

MAIN CONCLUSIONS

RAIL



TRANSPORT COALITION

HOW TO MAKE THE TRANSPORT SECTOR AN ACTIVE
CONTRIBUTOR TO THE REDUCTION OF BRAZILIAN EMISSIONS



CONTEXT AND MOTIVATION

- Brazil's New National Determined Contribution (NDC) and Climate Plan **represent opportunities to position the country as a global decarbonization leader**, especially as it is the host of COP 30 in 2025.
- The transport sector is critical, accounting for **~11% of national gross emissions (260 Mton in 2023, well-to-wheel vision¹)**; **~1,6% of transport emissions come from the rail mode**.
- Given the expected growth for the country, in an inaction scenario, the emissions of the rail mode can **reach 5,5 Mton CO₂e in 2050**.



THE COALITION

- The magnitude of the challenge **requires widespread engagement and debate** by the transport sector.
- **Led by Motiva, CEBDS, CNT and Insper's Mobility Observatory**, the Coalition mobilized **+50 entities of 6 groups**: urban mobility, road, rail, coastal & inland navigation, airway and infrastructure/ cross-sectionality.



INITIAL OBJECTIVES

- The effort, started in Nov/2024, developed from the **active contribution of coalition entities and primary data** available until Feb/2025, materialized important deliveries, such as:
 1. Measurement of the emissions baseline in 2050²;
 2. Mapping of 90 decarbonization levers;
 3. Quantification of impacts for decarbonization path.

The conclusions of this study are the result of a collective effort in favor of sustainable decarbonization of the transport sector, based in the technologies and information currently available, and may evolve with new future advances.

1. Emissions from the transport sector calculated based on sources external to SEEG; 2. Baseline 2050 is a projection based on estimates of passenger and cargo growth and inertial vision of the fuel consumption matrix

RAIL – MEMBER ENTITIES

This document was supported by the following entities from the rail transport mode.



COORDINATION



OTHER MEMBERS

CNT / SEST SENAT / ITL
Sistema Transporte



OBSERVATÓRIO
NACIONAL DE MOBILIDADE
SUSTENTÁVEL
Insper | CENTRO DE
ESTUDOS
DAS CIDADES

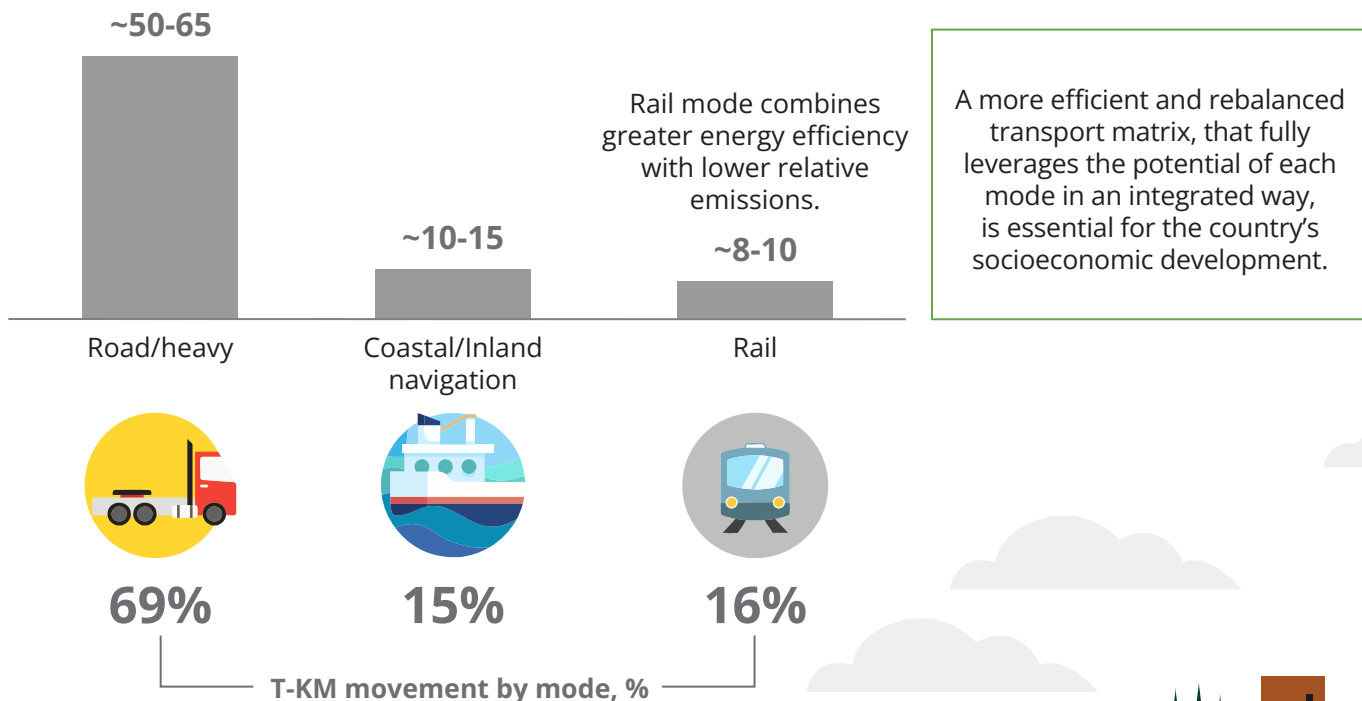


CONSULTATIVE CROSS-SECTION
ENTITIES

COMPARISON OF EMISSION LEVELS BY FREIGHT MODE IN 2022 (CO₂e/T-KM)

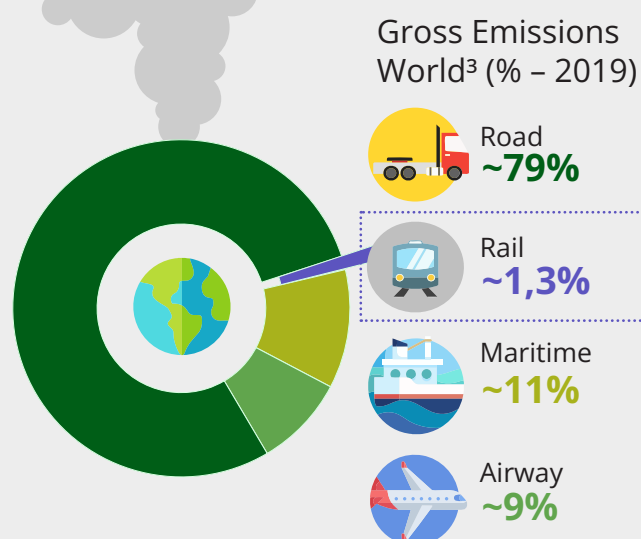
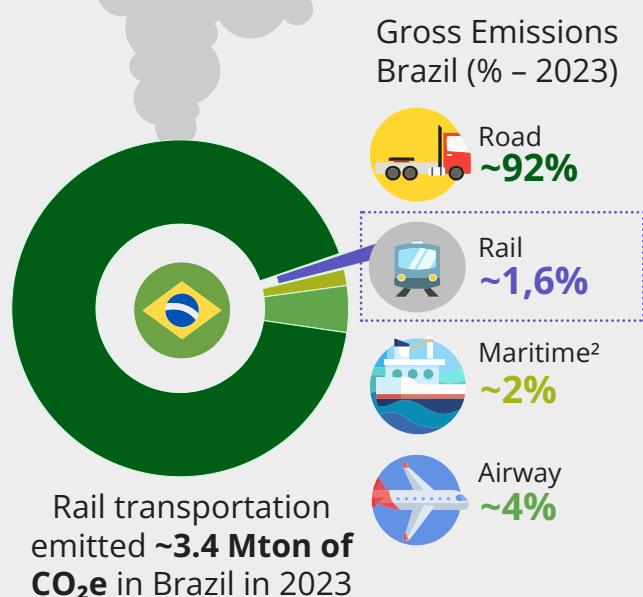
Rail transport has a less polluting nature compared to other modes of transportation (e.g., it emits about 6 times less CO₂e per T-KM than road transport). Currently, it represents 16% of national freight movements and emits ~1.6% of transport-related CO₂e, which reinforces its emissions efficiency.

RELATIVE EMISSIONS BY TRANSPORT MODE¹ (gCO₂e / T-KM)



1. Restricted to rail freight transport; Passenger/urban trains were considered in Urban Mobility; Source: Based on data from ANTF and SEEG 2022.

EMISSIONS¹ OF RAIL MODE REPRESENT ~1.6% OF THE TOTAL FROM TRANSPORT IN BRAZIL



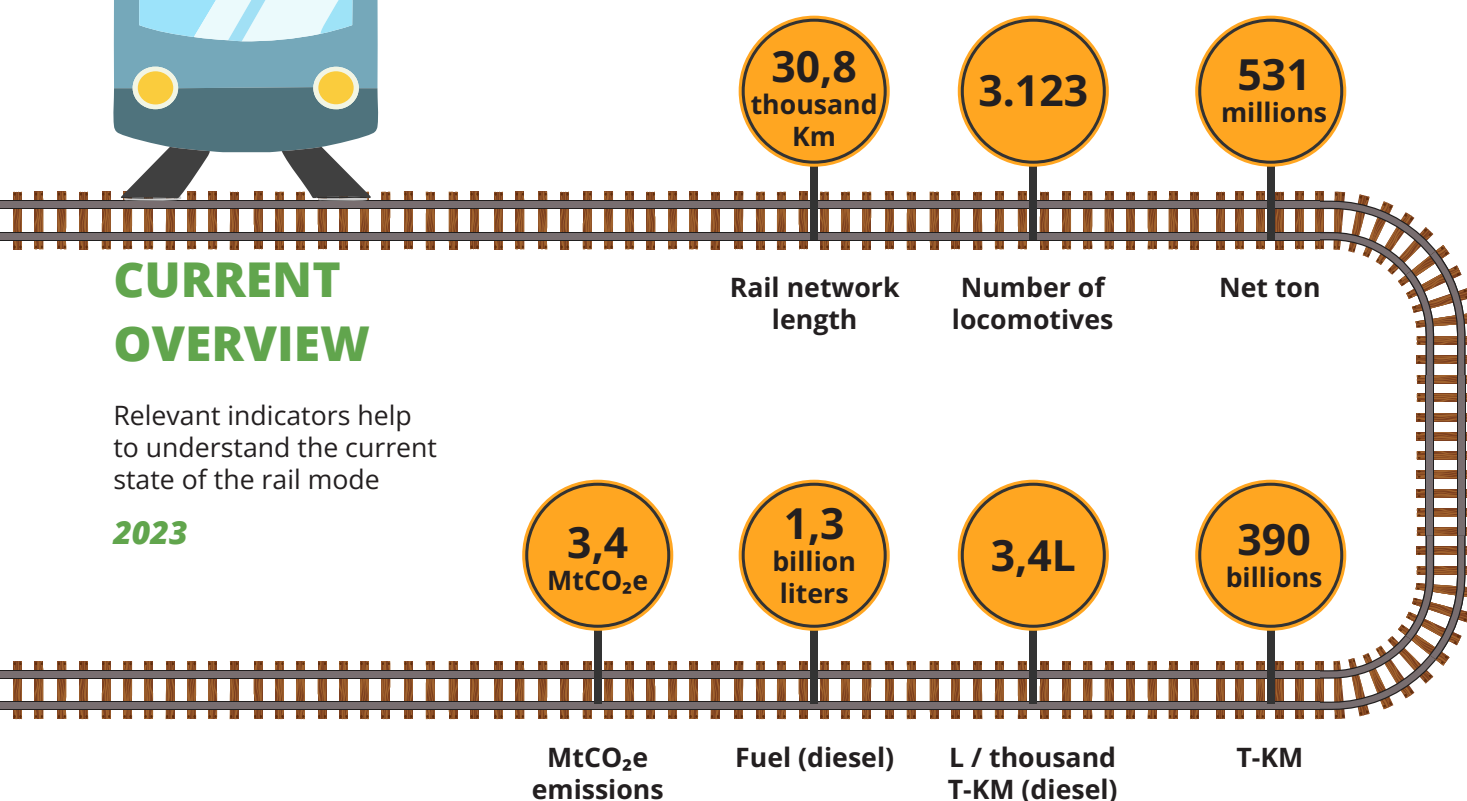
1. Transport emissions reported by SEEG are restricted to burning fuels; 2. Considers coastal and inland navigation, without long haul; 3. Global value excluding Brazil; Source: Anfavea; SEEG; CAIT; CLIMATE TRACE.



CURRENT OVERVIEW

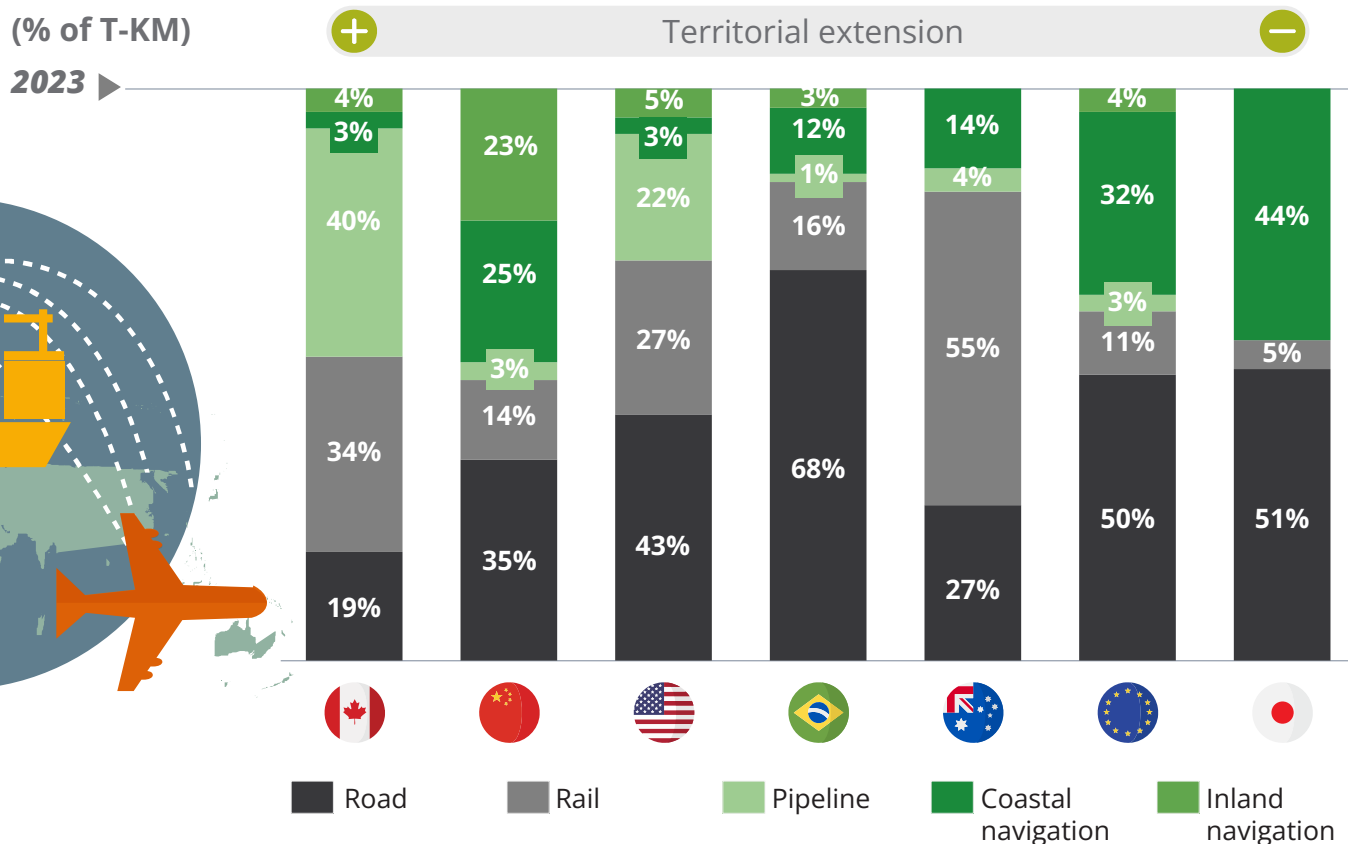
Relevant indicators help to understand the current state of the rail mode

2023

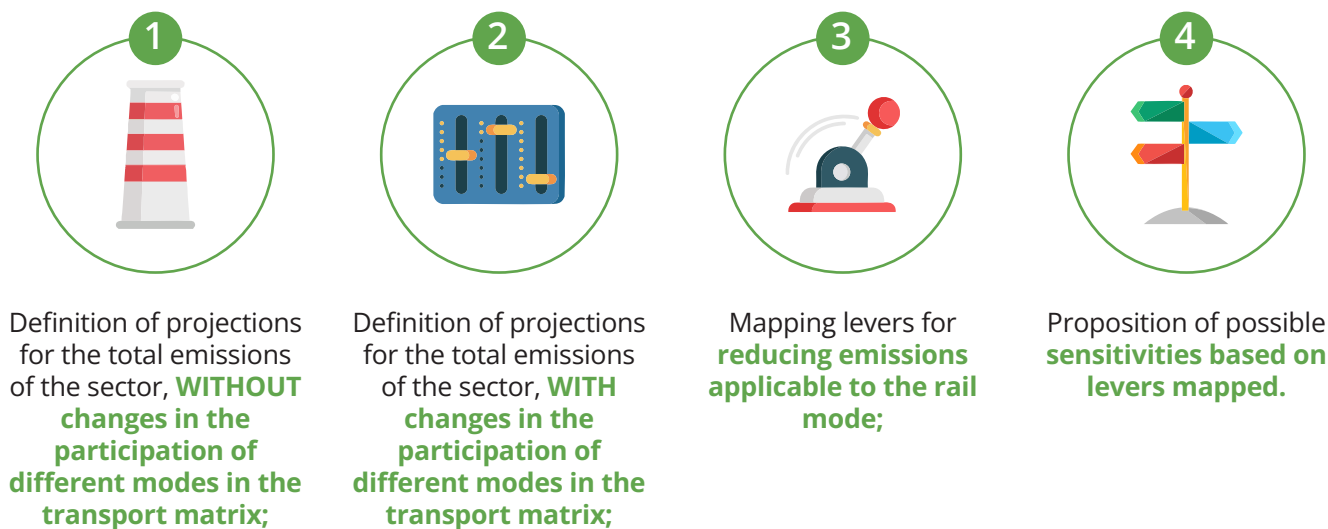


RAIL MODE WITH LOWER RELATIVE REPRESENTATION IN BRAZIL COMPARED TO OTHER COUNTRIES

Comparison of Brazil's freight transport matrix with other countries highlights that the current matrix is predominantly road-based.



APPROACH I FOUR STEPS FOR DECARBONIZATION OF THE RAIL MODE

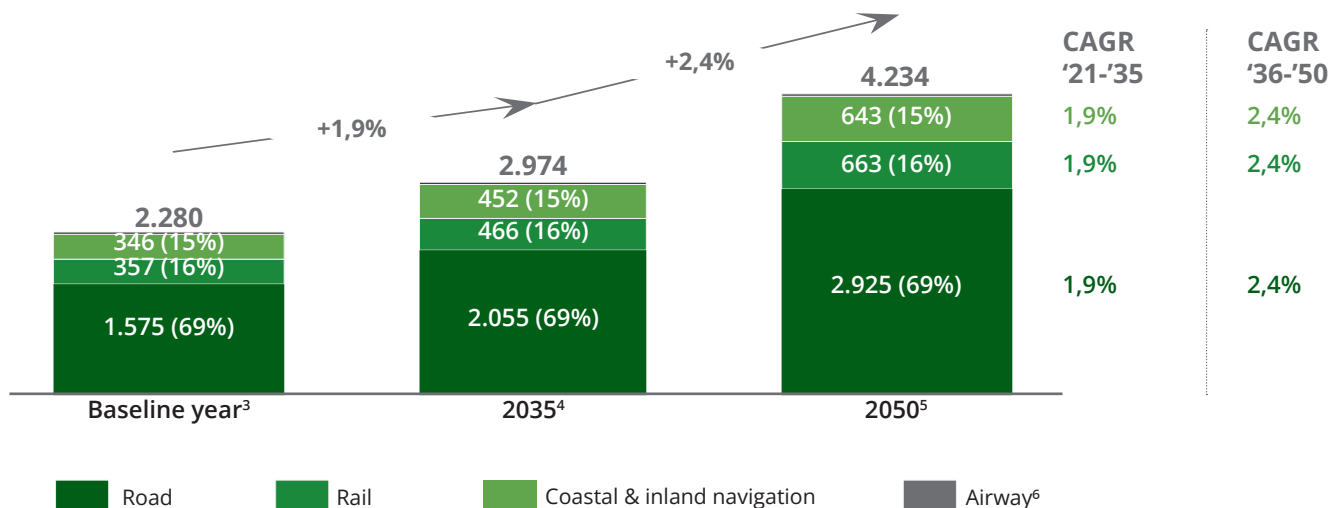


1 DEFINITION OF BAU¹ EMISSIONS WITHOUT CHANGES IN THE TRANSPORT MATRIX

In an inaction scenario, the total transport emissions would reach **~424 Mton CO₂e in 2050**; in this context, the representativeness of the transport mode in the national transport matrix would remain unchanged (rail would remain ~16%).

EVOLUTION OF THE CARGO² MATRIX (BILLIONS OF T-KM, %)

Inaction scenario

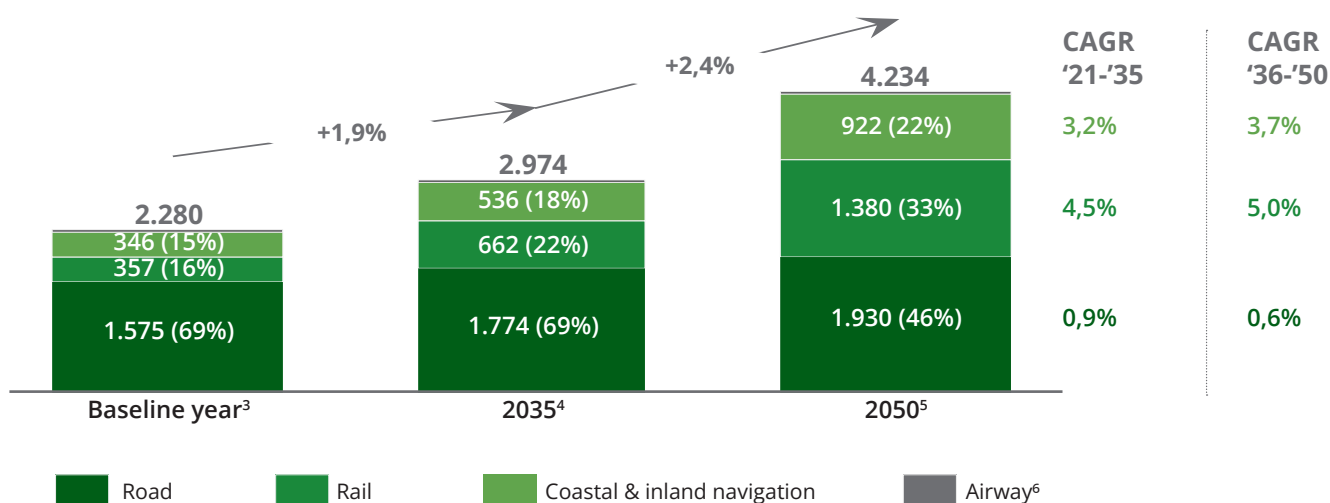


2 DEFINITION OF BAU¹ EMISSIONS WITH CHANGES IN THE PARTICIPATION OF MODES OF TRANSPORT

In the second stage, an alternative scenario was explored in which the share of the rail in the transport matrix could be expanded, which would already be able to generate impacts of emission reduction due to the lower relative emission factor (gCO₂/T-KM) in this mode vs other more emitters.

EVOLUTION OF THE CARGO² MATRIX (BILLIONS OF T-KM, %)

With change in matrix

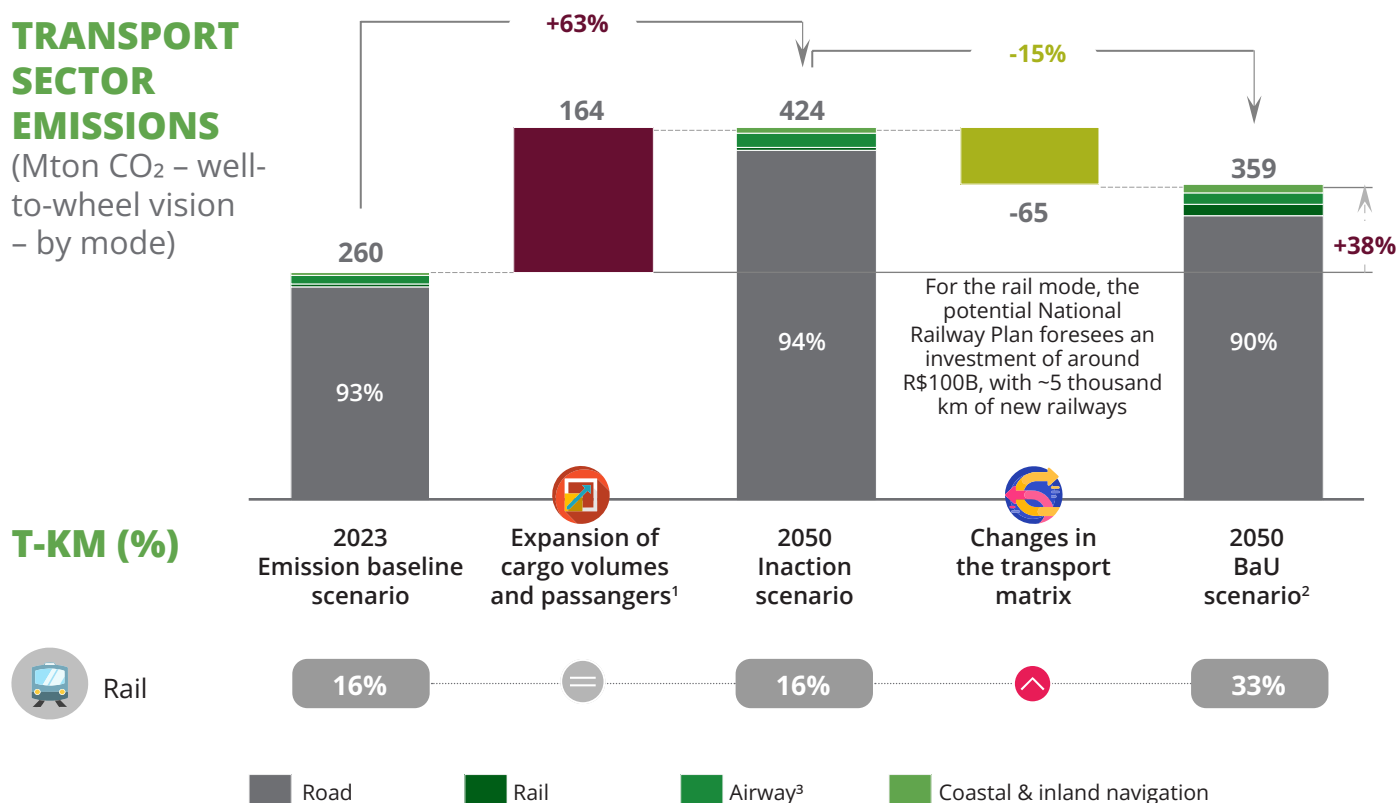


1. BaU = Business-as-Usual; 2. Projections based on the Sectoral Transport Plans (PSTR and PSTF) and the PNL 2035 – National Logistics Plan; 3. 2021 was the year the PNL/PSTF were carried out, in addition to presenting more comprehensive historical parameters; 4. T-KM values refer to scenario PSR1 from PSTR; 5. T-KM projected in line with GDP, with distribution of scenario PSR3 from PSTR; 6. Emissions from the airway mode are not related to cargo transportation, only to passenger transportation; Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

In summary, the balance in the Brazilian transport matrix would mitigate about 15% (considering the change of matrix foreseen in the rail and coastal & inland navigation modes) of the expected volume of CO₂ emissions by 2050:

TRANSPORT SECTOR EMISSIONS

(Mton CO₂ – well-to-wheel vision – by mode)



1. Increased emissions due to expected growth in T-KM and passenger demand until 2050; 2. Business-as-usual; 3. Emissions from airway transport are not related to cargo transportation, only passenger transportation.

3 LEVER MAPPING FOR EMISSION REDUCTION

After the presentation of the transport matrix, levers with potential to reduce emissions in the rail mode were identified by the working group.

Such levers were mapped into three large blocks as described below. For each of them, a qualitative feasibility analysis¹ was performed and local and global references were presented that illustrate the respective application.

Although there are different sources of emissions in the rail transport chain, this document focused on levers with the potential to reduce emissions from the combustion of fuel by locomotives (well to wheel vision).

LEVERS BLOCKS FOR REDUCING EMISSIONS in rail mode



EFFICIENCY



BIOFUELS



ELECTRIFICATION AND POWER-TO-X

1. The complete details of the viabilities and references can be found in the complete document of the rail mode, which can be accessed via QR Code at the end of material.



EFFICIENCY

Levers

- 1 **Design improvement**, through the use of lighter materials to reduce the weight of locomotives and the application of new aerodynamic solutions.
- 2 **Renewal of the current fleet**, by replacing older locomotives with newer, more efficient ones with greater cargo/wagon capacity.
- 3 **Infrastructure optimization**, through the use of technologies and automated systems to optimize the operation and maintenance of rail infrastructure.
- 4 **Smart route and fleet optimization**, using technology and data-driven systems to optimize locomotive operations.
- 5 **Eco-efficient and assisted driving**, by changing driver behavior and using technology to optimize energy consumption.



BIOFUELS

Levers

- 1 **Green Diesel blend in Fossil Diesel** – Green Diesel has similar properties to Fossil Diesel, but its application in rail is still in the early development phase.
- 2 **Ethanol** – widely used in Brazil, typically adapted for use in internal combustion engines; application in rail is still in its early stages, requiring infrastructure and engine adaptations.
- 3 **Biodiesel as an alternative via Fossil Diesel blend** – increasing the blend percentage should be done with caution.

Potential intensification of biofuels to reduce the carbon footprint can be applied provided that the technical, mechanical, operational and laboratory viability of the said energy input is verified, as well as respecting the diversity of matrices and regional specificities.



ELECTRIFICATION & POWER-TO-X

Levers

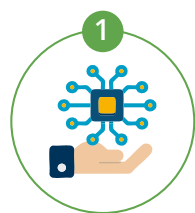
- 1 **Locomotives powered by low-carbon H₂ routes** – energy generation with lower CO₂ emissions; low-carbon hydrogen can be transformed into routes such as methanol and others, to make it more viable.
- 2 **Electric locomotives** – electrical energy is used as a driving force for the traction motors of electric locomotives, replacing fossil fuels (technology currently limited to short distances).
- 3 **Hybrid locomotives** – diesel-electric system combined with battery units, where the energy source feeding the traction motors can come from both sources.

Levers can be applied since the technical and operational viability of the respective solutions are verified.

Source: Press search, company websites; ANTF; Senate; Iberdrola – Hydrogen.

4 PROPOSITION OF SENSITIVITIES BASED ON THE MAPPED LEVERS

Finally, sensitivities were proposed to evaluate the impact of different decarbonization paths:



Current technologies

Restricted to the application of efficiency levers and compliance with regulatory requirements;



Intensification of biofuels

Predominance of the application of levers for intensification of the use of biofuels;



Acceleration of Electrification / Power-to-X

Predominance of electrification/power-to-x levers of the locomotives fleet;



Transformational

Combination of efforts considering the levers of sensitivities 1, 2 and 3 for closer reach of zero net emissions.

For the purposes of this material, we will only analyze the impact range between the most conservative (1) and the most ambitious (4) sensitivities — the detailed breakdown of the other sensitivities can be found in the full document, accessible via the QR Code at the end of this material.



CURRENT TECHNOLOGIES



TRANSFORMATIONAL



Efficiency

All efficiency levers were considered across the different sensitivity levels.



Biodiesel² (Blend in diesel)

20% in 2030.

20% in 2030, 30% in 2050.

Green diesel² (Blend in diesel)

–

70% in 2050, starting in 2030.

Ethanol²

–

Penetration aligned with what would be expected for methanol¹, given the same adaptation needs.



Hybridization

0,2% of new locomotives by 2050, with 30% battery usage.

45% of new locomotives, with 50% battery usage by 2035.

Low-Carbon H₂ Routes

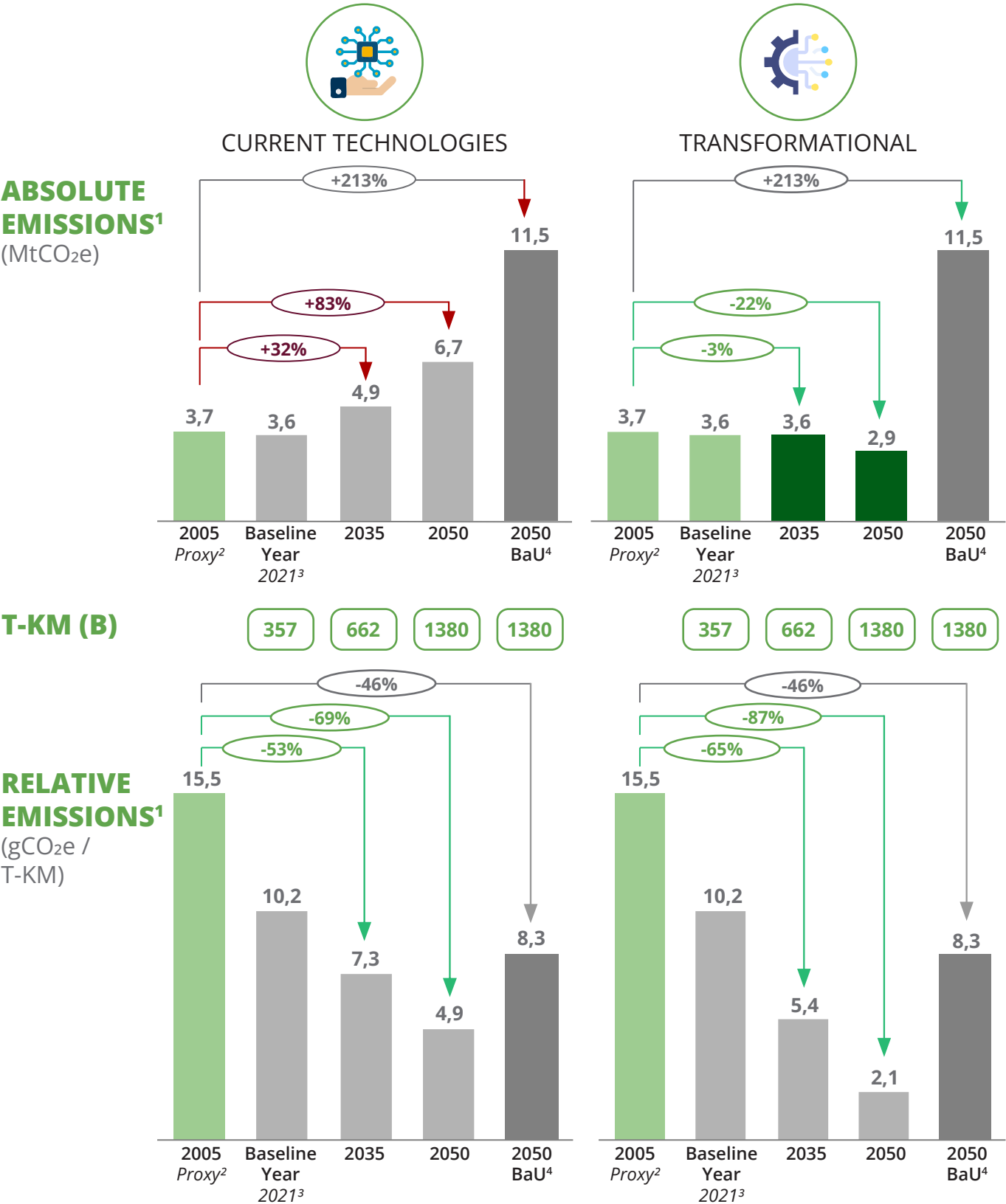
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20% of new locomotives starting in 2035, through different routes (e.g., methanol, others).

1. Low-carbon hydrogen routes; 2. Potential intensification of biofuels to reduce the carbon footprint can be applied provided that the technical, mechanical, operational and laboratory viability of the said energy input is verified, as well as respecting the diversity of matrices and regional specificities.

RESULTS OF SENSITIVITIES ON EMISSION IMPACT

As a result of the implementation of the mapped levers, transport sector emissions could **reach up to 2,9 MtCO₂e absolute and ~2,1 gCO₂e/T-KM relative in the transformational sensitivity scenario in 2050¹** (up to ~50% and ~75% reduction compared to the baseline scenario in the same year, respectively).



1. Emission factors consider the WTW (Well To Wheel) vision; 2. Proxy for the year 2005, based on SEEG tank-to-wheel data; 3. 2021 is the baseline year from PSTF/PNL, also chosen for presenting more comprehensive historical parameters; 4. BaU = Business-as-Usual scenario, considers sector growth projections in PNL 2050, with changes in mode shares.



EXAMPLES ILLUSTRATE HOW ENABLERS HELP THE APPLICATION OF DECARBONIZATION LEVERS

PUBLIC AND PRIVATE INCENTIVES TO ENABLE GREATER RELEVANCE OF RAIL IN BRAZIL'S LOGISTICS MATRIX

Contract Renegotiations¹

Evolution of concession contract renegotiations, including the emergence of investment clauses for network expansion and the unlocking of investments to increase capacity in the current rail network.

New Legal Framework of Railways²

Investments promotion through regulatory reduction (e.g.: self-regulation incentives) and feasibility of a more attractive grant model for private players (authorizations), with the aim of expanding the capacity of the railway mode.

Structural Investments in Railways

Continued public investments (e.g.: FIOL³) and private investments, such as R\$ 4 billion from Rumo for the completion of FNS⁴ Central Trunk, establishing a new structural axis for rail mode.

INCENTIVES TO CONCRETE SUSTAINABILITY COMMITMENTS

Sustainability Program⁵ (2024)

Encouragement of regulatory benefits to companies (e.g.: differentiated conditions for signing Conduct Adjustment Agreements – TACs⁶), conditional on sustainability initiatives.

TANGIBLE MECHANISMS TO PROMOTE PRIVATE FINANCING

Etihad Rail

Facilitating the issuance of green bonds and sustainable loans, promoting the raising of funds for sustainable projects and low-carbon technologies.

CONCRETE ACTIONS BY THE PRIVATE SECTOR THROUGH PARTNERSHIPS FOR CLEANER TECHNOLOGY DEVELOPMENT

Alstom and Linde

Development of Europe's first hydrogen locomotive, which began operating in 2017.

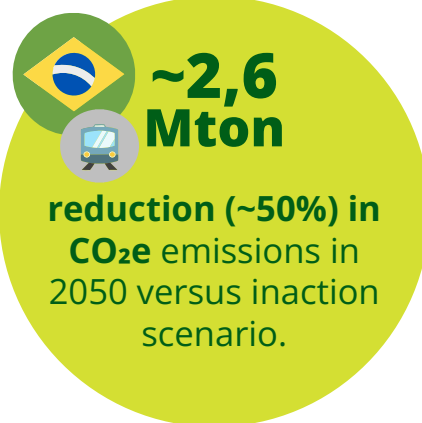
Vale and Wabtec

Partnership for the development of less polluting battery-electric locomotives.

1. Law nº 13.448/2017; 2. Law nº 14.273/2021; 3. West-East Integration Railway (FIOL); 4. North-South Railway (FNS); 5. ANTT Resolution 6.057/2024; 6. TACs = Conduct Adjustment Agreements; Sources: ANTF; IBPF; Railway Magazine; National Department of Transport Infrastructure; Ministry of Transport.

WE AIM FOR SUSTAINABLE GROWTH FOR THE RAIL MODE

Considering the projected growth for the sector, the rail mode should reach **33% of T-KM transported in 2050 (vs 16% in the baseline year¹)**, while **CO₂e emissions should represent only ~2% of total transport emissions in Brazil** under the transformational sensitivity in the same year (vs 1.6% in the baseline year¹).



Conclusions sought by the work toward the rail mode in Brazil in 2050:

CURRENT RAIL¹

 **16% OF NATIONAL T-KM** transported.

 **~0.1 BILLION LITERS** of biofuels consumed.

 **~0% OF HYBRID LOCOMOTIVES.**

 **~0% OF LOCOMOTIVES** powered by low-carbon H₂ routes.

FUTURE RAIL²

 **33% OF NATIONAL T-KM** transported.

 **~1.0 BILLION LITERS** of biofuels consumed.

 **~60% OF HYBRID LOCOMOTIVES.**

 **EXPANSION OF H₂ ROUTES³** given the materialization of the technology.

1. 2021 (baseline year of PSTF/PNL, also presenting more comprehensive historical parameters); 2. 2050 Transformational; 3. Low-carbon hydrogen

RAIL MODE

Scan the QR Code to access the full document

