engineering proceedings

MDPI

Proceeding Paper

The Impact of Implementing Carbon Border Adjustment Mechanisms on the Steel Industry until 2034: A Forecasting Study †

Slavomír Hubatka [1,*], Branislav Buľko [1], Dana Baricová [2], Lukáš Fogaraš [1], Andrii Pylypenko [1], Dominik Dubec [1], Jaroslav Demeter [1] and Peter Demeter [1]

[1] Institute of Metallurgy, Faculty of Materials, Metallurgy and Recycling Department of Metallurgy, Technical University of Košice, 04 001 Košice, Slovakia; branislav.bulko@tuke.sk (B.B.); lukas.fogaras@tuke.sk (L.F.); andrii.pylypenko@tuke.sk (A.P.); dominik.dubec@tuke.sk (D.D.); jaroslav.demeter@tuke.sk (J.D.); peter.demeter@tuke.sk (P.D.)

[2] Research–Innovation and Technology Center n.o., 04 001 Košice, Slovakia; dana.baricova@vtp.sk

* Correspondence: slavomir.hubatka@tuke.sk; Tel.: +421-944-429-025

† Presented at the 30th International Conference on Modern Metallurgy—Iron and Steelmaking, Kosice, Slovakia, 27–29 September 2023.

Abstract: The metallurgical sector, a key component of European industries, plays a crucial role both in advanced economies and in the infrastructure development of emerging nations. As environmental concerns increasingly influence global trade policies, the introduction of Carbon Border Adjustment Mechanisms (CBAMs) becomes a pivotal factor, especially those affecting the steel industry. This study focuses on assessing the impact of CBAM implementation on the steel industry's evolution until 2034, utilizing a combination of econometric models and scenario analysis.

Keywords: carbon border adjustment mechanisms; steel industry; environmental policy; economic impact; forecasting study; sustainable development

Citation: Hubatka, S.; Buľko, B.; Baricová, D.; Fogaraš, L.; Pylypenko, A.; Dubec, D.; Demeter, J.; Demeter, P. The Impact of Implementing Carbon Border Adjustment Mechanisms on the Steel Industry until 2034: A Forecasting Study. *Eng. Proc.* **2024**, *64*, 15. https://doi.org/10.3390/engproc2024064015

Academic Editor: Róbert Dzurňák

Published: 12 March 2024

1. Introduction

The metallurgical sector, specifically the steel industry, confronts a formidable challenge in decreasing its carbon dioxide (CO_2) emissions, while concurrently fulfilling the escalating global demand for steel products. To overcome this challenge, the sector is in a transformative phase characterized by differing strategic approaches. The first route centers on the design and implementation of innovative low-emission technologies that offer considerable potential for carbon reduction. The second path aims at fine tuning and enhancing the existing technologies to lower their carbon emissions. Given the early development stage of new low-emission solutions, temporary steps are necessary. These temporary measures involve boosting the thermodynamic performance, adopting alternative fuel options, and ramping up steel recycling to lessen the reliance on raw materials [1,2].

In a policy setting, where the European Union and other major global economies are increasingly aligning their environmental and trade agendas, the implementation of Carbon Border Adjustment Mechanisms (CBAMs) gains particular importance. According to the timeline for CBAM implementation, free emission allowances for heavy industries, including the steel sector, will be canceled by the year 2034. This upcoming transition necessitates in-depth analysis to comprehend its complex implications for the steel industry, functioning as both a potential obstacle and an accelerator of progress [3].

In recent years, the confluence of trade policy and environmental sustainability has become a focal point for both policymakers and industry leaders. One of the most notable examples of this collaborative effort is the European Union's introduction and upcoming implementation of Carbon Border Adjustment Mechanisms (CBAMs). The goal of CBAMs is to level the field for local industries that are obligated to meet strict emissions criteria, thereby reducing the likelihood of carbon leakage, where manufacturing relocates to a

region with less-stringent environmental rules. According to the timeline set forth for CBAM implementation, one of the pivotal shifts will be the phasing out of free emission allowances for heavy industries, which notably include the steel sector. This shift is anticipated to happen by 2034 and serves as a critical turning point that demands thorough, multi-layered assessment. Historically, free emission allowances have acted as a safety net for industries, enabling them to transition smoothly into compliance with the new emission guidelines. The discontinuation of these allowances could lead to an immediate and potentially sizable financial burden on these industries, calling for a comprehensive review of their current production models and cost structures [4–6].

2. Methodology

This article presents a methodology analyzing steel production's efficiency and emissions, aligning with the Carbon Border Adjustment Mechanisms (CBAMs). It aims to increase the metallurgical industry's market competitiveness, while lowering its carbon emissions through improved energy management and innovative technology integration. This research utilizes these models to effectively combine various datasets, targeting a reduction in CO_2 emissions in the steel sector.

Figure 1 offers a schematic representation of a simplified methodological model applicable to a brown-field steel plant [7].

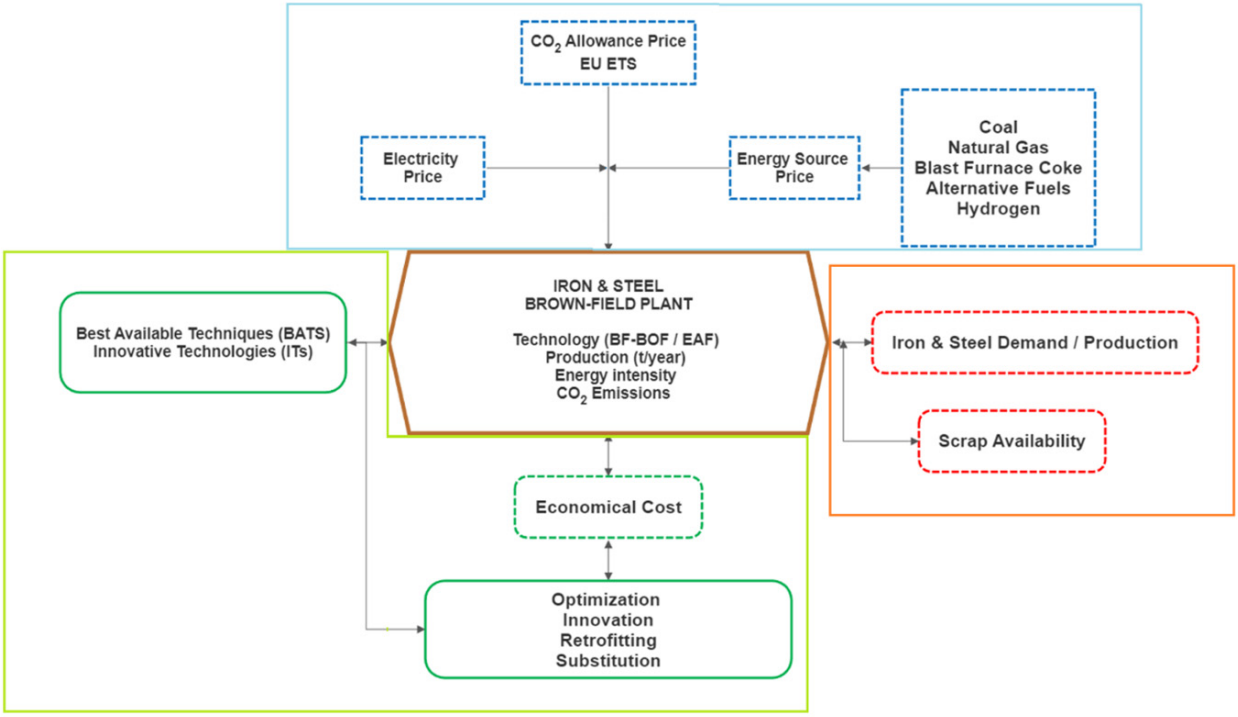


Figure 1. Methodology model of brown-field plant (schematic overview) [7].

The implementation strategy for the Carbon Border Adjustment Mechanisms (CBAMs) outlines the gradual phasing out of the free allocation of permits within the European Union Emissions Trading System (EU ETS). This process is set over a nine-year timeframe, starting in 2026 and concluding in 2034, and is specifically targeted at industries under the purview of the CBAMs. The withdrawal of free allocation will commence at a relatively slow pace, with acceleration anticipated towards the end of this period. This phased approach is intended to align directly with the progressive rollout of the CBAMs. During this transition period, the CBAMs will only apply to emissions not covered by free allocation in the EU ETS [8].

In addition, the procedural framework for the distribution of emission quotas at no cost, and its gradual deployment beginning in 2025, is illustrated in Figure 2. Compared to the previous annual reduction of 2.2%, this represents a substantial increase in the rate of allocation reduction [9].

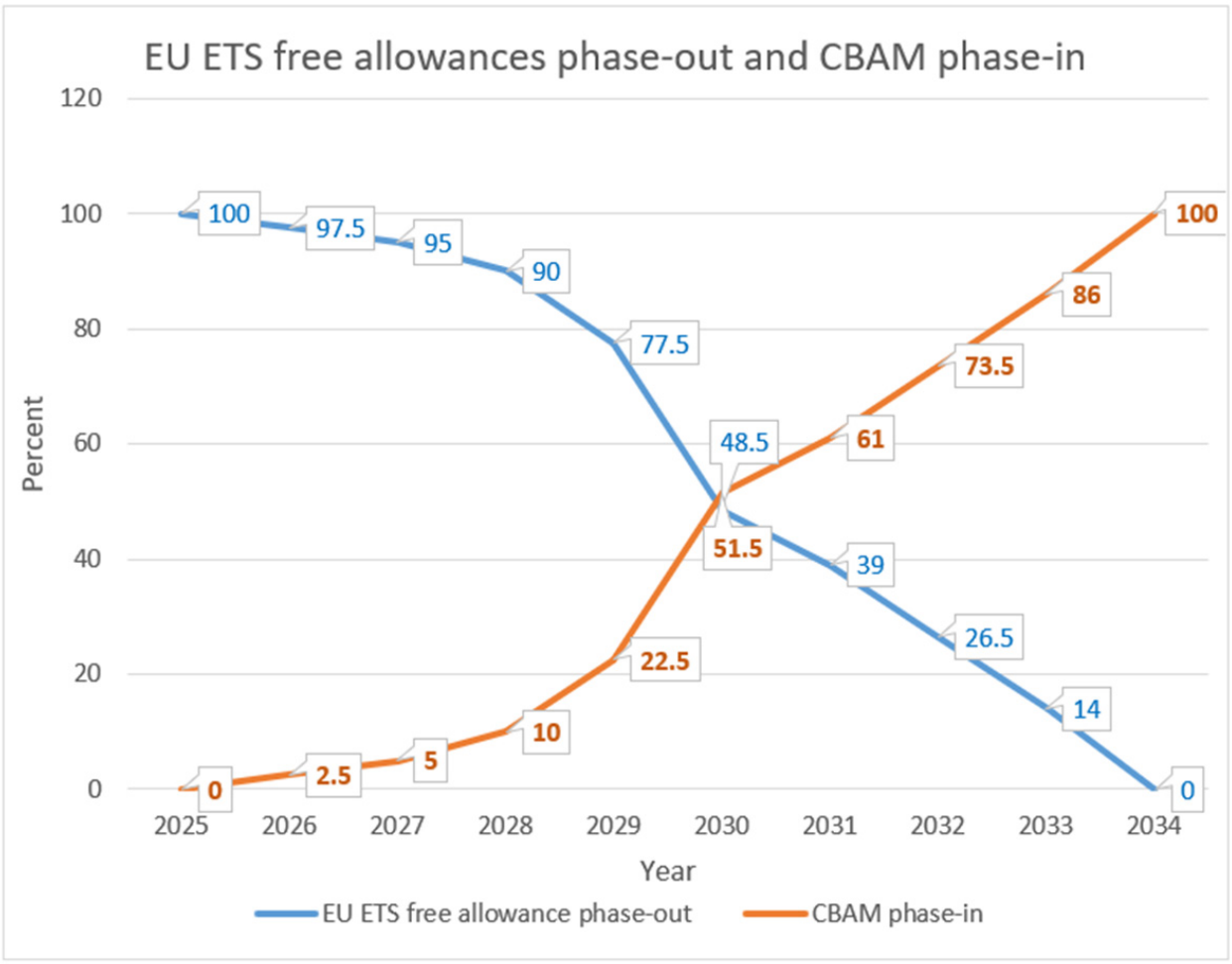


Figure 2. EU ETS free allowance phasing out and CBAM phasing in over 2025–2034 [9].

With the upcoming introduction of Carbon Border Adjustment Mechanisms (CBAMs), there is an urgent need is to optimize the existing production technologies to secure notable short-term emission reductions. Simultaneously, there should be ongoing progress in developing and incorporating cutting-edge technologies for the future.

3. Results and Discussion

The formulation of allocation scenarios for the steel industry from 2020 to 2030 is important for multiple reasons. This strategy enables an adaptable and responsive emission management approach, accommodating fluctuations in production levels and advancements in technology. These scenarios underscore the criticality of resilience and adaptability within the allocation mechanisms. This is essential to effectively manage unforeseen reductions in production, thereby maintaining the integrity and efficiency of the system under diverse conditions. Notably, a production decrement of 15% or greater, followed by a rebound to the prior levels, can markedly influence free allocation due to the system's dynamic nature. This highlights the necessity for a robust and flexible strategy in the allocation process.

In an illustrative scenario involving a hypothetical European steel production facility, which annually generates 3 million metric tons of hot-rolled steel products, the facility

emits approximately 2000 kilograms of carbon dioxide (CO_2) per metric ton of steel. The allocation of free emission permits within the framework of the European Union Emissions Trading System (EU ETS) for the year 2016 stood at four million, with a subsequent annual decrement of 2.2% post 2020. This trend exemplifies the historical pattern of emission quota allocations before the implementation of the Carbon Border Adjustment Mechanisms (CBAMs). The data pertinent to this entity for the third phase of EU ETS, spanning 2014–2018, are delineated in Table 1.

Table 1. Production and allowance allocation average for 2014–2018 EU ETS (Phase 3).

Product.	Production 2014–2018 Average [t]	Free Allocation 2014–2018 Average [-]
Coal-Coke	2,487,136	218,195
Sintered ore	1,003,827	322,988
Liquid Metal	2,627,792	3,385,953

The 'Business as Usual' scenario (encompassing a production variance within ±15%) outlines a situation where, during the period 2019–2026, the company's production remains relatively stable, not deviating substantially from the average production portfolio observed in Phase 3 (2014–2018). This stability is such that it does not trigger a significant alteration in the volume of allocated emission allowances, as shown in Figure 3. Figure 4 shows the direct CO_2 emissions from steel production processes based on technology implementation compared to the EU ETS free allowance decline [7].

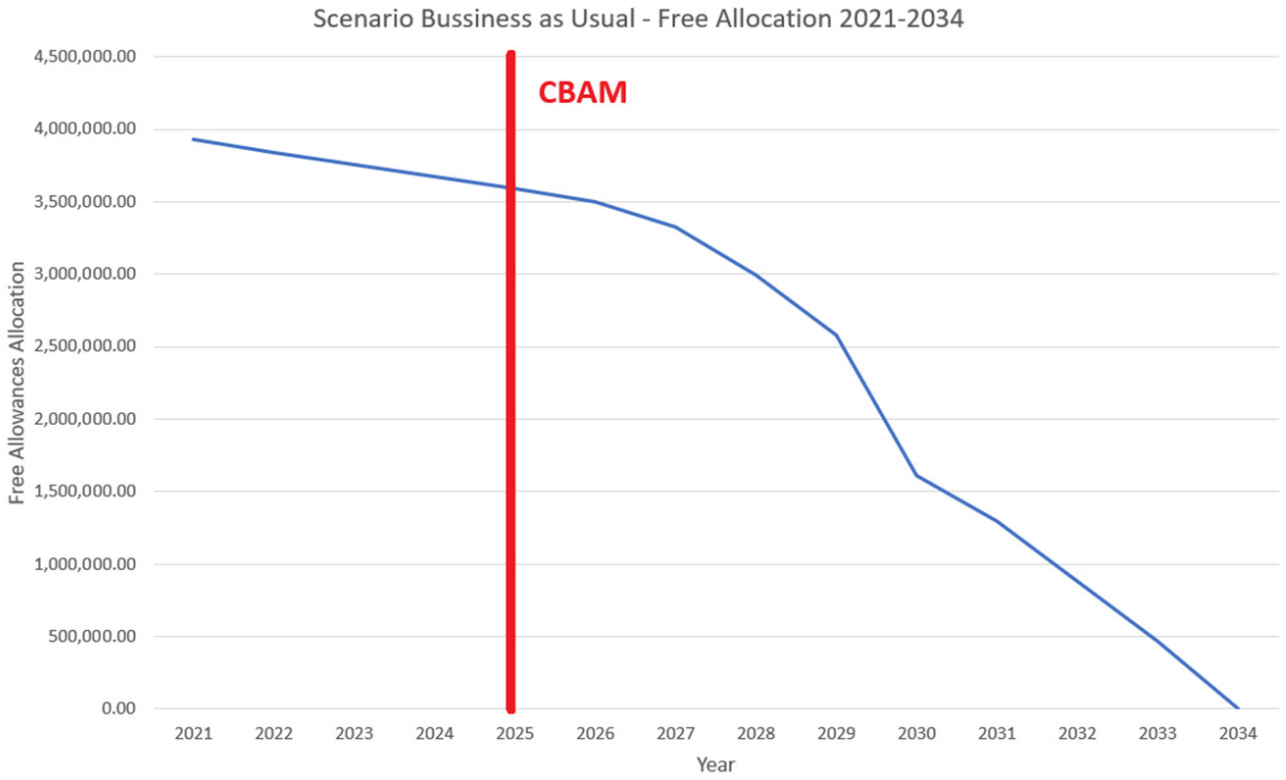
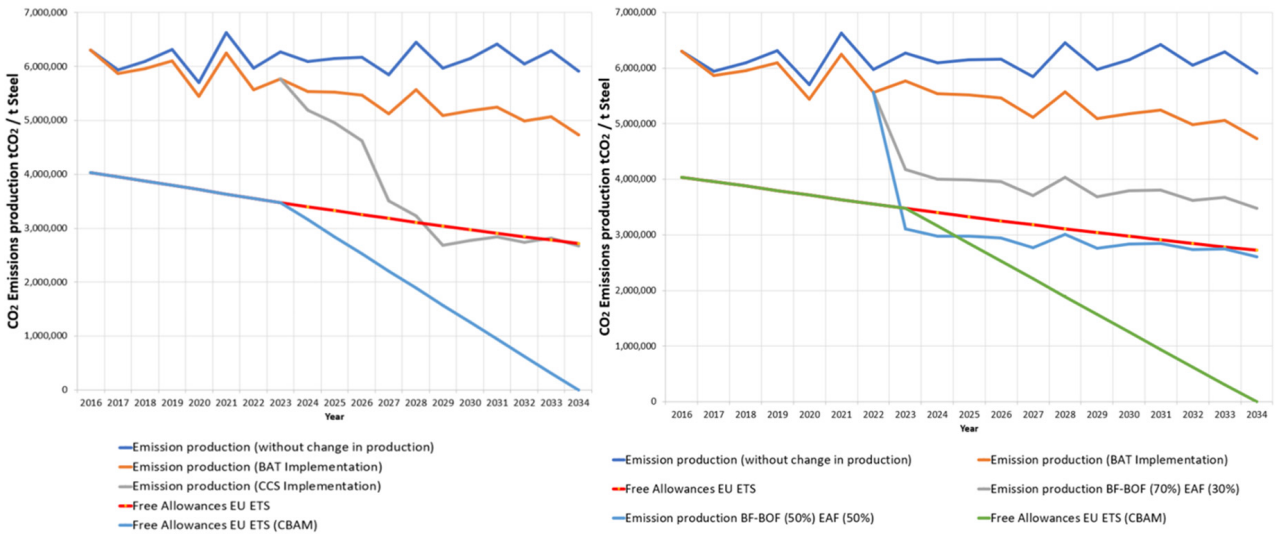


Figure 3. Business as usual scenario. Allowance allocation in 2021–2034.



(**a**) (**b**)

Figure 4. Direct carbon dioxide emissions. Integrated steel manufacturing (**a**) and the transition to electric arc furnace (**b**) compared to CBAM implementation and allowance removal in 2034 [7].

4. Conclusions

The steel industry stands at a crossroads, pulled in divergent directions by the conflicting priorities of economic viability and environmental sustainability. This study offers an overview of how the introduction of Carbon Border Adjustment Mechanisms (CBAMs) could shape this sector's trajectory until 2034. Through scenario and emission data analysis, it offers insights into the industry's future under varying policies and operational conditions. The findings underscore the need for strategic adaptation in production methods, emphasizing a shift towards more sustainable practices. This study highlights the critical role of policy frameworks in guiding the industry towards the balance of economic viability and environmental responsibility.

Author Contributions: Conceptualization, S.H. and B.B.; methodology, D.B.; software, L.F.; validation, P.D., J.D. and A.P.; formal analysis, D.D.; investigation, D.D.; resources, D.B.; data curation, P.D.; writing—original draft preparation, S.H.; writing—review and editing, D.B.; visualization, S.H.; supervision, B.B.; project administration, B.B.; funding acquisition, B.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research work was performed under the grant project no. 1/0212/21 and was financially supported by VEGA ME SR AND SAS.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Hubatka, S.; Buľko, B.; Baricová, D.; Demeter, P.; Fogaraš, L.; Šabík, V. Decarbonisation of the steel industry—pathway to brighter future—Slovakia and Czech Republic case study. In Proceedings of the 30th Anniversary International Conference on Metallurgy and Materials, Brno, Czech Republic, 26–28 May 2021. [CrossRef]
2. International Energy Agency. Iron and Steel Technology Roadmap. Available online: https://iea.blob.core.windows.net/assets/eb0c8ec1-3665-4959-97d0-187ceca189a8/Iron_and_Steel_Technology_Roadmap.pdf (accessed on 14 September 2023).
3. Taxation and Customs Union, European Commission. Carbon Border Adjustment Mechanism. Available online: https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en (accessed on 14 September 2023).

4. *Best Available Techniques (BAT) Reference Document for Iron and Steel Production*; European Commission: Brussels, Belgium, 2013; ISBN 978-92-79-26475-7. [CrossRef]
5. Material Economics. Industrial Transformation 2050—Pathways to Net-Zero Emissions from EU Heavy Industry. Available online: https://materialeconomics.com/publications/publication/industrial-transformation-2050 (accessed on 14 September 2023).
6. European Parliament. Carbon-Free Steel Production—Cost Reduction Options and Usage of Existing Gas Infrastructure. Available online: https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690008/EPRS_STU(2021)690008_EN.pdf (accessed on 14 September 2023).
7. Hubatka, S.; Buľko, B.; Baricová, D.; Demeter, P.; Fogaraš, L.; Demeter, J.; Hrubovčáková, M. Digitalisation-based optimization of steel production for competitiveness and sustainability. In Proceedings of the 32nd International Conference on Metallurgy and Materials, Brno, Czech Republic, 17–19 May 2023. [CrossRef]
8. Bellora, C.; Fontagné, L. EU in search of a Carbon Border Adjustment Mechanism. *Energy Econ.* **2023**, *123*, 106673. [CrossRef]
9. Pathway of EU ETS Free Allowances Phase-Out and Carbon Border Adjustment Mechanism (CBAM) Phase-in From 2025 to 2034. Available online: https://www.statista.com/statistics/1401673/eu-ets-free-allowance-cbam-pathway/ (accessed on 14 September 2023).