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Ievgeniia Kopytsia
Yaroslav Mudryi National Law University

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guest ed. by Sunkung Choi and S.E. Weishaar with contributions by

Sunkung Choi

Kateryna Holzer/ Ievgeniia Kopytsia

Claudia Kettner/Eva Wretschitsch

Eunjung Kim

Xie Ying

Xiaoping Zhang

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ORIGINAL ARTICLE

Legal Challenges of Tracing Carbon Emissions in Steel Trade

Kateryna Holzer
University of Eastern Finland, Finland

Ievgeniia Kopytsia
University of Eastern Finland, Finland

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Abstract
Recent initiatives on carbon restrictions on trade, such as the EU carbon border adjustment mechanism (CBAM), the US proposal on a Global Arrangement on Sustainable Steel and Aluminium, and the G7 Climate Club, raise questions of both legal and practical nature. Specifically, how the carbon footprint of imports will be determined and what the role of sector-related decarbonization initiatives and emissions certification schemes will be in this process. Different production methods and energy sources of steel production across countries, coupled with the absence of common emission accounting methodologies and universally accepted certification schemes in the steel industry, present a significant challenge for measurement and verification of carbon emissions in global value chains. Drawing on the case study of South Korea's steel exports to the EU and having analyzed the regulatory frameworks for emissions reductions in the steel sector of the EU and Korea, and the role of carbon pricing instruments in stimulating the transition to low-carbon steel production, this article comes to the conclusion that EU's use of its own MRV system for the verification of actual emissions of foreign producers will raise administrative costs of the EU CBAM and risks of trade tensions. The EU should therefore take the lead in creating a comprehensive international framework for tracing emissions in products, including steel. This can be achieved through leveraging the G7 Climate Club platform, garnering support from international organizations, fostering public-private steel decarbonization partnerships, and promoting cross-border collaboration among major steel manufacturers to facilitate data and best practice sharing.

Introduction

Steel is an essential production input for virtually all manufacturing sectors. Due to its high strength, durability, recyclability, and ease with which it can be used to manufacture goods, and its relatively low cost, steel as a production input cannot be substituted in the foreseeable future.[1] At the same time, steel production is very carbon-intensive due to a heavy reliance on burning coal. It accounts for about 7 percent of all greenhouse gas (GHG) emissions.[2] In the EU, steel is the highest CO_2 emitter of all industrial sectors, responsible for about 6 percent of total EU GHG emissions.[3] In South Korea, where 70 percent of steel production is dependent on the use of coal-based blast furnace-basic oxygen furnaces, the steel industry accounts for 18 percent of its total GHG emissions.[4]

Corresponding author
Kateryna Holzer
Law School, University of Eastern Finland, Joensuu, Finland
Email: kateryna.holzer[at]uef.fi

Reducing emissions from steel has been emphasized as one of the key conditions to achieve the Paris Agreement 1.5 degrees target in the 6th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).[5] To achieve this target, direct CO_2 emissions from the steel and other heavy industries would need to fall by 90–95 percent by 2050.[6] Emissions from steel alone must fall by at least 30 percent by 2030[7] and by 50 percent by 2050, with continuing declines towards zero emissions being pursued thereafter.[8] This is a difficult task, given the high costs of green steel technologies and the low substitution of steel as a production input. Despite the fact that between 1975 and 2015 steel production managed to cut energy use in half due to technological advances and, where it was possible, a shift from traditional blast furnaces toward electric arc furnaces,[9] the steel demand is predicted to steadily increase in the coming decades by more than a third by 2050, particularly in developing countries.[10] This will likely outpace the incremental decreases in the energy and carbon intensity of steel production.

The largest steel-producing countries have adopted national plans to decarbonize their steel industries. China, being the world's largest steel-producing country,[11] outlined the aim to increase the use of scrap in steelmaking by 30 percent by 2025 relative to estimates for 2020.[12] This intention is part of China's 14th Five-Year Plan (2021–2025) that focuses on innovation-driven growth, low-carbon development, and the creation of a circular economy. Similarly, India, which is the second largest steel-producing country in the world, has adopted a Steel Scrap Recycling Policy that aims to promote a circular economy in the steel sector by facilitating steel recycling across the product life cycle.[13]

The EU, accounting for 7.8 percent of global crude steel production in 2021,[14] and some other developed countries, driven by their ambitious national climate policies and commitments under the Paris Agreement, are planning to increase restrictions on the consumption of dirty steel and other products causing heavy emissions. A carbon border adjustment mechanism (CBAM) will apply to steel imports in parallel to the charge imposed on domestically produced steel through emissions allowances distributed under the EU emissions trading system (EU ETS). Starting from 1 October 2023, steel imported from countries without equivalent carbon prices will be subject to an emission reporting requirement, and starting from 2026, it will be charged a carbon fee for each tonne of CO2 embedded in the imported steel product.[15] Similarly, the US has launched negotiations with the EU on a trade arrangement, according to which dirty and dumped steel and aluminium will be banned from the US and the EU market.[16] This arrangement will be open for other countries to join so long as they meet criteria relating to "market orientation and reducing trade in high carbon-steel and aluminium products".[17] The arrangement, which is planned to be negotiated by the end of 2023, would become the world's first carbon-based sectoral arrangement on steel and aluminium trade. Moreover, following the EU Commission's proposal on a CBAM, the US Senate has introduced a legislative proposal for a Clean Competition Act, which pairs a border adjustment mechanism with a domestic carbon tax on certain high-emissions goods, including steel.[18] The mechanism is supposed to put charges on imports from carbon-intensive manufacturers encouraging decarbonization efforts.

These policy initiatives raise questions of both legal and practical nature, particularly how the carbon footprint of imports will be determined and what the role of sector-related decarbonization initiatives and emissions certification schemes will be in this process. Measurement and verification of emissions in global value

1. IEA, *Iron, and Steel* (Paris: IEA, 2022), https://www.iea.org/reports/iron-and-steel. Global crude steel production has nearly tripled over the past 50 years. Steel is also widely traded along global value chains. In 2021, global steel exports reached 458 million tonnes representing around 25 of global steel production. See Mateo Ferrero et al., *Trade and Climate Change: Decarbonization standards and the iron and steel sector: how can the WTO support greater coherence?* (Geneva: WTO Secretariat, 2022) https://www.wto.org/english/tratop_e/envir_e/trade-climate-change_info_brief_no7_e.pdf

2. Owen-Burge, "Steel and COP27.", https://climatechampions.unfccc.int/steel-cop27/.

3. Julian Somers, *Technologies to Decarbonise the EU Steel Industry* (Luxemburg: JRC Publications Repository, 2022), https://publications.jrc.ec.europa.eu/repository/handle/JRC127468.

4. Kim, Suarez, and Ecal, "Unveiling the Truth Behind Blast Furnace Pollution in South Korea –." https://energyandcleanair.org/publication/unveiling-the-truth-behind-blast-furnace-pollution/

5. Igor Bashmakov et al., ''Industry''. *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*

6. IEA, *World Energy Outlook 2022–Analysis,* https://www.iea.org/reports/world-energy-outlook-2022.

7. Gerres et al., Green Steel Production: How G7 Countries Can Help Change the Global Landscape, (Leadership Group for Industry Transition, 2021), https://www.industrytransition.org/insights/g7-green-steel-production/.

8. IEA, *Iron and Steel Technology Roadmap,* 26

9. IEA. *World Energy Outlook 2022,* 5

10. Ali Hasanbeigi, *Steel Climate Impact, (Florida: Global Efficiency Intelligence,* April 2022), https://static1.squarespace.com/static/5877e86f9de4bb8bce72105c/t/624ebc5e1f5e2f3078c53a07/1649327229553/Steel+climate+impact-benchmarking+report+7April2022.pdf.

11. In 2021 China was responsible for 52,9% of the world's total crude steel production, in the amount of 1 032.8 billion of tonnes. See: "China: Global Crude Steel Production Share 2021," Statista (Statista Research Department, February 3, 2023), https://www.statista.com/statistics/448874/china-share-in-worldwide-crude-steel-production/. 92% of steel in China is currently produced via BF-BOF. As a result, the steel sector is responsible for more than 30% of total coal use in China and has been the main source of growth in demand for coal. From: Belinda Schäpe and Byford Tsang, "Opinion: China's Crucial Role in Decarbonising

chains present a great challenge. This is because different production methods and energy sources are used for the production of steel products across countries and there are no common emission accounting methodologies and universally accepted certification schemes in the steel industry. Therefore, steel trade under carbon restrictions requires coordination on carbon standards, emission accounting methodologies, verification and certification procedures between importing and exporting countries.

Our article is aimed to examine the implications of the lack of unified steel emissions accounting methodologies on the implementation of carbon-related trade restrictions. To this end, we focus on the steel trade between the EU and South Korea in the context of the pending EU CBAM. Section 2 begins by comparing the emissions intensity of the EU and South Korean steel industries and their progress in the transition to low-carbon production methods. In section 3, we discuss the differences in the regulatory frameworks for emissions reductions in the steel sector of the EU and Korea and the role of carbon pricing instruments, such as emissions trading schemes, in stimulating the transition to low-carbon steel production. Section 4 deals with the EU CBAM and its implications for Korean steel exports. Section 5 highlights practical challenges arising from the lack of consistency and coordination in the use of steel sector emissions accounting methodologies hampering the implementation of the EU CBAM. Finally, in section 6, we underline the importance of agreement between importing and exporting countries on the ways of tracing emissions embedded in products and conclude with a brief discussion of prospects for international cooperation on emissions measurement methodologies and certification in the steel sector for the benefit of trade and climate.

Charting low-carbon steelmaking routes

Steel is primarily produced by one of the two methods: a blast furnace-basic oxygen furnace converting iron ore to steel and an electric arc furnace converting scrap to steel. The blast furnace-basic oxygen furnace (BF-BOF) route is the most widespread production method of primary steelmaking currently taking over 70 percent of the global steel production.[19] This method primarily relies on coal-based blast furnaces emitting huge amounts of carbon. For each tonne of steel produced in this route, between 1.5 and 3 tonnes of carbon are released into the atmosphere.[20] While BF-BOF plants have optimized their material and energy flows over the years, they are operating close to optimum levels.[21] This means that comprehensive decarbonization of the steel sector depends on the introduction of low-carbon solutions for primary steel production.[22] One of them is the use of green hydrogen in the direct reduced iron (DRI) route, which is used for a growing but still relatively small amount of primary steelmaking.[23]

The second major way of steel production is the electric arc furnace (EAF) route, also known as secondary steelmaking. It is the process of melting steel scrap in a furnace using the heat generated by a high-power electric arc. Due to the use of electricity to produce heat, EAF production is less carbon-intensive than BF-BOF, with an average of 1.2t CO_2 per tonne of crude steel.[24] In 2021, EAF production accounted for approximately 28 percent of global steel production.[25] Notably, the share of EAF has increased compared to 2019, which from decarbonization perspectives, is envisioned as the way to ensure significant emission reductions without innovation.[26] While the EAF is the preferred process for its lower energy and emissions intensity compared to BF-BOF, its potential is limited by scrap availability. However, in some countries, like the US, the share

the Global Steel Sector," China Dialogue (China Dialogue , May 24, 2022), https://chinadialogue.net/en/climate/opinion-chinas-crucial-role-in-decarbonising-the-global-steel-sector/.

12. Asian Development Bank. "The 14th Five-Year Plan of the People's Republic of China—Fostering," https://www.adb.org/publications/14th-five-year-plan-high-quality-development-prc.

13. "Steel Scrap Recycling Policy." https://pib.gov.in/newsite/PrintRelease.aspx?relid=194359.

14. World Steel Association, "2022 World Steel in Figures", 2022, https://worldsteel.org/wp-content/uploads/World-Steel-in-Figures-2022.pdf

15. European Commission, *Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism,* July 14, 2021.https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52021PC0564

16. "Joint EU-US Statement on a Global Arrangement on Sustainable Steel and Aluminium." https://ec.europa.eu/commission/presscorner/detail/en/IP_21_5724.

17. "Fact Sheet: The United States and European Union to Negotiate World's First Carbon-Based Sectoral Arrangement on Steel and Aluminum Trade," FACT SHEET: The United States and European Union To Negotiate World's First Carbon-Based Sectoral Arrangement on Steel and Aluminum Trade | The American Presidency Project, October 31, 2021, https://www.presidency.ucsb.edu/documents/fact-sheet-the-united-states-and-european-union-negotiate-worlds-first-carbon-based.

18. Read twice by the Senate, the bill is currently referred to the Committee on Finance. See 'A bill to amend the Internal Revenue Code of 1986 to create a carbon border adjustment based on carbon intensity, and for other purposes' See: Congress.gov. "Text - S.4355 - 117th Congress (2021-2022): Clean Competition Act."https://www.congress.gov/bill/117th-congress/senate-bill/4355/text.

19. IEA, *Iron and Steel Technology Roadmap.*

20. Ali Hasanbeigi and Cecilia Springer, *How Clean is the U.S. Steel Industry? An International Benchmarking of Energy and CO2 Intensities.* (San Francisco CA: Global Efficiency Intelligence, 2019) https://www.belfercenter.org/sites/default/files/files/publication/how-clean-is-the-us-steel-industry-nv.pdf

21. IEA, Iron and Steel Technology Roadmap

22. In blast furnaces, steel is made by injecting oxygen through a lance (blower) above a molten mixture of pig iron and scrap steel. Injecting oxygen lowers the carbon content of iron converting it into

of steel produced in EAF has reached 70 percent.[27]

The EU produces more steel from scrap than Korea, which makes its average steel carbon intensity comparatively lower and hence less vulnerable to carbon costs. In 2021, 56 percent of EU steel was produced via the BF-BOF and 44 percent via the EAF production route.[28] Whereas in Korea in the same year, 68 percent of steel was produced via the BF-BOF, and only 32 percent was made via the EAF production route.[29] Korea's largest steel plants, the POSCO-operated *Gwangyang* and *Pohang* plants and the *Hyundai Steel*-operated *Dangjin* plants, operate with BF-BOF facilities. Thus, around 70 percent of Korea's crude steel is produced from integrated BF-BOFs, accounting for about 92 percent of Korea's steel sector emissions.[30]

Several studies have pointed out that to keep up with the 2050 net-zero target, fundamental changes in the steelmaking process should be urgently made, particularly through the implementation of breakthrough low-carbon technologies.[31] Currently, several technological options exist for very low to zero emissions steel production (Table 1).

Green hydrogen-based Direct Reduced Iron and Electric Arc Furnace steel production (H2-DRI-EAF)			
Technology description	**Advantages**	**Limitations**	**Availability**
H2-DRI-EAF route Hydrogen-based direct reduction of iron (DRI) and EAF steel production	Replaces fossil fuels in the DRI production stage with hydrogen produced with renewable energy. Technically proven production method, enables nearly emission-free steel production	Depends on energy and ore feedstock cost, economies of scale and CO_2 price of more than USD 67/t.[32] Increased demand for electricity.[33]	One H2-DRI commercial plant *HYBRIT, ArcelorMittal*. Recently announced projects: *SALCOS* (Germany), *Liberty Steel* DRI plant (France), *Iberdrola* - H2 Green Steel (Iberian Peninsula), *Green Steel* - H2V CAP (Chile).
Carbon Capture and Storage and/or Utilization (CCUS)			
Carbon Capture and Storage (CCS) route Captures CO_2 from large point sources, transports to a storage site, and deposits.	Applicable on BF-BOF / SR-BOF / DRI-EAF plants. Economically attractive due to subsidies and tax credits.[34]	Requires CO_2 transport and storage infrastructure. 10-50 % additional costs to conventional technology.[35]	One operational CCS plant: *Emirates Steel*, DRI Unit (Abu Dhabi), annual 800kt of CO_2 captured.[36]Several demonstration projects at different stages of development. No BF-BOF plant in operation or development
Carbon capture and utilization (CCU) route Uses CO_2 to create new products for the chemical industry, such as ammoniac or bioethanol.[37]	Increases the economic value of CCUS projects, makes it possible to commercialize CCUS technology.[38]	Technologically premature, not economically proven. Requires developing synergies between the steel, chemical and energy to re-use CO_2 produced in the BOF.[39]	Several demonstration projects at different stages of development. Ternium DRI facilities (Mexico) captures CO_2 captures for use.

Table 1. Most promising carbon low-carbon technologies for the steel industry

At the same time, for primary steel production, the technological transformation required in the first place, low-carbon steelmaking technologies are not currently available in the market.[40] Accelerating commercialization of innovative technologies that replace carbon-based DRI with green hydrogen-based DRI or using carbon capture, utilization, and storage (CCUS) is critical. To comply with the Net Zero Scenario developed by the International Energy Agency (IEA),[41] such technologies must be developed at a commercial scale and enter the deployment stage before 2030.[42] In particular, the H2-DRI and CCUS-equipped routes would need to account for more than 5 percent of primary production by 2030, which, considering the current stage of technical readiness, is quite challenging. Under the IEA Sustainable Development Scenario, CCUS technology needs to be

steel. In this process, coking coal is used in the blast furnace, first, as a fuel to produce added heat; second, as a chemical-reducing agent for the reduction of iron oxides; and, third, as a permeable support in the molten iron in the furnace. See : Kentucky Geological Survey, "Coal to Make Coke and Steel, Kentucky Geological Survey, University of Kentucky," Earth Resources - Our Common Wealth, accessed February 6, 2023, https://www.uky.edu/KGS/coal/coal-for-cokesteel.php.

23. "Breakthrough Agenda Report 2022 – Analysis." https://iea.blob.core.windows.net/assets/49ae4839-90a9-4d88-92bc-371e2b24546a/THEBREAKTHROUGHAGENDAREPORT2022.pdf

24. Hasanbeigi and Springer, "HOW CLEAN IS THE U.S. STEEL INDUSTRY?", https://www.belfercenter.org/sites/default/files/files/publication/how-clean-is-the-us-steel-industry-nv.pdf

25. IEA, *Iron, and Steel Technology Roadmap*

26. IEA, *Iron and Steel Technology Roadmap.*

27. See https://www.recyclingtoday.com/article/the-growth-of-eaf-steelmaking/

28. "World Steel in Figures 2022." https://worldsteel.org/steel-topics/statistics/world-steel-in-figures-2022/#crude-steel-production-by-process-2021

29. "World Steel in Figures 2022." https://worldsteel.org/steel-topics/statistics/world-steel-in-figures-2022/#crude-steel-production-by-process-2021

30. "Steel Sector to Play a Key Role in 2050 Carbon Neutrality Pathway." https://forourclimate.org/en/sub/news/view.htmlidx105

31. Arens et al., 2017; Bataille et al., 2018; Fischedick et al., 2014; Toktarova et al., 2020), as well as private sector and institutional reports (Agora Energiewende and Wuppertal Institute, 2021; BloombergNEF, 2021a; Energy Transitions Commission, 2018; Fleiter et al., 2019; IEA, 2020; Material Economics, 2019; McKinsey, 2018

32. "InnovativeSolutionsToDecarbonizeIronAnd Steel Sector." https://www.irena.org/-/media/Files/IRENA/Agency/Events/2022/Mar/IID22_Canada_Day-2_S4-and-closing.pdf?la=en&hash=BAA30CE010EA89510A062997BB540C8338470D08

33. A tripling of electricity demand is projected in the German or Swedish steel industries if hydrogen-direct reduced iron and electric arc furnace steelmaking (DRI EAFs) replaces BF-BOFs. Igor Bashmakov et al., ''Industry''. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

applied to more than 53 percent of primary steel production by 2050, and about 75 percent of all the CO2 emitted globally from steelmaking must be captured by 2070.[43]To meet the goal, an average of 14 steel plants operating with CCUS need to be built every year from 2030 to 2070, making the scale-up challenges considerable.[44]

In addition to time constraints, the low-carbon technologies are currently very expensive, and their adoption would increase the steel price by 50 percent.[45] In the EU, for instance, it is projected that H2-DRI-EAF would reduce CO2 in Europe to about 0.1 metric ton per metric ton of steel in 2030 with the costs increase of 70 percent, or €260 per metric ton of steel.[46] This means that the commercialization of green H2-DRI-EAF inevitably requires governmental support, including fiscal incentives like pricing mechanisms, green public procurement policies, tax benefits, and other green subsidies.[47]

Regulating emissions in domestic steel production

To support the commercialization of near-zero-emission steel production technologies, governments are compelled to adopt adequate regulatory frameworks with concrete industry performance targets and push and pull mechanisms. The EU is pursuing a transition to low-carbon steel production methods as part of industrial decarbonization under the strategy to reduce GHG emissions by at least 55 percent by 2030. The target is anchored in the European Climate Law and supported by the comprehensive Fit for 55 legislation package developed in accordance with the European Green Deal and the long-term objective to become the first climate-neutral continent by 2050.[48] As stated in the European Commission's 2020 Industrial Strategy and its 2021 update, for these goals to be reached, the EU industry, including the iron and steel sector, will need to change its current highly carbon-intensive production processes.

While the EU and its Member States have several demand and supply-side instruments in their policy toolbox to create a supportive regulatory environment for steel industry decarbonization[48], the EU ETS is the main mechanism of reducing emissions from the steel. However, it has had a limited impact on steel emissions reduction so far. This is mainly because of the free allocation of emission allowances, which was long used as the main tool for preventing carbon leakage in the energy-intensive and trade-exposed (EITE) sectors. Since the early functioning of the EU ETS, the iron and steel sector, like other EITE industries, has been shielded from the full carbon price through the distribution of emission allowances for free. While this has effectively protected the industry from carbon leakage risks, it has not provided a sufficient incentive to transition to climate-neutral technologies. The free allocation rules based on technology-specific product benchmarks in the iron and steel sector, such as the blast furnace-made hot metal benchmark, have incentivized only incremental emission reduction improvements at the expense of deploying new breakthrough technologies.[49] As installations deploying innovative technologies can fall out of the specific product benchmark for free allocation, they are at a competitive disadvantage compared to existing technologies. This issue has been identified in the Commission's ETS revision proposal,[50] which suggests reviewing the benchmark definitions to make them technology-neutral, ensuring equal treatment of installations independently of the technology used.

Investments in low-carbon technologies were disincentivized by the low carbon price as a consequence of free allocation. The average ETS price in 2020 of 25€/t CO_2 was far below the current indicative breakeven costs of zero-car-

34. Carbon Clean, "Carbon Capture, Utilisation and Storage for the Steel Industry." https://www.carbonclean.com/blog/steel-carbon-capture

35. "Carbon Capture and Storage (CCS)." https://www.saisi.org/wp-content/uploads/2021/06/Carbon-Capture-Storage-Fact-Sheet.pdf

36. "Carbon Capture and Storage (CCS)." https://www.saisi.org/wp-content/uploads/2021/06/Carbon-Capture-Storage-Fact-Sheet.pdf

37. Christian Hoffmann, Michel Van Hoey, and Benedikt Zeumer. *Decarbonization Challenge for Steel.* (McKinsey & Company, 2020), https://www.mckinsey.com/~/media/McKinsey/Industries/Metals%20and%20Mining/Our%20Insights/Decarbonization%20challenge%20for%20steel/Decarbonization-challenge-for-steel.pdf

38. Yao et al., "Economic Feasibility Analysis of Carbon Capture Technology in Steelworks Based on System Dynamics."

39. De Ras et al., "Carbon Capture and Utilization in the Steel Industry: Challenges and Opportunities for Chemical Engineering," https://doi.org/10.1016/j.coche.2019.09.001.

40. In addition to breakthrough technologies, decarbonization of the steel sector requires the integration of material use efficiency, recycling and biomass replacing coal/coke in BF-BOF. However, these pathways can provide only with a CO2 emissions reduction, not elimination, and are not a long-term solution, compatible with near zero emission targets. As an example, material efficiency can potentially reduce steel demand by up to 40% based on design with less steel use, long life, reuse, constructability and low contamination recycling. See Igor Bashmakov et al., ''Industry''.*Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*.

41. "Net Zero Emissions by 2050 Scenario (NZE)–Global Energy and Climate Model–Analysis." https://www.iea.org/reports/global-energy-and-climate-model/net-zero-emissions-by-2050-scenario-nze.

42. IEA, *Iron, and Steel Technology Roadmap*

.43.IEA. *Clean Energy Innovation,* (Paris: IEA, 2020), https://www.iea.org/reports/clean-energy-innovation/innovation-needs-in-the-sustainable-development-scenario

44. "Carbon Capture and Storage (CCS)." https://www.saisi.org/wp-content/uploads/2021/06/Carbon-Capture-Storage-Fact-Sheet.pdf

45.Voigt et al., "Transforming the Steel Industry May Be the Ultimate Climate Challenge." https://www.bcg.com/publications/2022/steel-indusbon technologies.[51] Only in 2021, in the wake of adopting the Fit for 55 legislative package and in anticipation of stricter emissions restrictions, the ETS prices reached record levels climbing over 80€/t CO_2 and higher. Following the increased climate ambition, the emissions reduction target for ETS sectors, including the iron and steel industry, has been increased to 62 percent by 2030 vs. 2005.[52] The updated target will entail a graduate phase-out of free allocation of emission allowances during 2026-2034[53] and, consequently, a sharp rise in the carbon price that will motivate steel producers to speed up the transition to low-carbon production methods.

The EU has taken the global leadership in steel decarbonization. As of autumn 2021, 42 percent of the world's announced new low-carbon steelmaking projects were located in the EU.[54] As of November 2022, sixty low-carbon projects (with a technology readiness level of at least 7 out of 9) have been launched in the EU, with an expected start before 2030.[55] The vast majority of the projects aim to support the technological transition from conventional, coal-based blast furnaces by implementing innovative (hydrogen-based) DRI and EAF routes, as well as CCUS technologies. To name just a few, the German industrial group *Thyssenkrupp* is planning to replace the coal-fueled blast furnace in its *Duisburg* plant with H2-DRI plants to produce low-carbon steel within the existing plant structure.[56]Another German flat steelmaker *Salzgitter,* going to convert its integrated steelworks into low-carbon crude steel production in three stages over the period until 2033 by building hydrogen-based DRI and EAF plants to replace the conventional blast furnaces.[57] A recently created Swedish steel producer *H2 Green Steel,* is planning to build a DRI unit powered entirely through green hydrogen, with a facility expected to reach its full capacity by 2026.[58] Moreover, some projects are working on incorporating CCU, such as the use of internal CO_2 to produce fuels by *ArcelorMittal***,** the conversion of metallurgical gases into valuable base chemicals by *Thyssenkrupp Steel Europe*, the use of waste heat and carbon dioxide for food production in greenhouses by *Höganäs* etc.[59]

In light of the recent developments in the steel decarbonization policy of the EU, Korea, being the sixth largest steel producer and the fourth largest steel exporter in the world,[60] cannot stand aside from the steel decarbonization path. Moreover, the achievement of the 2050 carbon neutrality goal fixed in the Korean legislation[61] is impossible without the effective decarbonization of its steel sector, taking into consideration that Korea's steel industry is the largest emitter of GHGs in the industrial sector accounting for 39 percent of all industrial GHG emissions and 13 percent of the country's total GHG output in 2018.[62]

In response to the Korean 2050 Carbon-Neutral Strategy and the Carbon Neutral Green Growth Framework Act for Response to Climate Crisis,[63] the Korean Iron and Steel Association released the '2050 Net Zero Declaration' signed by all its member companies stating a commitment to the decarbonization of the steel sector.[64] The leading Korean steelmakers *POSCO* and *Hyundai Steel* have both supported the Korean government's 2050 net zero target.[65,] In addition, the Green Steel Committee, a collective body of industries, academic institutions, and government agencies launched by the Ministry of Trade, Industry, and Energy of Korea, adopted the 'Net-zero Carbon Joint Declaration 2050' aimed at gearing up the domestic steel industry for carbon neutrality with five key action plans accelerating the sector's technological innovation and investment.[66]

Regarding the practical implementation of emission reduction strategies in the steel sector, the steel industry emissions in Korea, like in the EU, are primarily regulated by the requirements set by the Korean national emissions

try-carbon-emissions-challenge-solutions.

46. Voigt et al., "Transforming the Steel Industry May Be the Ultimate Climate Challenge." https://www.bcg.com/publications/2022/steel-industry-carbon-emissions-challenge-solutions.

47. Igor Bashmakov et al., 'Industry'. *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*

48. E.g. carbon contracts for difference and green public procurement (GPP). GPP, as a demand-side policy, has a great potential to support the deployment and commercialization of green steel technologies and scale up markets for green and circular steel. However, despite the fact that the EU GPP procedure is in place, it is a voluntary instrument covering only a limited number of products and does not include steel or other base materials. See "Green Public Procurement - Environment - European Commission." https://ec.europa.eu/environment/gpp/index_en.htm

49. Somers, *Technologies to Decarbonise the EU Steel Industry,* 12

50. James Killick, William De Catelle, Guillermo Giralda Fustes, "European Parliament and Council Adopt Positions on ETS and CBAM Proposals: Next Steps-Final Agreement & Formal Adoption," White & Case LLP, July 6, 2022, https://www.whitecase.com/insight-alert/european-parliament-and-council-adopt-positions-ets-and-cbam-proposals-next-steps.

51. Sartor, O., Bataille, C. Decarbonising basic materials in Europe: How Carbon Contracts-for-Difference could help bring breakthrough technologies to market. IDDRI, *Study* N°06/19, 2019, https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Etude/201910-ST0619-CCfDs_0.pdf.

52. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/electric-power/121822-eu-ets-reform-raises-2030-carbon-reduction-target-to-62-on-2005-levels

53. The free allowances to industries in the ETS will be phased out as follows: 2026: 2.5%, 2027: 5%, 2028: 10%, 2029: 22.5%, 2030: 48.5%, 2031: 61%, 2032: 73.5%, 2033: 86%, 2034: 100%, https://www.europarl.europa.eu/news/en/press-room/20221212IPR64527/climate-change-deal-on-a-more-ambitious-emissions-trading-system-ets

54. "Towards Carbon Neutral Steel in Japan | Info Pack | Renewable Energy Institute," [Info Pack] Towards Carbon Neutral Steel in Japan: Learning from the Latest Trends in the European Union | Reports & Proposals | Renewable Energy Institute-hoge, https://www.renewable-ei.org/en/activities/reports/20211214.php.

trading scheme (K-ETS), launched in 2015. The K-ETS current annual emission caps are influenced by the Korean two main GHG reduction targets: at least 35 percent reduction below 2018 emissions by 2030 and carbon neutrality by 2050.[67] Before entering the third phase of the K-ETS in 2021, all emission allowances (Korean allowance units – KAU) during phase one and 97 percent of KAUs during phase two were allocated for free, which resulted in rewarding polluters for past inefficiencies and punishing carbon-efficient businesses for past low-carbon investments. During phase three (2021–2025) about 90 percent of KAUs will still be distributed for free.[68] As an example, the largest Korean steelmaker *POSCO* receives free emission allowances that cover most of its activities and buys additional allowances only if needed. It expects a future reduction in free allowances and an increase in prices but does not seem to specify the expected timing nor quantify the potential exposures.[69]

The Korean green public procurement (GPP) policies are not very supportive to steel decarbonization either.[70] As a member of the Organization for Economic Cooperation and Development (OECD), Korea has enforced GPP policies aimed at minimizing the environmental impact of products' lifecycles comprising the Mandatory Purchase of Green Products Program, the Minimum Green Standard Product Purchase Program, and the Low Carbon Product Certification Program of public institutions. Yet, the first two programs cannot currently be used for the decarbonization of the steel sector. Firstly, GHG emissions are not included in the assessment criteria of the minimum green standards. Secondly, steel products are not considered as green products that are subject to the minimum green standards. The Low Carbon Product Certification Program defines a low-carbon product as a product whose carbon footprint is not higher than the 'maximum carbon limit' and achieves greater GHG reductions than the 'minimum carbon reduction rate' of 3.3 percent over three years. Due to the fact that in Korea, there is often one producer per steel product, the average carbon content of steel products cannot be calculated. Thus, the maximum carbon limit is not applicable to steel products. Consequently, steel products that achieve the GHG reduction rate of 3.3 percent in 3 years can be certified as low-carbon products regardless of the absolute carbon intensity of the product. This questions the validity and objectivity of obtained low-carbon certificates. For instance, in 2019, 17 steel products produced by *POSCO* were registered as low-carbon products. They were not subject to the minimum carbon reduction rate, calculated based on the carbon emissions from three years ago.[71] Thus, the only criterion applied to the low-carbon certification of steel products - the minimum carbon reduction of 3.3 percent over three years - does not incentivize Korean steel manufacturers to adopt innovative technologies.[72]

All in all, the current Korean national policies are too weak to ensure decarbonization for its steel industry, which poses a threat to the country's long-term goal of carbon neutrality by 2050 and its steel producers' ability to comply with future more stringent carbon requirements on major export markets.[73] To be fair, Korean steelmakers understand the importance of the introduction of H2-DRI-EAF and DRI with CCS technologies while phasing out unabated blast furnaces.[74] In particular, aiming to cut its overall CO_2 emissions from 78.5 million tonnes in 2021 to 71 million tonnes or less by 2030 while still expanding capacity, *POSCO* has announced to invest 20 trillion won in installing H2-DRI-EAF technologies to replace aging blast furnaces in the *Gwangyang* (start in 2025) and *Pohang* plants (start in 2027).[75] That said, steel produced in Korea is currently 19 percent more carbon-intensive than steel produced in the EU.

55. https://www.eurofer.eu/issues/climate-and-energy/maps-of-key-low-carbon-steel-projects/

56. https://www.thyssenkrupp.com/de/newsroom/pressemeldungen/pressedetailseite/gruner-wasserstoff-fur-grunen-stahl-aus-duisburgsteag-und-thyssenkrupp-planen-gemeinsames-wasserstoffprojekt-91185

57. "Green Light for Green Steel," Salzgitter AG, accessed February 15, 2023, https://www.salzgitter-ag.com/en/newsroom/press-releases/details/green-light-for-green-steel-19904.html.

58. Julia Ström, "Green Steel Production," H2 Green Steel (H2 Green Steel, July 7, 2022), https://www.h2greensteel.com/articles/green-steel-production.

59. "Map of Key Low-CO2 Emissions Projects in the EU Steel Industry," Eurofer, accessed February 15, 2023, https://www.eurofer.eu/issues/climate-and-energy/maps-of-key-low-carbon-steel-projects/.

60. "2021 World Steel in Figures", https://worldsteel.org/wp-content/uploads/2021-World-Steel-in-Figures.pdf

61. The Government of Republic of Korea, '2050 Carbon Neutral Strategy of the Republic of Korea Towards a Sustainable and Free society', December 2020, https://unfccc.int/sites/default/files/resource/LTS1_RKorea.pdf.

62. "Steel Sector Pathways for Korea's 2050 Carbon Neutrality" https://forourclimate.org/en/sub/data/view.htmlidx72. See also "Steel Industry a Major Roadblock for South Korea's Green Future" https://forourclimate.org/en/sub/news/view.htmlidx128.

63. "기후위기 대응을 위한 탄소중립・녹색성장 기본법: 국가법령정보센터: 법령 > 본문," 기후위기 대응을 위한 탄소중립・녹색성장 기본법 | 국가법령정보센터 | 법령 > 본문, accessed February 15, 2023, https://www.law.go.kr/LSW/lsInfoP.do?efYd=20220325&lsiSeq=235581#0000.

64. InfluenceMap. *The Japanese and South Korean Steel Sectors and Climate Policy.* How the East Asian Steelmakers Perform on Climate Policy Engagement (n.p.: InfluenceMap, 2022). https://influencemap.org/report/Japanese-and-South-Korean-Steel-Sector-Climate-Policy-18077.

65. "Vision for POSCO Carbon Neutrality by 2050" https://aperc.or.jp/file/2021/5/14/S3-2+Ahn.pdf and "Hyundai Steel, Integrated Report 2022." https://esg.hyundai-steel.com/2022/front/contents/contentView.do?menuSn=412&cntntsCode=22enea0102.

Capturing emissions in the steel trade

Restricting emissions in domestic production is not enough. Achieving the goals of global industrial decarbonization requires capturing emissions in trade, especially for such a widely traded product as steel. Putting emissions restrictions on imports would encourage foreign producers to reduce emissions in return for getting access to markets with carbon restrictions. This would have an emissions reduction effect in other jurisdictions, which is essential from a global climate policy perspective, as cross border trade in global supply chains constitutes about 27 percent of global greenhouse gas (GHG) emissions.[76] Moreover, restricting imports of carbon-intensive products is also necessary from a national climate policy perspective, as it would enable a more ambitious domestic climate action without undermining the competitive position of domestic producers competing with products originating from countries without carbon restrictions. The most straightforward way to capture emissions from imports is to adjust emissions costs of domestic producers by imposing domestic carbon taxes or emission allowance requirements on imports.[77]

The EU has prepared the world's first carbon border adjustment mechanism (CBAM) on imports that will work as an extension of the emission allowance obligation under the EU ETS to imports from selected EU ETS sectors.[78] The iron and steel sector is one of the sectors falling under the EU CBAM scope.[79] Starting from October 2023, steel importers will be obliged to regularly report on embedded emissions in their products, including both direct and indirect emissions, and, from January 2026, submit emissions allowances at the rate of an average weekly carbon price of the EU ETS for the amount of 'imported' emissions.

The EU CBAM will affect imports from some countries more than from others. Korea is among the top ten countries estimated to be hit hardest by the EU CBAM,[80] which is primarily due to the large volumes of steel that Korea exports to the EU.[81] The EU will exempt from the CBAM charges imports from countries having their ETSs linked to the EU ETS. It will also provide reductions in the CBAM charges to those imports which have paid a carbon price in their countries of origin. The methodology for the calculation of exemptions and reductions has not been finalized yet. However, preliminary estimations about the implications of these provisions for Korean imports can be made.

Korean steel exporters would have chances to be exempted from the EU CBAM levies, if the K-ETS were comparable and linked to the EU ETS making carbon prices of two markets converge.[82] However, as we mentioned above, the extensive use of free allowances under the K-ETS has led to significant differences between the EU and Korean carbon prices. In the first quarter of 2022, the average allowance price per metric ton of carbon dioxide equivalent in Korea was US$28, whereas in the EU it was US$87.[83] This sharp divergence in the carbon prices with the EU in combination with the comparatively high carbon intensity of Korean steel production increases the vulnerability of Korean steel exports to carbon charges in the EU market.

The carbon costs paid by Korean steel producers under the K-ETS will certainly provide some relief, as Korean steel exporters will have their CBAM charges reduced by the amount of carbon charges they have already paid in Korea. However, a full exemption from the EU CBAM is unlikely given the large carbon price differences between the K-ETS and EU ETS. Moreover, the extent of vulnerability of Korean steel exports under the EU CBAM will also depend on the inclusion of indirect emissions in the scope of CBAM.[84] Korean exports will be additionally affected because the EU CBAM will cover both 'direct emissions'

66. Jung Min-hee, "Steelmakers Adopt Joint Statement for Carbon Emissions Reduction" http://www.businesskorea.co.kr/news/articleView.html?idxno=59780.

67. The Government of Republic of Korea, "2050 Carbon Neutral Strategy of the Republic of Korea Towards a Sustainable and Freen society", December 2020, https://unfccc.int/sites/default/files/resource/LTS1_RKorea.pdf.

68. Ko and Kim, "Revisiting Korean Green Public Procurement Policies to Promote Green Steel Demand".

69. Climate Accounting Project, *Company Analysis: POSCO: South Korea Steel,* May 17, 2021, https://www.unpri.org/download?ac=13753.

70. It should be noted that the Korean steel industry exports nearly 40% of its products. Given that the steel sector's dependence on the domestic market is relatively low, the market share of public procurement is also small, which limits the impact of low-carbon steel procurement on decarbonization of Korean steel. See Rachel Eun Ko and Geunha Kim, "Revisiting Korean Green Public Procurement Policies to Promote Green Steel Demand" (Solutions for Our Climate, August 8, 2022), https://forourclimate.org/hubfs/%5BNEXT-SFOC%5D%20Revisiting%20Korean%20Green%20Public%20Procurement%20Policies%20to%20Promote%20Green%20Steel%20Demand.pdf

71. POSCO. *Posco's dialogue for climate action building a better future together with sustainable steel,* (POSCO, December 11, 2022) http://corporatecitizenship.posco.com/citizen/resources/file/report/eng/2020_POSCO_CLIMATE_ACTION_REPORT.pdf

72. Rachel Eun Ko and Geunha Kim, Revisiting Korean Green Public Procurement Policies to Promote Green Steel Demand, (Solutions for Our Climate, August, 2022), https://forourclimate.org/hubfs/%5BNEXT-SFOC%5D%20Revisiting%20Korean%20Green%20Public%20Procurement%20Policies%20to%20Promote%20Green%20Steel%20Demand.pdf.

73. Steel Sector Pathways for Korea's 2050 Carbon Neutrality." https://21220177.fs1.hubspotusercontent-na1.net/hubfs/21220177/%5BKAIST-SFOC%5D%20GCAM2.0%20Steel%20Pathways%20for%20Carbon%20Neutrality.pdf

74. Jiyong Eom, Hanwoong Kim, Hanju Lee, Daeun Jung, Haewon McJeon, Joojin Kim, Kyungrak Kwon, Gahee Han, and Gyuri Cho, *2050 Carbon-Neutrality Transition Scenario: Analysis of a Korean Integrated Assessment Model,* (KAIST and Solutions for Our Climate, 2021) https://forourclimate.org/en/sub/data/view.htmlidx40.

75. Kotaro Hosokawa, and Shuhei Ochiai.

related to the production processes of goods and 'indirect emissions' related to the generation of electricity consumed during the production processes. Currently, Korean energy generation emits roughly twice the amount of carbon dioxide per kilowatt-hour of energy than the EU energy generation.[85]

Despite the anticipated negative impact on exports, Korean steel producers seem to linger with response measures. *POSCO* and *Hyundai Steel* both demonstrate negative engagement with key emissions requirements. *POSCO*'s proclaimed ambition for carbon neutrality in its steel production and its roadmap for delivering it, which sets milestones for 2025 and 2030, are reflected neither in the financial reporting nor in the narrative reporting in the 20-F, which are US reporting requirements for foreign-based business.[86] *Hyundai Steel*, on its part, does not ensure consistency with its climate policy goals by disclosing an emissions intensity using an emissions figure that are inconsistent with existing methodologies for this sector.[87]

However, the impact of the EU CBAM on Korean steel export volumes is beyond the scope of this article. The issue that we want to highlight here concerns the way in which emissions in steel imports will be accounted for and the role of steel emissions accounting methodology and certification schemes in facilitating the implementation of the CBAM. This is important because the CBAM costs for importers will depend on the way the carbon footprint of imported products is determined. According to the EU CBAM regulation, the calculation of carbon charges for imported steel will mainly be made based on the data on actual emissions at the installation level provided by importers and verified by accredited verifiers.[88] While the calculation of CBAM charges based on actual emissions is entirely in line with the goals of emissions reduction (for it will stimulate foreign producers wanting to export their products to the EU to cut emissions embedded in their products), it will create additional administrative costs due to the need of verification of emissions at the installation level abroad. It is no surprise, therefore, that the EU will rely on default values equal to the average emission intensity of the 10 per cent worst-performing EU installations for that product where verification of actual emissions is not possible.[89] With default values assuming more emissions in imported products than in domestic ones, cleaner foreign producers would be interested in getting their actual emissions verified. But to enable this, the EU needs to create an efficient and legally sound emissions monitoring, verification and reporting (MRV) system that would apply to foreign producers. This is not an easy task given the practical and legal challenges discussed below.

Choosing approaches to steel emissions accounting

The steel sector uses two kinds of emissions accounting methodologies: methodologies for measurement of process emissions and methodologies for calculating product-level emissions based on lifecycle assessment (LCA) of carbon footprint and its reporting to the market.[90] However, there is no unified methodology, and a great variety of emissions measurement methodologies are currently used in the steel sector making the comparability of emissions measurement outcomes difficult.

The most widely used methodologies for measuring process emissions include the Greenhouse Gas Protocol,[91] the ISO 14404 series standards,[92] the EN 19694 series standards,[93] and the ResponsibleSteel International Standard V 2.0.[94] All these standards are applicable (some of them to a certain extent) to three scopes of emissions: Scope 1 comprises direct emissions, Scope 2 covers indirect emissions from purchased electricity and heat, and Scope 3 includes emissions result-

"Posco to Invest $14bn in Low-Emissions Steel Production." Nikkei Asia. Nikkei Asia, September 23, 2022. https://asia.nikkei.com/Business/Materials/POSCO-to-invest-14bn-in-low-emissions-steel-production.

76. Ferrero, "Decarbonization standards and the iron and steel sector", 13

77. Kateryna Holzer, Carbon-related Border Adjustment and WTO Law (Edward Elgar, 2014). For a Korean edition of the book, see http://www.pybook.co.kr/mall/search?query=Kateryna+Holzer.

78. European Commission, *Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism,* July 14, 2021, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52021PC0564

79. The initial scope of covered sectors included steel, cement, fertilizers, aluminum, electricity. It has recently been revised by the European Parliament and Council to also include hydrogen, indirect emissions under certain conditions, certain precursors, as well as to some downstream products such as screws and bolts and similar articles of iron or steel. The possibility for a further extention of the scope to other goods at risk of carbon leakage, e.g. organic chemicals and polymers, will be assessed prior the end of the the transition period, with the goal to include all goods covered by the ETS by 2030. See: "Deal Reached on New Carbon Leakage Instrument to Raise Global Climate Ambition." European Parliament, December 13, 2022, https://www.europarl.europa.eu/news/en/press-room/20221212IPR64509/deal-reached-on-new-carbon-leakage-instrument-to-raise-global-climate-ambition.

80. Jeffrey J. Schott, and Megan Hogan. "22-10 Is South Korea Vulnerable to EU and US Carbon Border ... - Piie." Peterson Institute for International Economics, July 2022, https://www.piie.com/sites/default/files/documents/pb22-10.pdf.

81. Korea's steel exports to the EU between 2019 and 2021 equaled 7.9 million metric tons valued at $7.8 billion and $6.7 billion. "Global Steel Trade Monitor," International Trade Administration | Trade.gov, https://www.trade.gov/data-visualization/global-steel-trade-monitor.

82. Suk-yee, "Carbon Border Tax Not Targeting South Korea, EU Says." http://www.businesskorea.co.kr/news/articleView.html?idxno=71790

83. Schott and Hogan, " Is South Korea Vulnerable to EU and US Carbon Border Restrictions?"

84. Schott and Hogan, "22-10 Is South Korea Vulnerable to EU and US Carbon Border Restrictions?"

85. https://www.econotimes.com/Strengthened-

ing up and down the value chain.

Steel-related emissions calculation frameworks under the GHG Protocol include the Corporate Standard, which provides general principles of carbon accounting, and the GHG Emissions from Iron and Steel Production, a sector-specific guidance for calculating iron and steel emissions outside the general guidance scope.[95] The GHG Protocol's weak point is an approach chosen for measuring Scope 3 emissions, which allows companies to use average rather than specific and traceable data and results in double counting and ambiguous emission calculations.

The ISO 14404 series standards provide guidance for calculating CO_2 emissions from steel plants using various technologies and facility configurations. ISO 14404-1 concerns steel plants with blast furnaces, ISO 14404-2 covers EAF steel plants, ISO-14404-3 is applied to EAF steel plants with coal or gas-based DRI facilities, while ISO-14404-4 covers steel plants with all types of process routes.[96] These ISO standards specify calculation methods for carbon intensity of a steel plant from the amounts of the major inputs (purchased items) and outputs (sold items), such as natural resources, intermediate products and energy. However, the ISO 14404 series does not provide a fair basis for comparing the GHG emissions intensities to produce steel at sites with different technical configurations and input material feedstocks and does not include full consideration of the differences in the upstream indirect GHG emissions of sites, depending on their sourcing of input materials.[97]

EN 19694 series provides a harmonized methodology for calculating GHG emissions and GHG performance in the steel industry. It covers Scopes 1 and 2 and Scope 3 indirect emissions, while other indirect GHG emissions shall be included for the calculation of performance indicators. However, like ISO 14404, EN 19694 series is unable to compare the GHG emissions intensities at sites with different technical configurations and input material feedstocks on a fair basis, as well as to consider the variability of upstream indirect GHG emissions of sites with different sourcing of input materials.[98]

The ResponsibleSteel Standard provides a broad set of sustainability principles for steel sourcing and production, including GHG emissions. Version 2.0 includes guidance on measuring and benchmarking GHG emissions for crude steel production, while recognizing the GHG Protocol, EN 19694 (parts as applicable) and ISO 14404 (parts as applicable) for measurement of GHG emissions by steelmaking and other sites. However, the standard does not apply a full life cycle approach and does not consider downstream 'in use' GHG emissions.[99]

The process emissions measurement methodologies based on the installation level emissions measurement can in principle be used for the implementation of CBAMs. However, countries with ETSs use special methodologies, often based on benchmark emissions intensity values (emissions intensity performance thresholds) needed to carry out free allocation of emission allowances for producers of steel and other products. These ETS-related methodologies vary significantly too.[100] For instance, The EU under its ETS makes calculations of basic emissions (i.e. GHG emitted during manufacturing, so-called 'end-of-pipe' emissions) and oxidation factors (i.e. the actual amount of fuel combusted during industrial processes). Covered GHG include carbon dioxide,[101] nitrous oxide,[102] and perfluorocarbons.[103] Importantly, the EU ETS takes into consideration only direct emissions, and upstream emissions from imported electricity, heat, and steam are not included.[104] Under the K-ETS, both direct and indirect emissions are included, while covered GHGs include carbon dioxide, methane, nitrous oxide,

EU-carbon-border-tax-feared-to-hurt-local-exporters-1630744

86. "Climate Accounting Project Company Analysis" https://www.unpri.org/download?ac=13753.

87. "Hyundai Steel - Transition Pathway Initiative" https://www.transitionpathwayinitiative.org/companies/hyundai-steel.

88. Article 18 CBAM

89. European Commission (2021), CBAM Proposal, Article 7.2 and Annex III.

90. Ferrero, "Decarbonization standards and the iron and steel sector", 2

91. The GHG Protocol was developed in 1998 by World Resources Institute together with the World Business Council for Sustainable Development (WBCSD). It provides a comprehensive and standardized framework for measuring and managing emissions from private and public sector operations, value chains, products, cities and policies. GHG Protocol defines all of the three scopes of emissions. "Greenhouse Gas Protocol" https://ghgprotocol.org/.

92. These standards were developed by the International Organization for Standardization (ISO). See ISO (2020), Calculation method of carbon dioxide emission intensity from iron and steel production — Part 4: Guidance for using the ISO 14404 series, ISO 14404-4:2020, Geneva: ISO.

93. European Standards, "EN 19694-2." https://www.en-standard.eu/csn-en-19694-2-stationary-source-emissions-greenhouse-gas-ghg-emissions-in-energy-intensive-industries-part-2-iron-and-steel-industry/.

94. "ResponsibleSteel International Standard." https://www.responsiblesteel.org/wp-content/uploads/2022/09/ResponsibleSteel-Standard-2.0.pdf

95. Toledano, Perrine and Biberman, John and Lei, Baihui and Lulavy, Max and Ram Mohan, Rohini. *Conflicts Between GHG Accounting Methodologies in the Steel Industry.* COMET, December 2022, http://dx.doi.org/10.2139/ssrn.4342894

96. International Organization for Standardization (ISO) (2020), Calculation method of carbon dioxide emission intensity from iron and steel production — Part 4: Guidance for using the ISO 14404 series, ISO 14404-4:2020, Geneva: ISO.

97. Responsible Steel, "GHG Emissions Requirements for 'Steel Certification'"(Draft Version 2.1. for ResponsibleSteel Standard Version 2.0., n.p., February 2022), https://www.responsiblesteel.org

hydrogen fluorocarbons, perfluorocarbons and sulfur hexafluoride. A report on the amount of produced GHG emissions under K-ETS is issued by a compliance unit, which is a firm and not a unit of installation or product as in the EU ETS. Moreover, Korea does not apply the method of product benchmarking, which puts K-ETS effectiveness in question, lowering the probability of investment in better energy efficiency or lower carbon intensity. This gives us the grounds to assume that ETSs, which are initially intended to create a market-based instrument to reduce carbon emissions but not trace and tax products as they move along a global supply chain,[105] are not adequate enough to capture emissions in trade, as they cannot ensure interoperability and provide a common ground on which emissions charges at the border can be based.

As regards the second category of emissions measurement methodologies used in the steel sector - product-level emissions measurement standards based on lifecycle assessment (LCA) of carbon footprint of products - they are used for the assessment of embodied emissions of a specific steel product. They are often accompanied by environmental product declarations (EPD) under the ISO 14025 standard[106] and frequently used as the basis for green public procurement.[107] The most commonly applied LCA international standards are ISO 20915:2018 (Life Cycle Inventory Calculation Methodology for Steel Products), which specifies guidelines and requirements for conducting life cycle inventory (LCI) studies of steel products reflecting steel's capacity for closed-loop recycling,[108] and the World Steel Association's Life Cycle Inventory Methodology, a steel specific standard based on ISO 14040: 20062 and ISO 14044: 2006, which is used to quantify resource use, energy and environmental emissions associated with the manufacture of steel industry products from the extraction of raw materials in the ground to the steel factory gate.[109] The EU Product Environmental Footprint Category Rules (PEFCR) are another LCA-based standard, which provides guidelines for developing footprints for a wide range of products on the EU market, including metal sheets made of steel.[110] Moreover, the EPD certification programme by the Korean Ministry of Environment discloses quantitative information about the impact that the life cycle of a product and service has on the environment.[111] Notably, *POSCO* has obtained this EPD certification for thirteen of its products for seven environmental indicators: ozone layer influence, acid rain, eutrophication, photochemical smog, and carbon, resource and water footprints.[112]

The ResponsibleSteel certification is a private LCA standard which communicates emissions information to consumers from the extraction and transportation of input materials to crude steel leaving the facility gate, albeit not covering the full lifecycle.[113] A total of 130 companies and organizations are affiliated with ResponsibleSteel, including steelmakers, raw material, automotive, and energy companies that belong to the steel industry value chain.[114] Korea's major steel-producing company *POSCO* joined ResponsibleSteel as a member in January 2022 and in October 2022, two *POSCO*'s sites obtained ResponsibleSteel site certification.[115] Meanwhile, ResponsibleSteel Standard has a threshold for BF production that is nine times higher than the threshold for the same product set for EAF producers. This allows two identical steel products to be classified as equally green, while manufactured by the BF process produces much more carbon emissions and as a result, minimizes the important science-based role of scrap-based EAF production in making low-carbon-intensity steel.[116]

Thus, all these standards for steel emissions accounting are based on different measurement methodologies, each delivering different results and reporting them in different ways. This poses numerous inconsistency problems making

98. Responsible Steel, "GHG Emissions Requirements for 'Steel Certification'"(Draft Version 2.1. for ResponsibleSteel Standard Version 2.0., n.p., February 2022), https://www.responsiblesteel.org

99. Toledano, Perrine and Biberman, John and Lei, Baihui and Lulavy, Max and Ram Mohan, Rohini. *Conflicts Between GHG Accounting Methodologies in the Steel Industry.* COMET, December 2022, http://dx.doi.org/10.2139/ssrn.4342894

100. For instance, the same tonne of raw steel could have a carbon footprint that varies four-fold depending on whether it was determined under the methodology of ETS of the EU or California. See: Meagan Reid, "Measuring Carbon across Borders: A New Paradigm in Trade," Silverado Policy Accelerator, March 25, 2022, https://silverado.org/news/measuring-carbon-across-borders-Silverado.

101. From energy-intensive industry sectors, including steel works, production of iron, aluminium, metals, cement, etc., as well as from electricity and heat generation and commercial aviation within the European Economic Area

102. From production of nitric, adipic and glyoxylic acids and glyoxal;

103. From production of aluminium.

104. Toledano, Perrine and Biberman, John and Lei, Baihui and Lulavy, Max and Ram Mohan, Rohini. *Conflicts Between GHG Accounting Methodologies in the Steel Industry.* COMET, December 2022, http://dx.doi.org/10.2139/ssrn.4342894

105. Meagan Reid, "Measuring Carbon across Borders".

106. International Organization for Standardization (ISO) (2006a), Environmental Labels and Declarations: Type III Environmental Declarations – Principles and Procedures, ISO 14025:2006, Geneva: ISO.

107. Hasanbeigi et al., *Fostering Industry Transition through Green Public Procurement: A How to Guide in the Cement & Steel Sectors,* (Leadership Group for Industry Transition, 2021), https://www.industrytransition.org/insights/industry-transition-through-green-public-procurement-how-to-guide-cement-steel-sectors/

108. International Organization for Standardization (ISO) (2018b), Life Cycle Inventory Calculation Methodology for Steel Products, ISO 20915:2018, Geneva: ISO.

109. "Seventh Global LCI Study for Steel Products." https://worldsteel.org/wp-content/uploads/Life-cycle-inventory-LCI-study-2020-data-release.pdf

data across different methodologies practically incomparable. For example, each method uses different default emissions factors (e.g., those provided by ISO 14404 are greater than those used by GHG Protocol,[117] while reported direct emissions under ResponsibleSteel are nominally higher than under GHG Protocol[118]), emissions boundaries are subjectively set, and the encouragement to use primary data is nonexistent. Considerable discrepancies in reporting are also the result of the inclusion of indirect emissions from imported materials. Under ResponsibleSteel, reported net indirect emissions of all types are higher than those reported under the other frameworks, as it does not permit any netting from exported energy or materials.[119] Another differently covered area is mobile combustion emissions (related to transportation based on fuel quantities consumed), which are reported under the GHG Protocol[120] but not under ISO 14404. Moreover, most of the analyzed reporting frameworks (e.g., World Steel Association, Task Force on Climate-Related Financial Disclosures, Global Reporting Initiative, Carbon Disclosure Project, etc.) rely on company's self-reporting, allowing them companies to manipulate the data. According to a recent Boston Consulting Group report, 81 percent of the analyzed companies incorrectly reported their emissions and had an average error rate between 30 and 40 percent, which can be attributed to the use of inaccurate default emissions factors.[121]

While leaving steel producers with a big choice for certification, such a variety of different emissions measurement and reporting methodologies makes the comparison of carbon performance of steel producers on a global scale difficult, which, in turn, hampers the implementation of emissions-related trade restrictions, such as CBAMs. For example, the Korean largest steel producer *POSCO* obtained 'ResponsibleSteel site certification' for two sites–the *Pohang* and *Gwangyang* steelworks. This means that 370 requirements, including climate change and GHG emissions, have been fulfilled. At the same time, as already mentioned, steel products produced by *POSCO* were registered as low-carbon products under the Low Carbon Product Certification Program based on questionable criteria. The question is, what methods of measurement can be considered trustworthy for the purposes of CBAM? What methodologies will ensure accurate comparisons across products of different origins? The lack of unified emissions calculation methods and universally accepted certification schemes not only complicates the verification and compliance of producers with carbon-related restrictions on export markets but also creates uncertainty for producers discouraging greater scale of investment in breakthrough steelmaking technologies, increasing transaction costs and leading to trade tensions.[122] Addressing these challenges requires international cooperation on the measurement, verification and certification of emissions.

Building common ground for calculating emissions in steel products

When applying the CBAM to actual emissions and facing the need for emissions' verification, the EU can proceed in two ways: either to rely on its own emissions tracing methods or accept emissions measurement methodologies and monitoring, reporting, and verification (MRV) systems of foreign jurisdictions. Given the questionable environmental integrity of existing measurement standards described above and difficulties with their comparability, it seems to make more sense for the EU to create its own trustworthy MRV system and apply it to imports. Consistent and transparent measurement, traceability, and verification of emission reductions are critical for achieving the goals of carbon-related trade restrictions. By contrast, the current diversity of emissions measurement methodologies complicates the implementation of such measures. However, to avoid pro-

110. European Commission, PEFCR Guidance document, - Guidance for the 14 development of Product Environmental Footprint Category Rules (PEFCRs), https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_guidance_v6.3.pdf

111. "Environmental Certification System - Korea Environmental Industry & Technology Institute." https://www.keiti.re.kr/site/eng/02/10203010000002018121306.jsp

112. Cho Chung-un, "POSCO Measures Life Cycle of Steel for Eco-Efficiency," The Korea Herald (The Korea Herald, February 24, 2019), https://www.koreaherald.com/view.php?ud=20190224000077.

113. "Certification | ResponsibleSteel." https://www.responsiblesteel.org/certification/

114. "POSCO Obtains the Global ESG Standard 'Responsiblesteel Site' Certification for the First Time in Asia," – Official POSCO Newsroom, November 21, 2022, https://newsroom.posco.com/en/posco-obtains-the-global-esg-standard-responsiblesteel-site-certification-for-the-first-time-in-asia/.

115. "Issued Certificates," ResponsibleSteel, https://www.responsiblesteel.org/certification/issued-certificates/.

116. Zulma Herrera | Winter 2023 Scrap Recycling Supplement, "Steel Certification: The Case for Considering Alternatives," Recycling Today, https://www.recyclingtoday.com/article/the-case-for-considering-alternative-steel-certifications/.

117. The range of calculation outcomes for emissions according to these default emissions factors falls roughly within the ±10% expected range of uncertainty for use of default emissions factors anticipated by the IPCC Guidelines. From: Toledano et al. Conflicts Between GHG Accounting Methodologies in the Steel Industry, 29

118. Toledano et al. *Conflicts Between GHG Accounting Methodologies in the Steel Industry,* 29

119. Netting concerns credit emissions . 'When steel producers engage in activities expected to result in reductions of emissions outside the reporting boundary, various methodologies allow them to claim credits to represent this alleged reduction of emissions'. See: Toledano et al. *Conflicts Between GHG Accounting Methodologies in the Steel Industry,* 28

120. In particular, the GHG Protocol considers all mobile combustion from vehicles under company ownership or control, while ISO 14404 See: Toledano et al. Conflicts Between GHG Accounting Methodologies in the Steel Industry, 29

121. "New BCG Gamma Survey Reveals That

hibited discrimination under trade rules of the World Trade Organization (WTO), an MRV system for imports must follow the same characteristics as an MRV system applied to domestic producers of like products.[123] In the context of the EU CBAM, it means that verification of emissions should be done at the installation (plant) level based on average emissions caused by the installation facilities. WTO non-discrimination rules would also require the accreditation of verifiers from exporting countries. At the same time, not accepting emissions certification, which foreign producers attained under sector-based certification schemes, might give rise to claims of arbitrariness and a lack of flexibility. Accepting existing sector-based emissions certification seems also to be economically justifiable as it would lower the administrative costs of implementing the EU CBAM.

Be it as it may, it seems that the EU is considering using its own system for the verification of reports on 'imported' emissions. The EU Commission has recently established an informal expert group that should help to develop a methodology for monitoring, reporting, quantification, and verification of embedded emissions in goods under the scope of CBAM.[124] This methodology will later be laid down in a separate implementing act to the CBAM regulation.[125] At the recent meeting of the expert group, the progress on the horizontal issues of the methodology to monitor and report embedded emissions in the CBAM goods was presented.[126] In particular, a simplified example of the monitoring steps and reporting rules in a medium complexity installation was outlined. Additionally, the experts covered the issue of treatment of embedded emissions generated during the production process and the treatment of raw materials. It was pointed out that for raw materials it is necessary to align the monitoring with the EU ETS. Concerning the steel sector, the issue of ferroalloys, their relevance as precursor to certain CBAM goods and their treatment under CBAM was addressed. In particular, it was indicated that the cost share of certain ferroalloys in steel products should be used as a criterion for inclusion and suggested that the criteria used for such inclusion should be the same as those used in the impact assessment of the CBAM.

As the EU proceeds with the development of an MRV system for its CBAM, it is important to note that the choice of specific emission measurement methodologies will not only impact trade but also influence the decisions of foreign steel producers to take more radical steps of emission reduction contributing to decarbonization of the global steel production. This can be shown by the difference between the calculation of emissions at the level of installation and company.[127] Emissions counted at the individual installation level will likely lead to resource reshuffling, whereby the company will make efforts to reduce emissions only at those installations, which manufacture products for exports to the EU. Tracing emissions at the company level prevents resource reshuffling, but it faces the difficulties of the 'company' definition in vertically and horizontally integrated businesses in complex value chains.

Apart from deciding on the technical aspects of a MRV system for the implementation of CBAM, the EU should make efforts to ensure the system's acceptability by its trading partners. This would help to avoid trade disputes and retaliations. To make it happen, the EU should take the lead in international cooperation on developing common approaches to emissions tracing in traded products. During the whole process of preparing the CBAM legislation, the EU has been communicating with its trading partners on various issues of CBAM implementation through both bilateral and multilateral channels.[128] However, to the best of our knowledge, the issue of emissions accounting methodologies was not part of these discussions, which is a missed opportunity. A dialogue on MRV

Only 9% of Organizations Are Able to Measure Their Total Greenhouse Gas Emissions Comprehensively" https://www.bcg.com/press/13october2021-only-nine-percent-of-organizations-measure-emissions-comprehensively.

122. Ferrero et al., *Decarbonization standards and the iron and steel sector,* 13

123. Michael A. Mehling and Robert A. Ritz, "From theory to practice: determining emissions in traded goods under a border carbon adjustment", Oxford Review of Economic Policy 39, no. 1 (Spring 2023): 123–133, https://doi.org/10.1093/oxrep/grac043

124. "CBAM: Commission launches call for applications for informal expert group", 28 July 2022, https://taxation-customs.ec.europa.eu/news/cbam-commission-launches-call-applications-informal-expert-group-2022-07-28_en. See also Susanne Akerfeldt Senior Adviser and Susanne Akerfeldt, "Susanne Akerfeldt, Author at Kluwer International Tax Blog," Kluwer International Tax Blog, November 3, 2022, https://kluwertaxblog.com/author/susanneakerfeldt/. and "CBAM: Commission Launches Call for Applications for Informal Expert Group," Taxation and Customs Union, July 28, 2022, https://taxation-customs.ec.europa.eu/news/cbam-commission-launches-call-applications-informal-expert-group-2022-07-28_en.

125. See Article 35(6) CBAM

126. European Commission, "2nd Meeting of the Informal Expert Group on the Analytical Methods for the Monitoring, Reporting, Quantification and Verification of Embedded Emissions in Goods under the Scope of CBAM," Register of commission expert groups and other similar entities, https://ec.europa.eu/transparency/expert-groups-register/screen/meetings/consult?lang=en&meetingId=45998&fromExpertGroups=true.

127. Michael A. Mehling and Robert A. Ritz, 'From theory to practice: determining emissions in traded goods under a border carbon adjustment,- *Oxford Review of Economic Policy,* 2023, vol. 39, issue 1.

128. The EU held a public consultation on the proposal for a CBAM regulation from 15 July 2021 to 18 November 2021, during which all interested stakeholders, including the EU trading partners most affected by the CBAM, could submit their concerns and suggestions. The EU has also used the WTO forum to inform WTO members about the planned CBAM (e.g., at meetings of the WTO Committee on Trade and Environment) and provide answers to trade concerns raised by WTO members in relation to the proposed CBAM (e.g., at meetings of the Committee on Market Access). See https://www.wto.org/english/news_e/news22_e/envir_21oct22_e.htm) and https://docs.wto.org/dol2fe/Pages/SS/directdoc.aspx?filename=q:/G/MA/W172.pdf&Open=True

should have been launched earlier to reduce trade frictions and ensure that the measure contributes to emissions reduction.

It should be noted that the Global Arrangement on Sustainable Steel and Aluminium announced by the US[129] has also created momentum for pushing forward international cooperation on tracing emissions embedded in trade. For the purposes of this arrangement, negotiations on tracing emissions in products can be narrowed down to an agreement on the definition of dirty steel and aluminium with further identification of those production methods that cannot be used if products are produced for exports to the US, EU and other countries that can potentially join the arrangement. While much more straightforward, this way is not optimal from a climate policy perspective.It will lead to resource shuffling, whereby producers will continue to use dirty production methods for export production in countries without carbon-related trade restrictions.

More recently, the EU has got an opportunity to promote international emissions measurement standards in the framework of a climate club.[130] The primary focus of the newly established G7 Climate Club is on decarbonization of hard-to-abate industrial sectors "by discussing and aiming to align, as far as possible, methodologies, standards, sectoral strategies etc.".[131] Notably, the climate club is also envisioning to develop a common accounting system for hydrogen GHG footprints. An interesting area for cooperation on the development of common emissions accounting methodologies is government procurement, where the members of the climate club could undertake joint green procurement commitments.[132]

In addition, cooperation on emissions accounting methodologies can be intensified in forums provided by some international economic and trade-related organizations. For instance, the OECD's newly established Inclusive Forum on Carbon Mitigation Approaches (IFCMA)[133] aims to provide better data and information sharing about the comparative effectiveness of a full range of policy approaches beyond carbon pricing.[134] Along with developing and applying a consistent methodology to assess the effects of carbon mitigation policies and policy packages on emission reductions at the country level, IFCMA envisions investigating new methodological approaches for computing the carbon intensity of goods or sectors.[135] Additionally, the OECD is envisioned to play an essential role in supporting the implementation of G7 Climate Club. In addition to the fact that the club's work will consider and build upon work carried out under the IFCMA and data collection efforts,[136]the OECD, together with the International Energy Agency is expected to host an interim club's secretariat.[137]

The WTO also provides ample possibility for discussions on emissions standards and accounting methodologies at meetings of its Technical Barriers to Trade and Trade and Environment Committees within the framework of specific trade concerns discussions,[138] as well as thematic sessions. These discussions can also take place among WTO members participating in the Trade and Environmental Sustainability Structured Discussions (TESSD)[139] on a plurilateral basis. While it is not a task of the WTO to develop standards and methodologies, the WTO can contribute to consistency among these standards by encouraging its members to use international standards if they exist.[140] It also can contribute to the quality of standards by providing its member countries the possibility to respond to critiques concerning the design of standards, exchange best regulatory practices, and learn from experience of each other.

Moreover, cooperation on harmonizing measurement methodologies can be promoted within the existing private and public-private initiatives, which have been launched to support the decarbonization of the steel sector and heavy

129. The White House, "JOINT US-EU STATEMENT ON TRADE IN STEEL AND ALUMINUM" https://www.whitehouse.gov/briefing-room/statements-releases/2021/10/31/joint-us-eu-statement-on-trade-in-steel-and-aluminum/.

130. The establishment of the first open and cooperative international climate club was announced by the Heads of State and Government of the G7 on 12 December 2022. The G7 now invites all states that pursue an ambitious climate policy to join the climate club and participate in the further elaboration of its concept and structure in the course of 2023.

131. G7 Germany. *Terms of Reference for the Climate Club,* 2022, https://www.g7germany.de/resource/blob/974430/2153140/a04dde2adecf0ddd38cb9829a99c322d/2022-12-12-g7-erklaerung-data.pdf?download=1.

132. Chris Bataille, *Low and Zero Emissions in the Steel and Cement Industries.* (OECD, November 2019), https://www.oecd.org/greengrowth/GGSD2019_Steel%20and%20Cemement_Final.pdf.

133. The first meeting of the IFCMA took place in Paris on 9-10 February 2023.

134. "Share of Emissions Covered by Carbon Prices Is Rising, OECD Data Shows," OECD, https://www.oecd.org/tax/share-of-emissions-covered-by-carbon-prices-is-rising.htm.

135. "Inclusive Forum on Carbon Mitigation Approaches," OECD, https://www.oecd.org/climate-change/inclusive-forum-on-carbon-mitigation-approaches/.

136. G7 Germany. *Terms of Reference for the Climate Club,* 2022, https://www.g7germany.de/resource/blob/974430/2153140/a04dde2adecf0ddd38cb9829a99c322d/2022-12-12-g7-erklaerung-data.pdf?download=1.

137. BMWK - Federal Ministry for Economics Affairs and Climate Action, "G7 Establishes Climate Club," BMWK, https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2022/12/20221212-g7-establishes-climate-club.html.

138. Holzer, 'Addressing Tensions and Avoiding Disputes: Specific Trade Concerns in the TBT Committee'.

139. "World Trade Organization," WTO, https://www.wto.org/english/tratop_e/tessd_e/tessd_e.htm.

140. Kateryna Holzer and Aik Hoe Lim, 'Trade and Carbon Standards: Why Greater Regulatory Cooperation is Needed', https://envirocenter.yale.edu/sites/default/files/files/CoolHeads_Holzer(1).pdf

industries in general. Apart from the above-mentioned ResponsibleSteel[141] and the World Steel Association,[142] steel-industry decarbonization efforts have been led by the First Movers Coalition,[143] and the recently launched Industrial Deep Decarbonisation Initiative (IDDI).[144] Since 2021, IDDI, coordinated by the UN Industrial Development Organization (UNIDO) in collaboration with national governments (as of 2023 including Canada, Germany, India, the UK, the UAE, Saudi Arabia, and the USA) works to standardize carbon assessments, establish ambitious public and private sector procurement targets, incentivise investment into low-carbon product development and design industry guidelines. The common goal of all the initiatives is to ensure coherent measurement, verification, and traceability across the supply chain. However, their ability to produce unified standards on measurement methodologies is constrained by the lack of coordination among these initiatives and the non-participation of some major world producers. For instance, what concerns Korean steel producers, none of them is a member of the First Movers Coalition, and only *POSCO*[145] and *Hyundai Steel*[146] are full members of the ResponsibleSteel organization. While the Korea Iron and Steel Association (KOSA)[147] has been affiliated with World Steel Association since 1976,[148] the government of Korea has not joined IDDI so far.

Finally, given that emissions standards and accounting methodologies are also promulgated by steelmakers themselves,[149] international collaboration among major steel producers is important for setting common standards. Steelmakers' collaboration can revolve around sharing of data and best practices, which is essential for the spread of clean technology.[150] An example is IN4climate. NRW is a regional collaborative platform developed by the German State of North Rhine-Westphalia, which brings together industrial stakeholders to focus on research towards a climate-neutral industrial sector.[151] An example of collaboration at the national level is a competence centre on climate change mitigation in energy-intensive industries KEI, launched by the German government to advise and support in reducing emissions.[152] To achieve alignment in emissions accounting methodologies at a global scale, collaboration among major steel producers should extend beyond national borders.

Conclusion

Achieving the goal of a carbon-neutral economy requires accelerating the transition to low-carbon technologies of steel production. Given the very high costs of these technologies, their rapid commercialization depends on regulatory incentives, including the imposition of carbon price on dirty steel imports. However, the implementation of carbon-related trade restrictions raises questions of both legal and practical nature, particularly how the carbon footprint of imported steel will be determined and what the role of sector-related decarbonization initiatives and emissions certification schemes will be in this process.

In this article, we examined the implications of the lack of unified steel emissions accounting methodologies for the implementation of the EU CBAM focusing on trade between the EU and South Korea. We found that measurement and verification of emissions in global value chains for the purposes of CBAM present a great challenge. This is because different production methods and energy sources are used for the production of steel products across countries, and there are no common emission accounting methodologies and universally accepted certification schemes in the steel industry. The use of its own MRV system for the verification of actual emissions of foreign producers raises administrative costs of the EU CBAM and risks of trade tensions. Therefore, trade under carbon

141. Which, as a global multi-stakeholder standard and certification programme, provides measurement standards, definitions and performance thresholds. See: ResponsibleSteel." https://www.responsiblesteel.org/

142. Its Climate Action Programme requires steelmakers to report on site-level emissions based on a common methodology, definitions and boundaries. See: "World Steel Association" https://worldsteel.org/

143. Global initiative promoting decarbonization of "hard to abate" industrial sectors including steel by leveraging companies' purchasing power. Provides definitions and performance thresholds. See: "First Movers Coalition" https://www.weforum.org/first-movers-coalition/members

144. "Industrial Deep Decarbonisation Initiative | UNIDO." https://www.unido.org/IDDI

145. "POSCO." https://www.posco.co.kr/homepage/docs/eng6/jsp/s91a0000001i.jsp

146. "HYUNDAI STEEL" https://www.hyundai-steel.com/en/index.hds

147. "Korea Iron and Steel Association", http://www.kosa.or.kr/

148. "KOSA History ," Welcome to the Korea Iron & Steel Association, https://www.kosa.or.kr/eng/sub/sub02_02_01.jsp.

149. To name just a few: Econiq certification for net-zero steel by *Nucor*, XCarb green steel certificates by *ArcelorMittal,* Circle Green label for its stainless steel by *Outokumpu*, Green Steel Labelling System by *Wirtschaftsvereinigung Stahl,* Zeremis by *Tata Steel,* NSCarbolex by *Nippon Steel's,* GreenTec Steel by *Voestalpine*, Bluemint Steel by *Thyssenkrupp,* and others. See: Ferrero, "Decarbonization standards and the iron and steel sector", 15

150. IEA, *Iron and Steel Technology Roadmap,*152

151. IN4climate.NRW, 2020, https://www.in4climate.nrw/en.

152. KEI, Competence Centre on Climate Change Mitigation in Energy-Intensive Industries, 2020, https://www.klimaschutz-industrie.de/en/

restrictions requires coordination and cooperation on carbon standards, emission accounting methodologies, verification and certification procedures between importing and exporting countries. The creation of a comprehensive international framework for tracing emissions in the steel sector could take place under the leadership of the EU within the newly established G7 Climate Club while supported by international organizations, public-private steel decarbonization partnerships and cross-border collaboration between major steel producers on sharing data and best practices.

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Contact:
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