

Policies on Emissions of Greenhouse Gases and Other Atmospheric Pollutants by the Railway Transport Sector

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Abstract

This work seeks to identify, understand, and analyze laws and regulations from different European Union countries that focus on emissions of greenhouse gases and other atmospheric pollutants by the rail transport sector, both freight and passenger. The search to identify legislation was carried out through the use of artificial intelligence and, subsequently, an active search for documents relevant to the topic was carried out. During the research, data on the topic defined in some European countries were identified, namely – Germany, Spain, France, Holland, Portugal, Switzerland, and finally, also from Brazil. The results of this study highlight the importance and need for a regulatory framework that establishes actions aligned with international environmental policies, especially in response to the growing global emergency related to increased emissions in the transport sector. The analysis reinforces the need for measures that promote rail transport as a sustainable alternative, contributing significantly to reducing emissions and combating climate change on the global stage. Additionally, the study highlights the pivotal role of rail transport in reducing emissions compared to more polluting transport modes, such as road and air transport. It stresses the need for continuous innovation in rail technologies, such as electrification and the adoption of hydrogen-powered trains, which are being explored in countries like Germany and the Netherlands. The research also draws attention to Brazil's emerging efforts in the rail sector, illustrating a global shift towards more sustainable transport solutions in response to the growing urgency of climate change.

Keywords: Rail transport, greenhouse gas emissions, laws, sustainability

INTRODUCTION

Since the beginning of the pre-industrial era, planet earth has experienced drastic climate changes, largely caused by human activities. industrialization, accompanied by the intensive burning of fossil fuels, in addition to deforestation, significantly increased the concentration of greenhouse gas (GHG) emissions and

other pollutants in the atmosphere. these emissions are intensifying, resulting in global warming at an alarming rate. the rapid rise in global temperatures represents an immense challenge, putting entire ecosystems at risk and making it difficult for species and human societies to adapt [1, 2].

The main responsibility for global warming is GHG emissions, mainly carbon dioxide (CO₂). Furthermore, other atmospheric pollutants emitted by transport systems, such as carbon monoxide (CO) and nitrogen oxides (NO_x), have significant negative impacts on human health and the existence of other living beings in the environment. in response to these concerns, there is a global effort

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by countries, through the 2030 agenda, to reduce emissions, aiming to combat global warming and improve efficiency and sustainability [3–6].

The implementation of new technologies in railway operations results in significant improvements and allows the adoption of actions that mitigate emissions produced by railway systems, such as the use of “platform screen doors” and “regenerative braking.” furthermore, these innovations contribute to reducing emissions produced by railway systems, supporting more sustainable transport [7–14].

Despite the advantages of electrifying the railway system, there are several challenges, such as the adoption of alternative fuels and the use of renewable energy for electrical supply. replacing part of the operations carried out by road or air transport with rail can have a significant impact on reducing emissions. modal substitution results in lower emissions [15].

Therefore, the objective of this work is to identify, understand, and analyze the main legislation, from some European countries and Brazil, in relation to emissions produced by rail transport, passengers, or cargo. given the context of climate urgency, this analysis may be relevant with the growth of rail transport as a sustainable alternative to road and air transport [16].

After this brief introduction and definition of the objective of this work in the first section, the work is divided into three more sections. The next section presents the methodology used in this research. Then, in the third section, the results and discussion of the work are presented, carrying out a critical analysis. Finally, the fourth section is dedicated to the conclusions of this work [17–19].

METHODOLOGY

To carry out this research, artificial intelligence (AI) was used to search for a list of legislations and regulations on the subject of emissions from rail transport in different European countries, identifying relevant data for the preparation of this work [20].

Further, as this is a tool that can make mistakes, we sought to identify the respective legislation specified by the AI in each selected country. Next, the search for publications relating to energy emissions in the selected countries began. For this stage, searches were carried out on Google Scholar, Capes Periodicals, Springer Link, BASE system and Refseek, using the following keywords: “emissions”, “sustainability”, “carbon reduction”, “sustainable technologies”, “emissions in rail transport in Europe and Brazil”.

RESULTS AND DISCUSSION

Concern about emissions from the transport sector has increased significantly in recent years. In the European Union (EU), energy consumed by the transport sector represents around 28% of total energy. In response, different countries have implemented legislation and regulations to reduce the environmental impact of the transport sector, including rail. These specific measures for the railway mode of transport seek to promote energy efficiency and sustainability, aiming to mitigate GHG emissions and other atmospheric pollutants produced by railway systems, whether from passengers or cargo. Global efforts to promote sustainability in passenger and freight rail transport have been highlighted, showcasing the increasing focus on these areas [21, 22].

In the EU, regulations set requirements for air emissions from new railway vehicles, aiming to reduce the environmental impact of rail transport by imposing strict limits on emissions such as nitrogen oxides (NOx) in diesel and gasoline engines. This encourages the adoption of more efficient and cleaner technologies, improving air quality and public health. The regulation also fosters innovation and the development of more sustainable rail transport solutions in line with the EU's environmental and climate objectives.

When examining the legislation of countries like Germany, Spain, France, the Netherlands, Portugal, Switzerland, and Brazil, various trends, differences, and similarities in the regulation of emissions in

the railway sector emerge, offering insights into policies and strategies for promoting more sustainable practices in rail transport:

- *Germany* demonstrates commitment to reducing emissions in the railway sector and promoting environmental sustainability. Its federal law regulates air emissions and other pollution forms, aiming to minimize emissions through advanced technologies and sustainable practices. The law encourages rail transport as the most environmentally friendly alternative, continuously improving the efficiency and sustainability of the rail system.
- *Spain* focuses on reducing emissions in its transport sector, encouraging the integration of multimodal transport systems for a more efficient distribution of goods and the promotion of rail and maritime infrastructure. The responsible agency ensures compliance with environmental standards, fostering sustainability in the rail sector.
- *France* prioritizes reducing emissions through its legislation on energy transition and green growth. The law promotes a modal shift from road to rail transport, reducing road traffic and its associated emissions. Investments in railway infrastructure for freight transport further reinforce the country's commitment to sustainability and energy efficiency.
- *The Netherlands* stands out for its near-total electrification of the railway network, largely powered by renewable energy sources like wind energy. This initiative aims to reduce emissions from railway transportation and overall greenhouse gas emissions, with additional support for innovative technologies such as hydrogen-powered trains.
- *Portugal* is heavily investing in railway electrification to reduce reliance on fossil fuels and lower CO₂ emissions. The national transport policy integrates goals for cleaner technologies, emphasizing sustainable practices in rail transport.
- *Switzerland* has implemented a regulatory framework to reduce carbon emissions, including a system of emissions taxes and incentives to achieve climate neutrality by 2050. The law promotes sustainable rail transport and the integration of different modes of transportation to meet ambitious climate goals.
- *Brazil* is increasingly focusing on railway transportation as a sustainable alternative for long-distance goods transport, contributing indirectly to emissions reduction. Although Brazil lacks specific legislation focused solely on emissions in the railway sector, progress is being made through national logistics and environmental policies.

The alignment of EU countries with emissions reduction regulations represents a valid commitment to improving air quality and reducing reliance on polluting transport modes. Each country adapts its laws to meet its specific needs and environmental goals, benefitting from the promotion of cleaner technologies and sustainable development. While Brazil still approaches the issue of emissions more generally, its growing focus on railway transport could significantly contribute to reducing environmental impacts, particularly in logistics.

FINAL CONSIDERATIONS AND CONCLUSION

The approach adopted by various European countries, as detailed in this context, offers a solid foundation for developing a valuable model that could be adapted and implemented in Brazil. The European experience, which combines well-structured public policies with consistent investments in cutting-edge technologies, demonstrates unequivocally that it is entirely feasible to achieve a more sustainable and efficient transport system. This example shows that with the formulation and execution of adequate public policies, combined with a firm commitment to strict environmental standards and the promotion of advanced technologies, Brazil has the potential to bring about a significant transformation in its railway sector. This transformation would not only contribute to a significant reduction in GHG emissions and other atmospheric pollutants from freight and passenger rail transport but also position Brazil as a leader in the global fight for sustainability.

The integration of European best practices can, therefore, not only ensure a more sustainable future for transportation in Brazil but also ensure that the country remains competitive and relevant on the

international stage. Thus, the exchange of knowledge and international cooperation emerges as essential components for Brazil to establish itself as one of the world's leaders in sustainability in the transport sector.

The search for environmental legislation and standards in the international context presented considerable challenges. These challenges manifested themselves both in locating and accessing relevant information, and in the appropriate and contextualized interpretation of such legislation, given the intrinsic complexity of the technical terms involved and the specificities of each language. The linguistic and technical complexity that permeates these standards became a significant obstacle in conducting this work. Although artificial intelligence was explored as a tool to assist in the logical understanding and interpretation of these laws, it is important to recognize that the AI technologies currently available still lack a sufficiently robust theoretical basis and specialized support to perform this task with the necessary effectiveness.

Given this scenario, it is clear that, for future work, it will be crucial to foster interdisciplinary collaboration, involving both environmental law specialists and computer scientists. This collaboration has the potential to enhance the applicability and effectiveness of AI technologies in this context, ensuring they become more reliable, accurate, and accessible tools for interpreting complex environmental regulations.

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REFERENCES

1. AESF. State Railway Safety Agency. [Online]. 2024. Available at <https://www.seguridadferroviaria.es/>.
2. Andrade CES, D'Agosto MA. Evaluation of subway systems in CO₂ emissions: comparative analysis of emissions by cars, buses, and subways. *Environ Eng Sanitation*. 2019; 24: 919–927. doi: 10.1590/S1413-41522019139710.
3. Brazil. Law n° 14.273, December 23, 2021. Provides for the National Export Culture Plan (PNCE) and the National Export Culture Council (CNCE). Official Gazette of the Union, section 1, Brasília, DF, 24 December. [Online]. Available at https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/lei/114273.htm.
4. Bundes-Immissions schutzgesetz. Federal Ministry of Justice of Germany. [Online]. 2024. Available at <https://www.gesetze-im-internet.de/bimschg/>.
5. Cipek M, Pavković D, Krznar M, Kljaić Z, Mlinarić TJ. Comparative analysis of conventional diesel-electric and hypothetical battery-electric heavy haul locomotive operation in terms of fuel savings and emissions reduction potentials. *Energy*. 2021; 232: 121097. doi: 10.1016/j.energy.2021.121097.
6. D'Agosto MA. *Transport, Energy Use, and Environmental Impacts*. 1st edition. Rio de Janeiro, Brazil: GEN LTC; 2015.
7. European Environment Agency. Current situation: energy is at the base of Europe's climate ambitions. [Online]. European Environment Agency. 2023. Available at <https://www.eea.europa.eu/pt/sinai-da-aea/sinai-2022/artigos/situacao-atual-a-energia-esta>.
8. Hirschy F, Ridard E. A “yes” stronger than expected to the climate law. [Online]. SWI - Swissinfo.ch. 2023. Available at <https://www.swissinfo.ch/por/economia/su%C3%AD%C3%A7os-aprovam-lei-para-protoger-o-clima/48599904>.
9. Horvath A. Environmental assessment of freight transportation in the U.S.. *Int J Life Cycle Assess*. 2006; 11: 229–239. doi: 10.1065/lca2006.02.244.
10. Intergovernmental Panel on Climate Change (IPCC). *Climate report 2022 summary: the key findings*. [Online]. 2022. Intergovernmental Panel on Climate Change. Available at <https://climate.selectra.com/en/news/ipcc-report-2022>.

11. Klimaataakkoord. Execution of the Climate Agreement. [Online]. Available at <https://www.klimaataakkoord.nl/organisatie/uitvoering-van-het-klimaataakkoord>.
12. LOI n° 2015-992. Relating to the energy transition for green growth. [Online]. Available at <https://www.legifrance.gouv.fr/loda/id/JORFTEXT000031044385>.
13. Matinha GHF. Literature Review on Life Cycle Assessment of Greenhouse Gases in Railway Systems. Undergraduate thesis. Goiás, Brazil: Federal University of Goiás; 2024.
14. Ministry for Ecological Transition and Demographic Challenge. National Plan for Air Quality and Atmospheric Protection. Spain. [Online]. 2013. Available at https://www.miteco.gob.es/content/dam/miteco/es/calidad-y-evaluacion-ambiental/temas/atmosfera-y-calidad-do-ar/PLAN%20AIRE%202013-2016_tcm30-182392.pdf.
15. Da Conceição MCG, Rodrigues RAR, Cordeiro FR, Cesário FV, Selva GV, Maria C, et al. International climate change negotiation: The role of Brazil. *Sustentabilidade Em Debate*. 2019;10:379-95. DOI: 10.18472/SustDeb.v10n3.2019.2796.
16. NS. Sustainable accessibility of the Netherlands. For and by everyone. [Online]. 2014. Available at <https://www.ns.nl/over-ns/duurzaamheid>.
17. United Nations. Transforming Our World: The 2030 Agenda for Sustainable Development. [Online]. 2015. United Nations. Available at <https://sdgs.un.org/2030agenda>.
18. National Energy and Climate Plan – PNEC 2030. [Online]. 2024. Portuguese Environment Agency. Available at <https://apambiente.pt/clima/plano-nacional-de-energia-e-clima-pnec>.
19. PNL 2035. National Logistics Plan 2035. [Online]. 2021. Ministry of Infrastructure, Brazil. Available at <https://www.gov.br/transportes/pt-br/assuntos/planejamento-integrado-de-transportes/politica-e-planejamento/ResumoExecutivoPNL2035final.pdf>.
20. Regulation (EU) 2016/1628. Regulation of the European Parliament and of the Council. Official J Eur Union. 2016: L252/53–L252/117. Available at <https://eur-lex.europa.eu/legal-content/PT/TXT/PDF/?uri=CELEX:32016R1628&from=SK>.
21. UIC. Energy Efficiency and CO₂ Emissions. [Online]. 2017. International Union of Railways. Available at <https://uic.org/sustainability/energy-efficiency-and-CO2-emissions/>.
22. UIC. Global Rail Sustainability Report 2022. [Online] 2022. International Union of Railways. Available at <https://img3.uic.org/IMG/pdf/global-rail-sustainability-report-2022.pdf#:~:text=URL%3A%20https%3A%2F%2Fimg3.uic.org%2FIMG%2Fpdf%2Fglobal>.