WEF)**	2021	Scope 1, Scope 2, and Scope 3 emissions, assesses emissions from raw material extraction through to the point of production, ensuring that trade policies reflect the carbon intensity of these products up to the manufacturing stage.	Initiative	
First Movers Coalition Initiative	**World Economic Forum (WEF)** in collaboration with the U.S. State Department and Breakthrough Energy	2021	Scope 1, 2, and 3 Emissions	C, H	initiative
RINA Green Steel for Europe Project	**RINA**, an international engineering and certification company	2021	cradle-to-gate, lifecycle	tools/methods, Protocol	RINA Green Steel for Europe Project
German Steel Federation Green Label System	German Steel Federation	2022	Scope 1, Scope 2, Partial Scope 3	C	Certification
Pathfinder Framework	**WBCSD**: World Business Council for Sustainable Development, **RMI**: Rocky Mountain InstitutE, **EPD International**: Environmental Product Declaration International, **CDP**: Carbon Disclosure Project, Ecoinvet, Wrap,ipoint, microsoft	2022	Lifecycle/Footprint	B, C, D, E, F, H	protocol
Canada Green Public Procurement- Low carbon assets through LCA national guideline	Government of Canada	2022	Lifecycle/Footprint	C	Policy
IEA's Definition of Low-Carbon Steel	International Energy Agency (IEA)	2022	Scope 1, Scope 2, Partial Scope 3	C, F	Standards and protocols
World Steel Association Climate Action Data Provider Certificate	World Steel Association	2022	Scope 1, Scope 2, Partial Scope 3	C	Standard and protocols, initiative
Horizon Zero Initiative	Rocky Mountain Institute, RMI	2022	Scope 1, Scope 2, Partial Scope 3	B, C, D, G, H	Protocol, initiative
Product Carbon footprint guideline by tfs	Together for sustainability (TSF)	2022	Scope 3	C	Tools/methods

Science Based Targets Initiative for Steel	CDP (formerly the Carbon Disclosure Project), the United Nations Global Compact (UNGC), World Resources Institute (WRI), and the Worldwide Fund for Nature (WWF).	2022	Scope 1, Scope 2, Scope 3	C	Standard, certification, tools/method, initiative
Climate Neutral Certification	Climate Neutral Foundation	2022	Scope 1, 2, and upstream 3	Across all industries.	certification
International Sustainability and Carbon Certification (ISCC)	ISCC System GmbH	2023	Lifecycle/Footprint	A, B, C, D, H	certification
ArcelorMittal Low Carbon Emissions Steel Proposal	ArcelorMittal	2023	Scope 1, Scope 2, Partial Scope 3	C	Standard, Initiative
GreenPro Steel Certifications	JSW Steel	2023	Scope 1, Scope 2, Partial Scope 3	C, F	Certification
Global Steel Climate Council (GSCC) Steel Climate Standard	Global Steel Climate Council (GSCC)	2023	Scope 1, Scope 2, Scope 3	C	Standard
TÜV SÜD's VERIsteel Conformity Procedure	VERIsteel	2023	Scope 1, Scope 2	C, F	Protocols, standards
RMI Center for Climate Aligned Finance Initiative – Sustainable Steel Principles	Rocky Mountains Institute (RMI) Centre for Climate Aligned Finance	2023	Scope 1, Scope 2, and Scope 3) and recommend various accounting boundaries, including cradle-to-gate, cradle-to-grave, and cradle-to-cradle approaches.		protocol

TABLE A2: TECHNICAL ASSESSMENT OF MAJOR EEFS, CERTIFICATION AND VERIFICATION SCHEMES

MAJOR EEFS	DESCRIPTION	SYSTEM BOUNDARIES	ALLOCATION	SCOPE COVERAGE
Responsible Steel	a global certification program and standard-setting framework (Version 2.0) that promotes sustainable practices within the steel industry, focusing on environmental, social, and governance (ESG) criteria.	. Cradle to gate approach	Uses GHG Protocol guidance as its primary guidance for allocation methods. Defined based on either equity share or control (operational or financial). Consider all GHGs, including direct and indirect emissions	Scope 1 & 2, 3 is optional
World Steel	provides production-level emissions measurement guidelines, which calculates an overall site CO2 intensity irrespective of the product portfolio or location of the site. It has CO2 methodology (latest guidance available 2023) and LCI methodology (2017) The standard covers production (all routes) and 17 finished products	Cradle to gate system boundary, including recycling	physical allocation methods (mass or energy-based) and economic allocation when appropriate.	CO2 methodology includes direct emissions except emissions from fossil fuel supply, e.g. upstream fugitive methane. It only considers indirect emissions from raw materials manufacture, and doesn't include emissions from raw materials supply, emissions from waste treatment and associated processes. World steel LCI however, includes all GHGs –both direct and indirect
GHG Protocol	GHG Protocol Corporate Accounting and Reporting Standard	Defined based on either equity share or control (operational or financial). The GHG Protocol recommends against the use of cut-off criteria (that could exclude some emissions data) but indicates that decisions regarding the exclusion of Scope 3 emissions should consider size, influence, risk, stakeholders, etc.	Guided by ISO 14044 allocation hierarchy	Scope 1 & 2 focus on GHG emissions (expressed as carbon equivalents).
	GHG Protocol Scope 3 Accounting and Reporting Standard			Scope 3 (value chain)

				focus on GHG emissions (expressed as carbon equivalents).
	GHG Protocol Product Life Cycle Accounting and Reporting Standard	allows for cradle-to-gate or cradle-to-grave analysis,	GHG Protocol Product Standard specifies cut-off approaches and requires that 100% of system elements should be reported – exclusions can only be made if no data is available (including proxy data). specified cut-off approaches and exclusions are not allowed under the PEF guidance.	Scope 1, 2 & 3
ISO 20915: Life cycle inventory calculation methodology for steel products	product-level measurement methodology, developed in 2018 using the world steel LCI methodology as a guide	Direct: fossil fuel use in ironmaking, steelmaking and iron ore agglomeration and producing reducing agents; and off-gases. Indirect: electricity, heat and hydrogen; indirect fossil fuel and raw material supply; and waste treatment and associated processes. All GHG emissions, including CO2, CO, CH4 and N2O		
Bilan Carbone®	An organisational GHG accounting guidance document by Agence d l'Environnement et de la Maîtrise de l'Energie (ADEME) and Association Bilan Carbone® (ABC); version 8 was released in 2018 and is still current. The methodology can be used to calculate the GHG emissions of an organisation, an event, or a project. Unlike other GHG guidance, it considers all GHGs as opposed to the six Kyoto Protocol gases. It provides calculation templates for emissions factors and output that are relevant to reporting under other schemes.	Prioritises methods that include all the flows of material and energy that are biophysically relevant, rather than financial methods. It also covers methods for including capital goods in the assessment – guidance not provided in ISO 14064.	Follows the ISO guidance for multi-functional allocation, and when carrying out allocation for recycling specifies an avoided impacts method for open-loop recycling and the stock method for closed-loop recycling. It advises against economic allocation, with the view that it does not provide a foundation for a realistic representation of flows and their associated impacts.	Scope 1, 2 & 3 focus on GHG emissions (expressed as carbon equivalents).
Global Reporting Initiative (GRI) Standards	A suite of interconnected standards, with a structure of general, sector-specific, and topic-specific standards. It sets out principles and performance indicators that organisations can use to measure and report their economic, environmental, and social sustainability		No guidance available	focus on GHG emissions (expressed as carbon equivalents).

	performance. GHG emission reporting requirements are part of a wider standard on emissions based on the GHG Protocol (GRI305 Emissions 2016).			There are additional standards that help to account for a range of environmental, economic, and social indicators.
Carbon Disclosure Project, the CDP guidance	A disclosure system for investors, companies, cities, states, and regions to manage their environmental impact. Guided by a questionnaire format, the framework has three focus areas: climate, water, and forests. Companies reporting to CDP are scored according to reporting criteria, with the results published online.	Allows for various system boundary approaches to be taken, they recommend the use of financially determined boundaries to align with traditional accounting and reporting mechanisms.	No guidance available	focus on GHG emissions (expressed as carbon equivalents). offers guidelines for reporting on water foot printing alongside GHG emissions. emissions.
ISO 14044 SERIES **ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines**	This standard specifies and provides guidance for LCA, including specifying stages, covering the definition of goal and scope, life cycle inventory analysis (LCI), life cycle impact assessment (LCIA), life cycle interpretation, reporting and critical review. It works with ISO 14040:2006, *Environmental management – Life cycle assessment- Principles and framework*[19], as part of Environmental Management suite of standards that are owned and overseen by the Technical Committee ISO/TC 207 SC5.	ISO 14044 views the system boundary from the perspective of it determining which unit processes are included in the LCA. It focuses on the process of being iterative, starting with initial boundaries based on the goal and scope, and finishing with the boundaries determined by calculations and sensitivity analysis. ISO 14044 specifies cut-off approaches based on mass, energy, or environmental significance criteria. It allows for the selection of either an attributional approach (estimating what share of the global environmental burdens belong to a product) or consequential approach (estimating how the global environmental burdens are affected by the production and use of a product) to be taken towards data modelling.	ISO 14044 specifies that allocation should be avoided by applying process subdivision or system expansion. For the treatment of recycling allocation, no specific rule is specified under ISO 14044.	Scope 1, 2 & (3 is optional)
ISO 14067 SERIES **ISO 14067:2018 Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification**	ISO 14067 is based on the life cycle assessment standards ISO 14040 and ISO 14044, and it specifies principles for the quantification and reporting of the carbon footprint of a product. The standard provides for the adoption of product category rules (PCRs) that are aligned with the labelling requirements of ISO 14025. It addresses the single impact category of climate change only. The standard is owned and overseen by the Technical Committee ISO/TC 207 SC7, Greenhouse Gas Management and Related Activities.	allows for cradle-to-gate or cradle-to-grave analysis. BP-X30-323 excludes offsets, R&D, and employee and customer transport. ISO 14067 does not provide any specific cut-off criteria.	ISO 14067 links back to the guidance in ISO 14044 and provides example calculations for different open-loop and closed-loop recycling scenarios.	Scope 1, 2 & (3 is optional)

PAS 2050:2011 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services	The standard enables the entire life cycle assessment of GHG emissions of goods and services and mirrors the development period of the GHG Protocol Product Standard. It includes the entire stages from use-phase and land-use change emissions.	PAS 2050 allows for cradle-to-gate or cradle-to-grave analysis, stipulates the use of product-specific requirements if relevant, and where none are available, refers to the specification given by ISO 14044. It explicitly excludes capital goods (unless required under product category rules), human energy inputs, transport services provided by animals, transport of the consumer to and from point of retail purchase, and the commuting of employees. PAS 2050 specifies cut-off approaches and allows for 5% GWP to be excluded.	It provides calculations for estimating GHG emissions from reuse and where a product contains recycled or recyclable material. The latter uses different allocation approaches regarding how to take account of the various process emissions (including the recycled content method or closed-loop approximation method).	Scope 1, 2 & (3 is optional)
EU Product Environmental Footprint (PEF) method	A multi-criteria performance analysis of a product across its life cycle, covering the modelling of environmental impacts of the flow of materials and/or energy, emissions and waste streams associated with a product during its life cycle. It also includes product category specific methodological requirements for use in Product Environmental Footprint Category Rules (PEFCRs), which has been piloted by a range of sectors and the implementation started to get monitored in 2020.	Under the PEF method, the system boundaries should include all processes linked to the product supply chain relative to the unit of analysis, with a default approach of cradle-to-grave. The system boundaries should be divided into foreground processes and background processes	PEF follows the same multi-functional hierarchy as the OEF, with the provision of specific guidance and formula for recycling allocation scenarios.	Scope 1, 2 & (3 is optional)
Science-Based Target Initiative for Steel	offers a more granular methodology by introducing an iron & steel core boundary, differentiated pathways based on scrap input, and a mandatory scope 3 target covering upstream emissions from fuels, as well as aligning to the latest SBTi Criteria, Net-Zero Standard and 1.5°C ambition.	will report in agreement with the GHG Protocol Corporate Accounting Standard. The iron & steel core boundary closely matches the Responsible Steel Standard boundary, except for the inclusion of hot rolling for the SBTi, and the inclusion of upstream emissions for Responsible Steel.	The iron & steel core boundary closely matches the IEA “crude steel” system boundary for near zero emission steel production, except for upstream emissions from fossil fuel supply, which the IEA includes. Companies can use iron & steel Sectoral Decarbonisation Approach (SDA) or the cross-sector approach (Absolute Contraction Approach.	All scope 1 and 2 emissions shall be included. If a company’s relevant scope 3 emissions are 40% or more of total scope 1, 2 and 3 emissions, a scope 3 target is required. The coverage must be at least 67%. For calculation of the 40% threshold and the 67% coverage rate, scope 3 emissions from both inside and outside the iron & steel core boundary are to be considered.

A3: LIST OF SECTOR CODES

The sectors to which the scheme applies, coded in line with the ISIC international industry codes- The International standard industrial classification of all economic activities, abbreviated as ISIC, is a standard United Nations Statistics Division (UNSD) classification of economic activities arranged so that entities can be classified according to the activity they carry out.

Section, Divisions, Description

- A, 01–03, Agriculture, forestry and fishing
- B, 05–09, Mining and quarrying
- C, 10–33, Manufacturing
- D, 35, Electricity, gas, steam and air conditioning supply
- E, 36–39, Water supply; sewerage, waste management and remediation
- F, 41–43, Construction
- G, 45–47, Wholesale and retail trade; repair of motor vehicles and motorcycles
- H, 49–53, Transportation and storage
- I, 55–56, Accommodation and food service activities
- J, 58–63, Information and communication
- K, 64–66, Financial and insurance activities
- L, 68, Real estate activities
- M, 69–75, Professional, scientific and technical activities
- N, 77–82, Administrative and support service activities
- O, 84, Public administration and defence; compulsory social security
- P, 85, Education
- Q, 86–88, Human health and social work activities
- R, 90–93, Arts, entertainment and recreation
- S, 94–96, Other service activities
- T, 97–98, Activities of households as employers; undifferentiated goods- and services- producing activities of households for own use
- U, 99, Activities of extraterritorial organisations and bodies

TABLE A3: EXAMPLE OF VARIATION IN REPORTED EMISSIONS FROM A SINGLE STEEL PLANT (SOURCE: COMET 2022[5])

CO_2e Emissions Category	ISO 14404	Worldsteel	Environment Canada	GHG Protocol	Responsible Steel
Onsite Stationary Processes	16,863,987	16,866,287	13,579,633	15,365,804	16,345,458
Process-Critical Onsite	N/A	N/A	55,738	55,738	N/A[a]
Mobile Combustion					
Other Mobile Combustion under Company Control	N/A	N/A	N/A	36,927	N/A[a]
Credit from Byproduct Gas Export	(99,360)	(108,320)	(103,620)	(200,200)	(98,049)
Net Indirect Emissions from Other Materials	1,977,212	1,979,284	N/A	378,675	3,569,255
Net Indirect Emissions from Energy	(715,350)	(715,350)	N/A	47,157	50,400

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