

FULL STUDY

# TRANSPORTATION COALITION

HOW THE TRANSPORTATION SECTOR CAN BECOME AN ACTIVE CONTRIBUTOR TO THE REDUCTION OF BRAZILIAN EMISSIONS





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**CNT / SEST SENAT / ITL**  
— Sistema Transporte —



BRASÍLIA  
2025

Technical Information Sheet Transport Coalition: How to make the transport sector an active contributor to the reduction of Brazilian emissions

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Study conceived and coordinated by the **Brazilian Business Council for Sustainable Development (CEBDS)**, **Motiva**, the **National Confederation of Transport (CNT)**, and the **Inspere Sustainable Mobility Observatory**.

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# Introduction

By Marina Grossi

President of CEBDS and Special Envoy for the Business Sector to COP30

Mobility lies at the heart of climate transition and sustainable development.

It connects people, markets, and opportunities — and largely determines the efficiency and competitiveness of the economy. Responsible for about **11% of Brazil's national emissions**, the transport sector concentrates both the challenges and the solutions required for a decarbonization pathway capable of driving prosperity and improving quality of life.

With this vision, and at the invitation of **Ambassador André Corrêa do Lago**, President of COP30, **CEBDS**, in partnership with **Motiva**, the **National Confederation of Transport (CNT)**, and **Inspere's National Observatory of Sustainable Mobility**, structured the **Business Coalition for the Decarbonization of Transport**.

This initiative, which brings together **121 organizations**, was the first of the four sectoral coalitions coordinated by CEBDS — and has become a **model of pre-competitive and evidence-based collaboration**.

The visionary leadership of **Miguel Setas**, CEO of Motiva, made this initiative possible and encouraged the private sector to act in a cooperative and forward-looking way in building a sectoral decarbonization plan.

**CNT** served as a strategic partner, whose representativeness and technical expertise ensured the **regulatory and operational coherence** of the proposals.

And **Inspere**, as the academic partner,

contributed analytical precision and rigor, guaranteeing the study's methodological consistency.

The result is a **solid plan** containing **90 concrete measures** to reduce the sector's emissions by **up to 70% by 2050**, potentially attracting more than **R\$ 600 billion in green investments**.

The main levers include:

- **Large-scale electrification of vehicle fleets;**
- **Rebalancing the freight transport matrix**, with greater participation of rail and waterway modes;
- **Expansion and modernization of biofuel use.**

These measures do more than reduce emissions — they reposition Brazil's transport sector as a **driver of innovation, inclusion, and economic competitiveness**.

**COP30, in Belém**, marks the shift from ambition to implementation.

Brazil arrives with tangible results and with the strength of a movement that already mobilizes **more than 270 organizations** across four major coalitions — **Transport, Power, Agriculture, and Critical Minerals** — all coordinated by CEBDS.

The **Transport Coalition** was the first to pave this path.

Brazil can and must lead the **redefinition of mobility** as the foundation of a new economy — one that is **more efficient, inclusive, and aligned with the future**.

# CONTENTS



EXECUTIVE SUMMARY.....	7
------------------------	---



## ROAD TRANSPORT

Main conclusions.....	19
Details on the Road Transport mode.....	35
Appendix 1.....	54
Appendix 2.....	57
Appendix 3.....	61
Appendix 4.....	65



## RAIL TRANSPORT

Main conclusions.....	69
Details on the Rail Transport mode.....	81
Appendix 1.....	101
Appendix 2.....	105



## WATER TRANSPORT

Main conclusions.....	109
Details on the Water Transport mode.....	121
Appendix 1.....	143
Appendix 2.....	147



## AIR TRANSPORT

Main conclusions.....	149
Details on the Air Transport mode.....	161
Appendix 1.....	180
Appendix 2.....	184



## URBAN MOBILITY

Main conclusions.....	187
Details on the Urban Mobility mode.....	199
Appendix 1.....	210



CONCLUSIONS OF TRANSPORTATION COALITION.....	213
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# EXECUTIVE SUMMARY

## CONTEXT AND PURPOSE



- Brazil's updated Nationally Determined Contribution (NDC) and Climate Plan **offer strategic opportunities to position the country as a global leader in decarbonization efforts**, particularly in light of its role as host of COP30 in 2025.
- Transportation plays a pivotal role in Brazil's emissions profile, contributing **nearly 11% of gross national emissions (260 million metric tons in 2023, well-to-wheel<sup>1</sup>)**. **Of this, ~4% is attributed to air transport.**
- Given the expected growth for the country, where no additional interventions are made, emissions from air transport could reach **13.4 Mton CO<sub>2</sub>e in 2050**.

## THE COALITION



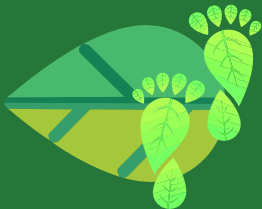
- The magnitude of this challenge requires mobilization and broad debate among stakeholders in the transportation sector.
- **Led by Motiva, CEBDS, CNT and Inspers' Mobility Observatory, the Coalition mobilized +50 entities from 6 verticals: Urban Mobility, Road Transport, Rail Transport, Water Transport, Air Transport and Infrastructure/ transversality.**

## INITIAL OBJECTIVES



- Initiated in November 2024 **with active input from Coalition stakeholders and supported by primary data collected** through February 2025, the initiative led to several important outcomes, such as:
  1. Measurement of the emission baseline in 2050<sup>2</sup>;
  2. Mapping of 90 decarbonization levers;
  3. Quantifying impacts along the decarbonization pathway.

## NEXT STEPS



- This is the **1st step in a lengthy journey** of the sector's continuing efforts to contribute to Brazil's climate agenda.
- The dialogue and collaboration between the **entities will continue to progress even after COP30**, with an ongoing effort to update the mapping of levers and outcomes based on new insights.

The conclusions of this study are the result of a collaborative effort toward the sustainable decarbonization of the transportation sector, based on currently available technologies and information, and may be expanded upon with future breakthroughs.

1. Emissions from the transportation sector calculated based on sources external to the Greenhouse Gas Emissions and Removals Estimating System (SEEG); 2. Baseline 2050 is a projection based on estimates of passenger and freight growth and inertial vision of the fuel consumption matrix.

# THE TRANSPORTATION COALITION INCLUDES THE ACTIVE PARTICIPATION OF MORE THAN 50 ENTITIES FROM THE SECTOR



## INFRASTRUCTURE & TRANSVERSALITY

Coordinating entities



## URBAN MOBILITY

Coordinating entities



## ROAD TRANSPORT

Coordinating entities



## RAIL TRANSPORT

Coordinating entities



## AIR TRANSPORT

Coordinating entities



## WATER TRANSPORT

Coordinating entities



Advisory Board: CEBDS, CNT/SEST SENAT, Motiva and Inspet's Mobility Observatory and coordinators of the respective verticals.

Following the study's publication, the Transportation Coalition gathered further support: 69 new companies and entities signed on, recognizing the urgent call for sectoral mobilization and climate action. The recommendations presented were able to help create the Climate Plan, available for Public Consultation and which will be released at COP30 in November, demonstrating that the business sector and civil society play a decisive role in building systemic solutions to climate challenges.

Listed below are the new companies and entities that joined the study:

## COMPANIES AND ENTITIES

ABLA	Associação Brasileira das Locadoras de Automóveis
ABTLP	Associação Brasileira de Transporte e Logística de Produtos Perigosos
AENA BRASIL	Aeroportos do Nordeste do Brasil S.A.
AEROM	Aerom Sistemas de Transporte S.A.
AGUIA BRANCA	Aguia Branca Transportes S.A
ALIANÇA	Aliança Navegação e Logística Ltda.
ARCO	Arco Consulting Partners Ltda.
BBM LOGÍSTICA	BBM Logística S.A.
BRADO	Brado Logística S.A.
BRASKEM	Braskem S.A
BRASPRESS	Braspres Transportes Urgentes Ltda.
BRAVO	Bravo Serviços Logísticos Ltda.
BRAZIL ON RAILS	Brazil on Rails
BUDEL	Budel Transportes Ltda.
CARVALIMA	Carvalima Transportes Ltda.
CBC	Câmara Brasileira de Contêineres
CRASA	Crasa Infraestrutura S.A.
CTB	Companhia de Transporte do Estado da Bahia
EDGE	EDGE Comercialização S.A.
ELCANO	Empresa de Navegação Elcano S.A
ENTREVIAS	Entrevias Concessionária de Rodovias S.A.
FENALOC	Federação Nacional das Empresas Locadoras de Veículos Automotores
FENOP	Federação Nacional das Operações Portuárias
FETCEMG	Federação das Empresas de Transporte de Carga do Estado de Minas Gerais
FETPESP	Federação das Empresas de Transporte de Passageiros do Estado de São Paulo
FETRAM	Federação das Empresas de Transporte de Passageiros do Estado de Minas Gerais
FETRAMAZ	Federação das Empresas de Logística, Transportes e Agenciamento de Cargas da Amazônia
FETRANORTE	Federação das Empresas de Transporte Rodoviário da Região Norte

<b>FETRANSCARGA</b>	Federação do Transporte de Cargas do Estado do Rio de Janeiro
<b>FETRANSPAR</b>	Federação das Empresas de Transporte de Cargas do Estado do Paraná
<b>FETRANSUL</b>	Federação das Empresas de Logística e de Transporte de Cargas no Rio Grande do Sul
<b>FLUMAR</b>	Flumar Transportes de Químicos e Gases Ltda.
<b>GRUPO REPORT</b>	Grupo Report Tecnologia e Serviços Ltda.
<b>GRUPO SADA</b>	Sada Transportes e Armazenagens Ltda.
<b>GT SOLUÇÕES LOGÍSTICAS</b>	GT Soluções Logísticas S.A.
<b>HITACHI</b>	Hitachi Energy Brasil Ltda.
<b>INTERTECHNE</b>	Intertechne Consultores S.A.
<b>ITAÚ UNIBANCO</b>	Itaú Unibanco Holding S.A.
<b>LATAM</b>	Tam Linhas Aéreas S.A.
<b>LOG-IN</b>	Log-in Logística Intermodal S.A.
<b>LWART</b>	Lwart Soluções Ambientais S.A.
<b>LYRA</b>	Lyra Navegação Marítima Ltda.
<b>MERCADO LIVRE</b>	Mercado Livre Atividades de Internet Ltda
<b>MERCOSUL LINE</b>	Mercosul Line Navegação e Logística Ltda.
<b>METRÔ DF</b>	Companhia do Metropolitano do Distrito Federal
<b>METRÔ RIO</b>	Concessão Metroviária do Rio de Janeiro
<b>MOBIBRASIL</b>	Mobibrasil Transporte São Paulo Ltda.
<b>MOVECTA</b>	Movecta S.A.
<b>NORCOAST</b>	Norcoast Logística S.A.
<b>NORSUL</b>	Companhia de Navegação Norsul
<b>NOVA ROTA DO OESTE</b>	Concessionária Rota do Oeste S.A.
<b>PROSEGUR</b>	Prosegur Brasil S/A Transportadora de Valores e Segurança
<b>ROTA DAS BANDEIRAS</b>	Concessionária Rota das Bandeiras S.A.
<b>SEMOBI NITERÓI</b>	Secretaria de Mobilidade e Infraestrutura de Niterói (RJ)
<b>SEMOVE</b>	Federação das Empresas de Mobilidade do Estado do Rio de Janeiro
<b>SETCESP</b>	Sindicato das Empresas de Transportes de Carga de São Paulo e Região
<b>SIMEFRE</b>	Sindicato Interestadual da Indústria de Materias e Equipamentos Ferroviário e Rodoviário

<b>SINTRAM</b>	Sindicato das Empresas de Transporte de Passageiros Metropolitanano
<b>SMTR RJ</b>	Secretaria Municipal de Transportes do Rio de Janeiro (RJ)
<b>SMU SANTO ANDRÉ</b>	Secretaria de Mobilidade Urbana de Santo André (SP)
<b>TRAGETTA</b>	Fl Brasil Holding, Logística e Transporte Ltda.
<b>TRANSHIP</b>	Tranship Transportes Marítimos Ltda.
<b>TRANSPES</b>	Transportes Pesados Minas Ltda.
<b>UNIMAR TRANSPORTES</b>	Unimar Transportes Ltda.
<b>URBANA-PE</b>	Sindicato das Empresas de Transportes de Passageiros no Estado de Pernambuco
<b>VIA APPIA</b>	Via Appia Concessões S.A.
<b>VIXPAR</b>	VIX Logística S.A.
<b>WILSON SONS</b>	Wilson Sons S.A.

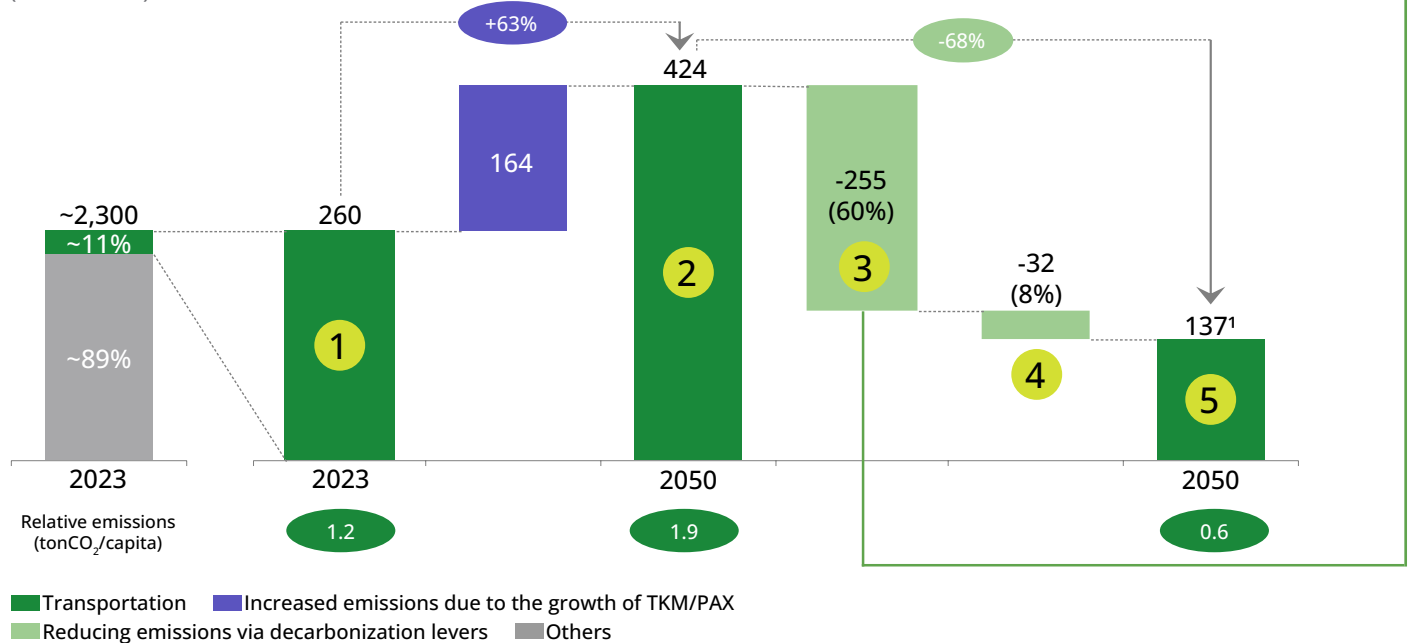


# PATH TO DECARBONIZATION

Decarbonization levers could reduce transportation sector CO<sub>2</sub>e emissions by nearly 70% by 2050 (vs. a scenario of inaction). Below is a chart containing the potential trend of the volume of transport emissions up to 2050, considering the growth predicted by the Sectoral Plans and the PNL 2035 for each type of transport as a starting point.

## EMISSIONS IN BRAZIL

(Mton CO<sub>2</sub>e) – Well-to-Wheel



**1 2023 emissions baseline:** The transportation sector in Brazil emits about 260 million tons<sup>1</sup> of CO<sub>2</sub>e per year, representing **~11% of total CO<sub>2</sub>e emissions<sup>2</sup> in the country, with +90% of them coming from road transport.**

**2 2050 emissions baseline in a scenario of inaction<sup>3</sup>:** Given the **expected development for an emerging country** such as Brazil and its implications for various areas of society, the transportation sector is anticipated to see significant growth by 2050. Given this, in a scenario of inaction, total emissions from the sector are expected to reach 424 Mton CO<sub>2</sub>e in 2050 (+63% vs. 2023). **Even with the anticipated growth, Brazil is projected to emit roughly 1.9 tons of CO<sub>2</sub>e per capita in 2050, a level that remains lower than developed nations such as the US and France (whose 2023 per capita emissions were estimated at ~6 and 2.5 tons, respectively).**

**3 Potential reduction through 3 critical vectors:** Based on the active contribution of the Coalition's member entities, **90 levers for the decarbonization of the sector were identified and assessed** — of these 90 levers, those with the highest impact on reduction were grouped into **3 critical vectors: i. Change in the transportation matrix; ii. Expansion of the use of biofuels; iii. Electrification and Power-to-X. Together, these three vectors represent a potential for a 60% reduction in emissions** (more details on the next page).

**4 Potential reduction of other levers:** Additional efficiency and optimization levers also play a relevant role. Despite the lower estimated potential for reducing emissions, many of these levers have a **high feasibility of implementation that can provide concrete impacts over the short term.**

**5 Potential volume of residual emissions in 2050:** Future innovations and large-scale technologies **should make the achievement of net-zero emissions in the transportation sector viable in Brazil by 2050.** There should be a focus on addressing the **residual emissions<sup>4</sup> when applying these new technologies, estimated at 137 MtCO<sub>2</sub>e, generated mainly by the remaining fleet that could still depend on fossil fuels.**

1. Well-to-wheel perspective; 2. Gross greenhouse gas emissions; 3. The model incorporates the projected growth in both passenger and freight demand through 2050, applied through the same transportation matrix and existing technologies in 2024; 4. ~70% of the potential residual volume of emissions in 2050 is expected to come from the remaining burning of fossil fuels. Diesel looks to represent more than 85% of this total.

## 3 VECTORS RESPONSIBLE FOR ~60% OF THE POTENTIAL EMISSION REDUCTION



### CHANGE IN THE TRANSPORTATION MATRIX

*Adjusting the distribution of freight loads across different modes of transportation with lower emissions per TKM*

**65 Mton**  
in reducing emissions (-15% vs. a scenario of inaction).

Expansion of rail and water transport modes, **increasing the share of the freight matrix from 31% of the TKM handled in 2023 to 55% in 2050.**

Despite the reduction in participation within the overall transportation matrix, road transport is projected **to experience an absolute increase in freight demand of +18% by 2050 (+150 billion TKM).**



### EXPANSION OF THE USE OF BIOFUELS

*Higher use of biomass-derived fuels*

**45 Mton**  
in reducing emissions (-10% vs. a scenario of inaction).

Expansion of the use of fuels with lower emissions (e.g. SAF, Green Diesel, in addition to other biofuels).

Estimated additional demand of **25 billion liters of biofuels in 2050.**

Adoption should take place as long as its viability is confirmed and as long as the diversity of energy sources and regional specificities are respected.



### ELECTRIFICATION AND POWER-TO-X

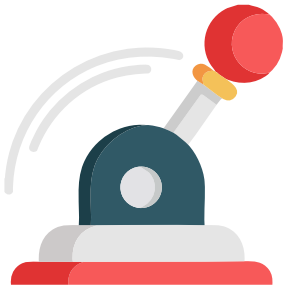
*Greater penetration of the electric and/or hybrid vehicle fleet*

**145 Mton**  
in reducing emissions (-35% vs. a scenario of inaction).

The shift toward electric mobility, especially in the individual road transport segment, is strongly supported by Brazil's electrical grid, which is ~90% renewable.

Low-carbon hydrogen routes for hard-to-abate transport modes, particularly maritime shipping.

Other levers are also relevant and responsible for eliminating another ~8% of CO<sub>2</sub>e (vs. 2050, a scenario of inaction).



## EXAMPLES OF LEVERS WITH HIGH RELATIVE FEASIBILITY<sup>1</sup>



### RENEWAL AND/OR IMPROVEMENT OF THE FLEET OF DIFFERENT MODES OF TRANSPORTATION

Replacement and/or improvement of current road, rail, water and air transport fleets with a view towards energy and operational efficiency gains.



### EXPANSION OF URBAN PUBLIC TRANSPORTATION

Incentive for public transportation in cities, as a replacement for individual motorized transport.



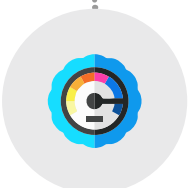
### IMPROVEMENT OF ROAD AND RAIL INFRASTRUCTURE

Improvement of existing road paving and rail infrastructure for improved operational efficiency.



### IMPROVEMENT OF PORT ACTIVITY MANAGEMENT

Easier access to ports, reducing the average waiting time through process improvements and use of management tools.



### OPTIMIZATION OF AIR ROUTES

Use of technologies to improve management and rationalize air transport operations.

1. Examples of levers with high relative potential for being adopted and requiring fewer significant structural changes to be implemented.



## ILLUSTRATIVE EXAMPLES SHOW HOW ENABLERS HELP TO FACILITATE DECARBONIZATION LEVERS

### REGULATORY EVOLUTION

#### New Legal Framework for Railways (Law No. 14.273/2021)

Promotion of investments by simplifying regulations (e.g., incentive to self-regulation) and make authorization models more appealing to private players (authorizations), in order to expand the capacity of the rail sector.

### IMPLEMENTATION OF FINANCIAL INCENTIVES

#### REFROTA Program (fleet renovation)

A federal government initiative to support the modernization of public transport through a financing program for the acquisition of 2,296 electric buses and urban electromobility systems/ technologies.

### FAVORABLE ENVIRONMENT FOR TECHNOLOGICAL INNOVATION

#### INPH

The National Institute of Waterway Research (INPH) is focused on implementing projects to modernize waterways and to encourage sustainable practices, such as optimization solutions for fuel consumption.

### COLLABORATION & PARTNERSHIPS

#### SAF - ANAC connection

Partnership between public and private entities to identify challenges and enable the production and use of SAF in Brazil.

### TRAINING & CAPACITY BUILDING

#### Pecém Complex

Capacity-building initiatives designed to equip professionals for roles within the low-carbon hydrogen ecosystem, emphasizing Research, Development & Innovation.

Sources: ANTF; Railway Magazine; Gov.BR; Ministry of Mines and Energy; ANAC; Fecombustíveis; Ministry of Education.

# WE AIM FOR SUSTAINABLE GROWTH IN THE TRANSPORTATION SECTOR

**Conclusions** aimed for as part of the efforts towards the Brazil of the Future in 2050:



**~290 Mton**

reduction in CO<sub>2</sub>e emissions in 2050 versus a scenario of inaction.

**~110%** of current emissions (2023) from the transportation sector

## BRAZIL TODAY



**~2.4 TRILLION TKM** transported, representing **58% OF TOTAL EMISSIONS**.



**~30% OF THE FREIGHT MATRIX** in lower relative emission modes (i.e. gCO<sub>2</sub>e/TKM).



**~25% OF THE POPULATION** travels via bus and **+60% OF THE RAIL SYSTEM** is concentrated in RJ and SP.



**+30 BILLION LITERS OF BIOFUELS** consumed, representing **23% OF THE ENERGY MATRIX**.



**<1% OF THE LIGHT VEHICLE FLEET** is electrified in 2023 (BEV and PHEV).



**H<sub>2</sub> ROUTES ARE CURRENTLY LIMITED TO PILOT PROJECTS**, testing **POWER-TO-X (PTX) SOLUTIONS** and other alternatives.



**~4.2 TRILLION TKM** transported, **GROWTH OF 2.2% P.A.** (+79% vs. 2023).



**~55% OF THE FREIGHT MATRIX** in lower relative emission modes (**RAIL AND WATER TRANSPORT**).



**~R\$53 BILLION IN INVESTMENTS** in **SUSTAINABLE URBAN MOBILITY** in Brazil from 2023.



**~55 BILLION LITERS OF BIOFUELS** consumed, **+25 BILLION LITERS OF DEMAND** vs. 2023 for SAF, Green Diesel, and others.



**+50% OF THE ELECTRIFIED LIGHT VEHICLE FLEET** and **~300,000 ELECTRIC BUSES** in circulation.



**15% OF VESSELS** using **SYNTHETIC FUELS (PTX)** (applications also used in other modes).



MAIN CONCLUSIONS

# ROAD TRANSPORT

# ROAD TRANSPORT – MEMBER ENTITIES

This document was supported by the following road transport entities.



COORDINATION

OTHER MEMBERS

TRANSVERSAL AND CONSULTATIVE ENTITIES

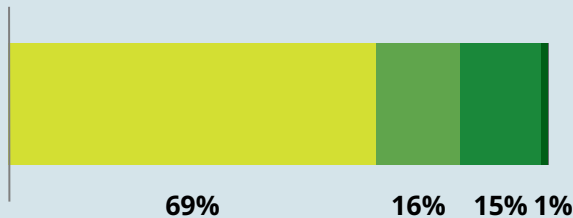
## BRAZIL'S TRANSPORTATION MATRIX IS PRIMARILY BASED ON ROAD TRANSPORT

Trucks handle **~70% of TKM** and cars and buses carry **+90% of all passengers in the country**.

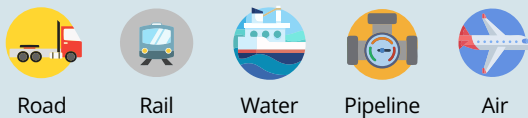
### FREIGHT<sup>1</sup>

Billion TKM, base year 2023<sup>3</sup>

Road Rail Water Pipeline Air



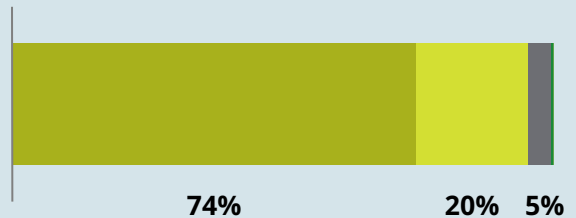
TKM (B) 1,636 371 360 31 1.5



### PASSENGERS<sup>2</sup>

Million PAX, base year 2023<sup>3</sup>

Light vehicle Bus Rail Water Air



1,580 433 91 6,5 1.3



1. Road Transport Sector Plan (PSTR); Rail Transport Sector Plan (PSTF); 2. PNL 2035 - National Logistics Plan; 3. 2017 base year of the PNL projected to the respective CAGRs of the reference scenario. Note: The passenger figures presented in the PNL reflect only intermunicipal and interstate travel, and do not account for intra-urban passenger travel. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.



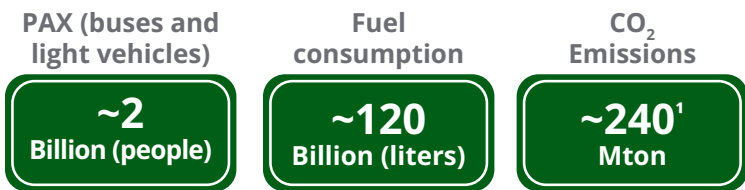
# CONSEQUENTLY, THIS MODE IS EXTREMELY IMPORTANT TO THE COUNTRY AND HAS EXPRESSIVE NUMBERS



## CURRENT OVERVIEW – ROAD TRANSPORT MODE

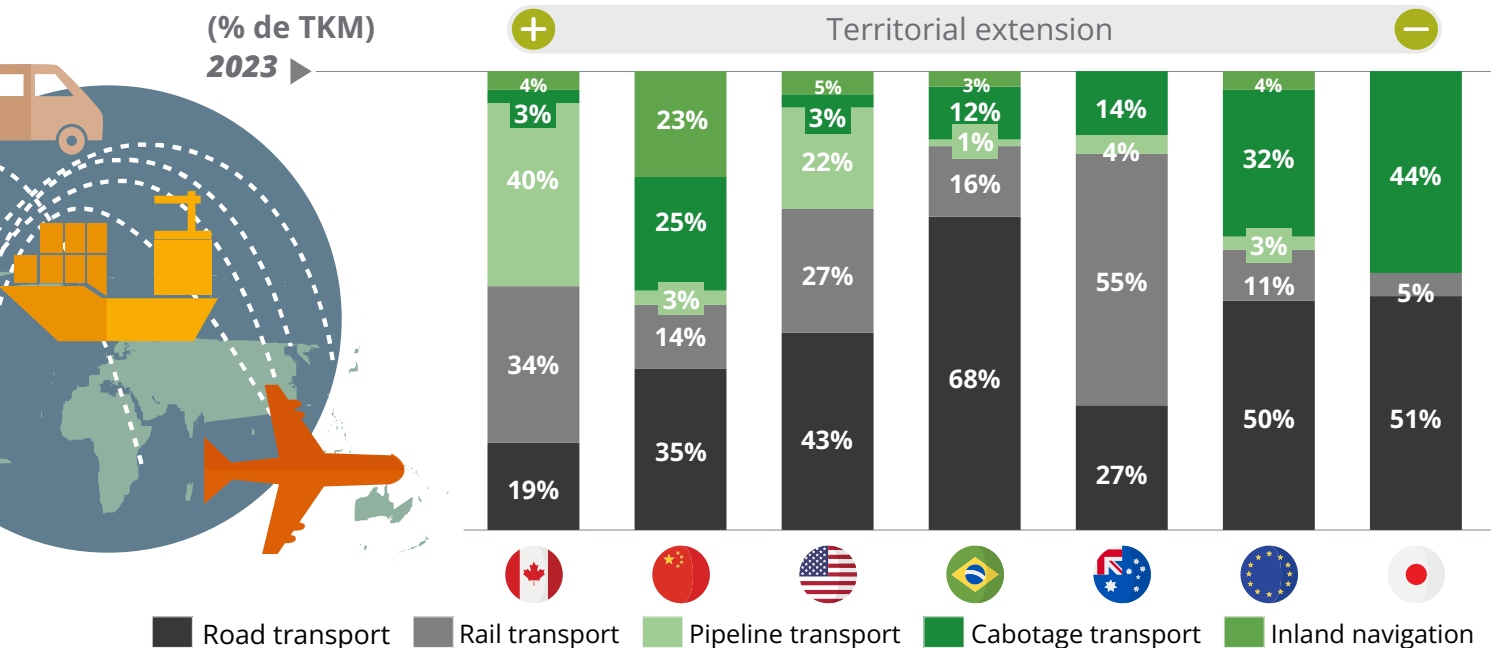
Relevant indicators help to understand the current landscape of road transport. **2023**

1. Well-to-wheel perspective



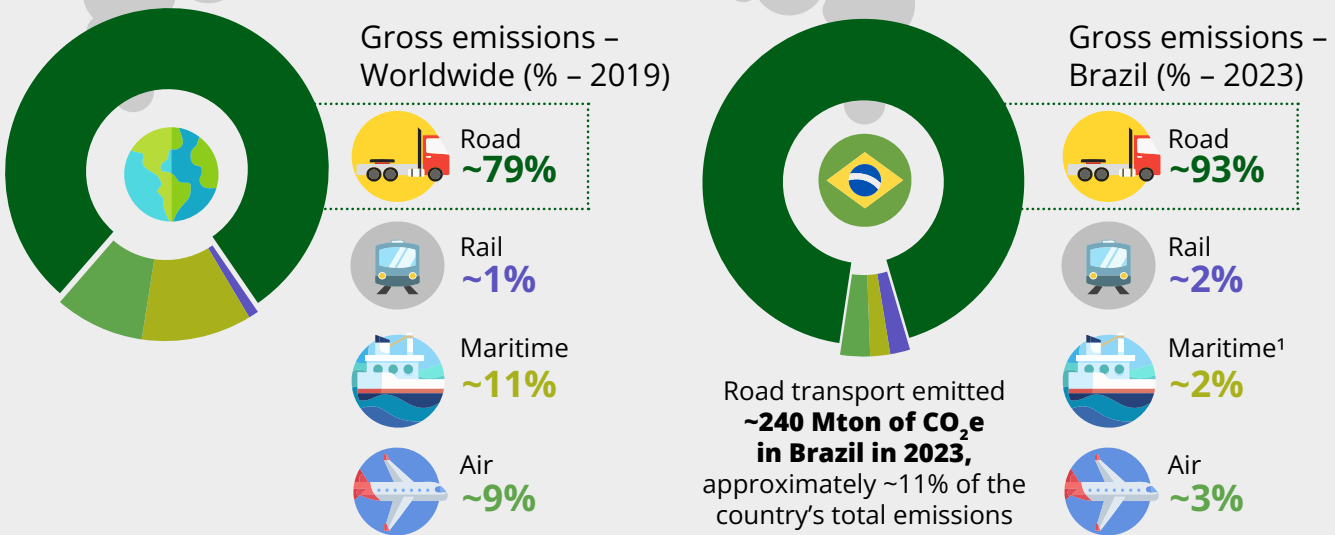
## IN RELATION TO OTHER COUNTRIES, THE BRAZILIAN FREIGHT MATRIX SHOWS A POTENTIAL CHANCE FOR IMPROVEMENT IN TERMS OF BALANCING

Comparisons of Brazil's freight transportation with other countries make it clear that the current matrix is predominantly reliant on road transport. A country with a large, expansive land area like Brazil presents unique opportunities for the development of different modes of transportation, such as rail and water transport, in addition to road transport.



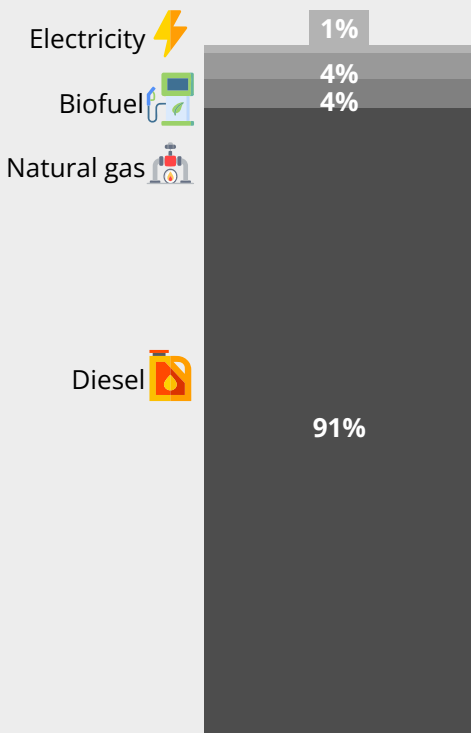
# EVEN WITH ~70% OF PARTICIPATION IN BRAZIL (VS. ~40% GLOBAL), ROAD TRANSPORT<sup>2</sup> EMITS LEVELS COMPARABLE WITH WHAT IS SEEN ON A GLOBAL SCALE: ~90% VS. ~80%

The greater concentration of road transport makes its emissions more representative, despite the fact that 22% of the transport energy matrix in the country is generated through biofuels vs. only ~4% in the rest of the world.

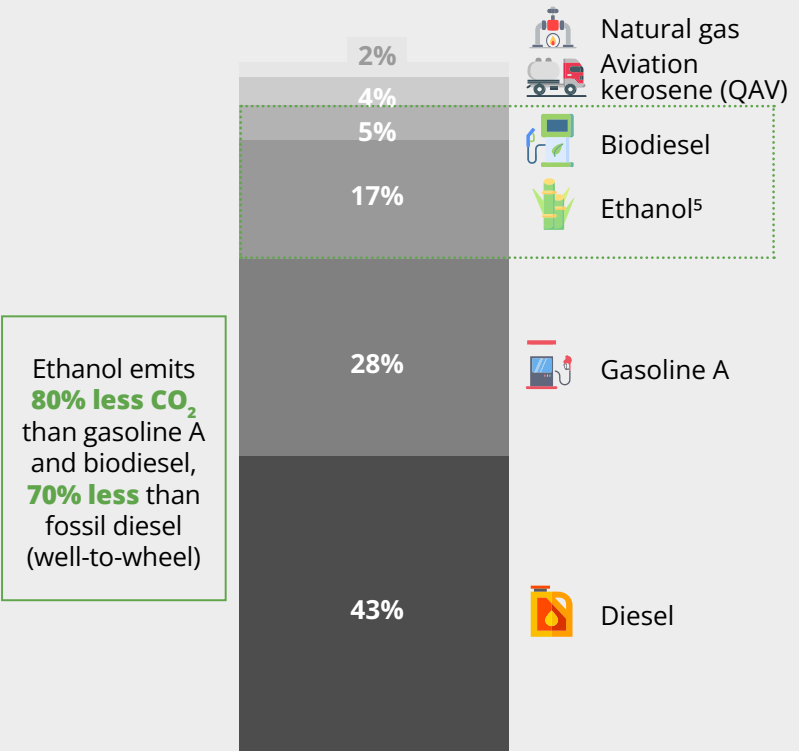


1. Considers cabotage and inland navigation, without long haul.

## TRANSPORT ENERGY MATRIX – WORLDWIDE (IEA<sup>4</sup> 2023)



## TRANSPORT ENERGY MATRIX – BRAZIL (BEN<sup>3</sup> 2024)

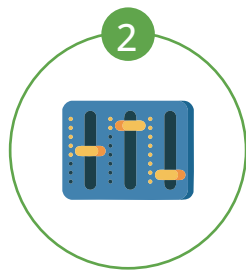


2. Regarding the road transport of freight 3. National Energy Balance 2024 - Synthesis Report, base year 2023; 4. Energy consumption in transport by fuel; 5. Includes anhydrous and hydrated ethanol. Sources: EPE, MME, IEA.

# APPROACH I FOUR STEPS FOR ROAD DECARBONIZATION



Setting projections for the total emissions of the sector, assuming there will be **no changes in the participation of the different modes within the transportation matrix**;



Setting projections for the total emissions of the sector, assuming **changes in the participation of the different modes within the transportation matrix**;



Mapping of levers to **reduce emissions applicable to the mode of transport**;



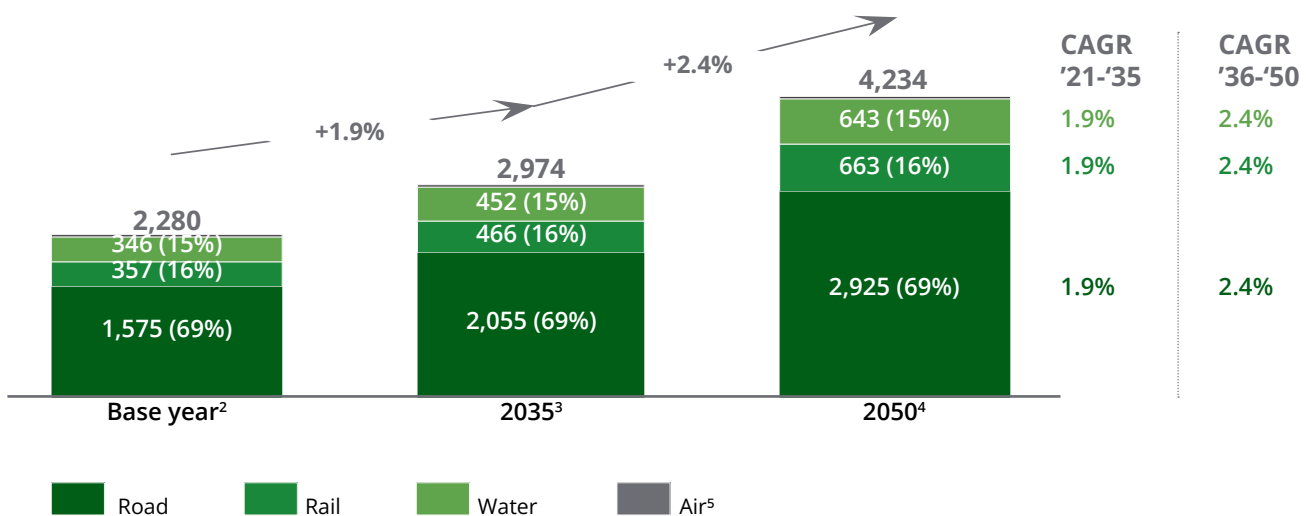
Proposal of possible **sensitivities based on the mapped levers**.

## 1 BAU<sup>1</sup> DEFINITION OF EMISSIONS WITHOUT CHANGES IN THE TRANSPORTATION MATRIX

In a scenario of inaction, total transport emissions would reach **~424 Mton CO<sub>2</sub>e in 2050**. Under this scenario, the composition of Brazil's transportation matrix would remain stable (with road transport maintaining its dominant share of ~70%).

### EVOLUTION OF THE FREIGHT MATRIX<sup>1</sup> (BILLION TKM, %)

Scenario of Inaction



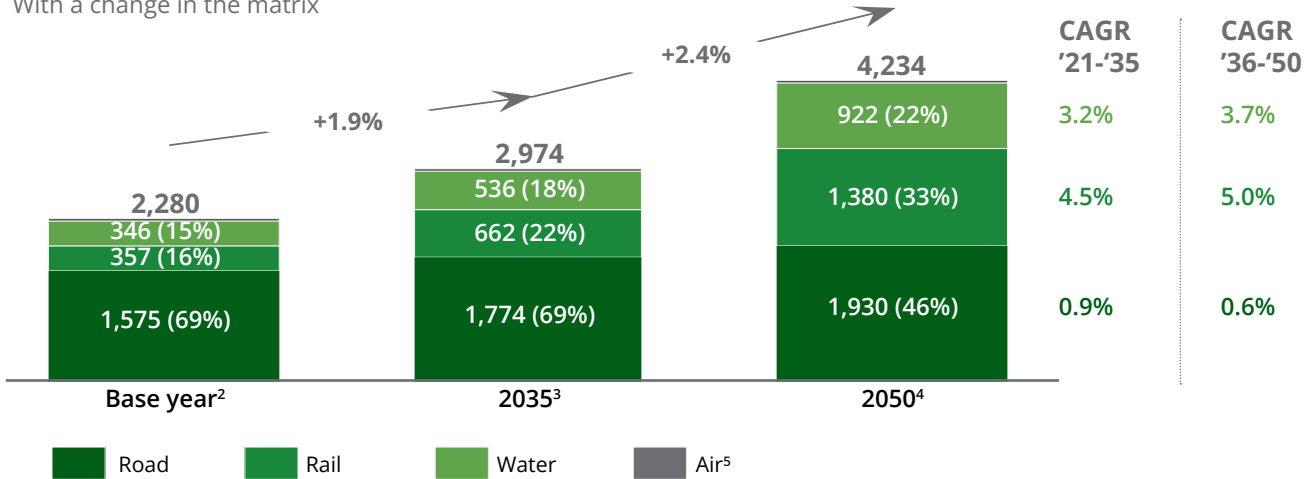
1. Projections based on the Transportation Sector Plans (PSTR and PSTF) and on PNL 2035 – National Logistics Plan; 2. 2021 was the year in which the PNL/PSTF was conducted, in addition to presenting more reliable historical parameters; 3. TKM 2035 values refer to the PSR1 scenario of the PSTR; 4. TKM projected at GDP with a share of the PSR3 scenario of the PSTR; 5. Air transport emissions are not related to freight transport, only to passenger transport; Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

## 2 PARTICIPATION OF RAIL AND WATER TRANSPORT MODES COULD BE EXPANDED

In the second stage, an alternative scenario was assessed in which the share of rail and water transport could be increased, potentially yielding emission reductions due to their lower relative emission factors (gCO<sub>2</sub>/TKM) compared with higher-emitting modes.

### EVOLUTION OF THE FREIGHT MATRIX<sup>1</sup> (BILLION TKM, %)

With a change in the matrix

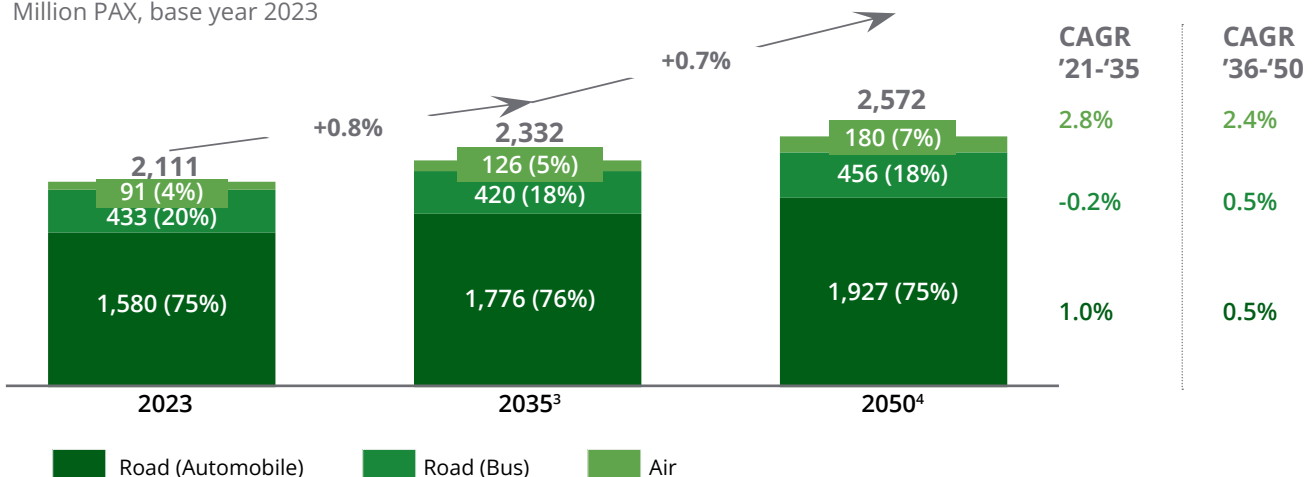


It should be noted that the **projected CAGR of 0.6% p.a. of the road transport mode** reflects the **growth** in demand for TKM in the **1.7 billion km of the Brazilian road network**. However, growth for the concessions sector — currently around 30,000 km granted — is expected to **continue above, around 3%-4% p.a.**

Regarding passenger transport (graph below), sector plans and PNL do not foresee changes between modes of transportation. The road industry is expected to continue to represent **+90% of total passenger transport**.

### PASSENGERS<sup>1</sup> (PASSENGERS, %)

Million PAX, base year 2023



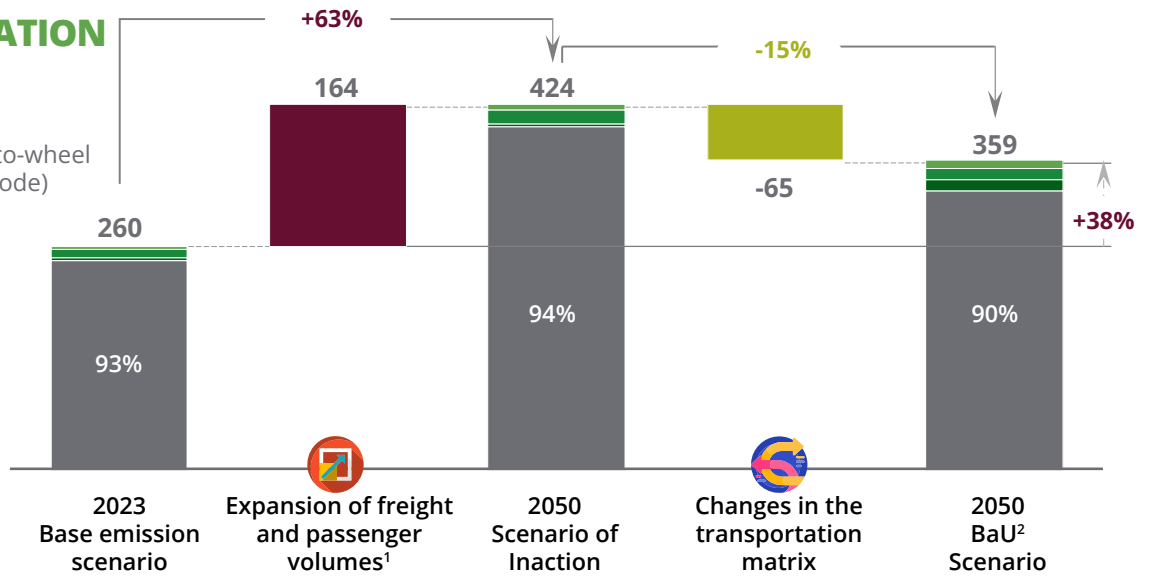
The figures point out that the demand for road passenger transport in the **entire Brazilian network is expected to show modest growth**, with a projected CAGR of 0.5% per year. However, **concession highways are expected to register a faster expansion**, with anticipated growth exceeding 3% p.a.

1. Projections based on the Transportation Sector Plans (PSTR and PSTF) and on PNL 2035 – National Logistics Plan; 2. 2021 was the year in which the PNL/PSTF was conducted, in addition to presenting more reliable historical parameters; 3. TKM 2035 values refer to the PSR1 scenario of the PSTR; 4. TKM projected at GDP with a share of the PSR3 scenario of the PSTR; 5. Air transport emissions are not related to freight transport, only to passenger transport; Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

In summary, optimizing this transportation matrix by shifting certain modes of transportation, specifically rail and water transport modes, can help reduce the expected volume of CO<sub>2</sub> emissions by approximately 15% by the year 2050:

## TRANSPORTATION SECTOR EMISSIONS

(Mton CO<sub>2</sub>e — well-to-wheel perspective — by mode)



## TKM (%)

Mode	2023 Base emission scenario	Expansion of freight and passenger volumes <sup>1</sup>	2050 Scenario of Inaction	Changes in the transportation matrix	2050 BaU <sup>2</sup> Scenario
Road	69%	=	69%	⬇️	46%
Rail	16%	=	16%	⬆️	33%
Water	15%	=	15%	⬆️	22%

Despite the reduction in participation within the overall transportation matrix, road transport is projected to experience an absolute increase in freight demand of **+18% by 2050 (+150 billion TKM)**

■ Road ■ Rail ■ Air<sup>3</sup> ■ Water

1. Increased emissions due to the expected growth in demand for TKM and passengers until 2050; 2. Business-as-Usual; 3. Air transport emissions are not related to freight transport, only to passenger transport.

# 3 MAPPING OF LEVERS TO REDUCE EMISSIONS

After the transportation matrix was presented, the working group identified levers that have the potential to reduce emissions in road transport.

These levers were mapped in three large blocks, as described below. A qualitative feasibility analysis<sup>1</sup> was performed for each of them, and local and global references that illustrate the respective application were presented.

Although road transport involves various emission sources, this report concentrates on levers aimed at reducing emissions from vehicle fuel combustion, based on a well-to-wheel approach.

## LEVERS FOR EMISSION REDUCTION

in the road transport sector



EFFICIENCY



BIOFUELS



ELECTRIFICATION AND POWER-TO-X

1. The full details of the feasibility and references can be found in the complete road transport document, which can be accessed through the QR Code at the end of this material.



## EFFICIENCY

Levers	Vehicle application
<p>1 <b>Optimization of driver behavior – short-term actions</b> (e.g., greater use of telemetry in fleets for guidance/training of drivers) and long-term initiatives (e.g., ongoing education).</p>	  
<p>2 <b>Traffic fluidity technologies</b> – reduce stopping times on highways to then reduce the average travel time and the volume of CO<sub>2</sub> emissions (e.g., free-flow systems, HS-WIM).</p>	  
<p>3 <b>Intelligent route and fleet optimization</b> – use technologies such as IoT, Big Data, and Artificial Intelligence to improve routing of freight transport and reduce emissions.</p>	  
<p>4 <b>Vehicle compliance</b> – ensure emissions compliance; reduce circulating vehicles with an emission factor that do not meet the established standards.</p>	  
<p>5 <b>Improvements to road paving</b> – expansion of the network granted through new auctions and increased investments in the network under public management.</p>	  
<p>6 <b>Tire energy efficiency</b> – promoting the wider use of energy-efficient tires, leading to lower fuel usage.</p>	  
<p>7 <b>Modernization and accelerated renewal of the current fleet</b> – replacement of old vehicles with new vehicles that have more efficient fuel consumption technologies and CO<sub>2</sub>/L emissions.</p>	  



## BIOFUELS

Levers	Vehicle application
<p>1 <b>Biodiesel – increasing the blend of biodiesel to fossil diesel</b> – it is currently blended at 14%; blending is expected to reach 20% in 2030 and 25% from 2031.</p>	  
<p>2 <b>Green diesel – enable green fuel alternative, such as HVO, but also other sources</b> – feasibility and potential being studied by CNPE.</p>	  
<p>3 <b>Biomethane – increasing the blend of biomethane in vehicular gas</b> – target of 1% will become effective in 2026, and may reach up to 10%.</p>	  
<p>4 <b>Ethanol – increasing the blend of anhydrous ethanol in gasoline A</b> – it is currently blended from 22% to 27%; blending can reach 35%.</p>	  
<p>5 <b>Preference at the pump – encourage filling up with ethanol</b> – currently, 80% of the fleet is flex, however, preference for using ethanol at the pump is less than 30%.</p>	  

**Intensification of the use of biofuels should be encouraged as long as:** technical, mechanical, operational and laboratory viability of said energy input is confirmed, as well as respecting the diversity of matrices and regional specificities.



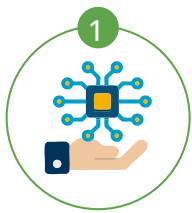
# ELECTRIFICATION AND POWER-TO-X

Levers	Vehicle application
<p><b>1 Hybrids - increase electrification</b> - reduce dependence on fossil fuel through hybrid vehicles (e.g., PHEV, HEV, MHEV).</p>	
<p><b>2 100% electric (BEV) - expand the share to 100% electric vehicles in the fleet</b> - a source of clean energy for recharging is a critical element.</p>	
<p><b>3 Electric with fuel cell (Hydrogen) - increase alternative solution of H<sub>2</sub>-powered vehicles through electrolysis</b> - leading to energy production with lower CO<sub>2</sub> emissions.</p>	

Levers can be applied as long as the technical and operational viability of the respective solutions is verified.

## 4 PROPOSAL OF SENSITIVITIES BASED ON THE MAPPED LEVERS

Finally, sensitivities have been proposed to assess the impact of different paths to decarbonization:



### Current technologies

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



### Intensification of biofuels

Predominance of the application of levers to intensify the use of biofuels;



### Electrification acceleration/power-to-X

Predominance of the application of levers to accelerate the electrification/power-to-X of the vehicle fleet;



### Transformational

Combination of levers from sensitivities 1, 2, and 3 leading to a trajectory closer to net-zero emissions.

For the purposes of this document, we will focus only on the range of impacts between the most conservative (1) and the most ambitious (4) sensitivities. Details of the other sensitivities are available in the full report, which can be accessed via the QR code at the end of this material.

The sensitivities caused some critical assumptions to vary in relation to the blending of biofuels in fossil fuels, preference for ethanol at the pump vs. gasoline C, as well as the acceleration of the electrification of light and heavy vehicle fleets.



## CURRENT TECHNOLOGIES

Growth of the fraction of biofuels in current fuels

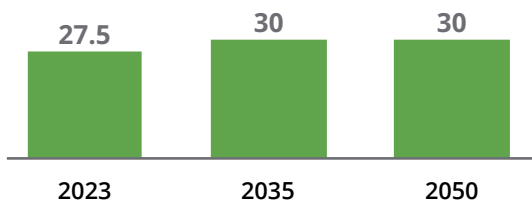
### Main variables of sensitivities

**Preference for ethanol at the pump<sup>1</sup> (%)**  
 - Resumption to 35% level (vs. 26% in 2023)

% of ethanol blended with gasoline



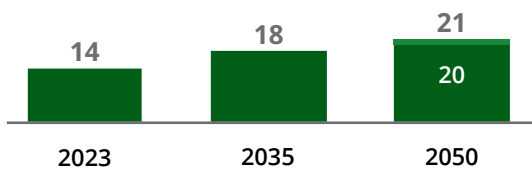
### LIGHT VEHICLES



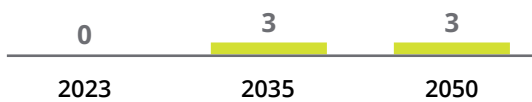
% of biofuels blended with diesel



### HEAVY VEHICLES



% of biomethane in the vehicular gas blend



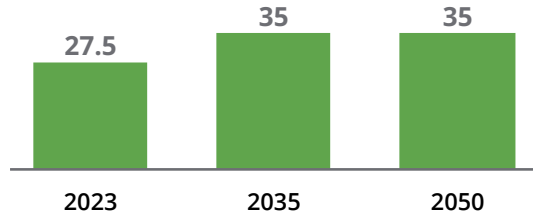
## INTENSIFICATION OF BIOFUELS

Developing new technologies that enable a wider use of biofuels

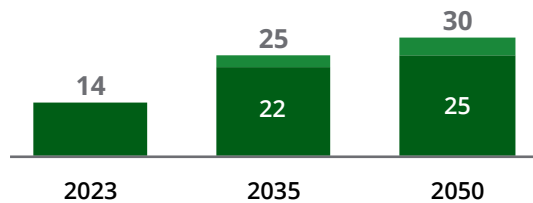
### Main variables of sensitivities

**Preference for ethanol at the pump<sup>1</sup> (%)**  
 - Assumes that flex-fuel vehicles always run on ethanol

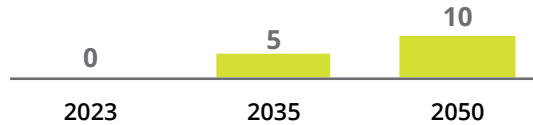
% of ethanol blended with gasoline



% of biofuels blended with diesel



% of biomethane in the vehicular gas blend



■ Ethanol   
 ■ Biodiesel   
 ■ Green Diesel   
 ■ Biomethane



## CURRENT TECHNOLOGIES

Gradual growth in the adoption of new engine technologies.



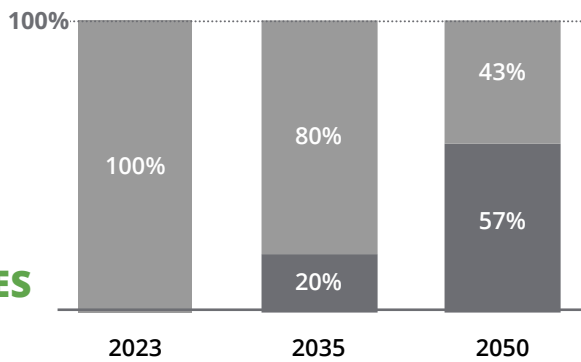
## ACCELERATION OF ELECTRIFICATION

Rapid convergence towards fleet electrification, with BEVs assuming dominance in sales.

### Main variables of sensitivities

#### Current fleet mix (%)

- Maintenance of the sales mix from 2040 to 2050

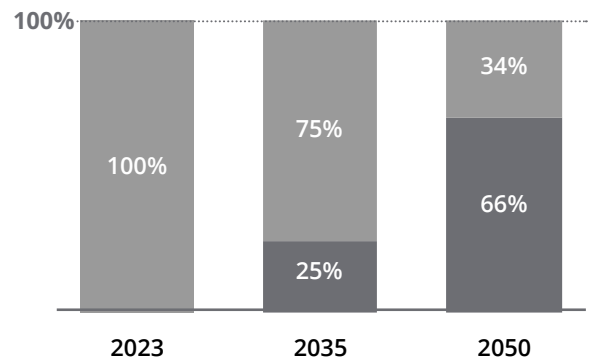


### LIGHT VEHICLES

### Main variables of sensitivities

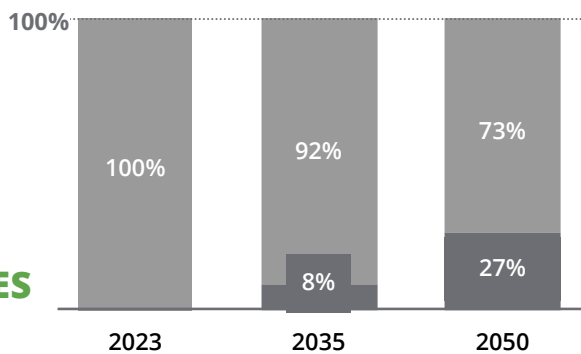
#### Current fleet mix (%)

- All vehicles sold are BEVs from 2040 to 2050



#### Current fleet mix (%)

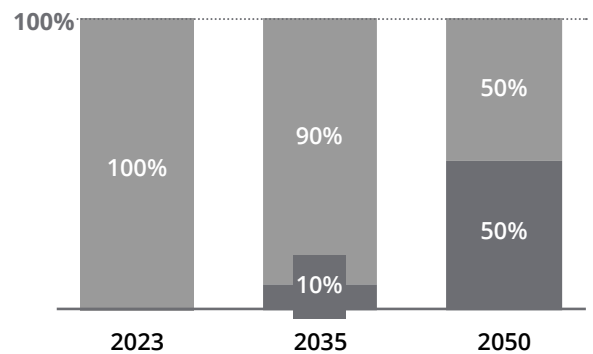
- Maintenance of the sales mix of 2040 to 2050



### HEAVY VEHICLES

#### Current fleet mix (%)

- All vehicles sold are BEV of 2040 to 2050

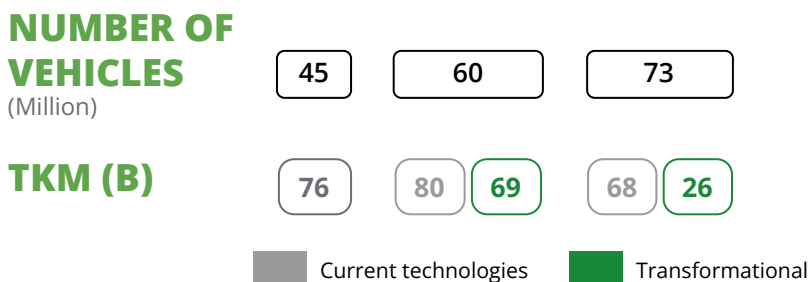
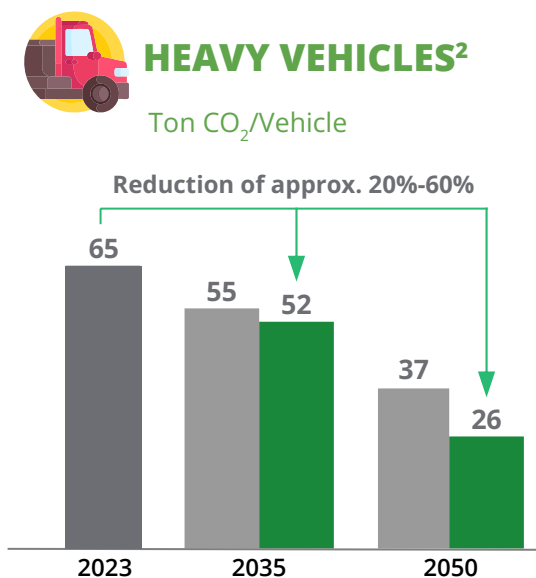
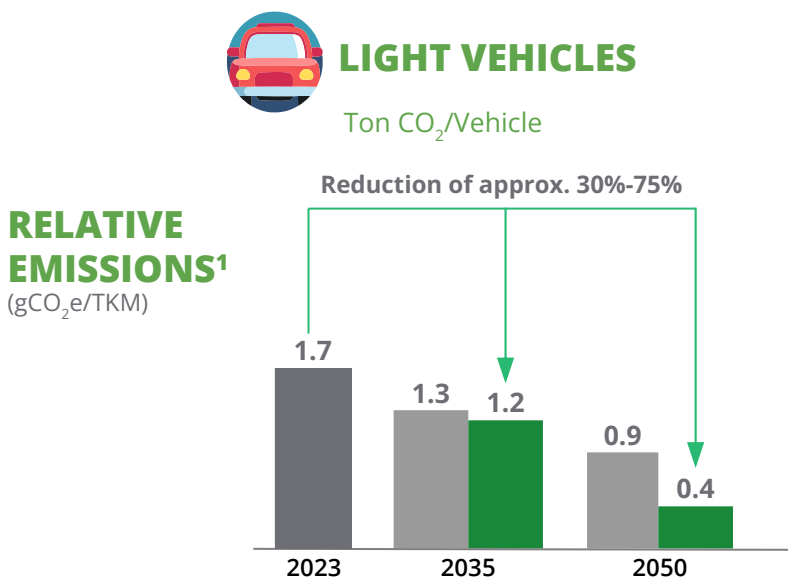
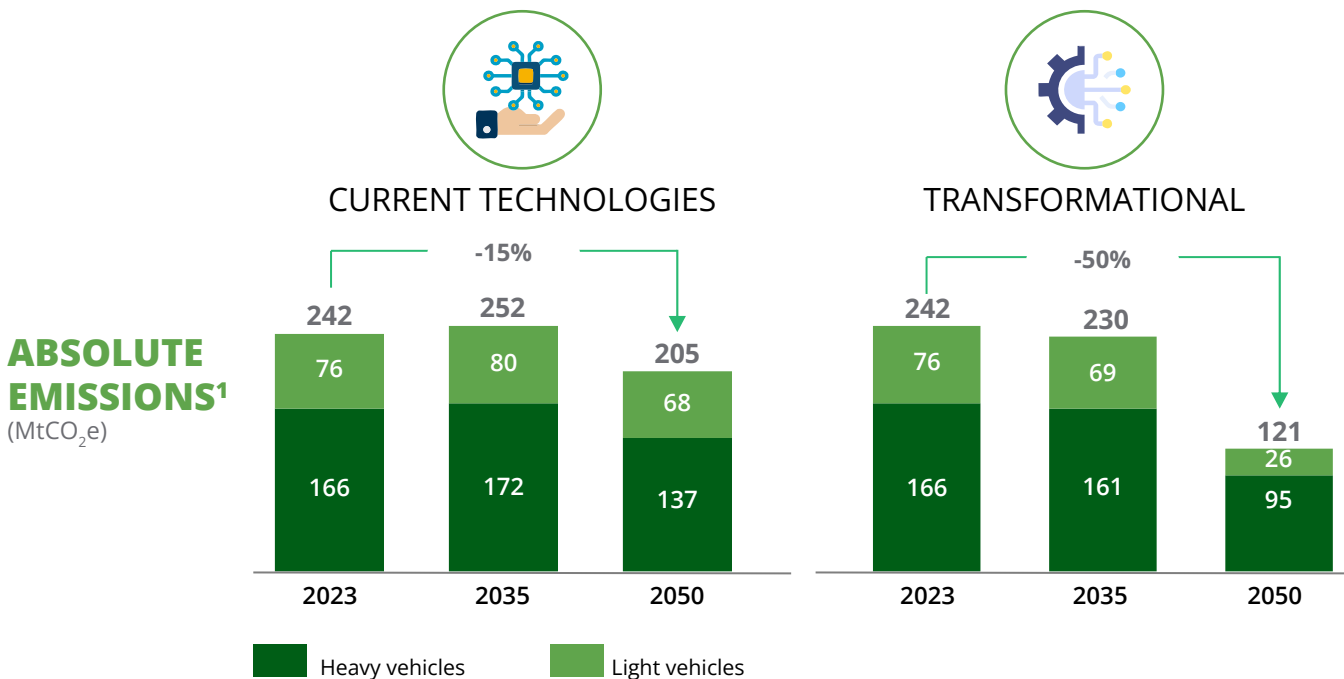


ICE (Internal Combustion Engine vehicles)

NEVs (Vehicles powered by new energy sources, e.g. BEV, PHEV)

# OUTCOMES OF SENSITIVITY ANALYSIS CONCERNING THE IMPACT ON EMISSIONS

Following the implementation of the mapped levers, emissions from road transport could drop to **121 Mton CO<sub>2</sub>e**, a **50% reduction relative to the 242 Mton CO<sub>2</sub>e recorded in 2023**. Additionally, relative emissions (Ton CO<sub>2</sub>/vehicle) can see reductions of **up to 60% in heavy vehicles and 75% in light vehicles**.



1. Emission factors considered are well-to-wheel (WTW); 2. Includes buses and trucks.



## ILLUSTRATIVE EXAMPLES SHOW HOW ENABLERS HELP TO FACILITATE DECARBONIZATION LEVERS

### PUBLIC AND PRIVATE INCENTIVES TO ENABLE THE REDUCTION OF EMISSIONS IN ROAD INFRASTRUCTURE

#### Concession Law<sup>1</sup>

The private sector is being given the opportunity to manage and improve road infrastructure by making structural investments in the modernization and improvement of road paving, as well as incorporating technologies that improve traffic flow (e.g., free-flow systems, HW-WIM), which in turn helps reduce emissions.

#### Incentives to encourage businesses to adopt sustainability commitments

The ANTT Sustainability Program<sup>2</sup> provides regulatory incentives to companies that implement qualifying sustainability measures.

#### Public investments earmarked for modernizing road infrastructure

Commitment to invest €2.3B per year by 2030 to modernize and construct transport infrastructure, including roads.

### PUBLIC AND PRIVATE MECHANISMS TO ENABLE ELECTRIFICATION

#### Regulation that fosters electrification infrastructure and recharge availability

Regulation packages and commitments that drive electrification such as Euro VI/ VII, EU Green Deal, Fit for 55 and the 2035 ICE<sup>3</sup> ban.

#### Tangible mechanisms to increase the attractiveness of the acquisition of electric and hybrid vehicles

US\$1B in subsidies for local manufacturers<sup>4</sup> to invest in the in-house production of EVs<sup>5</sup> batteries, solidifying the security of the supply chain.


#### Concrete private sector investment moves towards electrification



Private investments<sup>6</sup> in electric chargers in Brazil, contributing to infrastructure readiness.

1. Law No. 8.987/1995; 2. ANTT Resolution 6.057 (2024); 3. Internal Combustion Engine = Vehicles powered by internal combustion. 4. Toyota and Honda; 5. Electric vehicles; 6. Volvo. Sources: Gov.br; ANTT; European Commission; Época Negócios; Volvo Caminhões; Agência Brasil.

**PUBLIC AND PRIVATE MECHANISMS TO ENABLE THE EXPANSION OF THE PRODUCTION AND USE OF BIOFUELS IN THE ENERGY MATRIX**

**Regulatory frameworks that incentivize the scale-up of biofuel production and adoption, with safeguards for fuel quality and vehicle performance**

The Fuel of the Future Program and RenovaBio are designed to increase the production and use of biofuels, helping to boost the share of cleaner fuels in the matrix. 

Stricter specifications, such as ANP Resolution 920/2023 for biodiesel and testing, both combined with concrete mechanisms to ensure compliance with quality criteria (e.g. 2BSVS1 of the EU) will be fundamental to making the advancement of biofuels viable, preserving engine performance.  

**Tangible mechanisms to promote private financing for R&D<sup>2</sup>** 

The MOVER Program offers tax benefits to automotive players that invest more than 0.5% of revenue per year in R&D<sup>2</sup>.

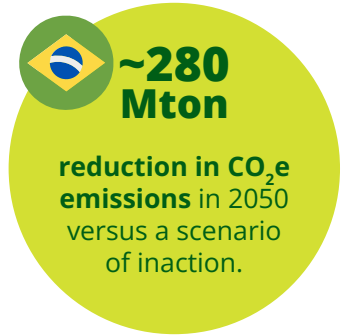
**Concrete private sector investment moves towards developing cleaner fuels** 

Agreements for joint exploration<sup>3</sup> of the production, purchase and sale of biomethane, clean fuel with applicability in road transport mode.

Note: The use of biodiesel blended in diesel requires adjustments across the production chain and assurance of product quality, as well as technical and economic feasibility analyses 1. Biomass Biofuels Sustainability Voluntary Scheme: EU-recognized framework that ensures, through independent audits, that biofuels comply with the criteria established by the Renewable Energy Directive (REDII); 2. Research and Development; 3. Petrobras and Raízen. Sources: Gov.br; ANTT; European Commission website, Agência Brasil, Petrobras.


# WE AIM FOR SUSTAINABLE GROWTH IN THE ROAD TRANSPORT SECTOR

Mapped decarbonization levers have the potential to reduce up to **~280 million tons of CO<sub>2</sub>e from the road transport mode by 2050**, depending on decarbonization efforts. The reduction is higher than the current volume of emissions from the transportation mode. However, the growth of the country and, consequently, of the road transport, magnifies the challenge of achieving net-zero emission scenarios.










**Conclusions** sought by the study on road transport in Brazil in 2050:

## CURRENT ROAD TRANSPORT<sup>1</sup>

-  **~1.6 TRILLION TKM** transported annually via road transport in Brazil.
-  **~25 BILLION LITERS OF ETHANOL** used by light vehicles in hydrated and anhydrous forms.
-  **~8 BILLION LITERS OF RENEWABLE DIESEL** used by heavy vehicles in the form of biodiesel<sup>3</sup>.
-  **~200,000 M<sup>3</sup>/DAY OF CNG** consumed as vehicular gas for heavy vehicle fleets.
-  **<1% OF THE H<sub>2</sub>-POWERED FLEET** operating with Power-to-X (PtX) solutions.
-  **<1% OF THE xEVs FLEET** in circulation in Brazil, including light and heavy vehicles.
-  **~200 GWH/YEAR** supplied for 100% electric and plug-in hybrid recharging.

## FUTURE ROAD TRANSPORT<sup>2</sup>

-  **~1.9 TRILLION TKM** transported, +18% growth vs. 2023 (0.8% p.a. 2024-2050).
-  **+40 BILLION LITERS OF ETHANOL** required to supply light vehicles with hydrated ethanol.
-  **+10 BILLION LITERS OF RENEWABLE DIESEL** required for heavy vehicles, including biodiesel<sup>3</sup> and green diesel<sup>3</sup>.
-  **~8 MILLION M<sup>3</sup>/DAY OF CNG** demanded, with 10% biomethane<sup>3</sup> in its composition.
-  **+230,000 TON/YEAR OF H<sub>2</sub>** applied as a solution for the operation of heavy fleets.
-  **+40% OF THE XEVs FLEET** in circulation, with ~40% of the heavy fleet and +50% of the light vehicle fleet electrified.
-  **+170,000 GWH/YEAR** required for recharging light and heavy BEV and PHEV vehicles.

1. 2023; 2. 2050 Transformational; 3. Intensification of the use of biofuels should be encouraged as long as: technical, mechanical, operational and laboratory viability of said energy input is confirmed, as well as respecting the diversity of matrices and regional specificities.





Details on the  
**ROAD  
TRANSPORT  
MODE**

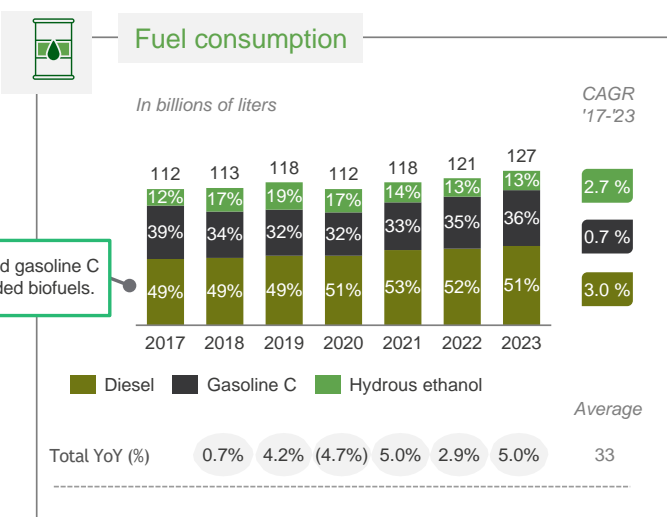
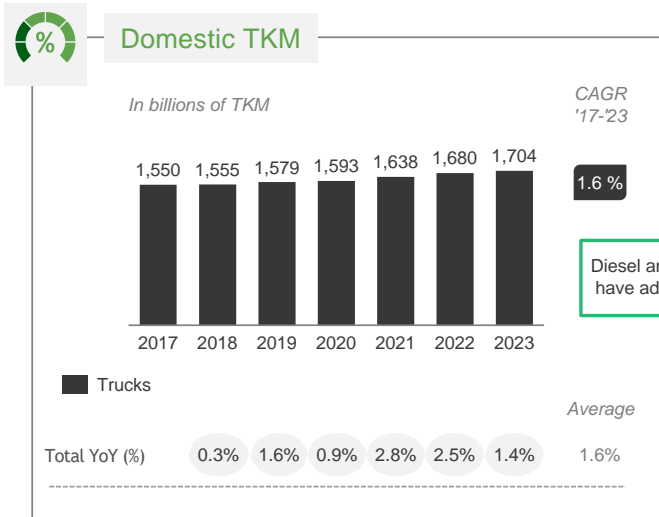
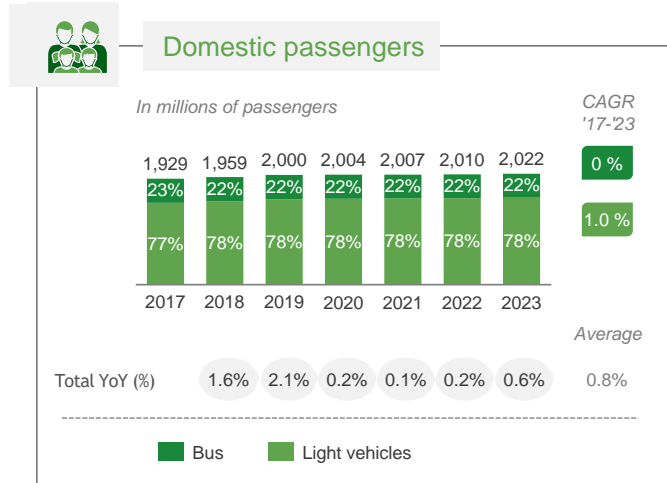
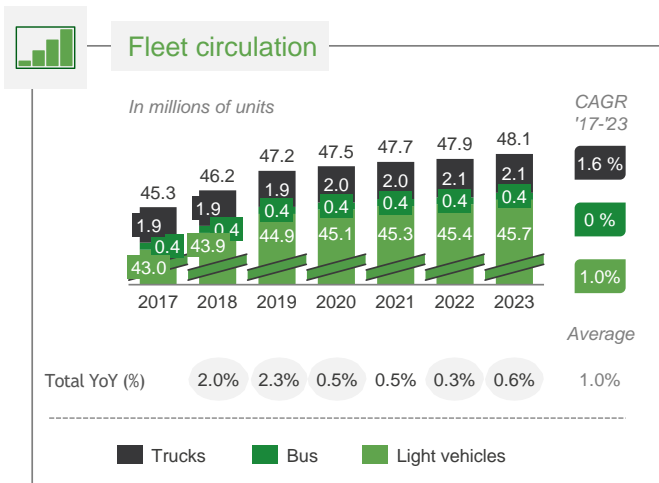
# KEY INDICATORS HELP IN UNDERSTANDING THE CURRENT STATE OF THE MODE

## ROAD TRANSPORT

The road transport sector represents +90% of the passenger transportation in Brazil and 67% of shipping/freight. Brazil's road fleet comprises roughly 48 million vehicles, which consume an estimated 120 billion liters of fuel per year, resulting in emissions of ~240 Mton CO<sub>2</sub>e representing more than 90% of the nation's transportation sector emissions.

KEY INFORMATION		2023	
● Road network (Km)	~1.7M	● PAX (buses and light vehicles) (passengers)	~2.0B
● Vehicle fleet (automobiles)	~48M	● Fuel consumption (liters)	~120B
● Trucks TKM (ton Km unit)	~1,700M	● CO <sub>2</sub> Emissions (Mton)	~240

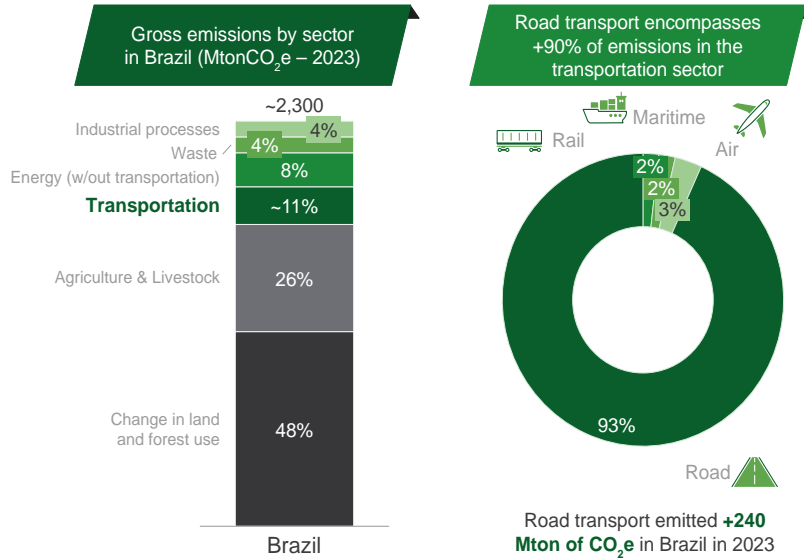
**THIS MODE IS EXTREMELY IMPORTANT TO THE COUNTRY, TRANSPORTING OVER 2 BILLION PASSENGERS (PAX) AND 1.7 TRILLION TON-KILOMETERS (TKM) ANNUALLY**



Sources: Anfavea; ANP; SEEG; CNT; ANTT; PNL.

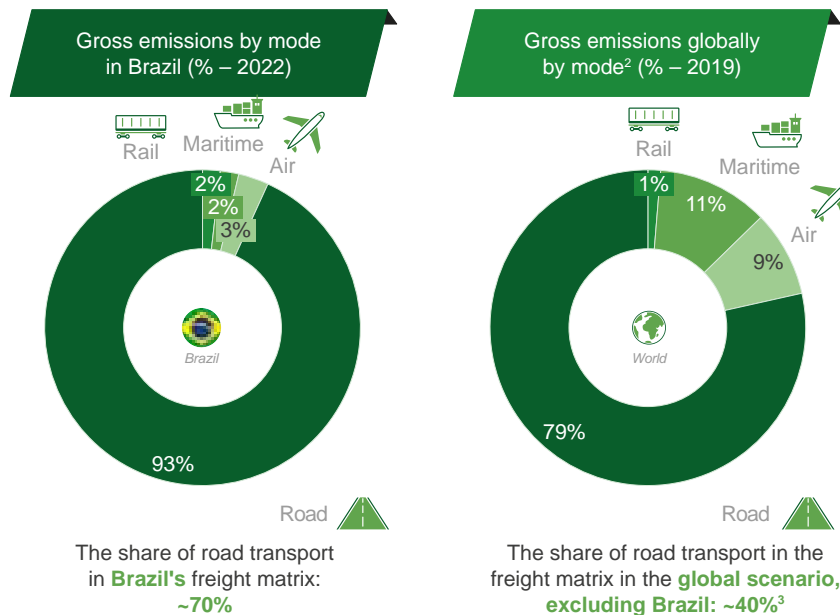
# THE TRANSPORTATION SECTOR IS CRITICAL FOR THE MITIGATION AGENDA, ACCOUNTING FOR ~11% OF NATIONAL EMISSIONS...

## ... ROAD TRANSPORT EMITS +90% OF THE TOTAL SECTOR



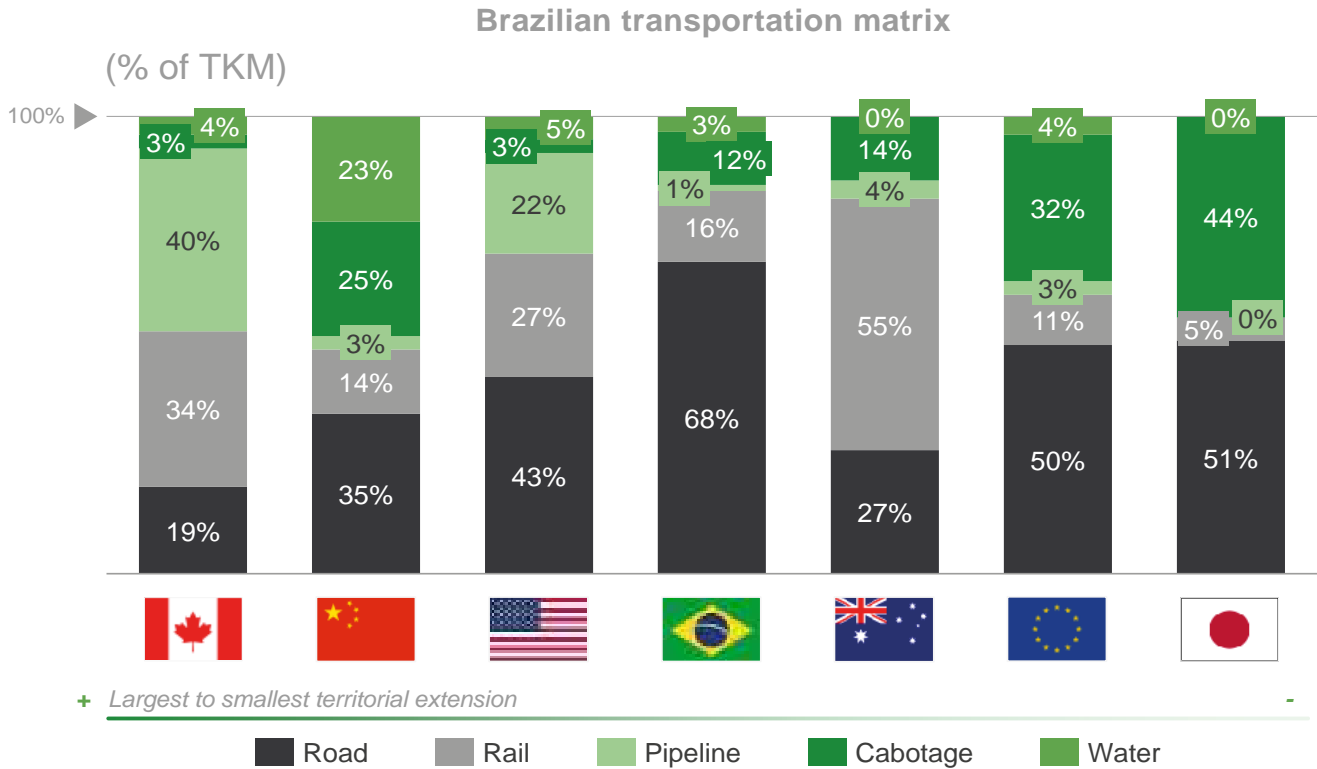
1. Global amount excluding Brazil; 2. Others = mining, maritime, waste, construction, oil and gas, manufacturing, energy, agriculture, forests. Sources: Anfavea; SEEG; CAIT; Climate TRACE.

## EVEN WITH 70% SHARE IN BRAZIL (VS. ~40% GLOBAL), ROAD TRANSPORT<sup>1</sup> EMITS LEVELS COMPARABLE WITH WHAT IS SEEN ON A GLOBAL SCALE: ~90% VS. ~80%, RESPECTIVELY



1. Freight transport, does not consider passenger transport; 2. Global amount excluding Brazil; 3. Calculation made considering the basic average of the following countries: Canada, China, USA, Australia, European Union and Japan. Sources: Anfavea; SEEG; CAIT; Climate TRACE; BCG analysis.

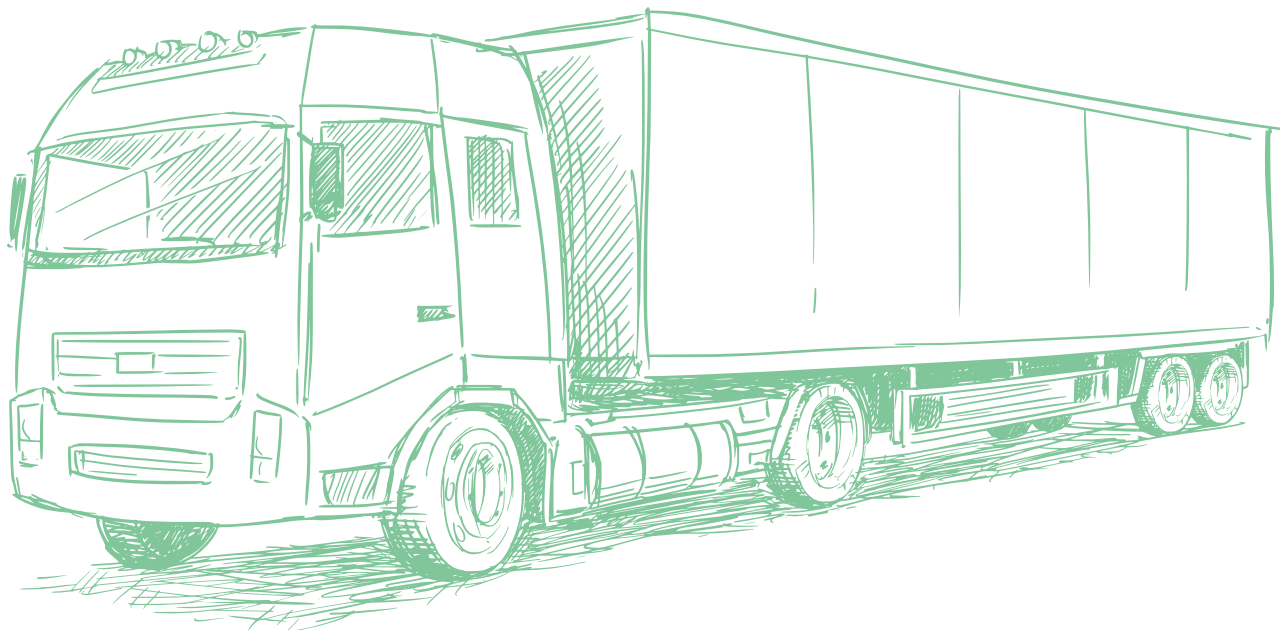
# BRAZIL'S MATRIX IS MORE CONCENTRATED ON THE ROAD TRANSPORT COMPARED TO OTHER COUNTRIES



Sources: ILOS (Brazil); National Bureau of Statistics of China; Bureau of Transportation Statistics (USA); Eurostat (EU); Transportation Sector Plan.  
 Note: Information from the Brazilian Matrix considers data from the Transportation Sector Plan, made available for public review in 2024.

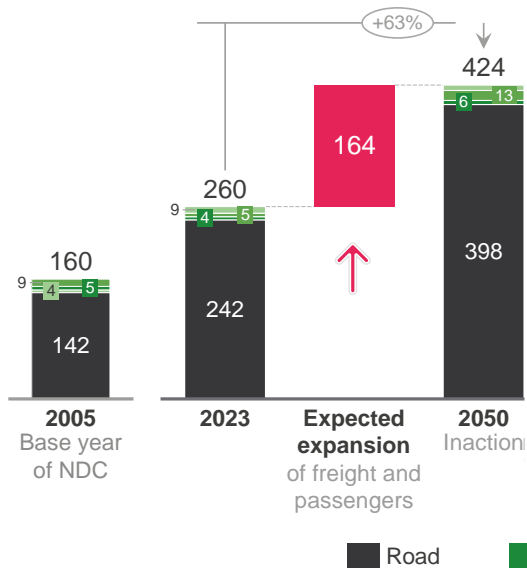


A country with a large, expansive land area like Brazil presents unique **opportunities for the development of different modes of transportation, such as rail and water transport, in addition to road transport.**



# SIZE OF THE CHALLENGE | IN A SCENARIO OF INACTION, THE SECTOR'S EMISSIONS COULD REACH UP TO 424 MTON CO<sub>2</sub>e IN 2050

## Emissions from the transportation sector (Mton CO<sub>2</sub>e % by mode) – Well-to-wheel perspective



- Emissions **increase due to the growth of Brazil** (GDP 2.4% p.a.) as an emerging country...
- ... which is reflected in the **relevant growth forecast for the sector** (TKM 2.2% p.a. and PAX 0.7% p.a.).
- Even so, **Brazil's relative emissions are expected to be below those of developed countries** (1.9 tons CO<sub>2</sub>e per capita in 2050 vs. 5.6 in the US and 2.5 in France in 2023).

Sources: Transportation Sector Plans; Infra S.A.; PNL 2035. Note: Scenario of inaction considers demand projected for 2050 without progress in efficiency gains, increased electrification or expansion of the use of biofuels beyond those currently stipulated by law.

## ROAD TRANSPORT GROUP | ABCR HAS BEEN RESPONSIBLE FOR COORDINATING DISCUSSIONS AND ENGAGING OTHER MEMBERS OF THE GROUP

**Advisory Board:**  
CEBDS, Motiva, CNT/SEST SENAT and Insuper's National Sustainable Mobility Observatory.



**Road Transport Group**

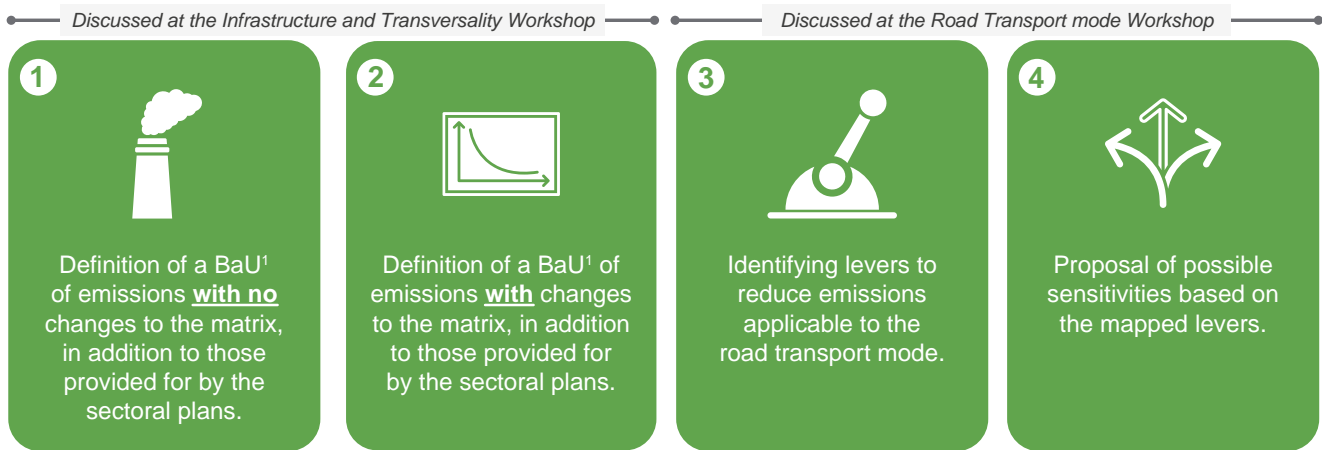
★ **ABCR** – Associação Brasileira de Concessionárias de Rodovias (Brazilian Association of Highway Concessionaires)

- ABOL
- ABTC
- ABTI
- ANFAVEA
- Motiva
- Edenred
- Ecorodovias
- FRESP
- Michelin
- NTC & Logística
- SINDIPESA
- Unilever
- Vibra
- Vinci Concessions

Legend : ★ Coordinator Other Members

# PATHWAYS TO DECARBONIZATION

## THE DEFINITION OF POTENTIAL PATHWAYS FOR REDUCING EMISSIONS IN THE ROAD TRANSPORT SECTOR WAS ARRANGED INTO 4 STEPS



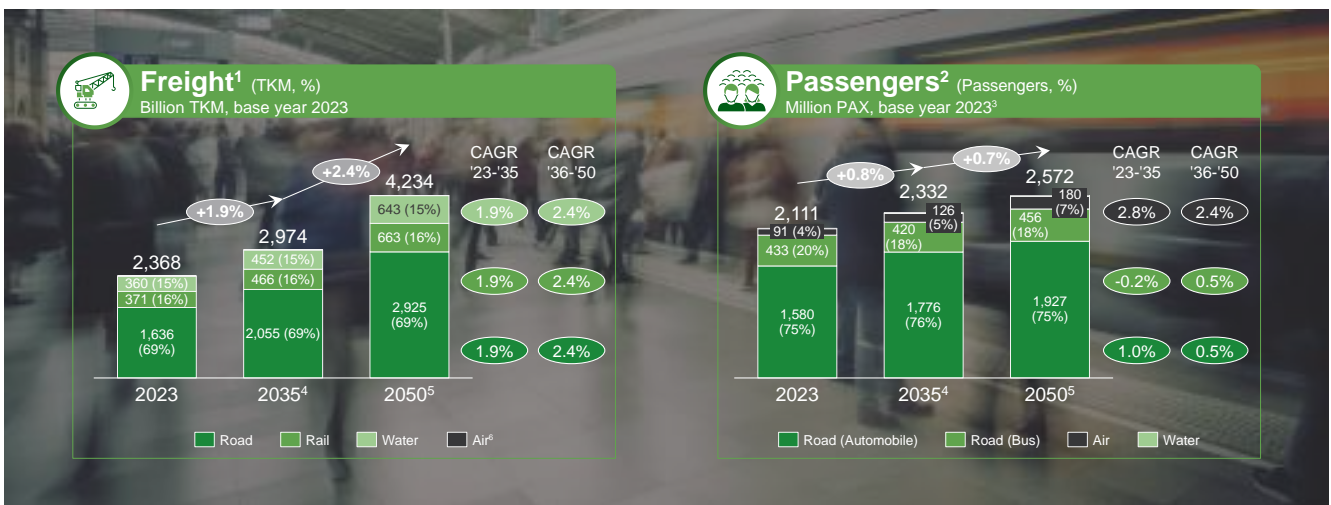
1. BaU = Business-as-usual.



### STEP 1


## 2050 | MAINTENANCE OF THE PREPONDERANCE OF ROAD TRANSPORT MAY REACH 3 TRILLION TKM AND 2 BILLION OF PASSENGERS BY 2050

Development of the matrix for 2050 projected based on the Transportation Sector Plans and PNL 2035



1. Road Transport Sector Plan (PSTR); Rail Transport Sector Plan (PSTF); 2. PNL 2035 - National Logistics Plan; 3. 2017 base year of the PNL projected to the respective CAGRs of the reference scenario. 4. TKM 2035 values refer to the PSR1 scenario of the PSTR and PAX values come from the reference scenario of the PNL 2035 passenger matrix. 5. TKM is projected based on GDP growth, using the modal share from the PSR3 scenario of the PSTR, while PAX is projected according to population growth, assuming constant modal share. 6. Road transport is not considered relevant in freight, so it is not included in the graph on the left; Note: Passenger information provided in the PNL only includes intermunicipal and interstate flows and does not account for passengers within urban centers. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

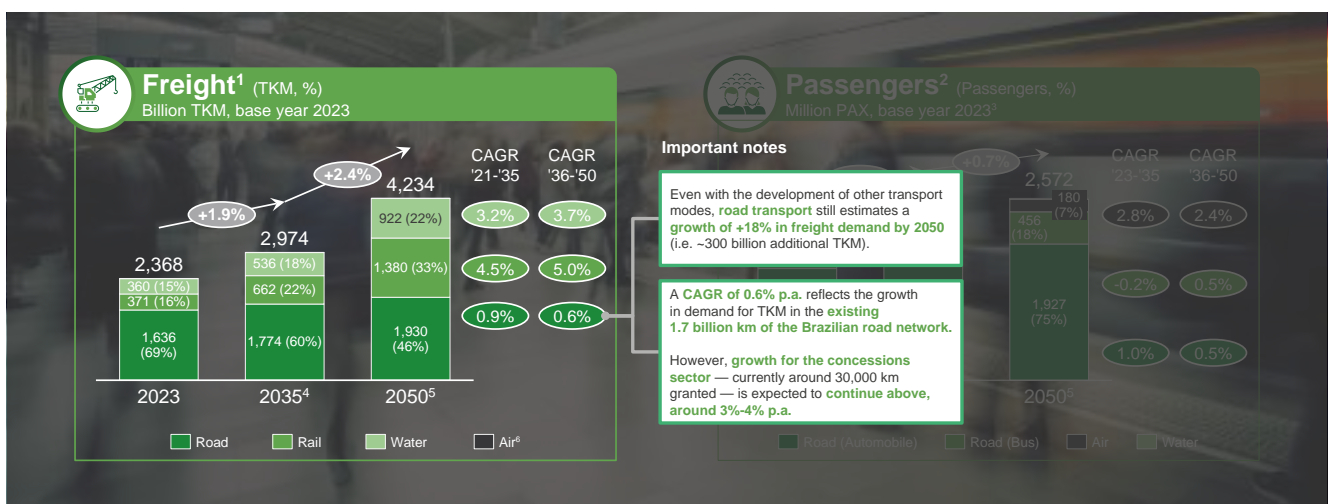


2  
  
 Definition of a BaU<sup>1</sup> of emissions **with** changes to the matrix, in addition to those provided for by the sectoral plans

## STEP 2

# 2050 | BALANCING THE MATRIX, RAIL AND WATER TRANSPORT INCREASE SHARE WHILE ALL MODES SEE GROWTH IN TKM

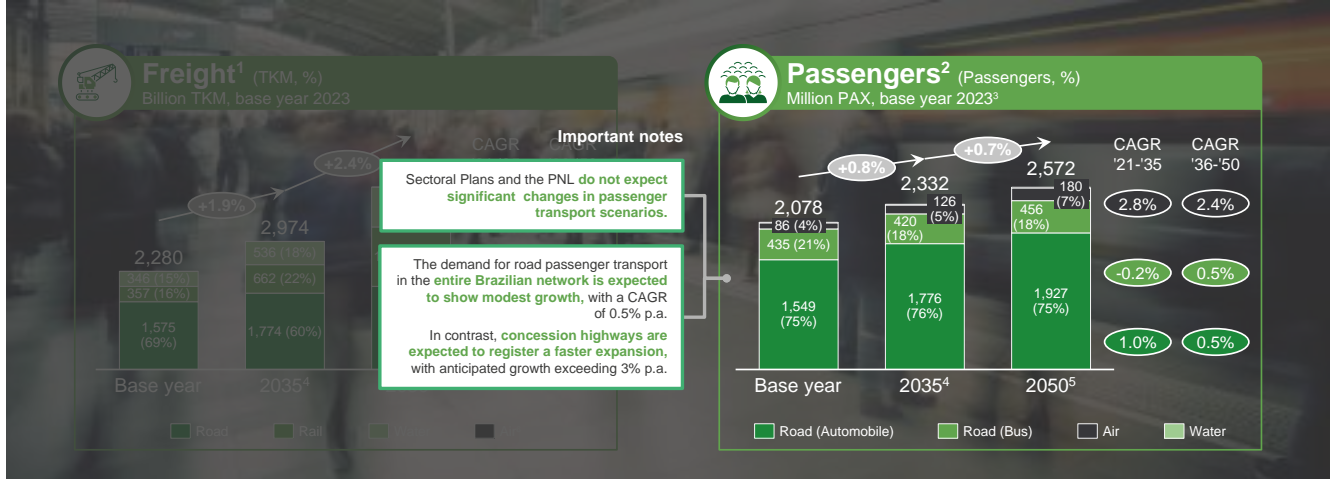
Development of the matrix for 2050 projected based on the Transportation Sector Plans and PNL 2035



1. Road Transport Sector Plan (PSTR); Rail Transport Sector Plan (PSTF); 2. PNL 2035 – National Logistics Plan; 3. 2017 base year of the PNL projected to the respective CAGRs of the reference scenario. 4. TKM 2035 values refer to the PSR1 scenario of the PSTR and PAX values come from the reference scenario of the PNL 2035 passenger matrix. 5. TKM is projected based on GDP growth, using the modal share from the PSR3 scenario of the PSTR, while PAX is projected according to population growth, assuming constant modal share. 6. Road transport is not considered relevant in freight, so it is not included in the graph on the left; Note: Passenger information provided in the PNL only includes intermunicipal and interstate flows and does not account for passengers within urban centers. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

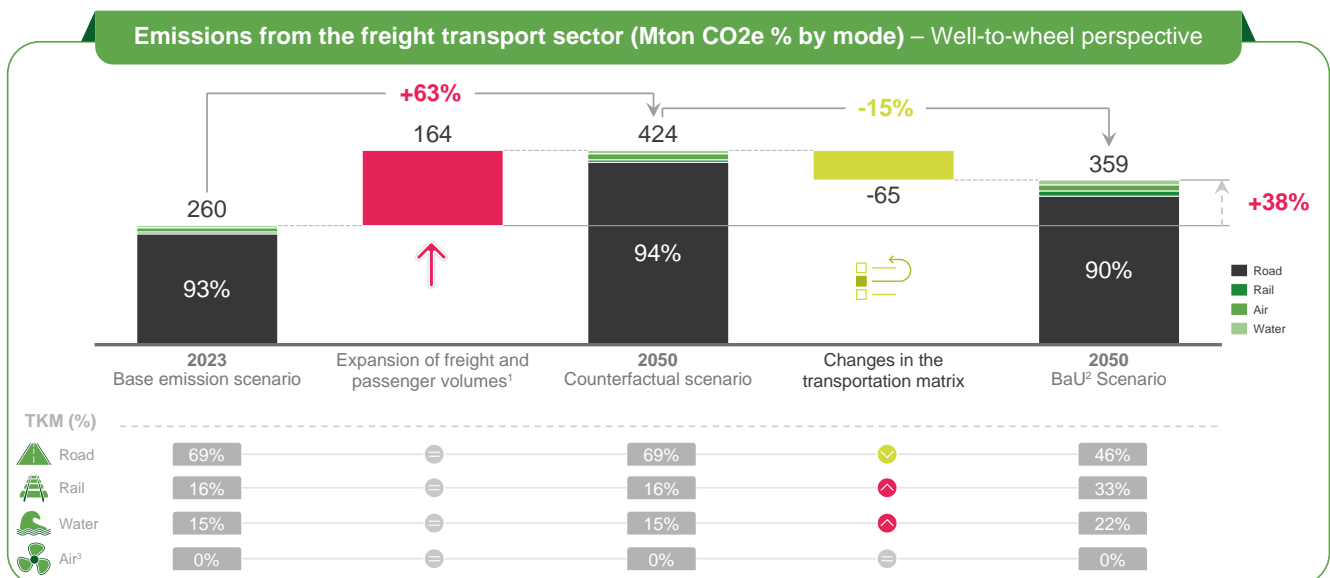
# 2050 | WITH NO CHANGES TO THE PASSENGER MATRIX, SECTORAL PLANS POINT TO CONTINUED GROWTH IN ROAD TRANSPORT

Development of the matrix for 2050 projected based on the Transportation Sector Plans and PNL 2035




1. Road Transport Sector Plan (PSTR); Rail Transport Sector Plan (PSTF); 2. PNL 2035 – National Logistics Plan; 3. 2017 base year of the PNL projected to the respective CAGRs of the reference scenario. 4. TKM 2035 values refer to the PSR1 scenario of the PSTR and PAX values come from the reference scenario of the PNL 2035 passenger matrix. 5. TKM is projected based on GDP growth, using the modal share from the PSR3 scenario of the PSTR, while PAX is projected according to population growth, assuming constant modal share. 6. Road transport is not considered relevant in the graph on the left; Note: Passenger information provided in the PNL only includes intermunicipal and interstate flows and does not account for passengers within urban centers. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

## BALANCING THE BRAZILIAN TRANSPORTATION MATRIX CAN AVOID AN INCREASE OF ~15% IN THE VOLUME OF CO<sub>2</sub> EMISSIONS BY 2050



1. Increased emissions due to the expected growth in demand for TKM and passengers until 2050; 2. Business-as-usual; 3. Air transport emissions are not related to freight transportation, only to passenger transport.

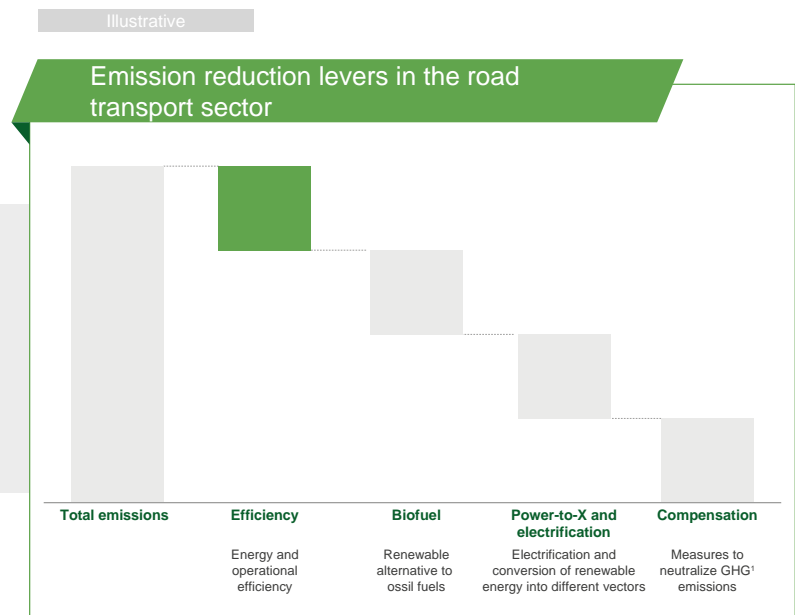
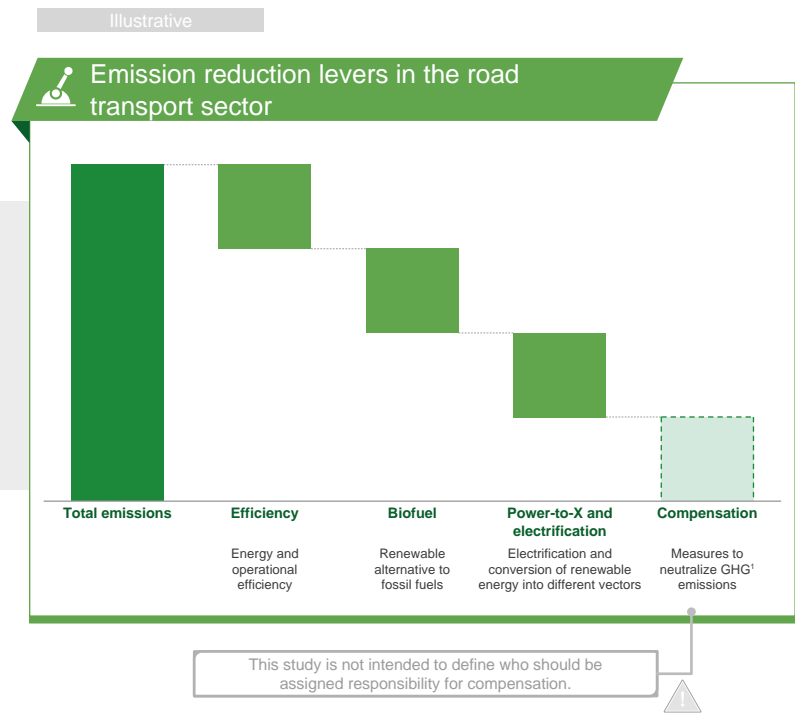
3



Identifying levers to reduce emissions applicable to the road transport mode.

## STEP 3

# TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE ROAD TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS



1. GHG = Greenhouse Gases.

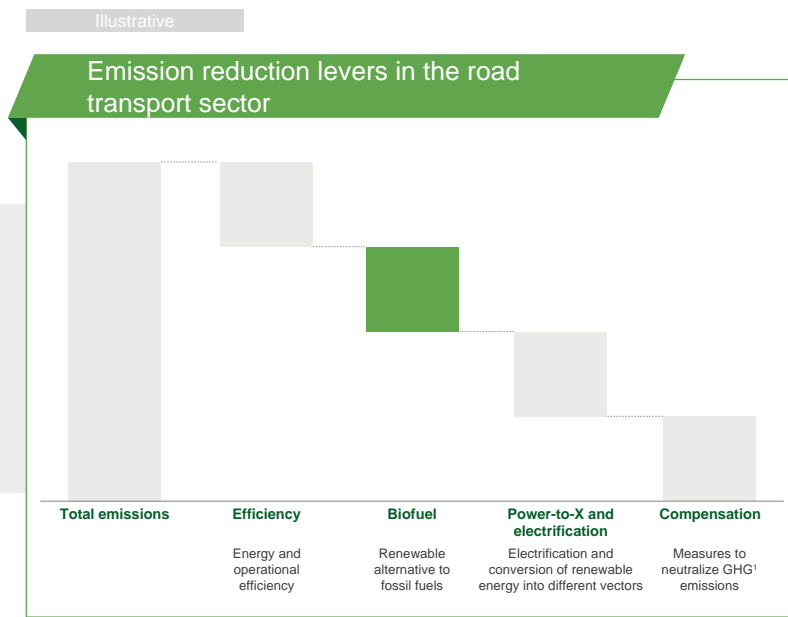
# EFFICIENCY | 7 MAPPED LEVERS WITH THE POTENTIAL TO REDUCE EMISSIONS IN THE MEDIUM TO LONG TERM

	Levers	Feasibility analysis <sup>1</sup>	References
Operational efficiency	<b>1 Optimization of driver behavior</b> – short-term actions (e.g., greater use of telematics in fleets for guidance/training of drivers) and long-term initiatives (e.g., ongoing education).	Existing technologies that are capable of generating impact in the short term; a involves behavioral change and requires less investment relative to other levers.	Viação Cometa   Use of <b>telemetry and monitoring</b> technology to assist in guidelines such as acceleration, idle time, engine speed outside the ideal range, etc., which can play a role in reducing emissions.
	<b>2 Traffic fluidity technologies</b> – Reduce stopping times on highways to then reduce the average travel time and the volume of CO <sub>2</sub> emissions (Free flow, HS-WIM).	Existing technologies, however, require investment to expand use on the country's highways.	Motiva   Operation of the first <b>Free flow</b> system (i.e. charging without the need for a toll plaza) ECORODOVIAS   Operation of the first HS-WIM system (i.e. weighing moving trucks) on BR-365/MG.
	<b>3 Intelligent route and fleet optimization</b> – Use technologies such as IoT, Big Data, and Artificial Intelligence to improve routing of freight transport and reduce emissions.	Existing technologies, capable of generating benefits in the short term with relatively low investment.	JSL   Use of an <b>internal platform</b> , which helps <b>optimize routes and reduce trips</b> without carrying any freight, increasing productivity and reducing greenhouse gas emissions.
	<b>4 Vehicle compliance</b> – Ensure emissions compliance – reduce circulating vehicles with an emission factor that do not meet the established standards.	Able to generate immediate benefits with low investment.	<b>Government efforts</b> (e.g., Proconve2, PCPV3, etc.) and <b>transport companies</b> to ensure compliance and greater inspection of the current fleet.
	<b>5 Improvements to road paving</b> – Expansion of the network granted through new auctions and increased investments in the network under public management.	Able to generate immediate impact, however, it depends on a significant level of investment to improve and maintain the quality of the pavement on the highways.	CNT   Impact study of pavement quality on fuel consumption/ emissions (like the CNT Highway Survey 2024 – difference in pavement quality for highways that have been concessioned to private entities or organizations for management).
	<b>6 Tire energy efficiency</b> – Promoting the wider use of energy-efficient tires, leading to lower fuel usage.	Able to generate immediate impact, but its widespread use by transport companies depends on the price of tires.	Michelin   Seeking to develop tires with greater <b>energy efficiency</b> that help reduce emissions, while—through the <b>PBE<sup>4</sup></b> labeling program—providing consumers with a <b>comprehensive overview of product quality and environmental performance</b> .
Fuel efficiency	<b>7 Modernization and accelerated renewal of the current fleet</b> – replacement of old vehicles with new vehicles that have more efficient fuel consumption and CO <sub>2</sub> L emissions technologies.	Able to generate impact in the medium/ long term, however, it depends on the technological advancement of the vehicles and mechanisms/incentives to increase renewal speed.	Grupo Rodonaves, JCA, Mahnic   Between 2023 and 2024, a number of <b>leading players announced the acquisition of heavy vehicles with new technologies</b> , underscoring their commitment to efficiency and environmental sustainability.

● Feasibility scale

1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. Air Pollution Control Program by Motor Vehicles; 3. Vehicular Pollution Control Plan; 4. Brazilian Tire Labeling Program.

## TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE ROAD TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS



1. GHG = Greenhouse Gases.

# BIOFUELS | THE FUEL OF THE FUTURE LAW IS NOW IN EFFECT AND IS EXPECTED TO DRIVE SIGNIFICANT REDUCTIONS IN EMISSION VOLUMES

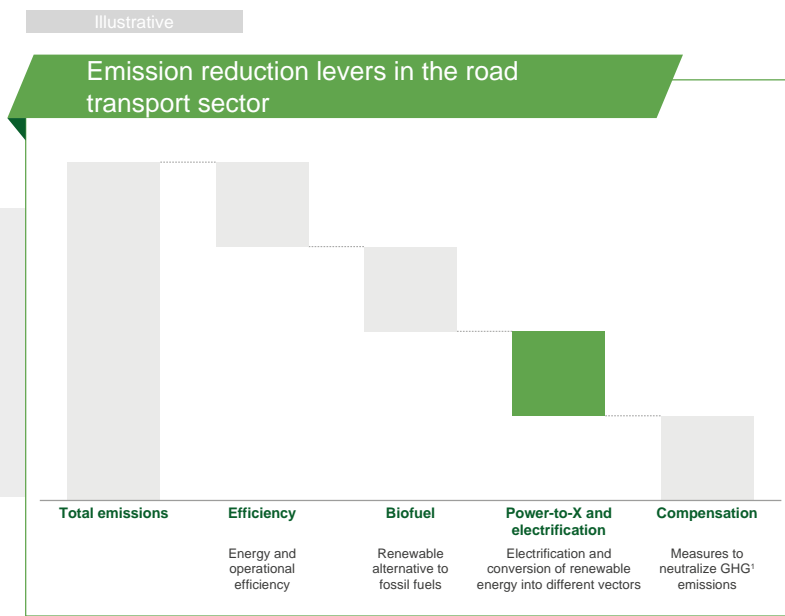
Non-exhaustive

Levers	Feasibility analysis <sup>1</sup>	References
<p>1 <b>Biodiesel – increasing the blend of biodiesel to fossil diesel</b> – It is currently blended 14%; blending is expected to reach 20% in 2030 and 25% from 2031.</p>	<p>It requires adjustments across the production chain and assurance of product quality, as well as technical and economic feasibility analyses.</p>	<p>A number of research institutes (e.g. AEA, CNT, UFRJ, UnB, Unicamp, etc.) are conducting studies to evaluate the technical, mechanical and operational viability of biodiesel in diesel at concentrations greater than 15%.</p>
<p>2 <b>Green diesel – enable green fuel alternative, such as HVO, but also other sources</b> – Feasibility and potential being studied by CNPE.</p>	<p>It requires investment to overcome technical challenges – still in the early stages of testing.</p>	<p>Scania, Volvo   Development of engines for heavy vehicles designed to operate on alternative fuels, including green diesel.</p>
<p>3 <b>Biomethane – increasing the blend of biomethane in vehicular gas</b> – target of 1% will become effective in 2026, and may reach up to 10%.</p>	<p>Infrastructure adjustments are required for biomethane production/distribution.</p>	<p>IVECO   The Stralis Natural Power is the first gas truck for long distances, equipped with a 460 HP engine and with a range of up to 1500 km.</p>
<p>4 <b>Ethanol – increasing the blend of anhydrous ethanol in gasoline A</b> – it is currently blended from 22% to 27%; blending can reach 35%.</p>	<p>Demanding infrastructure and minimum adaptation for mixtures up to 35%.</p>	<p>FedEx   Sustainable logistics solutions, including the use of biofuels, as part of strategies to minimize the environmental impact of operations.</p>
<p>5 <b>Preference at the pump – encourage filling up with ethanol</b> – Currently, 80% of the fleet is flex, however, the preference for ethanol at the pump is less than 30%.</p>	<p>Depends on economic incentives.</p>	<p>UNICA<sup>3</sup>   In 2024, it launched a campaign to explain the environmental and economic benefits of using ethanol.</p>
<p>⚠️ Intensification of the use of biofuels should be encouraged as long as: technical, mechanical, operational and laboratory viability of said energy input is confirmed, as well as respecting the diversity of matrices and regional specificities.</p>		

● Feasibility scale

1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency, and Time to Implementation, as well as inputs gathered during the Listening Session with the group; 3. Sugarcane and Bioenergy Industry Union; Note: The use of biodiesel blends in diesel requires adjustments across the production chain and assurance of product quality, as well as technical and economic feasibility analyses.

## TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE ROAD TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS



1. GHG = Greenhouse Gases.

# ELECTRIFICATION AND POWER-TO-X | ELECTRIFICATION IS EXPECTED TO GAIN TRACTION FOR LIGHTER VEHICLES, WITH HEAVY VEHICLES STILL DEPENDING ON TECHNOLOGICAL ADVANCES

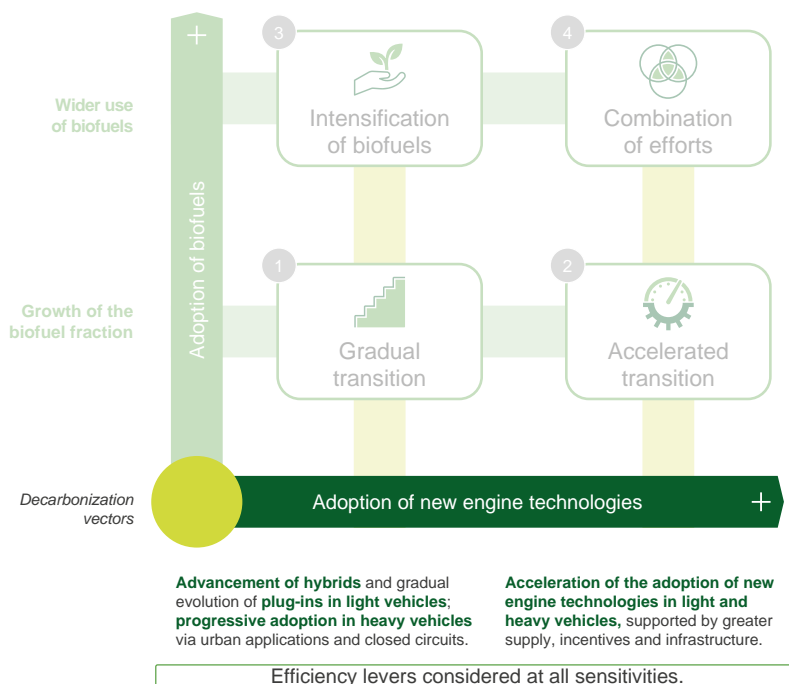
Levers	Feasibility analysis <sup>1</sup>	References
<p>1 <b>Hybrids – increase electrification</b> – reduce dependence on fossil fuel through hybrid vehicles (e.g., PHEV, HEV, MHEV).</p>	<p>Technology is already well-established and widely available in the market for light vehicles (still under development for heavy vehicles).</p>	<p>Scania, Volvo   Hybrid solutions with consolidated batteries and combustion engines for light fleets and in tests for heavy vehicles (e.g., Scania and Volvo have been testing hybrid trucks with automatic switching between modes).</p>
<p>2 <b>100% electric (BEV) – expand the share to 100% electric vehicles in the fleet</b> – a source of clean energy for recharging is a critical element.</p>	<p>It requires an expansion of the charging infrastructure.</p>	<p>UPS, Tesla, Nissan, BMW, Shell, BP   Different players have been investing in the development of electric vehicles, commercialization and charging infrastructure to expand electrification.</p>
<p>3 <b>Electric with fuel cell (Hydrogen) – increase alternative solution of H2-powered vehicles through electrolysis</b> – leading to energy production with lower CO<sub>2</sub> emissions.</p>	<p>It requires technological development and green hydrogen production/distribution infrastructure.</p>	<p>Scania, Hyundai   Pilot projects for hydrogen fuel cell buses and trucks are being upgraded to emission-free intercity operations.</p>

● Feasibility scale

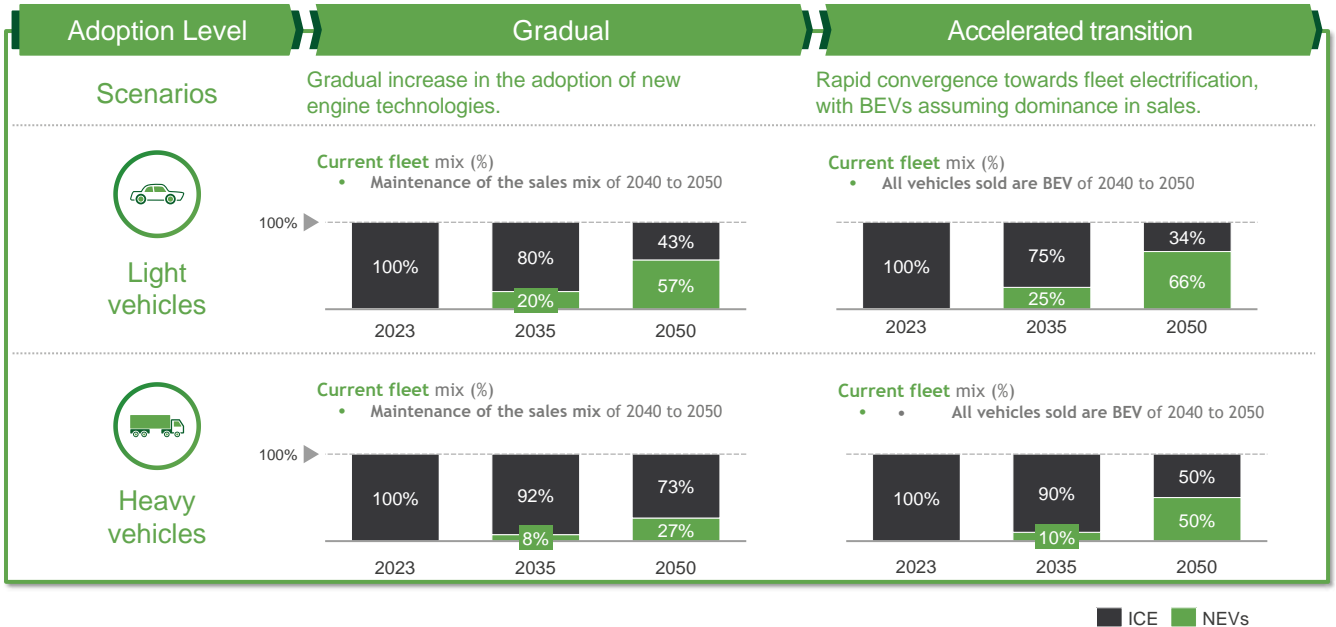
1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Session with the group.



## LEVERS CONSIDERED FOR PROPOSING SENSITIVITIES TOWARDS NET-ZERO EMISSIONS IN ROAD TRANSPORT MODE

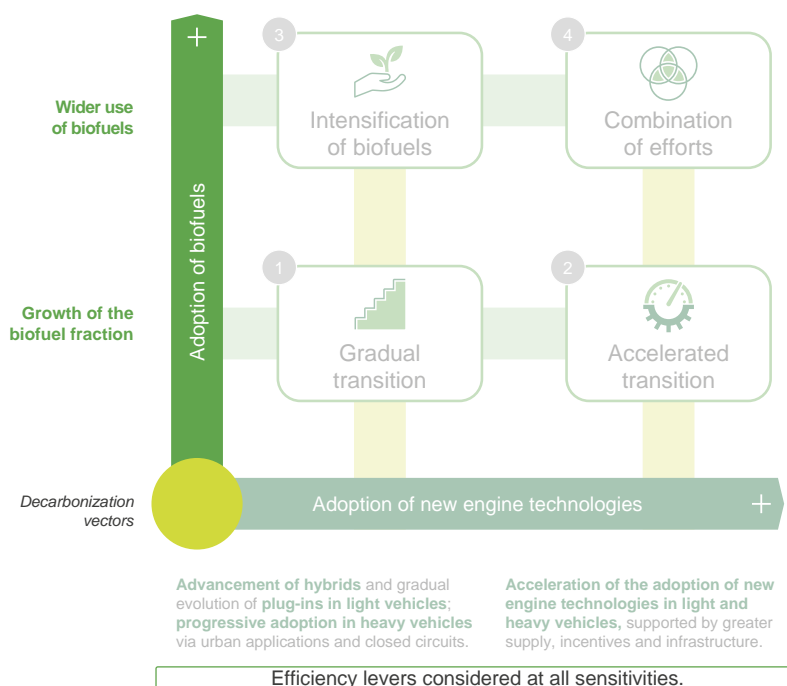


# FLEET ELECTRIFICATION PLAYS A KEY ROLE IN DECARBONIZATION, WITH TWO DISTINCT SCENARIOS UNDER CONSIDERATION: GRADUAL PROGRESS AND ACCELERATED TRANSITION

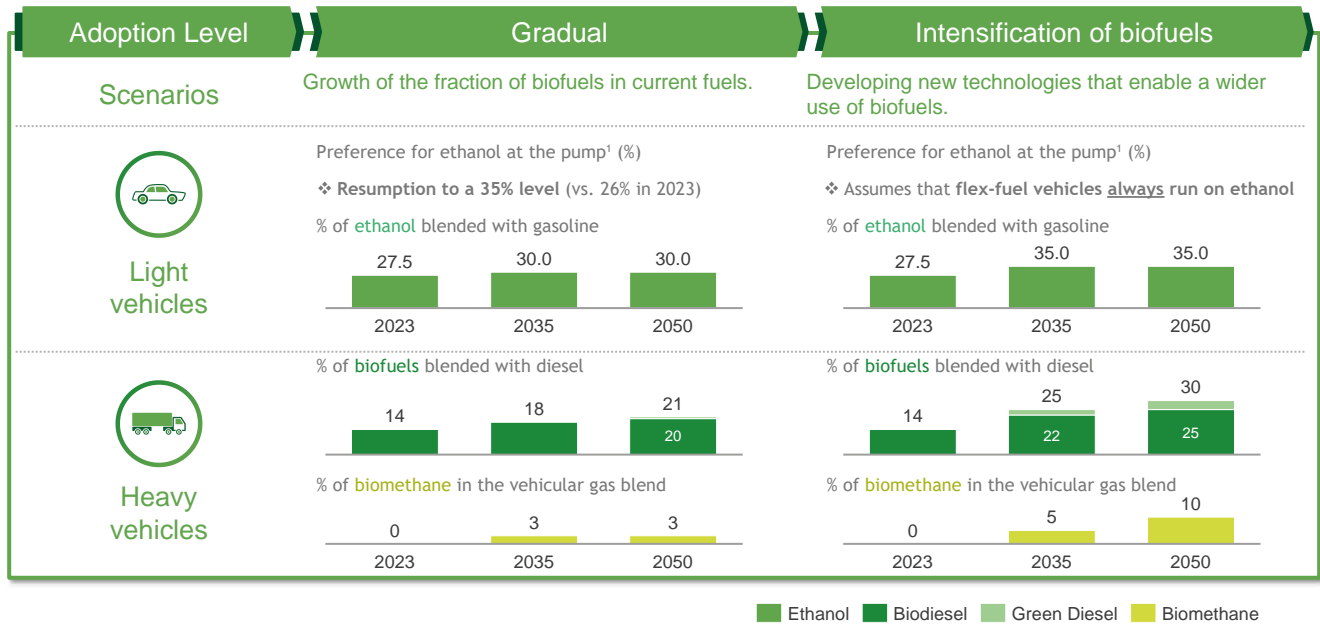


Note: Growth of the current fleet of light vehicles CAGR ('24-'40): ~2.5% p.a. and CAGR ('40-'50): ~1.0% p.a. - Heavy vehicles; CAGR ('23-'40): ~1.8% p.a. and CAGR ('40-'50): ~0.8% p.a. Sources: Advancing on automotive decarbonization paths in Brazil – Anfavea; Report on Energy Demand of Light-Duty Vehicle – EPE; Sectoral Plans and PNL; Transportation Coalition Analyses.

## LEVERS CONSIDERED FOR PROPOSING SENSITIVITIES TOWARDS NET-ZERO EMISSIONS IN ROAD TRANSPORT MODE

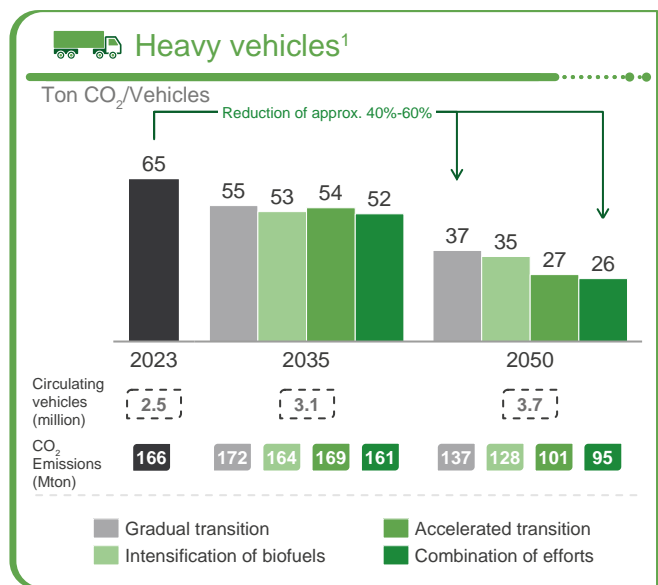
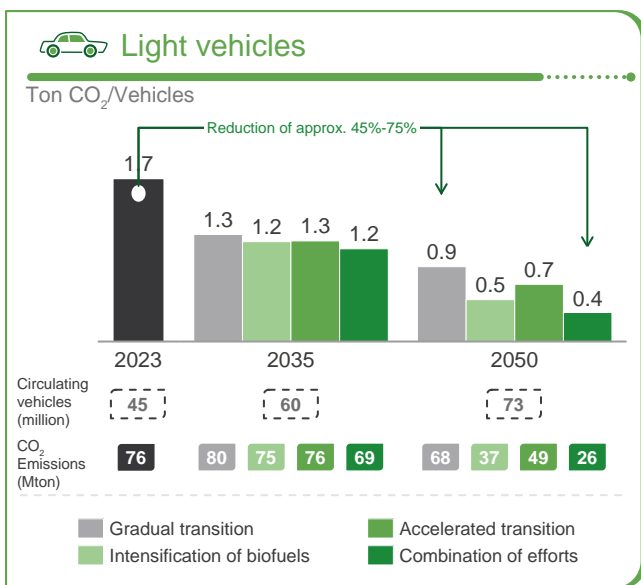


# ROLE OF BIOFUELS IN DECARBONIZATION CHARACTERIZED BY TWO SCENARIOS: GRADUAL PROGRESS AND INTENSIFICATION



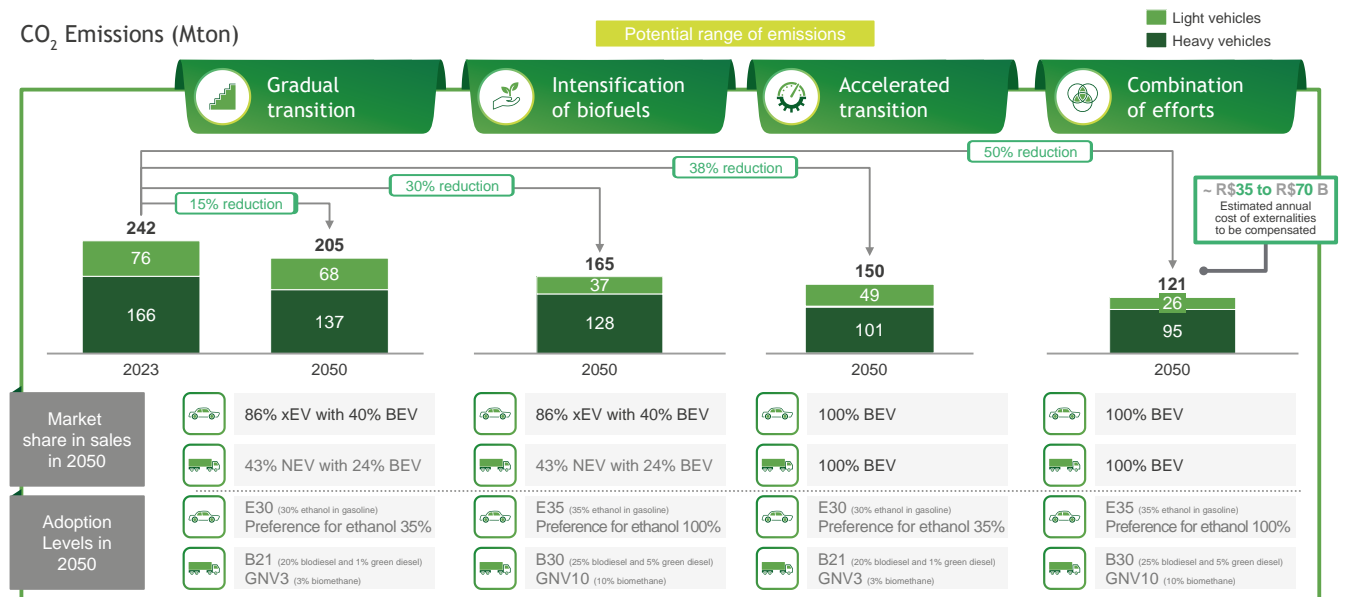
Note: The use of biodiesel blended in diesel requires adjustments across the production chain and assurance of product quality, as well as technical and economic feasibility analyses 1. Volume of hydrated ethanol (in liters) in relation to gasoline C (in liters). Sources: Advancing in the paths of automotive decarbonization in Brazil – Anfavea; EPE; Sectoral Plans and PNL; Transportation Coalition Analyses.

## MORE OPTIMISTIC SENSITIVITIES INDICATE A REDUCTION OF UP TO 75% OF UNIT EMISSIONS IN LIGHT VEHICLES AND UP TO 60% IN HEAVY VEHICLES



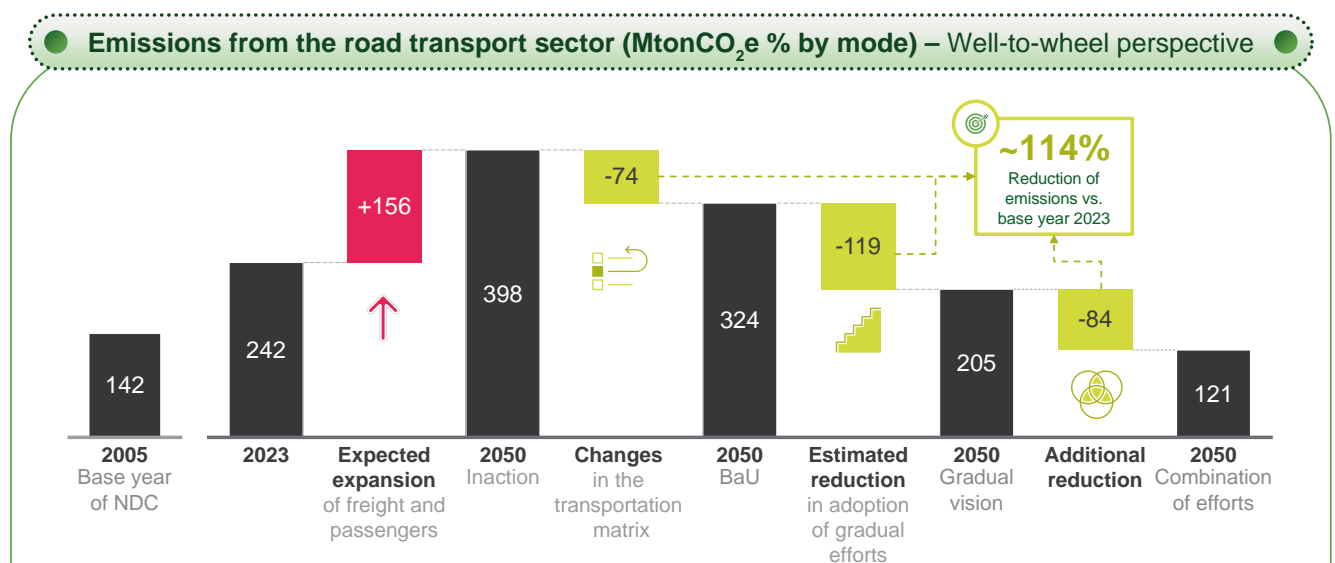
1. Includes buses. Sources: Anfavea Report, Sectoral Plans, PNL, EPE; Transportation Coalition Analysis.

# THE ROAD TRANSPORT SECTOR HAS THE POTENTIAL TO REDUCE CO<sub>2</sub> EMISSIONS BY UP TO 50% (VS. 2023), DEPENDING ON DECARBONIZATION EFFORTS



Sources: Anfavea Report, Sectoral Plans, PNL, EPE; Transportation Coalition Analysis. Note: BEV - 100% battery electric vehicles; xEV - Electrified vehicles (hybrid and 100% electric); NEV - Vehicles powered by new energy sources; The estimated externality is based on a carbon credit cost ranging from US\$50 to US\$100 per metric ton.

## RESULTS | MAPPED DECARBONIZATION LEVERS HAVE THE POTENTIAL TO REDUCE UP TO ~114% OF ROAD TRANSPORT EMISSIONS






# MAPPING OF ENABLERS

## RECENT EXAMPLES ILLUSTRATE HOW ENABLERS HELP UNLOCK KEY LEVERS FOR SECTOR DECARBONIZATION



Illustrative

### Selected examples




#### ✓ Public and private incentives to enable the reduction of emissions in road infrastructure



- **Concession Law<sup>1</sup>**: The private sector is being given the opportunity to manage and improve road infrastructure by making structural investments in the modernization and improvement of road paving, as well as incorporating technologies that improve traffic flow (e.g., free-flow systems, HW-WIM), which in turn helps reduce emissions. 
- **Incentives to encourage businesses to adopt sustainability commitments** | The ANTT Sustainability Program<sup>2</sup> provides regulatory incentives to companies that implement qualifying sustainability measures to the mode. 
- **Public investments earmarked for modernizing road infrastructure** | Commitment to invest €2.3B per year by 2030 to modernize and construct transport infrastructure, including roads. 

#### ✓ Public and private mechanisms to enable electrification

- **Regulation that fosters electrification infrastructure and recharge availability** | Regulation packages and commitments that drive electrification such as Euro VI/ VII, EU Green Deal, Fit for 55, and the 2035 ICE<sup>3</sup> ban.
- **Tangible mechanisms to increase the attractiveness of the acquisition of electric and hybrid vehicles** | US\$1B in subsidies for local manufacturers<sup>4</sup> to invest in the in-house production of EVs<sup>5</sup> batteries, solidifying the security of the supply chain. 
- **Concrete private sector investment moves towards electrification** | Private investments<sup>6</sup> in electric chargers in Brazil, contributing to infrastructure readiness. 

#### ✓ Public and private mechanisms needed to facilitate the expansion of the production and use of biofuels in the energy matrix

- **Regulatory frameworks that incentivize the scale-up of biofuel production and adoption, with safeguards for fuel quality and vehicle performance**
  - » The Fuel of the Future Program and RenovaBio are designed to increase the production and use of biofuels, helping to boost the share of cleaner fuels in the matrix; 
  - » Stricter specifications, such as ANP Resolution 920/2023 for biodiesel and testing, both combined with concrete mechanisms to ensure compliance with quality criteria (e.g. 2BSVS<sup>7</sup> of the EU) will be fundamental to making the advancement of biofuels viable, preserving engine performance.   



- **Tangible mechanisms to promote private financing for R&D<sup>8</sup>** | The MOVER Program offers tax benefits to automotive players that invest more than 0.5% of revenue per year in R&D<sup>8</sup>. 
- **Concrete private sector investment moves towards developing cleaner fuels** | Agreements for joint exploration<sup>9</sup> of the production, purchase and sale of biomethane, clean fuel with applicability in road transport mode. 

1. Law No. 8.987/1995; 2. ANTT Resolution 6.057 (2024); 3. Internal Combustion Engine = Vehicles powered by internal combustion. 4. Toyota and Honda; 5. Electric vehicles; 6. Volvo. Sources: Gov.br; ANTT; European Commission, Época Negócios; Volvo Caminhões, Agência Brasil, Petrobras. 7. Biomass Biofuels Sustainability Voluntary Scheme: EU-recognized framework that ensures, through independent audits, that biofuels comply with the criteria established by the Renewable Energy Directive (REDII); 8. Research and development; 9. Petrobras and Raízen. Note: The use of biodiesel blends in diesel requires adjustments across the production chain and assurance of product quality, as well as technical and economic feasibility analyses. Sources: Gov.br; ANTT; European Commission website, Agência Brasil, Petrobras.



## Target impact in 2050 – Road transport

# We aim for sustainable growth in the Brazilian road transport sector



**~280 Mton** reduction in CO<sub>2</sub>e emissions in 2050 versus a scenario of inaction.

**+110%** of current emissions<sup>1</sup> from the road transport sector.

### Current Road Transport<sup>1</sup>...

### ...Future Road Transport<sup>2</sup>



**~1.6 Trillion TKM**  
Transported annually via the **road transport mode** in Brazil.



**~1.9 Trillion TKM**  
Transported, **+18% growth vs. '23** (0.8% p.a. 2024-2050).



**~25 Bi L of ethanol**  
Used by **light vehicles** in **hydrated and anhydrous** form.



**+40 Bi L of ethanol**  
Required for **refueling light vehicles** with **hydrated ethanol**.



**~8 Bi L of renewable diesel**  
Used by **heavy vehicles** in the form of **biodiesel**.<sup>3</sup>



**+10 Bi L of renewable diesel**  
Required for **heavy vehicles**, including **biodiesel**<sup>3</sup> and **green diesel**.<sup>3</sup>



**~200,000 m<sup>3</sup>/day of CNG**  
Consumed as **vehicular gas** for **heavy vehicle fleets**.



**~8 million m<sup>3</sup>/day of CNG**  
In demand, with **10% biomethane**<sup>3</sup> in its composition.



**<1% of the fleet powered by H<sub>2</sub>**  
Operating with **Power-to-X (PtX)** solutions.



**+230,000 ton/year of H<sub>2</sub>**  
Applied as a solution for the **operation of heavy vehicle fleets**.



**<1% of the xEV fleet**  
In circulation in Brazil, including **light and heavy vehicles**.



**+40% of the xEV fleet**  
In circulation, with **~40% of the heavy fleet** and **+50% of the light fleet** electrified.



**~ 200 GWh/year**  
Provided for the purpose of **recharging 100% electric and plug-in hybrid vehicles**.



**+170,000 GWh/year**  
Required for **recharging light and heavy BEV and PHEV vehicles**.

1. 2021 (base year of the PSTF/PNL, in addition to showcasing more reliable historical benchmarks); 2. 2050 Transformational; 3. Intensification of the use of biofuels should be encouraged as long as: technical, mechanical, operational and laboratory viability of said energy input is confirmed, as well as respecting the diversity of matrices and regional specificities.

## SÍNTESE | RODOVIÁRIO

Currently, the road transport sector moves ~70% of TKM and ~75% of passengers in the country, emitting ~240 Mton CO<sub>2</sub>e/year (~90% of transport emissions), which is equivalent to ~5 tons of CO<sub>2</sub> per vehicle<sup>1</sup> per year.

In a **scenario of inaction**, in which the share of road transport in the national freight transportation matrix remains unchanged (~70% of the TKM handled), **total transport emissions would reach ~424Mton CO<sub>2</sub>e** in 2050<sup>2</sup>; emissions from road transport would reach ~400 Mton CO<sub>2</sub>e.

However, PSTR<sup>3</sup> and PNL<sup>4</sup> projections indicate a change in the logistics matrix, **reducing the share of road transport from ~70% to ~45%<sup>5</sup>**, in line with international benchmarks<sup>6</sup>. Still, demand in road transport is expected to grow 0.6% p.a. by 2050<sup>7</sup>, hitting **1.9 trillion TKM** (+18% vs. 2023).

Despite the percentage reduction, a critical decarbonization lever for the sector, **the absolute increase in demand for road transport is expected to highlight the need for new concessions in the future**, and this is aimed at ensuring that road transport remains attractive and relevant for the country's development.

In an effort to mitigate rising emissions and strengthen their contribution to the climate agenda, **+10 entities** from the Coalition's Road Transport Group have identified and assessed 15 decarbonization levers, with the most prominent being:

- **Electrification | Expansion of hybrid and electric vehicles:** Use of clean energy for recharging to replace fossil fuel;
- **Biofuel | Expansion of use<sup>8</sup>:** Enabling renewable biofuel alternatives to replace fossil fuels;
- **Efficiency | Fleet renewal:** Replacement of old vehicles with new and more efficient models;
- **Efficiency | Improvements to paving/road infrastructure:** Expansion of the network granted through new auctions and new investments in the public road network.



If implemented, the 15 levers can reduce emissions from the mode to ~120 Mton CO<sub>2</sub>e (-50% vs. 2023) in transformational sensitivity, with a drop in relative emissions intensity to **1.5 tons of CO<sub>2</sub>/vehicle<sup>1</sup>** (-70% vs. 2023)

To make decarbonization possible, **a variety of enabling factors will be required**. The following are some concrete examples that have the potential to help:

- **Regulation | Concession Law<sup>9</sup>:** Allows private investments to help modernize highways and implement advanced technologies to enhance transportation efficiency;<sup>10</sup>
- **Regulation | Fuel of the Future Law:** Establish guidelines for the expansion of the use of biofuels;
- **Incentives | MOVER Program:** Provides tax incentives for entities adopting decarbonization technologies;<sup>11</sup>

Despite the **relevant reduction potential of ~120 Mton CO<sub>2</sub>e** (~50% of current emissions from the modal, even with the sector growing in volume and passengers), **residual emissions will still be significant** (~120 Mton CO<sub>2</sub>e, 88% of total transport emissions in 2050). It is therefore **crucial that the Coalition maintains its commitment to finding novel solutions** for reaching net-zero emissions while minimizing the requirement for compensation.

1. Includes light and heavy vehicles; 2. 5. If there is maintenance of the predominance of road transport in freight transport (~70% of TKM by 2050); 3. Road Transport Sector Plan; 4. National Logistics Plan; 5. % of TKM handled nationally; 6. Like the USA and Europe; 7. Growth in line with the PSR3 scenario of the PSTR in 2050; 8. Adoption needs to be preceded by tests that prove technical feasibility, in addition to respecting the diversity of matrices and considering regional specificities; 9. Law No. 8.987/1995; 10. Examples: Free Flow and HS-WIM; 11. Indicators include advancements in energy consumption and energy source of vehicles.

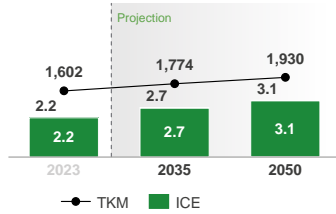
## APPENDIX 1

# DETAILING OF BaU PREMISES

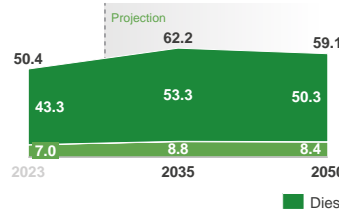


# TRUCKS | VOLUME OF CO<sub>2</sub> EMISSIONS COULD INCREASE 17% BY 2050

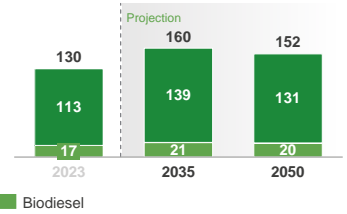
Truck fleet is expected to reach ~3M (+40%) in 2050.  
Fleet by engine type (Mm) and TKM (Bn)



Maintenance of the proportion of biodiesel in fossil diesel  
Consumption by type of fuel (Bn L)



Volume of CO<sub>2</sub> emissions is expected to increase by +17%.  
Projection of Mt CO<sub>2</sub> emissions (well-to-wheel)



Key assumptions for emissions BaU

**Electrification**

- Current fleet of hybrid or electric trucks is **not very representative** (less than 1%).

- Does not assume advances in the electrification of the truck fleet** for baseline purposes.

- Low share of emissions** from electric trucks.

**Biofuels**

- Fleet of trucks powered by biofuels is **not very representative** (HVO is still in the early stages of testing).

- Maintenance of biodiesel<sup>1</sup>** blend in diesel by 14% by 2050.

- Biodiesel** emits 1/3 less than fossil diesel.<sup>2</sup>

**Efficiency**

- Does not consider an increase** in average distance traveled or average ton moved per truck **efficiencies**.

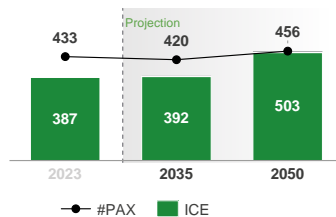
- Does not consider** efficiency gains in fuel consumption (more "economical" engines).

- Does not consider efficiency gains** in time emission factors.

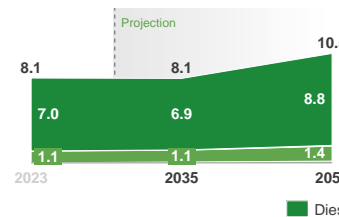
1. Sanctioned through the Fuel of the Future Law; 2. National inventory of atmospheric emissions by road motor vehicles; ICE – Internal combustion vehicle; Note: The use of biodiesel blended in diesel requires adjustments across the production chain and assurances of product quality, as well as technical and economic feasibility analyses; The various biofuels have different calorific powers, which impacts autonomy and power compared to fossil fuels. Sources: ANFAVEA; ANP; Transportation Sector Plans.

# BUS | VOLUME OF EMISSIONS COULD INCREASE BY 11% BY 2050

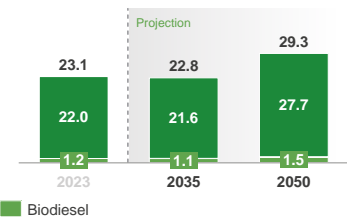
The bus fleet is expected to grow by about 5%  
Fleet by engine type (thousand) and PAX (million)



Maintenance of the proportion of biodiesel in fossil diesel  
Consumption by type of fuel (Bn L)



Increase in CO<sub>2</sub> emissions by 11%  
Projection of Mt CO<sub>2</sub> emissions (well-to-wheel)



Key assumptions for emissions BaU

**Electrification**

- Current fleet of hybrid or electric intercity buses is **not very representative** (less than 1%).

- Does not assume advances in the electrification of the intercity buses fleet** for baseline purposes.

- Low share of emissions** from electric intercity buses.

**Biofuels**

- Fleet of intercity buses powered by biofuels is **not very representative** (B100, HVO is still in the early stages).

- Maintenance of biodiesel<sup>1</sup>** blend in diesel by 14% by 2050.

- Biodiesel** emits 1/3 less than fossil diesel.<sup>2</sup>

**Efficiency**

- Does not consider an increase** in average distance traveled or average #PAX transported by bus **efficiencies**

- Does not consider** efficiency gains in fuel consumption (i.e. more "economical" engines).

- Does not consider efficiency gains** in time emission factors

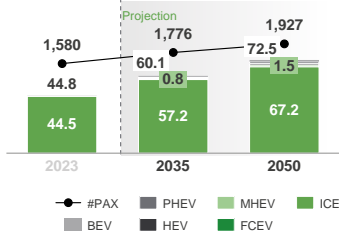
1. Sanctioned through the Fuel of the Future Law; 2. National inventory of atmospheric emissions by road motor vehicles; Note: The use of biodiesel blended in diesel requires adjustments across the production chain and assurances of product quality, as well as technical and economic feasibility analyses; The various biofuels have different calorific powers, which impacts autonomy and power compared to fossil fuels. Sources: ANFAVEA; ANP; PNL 2035; Infra S.A.

# LIGHT VEHICLES | VOLUME OF EMISSIONS COULD SEE A 68% INCREASE BY 2050



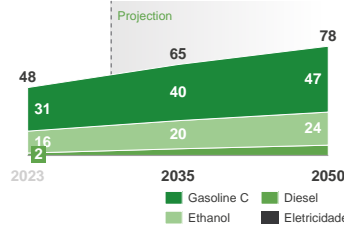
Light vehicle fleet is expected to top 72 million (+62%) in 2050...

Fleet by engine type (Mm) and PAX<sup>1</sup> (Mm)



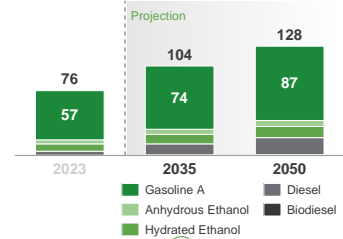
... and maintenance of biofuel blends.

Consumption by type of fuel (Bn L/TWh)



Volume of CO<sub>2</sub> emissions is expected to increase by +68%

Projection of Mt CO<sub>2</sub> emissions (well-to-wheel)



Key assumptions for emissions BaU

Electrification

• Current fleet of hybrid or electric light vehicles is still not very representative (approx. 5%).

• Does not assume advances in the electrification of the light vehicle fleet for baseline purposes.

• Despite existing, low share of electric vehicle emissions.

Biofuels

• Most (~80%) of the current Brazilian fleet already has flex-fuel engines that allow refueling with ethanol.

• Maintenance of the composition of ethanol in gasoline A of 27.5% by 2050<sup>2</sup>.

• Ethanol emits 1/4 of the gasoline.<sup>3</sup>

Efficiency

• Does not consider increase in efficiency (i.e. reduction of the average distance traveled or increase in passengers transported).

• Does not consider efficiency gains in fuel consumption (i.e. more "economical" engines).

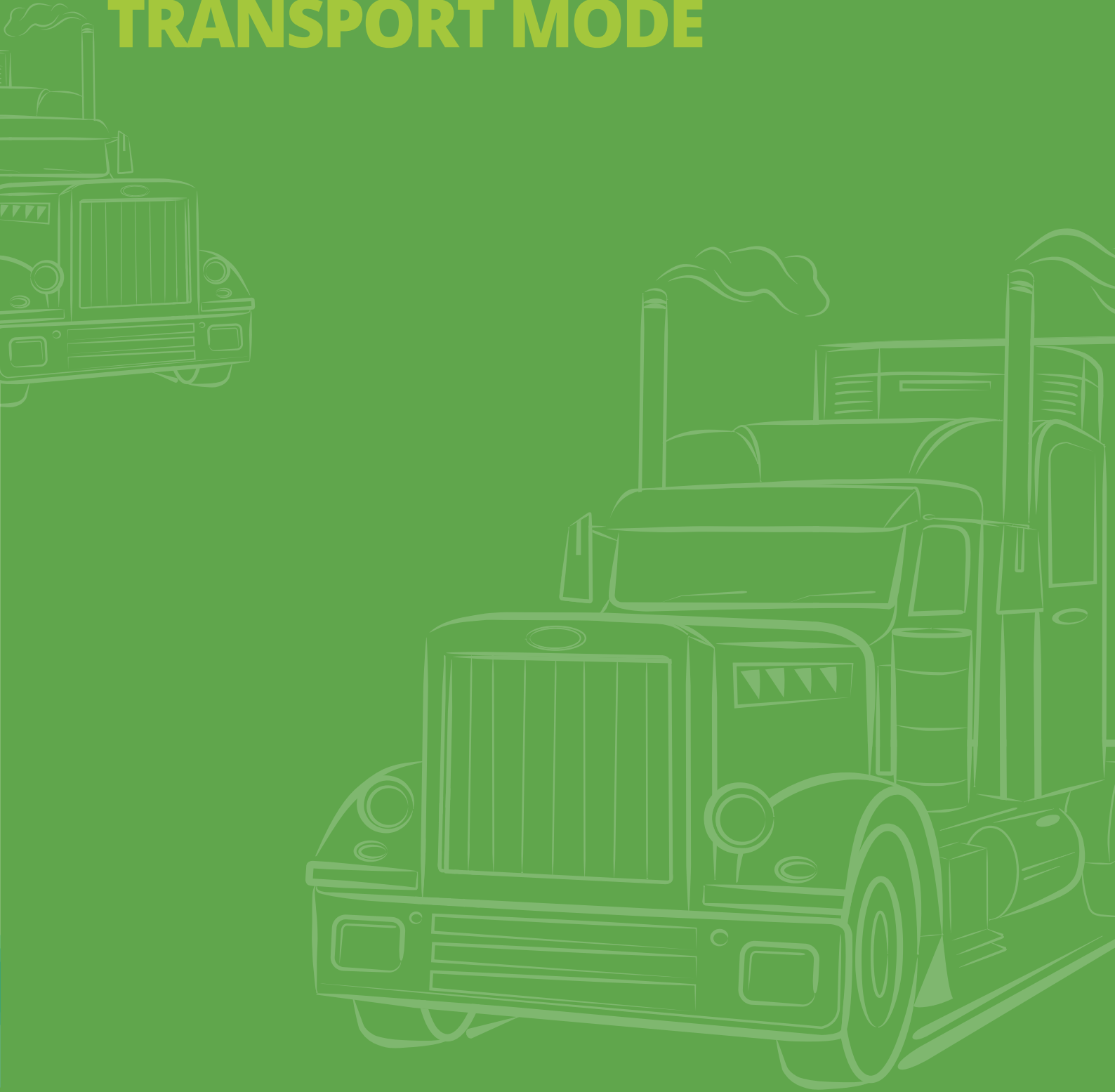
• Does not consider efficiency gains in time emission factors.

1. Considers only passengers in intercity flows (PNL 2035); 2. Sanctioned through the Fuel of the Future Law; 3. National inventory of atmospheric emissions by road motor vehicles; Note: The use of biodiesel blended in diesel requires adjustments across the production chain and assurances of product quality, as well as technical and economic feasibility analyses; The various biofuels have different calorific powers, which impacts autonomy and power compared to fossil fuels. Sources: ANFAVEA; ANP; PNL 2035; Infra S.A.



## APPENDIX 2

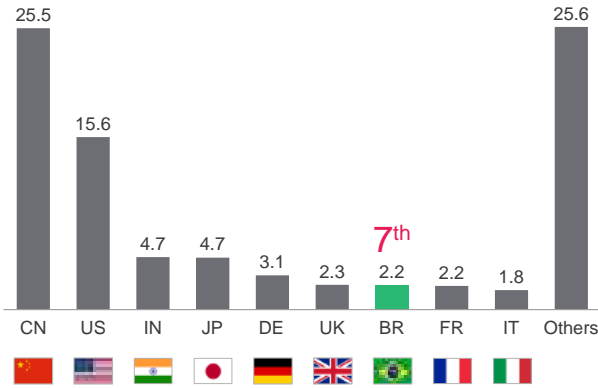
# GLOBAL TRENDS FOR THE ROAD TRANSPORT MODE



# BRAZILIAN AUTOMOTIVE MARKET IS AMONG THE 10 LARGEST MARKETS IN THE WORLD

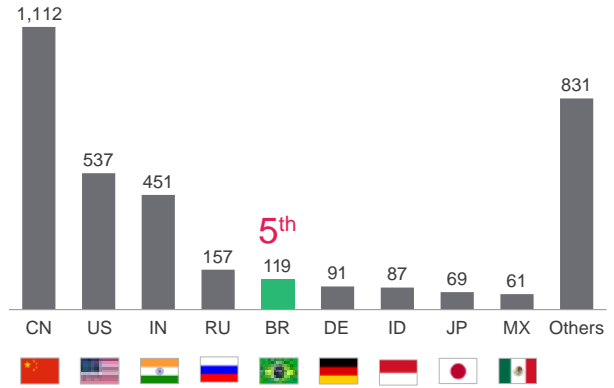
## Light vehicles

Light vehicle sales in 2023 (million)



## Heavy vehicles

Heavy vehicle sales in 2023 (thousands)



Sources: S&P Global Mobility.

# THE WORLD'S MAJOR AUTOMOTIVE MARKETS ARE ADVANCING ACROSS FIVE DIMENSIONS TO DECARBONIZE LIGHT-DUTY AND HEAVY-DUTY FLEETS



### Regulation and incentives

Regulations and incentives along the value chain covering charging stations, manufacturing and vehicle sales.



### Supply Chain (especially batteries)

Adaptation of the chain players to develop specific operational capacity for electrical and hybrid products (incl. raw material and components).



### NEV<sup>1</sup> and xEV<sup>2</sup> offerings & biofuels

Variety in the offer of light and heavy vehicles in various segments and technologies (e.g., pure electric and hybrid models).



### Attractiveness of purchase

Attractiveness of light and heavy vehicles compared to combustion vehicles, such as:

- Price;
- Readiness of use depending on the performance of the technology (km);
- Resale price (depreciation).



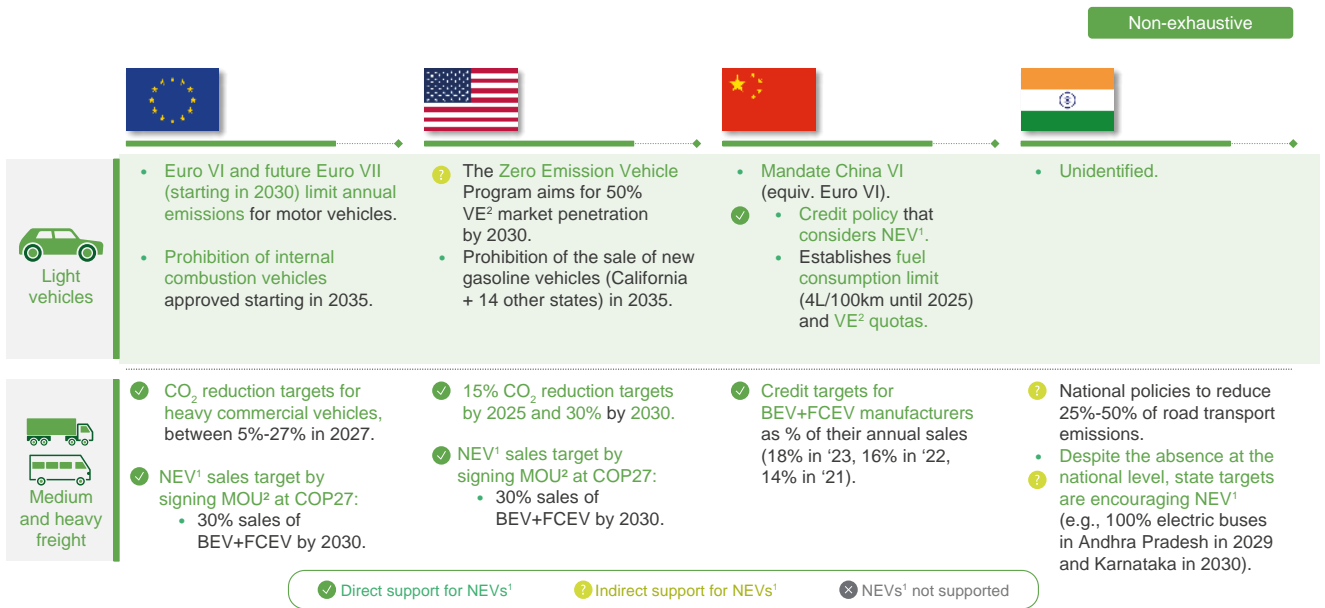
### Infrastructure readiness

Regional availability and accessibility of fast-charging infrastructure for electric vehicles.

Some examples are below

1. NEV: New Energy Vehicles 2. Electric vehicles.

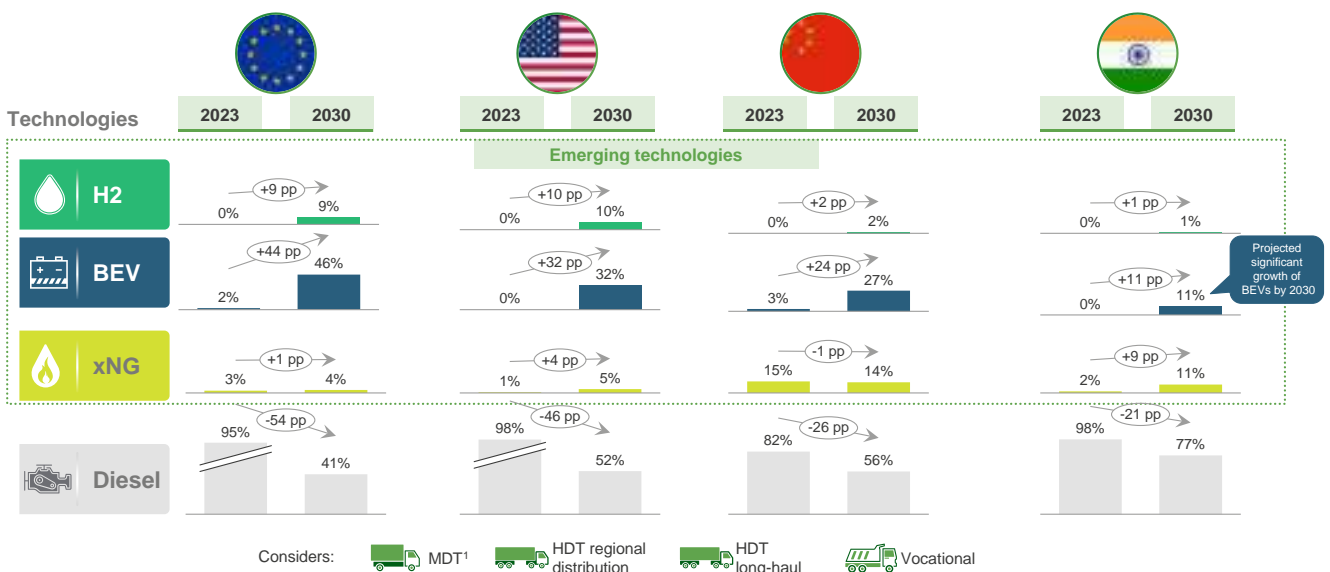
# REGULATIONS AND INCENTIVES APPEAR AS KEY ENABLERS TO PUSH THE AGENDA



1. NEV: New Energy Vehicles 2. Electric vehicles 3. Memorandum of understanding.




# INCREASING ATTRACTIVENESS FOR ENTRY OF BATTERY ELECTRIC VEHICLES FOR TRANSPORTING MEDIUM AND HEAVY FREIGHT IN VARIOUS COUNTRIES, REPLACING DIESEL

Increase in the share of BEVs, A H<sub>2</sub> and xNG vehicles in heavy and medium fleets is expected by 2030 (%)



# HEAVY-DUTY FLEETS: LEVERS FOCUSED ON EFFICIENCY AND DEVELOPMENT OF SOLUTIONS TO REDUCE EMISSIONS




Non-exhaustive

 <p>Efficiency</p>	<p><b>Test with autonomous trucks</b></p> <ul style="list-style-type: none"> <li>Autonomous trucks focusing on long-distance routes being tested in various regions of the United States.</li> </ul>	<p><b>Use of technologies and digitalization for intelligent route and fleet optimization</b></p> <ul style="list-style-type: none"> <li>Trucks developed with engines that are optimized for better fuel consumption and advanced fleet management systems that help optimize routes.</li> <li>Implement advanced solutions in their trucks to improve fuel efficiency, including aerodynamic technologies and hybrid systems for specific models.</li> </ul>
 <p>Biofuels</p>	<p><b>Development of engines and freight vehicles and buses to run using alternative fuels</b></p> <ul style="list-style-type: none"> <li>Players investing in engines adaptable to alternative fuels, including models that operate on ethanol, biogas, biomethane and HVO, ranging from buses to trucks.</li> <li>IVECO's Stralis Natural Power is the first gas truck for long distances, equipped with a 460 HP engine and with a range of up to 1500 km.</li> </ul> <p><b>Adoption of biodiesel and biogas/biomethane blends for heavy-duty fleets in various geographies</b></p> <ul style="list-style-type: none"> <li>Players using a line of trucks and buses that can run on biodiesel and biogas/biomethane.</li> <li>Test of the use of B100 biodiesel (100% biodiesel) in trucks in Europe, Singapore, Canada etc.</li> </ul>	
 <p>Electrification and Power-to-X</p>	<p><b>Pilot projects for H<sub>2</sub>-powered buses and trucks</b></p> <ul style="list-style-type: none"> <li>Buses and trucks powered by hydrogen fuel cells are being developed for emission-free intercity operations.</li> </ul>	<p><b>Hybrid solutions combining batteries and combustion engines</b></p> <ul style="list-style-type: none"> <li>Hybrid trucks combine the power of battery electric motors and combustion with automatic switching between modes, using regenerative and external power.</li> </ul>

Source: Press search.

# LIGHT-DUTY FLEETS: LEVERS DISTRIBUTED BETWEEN EFFICIENCY, ELECTRIFICATION AND THE USE OF BIOFUELS

Non-exhaustive

 <p>Efficiency</p>	<p><b>Autonomous vehicles automate and optimize delivery tasks</b></p> <ul style="list-style-type: none"> <li>Amazon Scout, Amazon's autonomous delivery vehicle, is in the testing phase in several US locations, assessing its effectiveness and safety for last-mile deliveries.</li> </ul>	<p><b>Use of technologies and digitalization for intelligent route optimization and driver training</b></p> <ul style="list-style-type: none"> <li>Utilizing advanced technology systems to plan and optimize delivery routes, minimizing miles traveled and maximizing fuel efficiency.</li> <li>Programs focused on educating drivers about cost-effective driving techniques to lower fuel consumption and emissions, as well as improving road safety.</li> </ul>
 <p>Biofuels</p>	<p><b>Adoption of biodiesel, biogas/biomethane and ethanol blends for light-duty fleets in various geographies</b></p> <ul style="list-style-type: none"> <li>Sustainable logistics solutions, such as the implementation of biofuels in its operations, as part of its efforts to reduce the environmental impact of activities.</li> </ul>	
 <p>Electrification and Power-to-X</p>	<p><b>Promotion of electric mobility via electric and hybrid vehicle solutions, and investment in infrastructure</b></p> <ul style="list-style-type: none"> <li>Development and commercialization of all-electric light vehicles as an alternative to those powered by fossil fuels.</li> <li>Players investing in charging for electric vehicles, with diversified solutions for public, residential and business spaces, actively promoting the adoption of EVs<sup>1</sup>.</li> <li>Sustainable logistics solutions, such as the use of electric and hybrid vehicles in operations, as part of its efforts to reduce the environmental impact of activities.</li> </ul>	

1. Electric vehicles. Source: Press search.

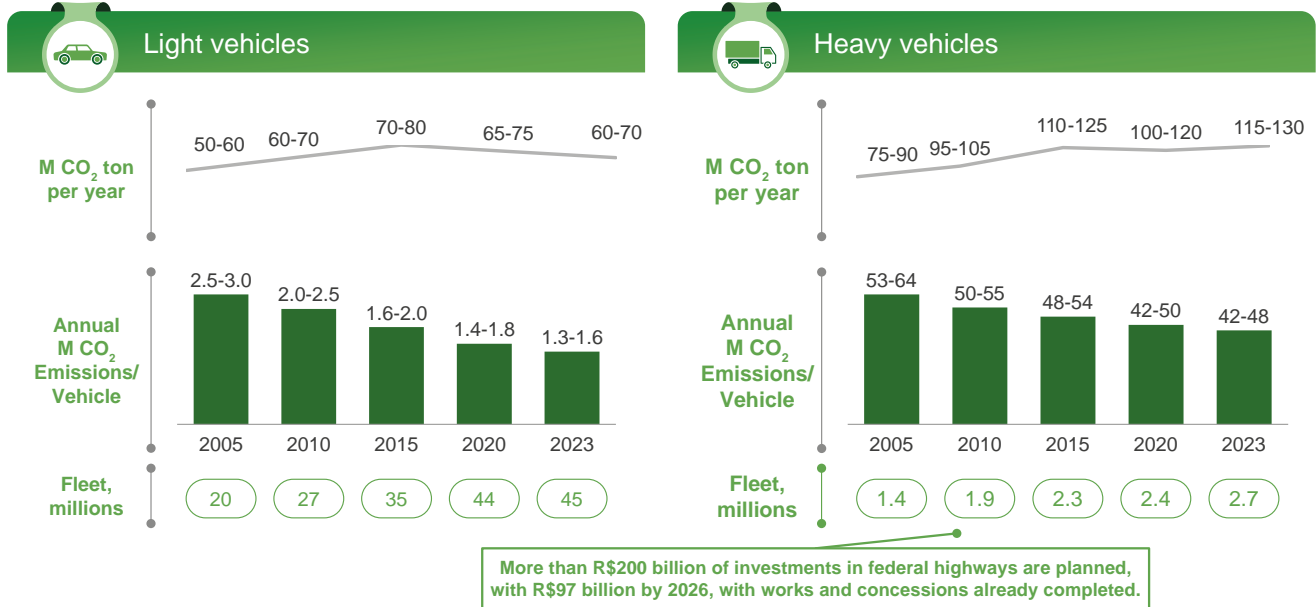
## APPENDIX 3

# LOCAL TRENDS FOR THE ROAD TRANSPORT MODE



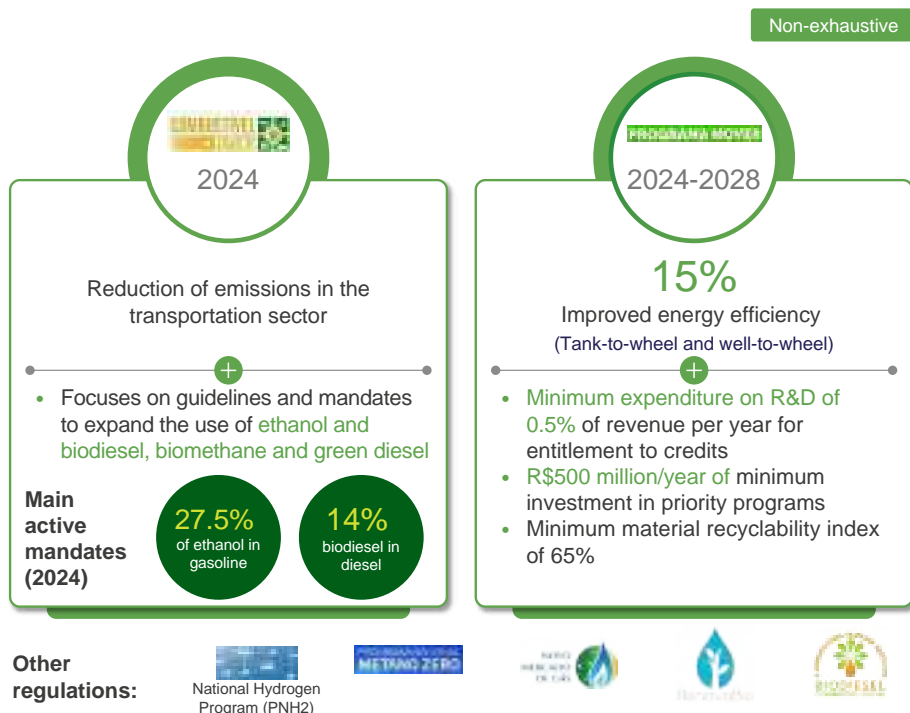
# BRAZIL HAS MADE PROGRESS IN REDUCING CO<sub>2</sub> EMISSIONS PER VEHICLE, YET A SIGNIFICANT PATHWAY REMAINS TO MEET ITS OVERALL CO<sub>2</sub> EMISSION REDUCTION TARGETS

Estimation of CO<sub>2</sub> emissions



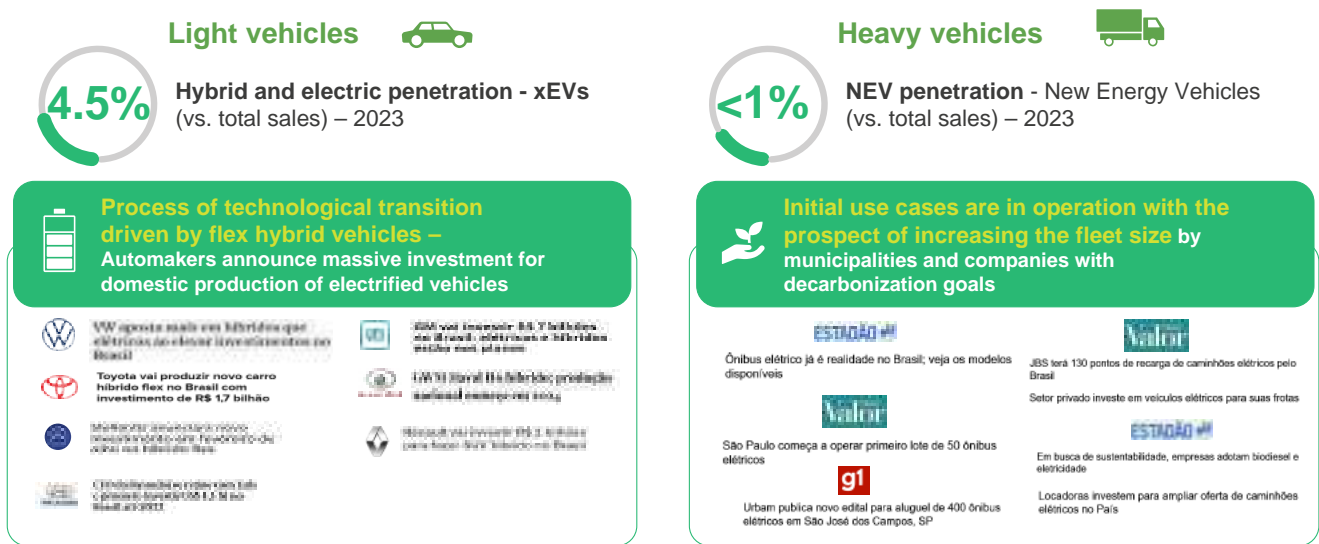
Sources: IEMA, Frota Circulante Sindipeças.

# GOVERNMENT PROGRAMS ALIGNED WITH THE ENERGY TRANSITION SEEK TO BOOST LOW-CARBON MOBILITY



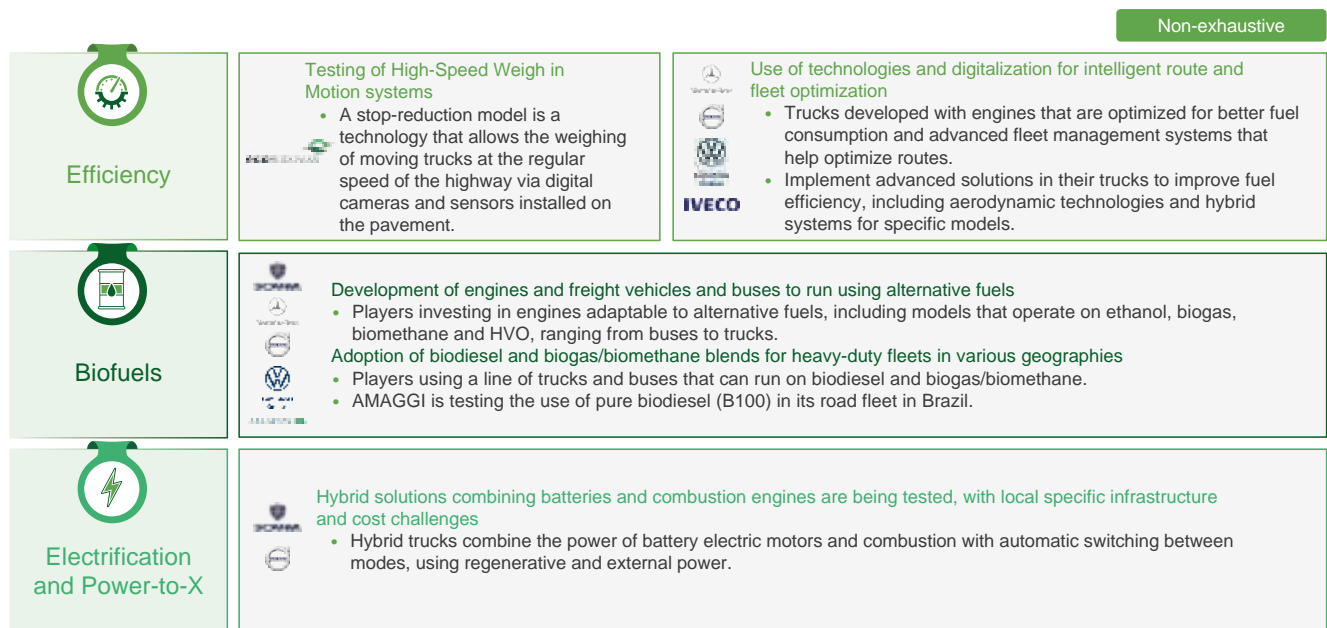
Sources: Press search, Gov.br.

# FOR 2024, FLEX-FUEL HYBRIDS EMERGED AS THE PRIMARY DECARBONIZATION PATH FOR LIGHT VEHICLES, WHILE NEW TECHNOLOGIES SAW GRADUAL ADVANCEMENT IN THE HEAVY-DUTY SEGMENT



Sources: IHS, S&P Global Mobility, Press Search







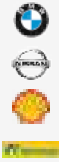
## HEAVY-DUTY FLEETS: LEVERS FOCUSED ON EFFICIENCY AND DEVELOPMENT OF SOLUTIONS TO REDUCE EMISSIONS



Source: Press search.

# LIGHT-DUTY FLEETS: LEVERS DISTRIBUTED BETWEEN EFFICIENCY, ELECTRIFICATION AND THE USE OF BIOFUELS

Non-exhaustive

 <p>Efficiency</p>	<p>Concessionaires implementing free flow models</p> <ul style="list-style-type: none"> <li>A stop-reduction model allows vehicles to pass without braking or waiting in queues, reducing fuel consumption and GHG emissions.</li> </ul> 	 <p>Use of technologies and digitalization for intelligent route optimization and driver training</p> <ul style="list-style-type: none"> <li>Utilizing advanced technology systems to plan and optimize delivery routes, minimizing miles traveled and maximizing fuel efficiency.</li> <li>Programs focused on educating drivers about cost-effective driving techniques to lower fuel consumption and emissions, as well as improving road safety.</li> </ul>
 <p>Biofuels</p>	<p>Adoption of biodiesel and ethanol blends for light-duty fleets</p> <ul style="list-style-type: none"> <li>Sustainable logistics solutions, such as the implementation of biofuels (e.g. blend of biodiesel in diesel and ethanol in gasoline) in its operations, as part of its efforts to reduce the environmental impact of activities.</li> </ul> 	
 <p>Electrification and Power-to-X</p>	<p>Promotion of electric mobility via electric and hybrid vehicle solutions, and investment in infrastructure</p> <ul style="list-style-type: none"> <li>Development and commercialization of all-electric light vehicles as an alternative to those powered by fossil fuels.</li> <li>Players investing in charging for electric vehicles, with diversified solutions for public, residential and business spaces, actively promoting the adoption of EVs<sup>1</sup>.</li> </ul> 	

1. Electric vehicles. Source: Press search.

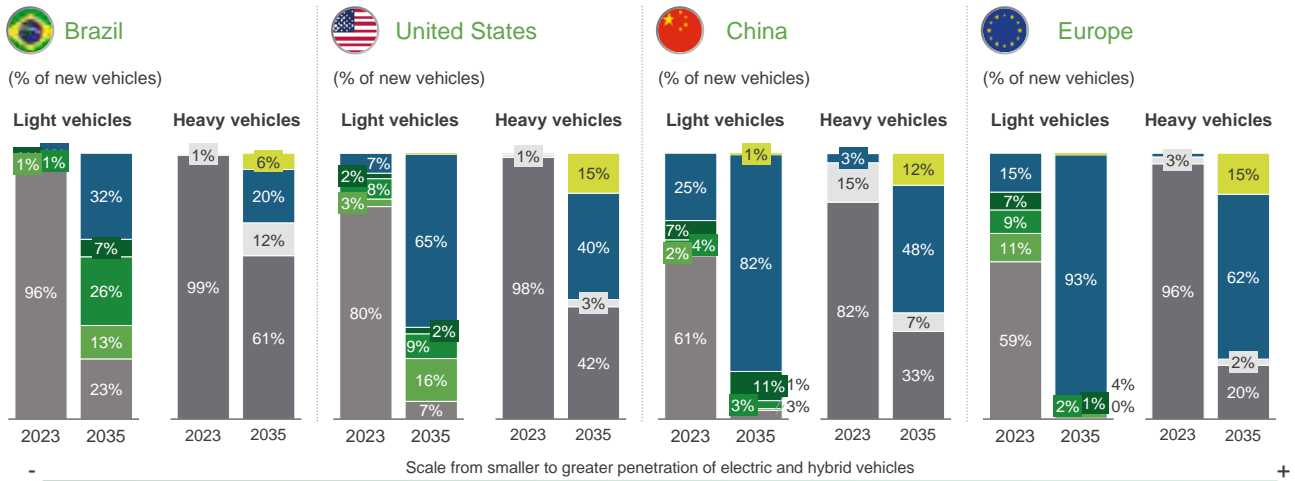


## APPENDIX 4

# DETAILED BREAKDOWN OF THE ASSUMPTIONS



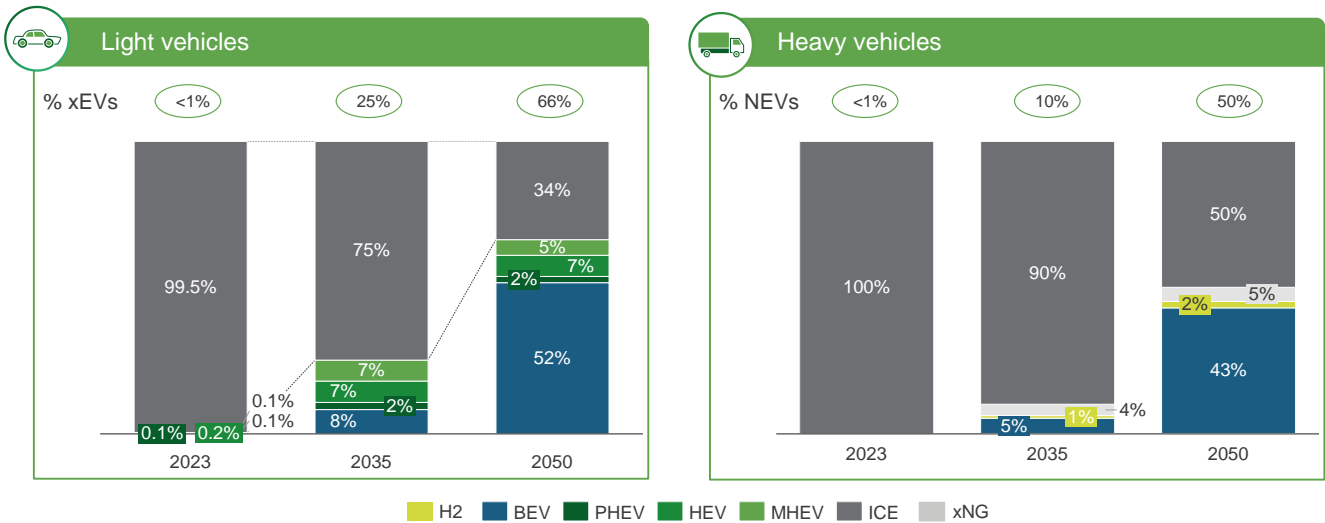
# GLOBAL BENCHMARK | THE ADOPTION OF ELECTRIC AND HYBRID VEHICLES IN BRAZIL IS PROJECTED TO BE LESS AGGRESSIVE THAN IN LEADING COUNTRIES OVER THE COMING YEARS



Note: Includes light vehicles <3.5t; Europe: EU27 + EFTA + UK; Mainland China; FCEV = fuel cell electric, BEV = 100% electric vehicles, PHEV = plug-in hybrid vehicle, HEV = hybrid vehicle, MHEV = light hybrid vehicle. Sources: IHS GADT (02/2024); Anfaeva.

## ALTHOUGH THE SALE OF BEVS WILL DOMINATE FROM 2040 ONWARDS, THE IMPACT ON THE CIRCULATING FLEET IS EXPECTED TO OCCUR AFTER 2050, DUE TO THE AVERAGE AGE OF THE FLEET EXCEEDING 10 YEARS

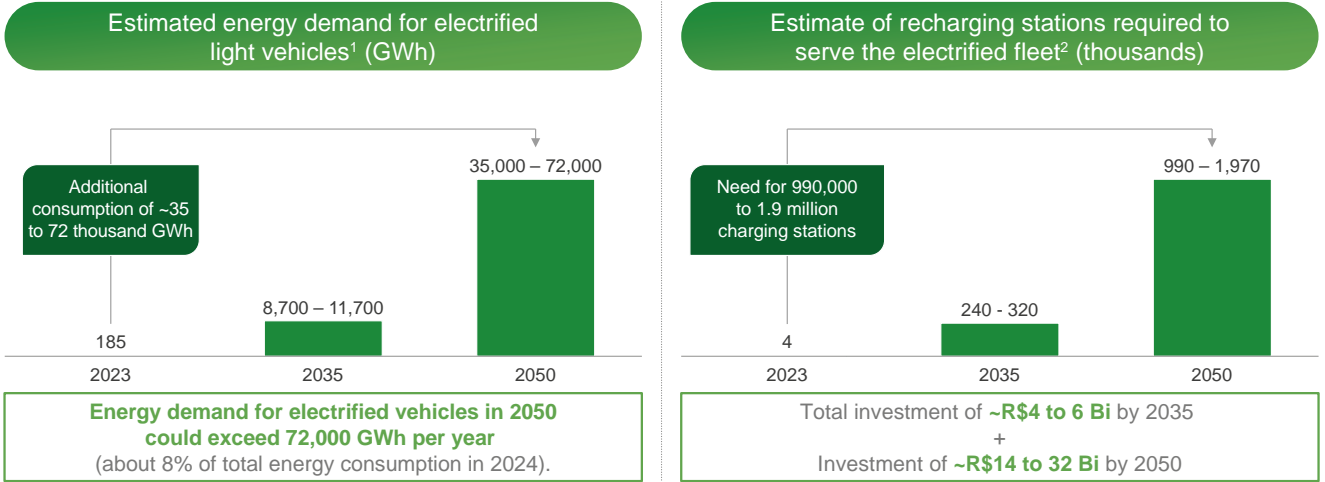
Estimate of fleet in circulation by type of motorization technology - Brazil (% of total circulating vehicles, numbers indicative of transformational sensitivity)



Note: BEV = 100% electric vehicle, PHEV = plug-in hybrid vehicle, HEV = hybrid vehicle, MHEV = light hybrid vehicle, ICE = internal combustion engine, H2 = hydrogen vehicle, xNG = gas vehicle. Sources: S&P Global Mobility; IHS Markit; Press Search; Anfaeva.

# ADVANCEMENT IN THE MARKET PENETRATION OF ELECTRIFIED LIGHT VEHICLES WILL REQUIRE THE DEVELOPMENT OF CHARGING INFRASTRUCTURE

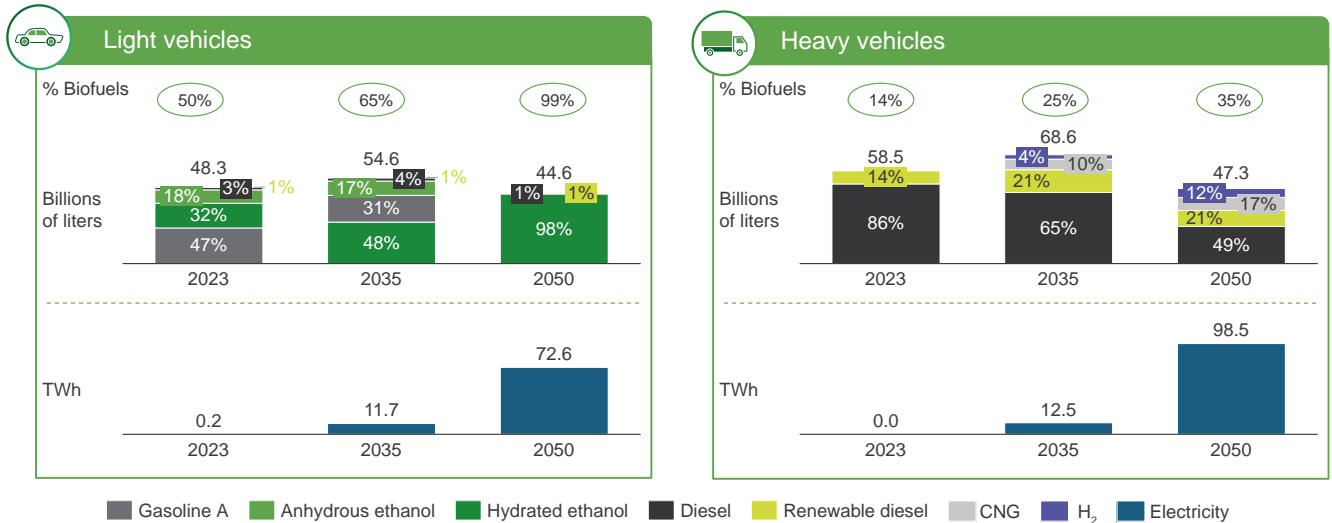
Indicative range between gradual and accelerated scenarios (estimates)



1. Only BEVs and PHEV; Energy efficiency of 3.54 km/kWh for PHEVs and 7 km/kWh for BEVs; in average distance 12,000 km/year and 61% of the km driven by PHEVs in electric battery. 2. Considers a list of BEVs+PHEVs/public charging stations = 20, in line with European values. 3. Considers that 15% of new chargers will be fast and the rest will be slow, with an average cost of R\$10,000 per slow charging station and R\$55,000 per fast charging station, with a cost drop by 2030  
 Note: Lower limit considers numbers of the gradual transition while upper limit considers accelerated transition, BEV = 100% electric vehicle, PHEV = plug-in hybrid vehicle  
 Sources: EPE, ICCT, Press Search, BCG Analysis.

# OF VEHICLES IN CIRCULATION NOT YET ELECTRIFIED BY 2050, ~100% OF LIGHT VEHICLES WILL BE SUPPLIED WITH ETHANOL AND 35% OF HEAVY VEHICLES WITH RENEWABLE FUELS

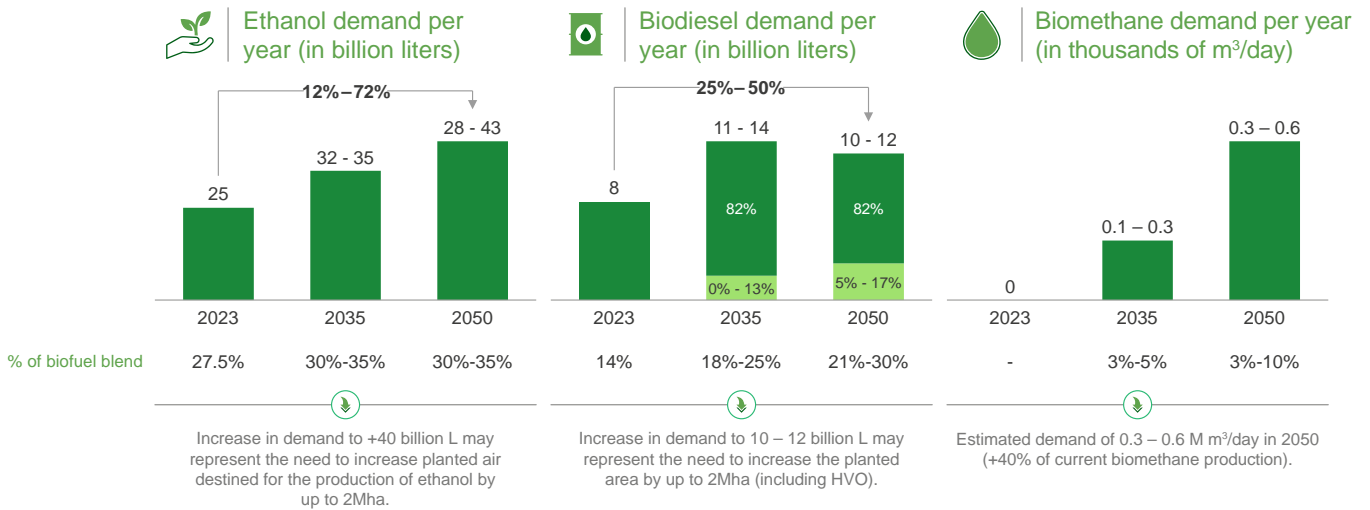
Estimated fuel and energy consumption of the circulation fleet by type of energy source – Brazil (% of total fuel consumption, numbers indicative of transformational sensitivity)



Note: Gas vehicles (conversion of kg CNG to liters considering density of 1kg CNG = 1,300 liters of CNG); FCEV vehicles powered by H<sub>2</sub> (conversion of kg H<sub>2</sub> to liters considering density of hydrogen in a gaseous state at 700 Bar (1 kg = 23.8 liters)). Sources: S&P Global Mobility; IHS Markit; Press Search; Anfavea.

# MORE INTENSE APPLICATION OF BIOFUELS WILL RESULT IN GREATER DEMAND FOR ETHANOL, BIODIESEL<sup>1</sup> (INCL. HVO) AND BIOMETHANE

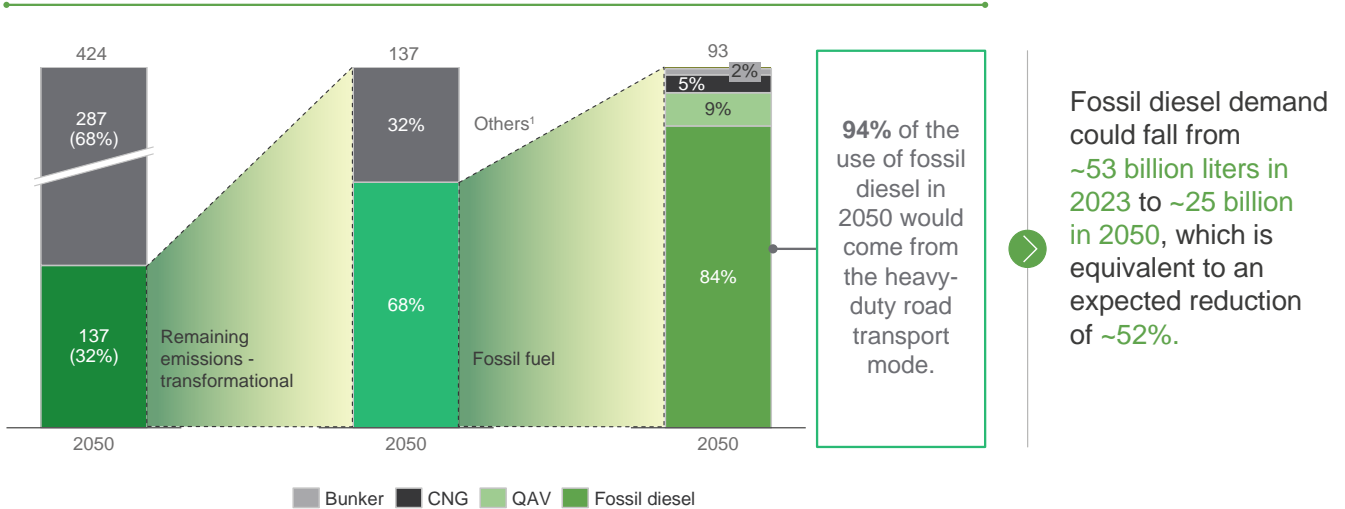
Indicative range between gradual and accelerated scenarios (estimates)



1. Note: The use of biodiesel blended in diesel requires adjustments to the production chain and assurance of product quality, as well as technical and economic feasibility analyses. Considers a productivity increase of 1.4% per year for sugarcane and 2.4% per year for corn; 2. Considers a productivity increase of 1.7% per year for soybeans and other oil crops; Source: EPE 2023, BCG Analysis.

## ~70% OF THE REMAINING EMISSIONS IN TRANSFORMATIONAL SENSITIVITY COME FROM FOSSIL FUELS, WITH FOSSIL DIESEL ACCOUNTING FOR ~84%

Transportation emissions in Brazil - in Mton CO<sub>2</sub>e



1. Others = Mainly composed of biofuels.



MAIN CONCLUSIONS

# RAIL TRANSPORT

# RAIL TRANSPORT – MEMBER ENTITIES

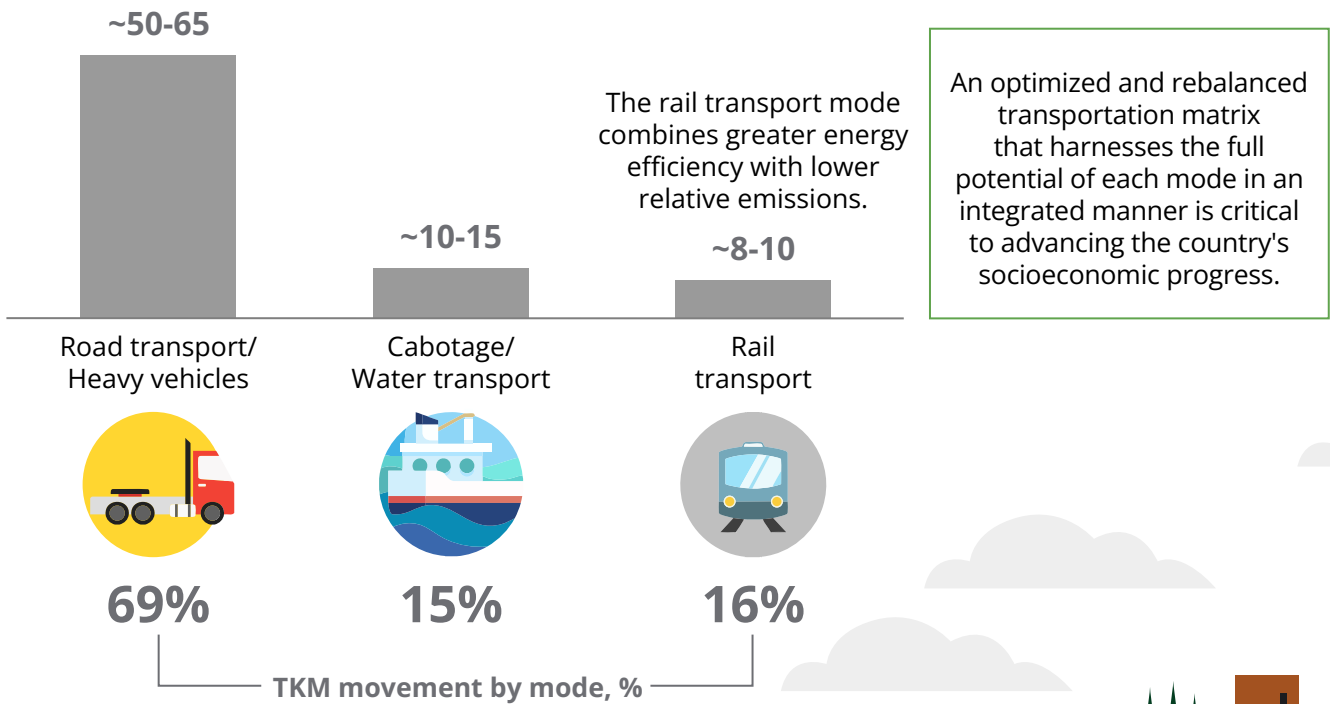
This document was supported by the following rail transport entities.

**COORDINATION**      **OTHER MEMBERS**      **TRANSVERSAL AND CONSULTATIVE ENTITIES**

## COMPARISON OF THE LEVEL OF EMISSIONS BY TYPE OF FREIGHT IN 2022 (CO<sub>2</sub>e/TKM)

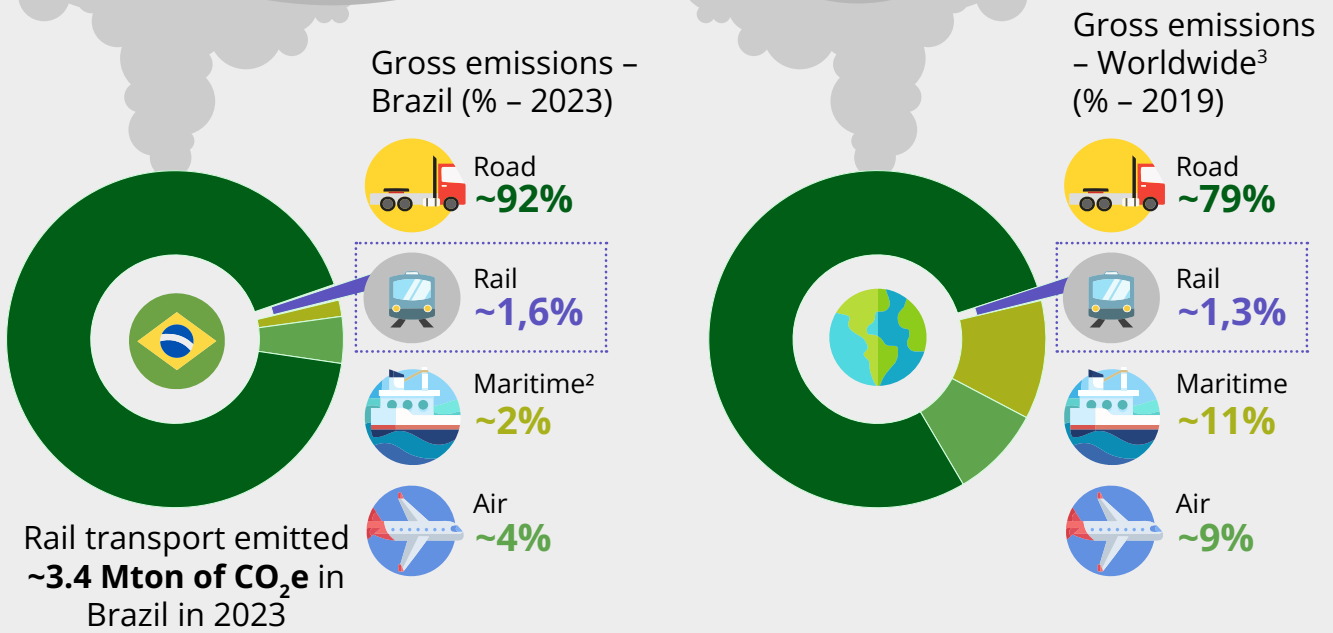
The rail transport mode is less polluting in nature compared to other types of transportation (e.g., it emits about 6x less CO<sub>2</sub>e by TKM than road transport). It currently represents 16% of national freight transport and contributes ~1.6% of the total CO<sub>2</sub>e emissions from transportation, which reinforces its efficiency in emissions.

### RELATIVE EMISSIONS BY TRANSPORT MODE<sup>1</sup> (gCO<sub>2</sub>e/TKM)

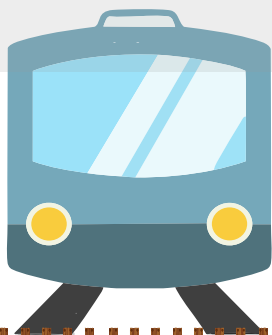


1. Restricted to rail freight transport; Passenger/urban trains were accounted for in Urban Mobility; Sources: Based on data from ANTF and SEEG 2022.

# RAIL TRANSPORT EMISSIONS<sup>1</sup> REPRESENT ~1.6% OF TOTAL TRANSPORTATION IN BRAZIL



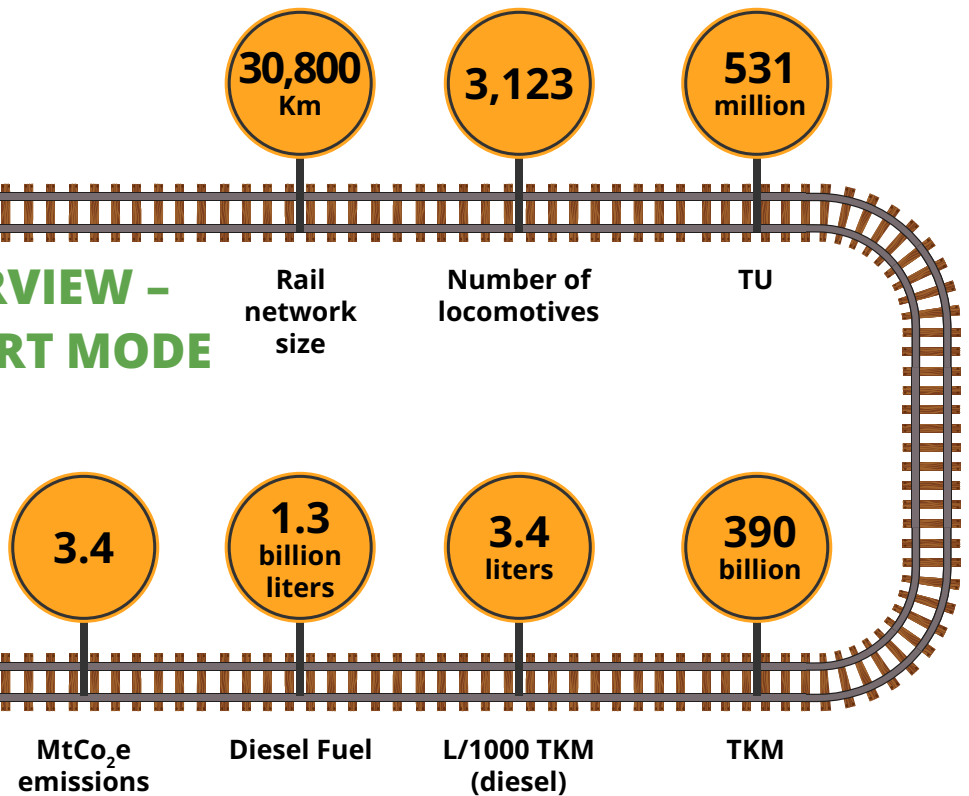
1. Transport emissions reported by SEEG are restricted to the burning of fuels; 2. Considers cabotage and inland navigation, without long haul; 3. Global amount excluding Brazil; Sources: Anfavea; SEEG; CAIT; Climate TRACE.



## CURRENT OVERVIEW – RAIL TRANSPORT MODE

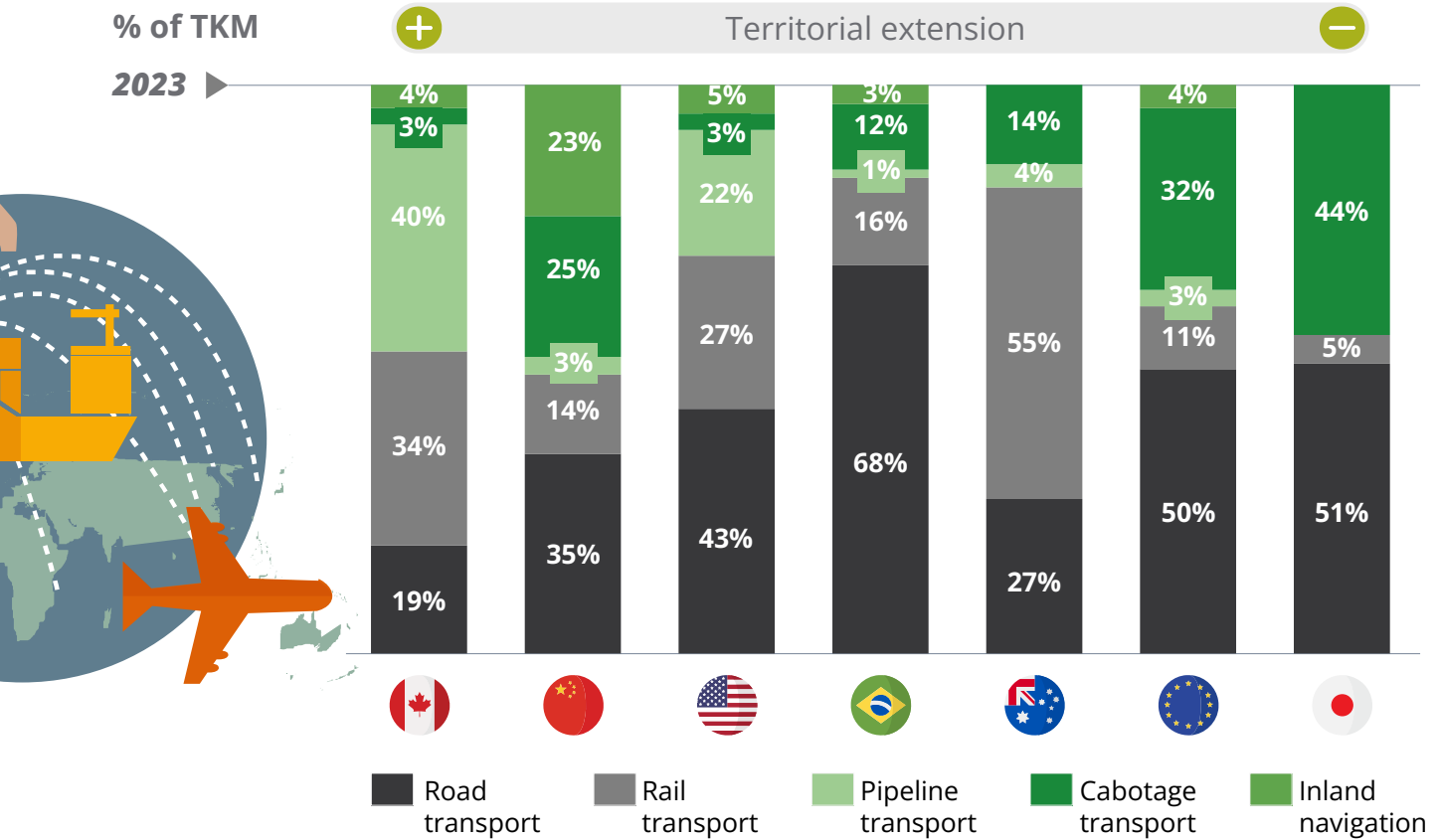
Relevant indicators help to understand the current landscape of rail transport

**2023**



# RAIL TRANSPORT HAS A LESSER RELATIVE PRESENCE IN BRAZIL COMPARED TO OTHER COUNTRIES

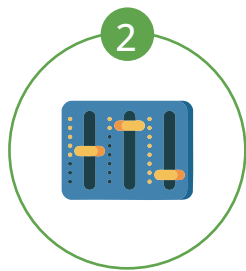
Comparisons of Brazil's freight transportation with other countries makes it clear that the current matrix is predominantly reliant on road transport.



## APPROACH I FOUR STEPS FOR RAIL DECARBONIZATION



Setting projections for the total emissions of the sector, assuming there will be **no changes in the participation of the different modes within the transportation matrix;**



Setting projections for the total emissions of the sector, assuming **changes in the participation of the different modes within the transportation matrix;**



Mapping of levers to **reduce emissions applicable to the mode of transport;**



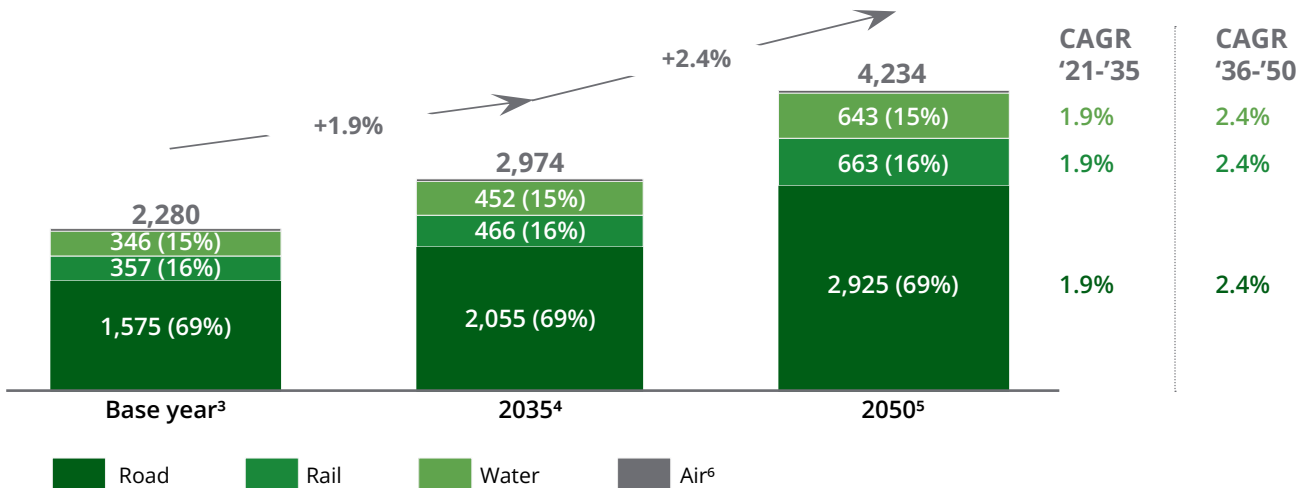
Proposal of possible **sensitivities based on the mapped levers.**

# 1 BaU<sup>1</sup> DEFINITION OF EMISSIONS WITHOUT CHANGES IN THE TRANSPORTATION MATRIX

In a scenario of inaction, total transport emissions would reach ~424 Mton CO<sub>2</sub>e in 2050. Under this scenario, the representation of transport modes within the national transportation matrix would remain unchanged (rail transport would remain at 16%).

## EVOLUTION OF THE FREIGHT MATRIX<sup>2</sup> (BILLION TKM, %)

Scenario of Inaction

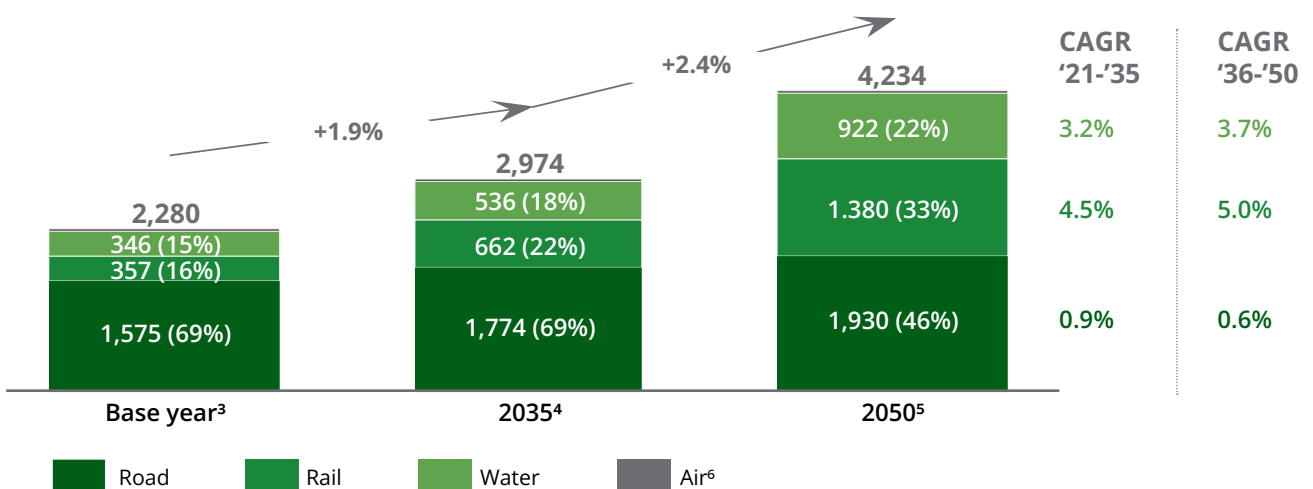


# 2 BaU<sup>1</sup> DEFINITION OF EMISSIONS WITH CHANGES IN THE SHARE OF MODES OF TRANSPORTATION

The second stage examined an alternative scenario where rail transport's role in the transportation matrix could be increased, generating emission reductions given its comparatively lower emission intensity (gCO<sub>2</sub>/TKM) relative to higher-emitting modes.

## EVOLUTION OF THE FREIGHT MATRIX<sup>2</sup> (BILLION TKM, %)

With a change in the matrix

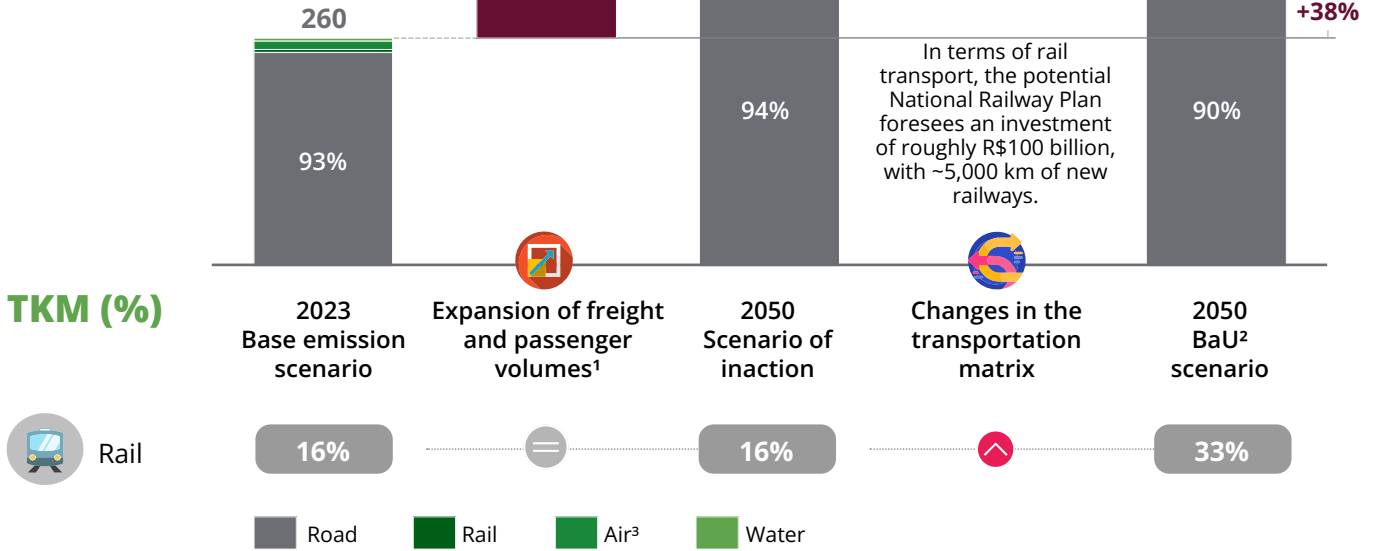


1. BaU = Business-as-Usual; 2. Projections based on the Transportation Sector Plans (PSTR and PSTF) and on PNL 2035 – National Logistics Plan; 3. 2021 was the year in which the PNL/PSTF was conducted, in addition to presenting more reliable historical parameters; 4. TKM 2035 values refer to the PSR1 scenario of the PSTR; 5. TKM projected at GDP with a share of the PSR3 scenario of the PSTR; 6. Air transport emissions are not related to freight transport, only to passenger transport; Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

In summary, optimizing this transportation matrix by shifting certain modes of transportation, specifically rail and water transport modes, will help reduce the expected volume of CO<sub>2</sub> emissions by approximately 15% by the year 2050:

### TRANSPORTATION SECTOR EMISSIONS

(Mton CO<sub>2</sub>e — well-to-wheel perspective — by mode)



1. Increased emissions due to the expected growth in demand for TKM and passengers until 2050; 2. Business-as-Usual; 3. Air transport emissions are not related to freight transport, only to passenger transport.

## 3 MAPPING OF LEVERS TO REDUCE EMISSIONS

After the transportation matrix was presented, the working group identified levers that have the potential to reduce emissions in rail transport.

These levers were mapped in three large blocks, as described below. A qualitative feasibility analysis<sup>1</sup> was performed for each of them, and local and global references that illustrate the respective application were presented.

Although rail transport involves various emission sources, this report concentrates on levers aimed at reducing emissions from locomotive fuel combustion, based on a well-to-wheel approach.

### LEVERS FOR EMISSION REDUCTION

in the rail transport sector



**EFFICIENCY**



**BIOFUELS**



**ELECTRIFICATION AND POWER-TO-X**

1. The full details of the feasibility and references can be found in the complete rail transport document, which can be accessed through the QR Code at the end of this document.



## EFFICIENCY

### Levers

- 1 **Design enhancement**, through the use of lighter materials to reduce locomotive weight and incorporating new aerodynamic solutions.
- 2 **Renewal of the current fleet** by replacing older locomotives with newer, efficient ones with greater freight capacity/railcars.
- 3 **Infrastructure optimization**, through the use of automated technologies and systems to optimize the operation and maintenance of rail infrastructure.
- 4 **Intelligent route and fleet optimization**, through the use of data-based technologies and systems to optimize locomotive operations.
- 5 **Energy-efficient and assisted** train operations, driven by operator behavior change and supported by technological solutions to reduce energy use.



## BIOFUELS

### Levers

- 1 **Blend of green diesel in fossil fuel** – green diesel has properties that are similar to fossil diesel, but its application in the rail transport mode is still in the early stages of development.
- 2 **Ethanol** – widely used in Brazil, normally adapted for use in internal combustion engines; application in the rail transport mode still in its embryonic phase, requiring infrastructure and engine adaptations.
- 3 **Biodiesel as an alternative via blending with fossil diesel** – increasing the percentage of blending should be done with caution.

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



## ELECTRIFICATION AND POWER-TO-X

### Levers

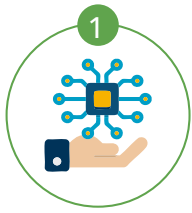
- 1 **Locomotives powered by low-carbon H<sub>2</sub> routes** – energy production with lower CO<sub>2</sub> emissions; low-carbon H<sub>2</sub> can be transformed into routes such as methanol and others to make it more viable.
- 2 **Electric locomotives** – electric energy is used as a power source for the traction motors of electric locomotives, replacing fossil fuels (technology limited to short distances).
- 3 **Hybrid locomotives** – diesel-electric system connected to a set of batteries, in such a way that the energy source that powers the traction motors can come from both parties.

Levers can be applied as long as the technical and operational viability of the respective solutions is verified.

Sources: Press Search, company websites; ANTF; Senate; Iberdrola – Hydrogen.

# 4 PROPOSAL OF SENSITIVITIES BASED ON THE MAPPED LEVELS

Finally, sensitivities have been proposed to assess the impact of different paths to decarbonization:



## 1 Current technologies

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



## 2 Intensification of biofuels

Predominance of the application of levers to intensify the use of biofuels;



## 3 Electrification acceleration/power-to-X

Predominance of the application of levers to accelerate the electrification/power-to-X of the locomotive fleet;



## 4 Transformational

Combination of levers from sensitivities 1, 2, and 3 leading to a trajectory closer to net-zero emissions.

For the purposes of this document, we will focus only on the range of impacts between the most conservative (1) and the most ambitious (4) sensitivities. Details of the other sensitivities are available in the full report, which can be accessed via the QR code at the end of this material.



### CURRENT TECHNOLOGIES



### TRANSFORMATIONAL



#### Efficiency

All possible levers to improve efficiency were taken into account when considering different sensitivities

Biodiesel<sup>2</sup>  
(Blended in diesel)

20% in 2030

20% in 2030, 30% in 2050



Green diesel<sup>2</sup>  
(Blended in diesel)

-

70% in 2050, starting in 2030

Ethanol<sup>2</sup>

-

Penetration in line with what could be expected for methanol<sup>1</sup>, given the same adaptation needs



#### Hybridization

0.2% of new locomotives in 2050, with 30% battery use

45% of new locomotives, with 50% battery use in 2035

Low-carbon H<sub>2</sub>  
routes

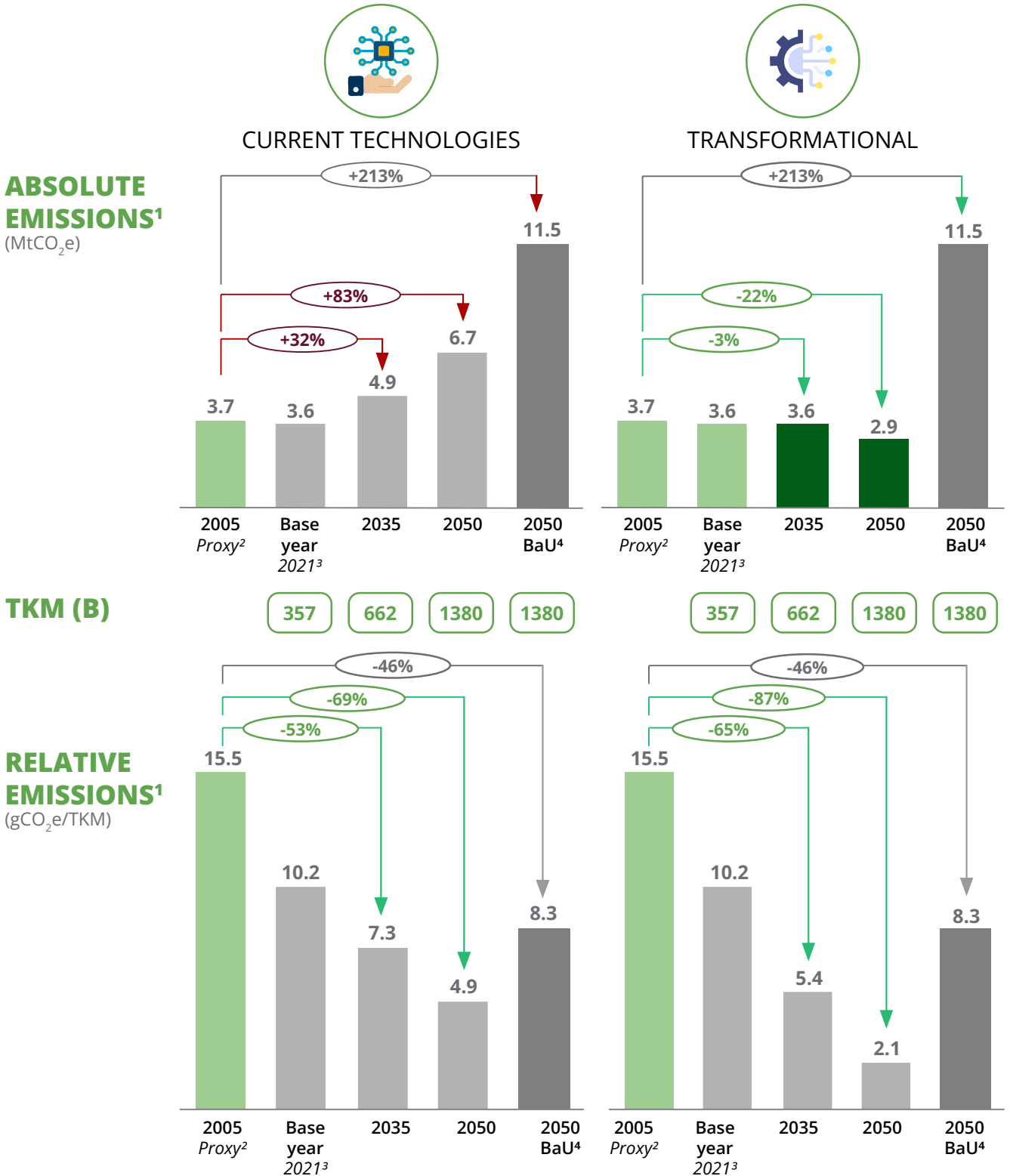
-

20% of new locomotives from 2035, via different routes (e.g., methanol, others)

1. Low-carbon hydrogen routes 2. Intensification of the use of biofuels should be encouraged as long as: technical, mechanical, operational and laboratory viability of said energy input is confirmed, as well as respecting the diversity of matrices and regional specificities.

# OUTCOMES OF SENSITIVITY ANALYSIS CONCERNING THE IMPACT ON EMISSIONS

As a result of implementing the mapped levers, transport emissions could reach **~2.9 Mton CO<sub>2</sub>e in absolute terms and ~2.1 gCO<sub>2</sub>e/TKM in relative terms under the transformational sensitivity scenario for 2050<sup>1</sup>**, representing reductions of up to ~50% and ~75%, respectively, compared to a scenario of inaction in the same year.



1. Emission factors considered are: Well-To-Wheel (WTW); BaU = Business-as-Usual; 2. Proxy for the 2005 WTW value, based on the Tank-To-Wheel (TTW) SEEG figures; 3. 2021 was the base year of the PSTF/PNL, in addition to presenting more reliable historical parameters; 4. BaU = Business-as-Usual, considers the sector's growth projections foreseen by the Sectoral Plans and PNL 2035, with changes in the share of the different modes.



## ILLUSTRATIVE EXAMPLES SHOW HOW ENABLERS HELP TO FACILITATE DECARBONIZATION LEVERS

**PUBLIC AND PRIVATE INCENTIVES TO MAKE THE RAIL TRANSPORT SYSTEM A MORE SIGNIFICANT COMPONENT OF THE COUNTRY'S OVERALL LOGISTICS MATRIX**

### Renegotiations<sup>1</sup>

Development of concession contract renegotiations, including the advent of investments in network expansion and the unlocking of investments in capacity increases in the current rail network.

### New Legal Framework for Railways<sup>2</sup>

Promotion of investments by simplifying regulations (e.g., incentive to self-regulation) and make authorization models more appealing to private players (authorizations), in order to expand the capacity of the mode.

### Structuring investments in railways

Continuation of public investments, such as in FIOL<sup>3</sup>, and private investments, such as Rumo's R\$4 billion to complete the central network of FNS<sup>4</sup>, which aims to establish a new structural axis in the rail sector.

**INCENTIVES TO ENCOURAGE SUSTAINABILITY COMMITMENTS**

### Sustainability Program<sup>5</sup> (2024)

Promotion of regulatory benefits for companies (e.g., unique conditions for entering into TACs<sup>6</sup>), contingent upon sustainability initiatives.

**TANGIBLE MECHANISMS TO PROMOTE PRIVATE FINANCING**

### Etihad Rail

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

**CONCRETE PRIVATE SECTOR ACTIONS VIA PARTNERSHIPS FOR THE DEVELOPMENT OF CLEANER TECHNOLOGIES**

### Alstom and Linde

Development of Europe's first hydrogen locomotive, which was put into operation in 2017.


### Vale and Wabtec

Partnership to develop battery-electric locomotives, which are less polluting.

1. Law No. 13.448/2017; 2. Law No. 14.273/2021; 3. West-East Integration Railway (*Ferrovía de Integração Oeste-Leste*, or FIOL); 4. North-South Railway (*Ferrovía Norte-Sul*, or FNS); 5. ANTT Resolution 6.057 (2024); 6. Conduct Adjustment Agreement; Sources: ANTF; IBPF; Railway Magazine; National Department of Transport Infrastructure; Ministry of Transport.

# WE AIM FOR SUSTAINABLE GROWTH IN THE RAIL TRANSPORT SECTOR

Considering the expected growth for the sector, the rail transport mode is expected to reach **33% of the TKM transported in 2050 (vs. 16% in the base year<sup>1</sup>)** while **CO<sub>2</sub>e emissions are forecast to represent only ~2% of Brazil's total transport** in transformational sensitivity in the same year (vs. 1.6% in the base year<sup>1</sup>).



**~2,6 Mton**  
reduction (~50%) in CO<sub>2</sub>e emissions in 2050 versus a scenario of inaction

**Conclusions** sought by the study on rail transport in Brazil in 2050:

## CURRENT RAIL TRANSPORT<sup>1</sup>

 **16% OF THE NATIONAL TKM** transported.

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

 **~0% OF HYBRID** locomotives.

 **~0% OF LOCOMOTIVES** powered by low-carbon H<sub>2</sub> routes.

## FUTURE RAIL TRANSPORT<sup>2</sup>

 **33% OF THE NATIONAL TKM** transported.

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

 **~60% OF HYBRID** locomotives.

 **EXPANSION OF H<sub>2</sub><sup>3</sup> RAIL ROUTES**, contingent on the maturation of the technology.

1. 2021 (base year of the PSTF/PNL, in addition to showcasing more reliable historical benchmarks); 2. 2050 Transformational; 3. Low carbon.





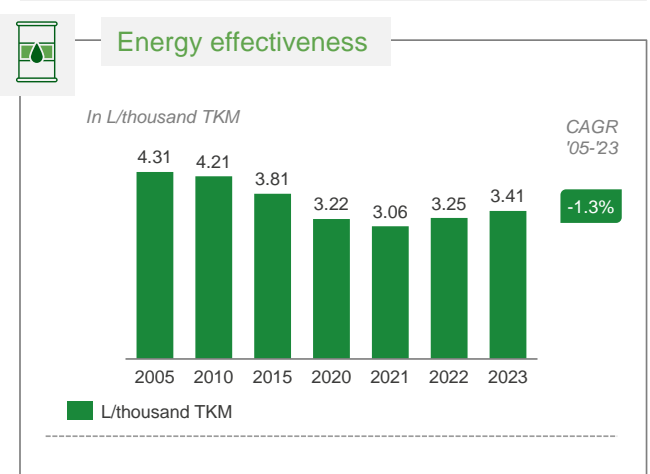
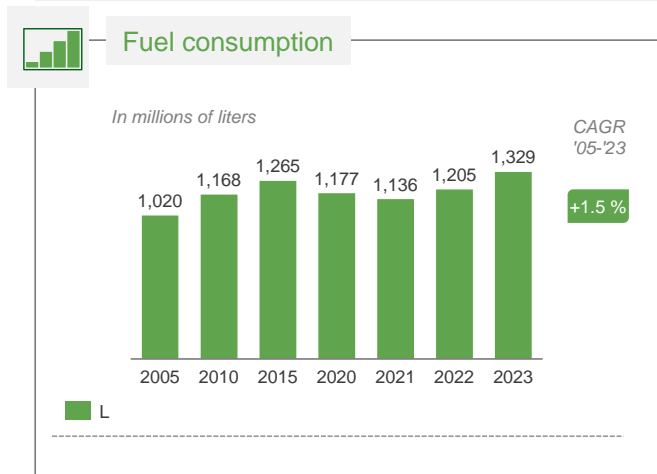
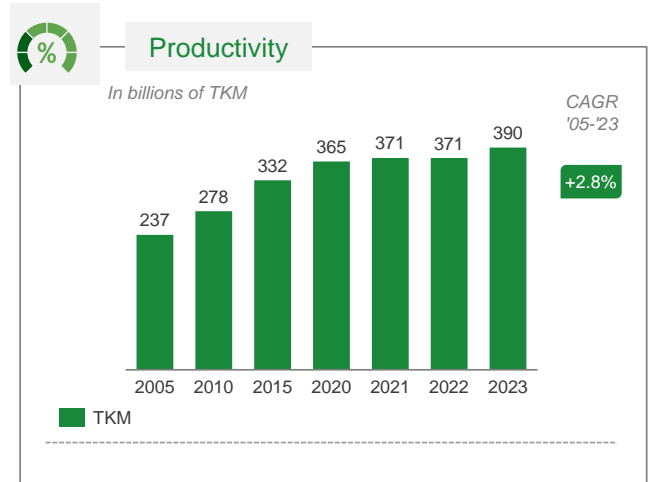
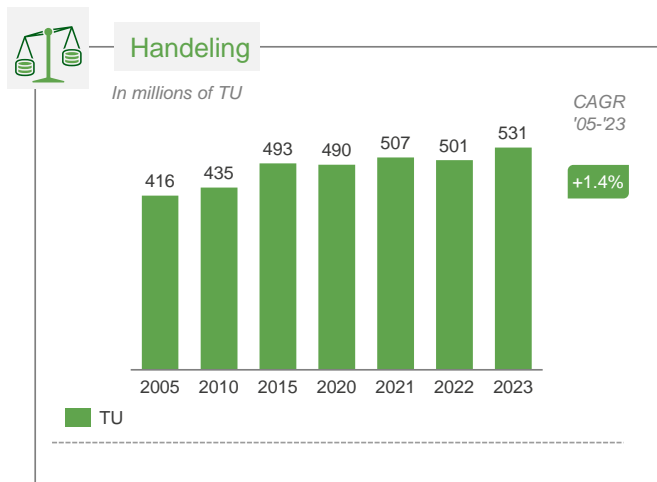
Details on the  
**RAIL  
TRANSPORT  
MODE**

# KEY INDICATORS HELP IN UNDERSTANDING THE CURRENT STATE OF THE MODE

## RAIL TRANSPORT

Brazilian rail transport is currently restricted to freight locomotives, powered by diesel, for the most part.

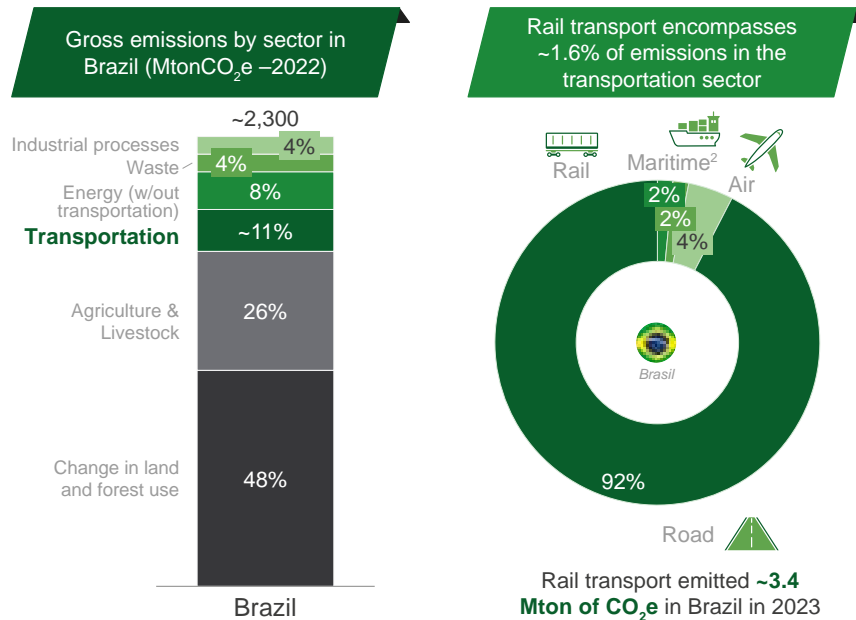
KEY INFORMATION		2023
● Rail network size (Km)	30.8 thousand	● L/thousand TKM (diesel) → 3.4L
● Number of locomotives	3,123	● Fuel (diesel) → 1.3B L
● TU	531M	● MtCO <sub>2</sub> e <sup>1</sup> Emissions → 3.3
● TKM	390B	



1. The most recent SEEG data found is from 2022. Source: ANTF.

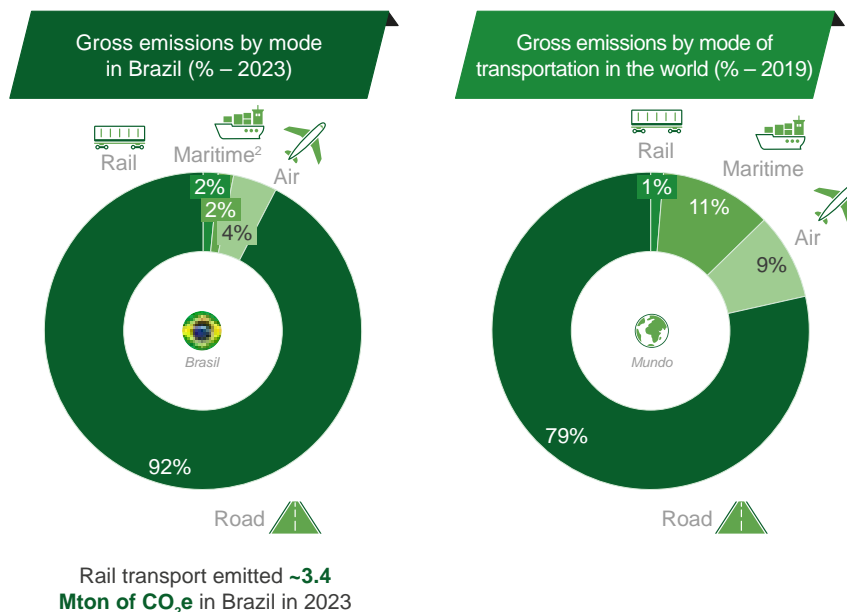
# THE TRANSPORTATION SECTOR IS CRITICAL FOR THE MITIGATION AGENDA, ACCOUNTING FOR ~11% OF NATIONAL EMISSIONS...

## ... RAIL TRANSPORT EMITS ~1.6% OF THE TOTAL SECTOR



1. Transportation emissions reported by SEEG are restricted to the burning of fuels; 2. Considers cabotage and inland navigation, without long haul; 3. Global amount excluding Brazil. Sources: Anfavea; SEEG; CAIT; Climate TRACE.

## RAIL TRANSPORT EMISSIONS<sup>1</sup> REPRESENT ~1.6% OF TOTAL TRANSPORTATION EMISSIONS

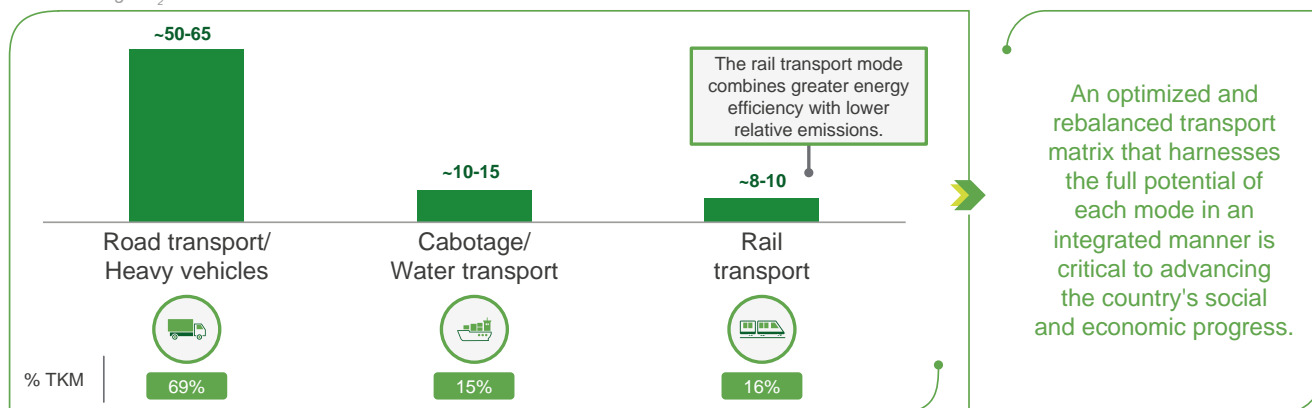


1. Transportation emissions reported by SEEG are restricted to the burning of fuels; 2. Considers cabotage and inland navigation, without long haul. Sources: Anfavea; SEEG; CAIT; Climate TRACE.

# THE GREATER SUSTAINABILITY OF THE RAIL TRANSPORT MODE IS ALSO EVIDENT WHEN COMPARING ITS CO<sub>2</sub>/TKM WITH THOSE OF OTHER MODES OF TRANSPORTATION



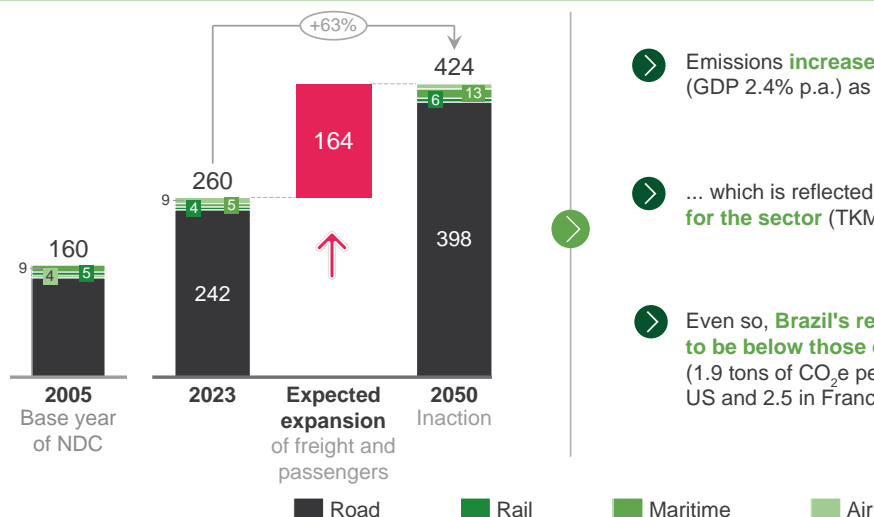
## Comparison of the level of emissions by type of freight in 2022 (CO<sub>2</sub>/TKM)



1. Cabotage, interstate and within the state. Sources: PNL 2035, ANTF, ANTT, SEEG.

## SIZE OF THE CHALLENGE | IN A SCENARIO OF INACTION, THE SECTOR'S EMISSIONS COULD REACH UP TO 424 MTON CO<sub>2</sub>e IN 2050

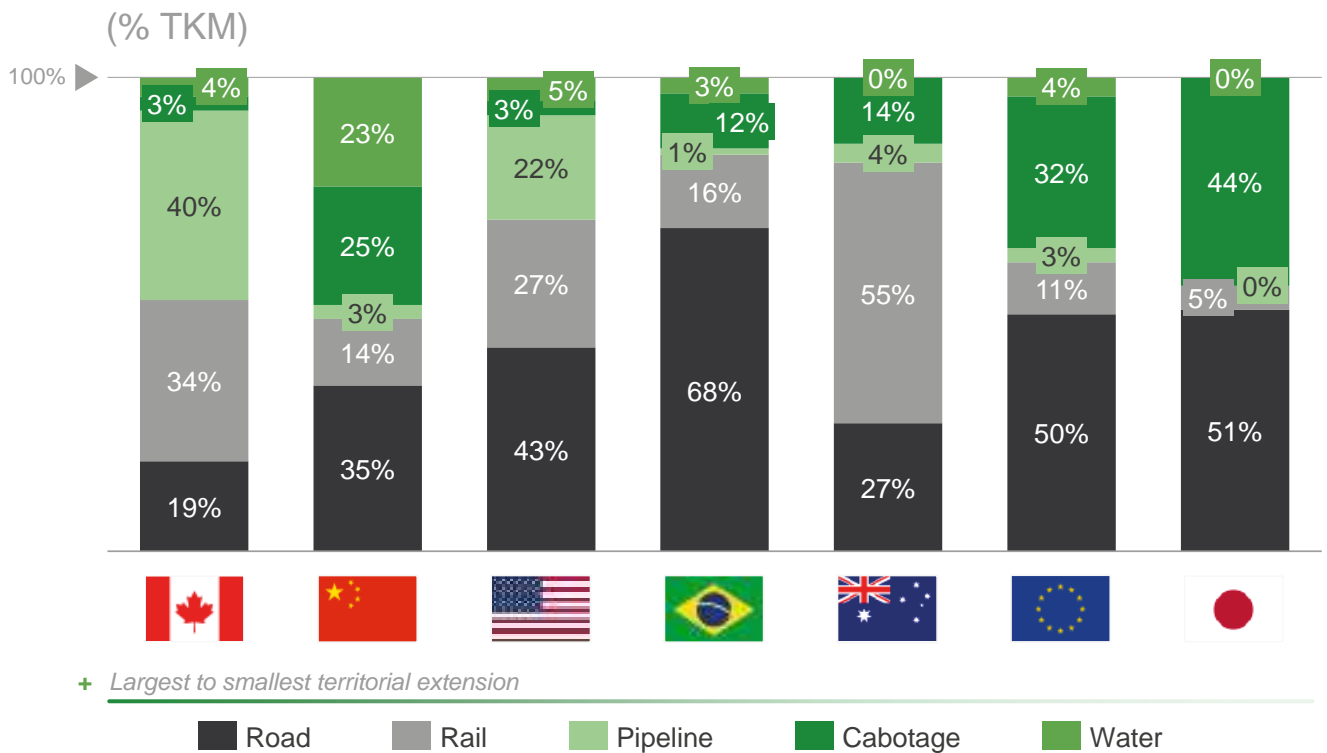
### Emissions from the transportation sector (Mton CO<sub>2</sub>e % by mode of transport) – Well-to-wheel perspective



- Emissions **increase due to the growth of Brazil** (GDP 2.4% p.a.) as an emerging country...
- ... which is reflected in the **relevant growth forecast for the sector** (TKM 2.2% p.a. and PAX 0.7% p.a.).
- Even so, **Brazil's relative emissions are expected to be below those of developed countries** (1.9 tons of CO<sub>2</sub>e per capita in 2050 vs. 5.6 in the US and 2.5 in France in 2023).

Sources: Transportation Sector Plans; Infra S.A.; PNL 2035. Note: Scenario of inaction considers demand projected for 2050 without progress in efficiency gains, increased electrification or expansion of the use of biofuels beyond those currently stipulated by law.

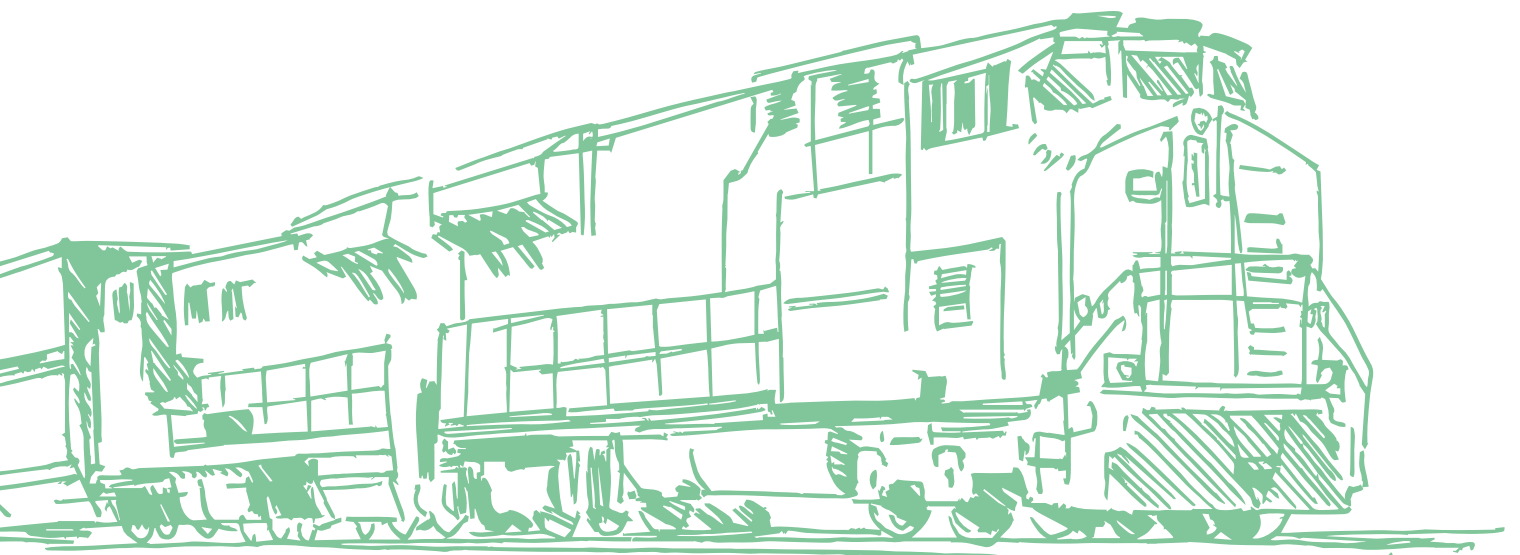
# BRAZIL'S MATRIX IS MORE CONCENTRATED ON THE ROAD TRANSPORT COMPARED TO OTHER COUNTRIES



Sources: ILOS (Brazil); National Bureau of Statistics of China, Bureau of Transportation Statistics (USA), Eurostat (EU); Transportation Sector Plan. Note: Information from the Brazilian matrix considers data from the Transportation Sector Plan, made available for public review in 2024.



The heavy reliance on road transport in a country of continental scale presents a strategic **opportunity to develop alternative modes, like rail and water transport systems.**



# RAIL TRANSPORT GROUP | ANTF RESPONSIBLE FOR COORDINATING DISCUSSIONS AND ENGAGING OTHER MEMBERS OF THE GROUP

**Advisory Board:**  
CEBDS, Motiva, CNT/SEST SENAT and Inspers's National Sustainable Mobility Observatory.



**Rail Transport Group**

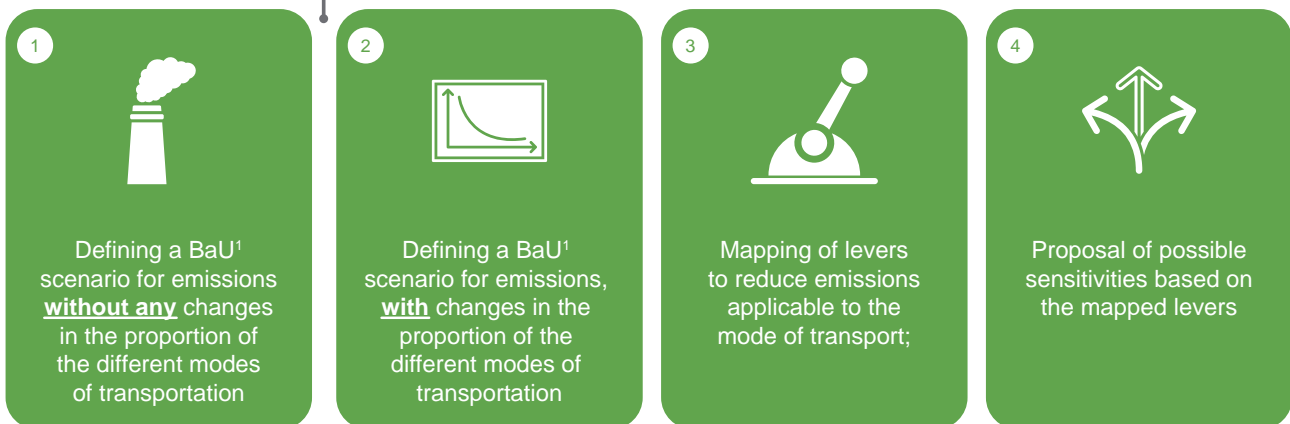
- ★ **ANTF** - Associação Nacional dos Transportadores Ferroviários (National Association of Rail Transporters)
- ABIFER – Associação Brasileira da Indústria Ferroviária (Brazilian Association of the Railway Industry)
- MRS
- Rumo
- Vale
- VLI
- Wabtec

Legend | ★ Coordinator | • Other Members

## PATHWAYS TO DECARBONIZATION

### DEFINING PATHWAYS FOR DECARBONIZING RAIL TRANSPORT WAS DIVIDED INTO FOUR BASIC STEPS

Summary in upcoming infographics, focusing on the Rail transport mode



1. BaU = Business-as-usual.

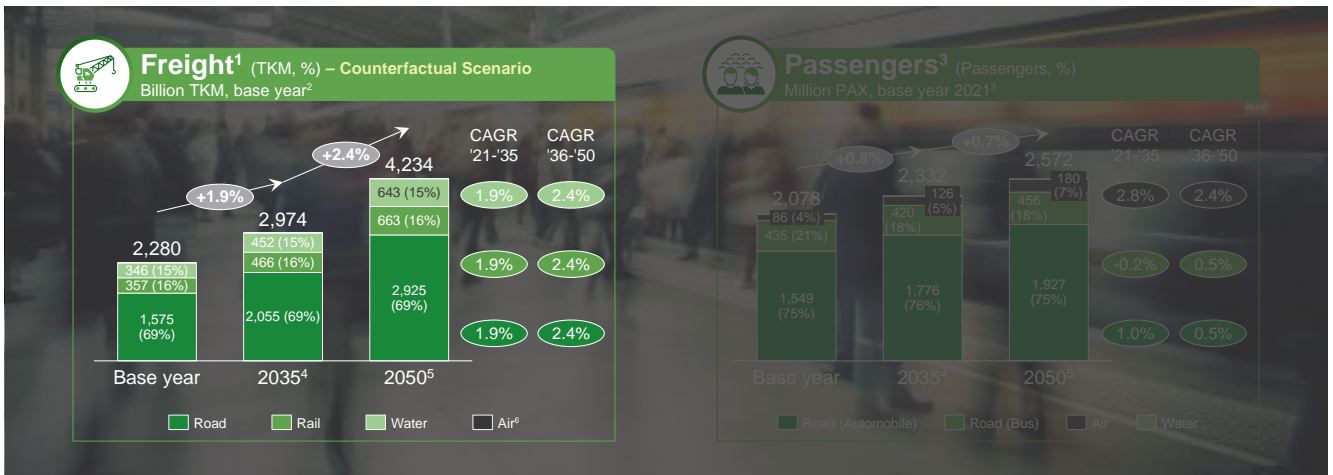
1

Defining a BaU<sup>1</sup> scenario for emissions **without any** changes in the proportion of the different modes of transportation

## STEP 1

# 2050 | COUNTERFACTUAL SCENARIO PREDICTS ~4.2 TRILLION TKM, WITH 16% LINKED TO THE RAIL TRANSPORT MODE

Development of the matrix for 2050 projected based on the Transportation Sector Plans and PNL 2035



1. Road Transport Sector Plan (PSTR); Rail Transport Sector Plan (PSTF); 2. 2021 was the year in which the PNL/PSTF was conducted, in addition to presenting more reliable historical parameters; 3. PNL 2035 – National Logistics Plan; 2017 base year of the PNL projected to the respective CAGRs of the reference scenario. 4. TKM 2035 values refer to the PSR1 scenario of the PSTR and PAX values come from the reference scenario of the PNL 2035 passenger matrix. 5. TKM is projected based on GDP growth, using the modal share from the PSR3 scenario of the PSTR, while PAX is projected according to population growth, assuming constant modal share; 6. Air transport emissions are not related to freight transport, only to passenger transport; Note: Passengers reported in the PNL only include intermunicipal and interstate flows, and do not consider passengers within urban centers. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.



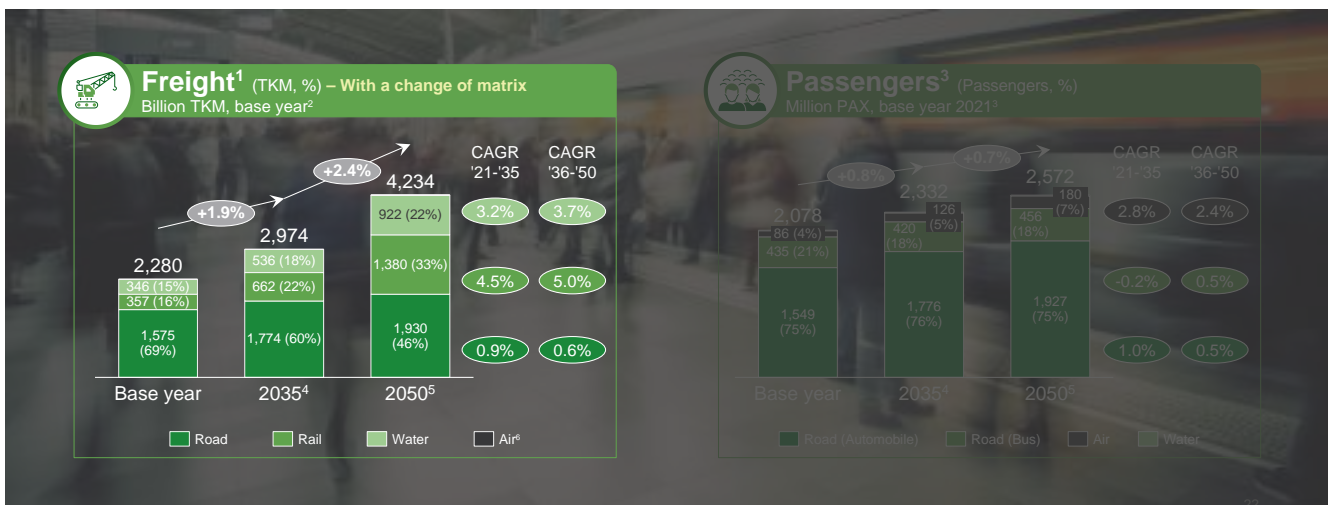
2

Defining a BaU<sup>1</sup> scenario for emissions, **with** changes in the proportion of the different modes of transportation

## STEP 2

# 2050 | BY BALANCING THE LOGISTICS MATRIX, RAIL TRANSPORT INCREASES ITS SHARE TO 33% OF TOTAL TRANSPORTED TKM

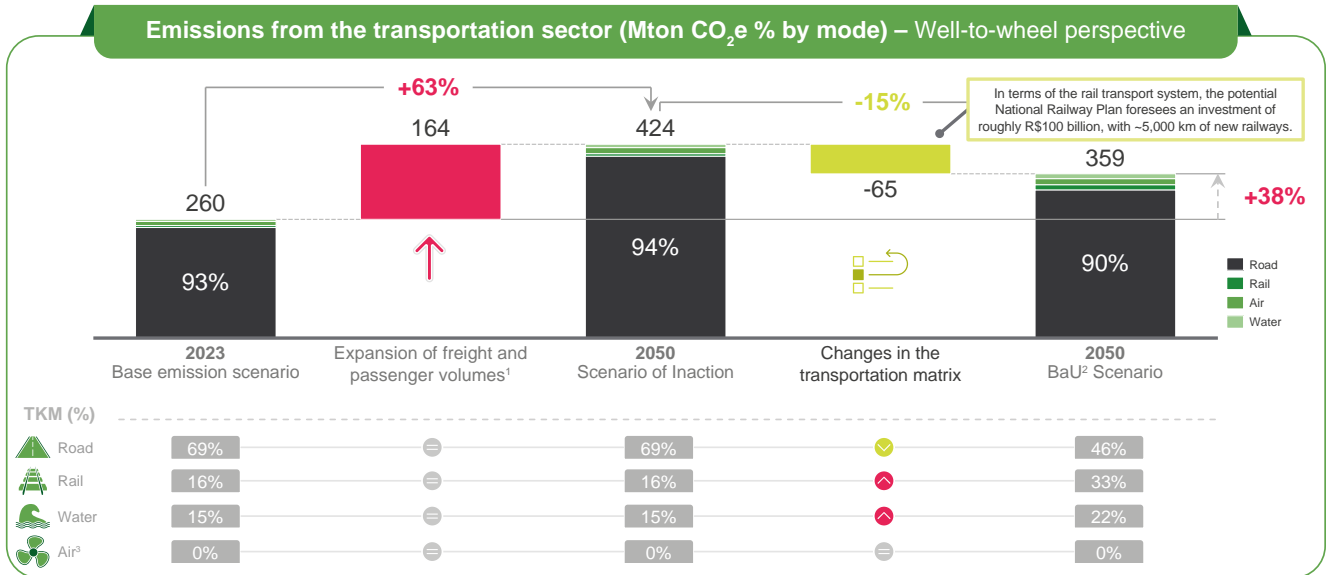
Development of the matrix for 2050 projected based on the Transportation Sector Plans and PNL 2035



1. Road Transport Sector Plan (PSTR); Rail Transport Sector Plan (PSTF); 2. 2021 was the year in which the PNL/PSTF was conducted, in addition to presenting more reliable historical parameters; 3. PNL 2035 – National Logistics Plan; 2017 base year of the PNL projected to the respective CAGRs of the reference scenario. 4. TKM 2035 values refer to the PSR1 scenario of the PSTR and PAX values come from the reference scenario of the PNL 2035 passenger matrix. 5. TKM is projected based on GDP growth, using the modal share from the PSR3 scenario of the PSTR, while PAX is projected according to population growth, assuming constant modal share; 6. Air transport emissions are not related to freight transport, only to passenger transport; Note: Passengers reported in the PNL only include intermunicipal and interstate flows, and do not consider passengers within urban centers. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

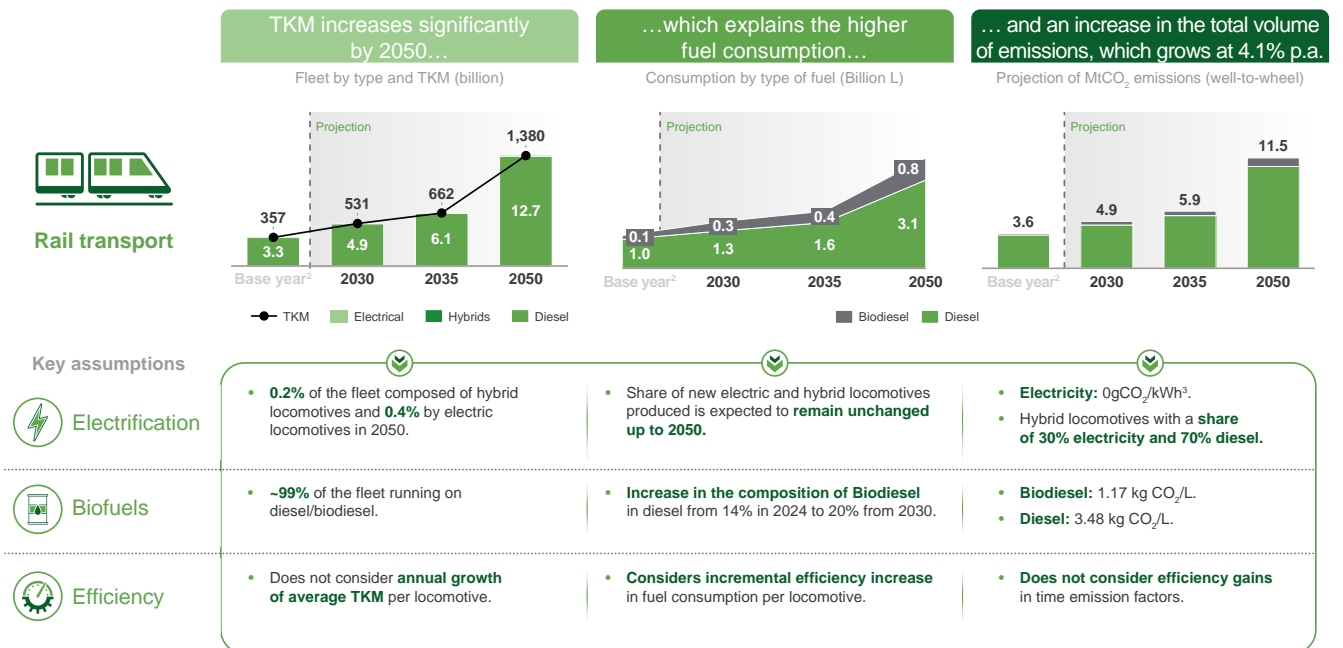


# BALANCING THE BRAZILIAN TRANSPORTATION MATRIX CAN AVOID AN INCREASE OF ~15% IN THE VOLUME OF CO<sub>2</sub> EMISSIONS BY 2050

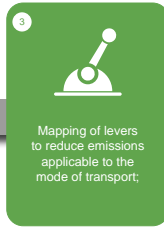


1. Increased emissions due to the expected growth in demand for TKM and passengers until 2050; 2. Business-as-usual; 3. Air transport emissions are not related to freight transportation, only to passenger transport.

## BAU1 | VOLUME OF EMISSIONS EXPECTED TO GROW 4.1% P.A. BY 2050

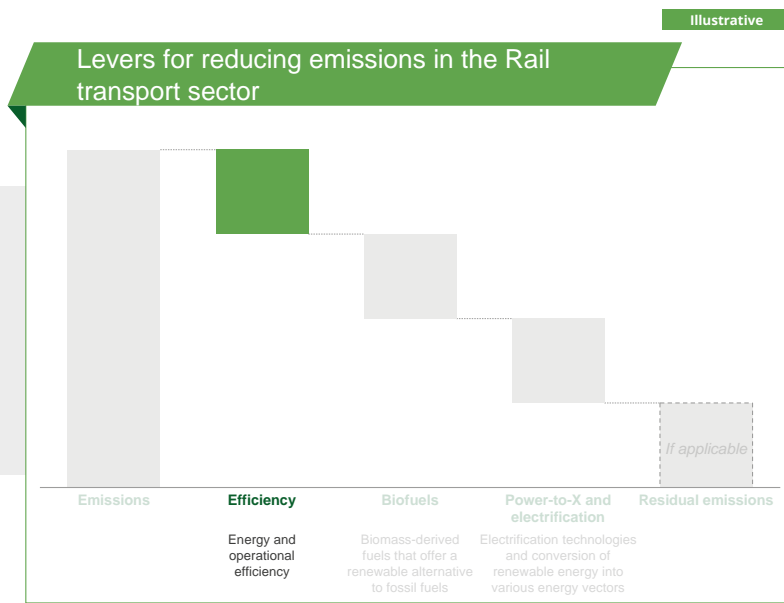
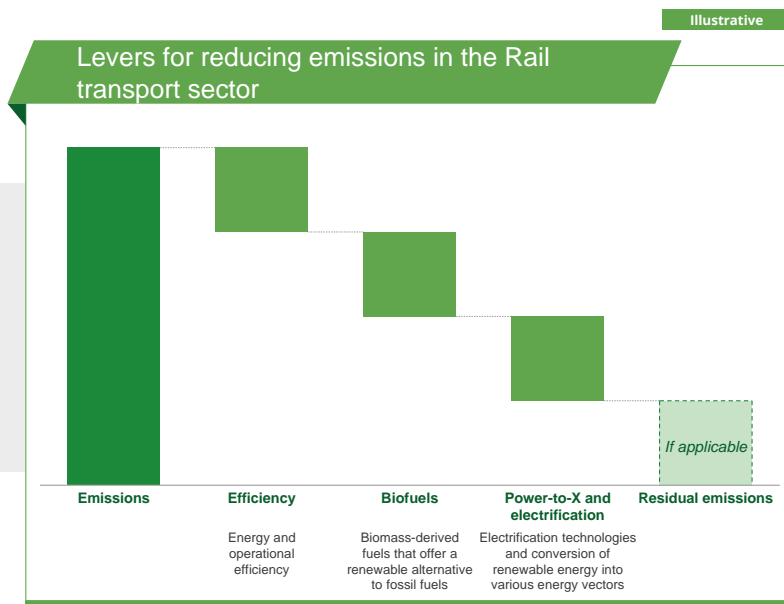


1. BaU = business-as-usual; 2. 2021 was the base year of the PSTF/PNL, in addition to presenting more reliable historical parameters; 3. Assuming a renewable energy matrix.



## STEP 3

# TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE RAIL TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS



# EFFICIENCY | FUEL EFFICIENCY AND OPERATIONAL MEASURES ARE VITAL FOR REDUCING EMISSIONS IN THE RAIL TRANSPORT SYSTEM

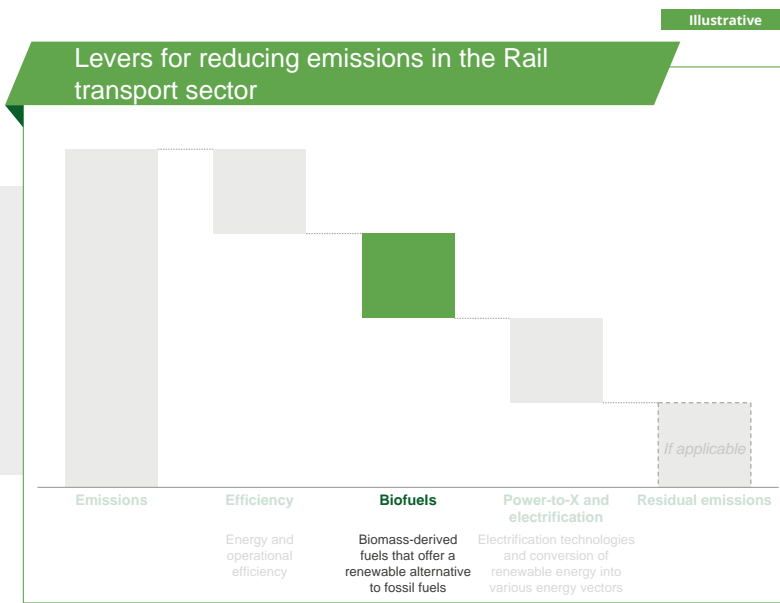
Non-exhaustive

	Levers	Current feasibility analysis <sup>1</sup>	References
Expected emissions impact	1 <b>Design enhancement</b> , through the use of <b>lighter materials</b> to reduce locomotive weight and incorporating new aerodynamic solutions.	Disruptive innovations, with complex implementation and uncertain gains.	Siemens, Alstom and Bombardier <sup>2</sup>   <b>Aerodynamic adjustments of the trains</b> (e.g., elongated "nose" and lighter materials in the bodies), reducing energy consumption by 9%-25% and maximizing internal space by up to 20%.
	2 <b>Renewal of the current fleet</b> by replacing older locomotives with newer, efficient ones with greater freight capacity/railcars.	Benefits depend on the scale and level of investment.	RUMO, MRS, VLI, VALE   Fleet modernization, incorporating <b>new technologies</b> to improve the performance, capacity, efficiency and safety of operations.
	3 <b>Infrastructure optimization</b> , through the use of <b>automated technologies and systems</b> to optimize the operation and maintenance of rail transport infrastructure.	Viable technologies, however, require time and integration to be effective.	VLI, VALE   Investment in <b>remote sensors to monitor critical components of locomotives</b> , collecting real-time performance data to predict failures and optimize maintenance.
	4 <b>Intelligent route and fleet optimization</b> , through the use of <b>data-based technologies and systems</b> to optimize locomotive operations.	Able to generate benefits over the short term with a lower investment level.	BNSF   Using <b>AI<sup>3</sup> in intermodal facilities to optimize the operation of hostlers</b> , reducing distances traveled (on average, 20 miles/train) and fuel consumption.
	5 <b>Energy-efficient and assisted train operations</b> , driven by <b>operator behavior change</b> and supported by technological solutions to <b>reduce energy use</b> .	Able to generate immediate or very short-term impact.	RUMO, VALE   <b>Trip Optimizer</b> for automatic <b>speed and acceleration adjustment</b> and use of <b>regenerative braking</b> to reuse energy in heavy operations

● The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. Bombardier acquired by Alstom in 2021; 3. AI = Artificial Intelligence. Sources: Press Search; company websites.

## TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE RAIL TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS



# BIOFUELS | REPLACING TRADITIONAL FUELS IS KEY FOR DECARBONIZING RAIL TRANSPORT

Non-exhaustive

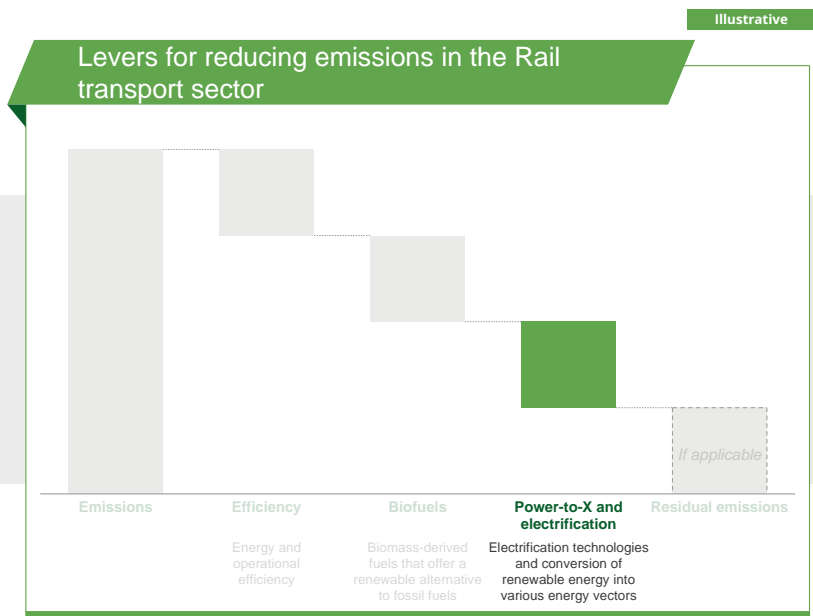
	Levers	Current feasibility analysis <sup>1</sup>	References
Expected emissions impact	<p>1 <b>Blend of green diesel in fossil fuel</b> – green diesel has properties that are similar to fossil diesel, but its application in the rail transport mode is still in the early stages of development.</p>	<p>Very similar properties to those of fossil diesel; difficulties linked to the high cost.</p>	<p><b>RUMO, VALE, MRS</b>   Execution of tests and feasibility studies of green diesel and advanced fuels use in freight transport, including export corridors.</p>
	<p>2 <b>Ethanol</b> – widely used in Brazil, normally adapted for use in internal combustion engines; application in the rail transport mode still in its embryonic phase, requiring infrastructure and engine adaptations.</p>	<p>Autonomy limitation, need for engine modification, and less technical proof makes it a less viable solution in the short term.</p>	<p><b>BRASIL</b>   The abundance of ethanol in the country, with a projected supply of 48 billion liters by 2034, associated with the experience of use in the road transport mode, positions it as an alternative, although it requires technical engine adaptations and further studies to make its application feasible.</p>
	<p>3 <b>Biodiesel as an alternative via blending with fossil diesel</b> – increasing the percentage of blending should be done with caution.</p>	<p>Need for tests to ensure technical feasibility at higher blending percentages, in addition to potential investments in the adaptation of locomotives.</p>	<p><b>VALE</b>   Execution of experiments with the use of biodiesel B25 in the Estrada de Ferro Carajás railway for iron ore transport.</p>

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

The greener, the more viable.

1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency, and Time to Implementation. Sources: Press Search; company websites; Senate.

## TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE RAIL TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS




# POWER-TO-X AND ELECTRIFICATION | HYDROGEN ROUTES AND HYBRIDIZATION ARE ESSENTIAL LEVERS FOR THE DECARBONIZATION OF THE RAIL TRANSPORT MODE

Non-exhaustive

	Levers	Current feasibility analysis <sup>1</sup>	References
Expected emissions impact	<p><b>1</b> Locomotives powered by low-carbon H<sub>2</sub> routes - energy production with lower CO<sub>2</sub> emissions; low-carbon H<sub>2</sub> can be transformed into routes such as methanol and others to make it more viable.</p>	<p>High investments, less technical proof and potential operational risks on some routes should be considered.</p>	<p>CRRG   Pilot testing of the world's first H<sub>2</sub>-powered train, reaching 160 km/h.</p>
	<p><b>2</b> Electric locomotives - electric energy is used as a power source for the traction motors of electric locomotives, replacing fossil fuels (technology limited to short distances).</p>	<p>Viable for maneuvers, but with low autonomy for long stops; High investment linked to the electrification of railways.</p>	<p>VALE   Studies have begun for electric switcher locomotives (field tests) and freight locomotives. BNSF Railway   Development of an electric locomotive in the USA that operates 100% battery-powered.</p>
	<p><b>3</b> Hybrid locomotives - diesel-electric system connected to a set of batteries, in such a way that the energy source that powers the traction motors can come from both parties.</p>	<p>Greater adaptability and less need for specific infrastructure; challenges still exist at higher cost.</p>	<p>Deutsche Bahn   Purchase of 50 hybrid locomotives announced in 2020, as part of the company's sustainability strategy.</p>

Levers can be applied as long as the technical and operational viability of the respective solutions is verified.

 The greener, the more viable.

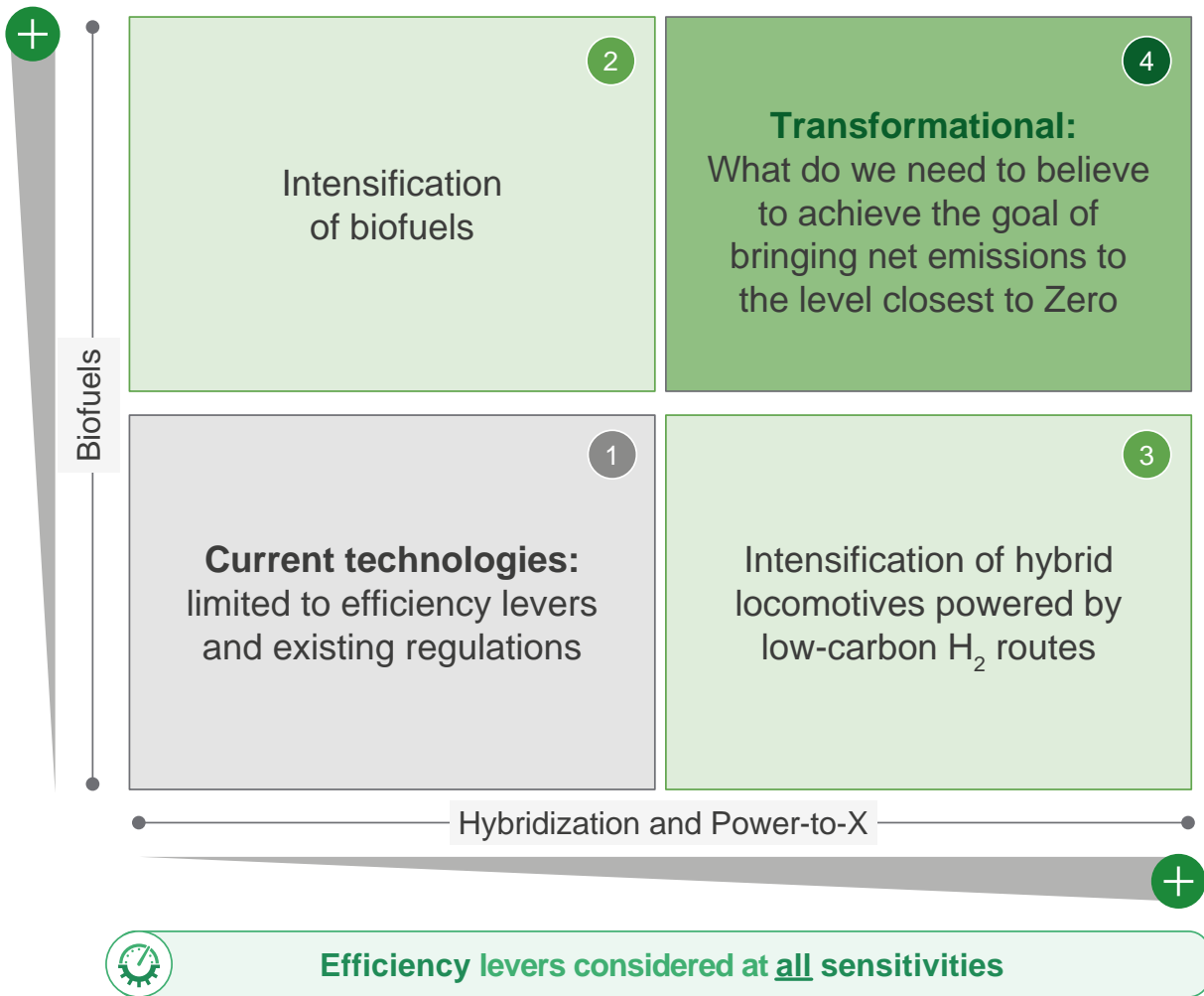
1. Qualitative, based on factors such as ease of implementation, expected impact on efficiency and time to implementation; Sources: Press Search; Company websites; Iberdrola - Hydrogen.



4  
  
 Proposal of possible sensitivities based on the mapped levers

## STEP 4

# FEASIBLE DECARBONIZATION LEVERS TAILORED TO THE BRAZILIAN CONTEXT WERE CONSIDERED IN THE FORMULATION OF FOUR SENSITIVITY SCENARIOS



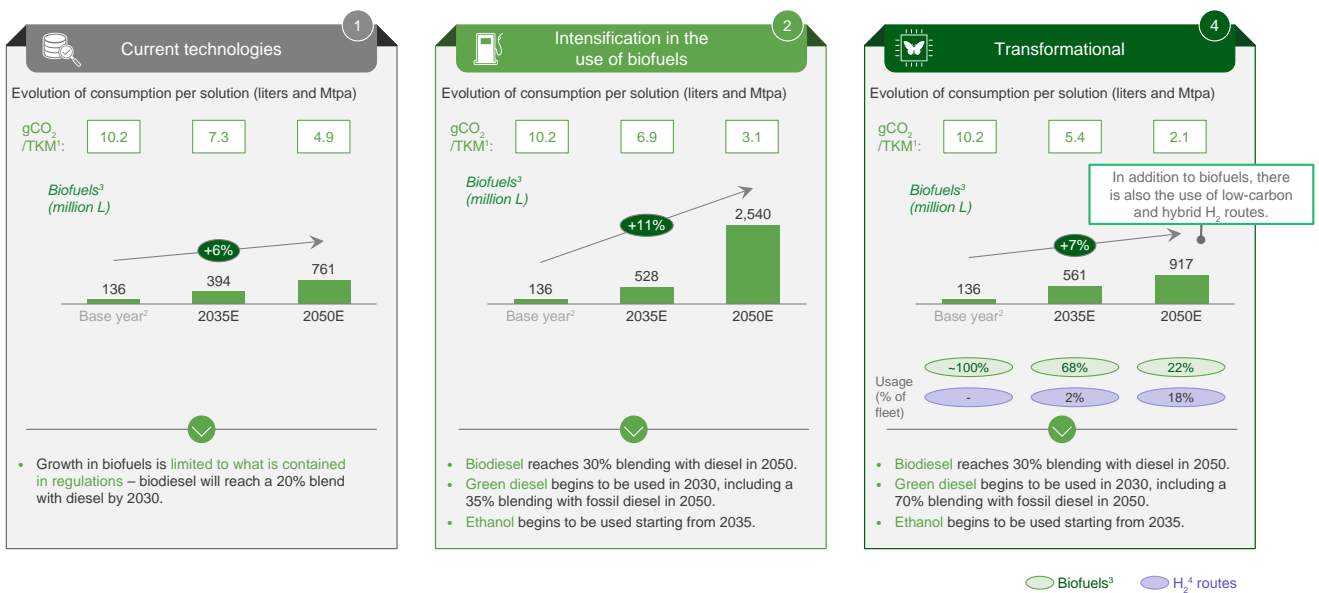
# THE PROPOSED SENSITIVITIES WERE BASED ON VARYING ASSUMPTIONS

	1 Current technologies	2 Intensification of biofuels	3 Hybrid intensification and low-carbon H <sub>2</sub> routes <sup>1</sup>	4 Transformational
Efficiency	✓	✓	✓	✓
Biodiesel	20% in 2030.	20% in 2030, 30% in 2050.	20% in 2030.	20% in 2030, 30% in 2050.
Green diesel	-	35% in 2050, with initial use in 2030.	-	70% in 2050, starting in 2030.
Hybrids	0.2% of new locomotives in 2050, with 30% battery use.	0.2% of new locomotives in 2050, with 30% battery use.	40% of new locomotives with 50% battery use in 2050.	45% of new locomotives, with 50% battery use in 2035.
Low-carbon H <sub>2</sub> routes	-	-	15% of new locomotives from 2035, via different routes (e.g., methanol, others).	20% of new locomotives from 2035, via different routes (e.g., methanol, others).
Ethanol	-	Penetration in line with what could be expected for methanol <sup>1</sup> , given the same adaptation needs.	-	Penetration in line with what could be expected for methanol <sup>1</sup> , given the same adaptation needs.

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

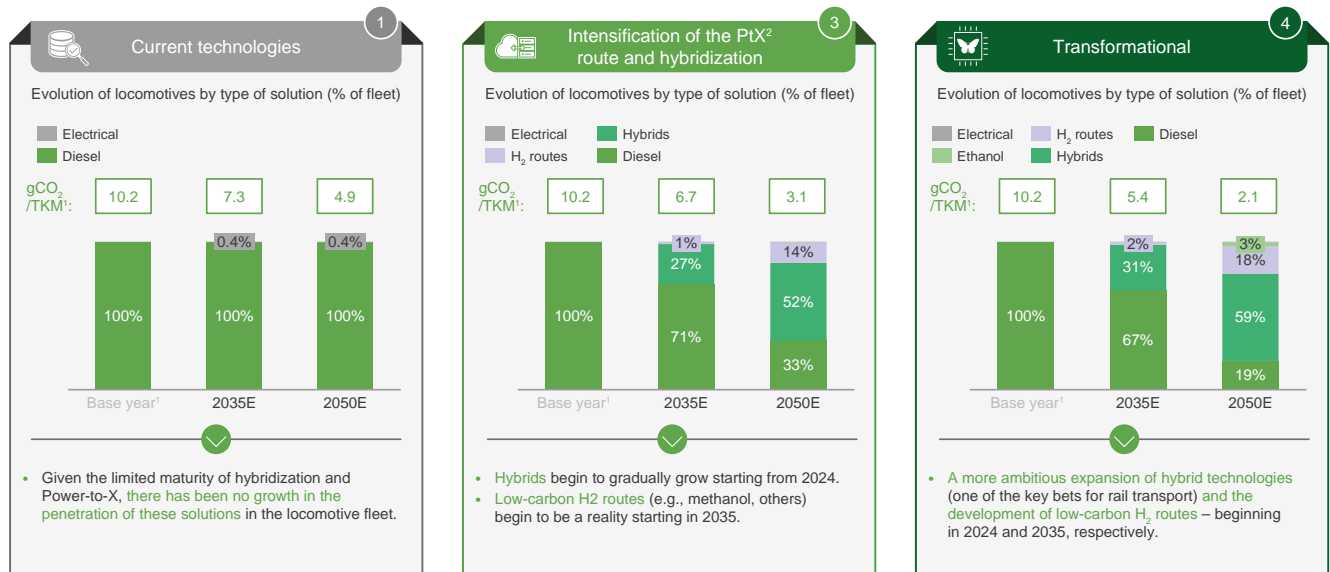
1. Assumptions described in the item "Low-carbon Hydrogen Routes".

# THE PROPORTIONS OF BIOFUELS AND H<sub>2</sub> ROUTES ARE INCREASING ACROSS EVERY SCENARIO SENSITIVITY, OFFERING THE POTENTIAL TO REDUCE FOSSIL FUELS



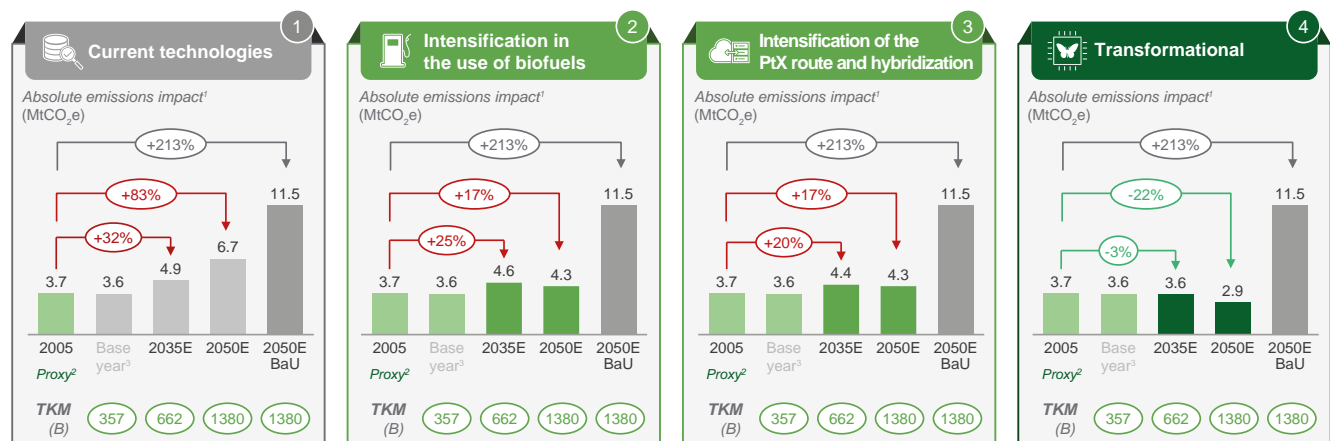
1. Emission factors considered are well-to-wheel (WTW); 2. 2021 was the base year of the PSTF/PNL, in addition to presenting more reliable historical parameters; 3. Biofuels = biodiesel, green diesel, ethanol; 4. Low-carbon H<sub>2</sub> routes, e.g., methanol, others.

# HYBRIDIZATION AND H<sub>2</sub> ROUTES MAY ACCOUNT FOR ~65%–75% OF THE RAIL LOCOMOTIVE FLEET IN 2050



1. 2021 was the base year of the PSTF/PNL, in addition to showcasing more reliable historical benchmarks; 2. Emission factors considered are well-to-wheel (WTW); 3. Power-to-X = Low-carbon H<sub>2</sub> route transformed into synthetic fuels (e.g., methanol, others).

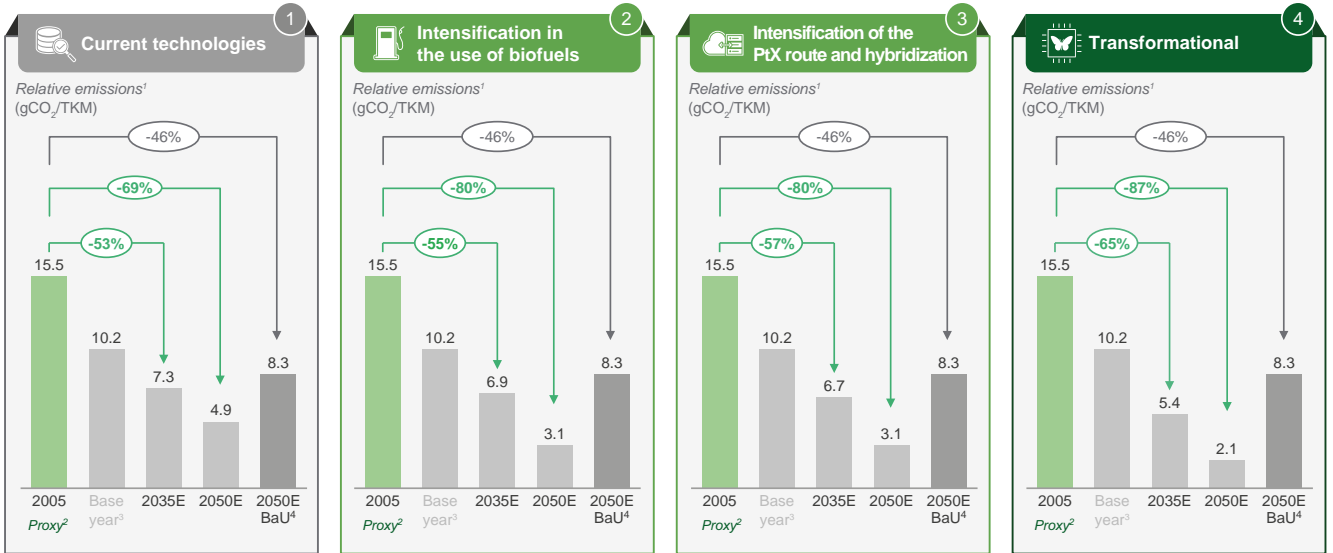
# THE PROPOSED SENSITIVITIES ARE ABLE TO PREDICT DIFFERENT POTENTIAL IMPACTS ON THE LEVEL OF EMISSIONS



The **absolute increase in emissions in some sensitivities comes from the growth of the TKM** of the mode, whose shares more than double by 2050; however, there is a drop in the emission values of 2035 and 2050 vs. 2005 in sensitivity 4 and, for the others, **the increase is smaller versus BaU<sup>4</sup>** – growth of **+62% 2005-35** and **+213% 2005-50**.

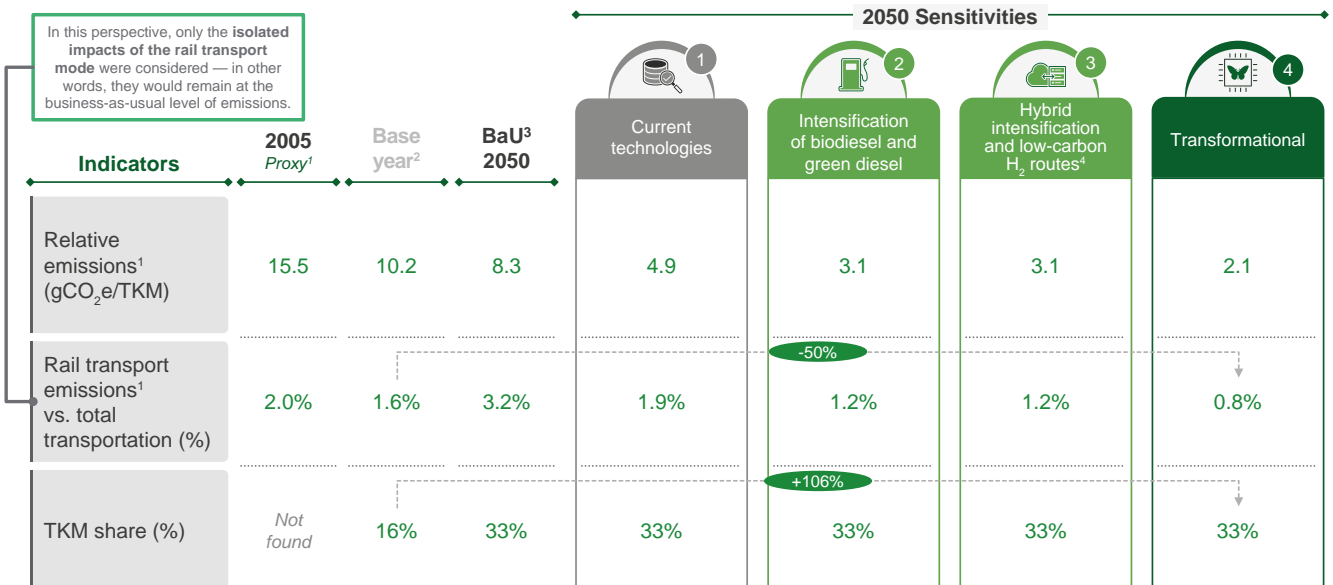
1. Emission factors considered are: well-to-wheel (WTW); BaU = Business-as-usual; 2. Proxy for the 2005 WTW value, based on the Tank-to-Wheel SEEG figures; 3. 2021 was the base year of the PSTF/PNL, in addition to presenting more reliable historical parameters; 4. BaU = Business-as-usual.

# THE IMPROVEMENT EFFECT CAN BE BETTER OBSERVED WHEN ANALYZING RELATIVE EMISSIONS (GCO<sub>2</sub>E/TKM)



1. Emission factors considered are: well-to-wheel (WTW); BaU = Business-as-usual; 2. Proxy for the 2005 WTW value, based on the Tank-to-Wheel SEEG figures; 3. 2021 was the base year of the PSTF/PNL, in addition to presenting more reliable historical parameters; 4. BaU= Business-as-Usual; Sources: SEEG, ANTF, GLEC Framework.

# DESPITE NOT REACHING 0, TKM SHARE DOUBLES WHILE EMISSIONS SHARE COULD SIGNIFICANTLY REDUCE BY 2050



1. Proxy for the 2005 WTW value, based on the Tank-to-Wheel SEEG figures; 2. Business-as-Usual, with a change of matrix provided for by the sectoral plans; 3. Business-as-Usual, with a change of matrix provided for by the sectoral plans; 4. Low-carbon hydrogen<sup>5</sup> 5. Emission factors considered are well-to-wheel (WTW). Sources: SEEG, ANTF, GLEC Framework.


# MAPPING OF ENABLERS


## EXAMPLES ILLUSTRATE HOW ENABLERS HELP UNLOCK KEY LEVERS FOR THE DECARBONIZATION OF THE TRANSPORTATION SECTOR

Ilustrativo

### Selected examples



✓ **Public and private incentives to make the rail transport system a more significant component of the country's overall logistics matrix.**

- **Renegotiations<sup>1</sup> |** Development of concession contract renegotiations, including the advent of investments in network expansion and the unlocking of investments in capacity increases in the current network.
- **New Legal Framework for Railways<sup>2</sup> |** Promotion of investments by simplifying regulations (e.g., incentive to self-regulation) and making authorization models more appealing to private players (authorizations), in order to expand the capacity of the mode. 
- **Structural investments in railways |** Continuation of public investments, such as in FIOL<sup>3</sup>, and private investments, such as Rumo's R\$4 billion to complete the central network of FNS<sup>4</sup>, which seeks to establish a new structural axis in the rail sector.

✓ **Incentives to encourage companies to adopt sustainability commitments | Sustainability Program<sup>5</sup> (2024) |** Promotion of regulatory benefits for companies (e.g., unique conditions for entering into TACs<sup>6</sup>), conditional on sustainability initiatives. 

✓ **Tangible mechanisms to promote private financing | Etihad Rail |** Facilitating the issuance of green bonds and sustainable loans, promoting fundraising for sustainable projects and low-carbon technologies. 

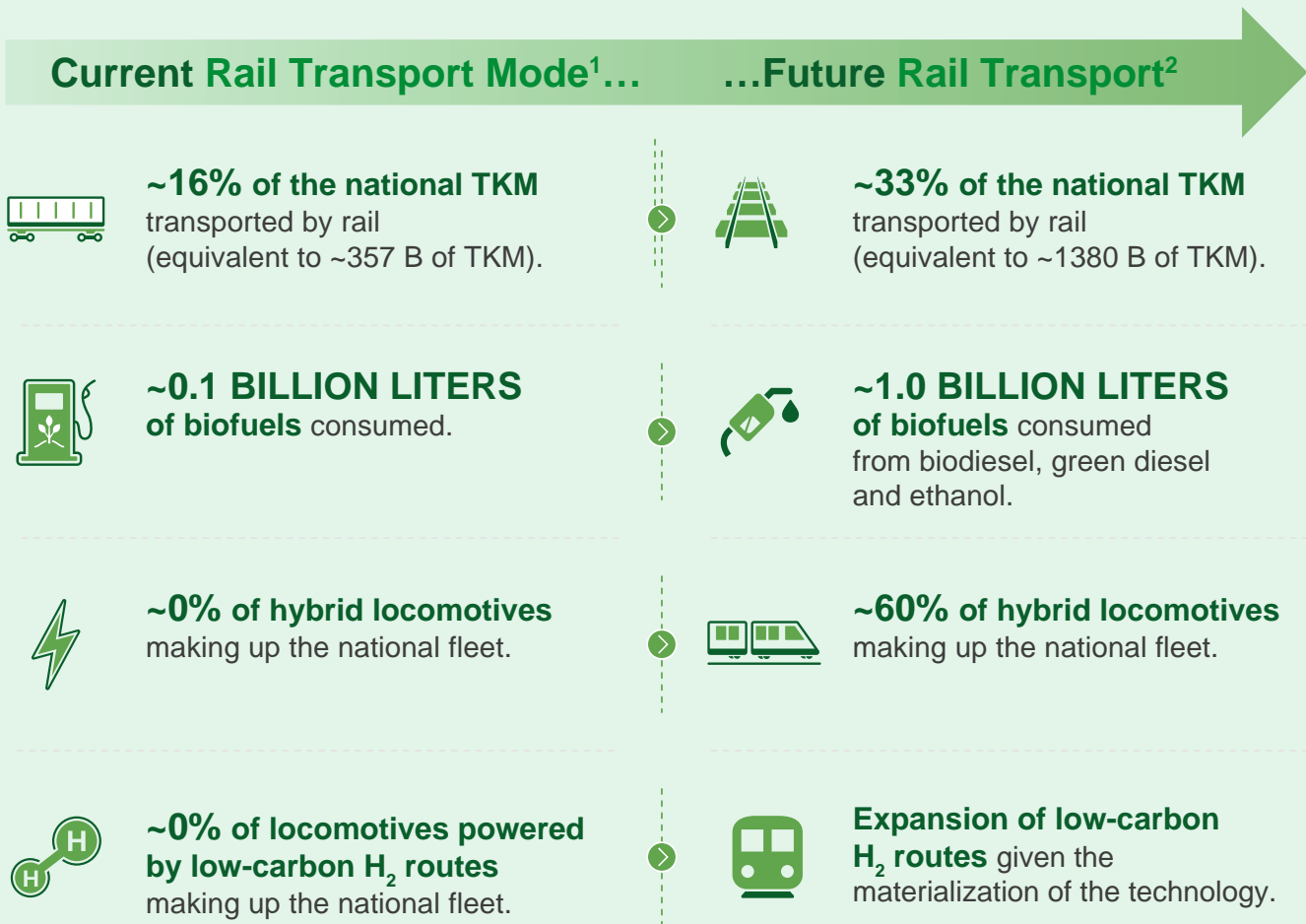
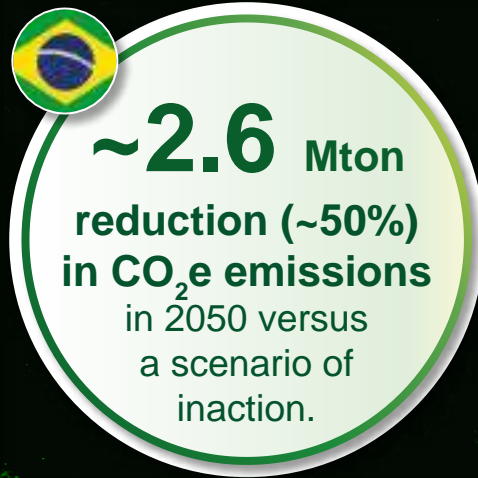
✓ **Concrete private sector actions via partnerships for the development of cleaner technologies.**

- **Alstom and Linde |** Development of Europe's first hydrogen locomotive, which was put into operation in 2017. 
- **Vale and Wabtec |** Partnership to acquire battery-electric locomotives, which are less polluting. 

1. Law no. 13.448/2017; 2. Law no. 14.273/2021; 3. West-East Integration Railway (*Ferrovía de Integração Oeste-Leste*, or FIOL); 4. North-South Railway (*Ferrovía Norte-Sul*, or FNS); 5. ANTT Resolution 6.057 (2024); 6. Conduct Adjustment Agreement. Sources: ANTF; IBPF; Railway Magazine; National Department of Transport Infrastructure; Ministry of Transport.

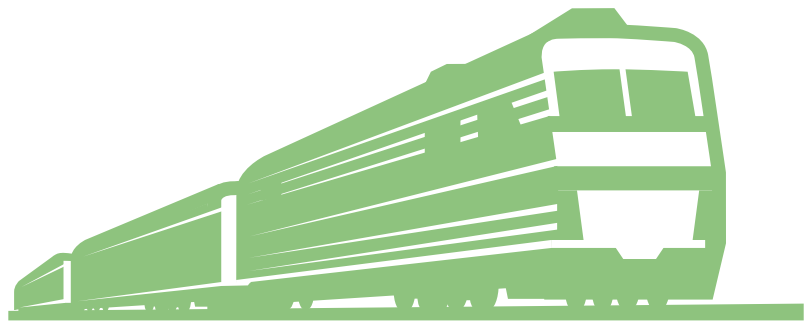
**Target impact in 2050 – Rail transport**

**We aim for sustainable growth in the Brazilian Rail transport sector**



1. 2021 (base year of the PSTF/PNL, in addition to showcasing more reliable historical benchmarks); 2. 2050 Transformational; Sources: Infra SA 2021.

# SÍNTESE | FERROVIÁRIO



The Rail transport<sup>1</sup> mode is less polluting in nature compared to the others (~8-10 gCO<sub>2</sub>e/TKM vs. ~50-65 gCO<sub>2</sub>e/TKM for the Road transport and ~10-15 gCO<sub>2</sub>e/TKM for the Water transport<sup>2</sup>), representing 16% of national freight transports and emitting ~1.6% of CO<sub>2</sub>e from transport<sup>3</sup>, which reinforces its efficiency in emissions.

In a scenario of inaction, total transport emissions would reach ~424 Mton CO<sub>2</sub>e in 2050. Under this scenario, the representation of transport modes within the national transportation matrix would remain unchanged (rail would remain at 16%). Emissions of the mode specifically, would reach ~5.5 Mton CO<sub>2</sub>e.

However, the PNL<sup>4</sup> and the Transport Sector Plans propose a significant change to the country's logistics matrix. Such a change would be a critical lever for decarbonization, leading to a reduction of ~50 Mton CO<sub>2</sub>e emissions from the sector as a whole. As such, the representativeness of the mode in the matrix would reach 33% of freight movements in 2050; As a consequence of this growth, emissions from the mode are expected to increase to ~11.5 Mton CO<sub>2</sub>e in 2050. The increased representativeness of the mode represents a tremendous challenge, requiring many new concessions and investments of +R\$270 billion.

To help curb rising emissions and strengthen their contribution to the climate agenda, the 9 entities<sup>5</sup> participating in the Coalition's Rail Transport vertical engaged in collaborative discussions and identified 11 key levers for decarbonizing the sector. Among them, the following stand out:

- **Biofuels** | Expansion of the use of biofuels (e.g. green diesel), as long as the adoption is preceded by tests that prove their technical, mechanical, operational and laboratory viability, respect the diversity of matrices and consider regional specificities;
- **Hybridization** | Greater adoption of hybrid locomotives, which are already adapted to the existing rail infrastructure;

- **Efficiency** | **Fleet renewal** geared towards gaining fuel and operational efficiency.

As a result of implementing the mapped levers, the emissions could reach ~2.9 Mton CO<sub>2</sub>e in absolute terms and ~2.1 gCO<sub>2</sub>e/TKM in relative terms under the transformational sensitivity scenario for 2050<sup>6</sup>, representing reductions of up to ~50% and ~75%, respectively, compared to a scenario of inaction in the same year.

Given the dimensions of the challenge, a series of enablers will be required to materialize such levers. Some concrete examples below illustrate how enablers can help progress the decarbonization agenda in rail transport mode:

- **Regulation** | **New Legal Framework for Railways**<sup>7</sup> | Promotion of investments by simplifying regulations (e.g., incentive to self-regulation) and make authorization models more appealing to private players (authorizations), in order to expand the capacity of the transport mode;
- **Incentives** | **Sustainability Program**<sup>8</sup> | Promotion of regulatory benefits to companies (e.g., unique conditions for entering into TACs<sup>9</sup>), conditional on compliance with initiatives in favor of sustainability.

Remaining emissions would represent ~2% of Brazil's total transport emissions in transformational sensitivity in 2050 (vs ~1.6% in the base year), reinforcing the benefits generated by the greater representativeness of the rail transport mode to the detriment of other more polluting modes. The entities participating in the Coalition will continue to promote ongoing discussions for progress towards net-zero emissions by 2050.

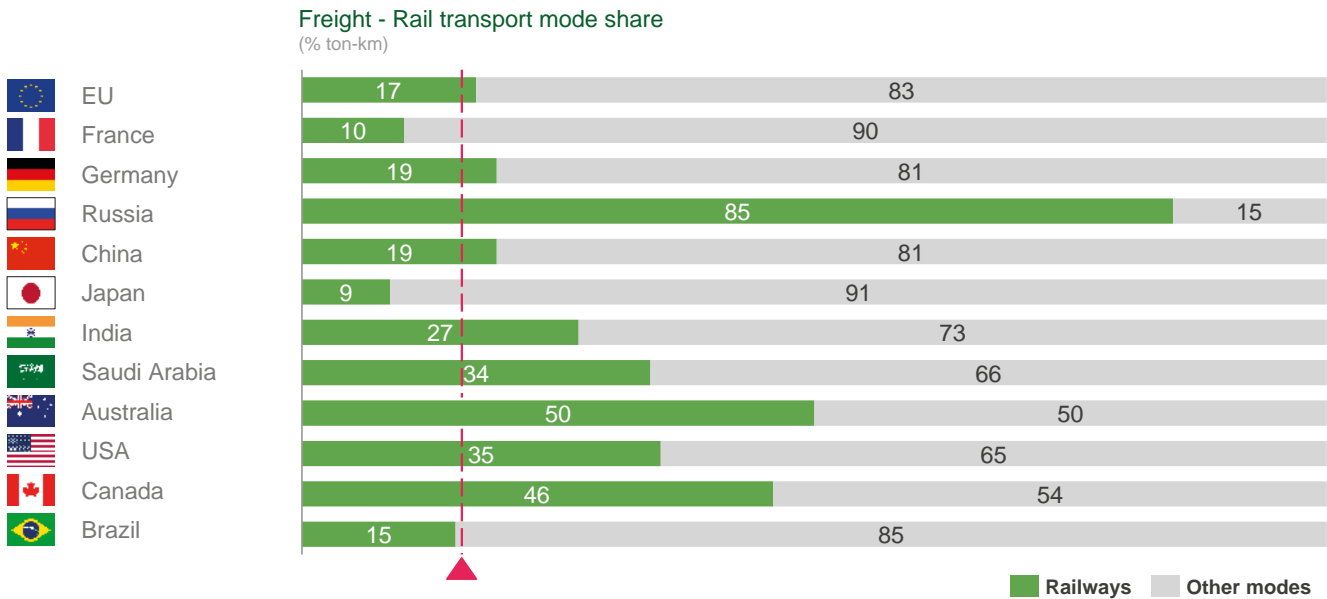
1. Restricted to rail freight transport; passenger/urban trains were accounted for in Urban Mobility; 2. Based on data from ANTF and SEEG 2022; 3. 2021 was used as a reference according to the base years of the Sectoral Plans; 4. Considers the sectoral transportation plans 5 as a basis. In addition to the 9 specific entities, CEBDS, Motiva, CNT and Inspier Mobility Observatory also coordinated the discussions across the different verticals of the Coalition; 6. Emission factors considered are well-to-wheel; 7. Law no. 14.273/2021; 8. ANTT Resolution 6.057 (2024); 9. Conduct Adjustment Agreement.



# **GLOBAL TRENDS FOR THE RAIL TRANSPORT MODE**



# RAIL FREIGHT TRANSPORT HAS AN UNDERREPRESENTED SHARE IN BRAZIL COMPARED TO SOME COUNTRIES



Sources: Organization for Economic Cooperation and Development (OECD); Oxford Economics; Eurostat; Australian National Transport Commission; EBRD (European Bank for Reconstruction and Development); Russian Railway Reform Program; International Transport Forum (ITF); China Climate Transparency Report; interviews with experts; Press survey.

## THE CONTEXT OF THE SECTOR IS SHIFTING AS COUNTRIES TAKE THEIR SUSTAINABILITY PLANS MORE SERIOUSLY

A number of countries are developing rail expansion plans, in favor of sustainability

Non-exhaustive examples



### European Green Deal

- Investment of EUR 260 billion in all sectors.
- Incentive for a switch to railways.
- Rail freight's share is expected to grow from 17% to 30% by 2030.
- Final target of reaching net-zero emissions by 2050.



### Infrastructure Plan

- Investment of US\$66 billion to develop rail transport infrastructure.
- 10 major projects, including the first high-speed rail systems.
- Increase PAX on railways as part of the net-zero emissions agenda by 2050.



### 15-year Transportation Plan

- Largest high-speed rail network in the world.
- Plans to double the rail network by 2035.
- Commitment to reach net-zero emissions by 2050.
- Switching to railways needs to come with greater use of renewable energy sources.



### National Railway Plan 2030

- Rail transport capacity is expected to grow to meet demand by 2050.
- By 2030, the country intends to:
  - Increase the mode's share of freight transportation from 27% to 45%;
  - Achieve 100% green power-based electrification.
- The country plans to be carbon neutral by 2050.



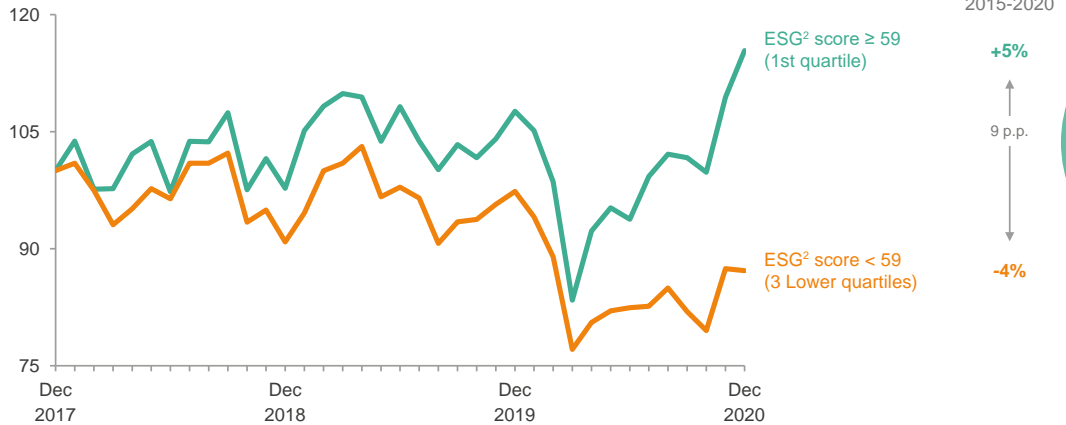
### Railway Concession Program

- Rail transport share is expected to rise to 33% by 2050.
- There are scheduled investments of around R\$95 billion, which depend on the continuity of public policies and partnerships with the private sector created in recent years.
- In addition to anticipated extensions, other high-magnitude initiatives are currently underway (e.g., FICO, FIOL).

Sources: ANTF; Railway Gazette International; International Energy Agency (IEA) Report – The Future of Rail (2019); CER (Community of European Railway and Infrastructure); Transport Sector Plans (Infra SA); press search.

# "DO GOOD BY DELIVERING GREATER TSR"

TSR Index: 12/31/2017 = 100<sup>1</sup>

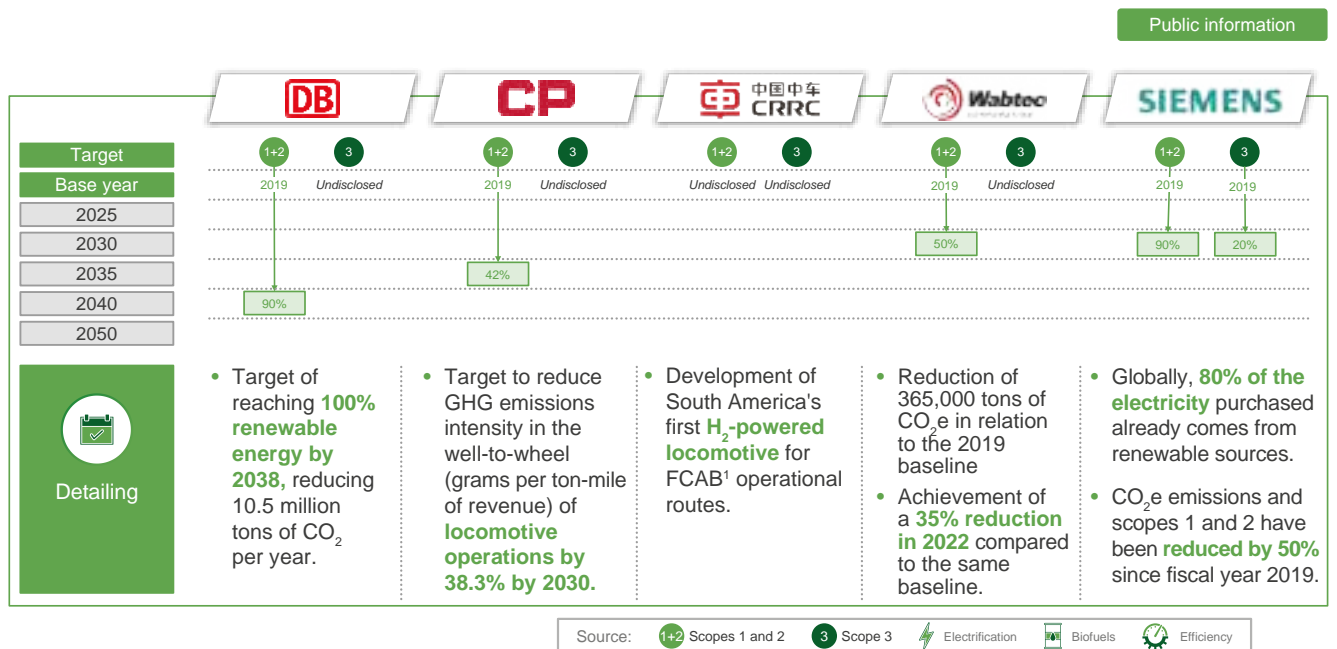


Rail transport players with a greater commitment to ESG impact deliver better returns to shareholders.

**ESG Score:** Environmental, social and governance performance, commitment and effectiveness  
**TSR:** Total Shareholder Return

1. Average monthly total return rebalanced from a set of 49 rail transport actors with FY2019 available; 2. ESG scores measure a company's relative performance in Environmental (resource use, emissions and innovation), Social (labor, human rights, community and product responsibility) and Governance (management, shareholders and CSR strategy), commitment and effectiveness. Sources: S&P Capital IQ; Refinitiv.

## GLOBAL PLAYERS WITH RAIL DECARBONIZATION TARGETS



1. Ferrocarril from Antofagasta to Bolivia. Sources: company reports; SBTi; press search.

# PARTICULARLY IN NORTH AND SOUTH AMERICA, ELECTRIFICATION IS STILL FAR FROM BECOMING A REALITY FOR RAIL TRANSPORT

There are various challenges to grid electrification in the Americas



## Infrastructure for grid electrification is expensive

- CAPEX can reach ~US\$2.5m per mile (~US\$4M per km) with additional costs for retrofitting locomotives.



## Distances can be quite extensive; the density of the network, in many cases, is low and the geography is not very favorable

- Railway network in North and South America can extend for thousands of km, with low traffic density.
- Many lines can be very long and "flat", with few braking points that help recharge batteries.



## In the Americas, rail transport is more focused on freight, which requires more energy

- Rail freight transport can often carry very heavy loads, on very long trains (up to 3 km in length) or up to two floors high ("double deckers").



## Geography can often be unfavorable to electrification

- Many regions are uninhabited, with limited access to energy and sometimes exposed to extreme weather conditions.



## Incentives are not available or may not be sufficient

- Most operators in the Americas are private and do not have public incentives to make such an expensive investment.



## General business case for electrification may not be feasible

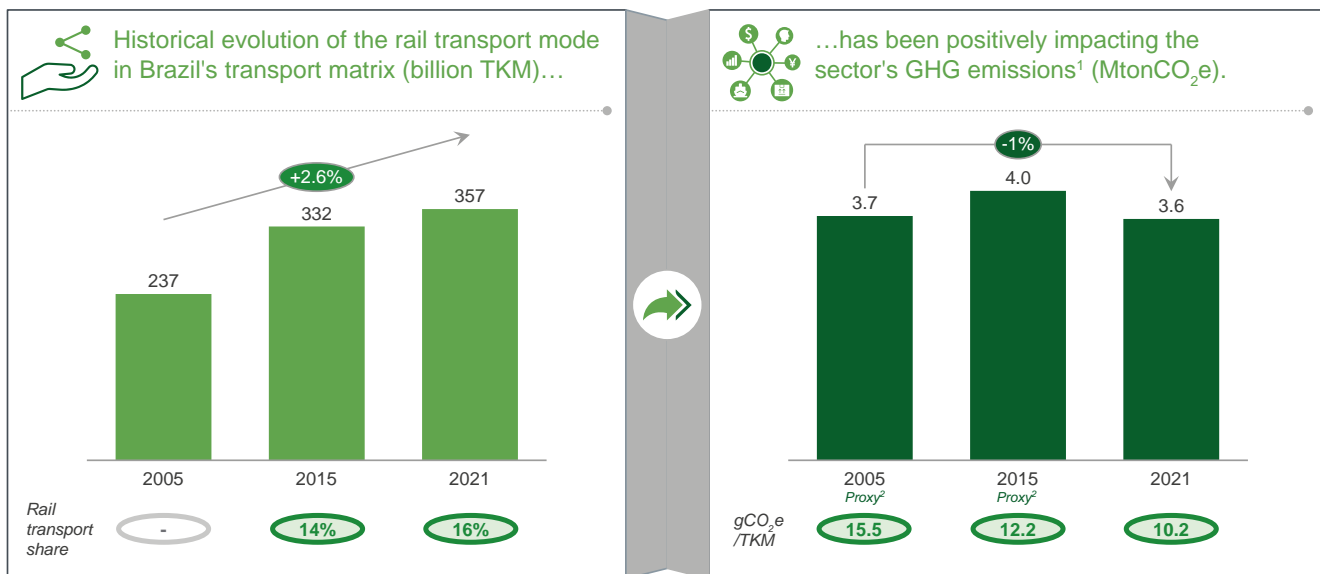
- Given the above, electrification may not provide sufficient returns for all freight / regions / operators.



# **LOCAL TRENDS FOR THE RAIL TRANSPORT MODE**



# THE RAIL TRANSPORT MODE IN BRAZIL SAW ADVANCEMENTS FOCUSED ON THE EXPANSION AND HIGHER SHARE OF PRIVATE INVESTMENTS



1. Emission factors considered are well-to-wheel (WTW); 2. Proxy for 2005 and 2015 WTW values, based on the Tank-to-Wheel SEEG figures. Sources: ANTF, PNLI 2015, Sectoral Plans, UNFCCC; SEEG, GLEC Framework.

## A NUMBER OF RAIL TRANSPORT PROJECTS ARE UNDERWAY IN RECENT YEARS, SOME ALREADY UNDER CONSTRUCTION

Non-exhaustive

Projects under construction		Total extension	Status
1	West-East Integration Railway – FIOL	~1,537 km	Underway
2	Transcontinental Railway and Midwest Integration Railway – FICO	~4,400 km / 888 km	Underway
3	Ferronorte	~743 km	Underway
4	North-South Railway	~1,537 km	Completed
Projects under study		Total extension	Status
1	Ferroeste	~1,567 km	Underway
2	Ferrogrão	~933 km	Underway
3	Pantanal Railway	~734 km	Underway
4	Railway Corridor of Santa Catarina	~245 km	Underway
5	North-South Railway Branches	~2,939 km	Underway

Legend: ✓ Completed ≈ Underway

Sources: PPI, Infra S.A, Ferrovia MT, press search.

Applicable to the transportation sector as a whole, including the road transport mode

## THE "FUEL OF THE FUTURE" LAW AIMS TO BOOST LOW-CARBON MOBILITY

### INCENTIVES UNLOCK THE BRAZILIAN AGENDA FOR THE DECARBONIZATION OF RAIL TRANSPORT

Non-exhaustive



#### Mandate for increasing the blend of biodiesel in diesel

Percentage of biodiesel added to diesel will increase annually to reach 20% in March 2030.



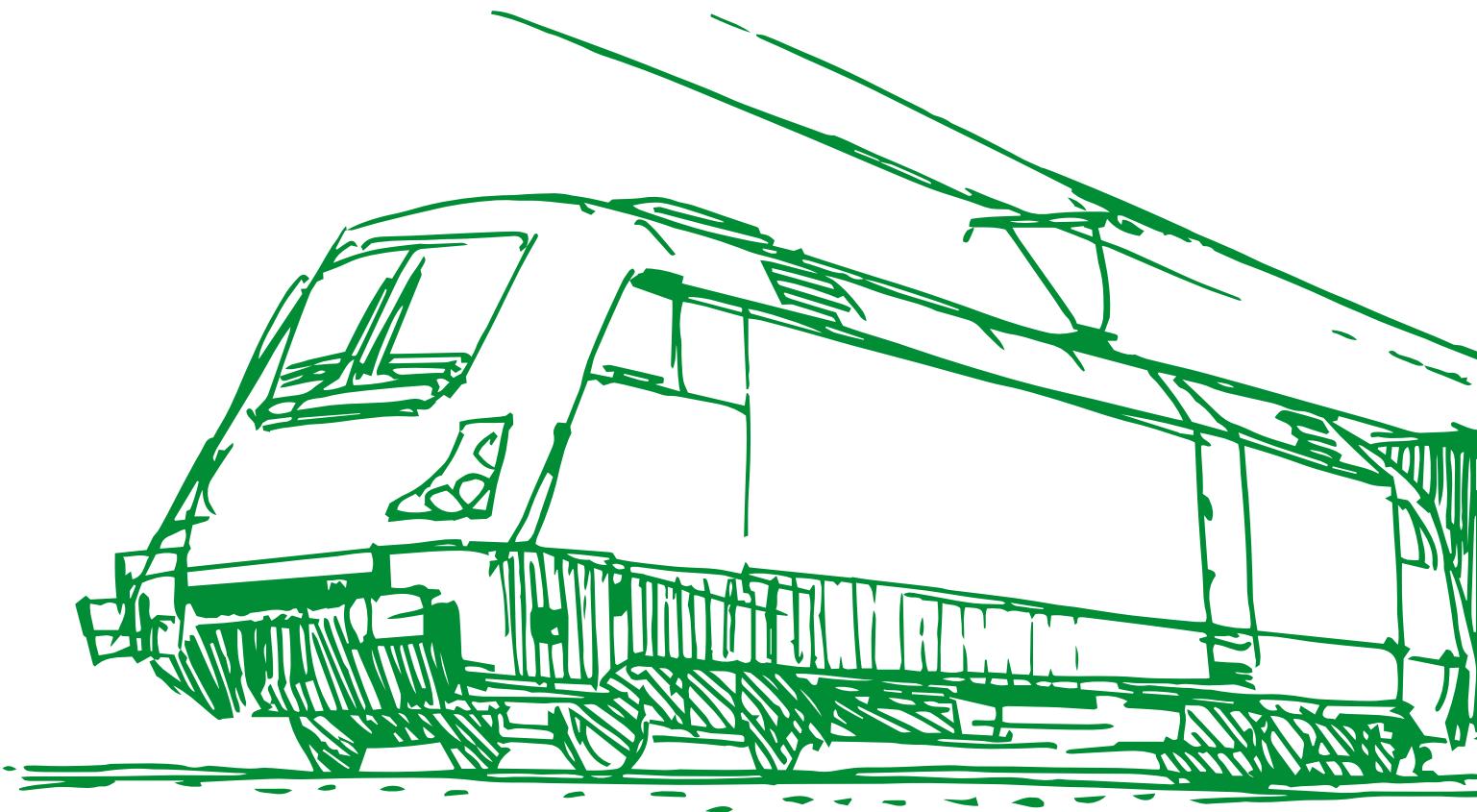
#### National Green Diesel Program (PNDV)

Gradual incorporation of green diesel in the country's energy matrix, reducing the share of fossil diesel by the CNPE<sup>1</sup>.



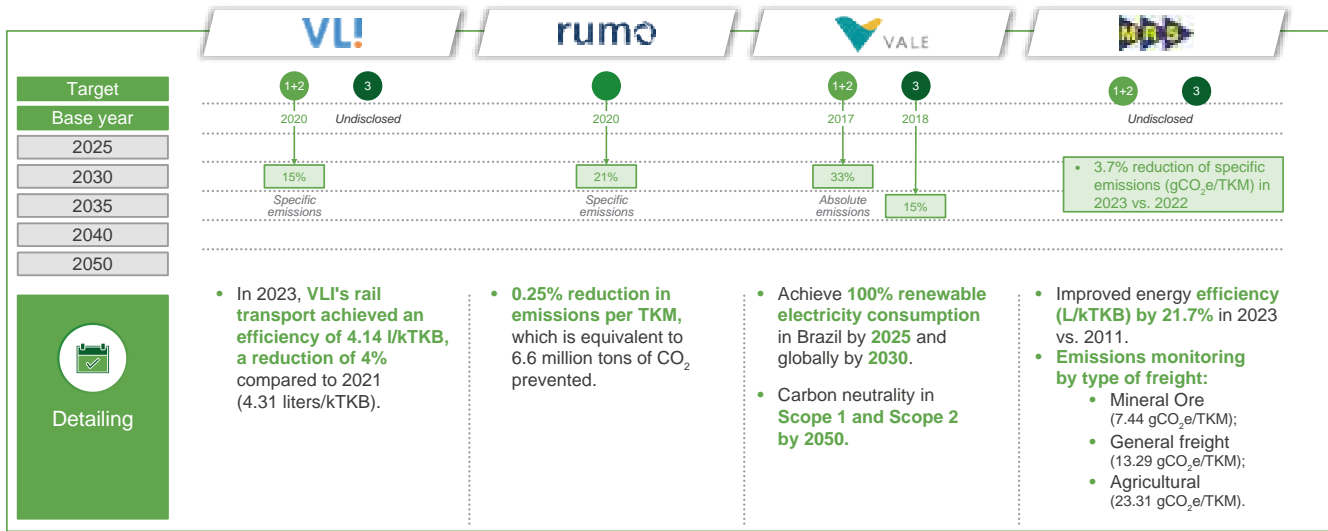
#### Regulation on synthetic fuels (e-fuels)

Definition of the regulatory framework for synthetic fuels in Brazil by the ANP<sup>2</sup>.



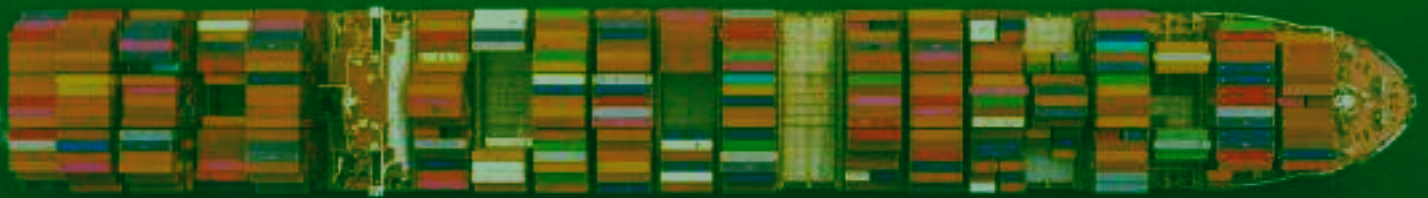
# VARIOUS LOCAL PLAYERS WITH DECARBONIZATION TARGETS

Public information



Source: 1+2 Scopes 1 and 2    3 Scope 3    ⚡ Electrification    🌱 Biofuels    ⚙️ Efficiency

Sources: Company reports; SBTi; press articles.



MAIN CONCLUSIONS

# WATER TRANSPORT

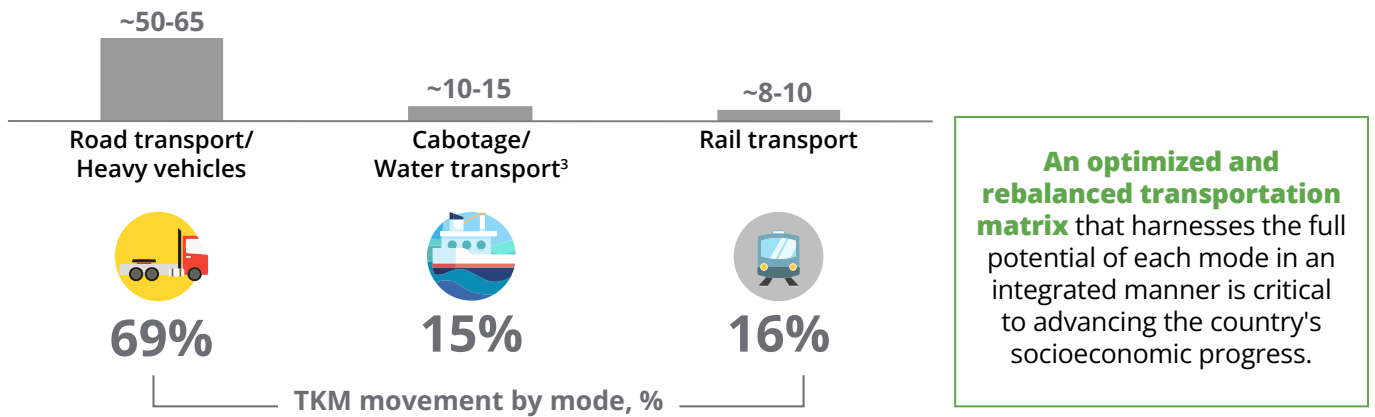
# WATER TRANSPORT – MEMBER ENTITIES

This document was supported by the following water transport entities.



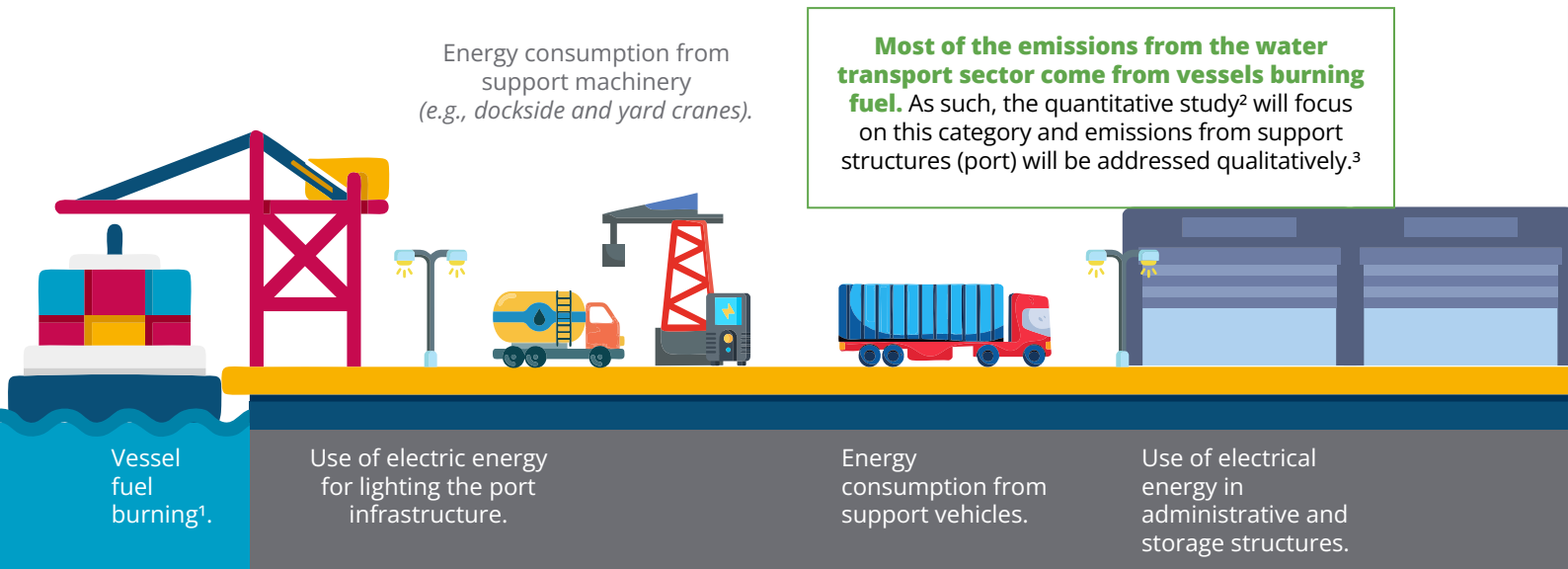
## COMPARISON OF THE LEVEL OF EMISSIONS BY TYPE OF FREIGHT IN 2022<sup>1</sup> (CO<sub>2</sub>/TKM)

Water transport is a more environmentally friendly option than road transport (it emits about 5x less CO<sub>2</sub>e by TKM). It currently represents **~15% of national freight transport and contributes ~1.8%<sup>2</sup> of the total CO<sub>2</sub>e emissions from transportation**, which reinforces its efficiency in emissions.



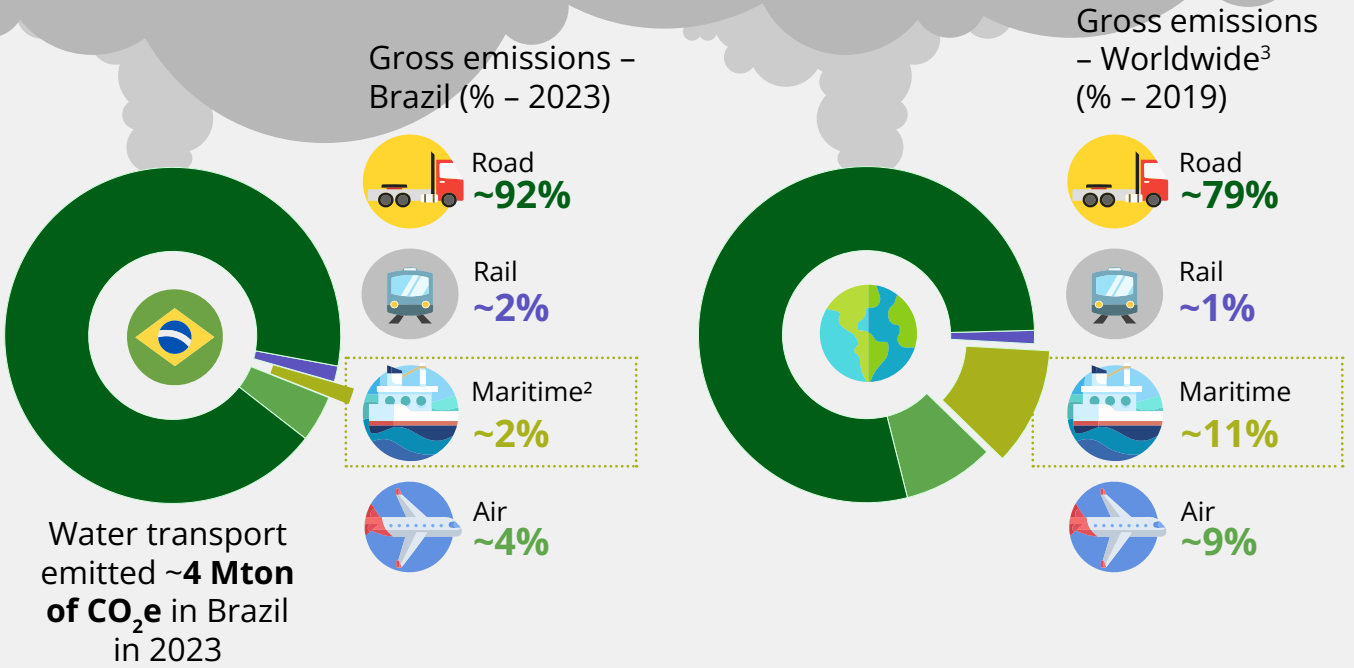
1. Calculated based on data from ANTF and SEEG 2022; 2. It considers Well-To-Wheel adjustments (WTW), even for actual values (2023); 3. Cabotage and Inland Transport at both State and Interstate levels. Sources: PNL 2035; ANTF; ANTT; SEEG.

## WATER TRANSPORT EMISSIONS COME MAINLY FROM TRANSPORTATION, WITH LESS IMPACT ON INFRASTRUCTURE



1. Port and maritime transport and support vessels; 2. The application of the levers took into account the diversity of the sector, covering different types of vessels and companies, and considering their varying characteristics in terms of size, resources, and capacity to adopt the identified levers; 3. Globally, emissions from ports represent <5% of total emissions from the water and maritime transport sector. Sources: PNL 2035; ANTF; ANTT; SEEG; OECD.

# EMISSIONS<sup>1</sup> FROM THE WATER TRANSPORT SECTOR REPRESENT ~1.8% OF TOTAL TRANSPORTATION IN BRAZIL



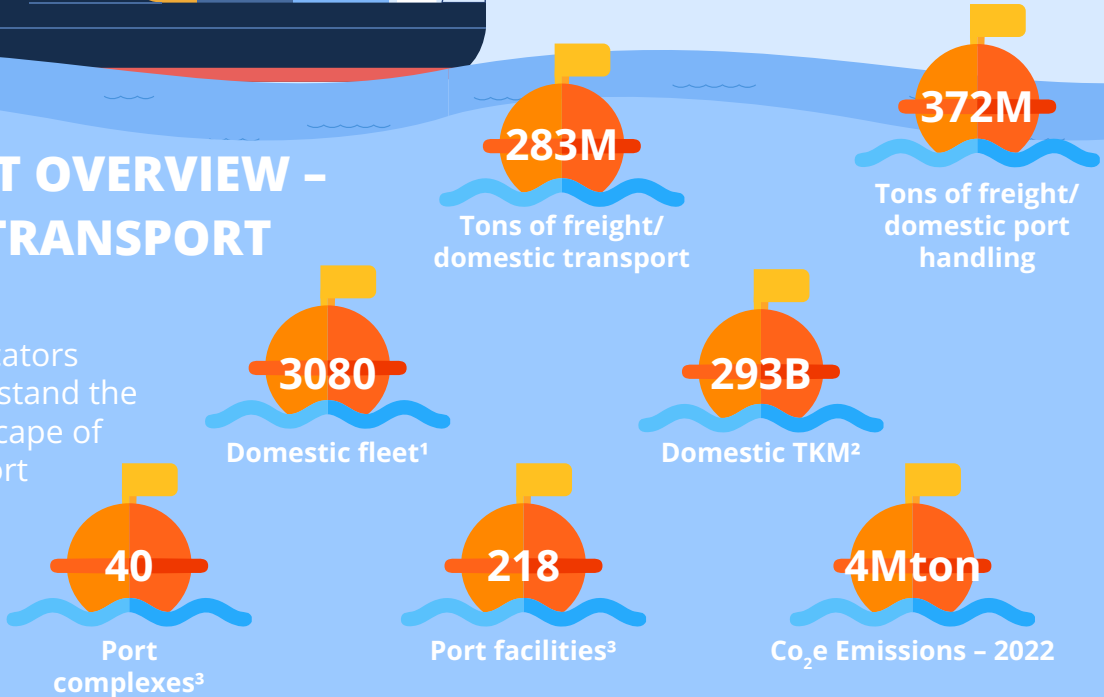
1. Transport emissions reported by SEEG are restricted to the burning of fuels; 2. Considers cabotage and inland navigation, without long haul; 3. Global amount excluding Brazil. Sources: Anfavea; SEEG; CAIT; Climate TRACE.



## CURRENT OVERVIEW – WATER TRANSPORT MODE

Relevant indicators help to understand the current landscape of water transport

2023

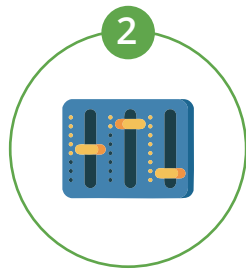


1. Transport emissions reported by SEEG are restricted to the burning of fuels; 2. Considers cabotage and inland navigation, without long haul; 3. Global amount excluding Brazil. Sources: Anfavea; SEEG; CAIT; Climate TRACE.

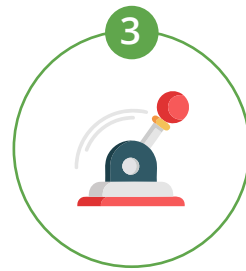
# APPROACH | FOUR STEPS FOR WATER TRANSPORT DECARBONIZATION



Setting projections for the total emissions of the sector, assuming there will be **no changes in the participation of the different modes within the transportation matrix;**



Setting projections for the total emissions of the sector, assuming **changes in the participation of the different modes within the transportation matrix;**



Mapping of levers to **reduce emissions applicable to the mode of transport;**



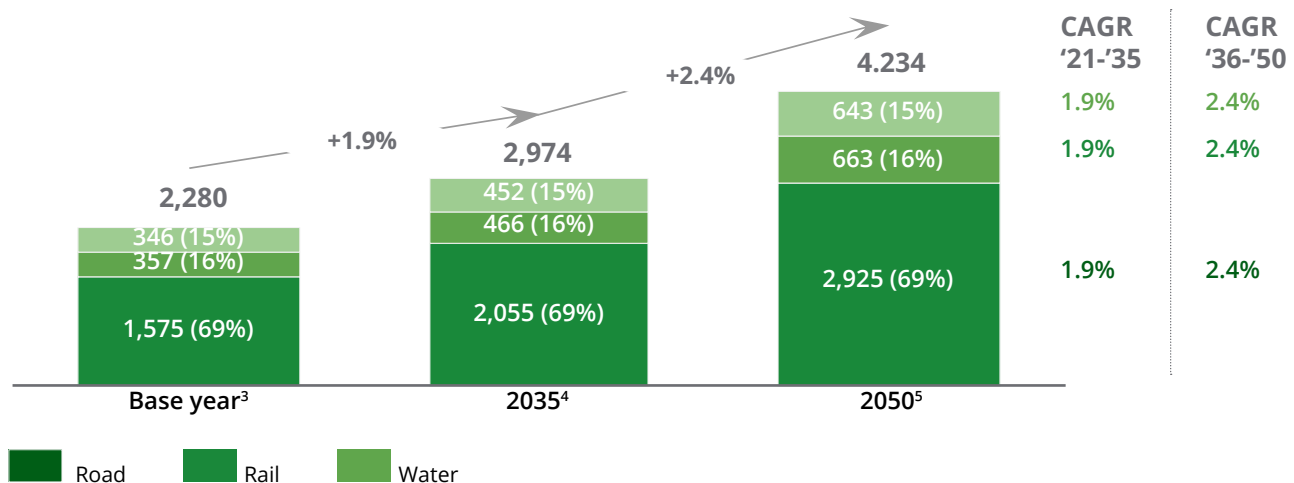
Proposal of possible **sensitivities based on the mapped levers.**

## 1 BaU<sup>1</sup> DEFINITION OF EMISSIONS WITHOUT CHANGES IN THE TRANSPORTATION MATRIX

In a scenario of inaction, total transport emissions are expected to reach **~424 Mton CO<sub>2</sub>e in 2050**. Under this scenario, share of different modes of transportation in the national transportation matrix would remain unchanged (water transport would continue to account for ~15%).

### EVOLUTION OF THE FREIGHT MATRIX<sup>2</sup>

Scenario of Inaction (Billion TKM, %)



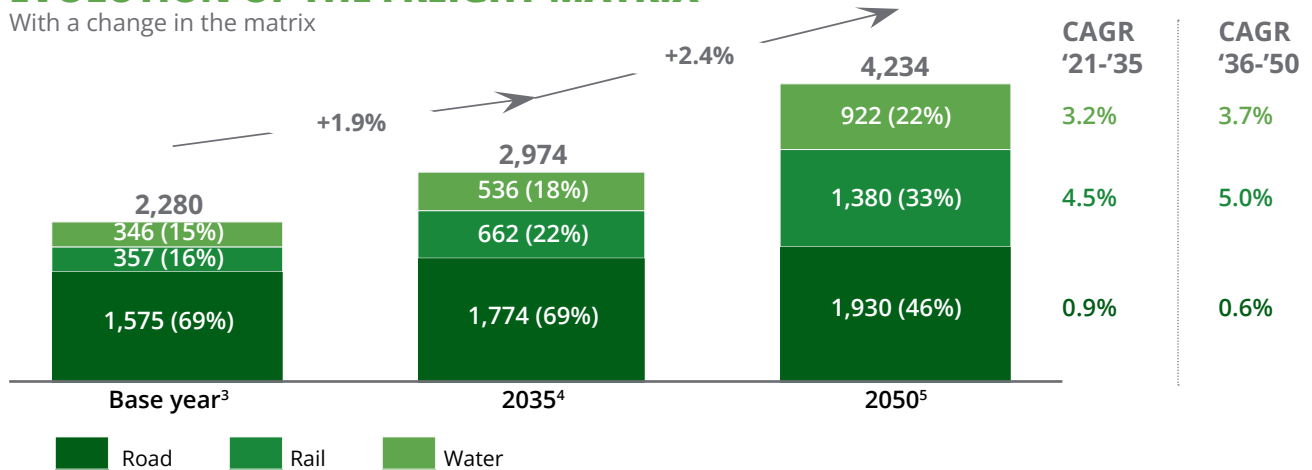
1. Road Transport Sector Plan (PSTR); Rail Transport Sector Plan (PSTF); 2. PNL 2035 – National Logistics Plan; 3. Base year = 2021, with the National Logistics Plan projected using the respective CAGRs of the reference scenario relative to 2017; 4. TKM 2035 values refer to the PSR1 scenario of the PSTR and PAX values come from the reference scenario of the PNL 2035 passenger matrix; 5. TKM projected in line with GDP, maintaining the modal share from the PSR3 scenario of the PSTR; PAX projected according to population growth, with no change in modal share; 6. Air transport is only marginally representative in total freight volumes; 7. The passenger figures presented in the PNL reflect only intermunicipal and interstate travel, and do not account for intra-urban passenger travel. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

## 2 BaU<sup>1</sup> DEFINITION OF EMISSIONS WITH CHANGES IN THE SHARE OF MODES OF TRANSPORTATION

The second stage examined an alternative scenario where the water transport's role in the transportation matrix could be increased, generating emission reductions given its comparatively lower emission intensity (gCO<sub>2</sub>/TKM) relative to higher-emitting modes.

### EVOLUTION OF THE FREIGHT MATRIX<sup>2</sup>

With a change in the matrix

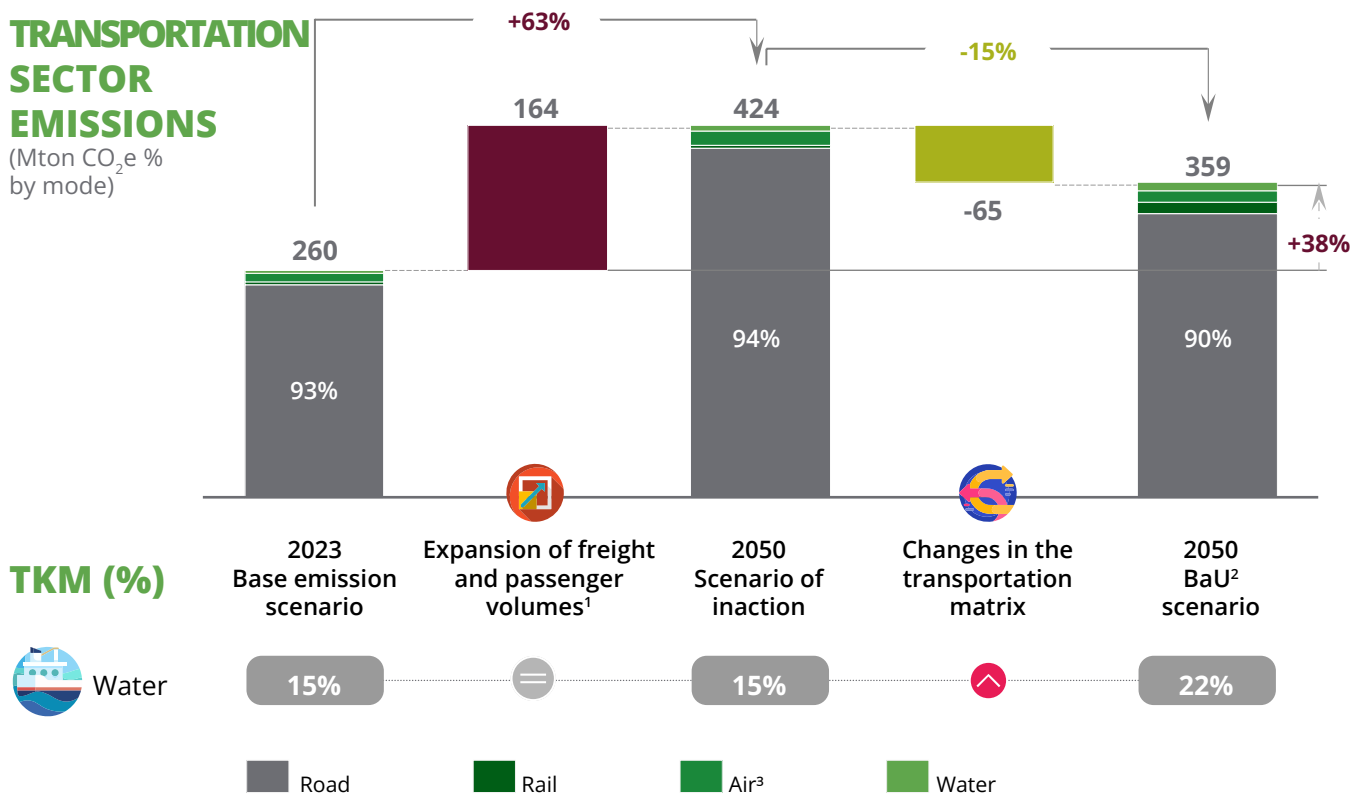


1. Road Transport Sector Plan (PSTR); Rail Transport Sector Plan (PSTR); 2. PNL 2035 – National Logistics Plan; 3. Base year = 2021, with the National Logistics Plan projected using the respective CAGRs of the reference scenario versus 2017; 4. TKM 2035 values refer to the PSR1 scenario of the PSTR and PAX values come from the reference scenario of the PNL 2035 passenger matrix; 5. TKM is projected based on GDP growth, using the modal share from the PSR3 scenario of the PSTR, while PAX is projected according to population growth, with no change in modal share; 6. The passenger figures presented in the PNL reflect only intermunicipal and interstate travel, and do not account for intra-urban passenger travel; 7. Air transport mode is not very representative in terms of freight transported compared to the total. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

In summary, optimizing this transportation matrix by shifting certain modes of transport, specifically rail and water transport modes, will help reduce the expected volume of CO<sub>2</sub> emissions by approximately 15% by the year 2050:

### TRANSPORTATION SECTOR EMISSIONS

(Mton CO<sub>2</sub>e % by mode)



1. Increased emissions due to the expected growth in demand for TKM and passengers until 2050; 2. Business-as-Usual; 3. Air transport emissions are not related to freight transport, only to passenger transport.

# 3

## MAPPING OF LEVERS TO REDUCE EMISSIONS

After the transportation matrix was presented, the working group identified levers that have the potential to reduce emissions in water transport.

These levers were mapped in three large blocks, as described below. A qualitative feasibility analysis<sup>1</sup> was performed for each of them, and local and global references that illustrate the respective application were presented.

1. The full details of the feasibility and references can be found in the complete water transport document, which can be accessed through the QR Code at the end of this document.

### LEVERS FOR EMISSION REDUCTION

in the water transport sector



EFFICIENCY



BIOFUELS



ELECTRIFICATION AND POWER-TO-X



### EFFICIENCY

#### Levers – Vessels

- 1 Adoption of **innovative materials and technologies** in the construction and operation of vessels to **improve hydrodynamic design and performance**.
- 2 **Intelligent route optimization and fleet allocation**, reducing average distances traveled.
- 3 **Reduce and control the average speed of vessels** to lower fuel consumption and optimize energy efficiency.
- 4 Use other **technical solutions to support** emission reduction, like **waste heat recovery, liquid cooling system**, and others.
- 5 Integrate **electric wind-assisted propulsion technologies (WAPs)** to complement **traditional motorization**.
- 6 **Increase the size of vessels and/or configurations**, thereby decreasing the frequency of trips required.
- 7 **Maximize the utilization of the stowage factor**, ultimately reducing the number of trips required and **improving the use of the fleet**.

Sources: EPE; IMO; Trafigura; Transpetro (RI).

#### Levers – Port Infrastructure (1/2)

- 1 **Enabling infrastructure and facilitating access, thereby reducing the average waiting and docking time** through the construction of more, or larger, terminals/berths.
- 2 Implementing **trade facilitation strategies to streamline port operations and minimize freight turnaround times**.
- 3 Construction and provision of **OPS (onshore power supply) structures for vessels**.<sup>1</sup>
- 4 **Optimization of vessel mooring management** through the use of data intelligence tools.

1. OPS = onshore power supply that allows vessels auxiliary engines to be shut down while moored. Sources: Maersk; EPA; Website Portos; ANTAQ; MPor.

## Levers – Port Infrastructure (2/2)

- 5 Implementation of **strategies to optimize support systems**, including automated lighting and water and waste management.
- 6 **Renewal of the support fleet (vehicles and machinery) for newer and more energy-efficient models.**

Sources: Maersk; EPA; Website Portos; ANTAQ; MPor.



## BIOFUELS

### Levers – Vessels

- 1 **Intensification of the use of biodiesel (FAME)** as an alternative to fossil or bunker diesel, or as a blending component.
- 2 Use of **bio-liquefied natural gas (Bio-LNG) as an energy source** for vessels.
- 3 **Use of other biofuels — such as ethanol, biomethanol and HVO —** as alternative energy sources to the current matrix.
- 4 **Replacement of HFO bunker use with LFO bunker or use of ammonia** (lower carbon footprint versus currently used options) **and LNG** (liquefied natural gas).

Sources: EPE; IMO; ANAP; Ministry of Mines and Energy.

### Levers – Port Infrastructure

- 1 **Use of clean fuels in fleet and support machinery** (e.g., LNG- or biodiesel-based trucks).
- 2 **Offering clean fuel supply options to vessels**, like cryogenic tanks for LNG, biodiesel supply structures, and others.

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

Sources: Maersk; EPA; Website Portos; ANTAQ; MPor.



## ELECTRIFICATION AND POWER-TO-X

### Levers – Vessels

- 1 **Use of synthetic fuels (PtX: PtL and PtG<sup>1</sup>), such as e-methane, e-methanol and e-ammonia**, produced from green hydrogen, renewable electricity and captured CO<sub>2</sub>.
- 2 **Shift to hybrid (or electric) technologies in small-scale and short-haul maritime operations** to replace fossil fuels and cut CO<sub>2</sub> emissions.
- 3 The direct use of **green hydrogen in fuel cells** offers a zero carbon and efficient alternative.

Levers can be applied as long as the technical and operational viability of the respective solutions is verified.

1. PtX: Power-to-X, PtL: Power-to-Liquid, and PtG: Power-to-Gas. Sources: EPE; IMO; CBO; CNN; RMI; Flagships Project.

## Levers – Port Infrastructure

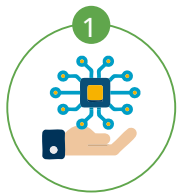
- 1 **Use of renewable energy in the groups' port and administrative operations** (e.g., use of solar/wind energy in offices, for port lighting, etc.).
- 2 **Hybridization or electrification of the fleet of vehicles and port support machinery** (e.g., 100% electric yard and dock trucks and cranes).

Levers can be applied as long as the technical and operational viability of the respective solutions is verified.

Sources: Maersk; EPA; Website Portos; ANTAQ; MPor.

# 4 PROPOSAL OF SENSITIVITIES BASED ON THE MAPPED LEVERS

Finally, sensitivities have been proposed to assess the impact of different paths to decarbonization:



### Current technologies

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



### Intensification of biofuels

Predominance of the application of levers to intensify the use of biofuels;



### Electrification acceleration/Power-to-X

Predominance of the application of levers to accelerate the electrification/power-to-X of the fleet of vessels;



### Transformational

Combination of levers from sensitivities 1, 2, and 3 leading to a trajectory closer to net-zero emissions.



### CURRENT TECHNOLOGIES



### TRANSFORMATIONAL



**Efficiency in ports** All levers of efficiency applied.

**Efficiency in transportation** All levers of efficiency applied.



**Use of biodiesel** -

- Use of B20 in **diesel** from 2030, reaching **B24 in 2040**.
- Use of **B24 in the bunker from 2030**.
- Reaching 7% of the matrix in 2050.

**Use of LNG and bio-LNG** -

- **Transition fuel** between current fuels and biofuels and PtX.
- Represents 4% of the matrix in 2050.

**Replacement of HFO with LFO**

- Same as baseline – gradual replacement, with LFO **reaching 50% of the bunker in 2050**.
- Faster replacement, with **LFO reaching 100% of the bunker in 2050**.

**Other fuels with a lower carbon footprint** -

- **Gradual addition of ammonia** (6%), **biomethanol** (18%), **ethanol** (15%) into the matrix.
- **Ammonia paving the way for PtX solutions** starting from 2040.

# OUTCOMES OF SENSITIVITY ANALYSIS CONCERNING THE IMPACT ON EMISSIONS



## CURRENT TECHNOLOGIES



## TRANSFORMATIONAL



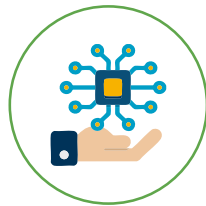
PtX solutions -

Use of battery-powered solutions (hybrids) -

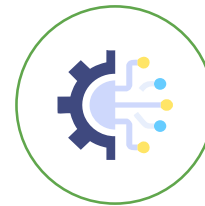
- Gradual entry of PtX solutions (e-ammonia and e-methanol).
- Reaching 20% of the energy matrix (MJ) in 2050.
- Focus on hybrid support vessels and tugboats.
- 7% of support and inland vessels will be hybrid in 2050 (214 vessels).

1. Only the levers for which numerical references were found have been quantified; 2. Matrix = energy matrix (MJ), does not consider electricity consumption; 3. Potential intensification of biofuels to reduce the carbon footprint can be applied as long as the technical, mechanical, operational and laboratory viability of said energy input is confirmed, as well as respecting the diversity of matrices and regional specificities. Sources: EPE; Interviews with sector experts; Clarkson; ANTAQ; DVN; RMI; Mpor.

As a result of implementing the mapped levers, the sector's absolute emissions could be reduced to ~3.1 Mton CO<sub>2</sub>e (-32% vs. 2023) in transformational sensitivity in 2050.

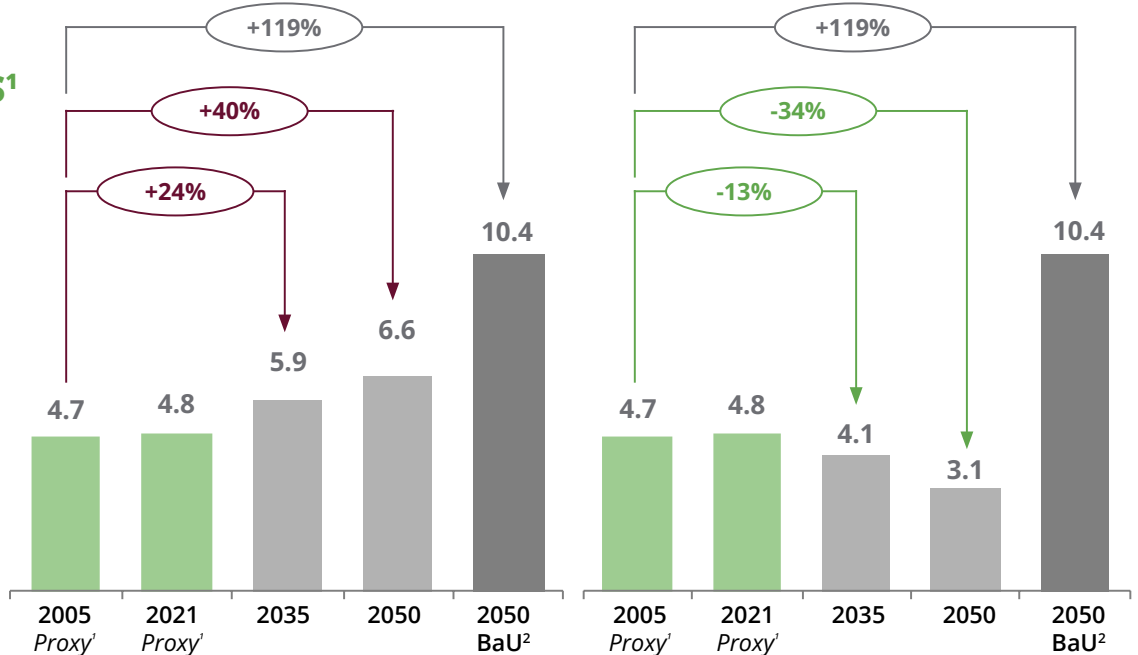


## CURRENT TECHNOLOGIES



## TRANSFORMATIONAL

**ABSOLUTE EMISSIONS<sup>1</sup>**  
(MtCO<sub>2</sub>e)



**TKM (B)**



1. The SEEG emission data was adjusted using a Well-To-Tank (WTT)/Tank-To-Wheel (TTW) emission factor for the mode; however, the 2005 and 2021 values reflect the numbers reported by SEEG (and not those modeled via the PNL); 2. BaU = Business-as-Usual. Sources: EPE; Interviews with sector experts; Clarkson; ANTAQ; DVN; RMI; Mpor.



## ILLUSTRATIVE EXAMPLES SHOW HOW ENABLERS HELP TO FACILITATE DECARBONIZATION LEVERS

### TRACKING SUSTAINABILITY PERFORMANCE

#### IMO

Requirement to report the Energy Efficiency Existing Ship Index (EEXI), which assesses vessel design, and the Carbon Intensity Indicator (CII), which monitors operational carbon intensity.


*It is a strategic measure to ensure the continuous alignment of Brazil's emissions calculation methodology with IMO guidelines, which is crucial for achieving international convergence and consistency.*

### PUBLIC INVESTMENT TO FACILITATE THE EXPANSION OF THE WATER TRANSPORT

#### New PAC

R\$60M for the construction of the Macapá Waterway Terminal, designed to enhance the transport of freight and passengers, which in itself has a more sustainable nature.

### PRIVATE TERMINAL EXPANSION

The growing number of privatized terminals, an increase of ~44% over the last 13 years<sup>4</sup>, promotes a more sustainable growth trend and contributes to a cleaner transport matrix. 

### INCENTIVE FOR INVESTMENTS IN CABOTAGE AND INLAND WATER TRANSPORT

#### BR do Mar and BR dos Rios<sup>1</sup>

Through the simplification of regulations and the expansion of contracting options for water transport, the goal is to increase supply, foster competitiveness, and encourage investment in operations and infrastructure.

### TANGIBLE MECHANISMS TO PROMOTE PRIVATE FINANCING

#### Green Shipping Fund

€420M fund offering loans to operators for the replacement or modernization of vessels using green fuels<sup>3</sup>.

### STIMULUS FOR PUBLIC INVESTMENTS IN TECHNOLOGICAL DEVELOPMENT

#### Merchant Marine Fund

R\$12 billion approved for modernization of the sector, including the first project to convert engines of maritime support vessels to operate using Brazilian ethanol as fuel.

### CONCRETE FINANCING TOOLS FOR FOSTERING R&D<sup>2</sup> BY THE PRIVATE SECTOR

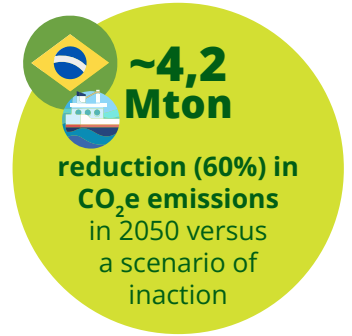
#### The Mærsk Mc-Kinney Møller Center

Partnership between Maersk, universities and the government for R&D<sup>2</sup> of green H<sub>2</sub> and ammonia.

1. Regulation is still in the drafting stage and has not been approved; 2. R&D = Research and Development; 3. Such as LNG, methanol, ammonia, green hydrogen, or electric vessels; 4. 2023 vs. 2010. Sources: Ministry of Education; Zero Carbon Shipping Initiative; Maersk; Government of Amapá – news page; FINEP; Green Shipping Fund; Petrobras; ANTAQ; Mpor.





# WE AIM FOR SUSTAINABLE GROWTH IN THE WATER TRANSPORT SECTOR

Considering the expected growth for the sector, the water transport mode is expected to reach **22% of the TKM transported in 2050 (vs. 16% in 2023)** while CO<sub>2</sub>e emissions are forecast to represent only ~2% of Brazil's total transport in transformational sensitivity in the same year (vs. ~1.8% in base year).







**Conclusions** sought by the study on water transport in Brazil by 2050:

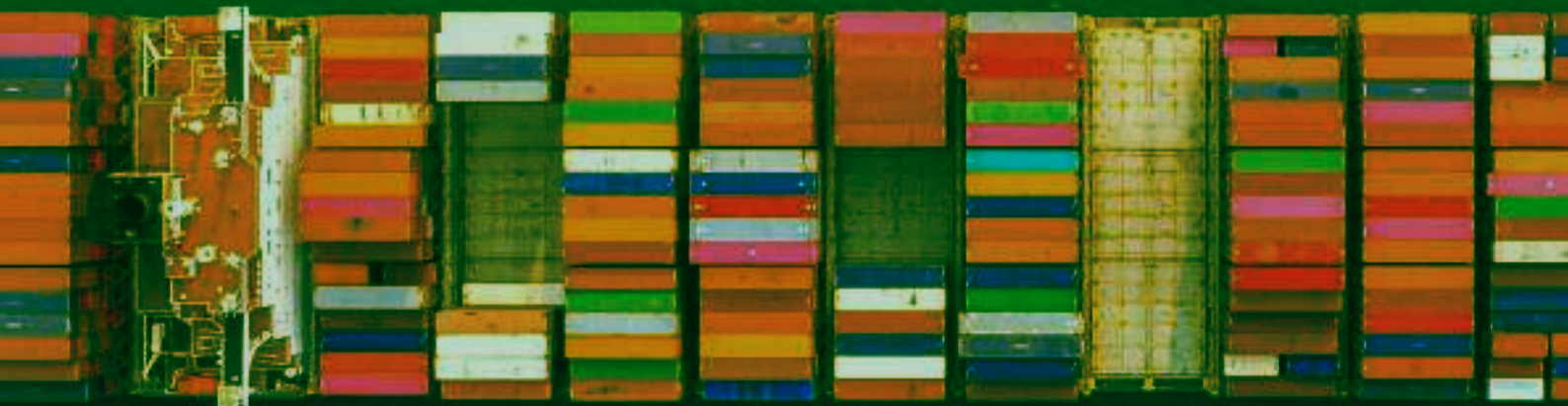
## CURRENT WATER TRANSPORT<sup>1</sup>

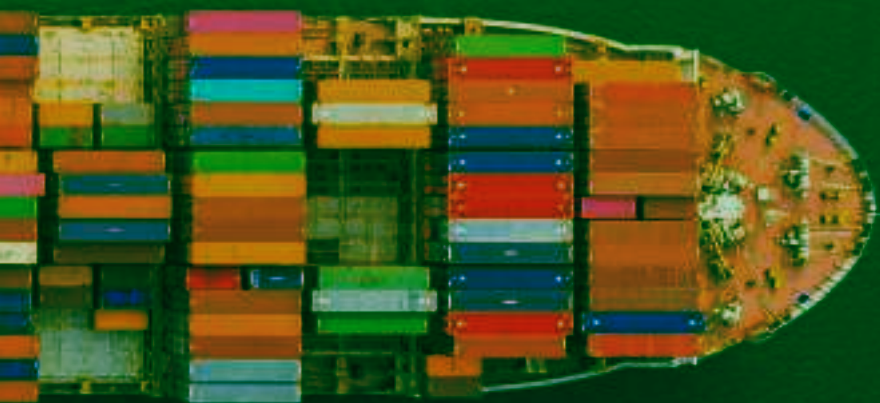
-  **~16% OF THE NATIONAL TKM** transported by water transport (equivalent to ~368 B of TKM).
-  **~0 BILLION LITERS OF BIOFUELS** consumed, with the matrix focused on the use of fossil options.
-  **<1% OF HYBRID VESSELS** making up the fleet, with few newly implemented exceptions.
-  **~0% OF THE FLEET USING PTX<sup>4</sup>** or other low-carbon H<sub>2</sub> solutions.

## FUTURE WATER TRANSPORT<sup>2</sup>

-  **~22% OF THE NATIONAL TKM** transported by water transport (equivalent to ~922 B of TKM).
-  **~1.0 BILLION LITERS OF BIOFUELS** consumed from biodiesel, green diesel and ethanol.
-  **~6% OF HYBRID VESSELS** making up the fleet, with a focus on inland navigation and support<sup>3</sup>.
-  **15% OF VESSELS** using synthetic fuels (PtX).

1. 2023; 2. 2050 Transformational; 3. Maritime and port support; 4. Power-to-X. Sources: Infra SA 2021; EPE; Interviews with sector experts; Clarkson; ANTAQ; DVN; RMI; Mpor.





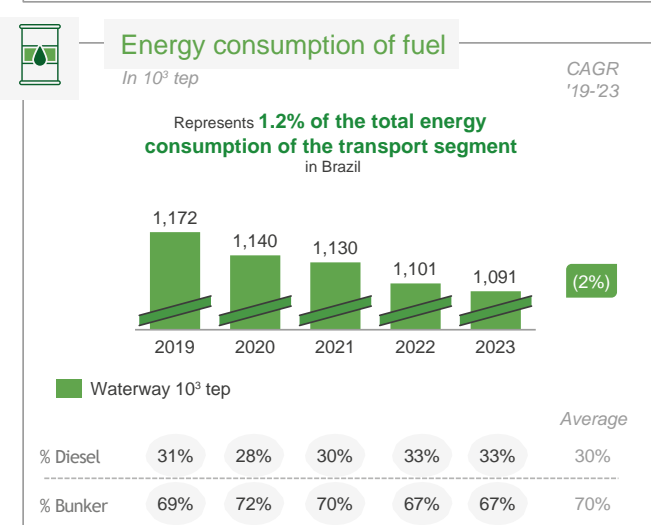
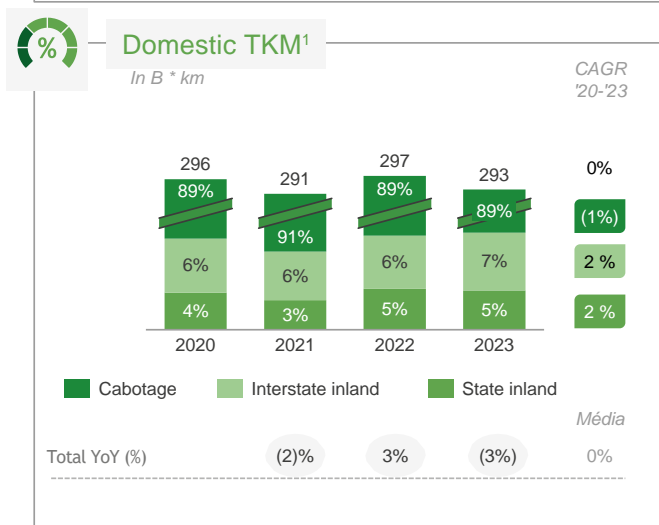
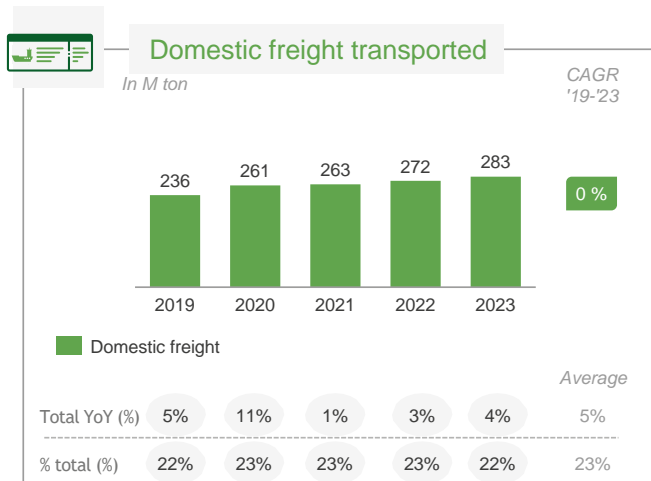
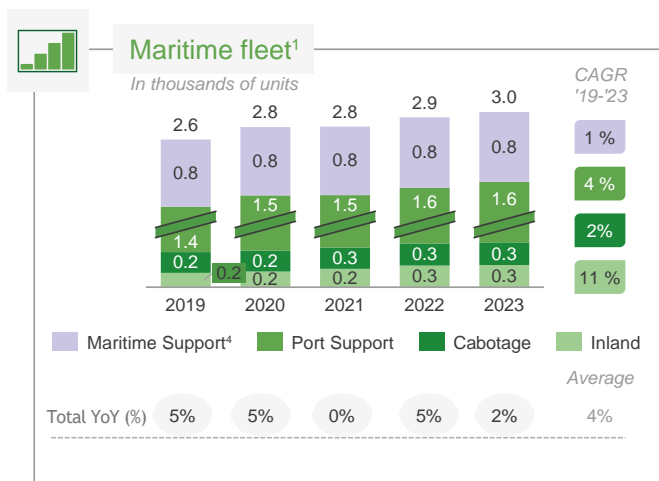
Details on the  
**WATER  
TRANSPORT  
MODE**

# KEY INDICATORS HELP IN UNDERSTANDING THE CURRENT STATE OF THE MODE

## WATER TRANSPORT

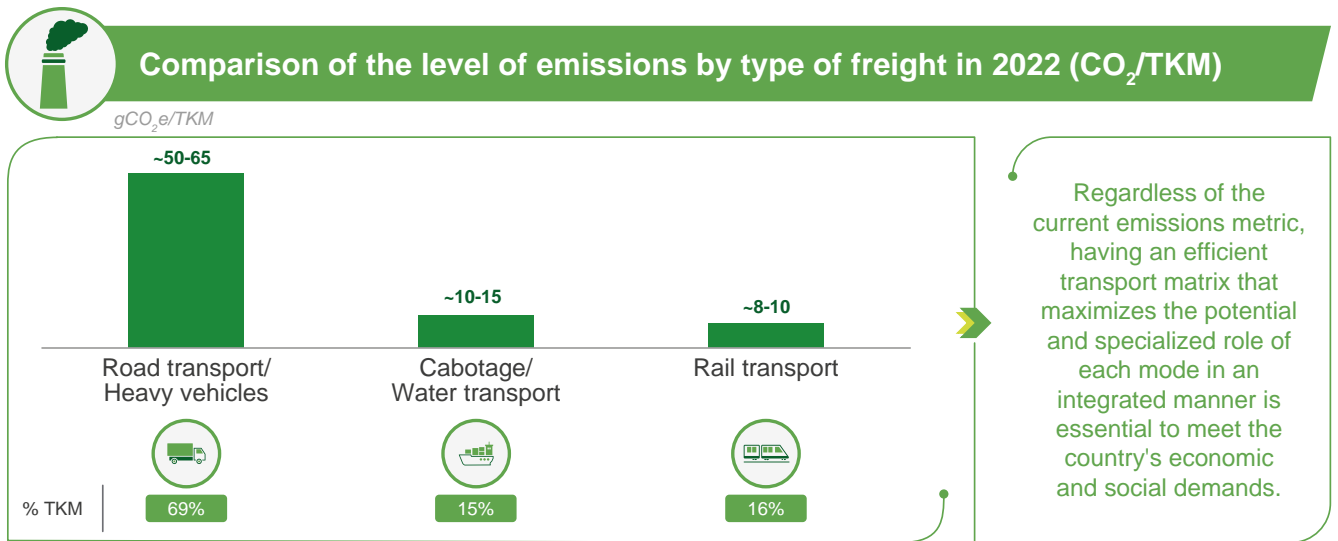
The domestic water transport sector (inland waterways, cabotage and port and maritime support) represents ~15% of Brazil's freight transportation and <1% of passengers in the same period.

KEY INFORMATION		2023	
● Domestic fleet <sup>1</sup>	3,080	● Port facilities <sup>3</sup>	218
● Domestic freight transported (ton)	283M	● Port complexes <sup>3</sup>	40
● Domestic TKM <sup>2</sup>	293B	● Energy consumption (10 <sup>3</sup> tep)	1,101
● Domestic port activity (ton)	372M	● CO <sub>2</sub> e Emissions – 2022 (CO <sub>2</sub> e)	4 Mton



(1) Does not consider ferries and support barges and passenger vessels; (2) Cabotage, interstate and state inland; (3) indicated in the ANTAQ Waterway Statistician with a single ID; (4) Maritime Support Fleet of platforms operating in AJB consists of 452 vessels.

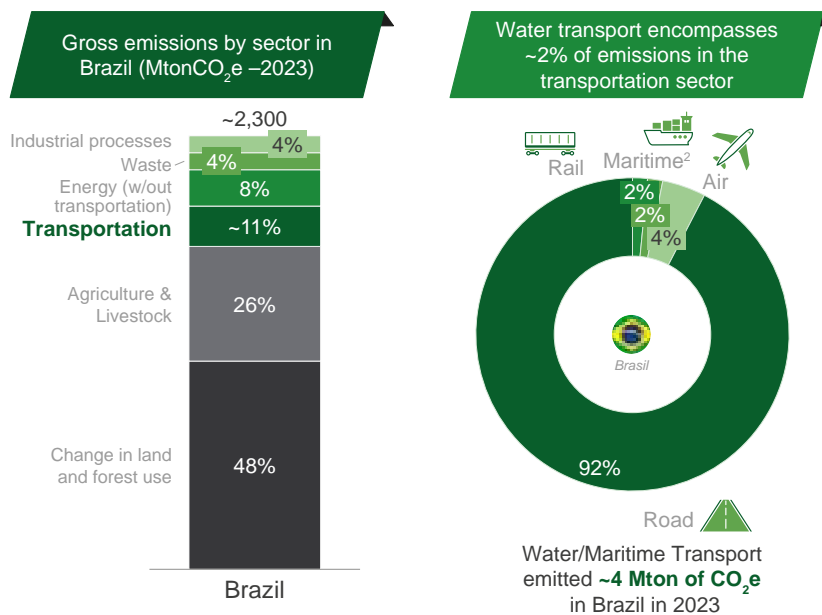
# IN BRAZIL, WHEN COMPARING CO<sub>2</sub>/TKM WITH MODES SUCH AS ROAD, THE WATER TRANSPORT SECTOR HAS A BETTER EMISSIONS PROFILE



1. Cabotage and Inland Transport at both State and Interstate levels; Sources: PNL 2035, ANTF, ANTT, SEEG.

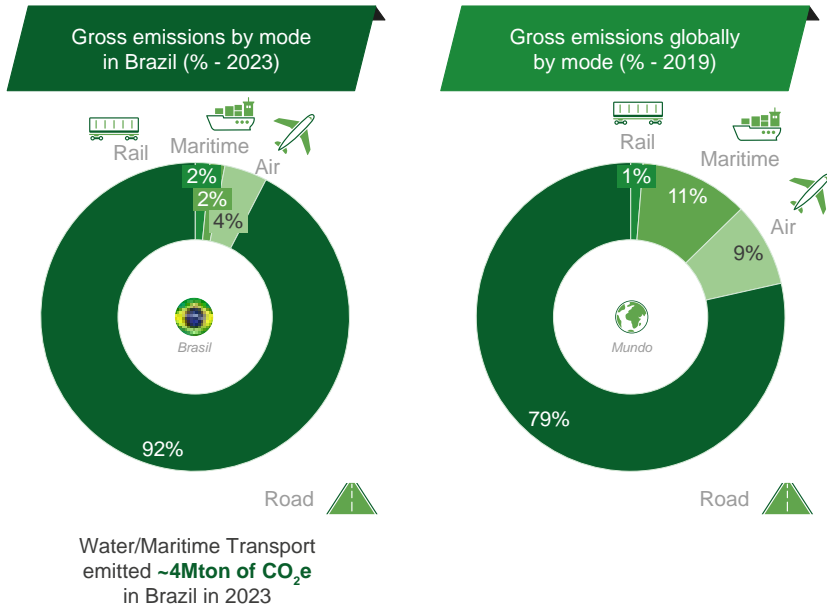
## THE TRANSPORTATION SECTOR IS CRITICAL FOR THE MITIGATION AGENDA, ACCOUNTING FOR ~11% OF NATIONAL EMISSIONS...

### ... WATER TRANSPORT EMITS ~2% OF THE TOTAL SECTOR



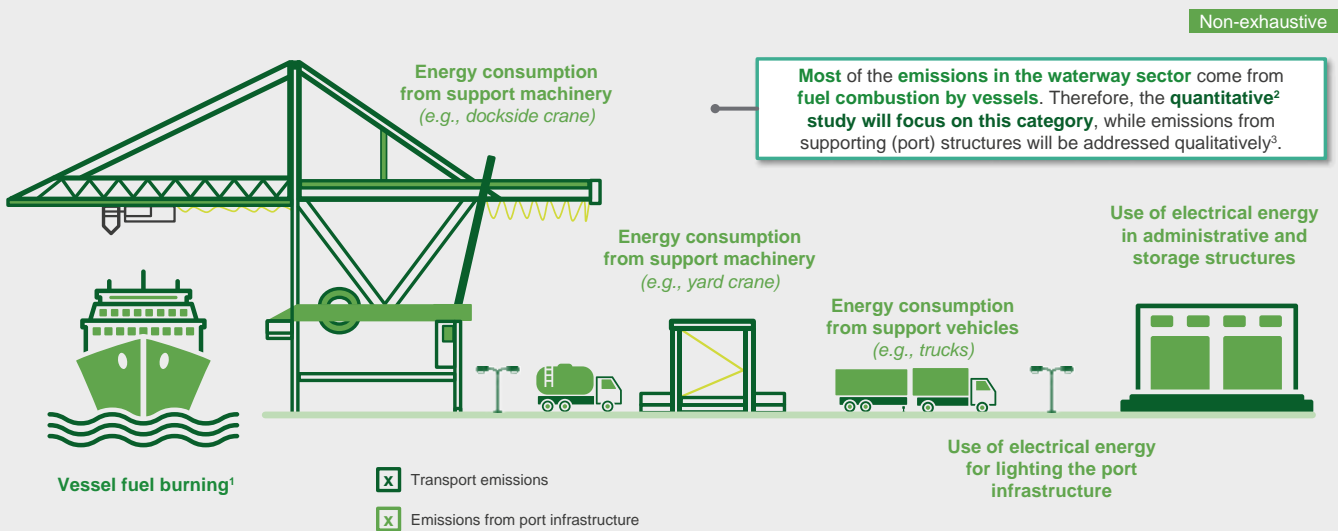
1. Transportation emissions reported by SEEG are restricted to the burning of fuels; 2. Considers cabotage and inland navigation, without long haul; 3. Global amount excluding Brazil. Sources: Anfavea; SEEG; CAIT; Climate TRACE.

# GLOBALLY, EMISSIONS FROM THE MARITIME/WATER TRANSPORT SECTOR REPRESENT ABOUT 11% OF THE TOTAL, WHILE IN BRAZIL THE METRIC IS LESS REPRESENTATIVE



1. Global amount excluding Brazil; 2. Others = mining, waste, construction, oil and gas, manufacturing, energy, agriculture, forests. Sources: Anfavea; SEEG; CAIT; Climate TRACE.

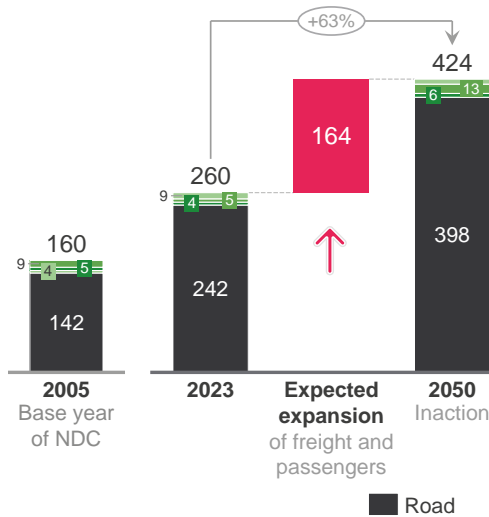
## EMISSIONS FROM THE WATER TRANSPORT ECOSYSTEM ARE DOMINATED BY TRANSPORTATION, WITH LESS CONTRIBUTION FROM PORT INFRASTRUCTURE



1. Port and maritime transport and support vessels; 2. The application of the levers took into account the diversity of the sector, covering different types of vessels and companies, and considering their varying characteristics in terms of size, resources, and capacity to adopt the identified levers; 3. Globally, emissions from ports represent <5% of total emissions from the water and maritime transport sector. Sources: PNL 2035, ANTF, ANTT, SEEG, OECD.

# SIZE OF THE CHALLENGE | IN A SCENARIO OF INACTION, THE SECTOR'S EMISSIONS COULD REACH UP TO 424 MTON CO<sub>2</sub>E IN 2050

## Emissions from the transport sector (MtonCO<sub>2</sub>e % by mode) – Well-to-wheel perspective



- Emissions **increase due to the growth of Brazil** (GDP 2.4% p.a.) as an emerging country...
- ... which is reflected in the **relevant growth forecast for the sector** (TKM 2.2% p.a. and PAX 0.7% p.a.).
- Even so, **Brazil's relative emissions are expected to be below those of developed countries** (1.9 tons CO<sub>2</sub>e per capita in 2050 vs. 5.6 in the US and 2.5 in France in 2023).

Sources: Transportation Sector Plans; Infra S.A.; PNL 2035. Note: Scenario of inaction considers demand projected for 2050 without progress in efficiency gains, increased electrification or expansion of the use of biofuels beyond those currently stipulated by law.

## WATER TRANSPORT GROUP | ABAC, ABANI, ABTP AND ATP COORDINATING DISCUSSIONS AND ENGAGEMENT OF OTHER MEMBERS



### Advisory Board:

CEBDS, Motiva, CNT/SEST SENAT and Insuper's National Sustainable Mobility Observatory.



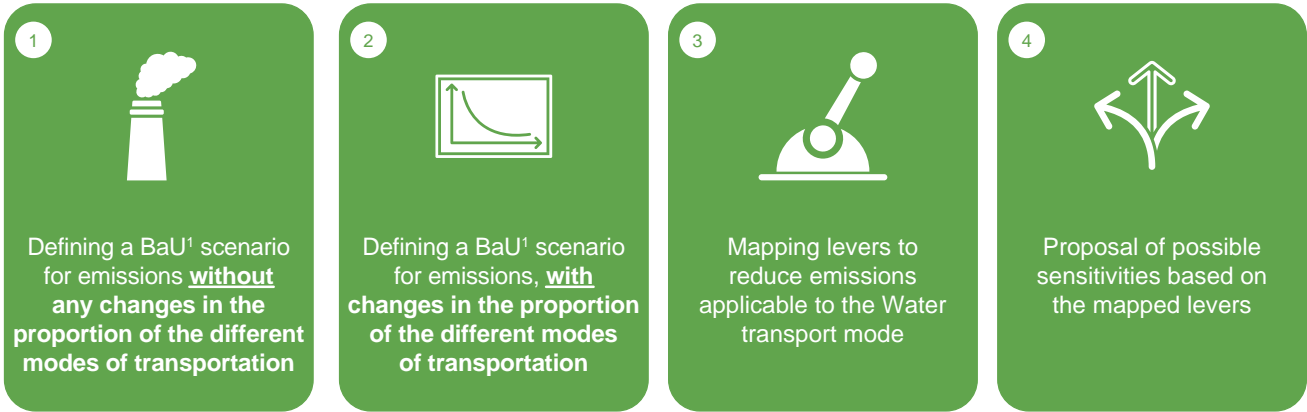
### Water transport group

- ☆ **ABAC** – Associação Brasileira de Armadores de Cabotagem (Brazilian Association of Cabotage Shipowners)
- ☆ **ABANI** – Associação Brasileira para o Desenvolvimento da Navegação Interior (Brazilian Association for the Development of Inland Navigation)
- ☆ **ABTP** – Associação Brasileira dos Terminais Portuários (Brazilian Association of Port Terminals)
- ☆ **ATP** – Associação de Terminais Portuários Privados (Association of Private Port Terminals)
  - ABRATEC
  - ABTRA
  - FENAMAR
  - FENAVERGA
  - Hidrovias do Brasil
  - Santos Brasil
  - Sindiporto
  - Syndarma

Legend | ☆ Coordinator | Other Members

# PATHWAYS TO DECARBONIZATION

## IDENTIFICATION OF THE MOST VIABLE PATHWAYS FOR REDUCING EMISSIONS IN THE WATER TRANSPORT SECTOR, STRUCTURED AROUND FOUR KEY STEPS



1. BaU = Business-as-usual.




## 2050 | COUNTERFACTUAL SCENARIO PREDICTS ~4.2 TRILLION TKM, WITH 15% LINKED TO THE WATER TRANSPORT MODE

Development of the matrix for 2050 projected based on the Transportation Sector Plans and PNL 2035



1. Road Transport Sector Plan (PSTR); Rail Transport Sector Plan (PSTR); 2. PNL 2035 – National Logistics Plan; 3. Base year = 2021, with the National Logistics Plan (PNL) projected using the respective CAGRs of the reference scenario versus 2017. 4. TKM 2035 values refer to the PSR1 scenario of the PSTR and PAX values come from the reference scenario of the PNL 2035 passenger matrix. 5. TKM projected in line with GDP, maintaining the modal share from the PSR3 scenario of the PSTR; PAX projected according to population growth, with no change in modal share. 6. Air transport is only marginally representative in total freight volumes; 7. The passenger figures presented in the PNL reflect only intermunicipal and interstate travel, and do not account for intra-urban passenger travel. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

2

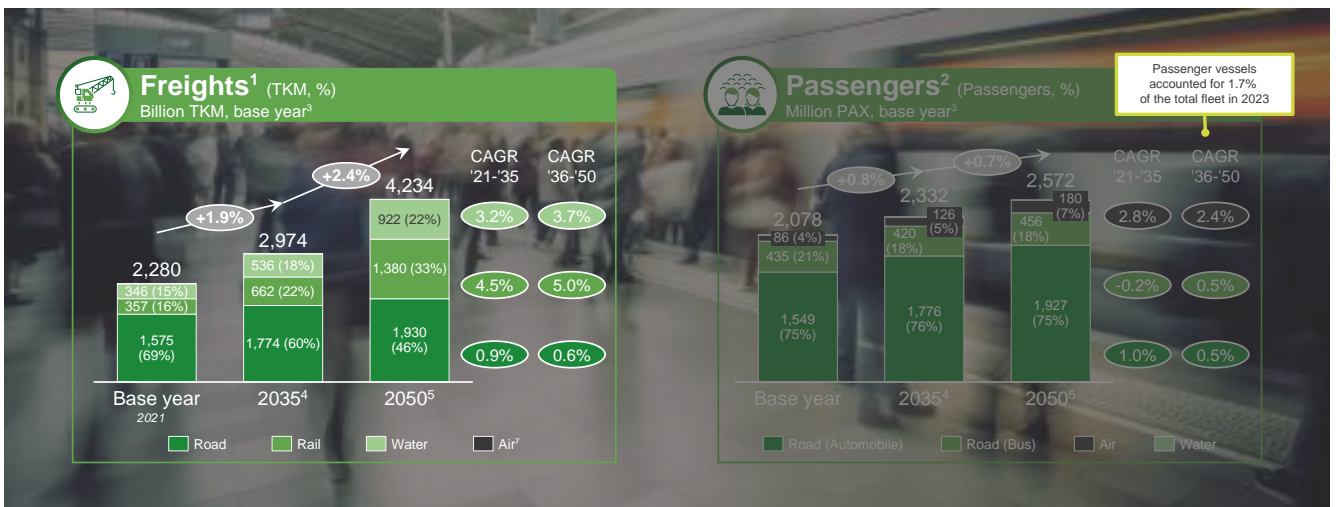


Defining a BaU<sup>1</sup> scenario for emissions, with changes in the proportion of the different modes of transportation

## STEP 2

# 2050 | BY BALANCING THE LOGISTICS MATRIX, WATER TRANSPORT INCREASES ITS SHARE TO 22% OF TOTAL TRANSPORTED TKM

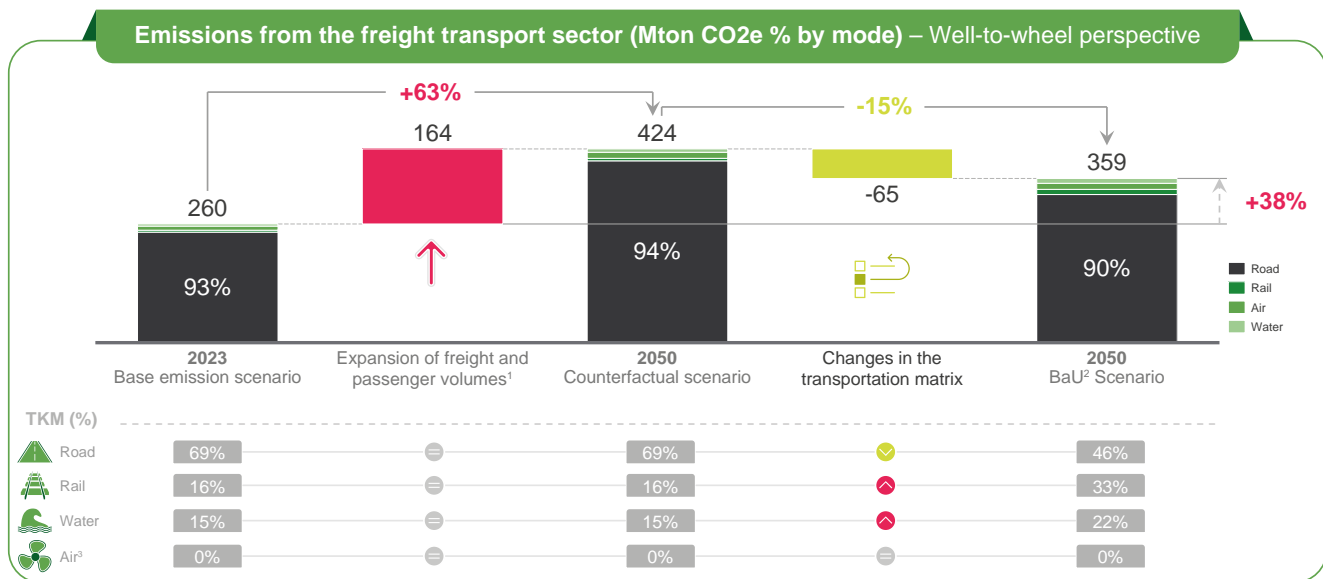
Development of the matrix for 2050 projected based on the Transportation Sector Plans and PNL 2035



1. Road Transport Sector Plan (PSTR); Rail Transport Sector Plan (PSTF); 2. PNL 2035 – National Logistics Plan; 3. Base year = 2021, with the National Logistics Plan (PNL) projected using the respective CAGRs of the reference scenario versus 2017. 4. TKM 2035 values refer to the PSR1 scenario of the PSTR and PAX values come from the reference scenario of the PNL 2035 passenger matrix. 5. TKM is projected based on GDP growth, using the modal share from the PSR3 scenario of the PSTR, while PAX is projected according to population growth, assuming constant modal share; 6. The passenger figures presented in the PNL reflect only intermunicipal and interstate travel, and do not account for intra-urban passenger travel; 7. The air transport mode is not very representative in terms of freight transported compared to the total. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

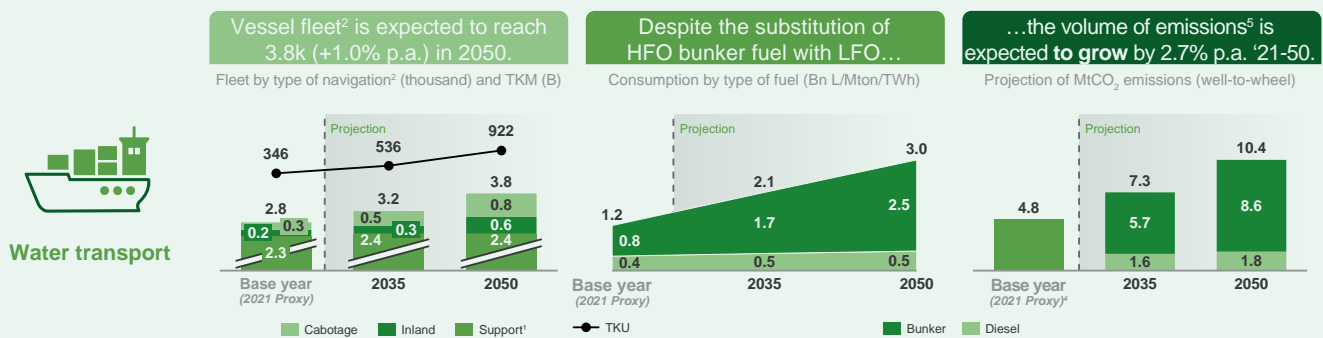


# BALANCING THE BRAZILIAN TRANSPORTATION MATRIX CAN AVOID AN INCREASE OF ~15% IN THE VOLUME OF CO<sub>2</sub> EMISSIONS BY 2050



1. Increased emissions due to the expected growth in demand for TKM and passengers until 2050; 2. Business-as-usual; 3. Air transport emissions are not related to freight transport, only to passenger transport.

## BaU<sup>1</sup> | VOLUME OF EMISSIONS EXPECTED TO GROW AT 2.7% P.A. BY 2050



### Key assumptions

**Electrification**

- Does not consider fleet electrification.

- The adoption of Power-to-X technologies is not considered at this stage, given the current low level of technological maturity for this mode of transport.

- n.a.

**Biofuels**

- 100% use of high carbon footprint fuels (bunker and diesel) in 2021.

- Does not consider an increase in biodiesel in the diesel or bunker mixture
- Considers gradual substitution of HFO bunker fuel with LFO<sup>3</sup>.

- Bunker HFO: 3.66 kg CO<sub>2</sub>/L.
- Bunker LFO: 3.26 kg CO<sub>2</sub>/L.
- Diesel (MGO): 3.37 kg CO<sub>2</sub>/L.

**Efficiency**


- Does not consider an increase in average distance traveled efficiencies or average ton moved per vessel (TKM per vessel remains constant).

- Does not consider additional efficiency gains in fuel consumption per vessel versus current (0.2 and 2.7 L / vessel in diesel and bunker engines, respectively).

- Does not consider efficiency gains in time emission factors.

Notes: 1. Maritime and port support; 2. Total number of ANTAQ fleet (in operation, approved and considered part of the existing fleet); 3. HFO = Heavy Fuel Oil and LFO = Light Fuel Oil (ULSFO and VLSFO), with the second having a lower content of greenhouse gases; 4. The SEEG emission was adjusted by a Well-to-Tank (WTT)/Tank-to-Wheel (TTW) emission factor from the water transport mode.

3



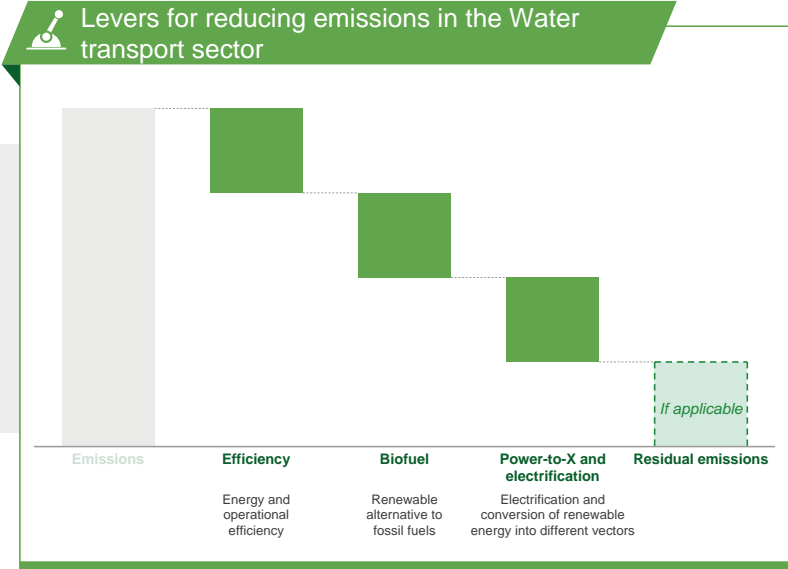
Mapping levers to reduce emissions applicable to the Water transport mode

# STEP 3

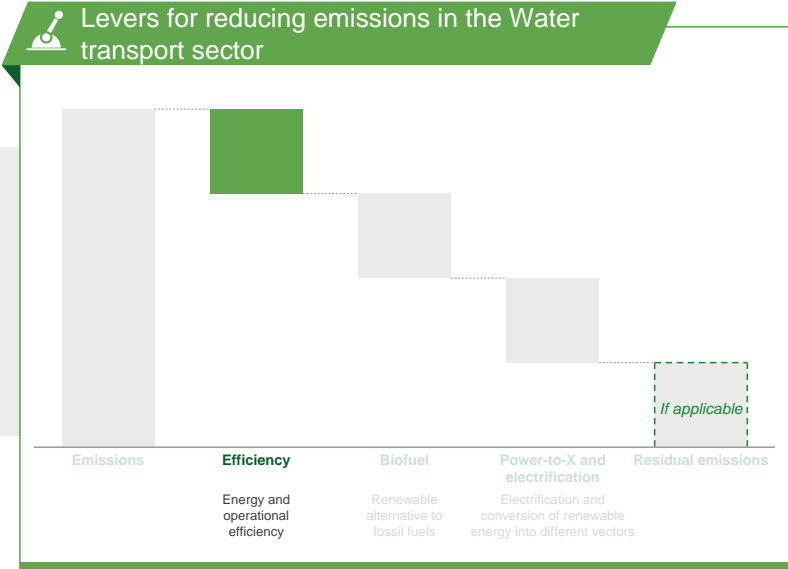
## TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE WATER TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS

The application of the levers took into account the diversity of the sector, covering different types of vessels and companies, and considering their varying characteristics in terms of size, resources, and capacity to adopt the identified levers.

Illustrative



Illustrative



# EFFICIENCY | THE IMPLEMENTATION OF EFFICIENCY GAIN MEASURES IS PARAMOUNT FOR REDUCING EMISSIONS FROM VESSELS...

Non-exhaustive

Levers – Vessels (1/2)	Current feasibility analysis <sup>1</sup>	References
<p>1 Adoption of <b>innovative materials and technologies</b> in the construction and operation of vessels to <b>improve hydrodynamic design and performance.</b></p>	<p>Ease of implementation varies by solution, some requiring higher investments.</p>	<p><b>MAERSK  </b> Focus on increasing the energy efficiency of the fleet by implementing technologies that provide better <b>hydrodynamic performance in owned and chartered vessels</b> (e.g., improved propellers, bulbous bows, and shore power capabilities).</p>
<p>2 <b>Intelligent route optimization and fleet allocation</b>, reducing average distances traveled.</p>	<p>Implementation is somewhat challenging due to reliance on multiple stakeholders, but there is potential for short/medium term benefits.</p>	<p><b>Transpetro  </b> Contributes to fuel consumption reduction through the <b>use of algorithms and software for route optimization</b> and decision support for fleet commanders.</p>
<p>3 <b>Reduce and control the average speed</b> of vessels to <b>lower fuel consumption and optimize energy efficiency.</b></p>	<p>Short-term impacts are expected, but the mode faces challenges related to potential loss of competitiveness.</p>	<p><b>MAERSK  </b> <b>Slow steaming is adopted as a strategy to reduce the speed of ships by up to 20%</b>, reducing fuel consumption by up to 40% and promoting energy efficiency and lower CO<sub>2</sub> emissions.</p>
<p>4 Use other <b>technical solutions to support</b> emission reduction, like <b>waste heat recovery, liquid cooling system</b>, and others.</p>	<p>Implementation varies by solution, but they are typically low-complexity design enhancements.</p>	<p><b>NORSUL  </b> Online monitoring system for <b>vessel emissions</b>, which stores and processes sensor data predicting the CII2 Rating and indicating the carbon efficiency of the fleet, resulting from the reduction solutions implemented.</p>

The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. Carbon Intensity Indicator. Sources: EPE; IMO; Trafigura; Transpetro (RI).

Non-exhaustive

Levers – Vessels (2/2)	Current feasibility analysis <sup>1</sup>	References
<p>5 Integrate <b>electric wind-assisted propulsion technologies (WAPs)</b> to complement traditional motorization.</p>	<p>Despite the potential for impact, retrofits are limited to specific routes/conditions.</p>	<p><b>Mitsubishi Corporation and Cargill  </b> In 2023, they carried out Pyxis Ocean's maiden voyage to Brazil; the ship is the first to be equipped with two <b>WindWings</b>, reducing emissions by up to 30%.</p>
<p>6 <b>Increase the size of vessels and/or configurations</b>, thereby decreasing the frequency of trips required.</p>	<p>Long-term capture, given the dependence on fleet renewal.</p>	<p><b>Hapag-Lloyd  </b> It increased its capacity by 19% in 2024, incorporating new vessels and <b>acquiring 9 neo-Panamax ships, which were retrofitted to increase capacity from ~13,000 TEUs<sup>3</sup> to 15,440 TEUs<sup>3</sup>.</b></p>
<p>7 <b>Maximize how space and resources are utilized during each journey</b> (Stowage Factor), ultimately reducing the number of trips required and <b>improving the use of the fleet.</b></p>	<p>Additional gains beyond current levels often depend on external factors, such as water draft limitations.</p>	<p><b>Maersk, CMA CGM and Hapag-Lloyd  </b> They use advanced <b>freight planning tools that optimize the distribution and use of space on ships</b> (e.g. Octopus), increasing the operational efficiency and use of the capacity of the vessels.</p>

The greener, the more viable.


Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency, and Time to Implementation, as well as inputs gathered during the Listening Session with the group; 3. Twenty-foot Equivalent Unit. Sources: EPE; IMO; Trafigura; O Globo.

# EFFICIENCY I ...AS WELL AS FOR EMISSIONS FROM BRAZILIAN PORT INFRASTRUCTURE

First levers consider the impact/feasibility of reducing emissions on the part of vessels.

Non-exhaustive


Levers – Port Infrastructure (1/2)	Current feasibility analysis <sup>1</sup>	References
<p>1 Enabling infrastructure and facilitating access, thereby reducing the average waiting and docking time through the construction of more or larger, terminals/berths.</p>	<p>High potential for impact, but linked to large investments in CAPEX.</p>	<p>Port of Santos   The government will auction the STS10 terminal in 2025, with an expansion of four berths, increasing capacity by 50% and reducing waiting time for berthing.</p>
<p>2 Implementing trade facilitation strategies to streamline port operations and minimize freight turnaround times.</p>	<p>Implementation is challenging due to reliance on multiple stakeholders, but there is potential for short-term benefits.</p>	<p>Port of Rotterdam   The Port Community System (PCS) is a platform that connects port operators, customs and logistics companies, integrating information to streamline processes and reduce freight turnaround time.</p>
<p>3 Construction and provision of OPS (onshore power supply) structures for vessels<sup>2</sup>.</p>	<p>High potential for impact, however, with the need for investments in infrastructure and technological evolution.</p>	<p>Port of Hamburg   Adapted terminals for electricity supply to moored vessels (OPS<sup>3</sup>) from 2025.</p>
<p>4 Optimization of vessel mooring management through the use of data intelligence tools.</p>	<p>Implementation is relatively easy, with potential in the short/medium term.</p>	<p>Port of Rotterdam   Ship arrival tracking system, avoiding unnecessary retentions at the terminals.</p>

 The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. OPS = onshore power supply that allows vessels auxiliary engines to be shut down while they are moored. Sources: Maersk; EPA; Website Portos; ANTAQ; MPor.

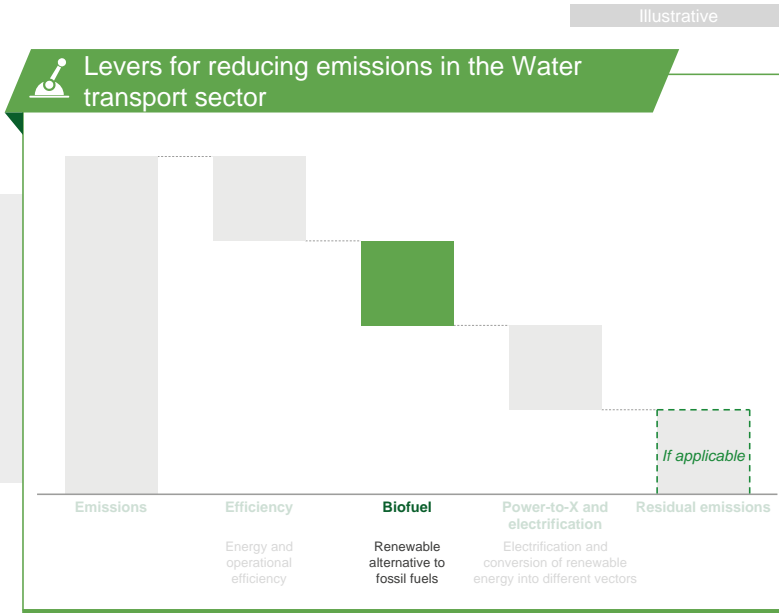
Non-exhaustive

Levers – Port Infrastructure (2/2)	Current feasibility analysis <sup>1</sup>	References
<p>5 Implementation of strategies to optimize support systems, including automated lighting and water and waste management.</p>	<p>Implementation is simple and relatively low cost, with potential for return in the short term.</p>	<p>Port of Hamburg   Intelligent lighting system, with sensors installed that recognize traffic and make lighting level adjustments with its intensity.</p>
<p>6 Renewal of the support fleet (vehicles and machinery) for newer and more energy-efficient models.</p>	<p>Medium/long term capture, given the dependency on fleet renewal.</p>	<p>PSA<sup>2</sup>   Investments were made in autonomous and electric vehicles for container handling, along with automated cranes featuring optimized energy consumption—enhancing productivity while reducing environmental impact.</p>

 The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. Port Singapore Authority. Sources: Maersk; EPA; Website Portos; ANTAQ; MPor.

# TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE WATER TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS



## BIOFUELS | LNG AND BIOMETHANOL STUDIES ALREADY EXIST WITHIN THIS TRANSPORT MODE; THEIR USE, ALONG WITH OTHER SOLUTIONS, CAN BE EXPANDED

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

Non-exhaustive

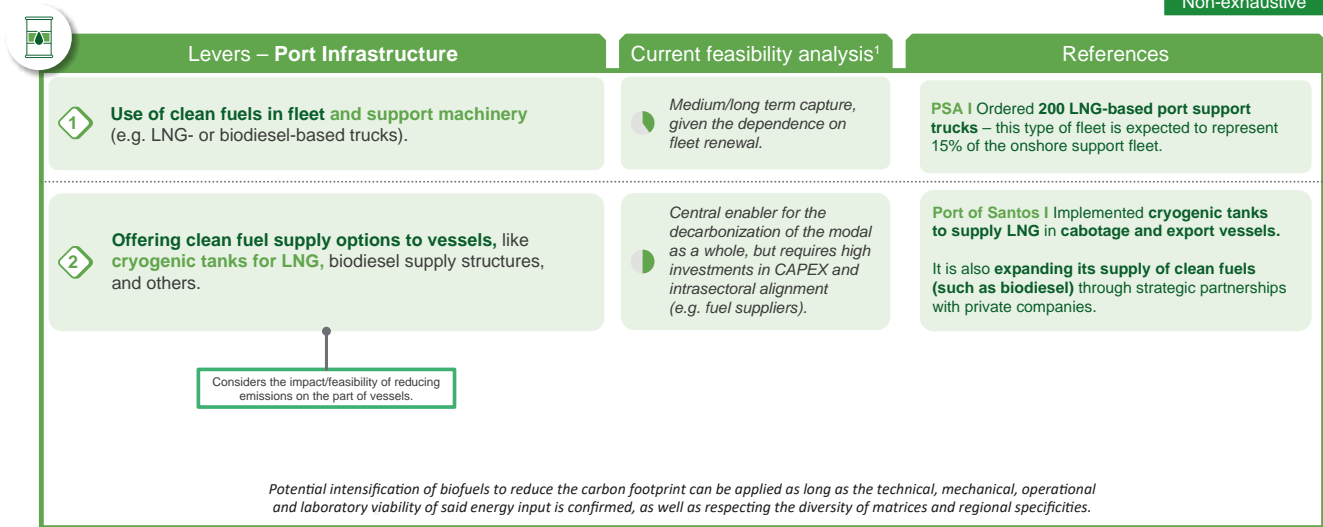
Levers – Vessels	Current feasibility analysis <sup>1</sup>	References
<p>1 <b>Intensification of the use of biodiesel (FAME)</b> as an alternative to fossil or bunker diesel, or as a <b>blending component</b>.</p>	<p>It requires adjustments across the production chain and assurance of product quality, as well as technical and economic feasibility analyses.</p>	<p><b>COSCO   Pilot project for biodiesel on ships</b> includes Venus (B24) and Sagittarius (B20) tests; in Brazil, the ANP authorized Petrobras to market a bunker with 24% biodiesel and to carry out tests with larger blends in river transport.</p>
<p>2 Use of <b>Bio-Liquefied Natural Gas (Bio-LNG)</b> as an <b>energy source</b> for vessels.</p>	<p>Available in the short term as a good transition solution, however, it requires adaptations to current engines<sup>2</sup>.</p>	<p><b>MAERSK   Investment in new vessels with dual fuel technology</b>, including the ability to operate with Bio-LNG and, in parallel, signing fuel supply agreements to ensure emission reduction.</p>
<p>3 <b>Use of other biofuels</b> – such as <b>ethanol, biomethanol and HVO</b> – as alternative energy sources to the current matrix.</p>	<p>Requires investment in retrofit or exchange of engines<sup>2</sup> and availability of fuels given the intra-sectoral demands.</p>	<p><b>MAERSK   The Laura Mærsk</b> is the <b>world's first container ship capable of running on green methanol</b>. The company signed an agreement with Goldwind, ensuring 500k tons of green methanol per year starting from 2026.</p>
<p>4 <b>Replacement of HFO bunker</b> use with <b>LFO bunker</b> or <b>use of ammonia</b> (lower carbon footprint versus currently used options) and <b>LNG</b> (liquefied natural gas).</p>	<p>Implementation depends on the solution, but generates quick gains in the short term.</p>	<p><b>CMA CGM   Operation of the CMA CGM Jacques Saadé</b>, an <b>LNG-powered container carrier</b> with a capacity of 23,000 TEUs<sup>3</sup>, which promises to reduce ~99% of sulfur emissions, ~85% of nitrogen oxides and 20% of CO<sub>2</sub>.</p>

● The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. E.g.: implementation of dual fuel systems; 3. Twenty-foot Equivalent Unit. Sources: EPE; IMO; ANAP; Ministry of Mines and Energy.

# BIOFUELS | BIODIESEL AND LNG CAN BE GOOD OPTIONS FOR REDUCING EMISSIONS FROM THE PORT SUPPORT FLEET

Non-exhaustive

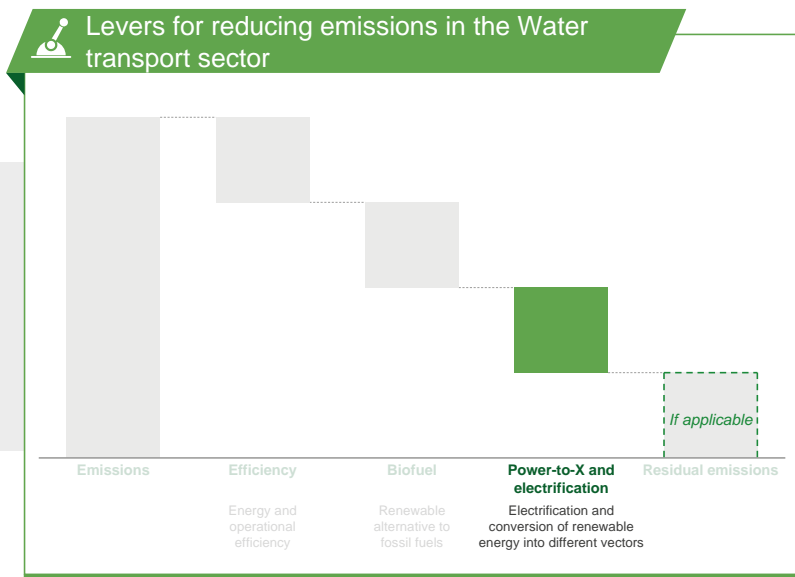


The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. e.g.: implementation of dual-fuel systems; 3. Twenty-foot Equivalent Unit. Sources: EPE; IMO; ANAP; Ministry of Mines and Energy.

# TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE WATER TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS

Illustrative



# PTX AND USE OF BATTERIES | DESPITE THEIR CURRENT TECHNOLOGICAL IMMATURITY, THESE SOLUTIONS COULD BECOME FEASIBLE OPTIONS FOR MARITIME FLEETS IN THE MEDIUM/LONG RUN

Non-exhaustive

Levers – Vessels	Current feasibility analysis <sup>1</sup>	References
<p>1 Use of <b>synthetic fuels (PtX: PtLe PtG<sup>2</sup>)</b>, such as <b>e-methane, e-methanol and e-ammonia</b>, produced from green hydrogen, renewable electricity and captured CO<sub>2</sub>.</p>	<p>It requires investments in tests given the immaturity of the technology, but there is a high potential for reducing emissions.</p>	<p><b>CMA CGM</b>   Entered into agreements with MASDAR, COSCO SHIPPING and SIPG to supply 24 new ships in its fleet with <b>e-methanol</b>.</p>
<p>2 <b>Shift to hybrid</b> (or electric) technologies in <b>small-scale and short-haul maritime operations</b> to replace fossil fuels and cut CO<sub>2</sub> emissions.</p>	<p>Limited to small and short-haul vessels currently, scale depends on technological developments.</p>	<p><b>Equinor and CBO</b>   Operation of <b>hybrid offshore vessels (PSVs<sup>4</sup>)</b>, combining electric batteries and diesel engines, began in Brazil in 2023.  <b>Waterways of Brazil</b>   First <b>hybrid pusher boats</b> in the world at the beginning of operation.</p>
<p>3 The direct use of <b>green hydrogen in fuel cells</b> offers a zero carbon and efficient alternative.</p>	<p>High cost of technology and a dearth of technical proof make the solution less viable, even in the medium term.</p>	<p><b>Flagships Project</b>   <b>Pilot project</b> to integrate <b>hydrogen fuel cells</b> into commercial vessels in Europe, including <b>river vessels</b> such as H2 Barge 2.</p>

The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. PtX: Power-to-X, PtL: Power-to-Liquid, and PtG: Power-to-Gas; 3. PSV: Platform Supply Vessels 4. Platform Supply Vessels. Sources: EPE; IMO; CBO; CNN; RMI; Flagships Project.

# PTX AND USE OF BATTERIES | ELECTRIFICATION, CLEAN ENERGY AND INFRASTRUCTURE ARE ESSENTIAL LEVERS TO DECARBONIZE PORT OPERATIONS

Non-exhaustive

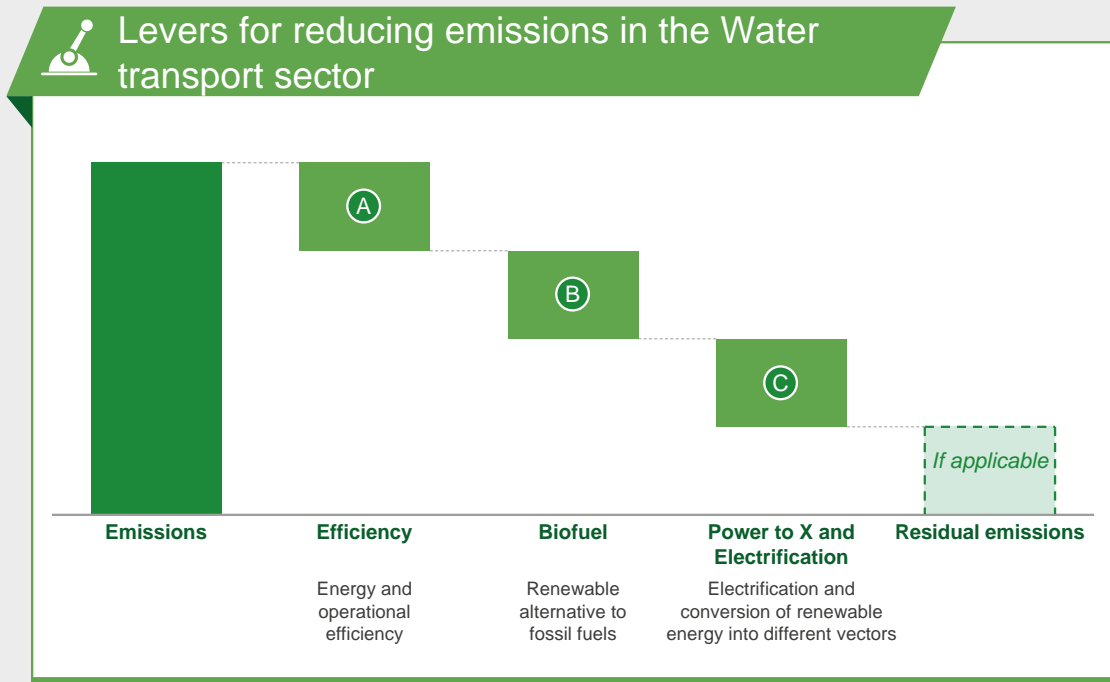
Levers – Port Infrastructure	Current feasibility analysis <sup>1</sup>	References
<p>1 Use of <b>renewable energy in the groups' port and administrative operations</b> (e.g., use of solar/wind energy in offices, for port lighting, etc.).</p>	<p>Implementation depends on the feasibility of providing renewable energy and on achieving a competitive advantage in terms of price.</p>	<p><b>Port of Rotterdam</b>   Integrates port support solutions with <b>renewable energy</b>.</p>
<p>2 <b>Hybridization or electrification</b> of the <b>fleet of vehicles and port support machinery</b> (e.g., 100% electric yard and dock trucks and cranes).</p>	<p>Medium/long term capture, given the dependence on fleet and equipment renewal.</p>	<p><b>PSA</b>   Development of <b>Tuas Mega Port</b> – the largest automated terminal in the world, with more than a thousand <b>battery-powered vehicles</b>.  <b>Santos Brasil</b>   Replacement of all RTGs<sup>2</sup> diesel cranes with <b>electric models</b> at Santos Terminal by 2031.</p>

The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. Rubber-Tired Gantry Cranes 3. Onshore Power Supply. Sources: Maersk; EPA; Website Portos; ANTAQ; MPor.

# WHICH WERE QUANTIFIED<sup>2</sup> IN DIFFERENT SENSITIVITIES

Illustrative




Quantification of each lever's impact on emission levels, based on four possible combinations of measures:



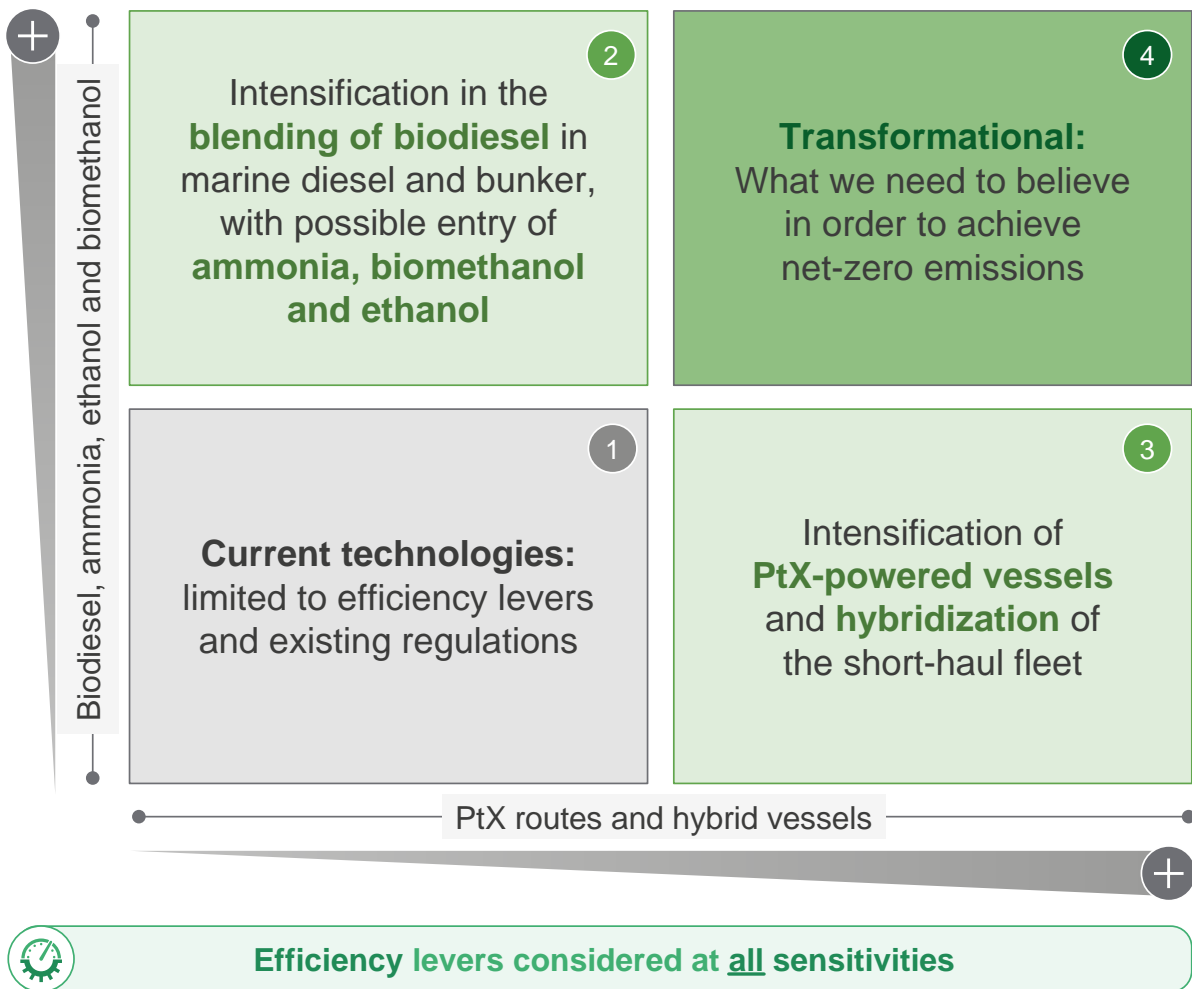
1. Unquantified port emissions.



4  
  
 Proposal of possible sensitivities based on the mapped levers

## STEP 4

# VIABLE LEVERS FOR THE BRAZILIAN CASE WERE CONSIDERED FOR THE PROPOSAL OF FOUR SENSITIVITIES AIMED AT ACHIEVING NET-ZERO EMISSIONS IN THE WATER TRANSPORT MODE

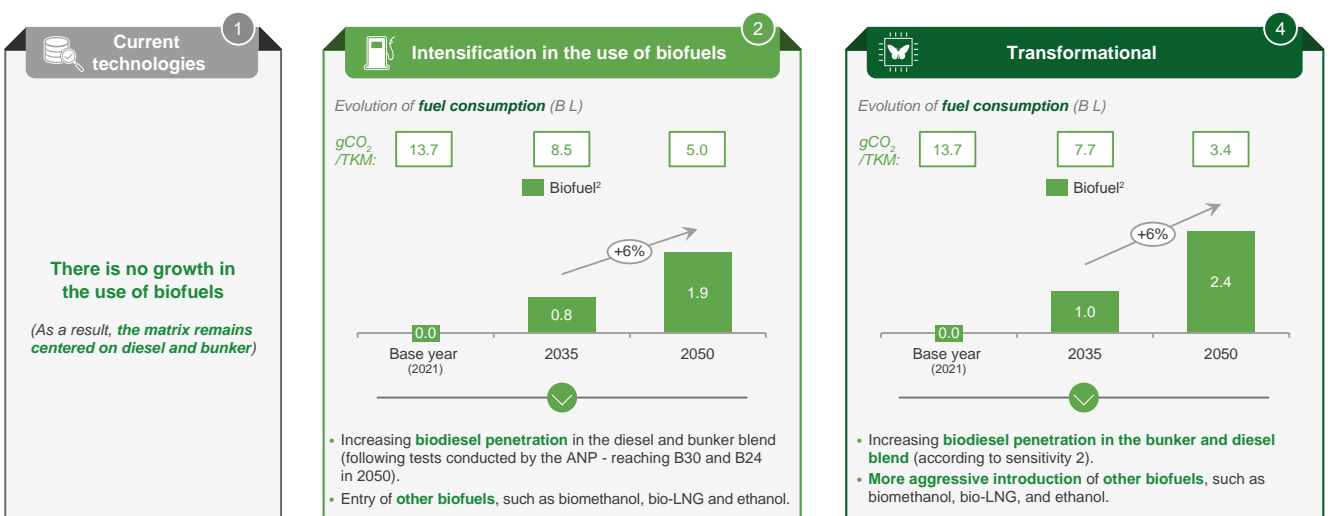


# THE PROPOSED SENSITIVITIES WERE BASED ON VARYING ASSUMPTIONS...

	1	2	3	4
	Current technologies	Intensification in the use of biofuels	Intensification of the PtX route and hybridization	Transformational
Efficiency levers	Efficiency in Ports	✓	✓	✓
	Efficiency in Transportation <sup>1</sup>	✓	✓	✓
Biofuel levers <sup>2</sup>	Use of biodiesel	-	-	-
	Use of LNG and Bio-LNG	-	<ul style="list-style-type: none"> <li>• Use of B20 in diesel from 2030, reaching B24 in 2040.</li> <li>• Use of B24 in the bunker from 2030.</li> <li>• Reaching 13% of the matrix in 2050.</li> </ul>	<ul style="list-style-type: none"> <li>• Use of B20 in diesel from 2030, reaching B24 in 2040.</li> <li>• Use of B24 in the bunker from 2030.</li> <li>• Reaching 7% of the matrix in 2050.</li> </ul>
	Replacement of bunker HFO with LFO	<ul style="list-style-type: none"> <li>• Same as baseline – gradual replacement, with LFO reaching 50% of the bunker in 2050.</li> </ul>	<ul style="list-style-type: none"> <li>• Same as baseline – gradual replacement, with LFO reaching 70% of the bunker in 2050.</li> </ul>	<ul style="list-style-type: none"> <li>• Same as baseline – gradual replacement, with LFO reaching 50% of the bunker in 2050.</li> </ul>
PtX and electrification levers	Other fuels with a lower carbon footprint	-	<ul style="list-style-type: none"> <li>• Gradual entry of ammonia, biomethanol and ethanol from the matrix (8%, 9% and 9% of the matrix in 2050, respectively).</li> </ul>	<ul style="list-style-type: none"> <li>• Transition fuel between current fuels and biofuels and PtX.</li> <li>• Represents 4% of the matrix in 2050.</li> <li>• Faster replacement, WITH LFO reaching 100% of the bunker in 2050.</li> <li>• Gradual addition of ammonia (6%), biomethanol (18%), ethanol (15%) into the matrix.</li> <li>• Ammonia paving the way for PtX solutions starting from 2040.</li> </ul>
	PtX Solutions <sup>1</sup>	-	<ul style="list-style-type: none"> <li>• Gradual entry of PtX solutions (e-ammonia and e-methanol).</li> <li>• Reaching 18% of the energy matrix (MJ) in 2050.</li> </ul>	<ul style="list-style-type: none"> <li>• Gradual entry of PtX solutions (e-ammonia and e-methanol).</li> <li>• Reaching 20% of the energy matrix (MJ) in 2050.</li> </ul>
	Use of battery solutions (hybrids)	-	-	<ul style="list-style-type: none"> <li>• Focus on hybrid maritime and port support vessels.</li> <li>• 8% of the hybrid support fleet in 2050 (195 vessels).</li> </ul>

1. Only the levers for which numerical references were found have been quantified; 2. Matrix = energy matrix (MJ), does not consider electricity consumption; 3. Potential intensification of biofuels to reduce the carbon footprint can be applied as long as the technical, mechanical, operational and laboratory viability of said energy input is confirmed, as well as respecting the diversity of matrices and regional specificities. Sources: EPE; Interviews with sector experts; Clarkson; ANTAQ; DVN; RMI; Mpor.

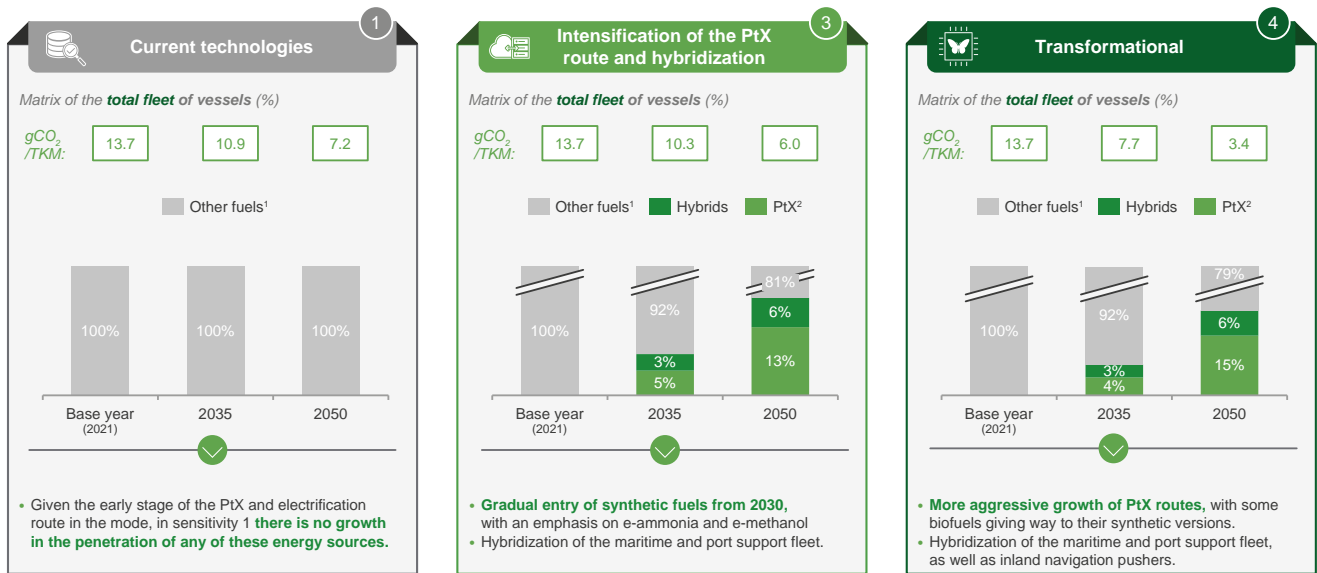
# THE USE OF BIOFUELS INCREASES IN SCENARIOS FOCUSED ON ENERGY MATRIX TRANSITION, CONTRIBUTING TO REDUCED FOSSIL FUEL CONSUMPTION



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

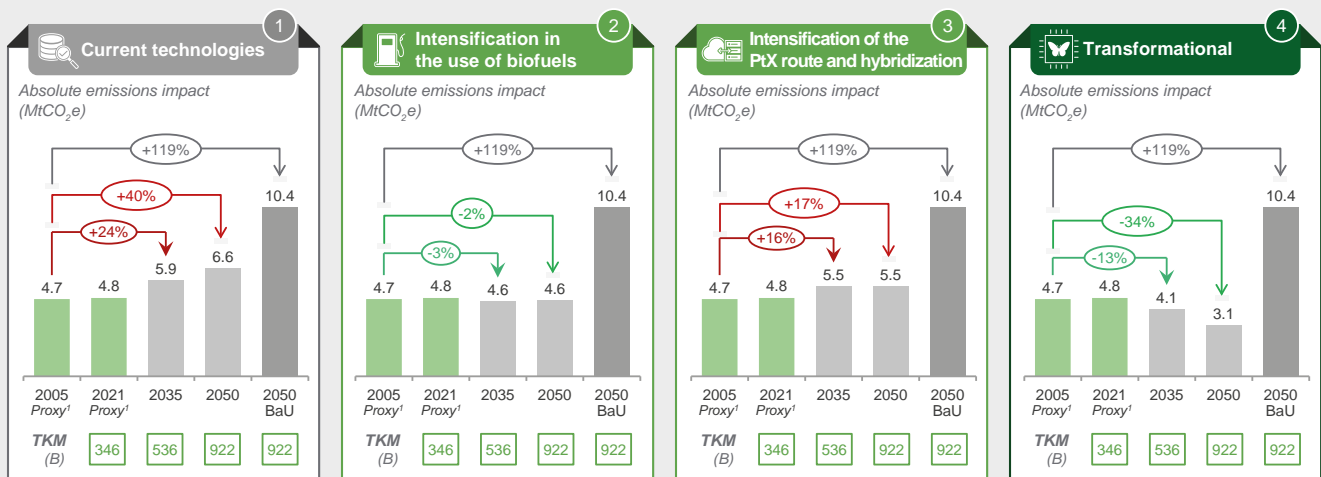
1. Current matrix fuels (diesel and bunker); 2. Biofuels: biodiesel, bio-LNG/LNG, biomethanol and ethanol (ammonia is not being accounted for). Sources: EPE; Interviews with sector experts; Clarkson; ANTAQ; DVN; RMI; Mpor.

# THE ENTRY OF PTX AND HYBRID ROUTES ARE EXPECTED TO INTENSIFY AS OF 2035, REACHING ~20% OF THE TOTAL FLEET



1. Includes fossil fuels and biofuels; 2; PtX = Power-to-X (green hydrogen route transformed into synthetic fuels such as e-ammonia and e-methanol). Sources: EPE; Interviews with sector experts; Clarkson; ANTAQ; DVN; RMI; Mpor.

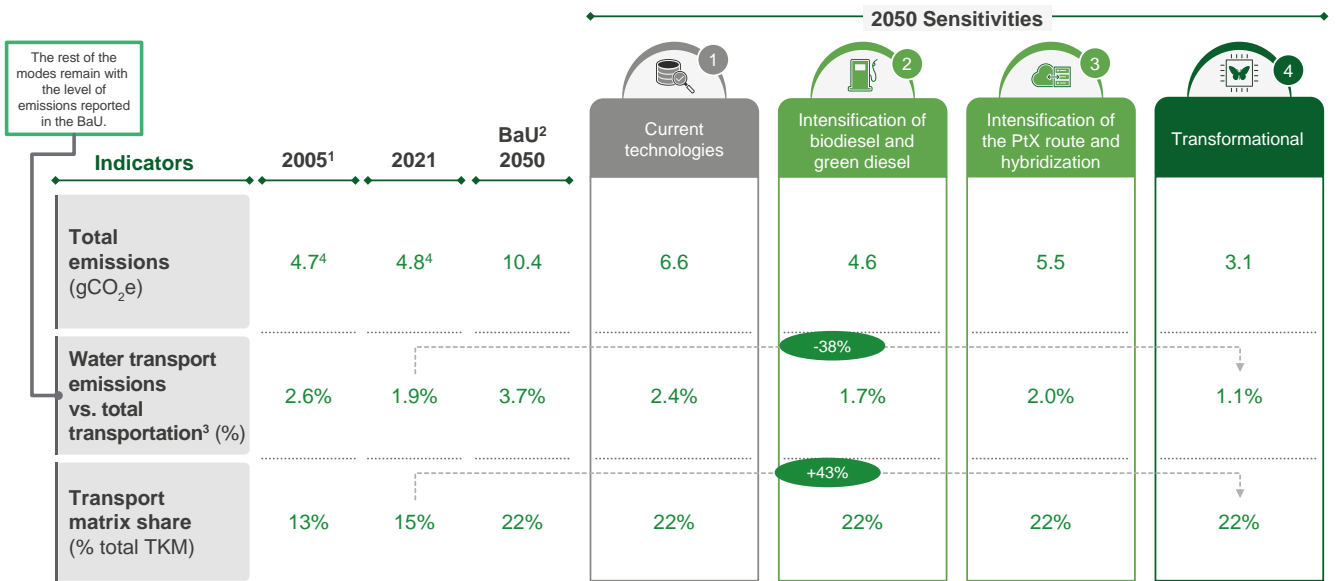
# THE PROPOSED SENSITIVITIES ARE ABLE TO PREDICT DIFFERENT POTENTIAL IMPACTS ON THE LEVEL OF EMISSIONS



The rise in emissions stems from increased TKM in the mode; however, the growth is lower compared to the BaU — growth of **+55% from 2005 to 2035 and +119% from 2005 to 2050.**

1. The SEEG emission data was adjusted using a Well-to-Tank (WTT)/Tank-to-Wheel (TTW) emission factor for the mode; however, the 2005 and 2021 values reflect the numbers reported by SEEG (and not those modeled via the PnL). Sources: EPE; Interviews with sector experts; Clarkson; ANTAQ; DVN; RMI; Mpor.

# ALTHOUGH EMISSIONS WILL NOT REACH ZERO, THE EMISSIONS SHARE CAN GROW AT A LESS ACCELERATED RATE COMPARED TO THE INCREASE IN TKM









1. Base year for NDCs; 2. Business-as-usual; 3. The rest of the modes remain with the level of emissions reported in the BaU; 4. The SEEG emission was adjusted by a Well-to-Tank (WTT) / Tank-to-Wheel (TTW) emission factor. Sources: SEEG, ANTAQ, PNL, ANTT.

## MAPPING OF ENABLERS

### RECENT EXAMPLES ILLUSTRATE HOW ENABLERS HELP UNLOCK KEY LEVERS FOR SECTOR DECARBONIZATION

Illustrative

#### Selected examples

- 
**Implementation of sustainability performance monitoring mechanisms | IMO |** Requirement to report the Energy Efficiency Index (EEXI), which assesses vessel design, and the Carbon Intensity Indicator (CII), which monitors operational carbon intensity 
- 
**Public investment to enable the expansion of the water transport mode | New PAC |** R\$60M for the construction of the Macapá Waterway Terminal, designed to enhance the transport of freight and passengers, which in itself has a more sustainable nature 
- 
**Expansion of private terminals |** The growing number of privatized terminals, an increase of ~44% over the last 13 years<sup>4</sup>, promotes a more sustainable growth trend and contributes to a cleaner transport matrix 

✓ **Regulation that encourages public and private investment in the cabotage and inland water transport matrix | BR do Mar and BR dos Rios<sup>1</sup> |** Through the simplification of regulations and the expansion of contracting options for water transport, the goal is to increase supply, foster competitiveness, and encourage investment in operations and infrastructure



✓ **Tangible mechanisms to promote private financing | Green Shipping Fund |** A €420 million fund that offers loans to operators for the replacement or modernization of vessels that use green fuels<sup>3</sup>



✓ **Stimulation of public investments in technological development | Merchant Marine Fund |** R\$12 billion approved for modernization of the sector, including the first project to convert engines of maritime support vessels to operate using Brazilian ethanol as fuel



✓ **Concrete financing tools for fostering R&D<sup>2</sup> by the private sector | The Mærsk Mc-Kinney Møller Center |** Partnership between Maersk, universities and the government for R&D<sup>2</sup> of green H<sub>2</sub> and ammonia

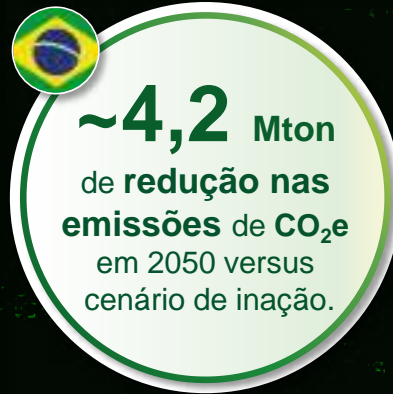


Notes: 1. Regulation still in the drafting stage and has not been approved; 2. R&D = Research and Development; 3. Such as LNG, methanol, ammonia, green hydrogen, or electric vessels; 4. 2023 vs. 2010. Sources: Ministry of Education; Zero Carbon Shipping Initiative; Maersk; Government of Amapá – news page; FINEP; Green Shipping Fund; Petrobras; ANTAQ; Mpor.

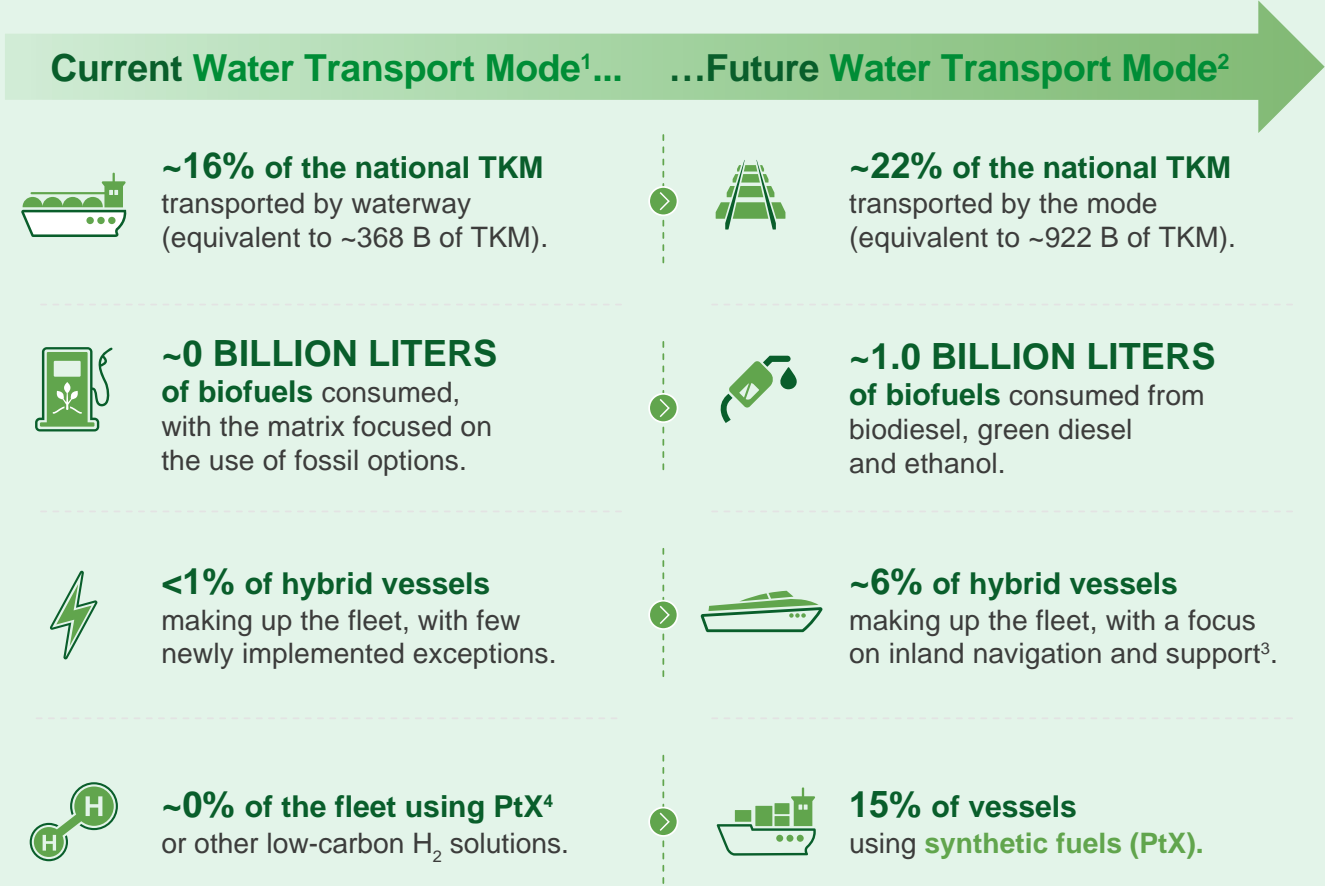


Target impact in 2050 - Water transport

We aim for sustainable growth in the Water transport sector



O que pode representar ~7,3 Mton de redução de CO<sub>2</sub>e vs BaU com mudança de matriz prevista pelos planos setoriais.



1. 2023; 2. 2050 Transformational; 3. Maritime and port support; 4. Power-to-X. Sources: Infra SA 2021; EPE; Interviews with sector experts; Clarkson; ANTAQ; DVN; RMI; Mpor.

## SUMMARY | WATER TRANSPORT SYSTEM

The Water transport is less polluting compared to Road transport (~10-15 gCO<sub>2</sub>e/TKM vs. ~50-64 gCO<sub>2</sub>e/TKM<sup>1</sup>), representing 16%<sup>2</sup> of national freight movements and emitting ~4.6 Mton CO<sub>2</sub>e<sup>2,3</sup> (~1.8%<sup>2,3</sup> of total CO<sub>2</sub>e emissions from the transport sector).

In a scenario of inaction, total transport emissions are expected reach ~424 Mton CO<sub>2</sub>e in 2050; In this context, the representation of modes in the freight transport matrix would remain unchanged (Water transport would remain at 15%); Emissions from the mode would reach ~7.3 Mton CO<sub>2</sub>e (+60% vs. 2023).

However, the PNL<sup>4</sup> and the Transport Sector Plans propose a significant change to the country's logistics matrix. Such a change would be a critical lever for decarbonization, leading to a reduction of ~15 Mton CO<sub>2</sub>e emissions from the sector as a whole. As such, the representativeness of the mode in the matrix should reach 22% of freight movements in 2050. As a consequence of this growth, emissions from the mode are expected to increase to ~10.4 Mt CO<sub>2</sub>e in 2050 (+127% vs. 2023). However, the projected increase in modal share poses a significant challenge and requires substantial investment in the expansion and modernization of water transport infrastructure<sup>5</sup>.

To mitigate emissions growth and reinforce the climate agenda, the 14 entities<sup>6</sup> of the Coalition's Water Transport vertical identified and analyzed the decarbonization potential of 24 levers. Some of the main ones include:

- **Biofuel | Expansion of use:** Adoption of alternative fuels (e.g. bio-LNG, biomethanol) – must be preceded by technical and operational tests that prove viability, respecting the diversity of matrices and regional specificities;
- **Power-to-X | Granular adoption of solutions:** Enabling the use of synthetic fuels<sup>7</sup> in the medium/long term;



- **Efficiency | Enabling infrastructure and facilitating port access:** Reducing the average waiting and docking time in ports.

As a result of implementing the 24 mapped levers, the sector's absolute emissions could be reduced to ~3.1 Mton CO<sub>2</sub>e<sup>3</sup> (-32% vs. 2023) in transformational sensitivity in 2050.

Given the dimensions of the challenge, a series of enablers will be required to materialize such levers. Some concrete examples below illustrate how enablers can help progress the decarbonization agenda in the Water transport mode:

**Regulation | E.g.: BR do Mar and BR dos Rios<sup>8</sup> |** Incentive to public and private investment in the cabotage and water transport matrix through initiatives aimed at expanding supply, fostering competitiveness, and stimulating investment in operations and infrastructure;

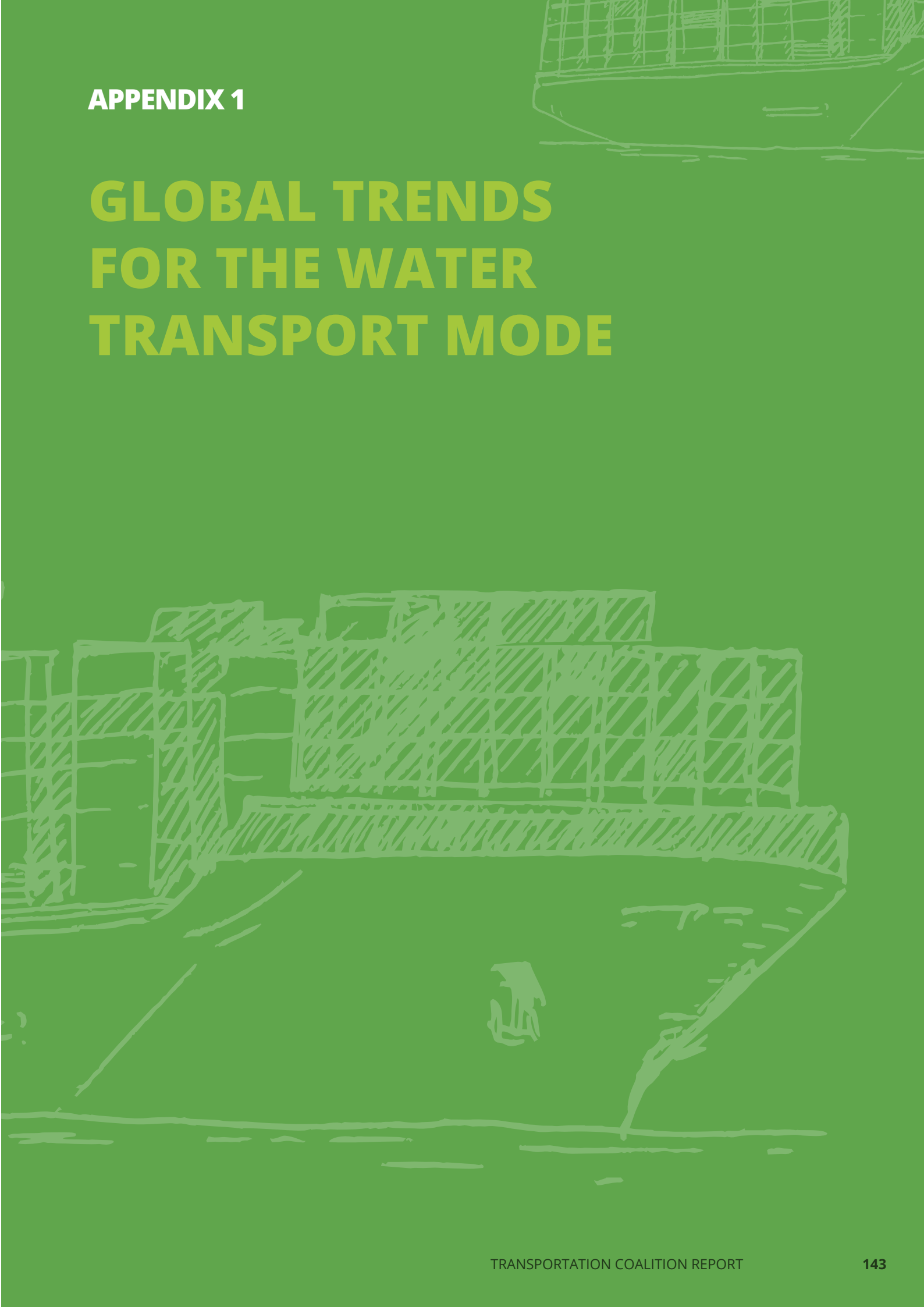
**Regulation | E.g.: New Regulatory Framework for Ports<sup>9</sup> |** Improving the mode's competitiveness through the modernization of the port sector by increasing private participation, unifying regulations for public and private terminals, and strengthening regulatory governance.

Remaining emissions are expected to represent ~2%<sup>3</sup> of Brazil's total transport emissions in transformational sensitivity in 2050 (3.1 Mton CO<sub>2</sub>e<sup>3</sup>) reinforcing the benefits generated by the greater representativeness of the mode to the detriment of other more polluting ones. However, given the existing residual volume of emissions, entities participating in the Coalition should continue discussions for progress towards net-zero emissions by 2050.

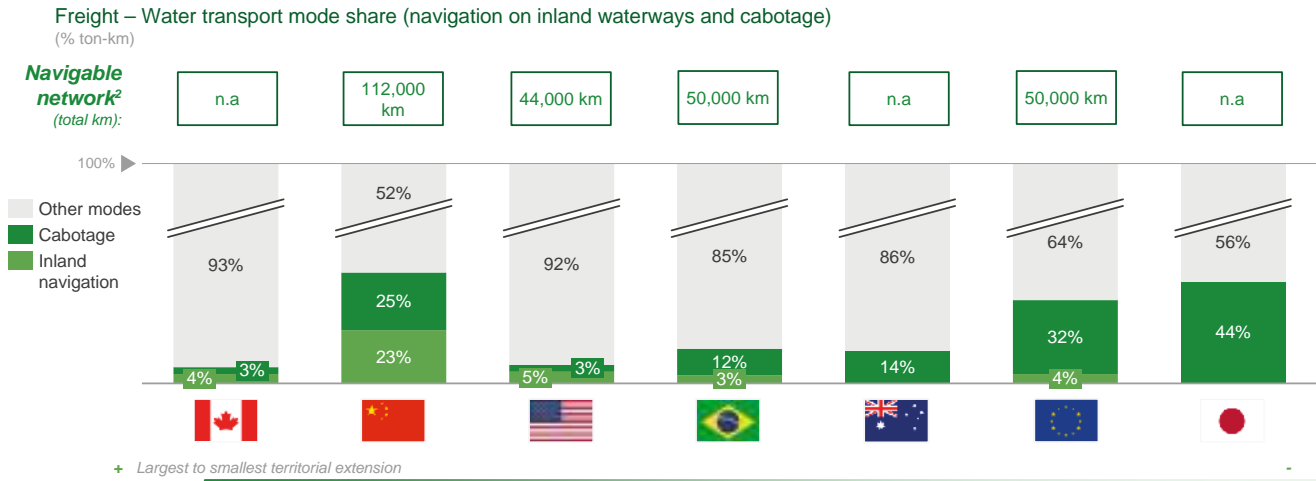
1. Calculated based on data from ANTF and SEEG 2022; 2. 2023; 3. Considers well-to-wheel adjustments (WTW), even for actual values (2023); 4. Considers the sectoral transportation plans as a basis; 5. Information provided in the Sector Plans is not yet granular enough to allow a quantification of the investment required; 6. In addition to the 9 specific entities, CEBDS, Motiva, CNT and Insuper Mobility Observatory also coordinated the discussions across the different verticals of the Coalition; 7. E.g.: e-methanol and e-ammonia, for example; 8. Approval still pending; 9. Law No. 12.815/2013.

**APPENDIX 1**

**GLOBAL TRENDS  
FOR THE WATER  
TRANSPORT MODE**



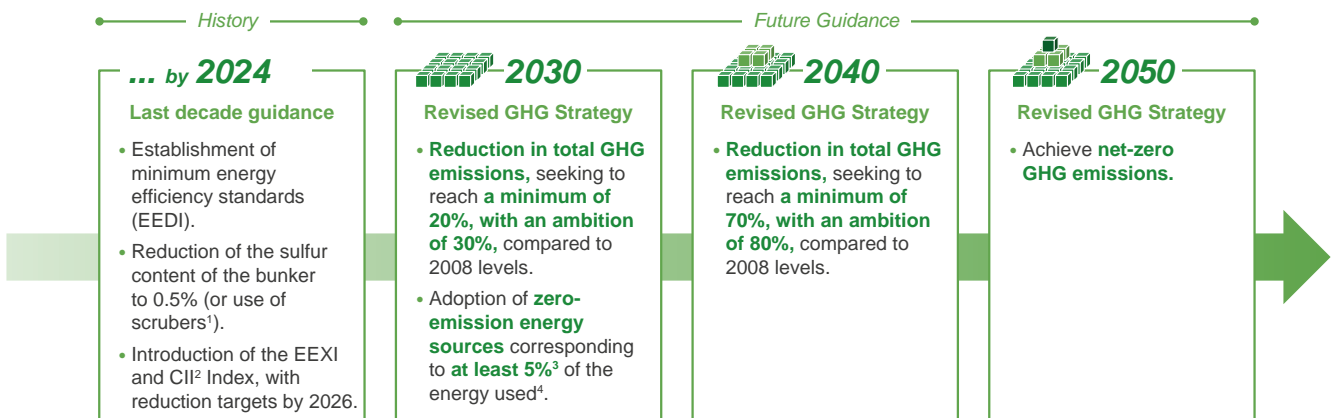
# IN CONTRAST TO REGIONS LIKE THE EU AND CHINA, BRAZIL'S WATER TRANSPORT MODE ACCOUNTS FOR A COMPARATIVELY LOWER SHARE OF FREIGHT ACTIVITY



Sources: OECD; ILOS (Brazil); National Bureau of Statistics of China, Bureau of Transportation Statistics (USA), Eurostat (EU); Transportation Sector Plan. Note: 1. Information from the Brazilian matrix considers data from the Transportation Sector Plan, made available for public review in 2024; 2. Total potential navigable network (OECD data).

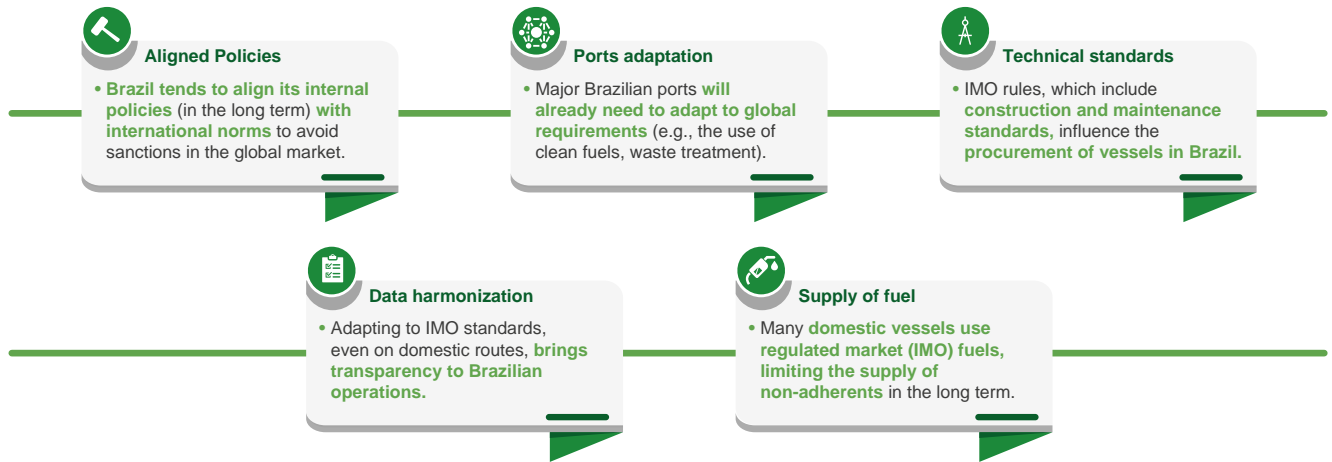
# THE QUEST FOR DECARBONIZATION ALTERNATIVES IS BECOMING INCREASINGLY PERTINENT WITH THE NEW IMO REGULATIONS...

## IMO Guidance for maritime transport



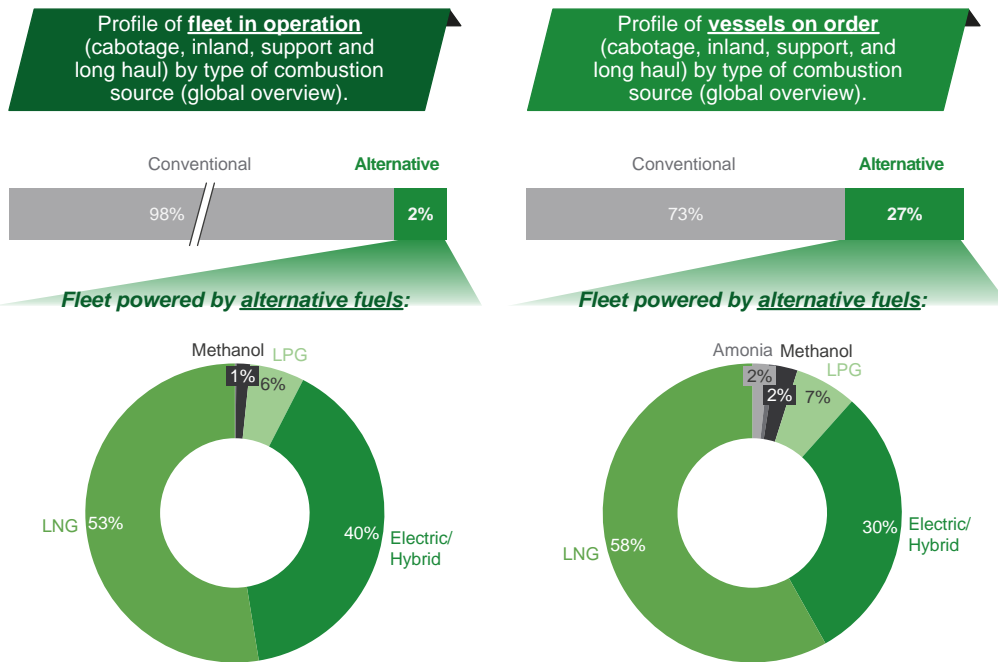
Notes: 1. Air pollution control device that helps reduce the emission of harmful gases and particles; 2. Energy Efficiency for Existing Ships (EEXI) and the Operational Carbon Intensity Indicator (CII); 3. Reach at least 5%, with an ambition of 10%; 4. fuel used. Sources: EPE; IMO; Folha de São Paulo.

# ... DESPITE THE FOCUS ON INTERNATIONAL SHIPPING, NEW REGULATIONS MAY AFFECT DOMESTIC SHIPPING



Source: IMO.

# GLOBAL COMPANIES HAVE BEGUN ORDERS FOR NEW VESSELS, SEEKING TO MEET THE NEW GOALS

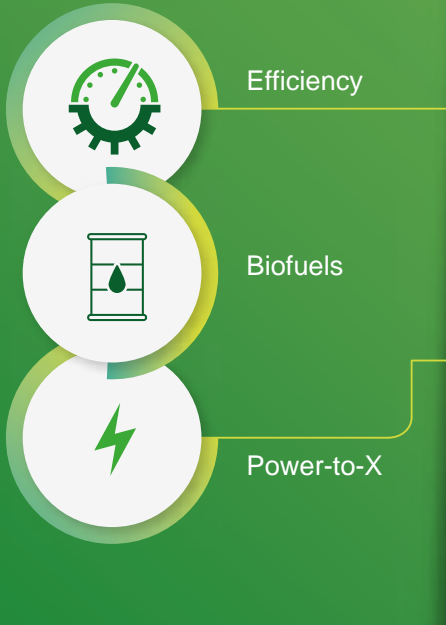


**Alternative fuels and less emitters represent 27% of new orders versus 2% of the current fleet.**

Notes: 1. Data for June 2024, including long-haul, cabotage, inland and support vessels. Sources: EPE; Ministry of Mines and Energy.

## WATER TRANSPORT

Other selected benchmarks



### Illustrative

- Focus on **increasing the fleet's energy efficiency** through more fuel-efficient operations and the continuous implementation of technologies on owned and chartered vessels, including new and improved propellers, bulbous bows, and shore power enablement.
- New CSL ships will incorporate **energy-efficient technologies and devices** such as advanced engines, HVAC (heating, ventilation and air-conditioning) systems and other energy-saving devices, as well as optimized hull and propeller designs.
- The **Laura Mærsk is the world's first container ship capable of running on green methanol**. Maersk signs a large-scale purchase agreement with Goldwind, ensuring 500,000 tons of green methanol per year starting from 2026.
- Pilot project for the use of biodiesel on ships:**

  - COSCO Venus ship fueled with **B24**, reducing about 1,240.5 tons of CO<sub>2</sub>.
  - The ship Sagittarius, which used **B20** fuel, reduced CO<sub>2</sub> emissions by approximately 259 tons.
- Entered into agreements with MASDAR, COSCO SHIPPING and SIPG to **supply 24 new ships in its fleet with e-methanol**.
- APM Terminals, a subsidiary of the Maersk Group, has begun to **replace diesel-powered equipment with electric alternatives, such as RTG (Rubber-Tired Gantry Cranes) cranes and electric forklifts**, at some terminals. Examples include terminals in Aarhus (Denmark) and Barcelona (Spain).

## HOWEVER, ENABLING TRANSPORT COMPANIES TO ACT EFFECTIVELY REQUIRES THAT PORT PLAYERS ADAPT AND ACTIVELY CONTRIBUTE

### Illustrative – Non-exhaustive

#### Application of decarbonization levers by international port players

- Ship arrival tracking system, **avoiding unnecessary delays** at the terminals.
- Integrates **port support solutions with renewable energy** available during berthing.
- Offers **monetary and operational incentive** (e.g. priority queue to dock) for **vessels using clean fuels**.

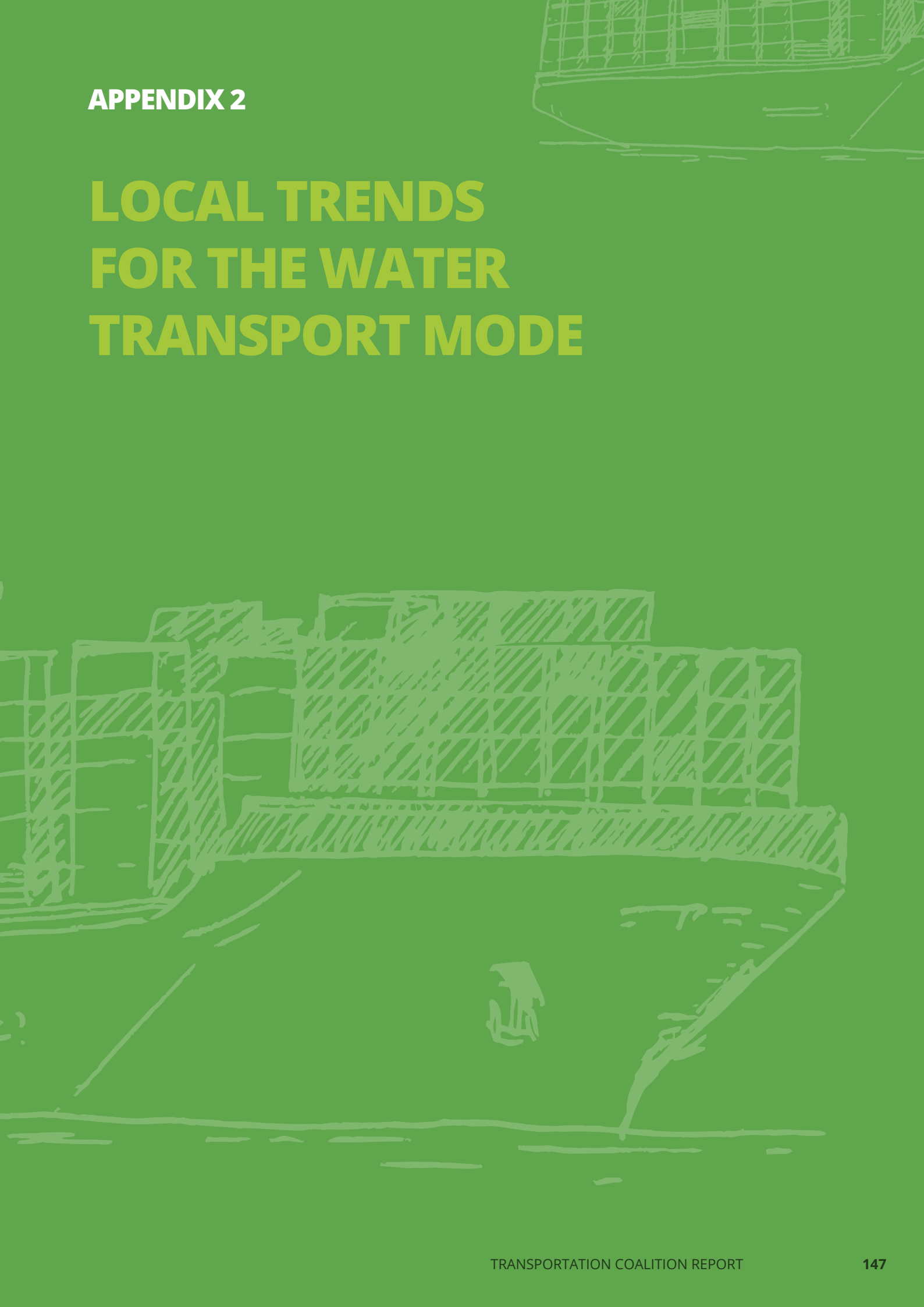
- Implementation of intelligent lighting**, with sensors installed that recognize the level of traffic and adjust lighting levels accordingly.
- Electricity supply for moored vessels (OPS<sup>1</sup>)** – from 2025, all major terminals must be adapted.

- Ordered 200 **LNG-based port support trucks** – this type of fleet is expected to represent 15% of the onshore support fleet.
- Development of Tuas Mega Port – **the largest automated terminal in the world, with more than a thousand battery-powered vehicles**.

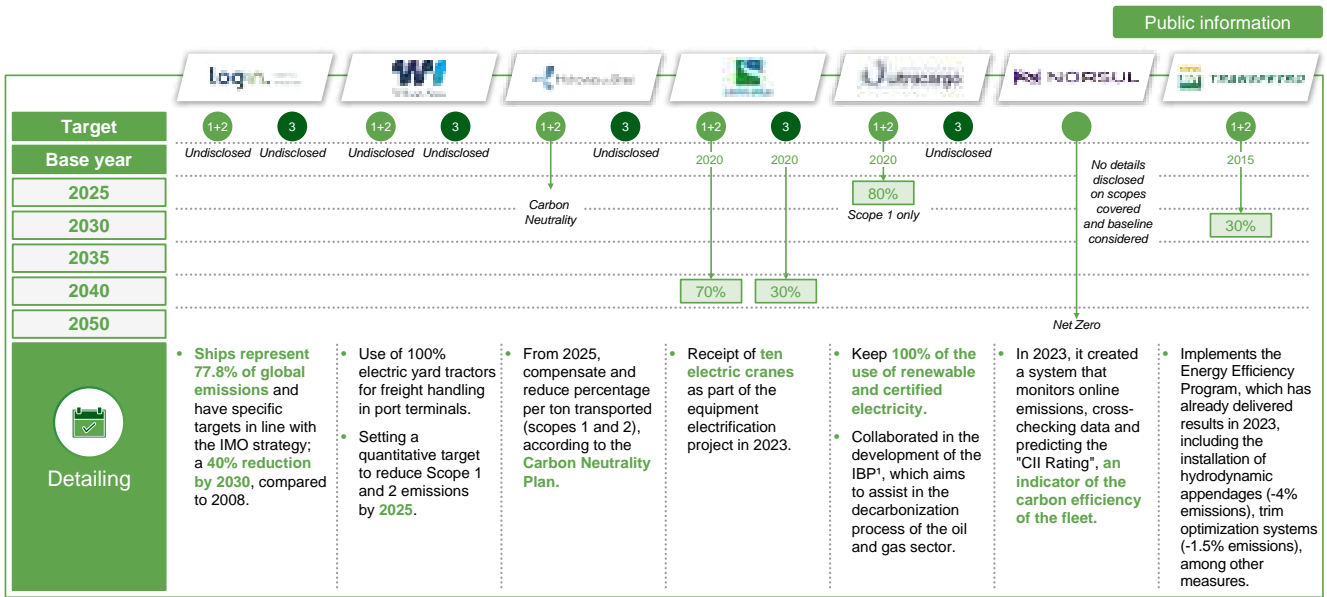
Notes: 1. OPS (Onshore Power Supply) = provide onshore power supply and allow vessels auxiliary engines to be shut down while they are moored; Sources: respective sites.

**APPENDIX 2**

**LOCAL TRENDS  
FOR THE WATER  
TRANSPORT MODE**



# BRAZILIAN PLAYERS INVESTING IN DECARBONIZATION OF THE PORT TRANSPORTATION MODE

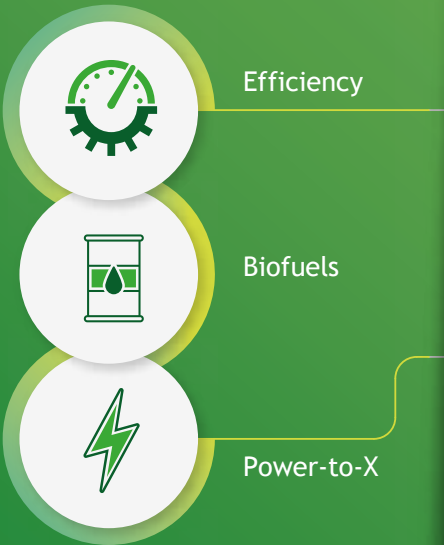


Source: 1+2 Scopes 1 and 2 3 Scope 3

1. Applies to purchased goods and services and activities related to fuel and energy; 2. Applies to GHG (greenhouse gas) emissions from aviation fuel in scope 1 and 3, well-to-wake, per tonne-kilometre of revenue; 3. Sectoral Inventory of the Brazilian Institute of Petroleum and Gas. Sources: company reports; SBTi; press articles; (until Feb. 2024).

## WATER TRANSPORT

Other selected benchmarks



1. Carbon Intensity Indicator 2. Rubber-Tired Gantry Cranes

### Illustrative

- In Brazil, Wilson Sons is aligning with new regulations by following the IMO Tier III standard, which includes the deployment of RSD 2513 tugs that reduce nitrogen oxide emissions by up to 75%.
- A system was created that monitors emissions from online vessels, stores and processes sensor data predicting the CII<sup>1</sup> Rating and indicating the carbon efficiency of the fleet.
- Transport of Be8 biofuel via a cabotage route to the Northeast region, with the neutralization of GHG emissions through the Norsul Carbon Neutral Program.
- Replacement of 100% diesel used in 18 Brazilian ports. Conducts navigation trials with a main engine optimized for higher combustion efficiency using biodiesel blends, without disclosing the specific blend.
- The first hybrid maneuvering pusher boats in the world, which use electrical energy for navigation, are beginning to be used. They are designed to reduce carbon dioxide emissions by up to 2,168 of CO<sub>2</sub> per year.
- Replacement of all RTGs<sup>2</sup> diesel-powered cranes with electric models at Santos Terminal by 2031. Reduction of expected monthly emissions equivalent to 97% of emissions from this equipment.



MAIN CONCLUSIONS

# AIR TRANSPORT

# AIR TRANSPORT – MEMBER ENTITIES

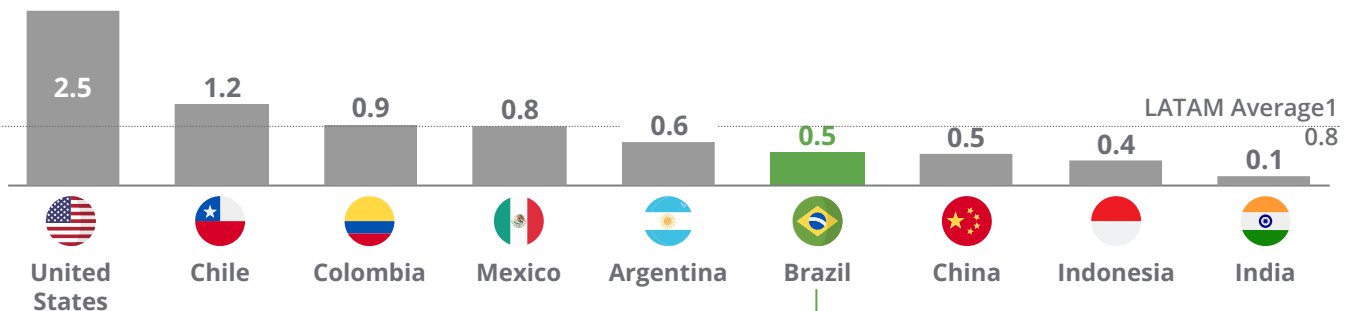
This document was supported by the following air transport entities.

**COORDINATION**      **OTHER MEMBERS**      **TRANSVERSAL AND CONSULTATIVE ENTITIES**

When comparing the number of air transport passengers per inhabitant in different countries, it is observed that Brazil still has room to grow.

## TOTAL PASSENGERS PER INHABITANT

(PAX/1000 inhabitants) 2023

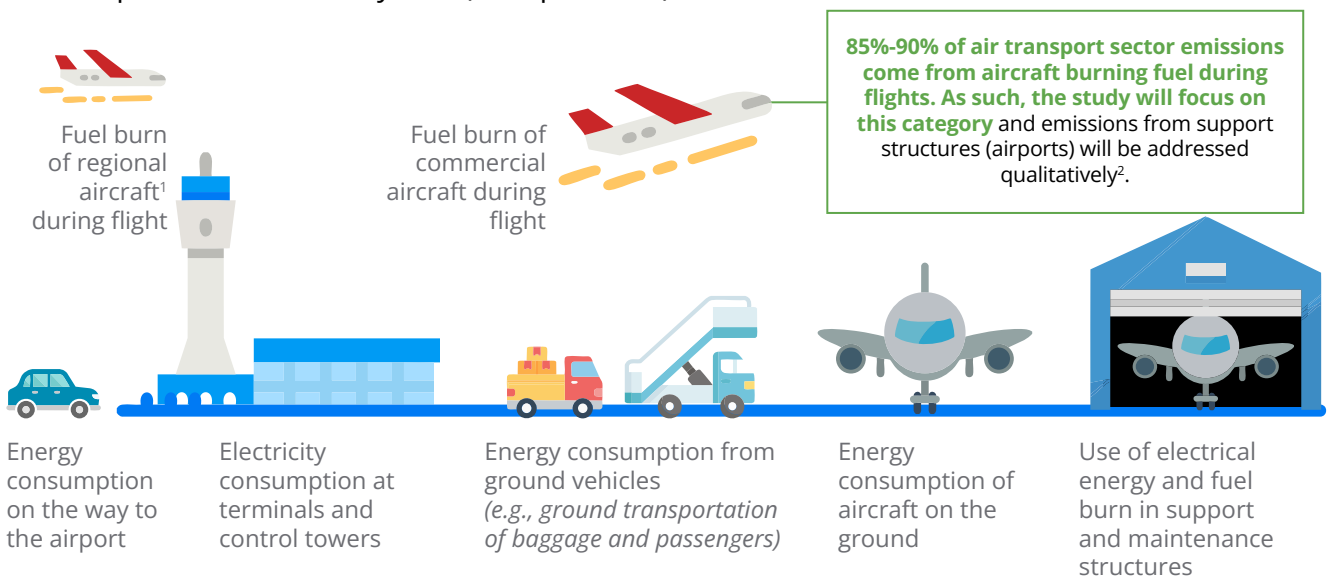


**Brazil has a 38% lower PAX/inhabitant ratio than the LATAM average<sup>1</sup>. When we look at countries like the United States, this number is up to 5x lower.**

1. Only considers Chile, Colombia, Mexico, Argentina and Brazil. Sources: IATA; OAG; ICAO; UNWTO; EIU; ANAC.

# AIR TRANSPORT EMISSIONS COME MAINLY FROM TRANSPORTATION, WITH LESS IMPACT ON INFRASTRUCTURE

Air transport emissions ecosystem (transportation).



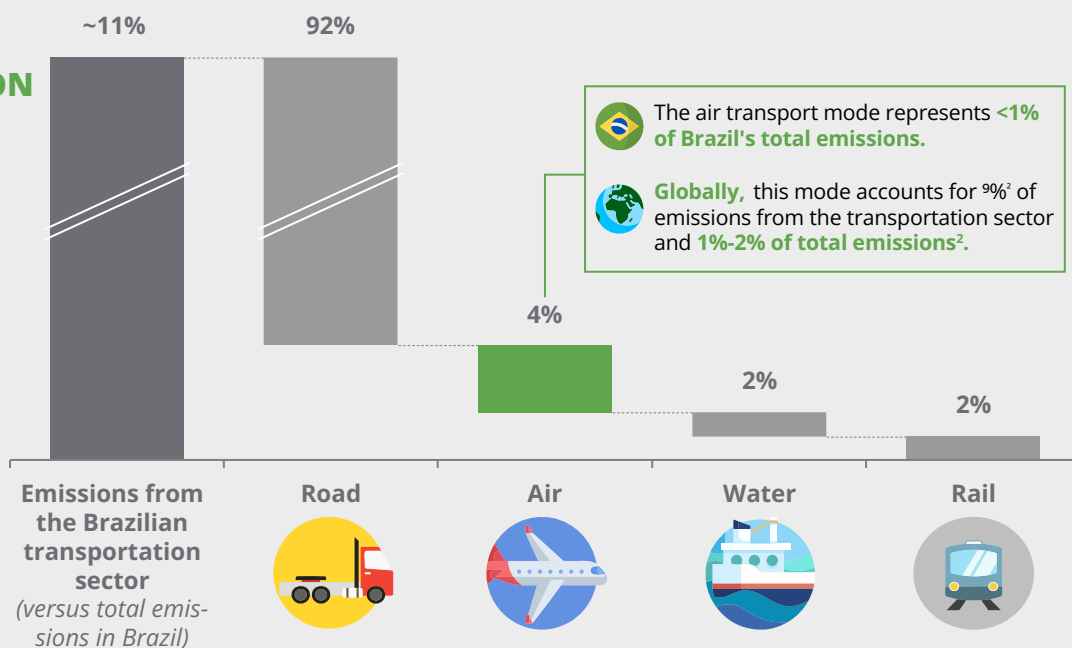
1. Regional aircraft include all non-commercial categories; 2. It is estimated that emissions from airports represent 10%-15% of total emissions from the air transport sector globally. Sources: SEEG; Interviews with sector experts.

# AIR TRANSPORT EMISSIONS<sup>1</sup> REPRESENT ~4% OF THE TOTAL TRANSPORTATION SECTOR IN BRAZIL

— % emissions versus emissions from the transportation sector —

## TRANSPORTATION SECTOR GROSS EMISSIONS

(%) – BRAZIL (2023)



The air transport mode represents <1% of Brazil's total emissions.

Globally, this mode accounts for 9%<sup>2</sup> of emissions from the transportation sector and 1%-2% of total emissions<sup>2</sup>.

1. Regional aircraft include all non-commercial categories; 2. It is estimated that emissions from airports represent 10%-15% of total emissions from the air transport sector globally. Sources: SEEG; Interviews with sector experts.



## PANORAMA ATUAL - SETOR AEROVIÁRIO

Indicadores relevantes do modo aeroviário

2023

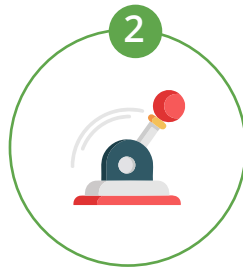


1. Size per # of passengers: small (up to 100), medium (101-250) and large (251+); 2. Airports that received regular domestic flights. Source: ANAC.

# APPROACH I THREE STEPS FOR DEFINING THE POSSIBLE PATHS FOR AIR TRANSPORT DECARBONIZATION



Setting projections for the total emissions of the sector, assuming **changes in the participation of the different modes of transportation;**



Mapping of levers to **reduce emissions applicable to the air transport mode;**



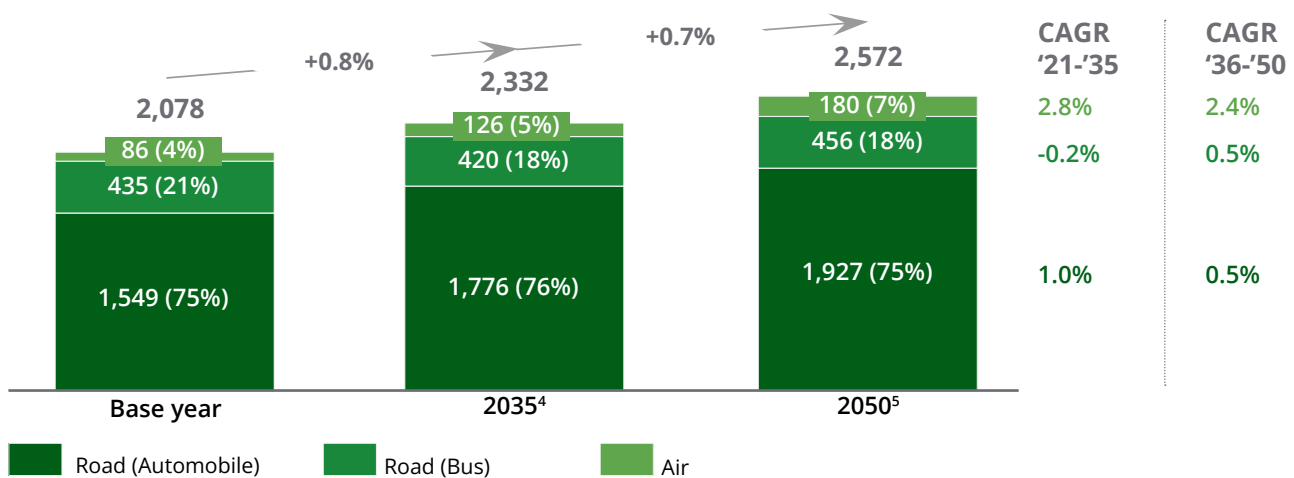
Proposal of possible **sensitivities based on the mapped levers.**

## 1 DEFINITION OF BaU<sup>1</sup> CONSIDERING THE GAIN OF REPRESENTATIVENESS IN THE PASSENGER MATRIX

Phase one assessed a future scenario aligned with the PNL and Sectoral Plans, envisioning greater participation of air transport and its implications for the modal split of passenger mobility.

### EVOLUTION OF THE PASSENGER MATRIX<sup>2</sup>

(Passengers, %) Million PAX, base year<sup>3</sup>



1. BaU = Business-as-Usual; 2. Designed based on the Transportation Sector Plans and PNL 2035 – National Logistics Plan; 3. Base year = 2021, with the National Logistics Plan projected using the respective CAGRs of the reference scenario versus 2017; 4. TKM 2035 values refer to the PSR1 scenario of the PSTR and PAX values come from the reference scenario of the PNL 2035 passenger matrix; 5. TKM is projected based on GDP growth, using the modal share from the PSR3 scenario of the PSTR, while PAX is projected according to population growth, with no change in modal share. Note: The passenger figures presented in the PNL reflect only intermunicipal and interstate travel, and do not account for intra-urban passenger travel. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

# 2 MAPPING OF LEVERS TO REDUCE EMISSIONS

After the transportation matrix was presented, the working group identified **levers that have the potential to reduce emissions in air transport.**

These levers were mapped in three large blocks, as described below. A qualitative feasibility analysis<sup>1</sup> was performed for each of them, and local and global references that illustrate the respective application were presented.

1. The full details of the feasibility and references can be found in the complete air transport document, which can be accessed through the QR Code at the end of this document.

## LEVERS FOR EMISSION REDUCTION

in the air transport sector



**EFFICIENCY**



**BIOFUELS**



**ELECTRIFICATION AND POWER-TO-X**



## EFFICIENCY

### Levers – Aircraft (flight time)

- 1 Accelerated renewal of the current fleet** by faster replacement of older aircraft with more efficient models (e.g., Max and Neo models) and better design.
- 2 Intelligent route optimization and fleet allocation** by modernizing the air traffic operation system, reducing average distance and other effects.
- 3 Influence the behavior of engines and pilots** through eco-efficient and assisted driving programs to optimize the high dispersion of energy consumption between different flights.
- 4 Better use of aircraft,** with a focus on increasing the load factor.

Sources: Skypower Reports; EPE; The Economist; ProQR; FAPES.

## Levers – Airports and ground emissions

- 1 **Improvement of operational management**<sup>1</sup> (e.g., ground ops., ground control, flight control, etc.) and landing and takeoff trajectories through the **modernization of systems** and improving **airport infrastructure**.
- 2 Support to **increase the efficiency of the aircraft's energy consumption on the ground** (e.g., use of electric tow vehicles, use of electric GPUs — e.g., 400Hz — instead of APUs, etc.).
- 3 Implementation of strategies to help **have more efficient consumption of electricity, refrigerant gases, waste and water** (e.g., LED lamps, use of natural ventilation, etc.).
- 4 **Accelerated renewal of the current fleet and support machinery** by replacing it with more efficient models.

The first two levers consider the impact/feasibility of reducing emissions on the part of aircraft.

1. Considers runway/tarmac and landing/takeoff management decisions. Sources: ICAO; NLR; FAPESP; ACI.



## BIOFUELS

### Levers – Aircraft (flight time)

- 1 **Intensification of the use of bio-SAF** directly as an alternative to QAV and aviation gasoline.
- 2 **Use of Book & Claim**<sup>1</sup> practices, through the acquisition of SAF credits.

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

Cutting emissions related to SAF at another stage in its lifecycle might not occur within the scope of Brazilian domestic emissions<sup>2</sup>.

1. Practice in which a certain airline buys the credits corresponding to the SAF produced, but uses conventional fuel on its flights, another part of the system consumes the physical SAF and the purchasing company receives carbon credits; 2. Although it can be accounted for in CORSIA. Sources: Skypower Reports; EPE; The Economist; ProQR; FAPESP; Gol.

### Levers – Airports and ground emissions

- 1 **Use of clean fuel in support machinery**, such as APU (Auxiliary Power Unit) and GPU (Ground Power Unit).
- 2 **Use of clean fuels in the support fleet** (e.g., internal buses and CNG- or ethanol-based baggage tractors).
- 3 **Support for the provision of clean fuels** to aircraft (e.g., infrastructure, facilitation, etc.).

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

Sources: ICAO; NLR; FAPESP; ACI.



# ELECTRIFICATION AND POWER-TO-X

## Levers - Aircraft (flight time)

- 1 Use of **Power-to-Liquid solutions** (PtL: e-SAF<sup>1</sup>) as energy sources.
- 2 Use of **hydrogen solutions as a direct energy source** (through direct combustion or fuel cell).

Levers can be applied as long as the technical and operational viability of the respective solutions is verified.

Other initiatives that are potential levers for smaller and short-haul aircraft, such as electrification/hybridization, have not been analyzed in detail given the limitation of the solution and implementation time.

1. Synthetic fuels produced from green hydrogen, renewable electricity and captured CO2 — the synthetic gas needs to go through a conversion process (Fischer-Tropsch) to produce liquid products that can be refined for fuels. Sources: Skypower Reports; EPE; The Economist; ProQR; FAPESP.

## Levers - Airports and ground emissions

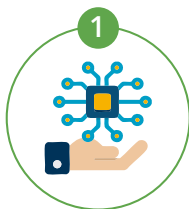
- 1 Use of **renewable energy** (e.g., photovoltaic matrix) in operations (terminals, yard and administrative).
- 2 **Electrification** (or use of hybrid batteries) **of the fleet** (e.g., buses and baggage tractors) and support **machinery** (e.g., GPU).
- 3 Use of **clean energy matrix** in electrical/hybrid support systems and machinery (e.g., GPU).
- 4 **Improvement of the airport's infrastructure**, allowing electrification (e.g., socket infrastructure, adapted transmission power network, etc.).

Levers can be applied as long as the technical and operational viability of the respective solutions is verified.

Sources: ICAO; NLR; FAPESP; ACI.

## 3 PROPOSAL OF SENSITIVITIES BASED ON THE MAPPED LEVERS

Finally, sensitivities have been proposed to assess the impact of different paths to decarbonization:



### Current technologies

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



### Intensification of biofuels

Predominance of the application of levers to intensify the use of biofuels;



### Electrification acceleration/Power-to-X

Predominance of the application of levers to accelerate the electrification/power-to-X of the aircraft fleet;



### Transformational

Combination of levers from sensitivities 1, 2, and 3 leading to a trajectory closer to net-zero emissions.

# THE PROPOSED SENSITIVITIES WERE BASED ON VARYING ASSUMPTIONS:

As in BaU<sup>1</sup>, the increase in SAF penetration does not impact the passenger matrix in any sensitivity.

The use of new emission profiles (e.g., hybrid/electrical, eVTOL) is not planned at scale for aircraft.<sup>2</sup>



## CURRENT TECHNOLOGIES

## TRANSFORMATIONAL



Efficiency at airports

All possible levers to improve efficiency were taken into account when considering different sensitivities.

Efficiency in aircraft

New models up to 25% more fuel-efficient vs. old, with orders coming in ahead of schedule.<sup>3</sup>



Use of SAF (biofuel<sup>4</sup>)

The penetration of BaU<sup>1</sup> continues, with bio-SAF reaching 11% of the total fuel matrix by 2050.

More optimistic scenario, with bio-SAF reaching 22% penetration in 2050.



Rota PtL (e-fuels / e-SAF)<sup>2</sup>

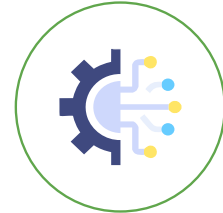
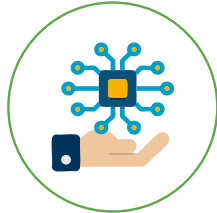
-

The PtL (e-SAF) route reaches 11% of the total matrix by 2050.

1. BaU - Business-as-Usual (emissions baseline); 2. Given the focus on large-scale commercial aviation and the immaturity of the respective solutions for the mode, electrification, eVTOL and the use of pure hydrogen are not being considered in the model; 3. The total fleet is, on average, 30% more efficient in 2050 versus base year; 4. Potential intensification of biofuels to reduce the carbon footprint can be applied as long as the technical, mechanical, operational and laboratory viability of said energy input is confirmed, as well as respecting the diversity of matrices and regional specificities. Sources: AviationWeek; IATA; sustainability report of Brazilian airlines; ReFuelEU legislation; U.S. Department of Energy; S&P; EPE; ICAO; Argus; Interviews with sector experts.

# OUTCOMES OF SENSITIVITY ANALYSIS CONCERNING THE IMPACT ON EMISSIONS

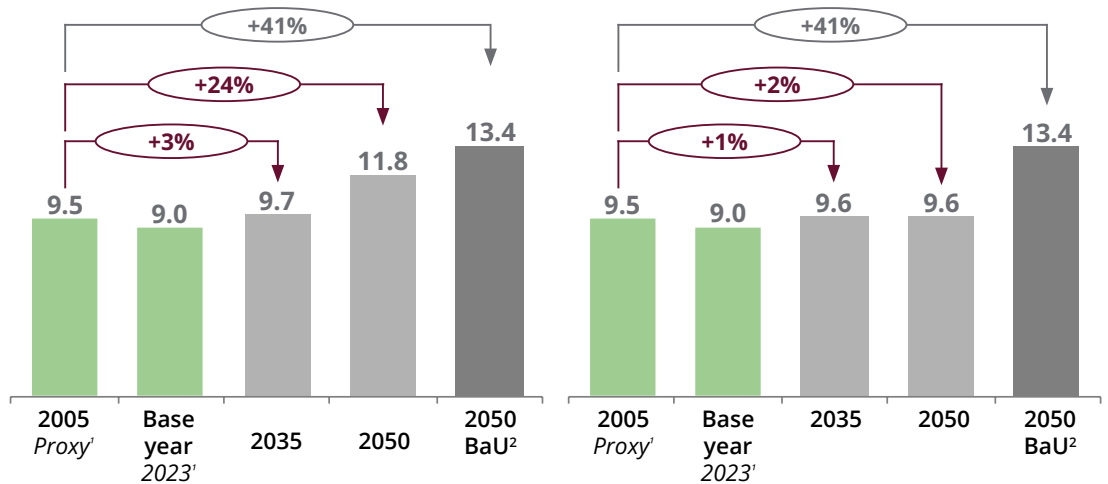
Due to the expected growth in passenger volume, the sector's emissions could reach **13.4 Mton CO<sub>2</sub>e absolute in 2050** under the baseline scenario (BaU), a growth of ~50% vs. 2023. With the implementation of the mapped levers, the sector should reach **9.6 Mton CO<sub>2</sub>e absolute (+7% vs. 2023)** in transformational sensitivity in 2050, a reduction of 28% vs. BaU, reaching **53g CO<sub>2</sub>e/PAX (-46% vs. 2023 and -28% vs. BaU) of relative emissions**.



CURRENT TECHNOLOGIES

TRANSFORMATIONAL

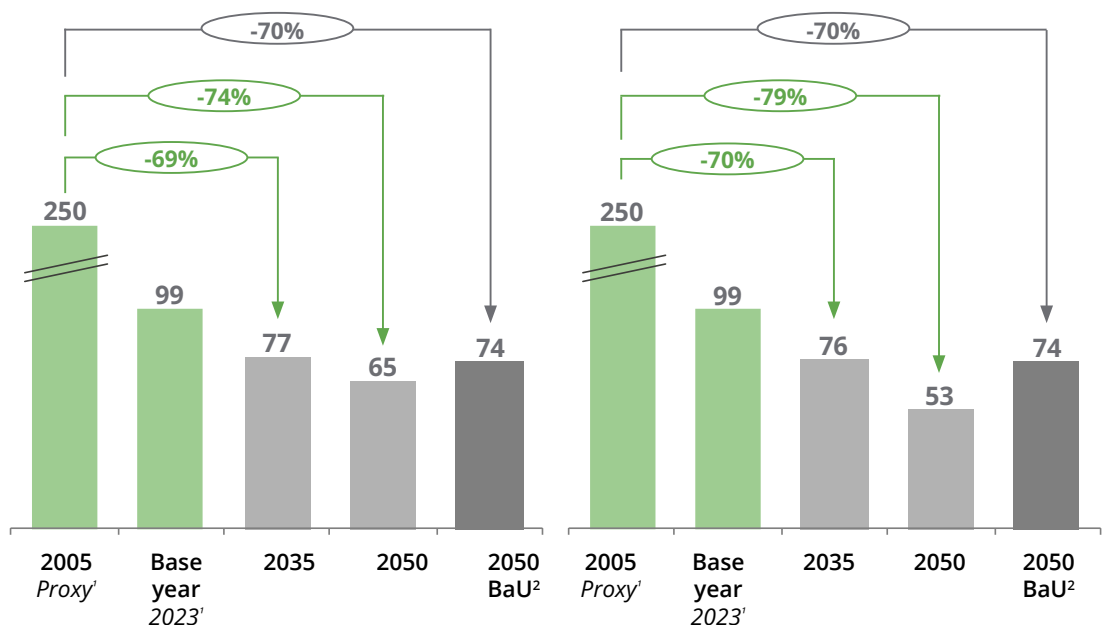
**ABSOLUTE EMISSIONS<sup>1</sup>**  
(MtCO<sub>2</sub>e)



**TKU (B)**



**RELATIVE EMISSIONS<sup>1</sup>**  
(GCO<sub>2</sub>E/PAX)



1. The 2005/2023 SEEG emissions (2023: proxy by GLEC emission factor) were adjusted by a Well-To-Tank (WTT)/Tank-To-Wheel (TTW) emission factor of the mode; 2. BaU = Business-as-Usual. Sources: SEEG; AviationWeek; IATA; Sustainability report of airlines; ReFuelEU legislation; U.S. Department of Energy; S&P; EPE; ICAO; Argus; Interviews with sector experts.




## ILLUSTRATIVE EXAMPLES SHOW HOW ENABLERS HELP TO FACILITATE DECARBONIZATION LEVERS

**PUBLIC GUIDELINES AND INCENTIVES TO FACILITATE THE REDUCTION OF AIR TRANSPORT EMISSIONS**

**CORSIA** 

Regulation that establishes mandatory targets for offsetting and reducing carbon emissions in international aviation, impacting domestic aviation.\*

**MULTISECTORAL COORDINATION MECHANISMS THAT FOSTER THE INFRASTRUCTURE AND AVAILABILITY OF SAF**

Sea-Tac<sup>1</sup> International Airport, in collaboration with 13 airlines<sup>2</sup>, is adjusting its infrastructure to supply 10% of flights with SAF by 2028. 

**REGULATION THAT ENCOURAGES PUBLIC AND PRIVATE INVESTMENTS IN CLEANER FUELS**

**Fuel of the Future Law** 

ProBioQAV promotes research, production and use of SAF to decarbonize domestic air transport.

**TANGIBLE MECHANISMS TO PROMOTE PRIVATE FINANCING**

**Sustainable Flight Fund** 


+20 global and Brazilian partners (e.g., Embraer) committed to financing more than US\$200 million in projects aimed at decarbonizing air transport.

**ACCOUNTING FOR EMISSIONS WITH BOOK & CLAIM**

**ICAO** 

The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) recognizes and systematizes the Book & Claim model, allowing the use of these credits to account for emission reductions and alleviate the shortage of SAF in countries where it is less available.

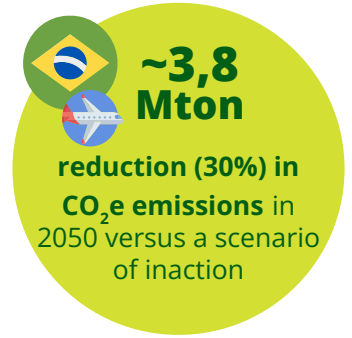
**CONCRETE STEPS FOR BRAZIL TO BECOME A MAJOR PLAYER IN THE GLOBAL SAF CHAIN**

In 2024, Raízen conducted the first shipment of sugarcane ethanol from Brazil to the United States, where it was intended to be converted into SAF at a plant in Georgia. 

1. Seattle-Tacoma; 2. Including Alaska Airlines, Delta Air Lines, Emirates, Horizon Air, Icelandair and Lufthansa. Sources: Bloomberg; FINEP; IATA; United Airlines Ventures; Aero Magazine; Embraer; Airport Technology News.

# WE AIM FOR SUSTAINABLE GROWTH IN THE AIR TRANSPORT SECTOR

Given the significant growth in the number of passengers transported by air (+100% 2023-50) and its greater representativeness in the Brazilian matrix (7% vs. 4% in base year<sup>1</sup>), **the remaining emissions in 2050 are expected to represent 7.0% of Brazil's total transport emissions even in the most transformational sensitivity.**



**Conclusions** sought by the study on air transport in Brazil by 2050:

## CURRENT AIR TRANSPORT<sup>1</sup>



**~4% OF AIR TRANSPORT PASSENGERS**  
(equivalent to ~91M of PAX<sup>3</sup>).



**~0 BILLION LITERS OF BIOFUELS CONSUMED**  
(focused on the use of fossil fuel options<sup>4</sup>).



**~0% of the fuel matrix ORIGINATING FROM PTX5 OR HYDROGEN SOLUTIONS.**

## FUTURE AIR TRANSPORT<sup>2</sup>



**~7% OF AIR TRANSPORT PASSENGERS**  
(~180M), growth of +2.5% p.a.



**~1.1 BILLION LITERS OF BIO-SAF**  
consumed, representing 22% of the mode's fuel matrix.



**11% OF AIRCRAFT**  
using synthetic fuels (PtX – e-SAF).

1. 2023 Proxy; 2. 2050 Transformational; 3. Passengers; 4. Aviation kerosene or gasoline; 5. Power-to-X; 6. Given the focus on large-scale commercial aviation and the immaturity of the respective solutions for the mode, electrification, eVTOL and the use of pure hydrogen are not being considered. Sources: SEEG; AviationWeek; IATA; ReFuelEU; U.S. Department of Energy; S&P; EPE; ICAO; Argus; Interviews with sector experts.





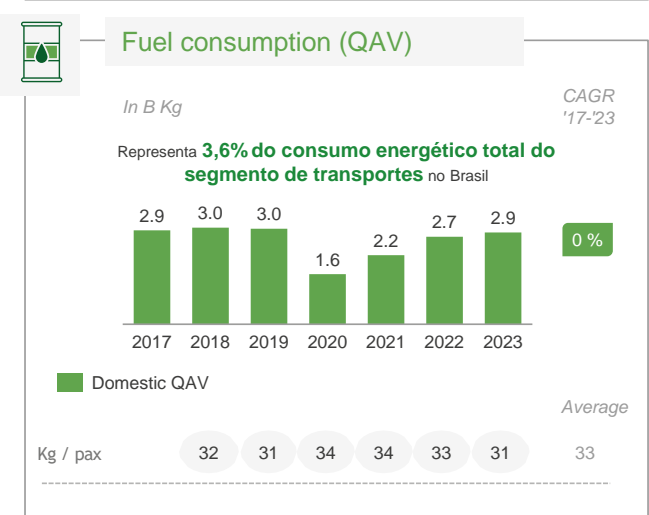
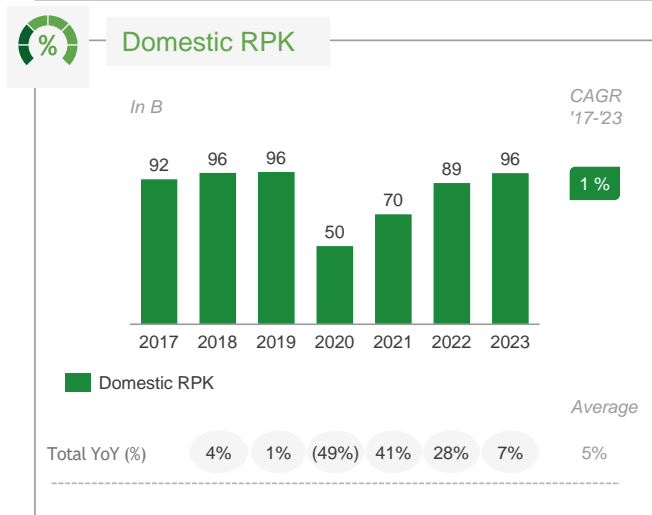
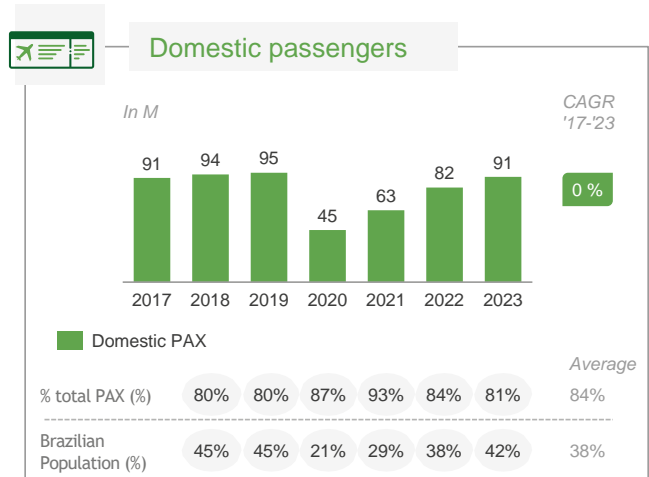
Details on  
the **AIR**  
**TRANSPORT**  
mode

# KEY INDICATORS HELP IN UNDERSTANDING THE CURRENT STATE OF THE MODE

## AIR TRANSPORT

The air transport sector (2023) represents ~6% of the passenger transportation mode in Brazil and <1% of freight in the same period. This required 3 billion kg of QAV, causing emissions of ~10 Mton CO<sub>2</sub>e (4.4% of the country's total transport emissions).

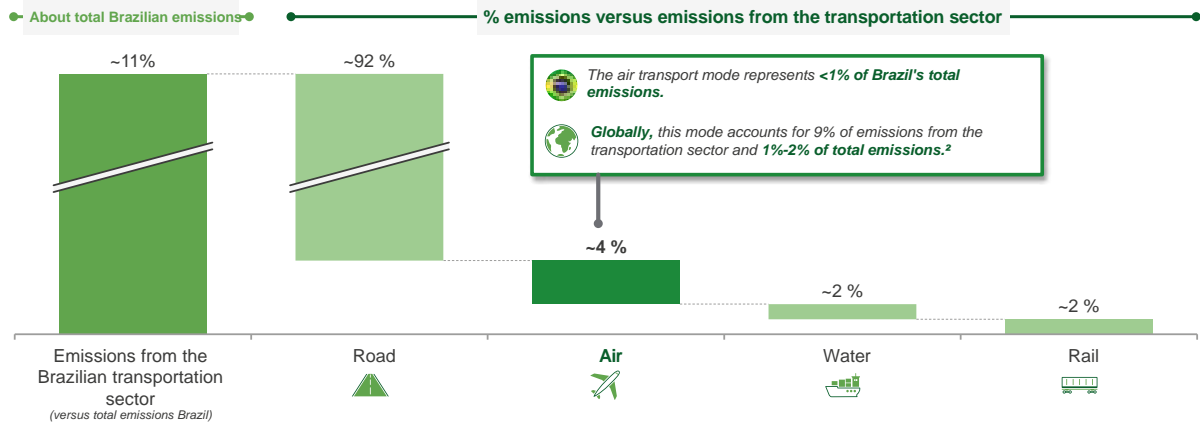
KEY INFORMATION		2023	
● Aircraft fleet <sup>1</sup>	514	● Public airports <sup>2</sup>	159
● Domestic flights	789,000	● Domestic fuel - QAV	3B kg
● Domestic PAX	91M	● CO <sub>2</sub> e Emissions - 2022 (CO <sub>2</sub> e)	~10 Mton
● Domestic RPK	96B		



1. Portions per # of passengers: small (up to 100), medium (101-250) and large (251+); 2. Airports that received regular domestic flights. Source: ANAC.

# THE AIRLINE INDUSTRY IS NOT THE BIGGEST CULPRIT WHEN IT COMES TO EMISSIONS – REPRESENTING <1% OF THE COUNTRY'S TOTAL EMISSIONS

## Gross emissions from the transportation sector (%) – Brazil (2023)

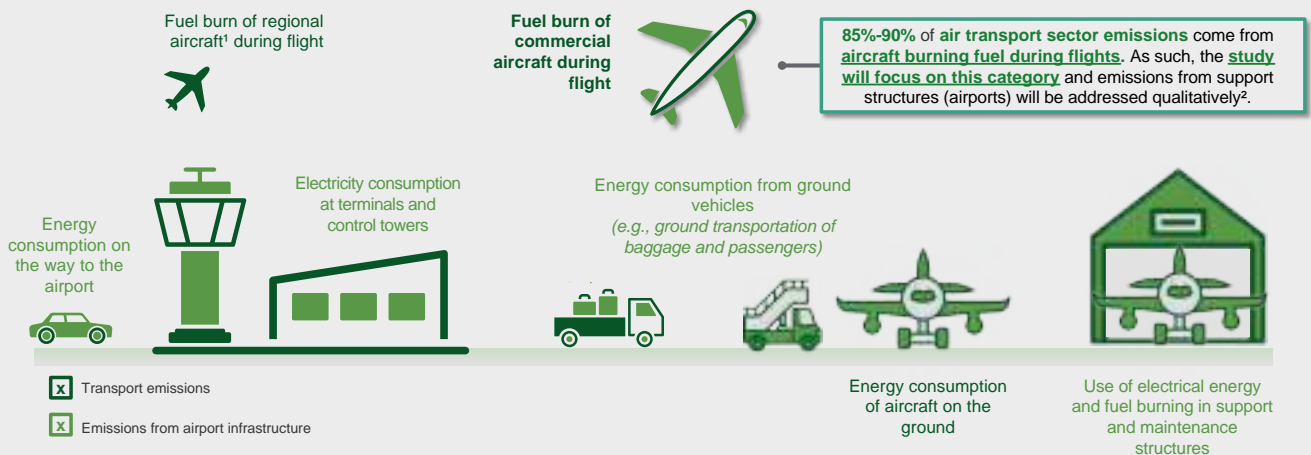


1. Transportation emissions reported by SEEG not restricted to the burning of fuel; 2. Global value (2019) excluding Brazil and considering emissions from international flights. Sources: Anfavea; SEEG; CAIT; Climate TRACE.

# EMISSIONS FROM THE AIRWAY ECOSYSTEM COME MAINLY FROM TRANSPORTATION, WITH LESS IMPACT ON AIR TRANSPORT INFRASTRUCTURE

## Air transport emissions ecosystem (transportation)

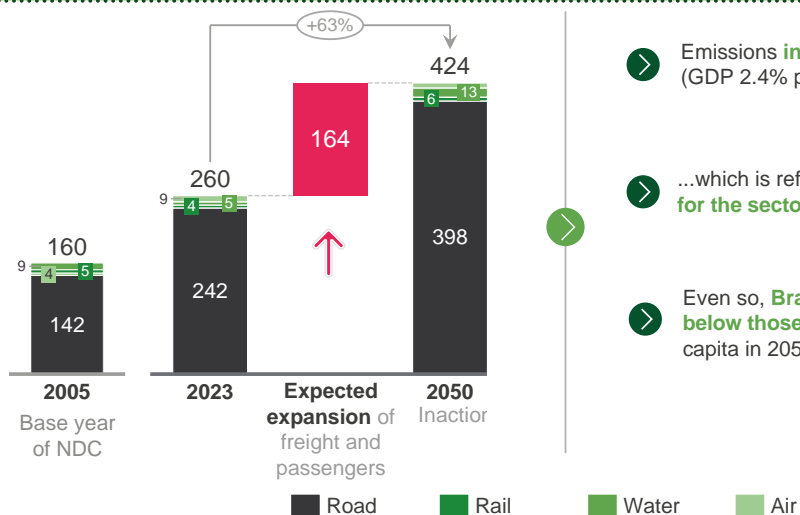
Illustrative



Notes: 1. Regional aircraft include all non-commercial categories; 2. It is estimated that emissions from airports represent 10%-15% of total emissions from the airline industry globally. Sources: SEEG; interviews with industry experts.

# SIZE OF THE CHALLENGE | IN A SCENARIO OF INACTION, THE SECTOR'S EMISSIONS COULD REACH UP TO 424 MTON CO<sub>2</sub>E IN 2050

## Emissions from the transport sector (MtonCO<sub>2</sub>e % by mode) – Well-to-wheel perspective



- Emissions **increase due to the growth of Brazil** (GDP 2.4% p.a.) as an emerging country...
- ...which is reflected in the **considerable growth predicted for the sector** (TKM 2.2% p.a. and PAX 0.7% p.a.).
- Even so, **Brazil's relative emissions are expected to be below those of developed countries** (1.9 tons of CO<sub>2</sub>e per capita in 2050 vs. 5.6 in the US and 2.5 in France in 2023).

Sources: Transportation Sector Plans; Infra S.A.; PNL 2035. Note: Scenario of inaction considers demand projected for 2050 without progress in efficiency gains, increased electrification or expansion of the use of biofuels beyond those currently stipulated by law.

## AIR TRANSPORT GROUP | ABR COORDINATING DISCUSSIONS AND ENGAGEMENT OF OTHER MEMBERS



### Advisory Board:

CEBDS, Motiva, CNT/SEST SENAT and Inesper's National Sustainable Mobility Observatory



### Air Transport Group

#### ☆ ABR – Aeroportos do Brasil (Brazilian Airports Association)

- ABAG
- ABESATA
- ABOL
- Motiva
- ACI-LAC
- Vibra
- Vinci Concessões

Legend | ☆ Coordinator | Other Members

# PATHWAYS TO DECARBONIZATION

## DEFINING PATHWAYS FOR DECARBONIZING AIR TRANSPORT WAS DIVIDED INTO THREE KEY STEPS

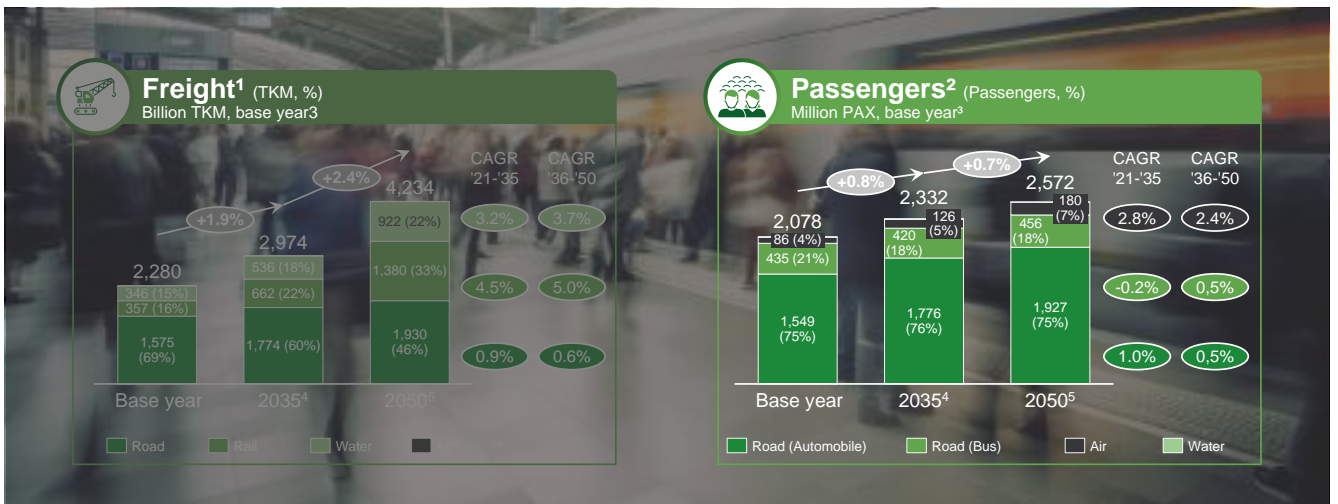


1. BaU = Business-as-usual.



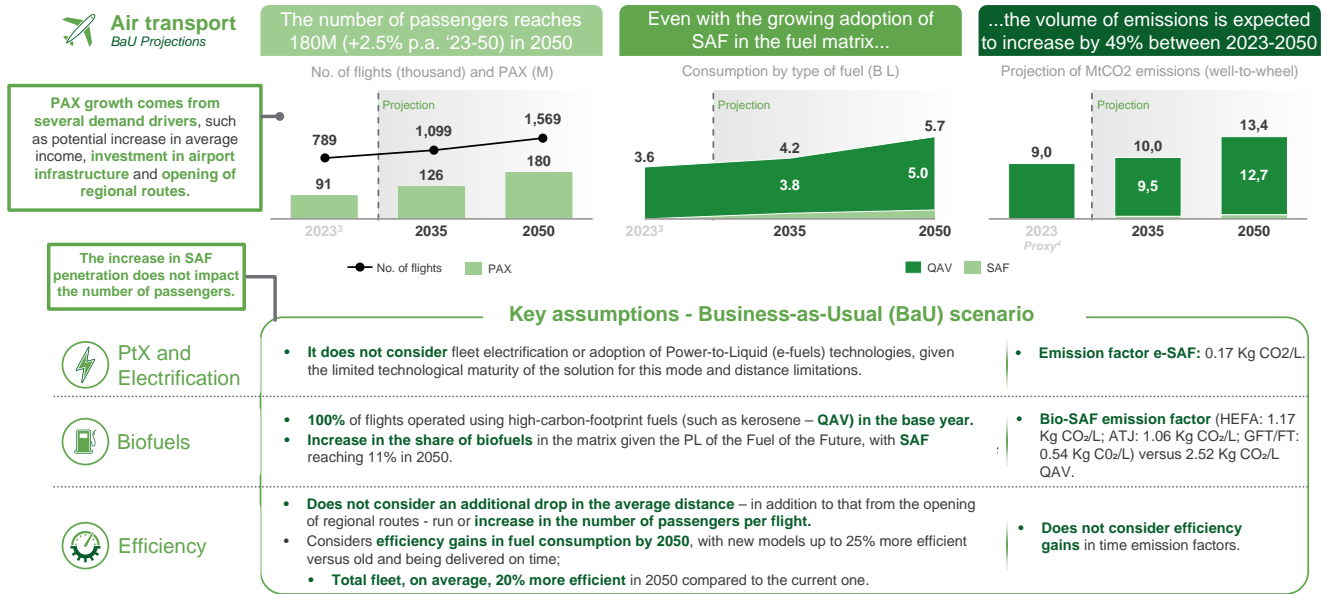
## 2050 | MATRIX PREDICTS ~4.2 TRILLION TKM AND ~2.5 BILLION PASSENGERS TRANSPORTED

Development of the matrix for 2050 projected based on the Transportation Sector Plans and PNL 2035

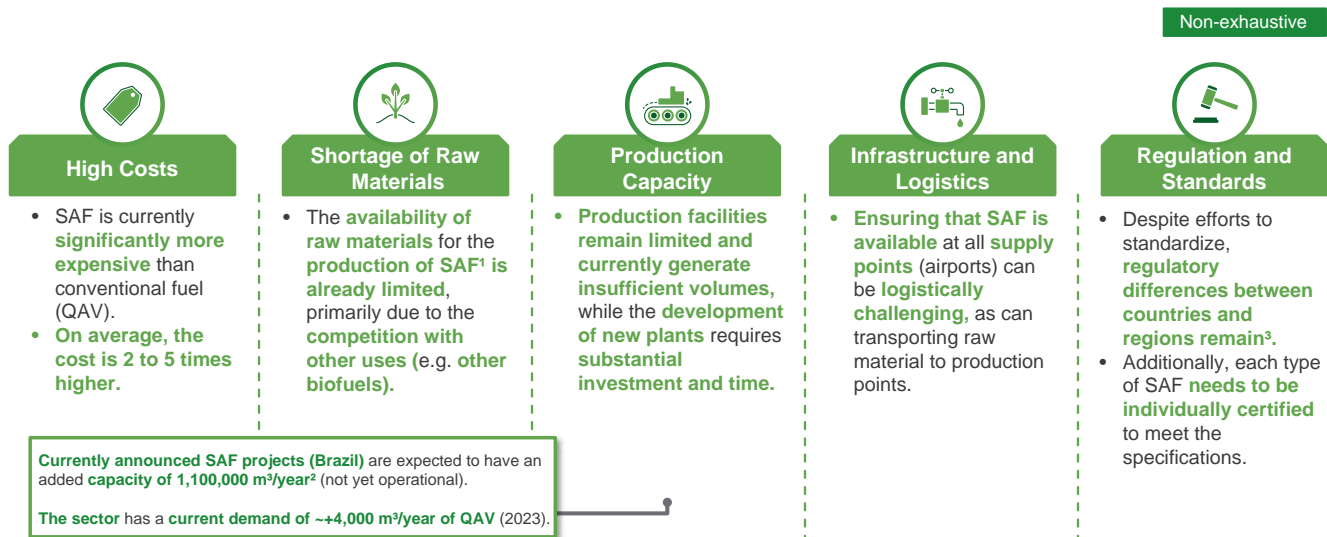


1. Road Transport Sector Plan (PSTR); Rail Transport Sector Plan (PSTF); 2. PNL 2035 – National Logistics Plan; 3. Base year = 2021, with the National Logistics Plan (PNL) projected using the respective CAGRs of the reference scenario relative to 2017. 4. TKM 2035 values refer to the PSR1 scenario of the PSTR and PAX values come from the reference scenario of the PNL 2035 passenger matrix. 5. TKM is projected based on GDP growth, using the modal share from the PSR3 scenario of the PSTR, while PAX is projected according to population growth, assuming constant modal share; 6. Air transport emissions are not related to freight transportation, only to passenger transport. Note: The passenger figures presented in the PNL reflect only intermunicipal and interstate travel, and do not account for intra-urban passenger travel. Sources: Infra S.A.; Ministry of Transport; Ministry of Infrastructure.

# BaU<sup>1</sup> | VOLUME OF EMISSIONS EXPECTED TO INCREASE BY 49% BY 2050



## THE INCREASE IN THE REPRESENTATIVENESS OF SAF IN THE FUEL MATRIX DOES NOT COME WITHOUT ITS CHALLENGES



Notes: 1. Biomass, agricultural waste, waste oils, animal fats and other renewable sources; 2. The last project is expected to become operational only from 2028, requiring a certain time until it is producing the maximum projected capacity considered in the account of 1,100,000 m<sup>3</sup>/year; 3. It is important to observe a certain degree of compatibility between national standards (e.g. Renova Bio) and other international laws/standards (e.g. Corsia). Sources: Argus; ANAC; EPE; FAPESP; ICS; PRO QR; World Economic Forum, Folha de S. Paulo.

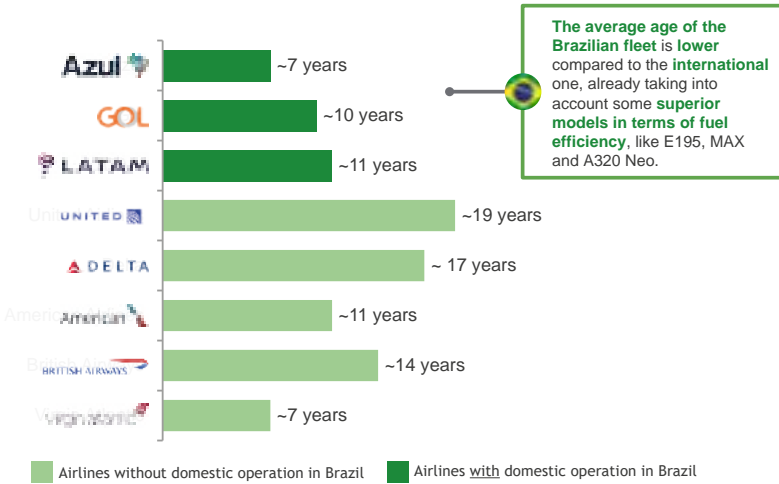
# BRAZILIAN AIRLINES HAVE A RELATIVELY NEW FLEET AND ARE NOTABLE FOR THEIR EFFORTS IN IMPLEMENTING EFFICIENCY INITIATIVES

Fleet and Efficiency Initiatives on the part of Brazilian companies

SAF: scalability challenges

Non-exhaustive

Average fleet age (in # of years, rounded values)



The average age of the Brazilian fleet is lower compared to the international one, already taking into account some superior models in terms of fuel efficiency, like E195, MAX and A320 Neo.

- Other operational efficiency initiatives have been tested by Brazilian companies:
  - LATAM has initiated a program to upgrade its A320 fleet with the function of DPO<sup>1</sup> — improving fuel economy at the time of landing — starting in 2021.
  - In 2024, Gol announced the use of AI tools for intelligent routing services and automated real-time traceability.
  - Azul is jointly developing the APZero program with airports, seeking to replace the APUs with external electrical power sources during boarding and deplaning, thereby avoiding the consumption of QAV.

Notes: 1. DPO – Descent Profile Optimization. Sources: Aviação Brasil; LATAM; ABRALOG; Azul; Gol; Planespotter.

# SOME BRAZILIAN AIRPORTS HAVE ALSO BEEN IMPLEMENTING A SERIES OF MEASURES FOR DECARBONIZATION

Fleet and Efficiency Initiatives on the part of Brazilian companies

SAF: scalability challenges

Non-exhaustive

Examples of decarbonization measures being implemented by Brazilian airports

**Congonhas Airport**

- Investment of **R\$2.4 billion** in its modernization, which includes the installation of a new **electric substation** and ten 100% electric buses.
- Start of **testing of a new biofuel** — BeVant, a fuel developed from biodiesel — in its internal operations.

**Efficiency Initiatives**

- Circula<sup>1</sup> Project:** transformation of the traditional **linear economic model** in airport constructions, processes and operations considering the **principles of circular economy<sup>2</sup>**.
- Target to **migrate the entire light vehicle fleet to biofuels** by 2025.

**Francisco Sá Carneiro Airport**

- PRIO & Beyond Fuels signed a **protocol for the use of biofuels** in heavy-duty vehicles.

**Manaus Airport**


- Target of a **5% reduction in electricity consumption by 2030**, in addition to prioritizing the use of **clean energy**.

**Efficiency Initiatives**

- Replacing **110 guidance lights on one of its runways with LED fixtures**, reducing energy consumption by 85%, enhancing safety, and extending operational lifespan to 50,000 hours.
- The goal of **reducing electricity consumption is 5% per passenger by 2037**.

Notes: 1. Focused on the revitalization of essential equipment for the operation of the terminals, such as airbridges and ground support equipment, as well as structural beams and baggage conveyor belts; 2. Rethink, Reduce, Reuse, Recycle, Repair and Recondition. Sources: Aena; Globo Rural; CNN Brasil, Motiva; Vinci; Brasília Airport.

2

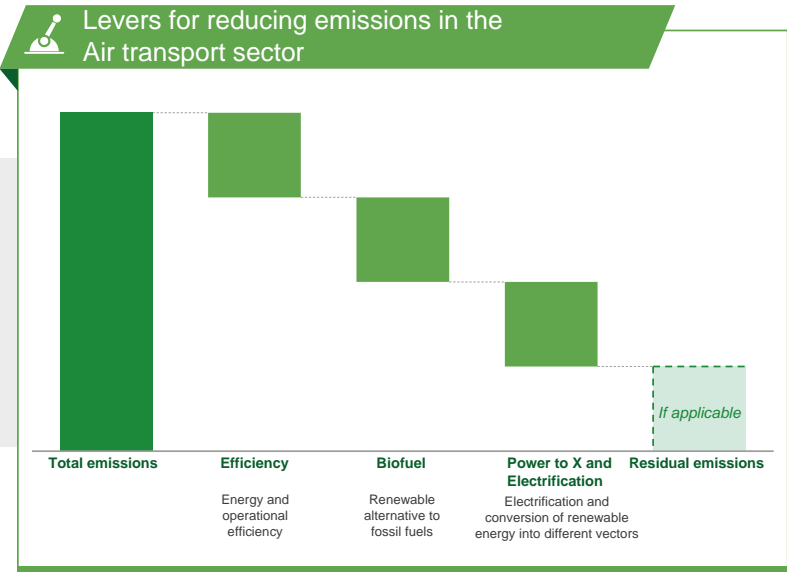


Mapping of levers to reduce emissions applicable to the air transport mode

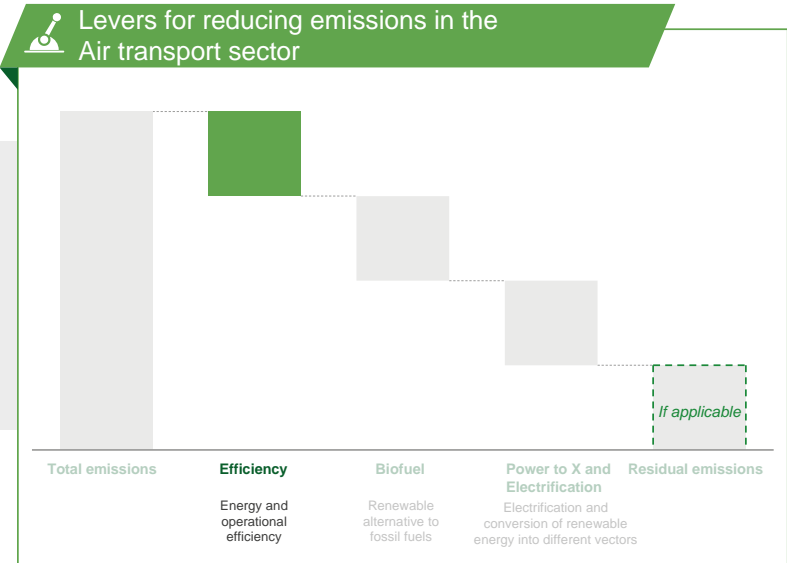
## STEP 2

# TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE AIR TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS

Illustrative



Illustrative



# EFFICIENCY | OPERATIONAL EFFICIENCY AND FUEL CONSUMPTION MEASURES ARE PARAMOUNT FOR REDUCING EMISSIONS

Non-exhaustive

Levers – Aircraft (flight time)	Current feasibility analysis <sup>1</sup>	References
<p>1 Accelerated renewal of the current fleet by faster replacement of older aircraft with <b>more efficient models</b> (e.g., Max and Neo models) and <b>improved design</b>.</p>	<p>Requires intense investments in Capex for a longer implementation period given the age of the Brazilian fleet, but offers a high potential benefit.</p>	<p>GOL   A fleet of <b>52 units</b> of the Boeing 737 MAX 8, an aircraft that is <b>15% more efficient</b> in terms of fuel consumption and emissions.</p>
<p>2 Intelligent route optimization and fleet allocation by <b>modernizing the air traffic operation system</b>, reducing average distance and other effects.</p>	<p>Implementation is somewhat challenging due to reliance on multiple stakeholders, but there is potential for short/medium term benefits.</p>	<p>IATA and DECEA   Study of <b>300 optimized air routes</b>, analyzing the period from 2020 to early 2023, it is possible to achieve a saving of 740,000 km and prevent the emission of 196 million kg of CO<sub>2</sub>.</p>
<p>3 Influence the <b>behavior of engines and pilots</b> through <b>Eco-Efficient and Assisted Driving</b> programs to optimize the high dispersion of energy consumption between different flights.</p>	<p>Relatively simple to implement, with investment dependent on the solution (technology or training).</p>	<p>LATAM   Use of DPO2 in some fleets to improve the <b>efficiency of a plane's descent with the engines idling</b>, reducing more than 300 tons of CO<sub>2</sub>/year per aircraft.</p>
<p>4 Better use of aircraft, with a focus on <b>increasing the load factor</b></p>	<p>Airlines already operate with a high level of occupancy; additional increments have marginal benefits.</p>	<p>VOA Brasil   <b>Additional incentive program</b> for the purchase of air tickets for new segments of the population, <b>stimulating demand</b> in the sector.</p>

The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. Descent Profile Optimization. Sources: Skypower Reports; EPE; The Economist; ProQR; FAPESP.

# EFFICIENCY | EFFICIENCY IN ENERGY CONSUMPTION AND IMPROVEMENT OF AIRPORT MANAGEMENT ARE CENTRAL ENABLERS

Non-exhaustive

Levers – Airports and ground emissions	Current feasibility analysis <sup>1</sup>	References
<p>1 Improvement of operational management<sup>2</sup> (e.g., ground ops., ground control, flight control, etc.) and landing and takeoff trajectories through the <b>modernization of systems</b> and improving airport infrastructure.</p>	<p>Central enabler, but complex implementation in operational and stakeholder management terms.</p>	<p>DXB4   <b>'Follow the Greens'</b> runway guidance system optimizes aircraft taxi routes.</p>
<p>2 Support to <b>increase the efficiency of the aircraft's energy consumption on the ground</b> (e.g., use of electric tow vehicles, use of electric GPUs — e.g., 400Hz — instead of APUs, etc.).</p>	<p>Deployment varies by solution type, as electric towing vehicles require compatibility with the airport's current infrastructure.</p>	<p>Schiphol   <b>Taxibot</b> - Towing vehicle with hybrid motorization that can drive airplanes with engines off to the head of the runway.</p>
<p>3 Implementation of strategies to help <b>have more efficient consumption of electricity, refrigerant gases, waste and water</b> (such as LED lamps, use of natural ventilation, etc.).</p>	<p>Generally low complexity and faster implementation with a high potential for impact.</p>	<p>BSB<sup>3</sup>   Replacing <b>110 guidance lights on one of its runways with LED fixtures</b>, reducing energy consumption by 85%, enhancing safety, and extending operational lifespan to 50,000 hours.</p>
<p>4 Accelerated renewal of the current fleet and support machinery by replacing it with <b>more efficient models</b>.</p>	<p>Benefit may be relevant, but it depends on the scale and timing of implementation.</p>	<p>Embraer   Drives an innovation plan with BNDES financing of R\$500 million, seeking to increase energy efficiency and strengthen the national supply chain.</p>

The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. Considers runway/tarmac and landing/takeoff management decisions; 3. Aeroporto Internacional de Brasília Presidente Juscelino Kubitschek; 4. Dubai International Airport. Sources: ICAO; NLR; FAPESP; ACI.

# TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE AIR TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS



## BIOFUELS | THE USE OF SAF CAN GAIN TRACTION IN THE SECTOR'S FUEL MATRIX

Non-exhaustive

Levers – Aircraft (flight time)	Current feasibility analysis <sup>1</sup>	References
<p><b>1</b> Intensification of the use of bio-SAF directly as an alternative to QAV and aviation gasoline.</p>	<p>Use still requires testing and investment in the supply chain, but has potential benefits in the short/medium term.</p>	<p>Latam   Commitment to incorporate 5% SAF in its operations by 2030. Air France KLM   Agreement with TotalEnergies for the supply of up to 1.5 million tons of SAF over 10 years, until 2035. British Airways   Multi-year agreement with Phillips 66 Ltda. for the supply of SAF produced at the Humber Refinery.</p>
<p><b>2</b> Use of <b>Book &amp; Claim</b> practices, through the acquisition of SAF credits.</p>	<p>Relative ease of implementation, although linked to an increase in Opex.</p>	<p>Gol   Announced in 2023, the company partnered with VIBRA and the RBS platform for a pilot SAF compensation program through the Book &amp; Claim system.</p>

Expected emissions impact

Cutting emissions related to SAF at another stage in its lifecycle might not occur within the scope of Brazilian domestic emissions.<sup>3</sup>

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

● The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. Practice in which a certain airline buys the credits corresponding to the SAF produced, but uses conventional fuel on its flights, another part of the system consumes the physical SAF and the purchasing company receives carbon credits; 3. Although it can be accounted for in CORSIA. Sources: Skypower Reports; EPE; The Economist; ProQR; FAPESP; Gol.

# BIOFUELS | REPLACING TRADITIONAL FUELS IS KEY FOR DECARBONIZING AIRPORTS

Non-exhaustive

Levers – Airports and ground emissions	Current feasibility analysis <sup>1</sup>	References
<p>1 Use of <b>clean fuel in support machinery</b>, such as in <b>APU</b> (Auxiliary Power Unit) and/or <b>GPU</b> (Ground Power Unit).</p>	<p>Low implementation complexity, but capable of generating benefits in the short term.</p>	<p>VINCI Airports   PRIO &amp; Beyond Fuels signed a protocol for the use of biofuels in heavy-duty vehicles at Francisco Sá Carneiro Airport.</p>
<p>2 Use of <b>clean fuels</b> in the <b>support fleet</b> (e.g., internal buses and CNG- or ethanol-based baggage tractors).</p>	<p>Benefit may be relevant, but it depends on the scale and timing of implementation.</p>	<p>Motiva   Target to migrate the entire <b>light vehicle fleet to biofuels</b> by 2025.</p>
<p>3 Support for the <b>provision of clean fuels</b> to aircraft (e.g., infrastructure, facilitation, etc.).</p>	<p>Central enabler of the sector's decarbonization, however, certain actions are more complex to implement.</p>	<p>Schiphol &amp; NESTE   Partnership for the supply of more than <b>2 million gallons of SAF</b> integrated into the fuel system in 2024.</p>

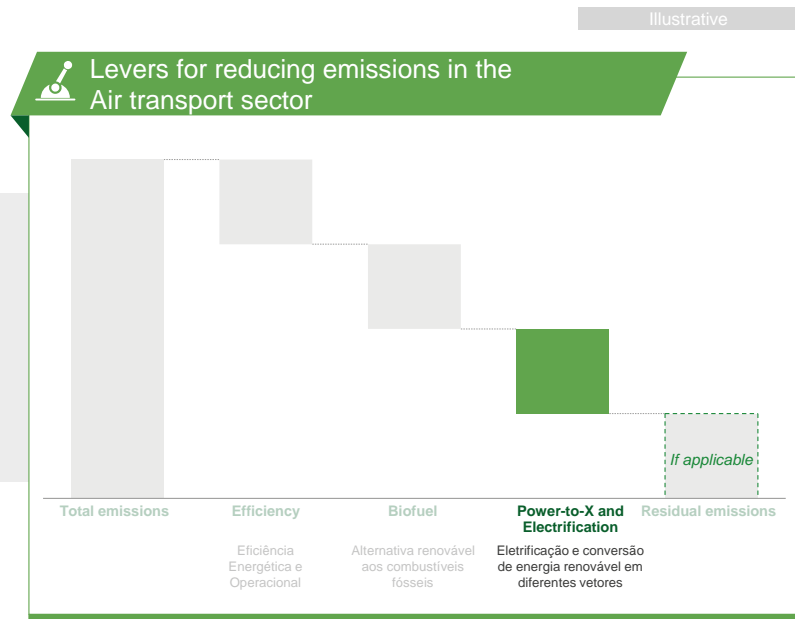
*Potential intensification of biofuels to reduce the carbon footprint can be applied as long as the technical, mechanical, operational and laboratory viability of said energy input is confirmed, as well as respecting the diversity of matrices and regional specificities.*

Expected emissions impact

● The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; Sources: ICAO; NLR; FAPESP; ACI.

## TYPICAL LEVERS FOR REDUCING EMISSIONS IN THE AIR TRANSPORT MODE WERE ADDRESSED IN THREE IMPORTANT BLOCKS



# PtX AND ELECTRIFICATION | ALTHOUGH STILL IN THE EARLY STAGES OF DEVELOPMENT, SOLUTIONS MAY GAIN STRENGTH IN REGIONAL AVIATION

Non-exhaustive

	Levers – Aircraft (flight time)	Current feasibility analysis <sup>1</sup>	References
Expected emissions impact	<p>1 Use of Power-to-Liquid solutions (PtL: e-SAF<sup>2</sup>) as an energy source.</p>	<p>Technology is still under development and depends on testing and time to become viable at scale.</p>	<p>United   UAV3 investment + commercial agreement with Dimensional Energy, committing to acquire at least 300 million gallons of PtL SAF over 20 years.</p>
	<p>2 Use of hydrogen solutions as a direct energy source (through direct combustion or fuel cell).</p>	<p>Technology is still extremely nascent and depends on testing to analyze the feasibility at scale for commercial aviation.</p>	<p>Airbus   Through a joint venture with EirongKlinger AG, Airbus is conducting trials for the development of commercial aircraft using H2 fuel cell.</p>
	<p>Other initiatives that are potential levers for smaller and short-haul aircraft, such as electrification/hybridization, have not been analyzed in detail given the limitation of the solution and implementation time.</p>		

The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. Synthetic fuels produced from green hydrogen, renewable electricity and captured CO<sub>2</sub> – the synthetic gas needs to go through a conversion process (Fischer-Tropsch) to produce liquid products that can be refined for fuels; 3. United Airlines Ventures. Sources: Skypower Reports; EPE; The Economist; ProQR; FAPESP.

# PtX AND ELECTRIFICATION | ELECTRIFICATION, CLEAN ENERGY AND INFRASTRUCTURE ARE ESSENTIAL LEVERS TO DECARBONIZE AIRPORT OPERATIONS

Non-exhaustive

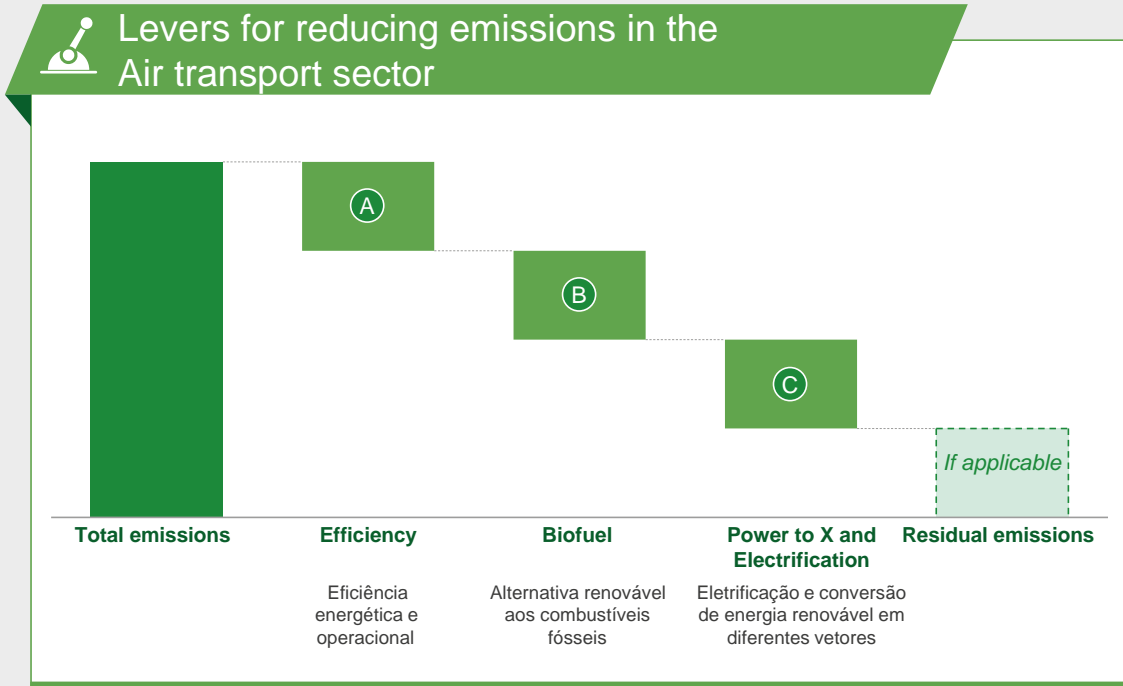
	Levers – Airports and ground emissions	Current feasibility analysis <sup>1</sup>	References
Expected emissions impact	<p>1 Use of renewable energy (e.g., photovoltaic matrix) in operations (terminals, yard and administrative).</p>	<p>Requires general access infrastructure of more complex implementation, but has the potential for benefits over the medium term.</p>	<p>Motiva   Solar farms were installed in seven managed airports with a total capacity to generate 40 million kWh per year. 750,000 m<sup>2</sup> of land.</p>
	<p>2 Electrification (or use of hybrid batteries) of the fleet (e.g., buses and baggage tractors) and support machinery (e.g., GPU).</p>	<p>Benefit may be relevant, but it depends on the scale and timing of implementation.</p>	<p>SFO<sup>2</sup>   Zero Emissions Vehicle Readiness Roadmap – Electrification of 38% of the light fleet, 50% of the bus fleet and 45% of the ground support eq. + 300 charging stations.</p>
	<p>3 Use of clean energy matrix in electrical/hybrid support systems and machinery (e.g., GPU).</p>	<p>Essential enabler for the decarbonization of the sector, but has a bit of a higher complexity and need for significant investments.</p>	<p>Zurich Airport Brasil<sup>3</sup>   Implementation of a system that supplies electricity provided by the airport from renewable sources, for aircraft on the ground.</p>
	<p>4 Improvement of the airport's infrastructure, allowing electrification (e.g., socket infrastructure, adapted transmission power network, etc.).</p>	<p>Requires general access infrastructure of more complex implementation, but has the potential for benefits over the medium term.</p>	<p>Congonhas Airport   Aena<sup>4</sup> Investment of R\$2.4 billion in its modernization, which includes the installation of a new electric substation and ten 100% electric buses.</p>

The greener, the more viable.

Notes: 1. Qualitative, based on factors such as Ease of Implementation, Expected Impact on Efficiency and Time to Implementation, as well as inputs from the Listening Moment (feedback session) with the group; 2. San Francisco International Airport; 3. Airports of Florianópolis and Vitória; 4. Aeropuertos Españoles y Navegación Aérea. Sources: ICAO; NLR; FAPESP; ACI.

# WHICH WERE QUANTIFIED IN DIFFERENT SENSITIVITIES

Illustrative



Quantification of each lever's impact on emission levels, based on four possible combinations of measures:



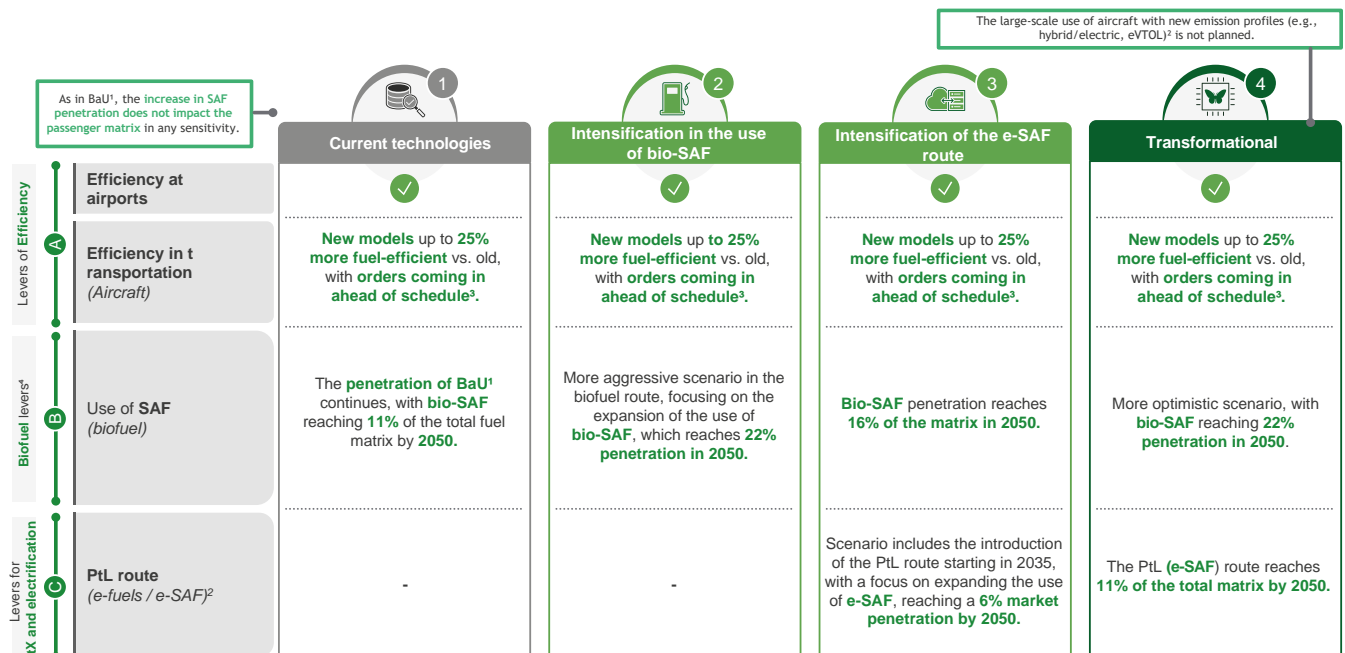
1. Unquantified airport emissions; 2. The use of remote-limited or very immature technologies, such as electrification or eVTOL, is not planned at scale.





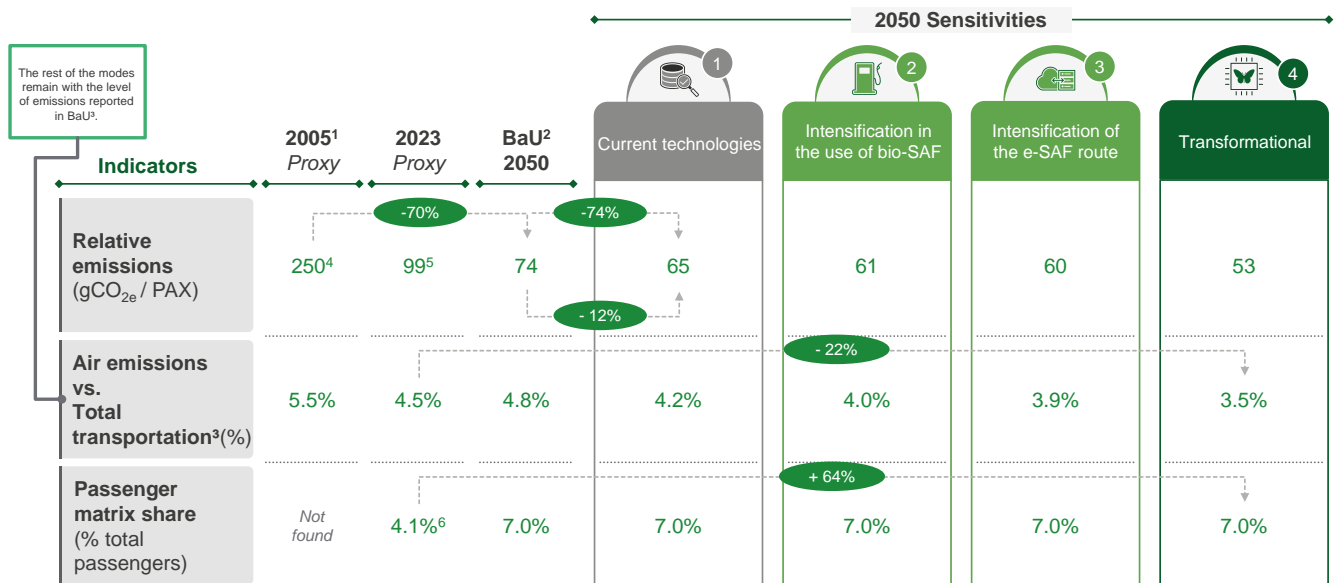
### STEP 3

## THE PROPOSED SENSITIVITIES WERE BASED ON VARYING ASSUMPTIONS...



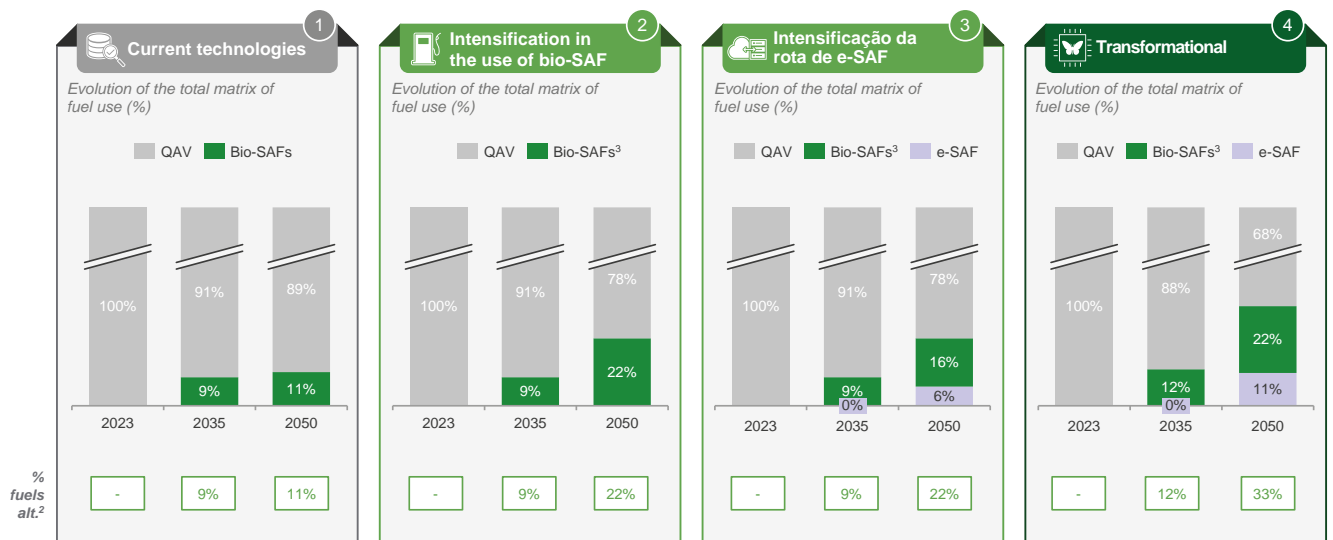
1. BaU – business-as-usual (emissions baseline); 2. Given the focus on large-scale commercial aviation and the immaturity of the respective solutions for the mode, electrification, eVTOL and the use of pure hydrogen are not being considered in the model; 3. The total fleet is, on average, 30% more efficient in 2050 versus base year; 4. Potential intensification of biofuels to reduce the carbon footprint can be applied as long as the technical, mechanical, operational and laboratory viability of said energy input is confirmed, as well as respecting the diversity of matrices and regional specificities. Sources: AviationWeek; IATA; sustainability report of Brazilian airlines; ReFuelEU legislation; U.S. Department of Energy; S&P; EPE; ICAO; Argus; interviews with sector experts.

# ALTHOUGH EMISSIONS WILL NOT BE ZERO, THE PASSENGER SHARE IS GROWING WHILE THE EMISSIONS SHARE MAY DECREASE BY 2050



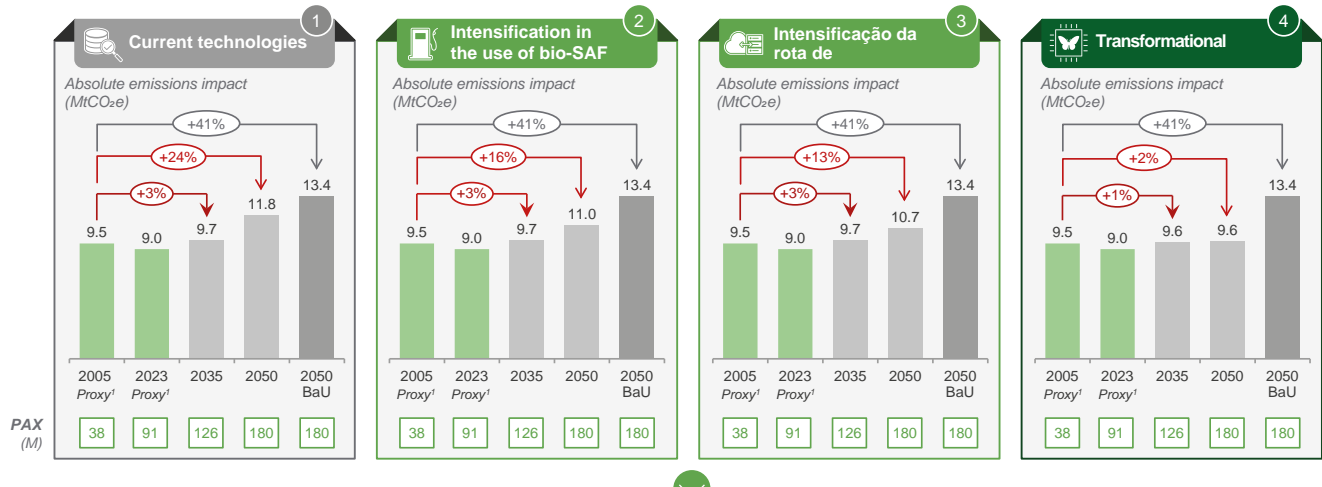
1. Base year for NDCs; 2. Business-as-usual; 3. The emissions level of other modes, after levers are applied, will be addressed in WS#3 on Infrastructure and Transversality; 4. The SEEG emission was adjusted by a Well-to-Tank (WTT)/Tank-to-Wheel (TTW) emission factor; 5. Emissions proxy (GLEC); 6. 2023 – base year. Sources: SEEG, ANAC, among others.

## ...WHICH ARE REFLECTED IN DISTINCT FUEL USE MATRICES



1. Bio-SAFs are those of the HEFA, Atj and FT/GFT routes; 2. % fuels alt. = % of the fuel matrix from bio-SAF and e-SAF; 3. Potential intensification of biofuels to reduce the carbon footprint can be applied as long as the technical, mechanical, operational and laboratory viability of said energy input is confirmed, as well as respecting the diversity of matrices and regional specificities. Sources: AviationWeek; IATA; sustainability report of Brazilian airlines; ReFuelEU legislation; U.S. Department of Energy; S&P; EPE; ICAO; Argus; interviews with sector experts.

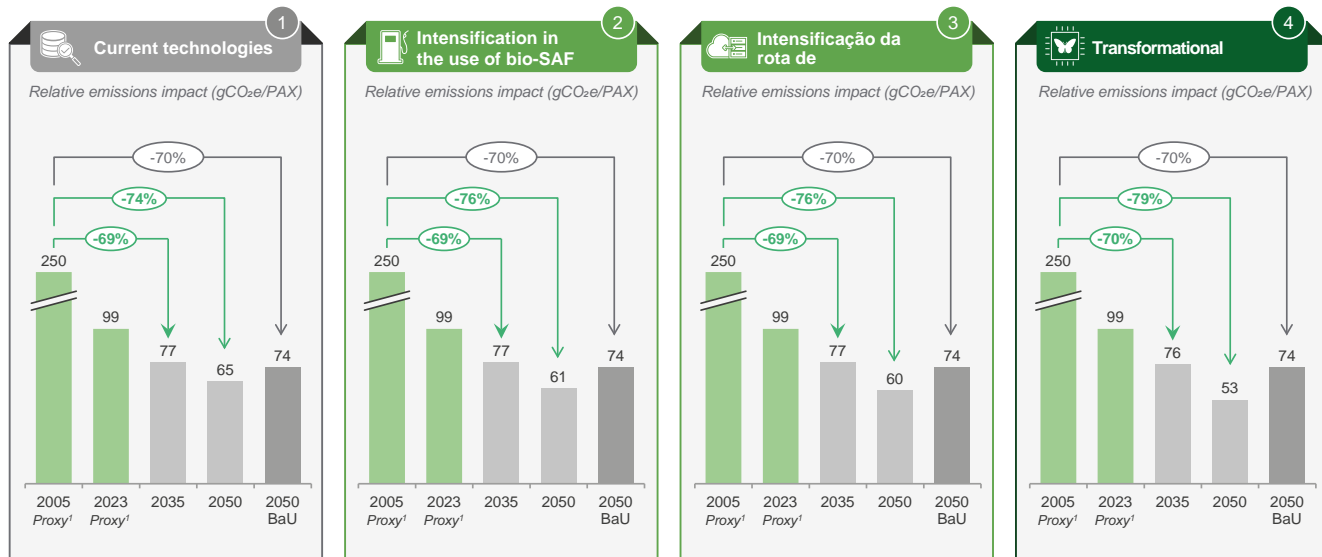
# ... AND DIFFERENT POTENTIAL IMPACTS ON THE LEVEL OF EMISSIONS



The emissions increase in the first three sensitivities stems from the growth in the mode's passenger volume; however, this increase is lower compared to the BaU scenario—which shows a growth of +5% 2005-35 and +41% 2005-50.

Note: 1. The 2005-2023 SEEG emissions (2023: proxy by GLEC emission factor) were adjusted by a Well-to-Tank (WTT) /Tank-to-Wheel (TTW) emission factor of the mode. Sources: SEEG; AviationWeek; IATA; sustainability report of airlines; ReFuelEU legislation; U.S. Department of Energy; S&P; EPE; ICAO; Argus; interviews with sector experts.

# THE IMPROVEMENT EFFECT CAN BE BETTER OBSERVED WHEN ANALYZING RELATIVE EMISSIONS (gCO<sub>2</sub>e/PAX)



Note: 1. The 2005-2023 SEEG emissions (2023: proxy by GLEC emission factor) were adjusted by a Well-to-Tank (WTT) /Tank-to-Wheel (TTW) emission factor of the mode. Sources: SEEG; AviationWeek; IATA; sustainability report of airlines; ReFuelEU legislation; U.S. Department of Energy; S&P; EPE; ICAO; Argus; interviews with sector experts.

# MAPPING OF ENABLERS

## RECENT EXAMPLES ILLUSTRATE HOW ENABLERS HELP UNLOCK KEY LEVERS FOR SECTOR DECARBONIZATION

Illustrative

### Selected examples

- ✓ **Public guidelines and incentives that make it possible to reduce emissions from the air transport sector | CORSIA** | Regulation that establishes mandatory targets for offsetting and reducing carbon emissions in international aviation, impacting domestic aviation. 
- ✓ **Multisectoral coordination mechanisms that foster SAF infrastructure and availability** | Sea-Tac<sup>1</sup> International Airport, in collaboration with 13 airlines<sup>2</sup>, is adjusting its infrastructure to fuel 10% of flights with SAF by 2028. 
- ✓ **Regulation that encourages public and private investments in cleaner fuels | Fuel of the Future Law** | ProBioQAV promotes research, production and use of SAF to decarbonize domestic air transport. 
- ✓ **Tangible mechanisms to promote private financing | Sustainable Flight Fund** | +20 global and Brazilian partners (e.g., Embraer) committed to financing more than US\$200 million in projects aimed at decarbonizing air transport. 
- ✓ **Accounting for emissions with Book & Claim | ICAO** | CORSIA recognizes and systematizes the Book & Claim model, allowing the use of these credits to account for emission reductions and alleviate the shortage of SAF in countries where it is less available. 
- ✓ **Concrete steps for Brazil to become a leading player in the global SAF chain** | In 2024, Raízen conducted the first shipment of sugarcane ethanol from Brazil to the United States, where it was intended to be converted into SAF at a plant in Georgia. 

Notes: 1. Seattle-Tacoma; 2. Including Alaska Airlines, Delta Air Lines, Emirates, Horizon Air, Icelandair and Lufthansa. Sources: Bloomberg; FINEP; IATA; United Airlines Ventures; Aero Magazine; Embraer; Airport Technology News.



## Target impact in 2050 – Air transport

# We aim for sustainable growth in the Brazilian Air Transport sector



Representing a reduction of ~30%, even with a gain in representativeness of the mode.

### Current Air Transport Mode<sup>1</sup>...

### ...Future Air Transport Mode<sup>2</sup>



**~4% of passengers** transported by air (equivalent to ~91 M of PAX<sup>3</sup>).



**~7% of passengers** transported by the mode (~180M), growth of +2.5% p.a.



**~0 BILLION LITERS of biofuels** consumed, with the matrix focused on the use of fossil options<sup>4</sup>.



**~1.1 BILLION LITERS of bio-SAF** consumed, representing 22% of the mode's fuel matrix.



**~0% of the fuel matrix** originating from PtX<sup>5</sup> or hydrogen solutions

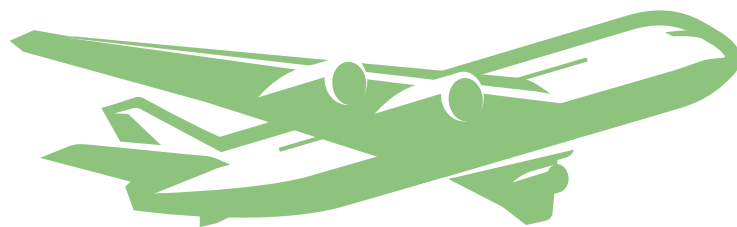


**~11% of aircraft** using **synthetic fuels (PtX – e-SAF)**.

The large-scale use of aircraft with new emission profiles, such as hybrid/electric models or eVTOL, is not expected<sup>6</sup>.

1. 2023 Proxy; 2. 2050 Transformational; 3. Passengers; 4. Aviation kerosene or gasoline; 5. Power-to-X; 6. Given the focus on large-scale commercial aviation and the immaturity of the respective solutions for the mode, electrification, eVTOL and the use of pure hydrogen are not being considered. Sources: SEEG; AviationWeek; IATA; ReFuelEU; U.S. Department of Energy; S&P; EPE; ICAO; Argus; interviews with sector experts.

## SUMMARY | AIR TRANSPORT SYSTEM



The Air transport mode currently makes up **~4% of the national passenger matrix<sup>1</sup>** (~91 million PAX<sup>2</sup>), emitting **~9.0 Mton CO<sub>2</sub>e<sup>1,3,4</sup>** in absolute emissions (about **3.5%<sup>1,3,4</sup>** of total emissions from the transport sector) and **99 gCO<sub>2</sub>e/PAX<sup>1,3,4</sup>** in relative emissions.

According to projections by the PNL and Sectoral Transport Plans<sup>5</sup>, the **Air Transport mode will make up 7.0% of Brazil's passenger matrix in 2050**, with ~180 million PAX transported (+2.5% p.a. by 2050); in a scenario of inaction, **emissions are expected to reach 13.4<sup>4</sup> Mton CO<sub>2</sub>e in the same year<sup>5</sup>** (+49% vs. 2023).

To mitigate emissions growth and contribute even more actively to the climate agenda, the **12 participating entities<sup>6</sup>** in the Coalition's Air Transport Vertical engaged in active discussions to evaluate the decarbonization potential of **19 sectoral levers**. Among them, the following stand out:

- **Biofuels | Expansion** of the use of alternative fuels, such as **Bio-SAF**;
- **Efficiency | Fleet renewal**, integrating aircraft models with better design and more fuel-efficient;
- **Efficiency | Improvement of airport operational management** through the modernization of systems and enhancing infrastructure.

Due to the expected growth in passenger volume, **the sector's emissions could reach 9.6 Mton CO<sub>2</sub>e<sup>3,4</sup> absolute** (+7% vs. 2023) in transformational sensitivity in 2050. **However**, as a result of the implementation of the **19 mapped levers**, absolute emissions are expected **to represent a reduction of 28% vs. an inaction scenario**, reaching 53 gCO<sub>2</sub>e/PAX<sup>3,4</sup> (-46% vs. 2023 and -28% vs. inaction) of relative emissions.

It should be pointed out that the **expansion of the use of SAF faces some challenges, such as high cost compared to QAV<sup>7</sup>, scarcity of raw material and low productive capacity** – factors that **need to be overcome to enable its implementation** as a key lever of decarbonization.

Given the scale of the challenge of implementing the use of SAF and the other levers, a series of **enablers will be required to materialize them. Some concrete examples below illustrate how enablers can help** progress the decarbonization agenda in the Air transport mode:

- **Regulation | Fuel of the Future Law |** The ProBioQAV program promotes the research, production and use of SAF to decarbonize domestic air transport;
- **Collaboration and Partnerships | SAF Connection - ANAC |** Partnership between public and private entities to identify challenges enable the production and use of SAF in Brazil.

Given the **significant growth of the mode, remaining emissions should represent 7.0%<sup>3,4</sup> of Brazil's total transport emissions** even in the most transformational sensitivity in 2050. As such, the **entities participating in the Coalition need to continue ongoing discussions** to make a bit more progress towards net-zero emissions by 2050, **minimizing the need for compensation**.

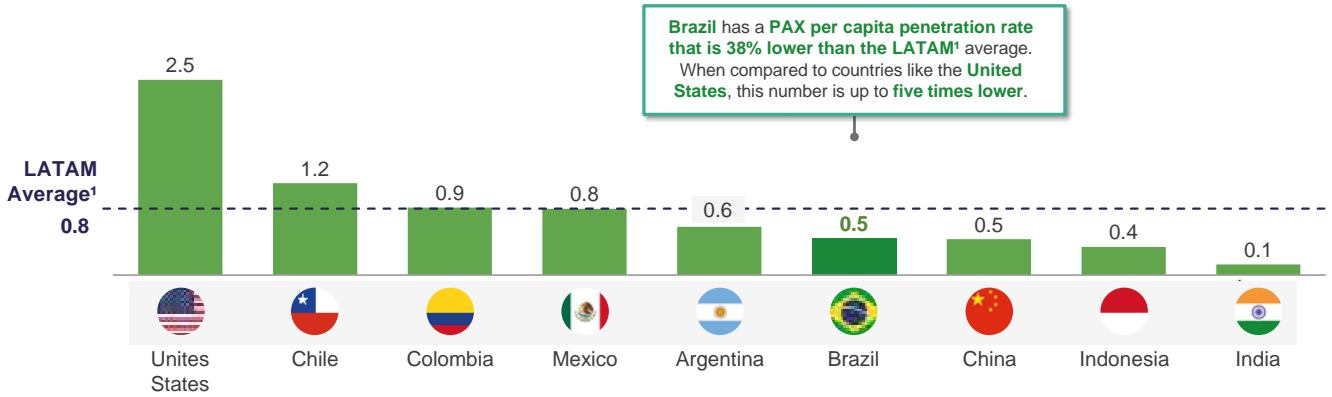
1. 2023; 2. PAX = passengers; 3. Considers well-to-wheel adjustments (WTW), even for actual values (2023), 4.5% ex adjustments; 4. Considers only the emissions that prevent the burning of fuel during the flight of domestic commercial aircraft (85%-90% of the sector's emissions); 5. Considers the sectoral transportation plans and adjustments as a basis, given the discussions with sectoral entities and experts; 6. In addition to the 9 specific entities, CEBDS, Motiva, CNT and Inesper Mobility Observatory also coordinated the discussions across the different verticals of the Coalition; 7. Aviation kerosene.

## APPENDIX 1

# GLOBAL TRENDS FOR THE AIR TRANSPORT MODE

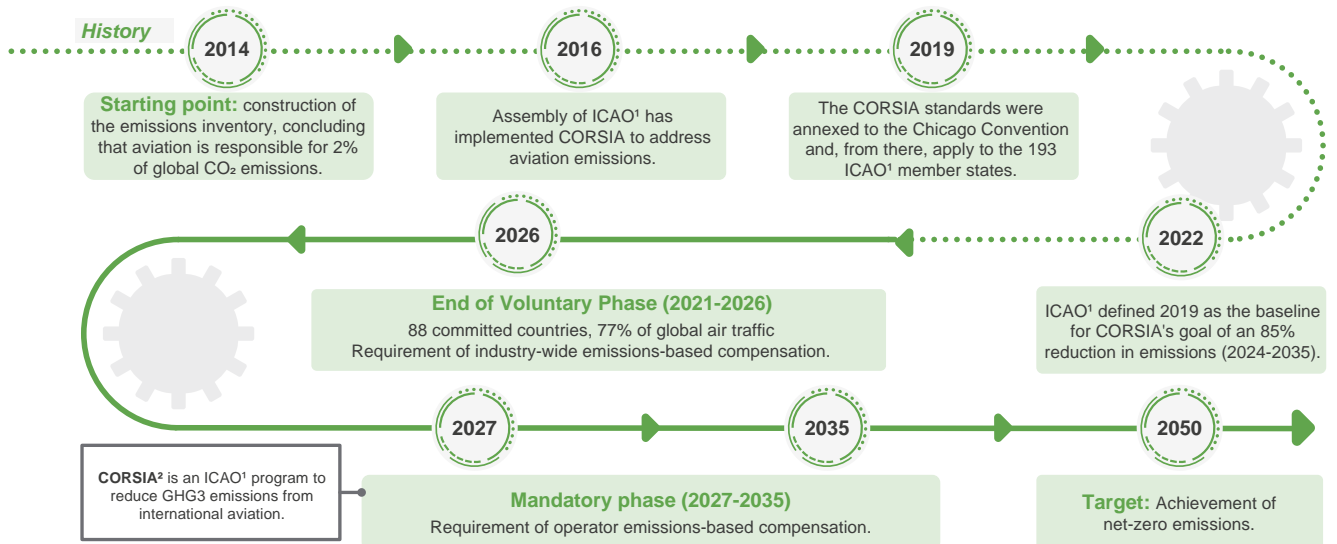
# WHEN COMPARED WITH OTHER COUNTRIES, THE BRAZILIAN AIR TRANSPORT SECTOR IS STILL UNDER-PENETRATED

Total passengers per inhabitant (PAX/1000 inhabitants) 2023



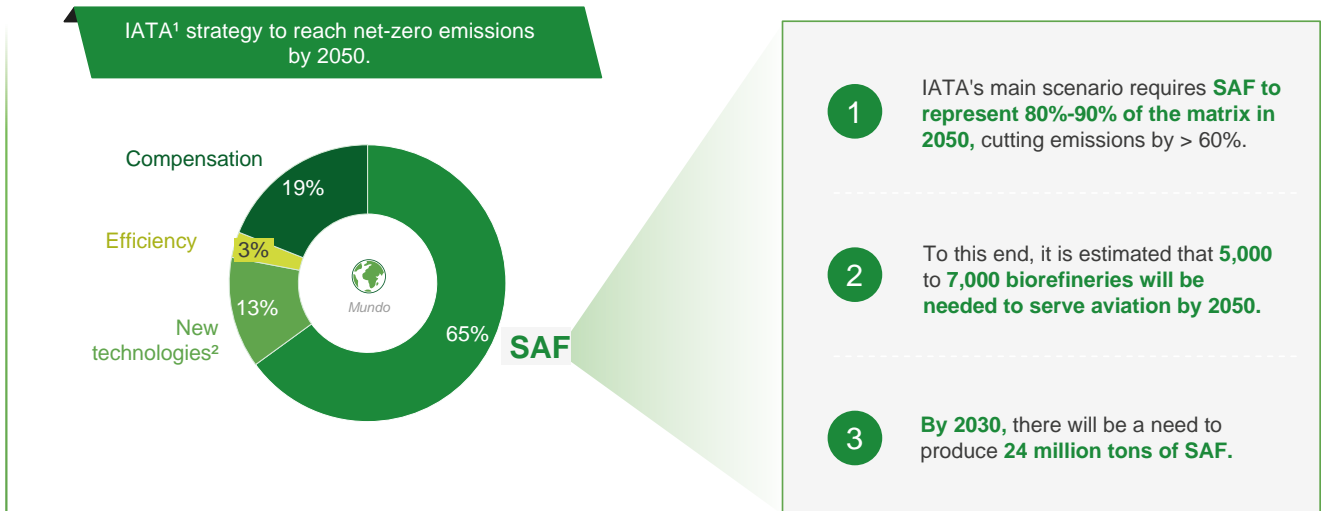
Notes: 1. Only considers Chile, Colombia, Mexico, Argentina and Brazil. Sources: IATA; OAG; ICAO; UNWTO; EIU; ANAC.

# ICAO<sup>1</sup> HAS SET A GOAL FOR THE DECARBONIZATION OF THE INTERNATIONAL CIVIL AVIATION SECTOR, 77% OF GLOBAL AIR TRAFFIC ALREADY PARTICIPATES



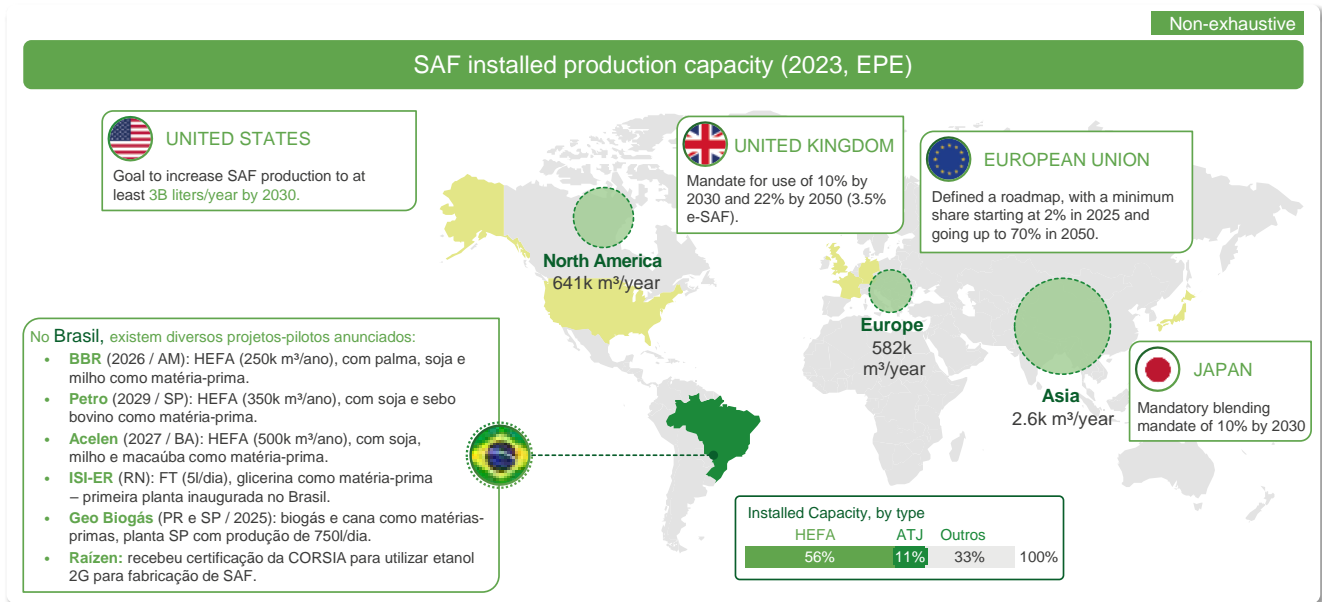
1. International Civil Aviation Organization 2. Carbon Offsetting and Reduction Scheme for International Aviation 3. Greenhouse Gas. Source: ICAO.

# IATA<sup>1</sup> POSITIONS SAF AS THE LEADING GLOBAL STRATEGY FOR DECARBONIZING THE AIR TRANSPORT SECTOR



1. International Air Transport Association 2. New technologies consider the use of pure hydrogen, electrification and others. Sources: T&E; IATA.

## HOWEVER, THE SUPPLY CAPACITY OF THE SAF IS STILL A RELEVANT BARRIER



Sources: EPE; FAPESP; PRO QR; S&P Global Commodity Insights.

## A NUMBER OF PROVIDERS OF AUXILIARY AIR TRANSPORT SERVICES HAVE ALSO BEGUN IMPLEMENTING A RANGE OF DECARBONIZATION MEASURES

Ground services, such as aircraft towing and pushback, freight and baggage handling, internal cleaning and disinfection of aircraft, surface transport of crew and passengers, X-ray and other activities to combat terrorism, are included in the project.

The current electrification of the fleet represents 8% of the total. The following companies have committed to increase the percentage of electrical or hybrid equipment to 50% by 2032, in a process that began in 2022:

Non-exhaustive



# **LOCAL TRENDS FOR THE AIR TRANSPORT MODE**

## ALTHOUGH BRAZIL IS SHOWING PROGRESS TOWARD AVIATION DECARBONIZATION, NATIONAL REGULATIONS ARE STILL MATURING



Brazil has signed CORSIA to offset emissions beyond the 2020 baseline, to achieve **zero net aviation CO<sub>2</sub> emissions by 2050**.



Launch of the **RenovaBio and Fuel of the Future programs as a starting point** to promote the use of sustainable and low-carbon fuels in Brazil.



**The recently announced HEFA project was included in the Growth Acceleration Program (PAC)**, in which the associated projects have a preferential focus on government funding.



**The ProBioQAV National Program was introduced** to stimulate research and promote energy production from biomass, intended to achieve aviation sustainability.



Despite this, **national regulations are still maturing and the certification criteria for bio-kerosene production are unclear in RenovaBio**, making it difficult for producers to benefit from incentives by issuing CBIOS.



# THE "FUEL OF THE FUTURE" LAW AIMS TO BOOST LOW-CARBON MOBILITY

Program to encourage the research, production, commercialization and use of SAF in order to unlock the Brazilian agenda for the decarbonization of air transport:



## National Sustainable Aviation Fuel Program (ProBioQAV)

Starting in 2027, air operators will be required to reduce GHG1 emissions on domestic flights through the use of SAF.

- Progressive goals starting with 1% reduction and gradually growing to reach 10% in 2037.

1. Greenhouse Gases; 2. The calculation basis on which the emission reduction obligations will be computed will be given by the volume of emissions arising from domestic operations carried out by the airline in the corresponding year, assuming that all operations have used fossil fuel. Source: Press research.





MAIN CONCLUSIONS

# URBAN MOBILITY

# URBAN MOBILITY – MEMBER ENTITIES

This document was supported by the following urban mobility entities.



COORDINATION

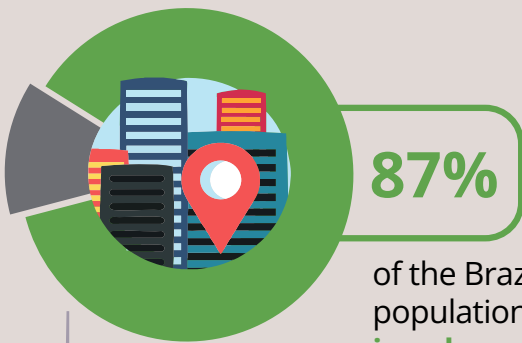


OTHER MEMBERS



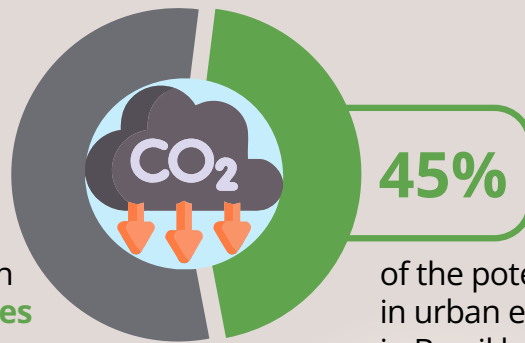
TRANSVERSAL AND CONSULTATIVE ENTITIES

# URBAN MOBILITY EMISSIONS ARE OF GREAT IMPORTANCE TO BRAZIL'S CLIMATE GOALS



of the Brazilian population **lives in urban centers.**

Source: 2022 Brazilian Census.



of the potential reduction in urban emissions in Brazil by the **year 2050 comes from the transportation sector.**

Source: Coalition for Urban Transitions.



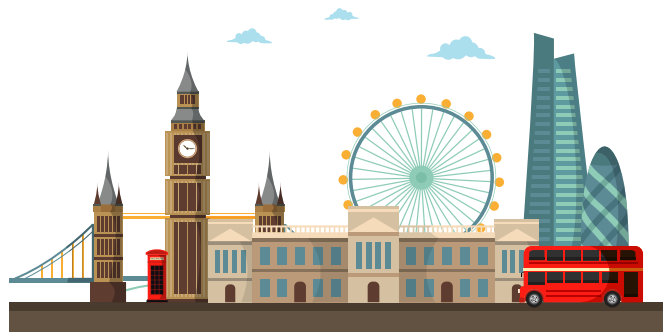
Emissions from individual motorized transport are much higher than those of public transportation (**127 gCO<sub>2</sub>/pkm<sup>1</sup> in cars vs. 16 gCO<sub>2</sub>/pkm in buses in the city of São Paulo**), reinforcing the thinking that expanding public transportation and emphasizing the importance of maintaining connections between different modes of transport is fundamental for the decarbonization of the transportation sector and for achieving net-zero emissions in urban mobility.

**GHG EMISSIONS<sup>2</sup>  
PER PASSENGER-KM**   
São Paulo perspective (gCO<sub>2</sub>/pkm)

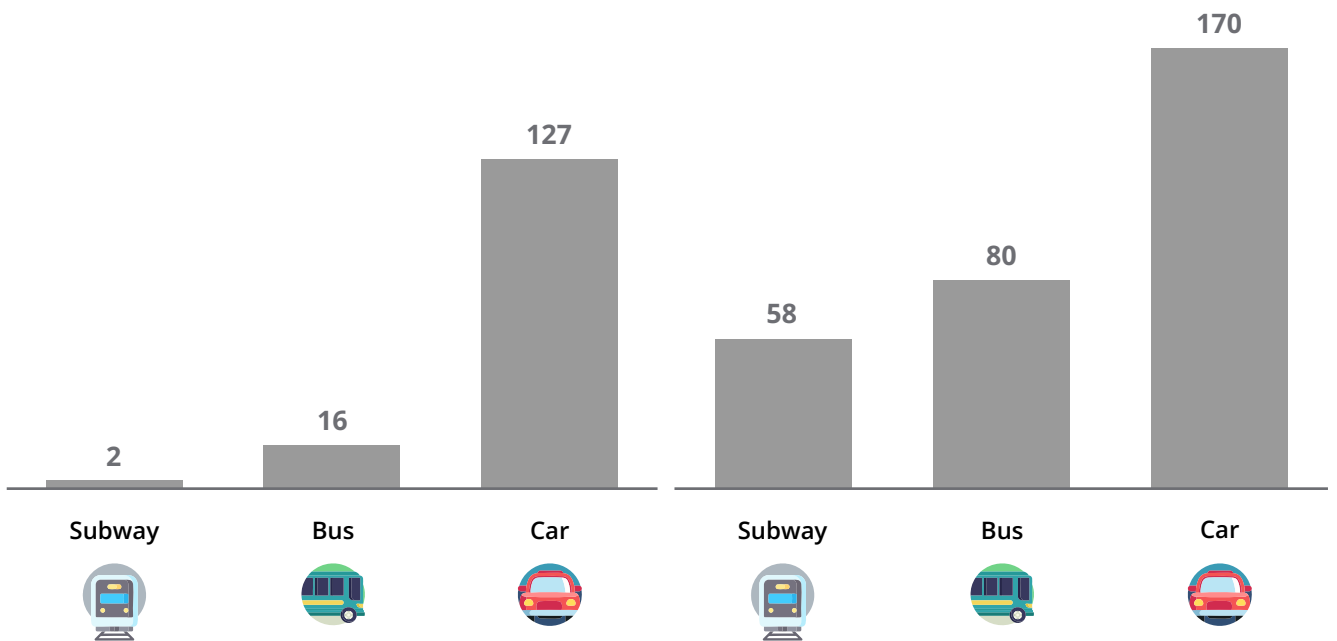


Public transport with much lower relative emissions compared to individual transport.

**GHG EMISSIONS<sup>2</sup>  
PER PASSENGER-KM**   
London perspective (gCO<sub>2</sub>/pkm)



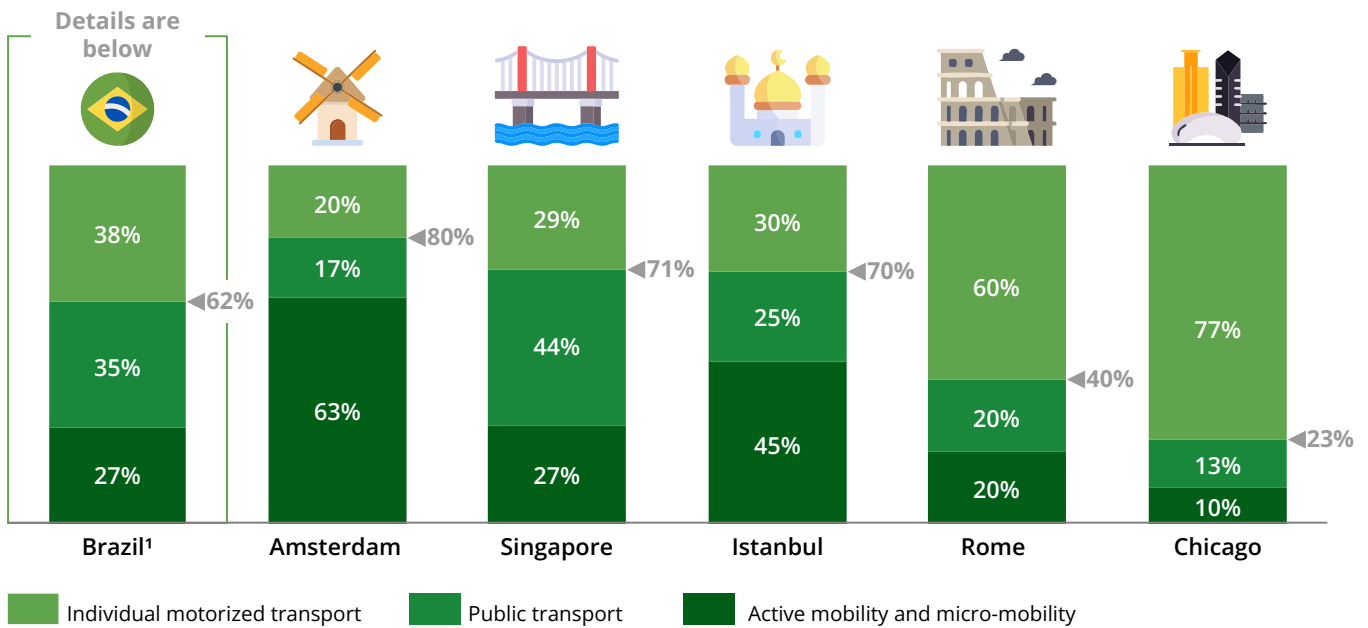
Brazil's leading role in topics such as biofuels puts it in a more favorable situation compared to other places.



1. Passenger-kilometre; 2. Greenhouse Gases. Sources: ANPTTrilhos; Technical article: Evaluation of subway systems in terms of CO<sub>2</sub> emissions: comparative analysis of emissions from cars, buses and subways (2019).

Although urban centers are treated in a uniform manner, in most cases there are many different types of urban centers, with various transport matrix profiles.

# DISTRIBUTION OF TRIPS BY URBAN MOBILITY MODES OF TRANSPORT IN BRAZIL AND IN MAJOR GLOBAL CENTERS



1. The CNT Urban Population Mobility Survey focuses on municipalities with more than 100K inhabitants and the result considers the 5,720 respondents aged 15 years or older who travel every day, 3 to 4 days a week or 1 to 2 days a week (participants were able to cite up to 3 response options for the most used means of transport for urban travel); Survey information was converted to the base 100%, considering the following classifications: Bus (public transport), personal car, on foot, personal motorcycles, personal bicycle, subway, urban/metropolitan train, light rail vehicle (LRV) and monorail. Sources: CNT Urban Population Mobility Survey; Moving Millions Study: A Recipe to Make Urban Mobility Work.

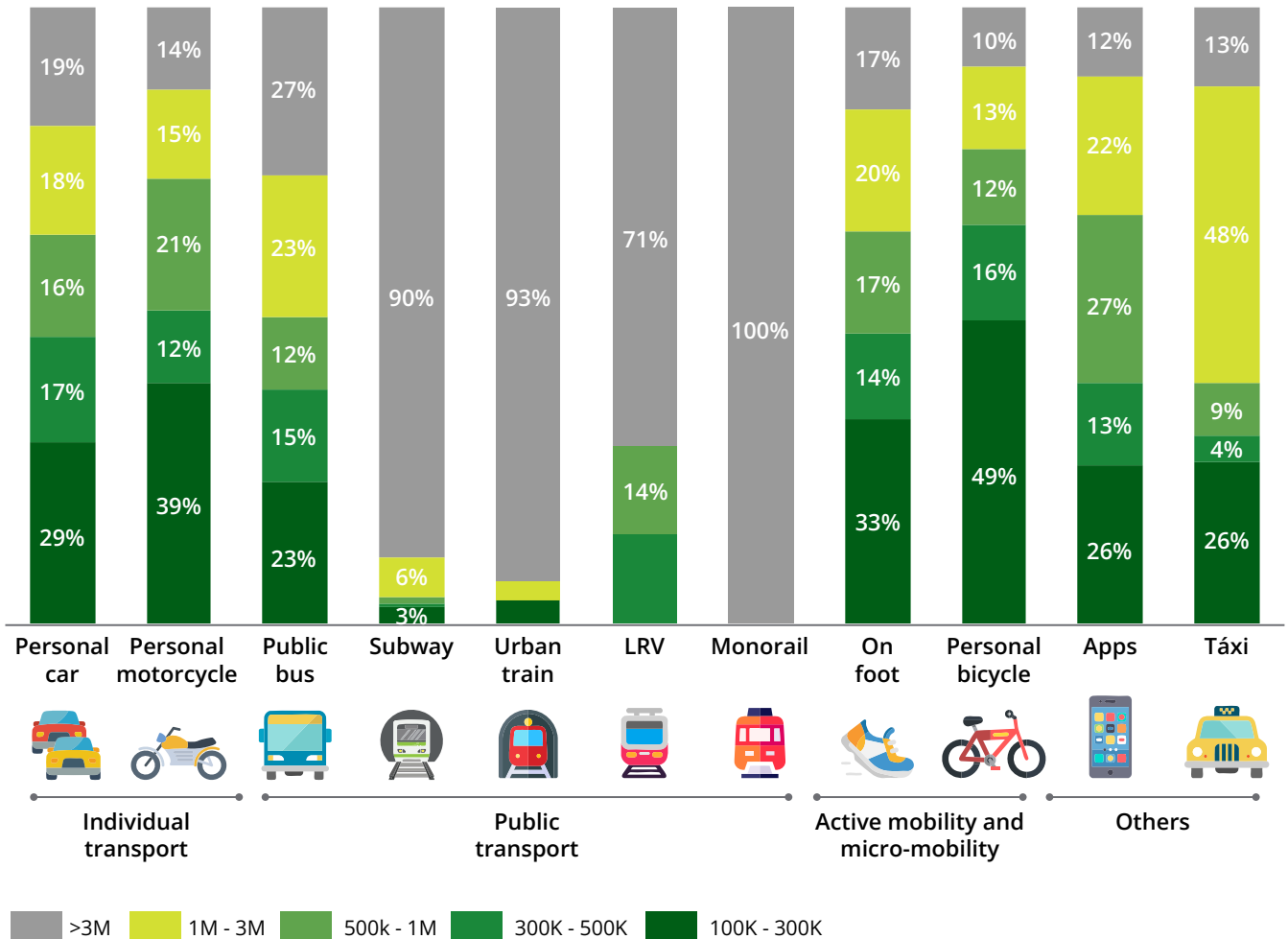
Within Brazil itself, profiles of modes of transport vary according to various archetypes of urban centers, and the size of cities are an important factor that influences the existence of these archetypes:

Population size				
Archetype	>= ~3M	~1M - 3M	~300K - 1M	Up to ~300K
<b>Description</b>	<b>Densely populated metropolises</b> , with major economic and political influence	<b>Large cities</b> with diverse economies and regional influence	<b>Mid-sized cities</b> in rapid population and economic growth	<b>Small towns</b> with a service-based local economy and agribusiness
<b>Examples (non-exhaustive)</b>	São Paulo (SP) Rio de Janeiro (RJ)	Porto Alegre (RS) Goiânia (GO)	Sorocaba (SP) Londrina (PR)	Ponta Porã (MS) Itabuna (BA)
<b>Urbanized Area</b>	>400 km <sup>2</sup>	200-400 km <sup>2</sup>	100-200 km <sup>2</sup>	Up to 100 km <sup>2</sup>
<b>Average HDI</b>	<b>High</b> (0.750 to 0.850)	<b>Medium - High</b> (0.700 to 0.850)	<b>Medium</b> (0.650 to 0.800)	<b>Medium</b> (0.650 to 0.800)

Source: IBGE.

In this sense, it should be recognized that different city profiles have varying levels of maturity concerning their transportation systems and emission reduction efforts. This variation can directly affect the decarbonization options suitable for each city.

## DISTRIBUTION OF THE SIZE OF THE MUNICIPALITIES, BY MEANS OF TRANSPORTATION USED

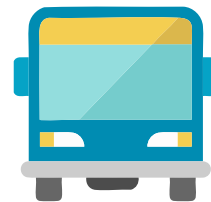


Source: CNT Urban Population Mobility Survey.

Some relevant patterns can be pointed out from the chart above.



Individual transport with a higher incidence in smaller cities



Public transport with a higher incidence in larger cities

In addition, there are other specifics that also influence urban mobility in some cities (as described below). Accordingly, studying the transport network with a tailored approach that respects the unique dynamics of each urban center is critical to identifying and deploying effective mobility solutions that can reduce emissions in large metropolitan regions.



VS



### SPRAWLING CITIES

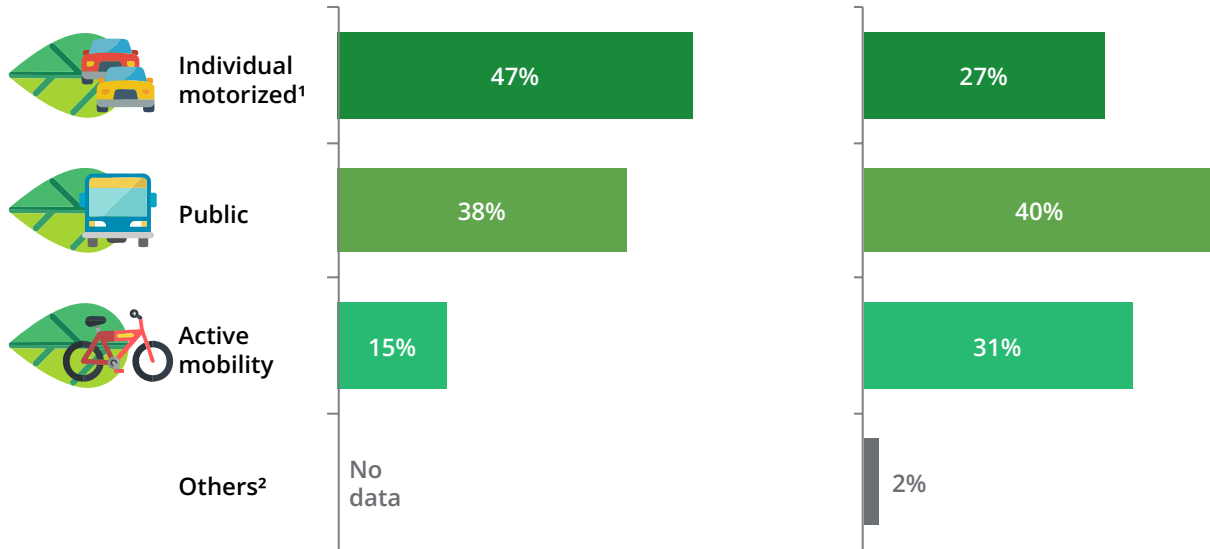
### >= ~3M INHABITANTS

High level of individual transport and less active mobility

E.g.: Brasília (DF)

Metropolises and megalopolises with > ~3M inhabitants

E.g.: São Paulo (SP)



VS



### RIVERINE CITIES

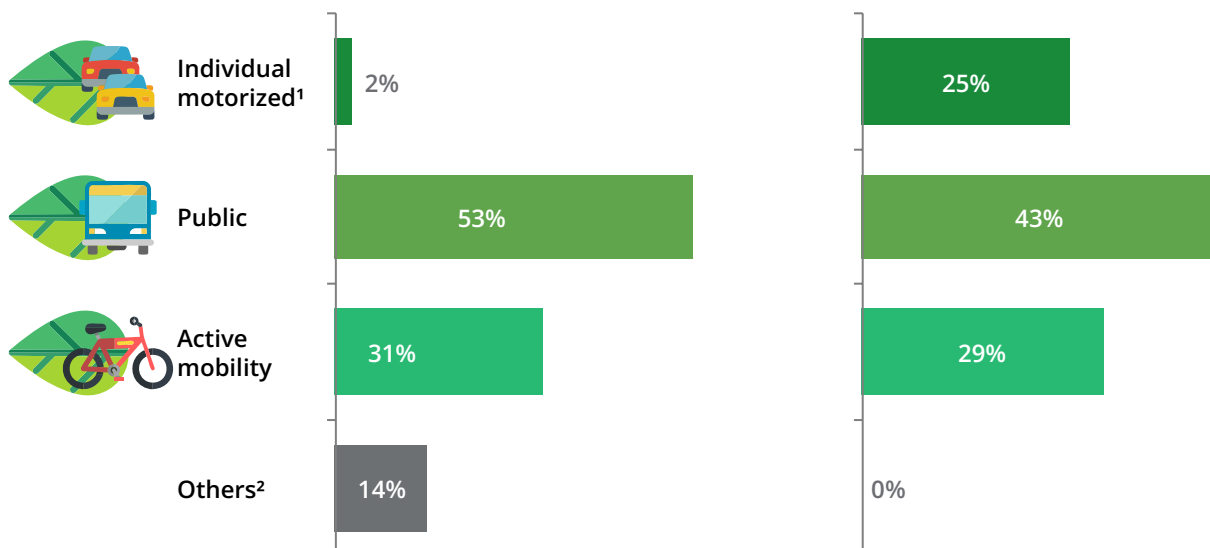
### ~1M-3M INHABITANTS

Near rivers, with high dependence on river transport

E.g.: Manaus (AM)

Cities with population between ~1M-3M inhabitants

E.g.: Porto Alegre (RS)



1. Individual motorized land transport; 2. Not explicitly described, but generally include cable cars, motorcycle taxi, waterway boats or systems, electric scooters, and utility vehicles such as tricycles. Source: Mobilize Study 2022.

# PROPOSAL OF DECARBONIZATION LEVERS

In order to mitigate emissions growth and contribute even more actively to the climate agenda, the working group identified levers that have the potential to reduce urban mobility emissions. These levers were mapped in three large blocks, as described below. A qualitative adherence analysis<sup>1</sup> was performed for each of them, and local and global references that illustrate the respective application were presented.



## Avoid

Use of planning tools to avoid travel and/or reduce distances;



## Shift

Replacement of the current matrix with the strengthening of sustainable public transportation between the different modes, active mobility and micro-mobility;



## Improve

Decarbonization of the different urban mobility modes.



## AVOID

### Levers

- 1 Adoption of route optimization mechanisms:** Implement route optimization systems and technologies (including features such as Artificial Intelligence) to improve the operational efficiency of existing modes.
- 2 Digitalization of public services:** Make services remotely accessible (e.g., health teleconsultations, online payments), enabling instant services and digital democratization of access to services.
- 3 Transit-Oriented Development (TOD):** Foster compact urban planning solutions that encourage efficient land use in areas near stations and public transport lines, shortening distances (e.g., concentration of stores around subway stations).
- 4 Urban densification based on mixed land use:** Promote urban solutions aimed at densification based on mixed land use, allowing access to work, services and leisure in short distances.

Doubling residential density combined with other changes such as mixed use **can reduce** miles traveled per vehicle **by up to 25%**.

<sup>1</sup> The full details of the adhesions and references can be found in the complete urban mobility document, which can be accessed through the QR Code at the end of this document. Sources: OICS; Estonia Hub; Urban Management of São Paulo; Somos Cidade; Fast Company.

## Levers

- 1 **Investment in improving public transport infrastructure:** Modernize and relocate roads, stations and lines to reduce congestion and improve the passenger experience.

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- 2 **Optimization of the urban train and light rail vehicles network:** Expand and improve urban train lines and light rail vehicles for greater coverage and efficiency.

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- 3 **Implementation of exclusive corridors for buses:** Adopt exclusive lanes for buses/BRTs, reducing travel time and increasing the efficiency of public transport.

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- 4 **Promotion of fare moderation and alternative sources of revenue:** Implement affordable and sustainable fares, combined with other sources of revenue to finance public transport (e.g., "charge for time gain", others).

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- 5 **Creation of low-emission zones:** Establish areas where only low-emission vehicles and/or public transport can circulate, taking into account the specificities of each region.

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- 6 **Creation of restriction policies for the circulation of private vehicles:** Limit the circulation of private vehicles on certain days or times to encourage the use of public transport and/or active micro-mobility.  
Proper supervision and disincentive rules are necessary for efficient implementation, preventing, for example, the purchase of more than one car by the same individual

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- 7 **Implementation of parking management policies:** Adopt parking management practices in order to limit the number and size of establishments and spaces available, encouraging the use of cleaner modes of transport.

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- 8 **Promotion of micro-mobility solutions:** Invest in and have bicycle infrastructure implementation goals<sup>1</sup>, including electric scooter and bicycle sharing services, as well as Zones 30 (Calm Traffic Zones).

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- 9 **Promotion of active mobility solutions (e.g., hiking):** Invest in safe and accessible infrastructure to stimulate pedestrian routes near the cycling infrastructure (e.g., closed streets for cars in periods of less movement, encouraging walking).

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- 10 **Creation of incentives for intermodality:** Invest in the integration between modes of transport (e.g., integration between bicycle lanes and subway/bus terminals, public transport with systems for internal loading of bicycles, secure bike racks inside public transport terminals).

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- 11 **Combating clandestine transport:** Avoid the use of illegal means of transport, reducing clandestine movements and making it possible to change them to legalized means of public transport.

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1. Covers bicycle lanes, cycle paths and cycle lanes. Sources: Egis Group; Mobilize; Government of Bahia; Viatrolebus; BRT Data RJ; Summit Mobility Estadão; City Hall of Fortaleza; Access Regulations in Europe; Tech Channel. Sources: Urban Data Portal; ES Brazil; Mobility Estadão; GV Bus; ANTT.



## IMPROVE

### Levers

- 1 Adoption of mandatory environmental vehicle inspection systems:** Implement regular environmental inspections so that vehicles meet emissions and safety standards, ensuring involvement at not only the federal but also the state level.
- 2 Eco-efficient and assisted driving:** Influencing the behavior of car and bus drivers to optimize fuel consumption (including features such as Artificial Intelligence).
- 3 Enhancing the use of ethanol in light vehicles:** Encourage the use of ethanol to supply light vehicles.
- 4 Intensification of the use of biofuels in urban buses:** Replace fossil fuels with less polluting biofuels, as long as: i) the technical, mechanical, operational and laboratory viability of said energy input is confirmed; ii) respecting the diversity of matrices; and iii) respecting regional specificities.
- 5 Conversion of diesel bus engines to gas (e.g., biomethane):** Adapt existing engines to become suitable for the use of less polluting gaseous solutions<sup>1</sup> as fuel (e.g., biomethane).
- 6 Intensification of solutions that promote vehicle emissions close to zero:** Implement vehicles that emit less GHG<sup>2</sup> (e.g., electric, hybrid, powered by low-carbon hydrogen routes), considering the local production capacity and the most appropriate moment for the implementation of each solution.

1. Compared to fossil diesel; 2. Greenhouse Gases. Sources: CNT/SEST SENAT; Mobiauto; Fecombustíveis; Biofuel Express; MWM; G1; Diário do Transporte.



## ILLUSTRATIVE EXAMPLES SHOW HOW ENABLERS HELP TO FACILITATE DECARBONIZATION LEVERS

### CAPABLE GOVERNANCE AND INTEGRATED PLANNING

#### Urban Mobility Law<sup>1</sup>



Defines guidelines for mobility services to be developed in a systemic and coordinated manner, encouraging multimodality and intermodality in urban development.\*

### TECHNOLOGICAL AND PHYSICAL INFRASTRUCTURE

#### Public and private investments in urban mobility in Brazil

TIC<sup>2</sup> North Axis: São Paulo – Campinas | In May 2024, the Government of São Paulo signed the concession rights to the consortium C2 Mobilidade sobre Trilhos<sup>3</sup>. The project intends to have trains of up to 140 km/h, with an expected investment of R\$14.2 billion.

Concession of Lines 8-Diamond and 9-Emerald of CPTM<sup>4</sup> | The ViaMobilidade consortium, led by Motiva, acquired a concession to operate and modernize the lines, with a contract that provided for technological improvements (e.g., signaling) for greater safety and efficiency.\*

### PUBLIC ENGAGEMENT, AWARENESS AND PERSUASION, ENSURING SOCIAL AND DIGITAL INCLUSION

The "World Car-Free Day" and the "Bike-to-Work Day" are dates that have already been observed in Brazilian cities and that are looking to make the population aware of the use of active mobility and micro-mobility solutions to the detriment of individual motorized transport. Financiamento com recursos públicos e/ou privados para subsídio de tarifas de transporte coletivo

### SUSTAINABLE ECONOMIC FINANCING AND INCENTIVES

#### Financing with public and/or private funds to subsidize public transport fares

The government has invested €3.4B since 2022 in the public transport subsidy, resulting in a 33% increase in its use in Spain.

#### Corporate economic incentives

Some Brazilian companies have already adopted mobility plans and corporate benefits aimed at reducing CO<sub>2</sub>e emissions in the trips made by their employees.

### MONITORING AND INSPECTION FOR THE SAKE OF LEGALITY

Implementation of surveillance mechanisms using cameras that verify the environmental badges of vehicles for monitoring Low Emission Zones in Bilbao.

1. Law No. 12.587, of January 3, 2012; 2. Intercity train (*Trem Intercidades*); 3. Made up of the Brazilian company Comporte and the Chinese company CRRC; 4. São Paulo Metropolitan Trains Company (*Companhia Paulista de Trens Metropolitanos*). Sources: National Mobility Policy; Planalto; Globo; ViaMobilidade; Investment Partnerships Program of São Paulo; Exame; Ministerio de Transportes y Movilidad Sostenible; City of São Paulo website; Mobility Estadão; Legislative Assembly of the State of Paraná.

# WE AIM FOR SUSTAINABLE GROWTH IN URBAN MOBILITY

Reducing urban mobility emissions is challenging, but implementing the AVOID, SHIFT and IMPROVE levers represents a **major step towards the transformation of Brazilian cities, in which sustainable, inter and multimodal public transport prevails as the main means of transportation, reducing the use of individual motorized transport.**

**Conclusions** sought by the study on urban mobility in Brazil in 2050:

## CURRENT URBAN MOBILITY<sup>1</sup>



**~25% OF THE POPULATION** traveling via bus.



**+60% OF THE RAIL TRANSPORT SYSTEM** concentrated in only two cities (RJ and SP).



**PUBLIC TRANSPORTATION LOSING SPACE** to the individual motorized transportation.



Means of **PUBLIC TRANSPORT** (e.g., buses, subways, light rail vehicles) with **SEPARATE SYSTEMS.**

## MOBILIDADE URBANA FUTURO<sup>2</sup>



**~53 BILLION OF PLANNED INVESTMENTS** in sustainable urban mobility in Brazil as of 2023<sup>3</sup>.



**PUBLIC TRANSPORT AS THE MAIN** means of transportation in urban centers.



Means of **PUBLIC TRANSPORT** (e.g., buses, subways, light rail vehicles) with **INTEGRATED SYSTEMS.**

1. 2023; 2. 2050; 3. Investments in projects provided for by the New PAC.





Details on the  
**URBAN  
MOBILITY  
MODE**

**Urban Mobility plays an important role in the reduction of emissions in Brazil by 2050.**




of the Brazilian population lives in **urban centers**



of the **potential reduction in urban emissions** in Brazil by the year 2050 comes from the transportation sector.

Sources: Coalition for Urban Transitions; 2022 Brazilian Census.

## URBAN MOBILITY | THE INSPER<sup>1</sup> MOBILITY OBSERVATORY AND ANPTRILHOS ARE RESPONSIBLE FOR COORDINATING THE DISCUSSIONS

 **Advisory Board:**  
CEBDS, Motiva, CNT/SEST SENAT and Inesper's National Sustainable Mobility Observatory



**Urban  
Mobility  
Group**

☆ **Inesper's National Sustainable Mobility Observatory**

☆ **ANPTrilhos** – Associação Nacional dos Transportadores de Passageiros sobre Trilhos (National Association of Passenger Rail Operators)

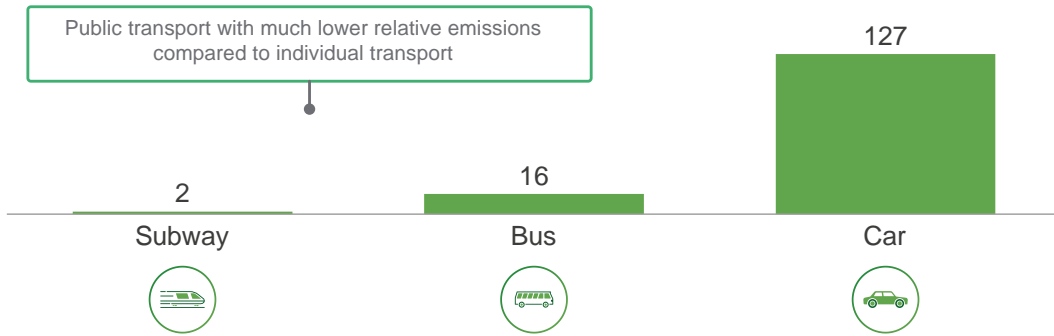
• Ambipar	• ITDP	• Siemens Energy
• ANTP	• Marcopolo	• UIC
• Motiva	• NTC & Logística	• Vibra
• Edenred	• NTU	

Legend | ☆ Coordinator | Other Members

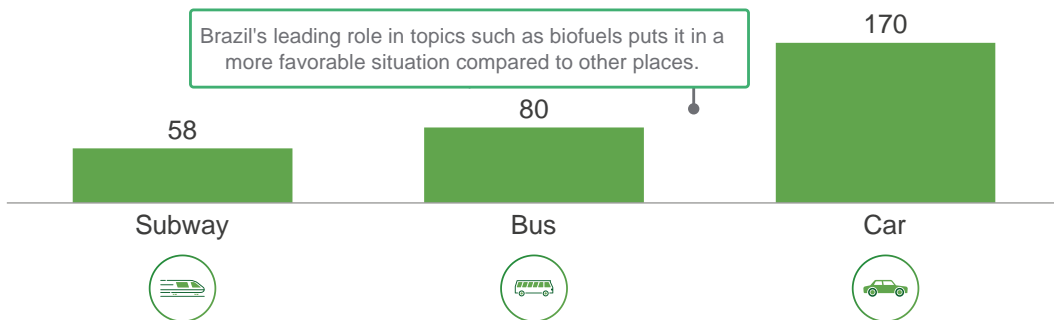
1. Inesper's National Sustainable Mobility Observatory.

# 70% OF TRANSPORT EMISSIONS FROM BRAZILIAN URBAN CENTERS COME FROM INDIVIDUAL MOTORIZED TRANSPORT<sup>1</sup>, WHICH IS EVIDENT IN COMPARISON WITH OTHER MODES

 GHG<sup>2</sup> emissions per passenger-km, São Paulo perspective (gCO<sub>2</sub>/pkm)



 GHG<sup>2</sup> emissions per passenger-km, London perspective (gCO<sub>2</sub>/pkm)

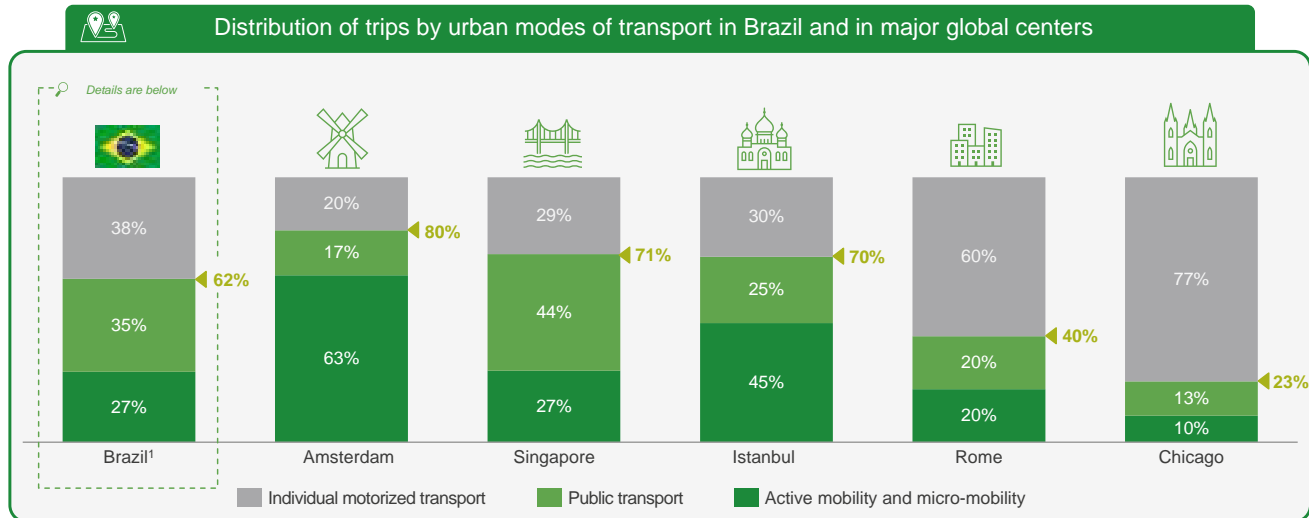


1. The Categories "Car" and "Motorcycle"; 2, Greenhouse Gases; Sources: CNT Urban Population Mobility Survey 2024; ANPTriLhos; Technical article: Evaluation of subway systems in terms of CO<sub>2</sub> emissions: comparative analysis of emissions from cars, buses and subways (2019).



# PATHWAYS TO DECARBONIZATION

## THERE ARE SEVERAL TYPES OF URBAN CENTERS, WITH DIFFERENT TRANSPORT MATRIX PROFILES



1. The CNT Urban Population Mobility Survey focuses on municipalities with more than 100K inhabitants and the result considers the 5,720 respondents aged 15 years or older who travel every day, 3 to 4 days a week or 1 to 2 days a week (participants were able to cite up to 3 response options for the most used means of transport for urban travel); Survey information was converted to the base 100%, considering the following classifications: Bus (public transport), personal car, on foot, personal motorcycles, personal bike, subway, urban/metropolitan train, light rail vehicle (LRV) and monorail. Sources: CNT Urban Population Mobility Survey; Moving Millions Study: A Recipe to Make Urban Mobility Work.

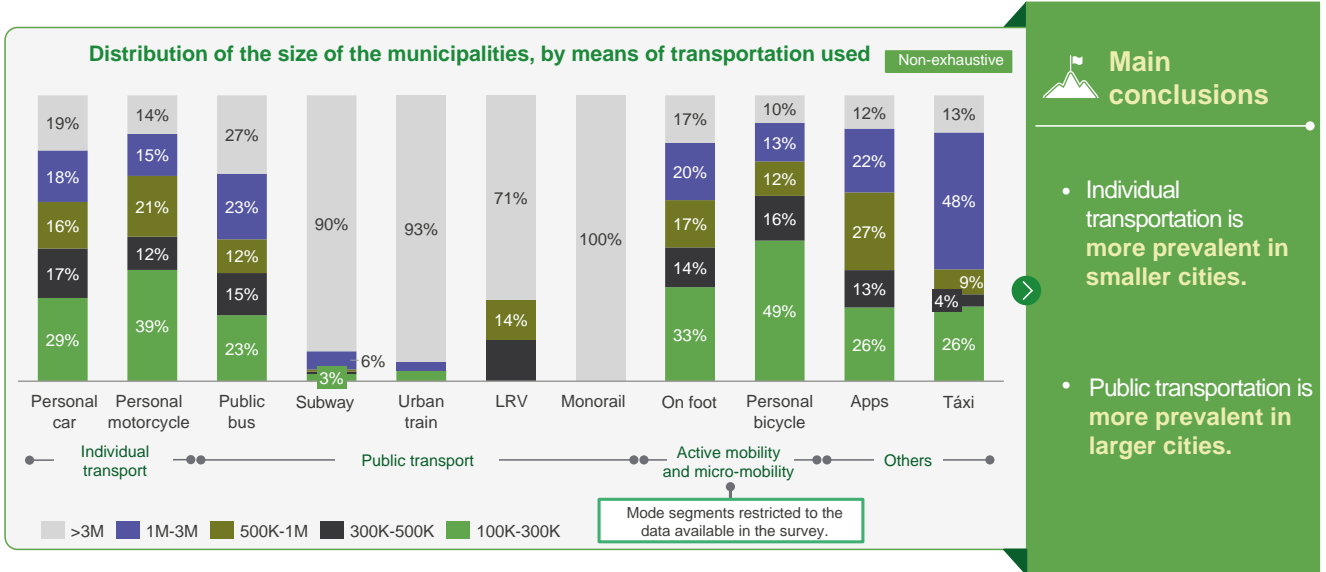
## IN BRAZIL, PROFILES OF MODES OF TRANSPORT VARY ACCORDING TO DIFFERENT ARCHETYPES OF URBAN CENTERS

Archetype	>= ~3M inhabitants	~1M – 3M inhabitants	~300K – 1M inhabitants	Up to ~300K inhabitants
<b>Description</b>	Densely populated metropolises, with major economic and political influence.	Large cities with diverse economies and regional influence.	Mid-sized cities in rapid population and economic growth.	Small towns with a service-based local economy and agribusiness.
<b>Examples (non-exhaustive)</b>	<ul style="list-style-type: none"> <li>São Paulo (SP)</li> <li>Rio de Janeiro (RJ)</li> </ul>	<ul style="list-style-type: none"> <li>Porto Alegre (RS)</li> <li>Goiânia (GO)</li> </ul>	<ul style="list-style-type: none"> <li>Sorocaba (SP)</li> <li>Londrina (PR)</li> </ul>	<ul style="list-style-type: none"> <li>Ponta Porã (MS)</li> <li>Itabuna (BA)</li> </ul>
<b>Urbanized Area</b>	>400 km <sup>2</sup>	200-400 km <sup>2</sup>	100-200 km <sup>2</sup>	Up to 100 km <sup>2</sup>
<b>Average HDI</b>	High (0.750 a 0.850)	Medium - High (0.700 a 0.850)	Medium (0.650 a 0.800)	Medium (0.650 a 0.800)

The size of cities is one of the factors that influences the existence of profiles of different modes of transport

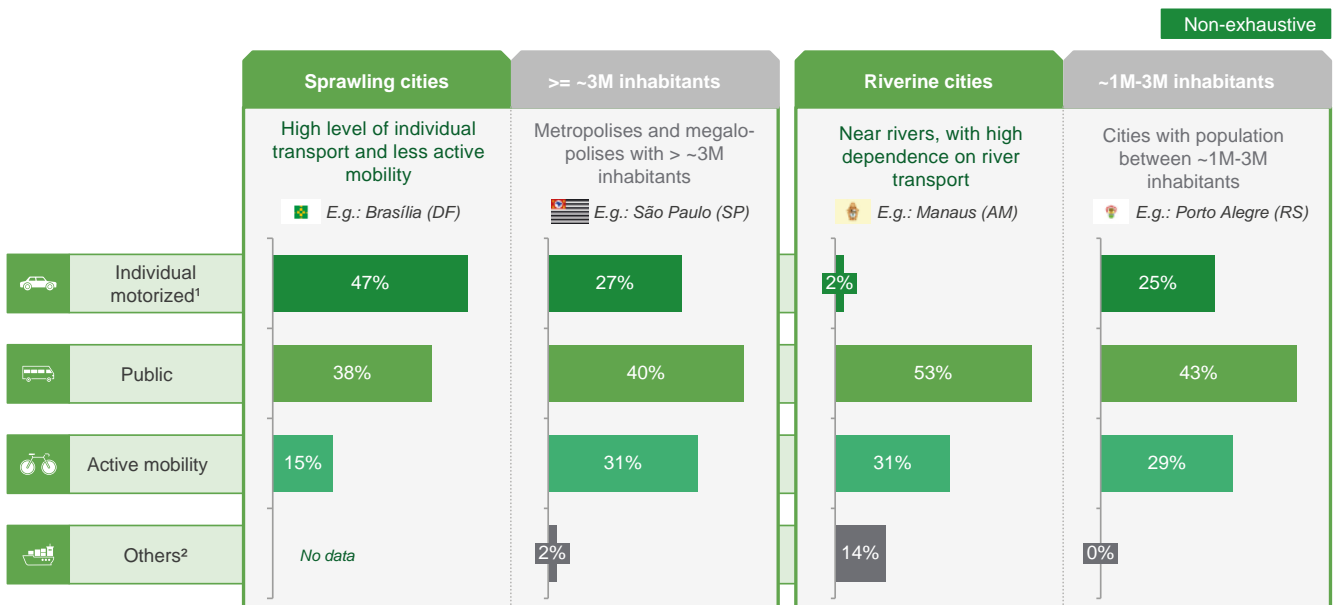
Source: IBGE.

# CITY PROFILES REVEAL VARYING LEVELS OF MATURITY CONCERNING THEIR TRANSPORT MATRIX AND EMISSIONS REDUCTION EFFORTS



Source: CNT Urban Population Mobility Survey 2024 (graph 40).

## THERE ARE ALSO OTHER SPECIFICS THAT ALSO INFLUENCE URBAN MOBILITY IN SOME CITIES



Studying the transport network with a tailored approach that respects the unique dynamics of each urban area is critical to identifying and deploying effective mobility solutions that can reduce emissions in large metropolitan regions.

1. Individual motorized land transport; 2. Not explicitly described, but generally include cable cars, motorcycle taxis, waterway boats or systems, electric scooters, and utility vehicles such as trikes. Sources: Mobilize Study 2022; interviews with industry experts.

# THREE COMMON AREAS ACROSS THE DIFFERENT CITY PROFILES NEED TO BE ANALYZED IN A TARGETED MANNER FOR EMISSIONS REDUCTION

## Emissions

Although the approaches are cross-cutting, solutions must be targeted, based on the specificities of each region



**1 AVOID:** Use of planning tools to avoid travel and/or reduce distances



**2 SHIFT:** Replacement of the current matrix with the strengthening of sustainable public transportation between the different modes (e.g., subways, light rail vehicles, buses, BRTs) active mobility (e.g., on foot) and micro-mobility (e.g., scooters)



**3 IMPROVE:** Decarbonization of the different urban mobility modes

Cross-cutting enablers that contribute to enabling the implementation of decarbonization levers



**1 AVOID:** Use of planning tools to avoid travel and/or reduce distances










## STEP 1

# LEVERS REQUIRED FOR IMPLEMENTATION WITH REFERENCES ON HOW THEY SHOULD BE APPLIED INSIDE AND OUTSIDE BRAZIL

Non-exhaustive

### Levers - AVOID

### References

 Adoption of route optimization mechanisms	Implement route optimization systems and technologies (including the use of features such as Artificial Intelligence) to improve the operational efficiency of existing modes.	 Curitiba <i>ITV</i> reorganized the public transit system by integrating modes, fares, and operations, resulting in more rationalized and efficient routing.
 Digitalization of public services	Make services remotely accessible (e.g., health teleconsultations, online payments), enabling instant services and digital democratization of access to services.	 Estônia Recognized for its advanced digital society, ~99% of public services are available online and 24 hours a day.
 Transit-Oriented Development (TOD)	Foster compact urban planning solutions that encourage efficient land use in areas near stations and public transport lines, shortening distances (e.g. concentration of stores around subway stations).	 Teresina Incorporation of the concept of Transit-Oriented Development in the city's Master Plan.
 Urban densification based on mixed land use	Promote urban solutions aimed at densification based on mixed land use, allowing access to work, services and leisure in short distances.	 São Paulo Master Plan encouraged urban densification.  Paris Reference in the "15 minutes" cities model.

Doubling residential density combined with other changes such as mixed use can reduce miles traveled per vehicle by up to 25%.














1. Rede Integrada de Transporte; 2. Adensamento urbano previsto ao longo dos Eixos de Estruturação da Transformação Urbana, áreas próximas a infraestruturas de transporte, nas quais são permitidos maiores índices de aproveitamento do solo, inca 1. Integrated Transport Network; 2. Urban densification planned along the Urban Transformation Structuring Axes, areas close to transport infrastructures, in which higher rates of land use are allowed, encouraging the construction of mixed-use buildings and allowing the co-existence of residential, commercial and short-distance service functions; Sources: OICS; Estonia Hub; Urban Management of São Paulo; Somos Cidade; Fast Company; Land and Use Driving. entivando a construção de edifícios de uso misto e permitindo a coexistência de funções residenciais, comerciais e de serviços em raios de curta distância; Fontes: OICS; Estonia Hub; Gestão Urbana de São Paulo; Somos Cidade; Fast Company; Land and Use Driving.













**SHIFT:** Replacement of the current matrix with the strengthening of sustainable public transportation between the different modes (e.g., subways, light rail vehicles, buses, BRTs) active mobility (e.g., on foot) and micro-mobility (e.g., scooters)

## STEP 2

# LEVERS REQUIRED FOR IMPLEMENTATION WITH REFERENCES ON HOW THEY SHOULD BE APPLIED INSIDE AND OUTSIDE BRAZIL

Non-exhaustive			References
Levers - SHIFT			
		Travel via public transport emits up to <b>55%</b> less GHG <sup>1</sup> than driving alone	
	Investment in improving public transport infrastructure	Modernize and relocate roads, stations and lines to reduce congestion and improve the passenger experience.	 Paris Grand Paris Express: +200 km by metro (+93%), with ~14 Mton CO2e of avoided emissions by 2050.
	Optimization of the urban train and LRV network	Expand and improve urban train and light rail vehicle (LRV) lines for greater coverage and efficiency.	 Salvador LRV project started in 2024, with tests scheduled for as early as 2026; +36 km long (~13% of the national network).
	Implementation of exclusive corridors for buses	Adopt exclusive lanes for buses/BRTs, reducing travel time and increasing the efficiency of public transport.	 Rio de Janeiro 4 exclusive corridors, 168 km long and +3M passengers per day (~22% of the state population).
	Promotion of fare moderation and alternative sources of revenue	Implement affordable and sustainable fares, combined with other sources of revenue to finance public transport (e.g., "charge for time gain", others).	 Curitiba Subsidies since 2012, avoiding tariff increases.  Fortaleza Blue Zone allocates revenue to strengthen bike lanes.
	Creation of low-emission zones	Establish areas where only low-emission vehicles and/or public transport can circulate, taking into account the specificities of each region.	 Milão Low emission zones, in which access is regulated according to the vehicle emission standard.
	Creation of restriction policies for the circulation of private vehicles	Limit the circulation of private vehicles on certain days or times to encourage the use of public transport and/or active micro-mobility.	 Santiago Restriction based on "green sea" – cars without catalyst in the exhaust cannot circulate for 2 days a week.
		Proper supervision and disincentive rules are necessary for efficient implementation, impeding, for example, the purchase of more than one car by the same individual	
		Effect	

1. Greenhouse Gases; Sources: Egis Group; Mobilize; Government of Bahia; Viatrolebus; BRT Data RJ; Summit Mobility Estadão; City Hall of Fortaleza; Access Regulations in Europe; Tech Channel; CNT Org.

Non-exhaustive			References
Levers - SHIFT			
	Implementation of parking management policies	Adopt parking management practices in order to limit the number and size of establishments and spaces available, encouraging the use of cleaner modes of transport.	 São Paulo 2014 Master Plan set maximum limits on parking spaces encouraged by urban regulation
	Promotion of micro-mobility solutions	Invest in and have bicycle infrastructure implementation goals, 1 including electric scooter and bicycle sharing services, as well as Zones 30 (Calm Traffic Zones).	 Vitória Massive investment in bike lanes – Growth of +19% in 2024
	Promotion of active mobility solutions (e.g., hiking)	Invest in safe and accessible infrastructure to stimulate pedestrian routes near the cycling infrastructure (e.g., closed streets for cars in periods of less traffic, encouraging walking).	 São Paulo As part of the Open Streets program, Av. Paulista is closed to motor vehicles on Sundays and holidays
	Creation of incentives for intermodality	Invest in the integration between modes of transport (e.g., integration between bicycle lanes and subway/bus terminals, public transport with systems for internal loading of bicycles, secure bike racks inside public transport terminals).	 Vitória Bike GV initiative made it possible to create an exclusive bus line for transporting cyclists and their bicycles
	Combating clandestine transport	Avoid the use of illegal means of transport, reducing clandestine movements and making it possible to change them to legalized means of public transport.	 Nacional "Centaur Operation" carried out by ANTT during Carnival to combat clandestine road transport














1. Greenhouse Gases; Sources: Egis Group; Mobilize; Government of Bahia; Viatrolebus; BRT Data RJ; Summit Mobility Estadão; City Hall of Fortaleza; Access Regulations in Europe; Tech Channel; CNT Org.

# LEVERS REQUIRED FOR IMPLEMENTATION WITH REFERENCES ON HOW THEY SHOULD BE APPLIED INSIDE AND OUTSIDE BRAZIL

Non-exhaustive

Levers - **IMPROVE**

References

 Adoption of mandatory environmental vehicle inspection systems	Implement regular environmental inspections so that vehicles meet emissions and safety standards, ensuring involvement at not only the federal but also the state level.	 National (BRA) <i>"Despoluir" Program (CNT/SEST Senat) launched the environmental vehicle assessment for inspection of diesel vehicles in 2007.</i>
 Eco-efficient and assisted driving	Influencing the behavior of car and bus drivers through training and technologies designed for optimizing fuel consumption (including the use of features such as Artificial Intelligence).	 National (BRA) <i>CNT/SEST Senat Smartdriver course focused on driving practices that reduce environmental impact.</i>
 Enhancing the use of ethanol in light vehicles	Encourage the use of ethanol to fuel light vehicles.	 National (BRA) <i>Flex vehicles are now ~85% of Brazil's light fleet – use of pure ethanol could reduce emissions by up to 33%.</i>
 Intensification of the use of biofuels in urban buses	Replace fossil fuels with less polluting biofuels, as long as: i) the technical, mechanical, operational and laboratory viability of said energy input is confirmed; ii) respecting the diversity of matrices; and iii) respecting regional specificities.	 Stockholm (SWE) <i>1st global capital with 100% of public buses operating without the use of fossil fuels.</i>
 Conversion of diesel bus engines to gas (e.g., biomethane)	Adapt existing engines to become suitable for the use of less polluting gaseous solutions <sup>1</sup> like fuel (e.g., biomethane).	 Pernambuco (PB) <i>MWM made the first vehicle conversion of a diesel engine to a gas engine in a truck – resulting in approximately 25% less fuel consumption every 140 km.</i>
 Intensification of solutions that promote vehicle emissions close to zero	Implement vehicles that emit less GHG2 (e.g., electric, hybrid, powered by low-carbon hydrogen routes), considering the local production capacity and the most appropriate time implementing each solution.	 São Paulo (SP)  Bogota(COL) <i>~3.2% of the bus fleet is now electric*. ~14% of the public bus fleet is now electric.</i>

1. Compared to fossil diesel; 2. Greenhouse Gases; 3. Includes conventional models and trolleybuses. Sources: CNT/SEST SENAT; Mobiauto; Fecombustíveis; Biofuel Express; MWM; G1; Diário do Transporte.




# MAPPING OF ENABLERS



## RECENT EXAMPLES ILLUSTRATE HOW ENABLERS HELP UNLOCK KEY LEVERS FOR SECTOR DECARBONIZATION


Illustrative

### Selected examples



- ✓ **Qualified governance and integrated planning | Urban Mobility Law<sup>1</sup>** | Defines guidelines for mobility services to be developed in a systemic and coordinated manner, encouraging multimodality and intermodality in urban development. 


### Technological and physical infrastructure | Public and private investments in urban mobility in Brazil

- **TIC<sup>2</sup> North Axis: São Paulo – Campinas** | In May 2024, the Government of São Paulo signed the concession rights to the consortium C2 Mobilidade sobre Trilhos<sup>3</sup>. The project intends to have trains of up to 140 km/h, with an expected investment of R\$14.2 billion 
- **Concession of Lines 8-Diamond and 9-Emerald of CPTM<sup>4</sup>** | The ViaMobilidade consortium, led by Motiva, acquired a concession to operate and modernize the lines, with a contract that provided for technological improvements (e.g., signaling) for greater safety and efficiency 

- ✓ **Public engagement, awareness and conviction, ensuring social and digital inclusion** | "World Car-Free Day" and the "Bike-to-Work Day" are dates that have been observed in Brazilian cities and that are looking to make the population aware of the use of active mobility and micro-mobility solutions instead of individual forms of motorized transportation 

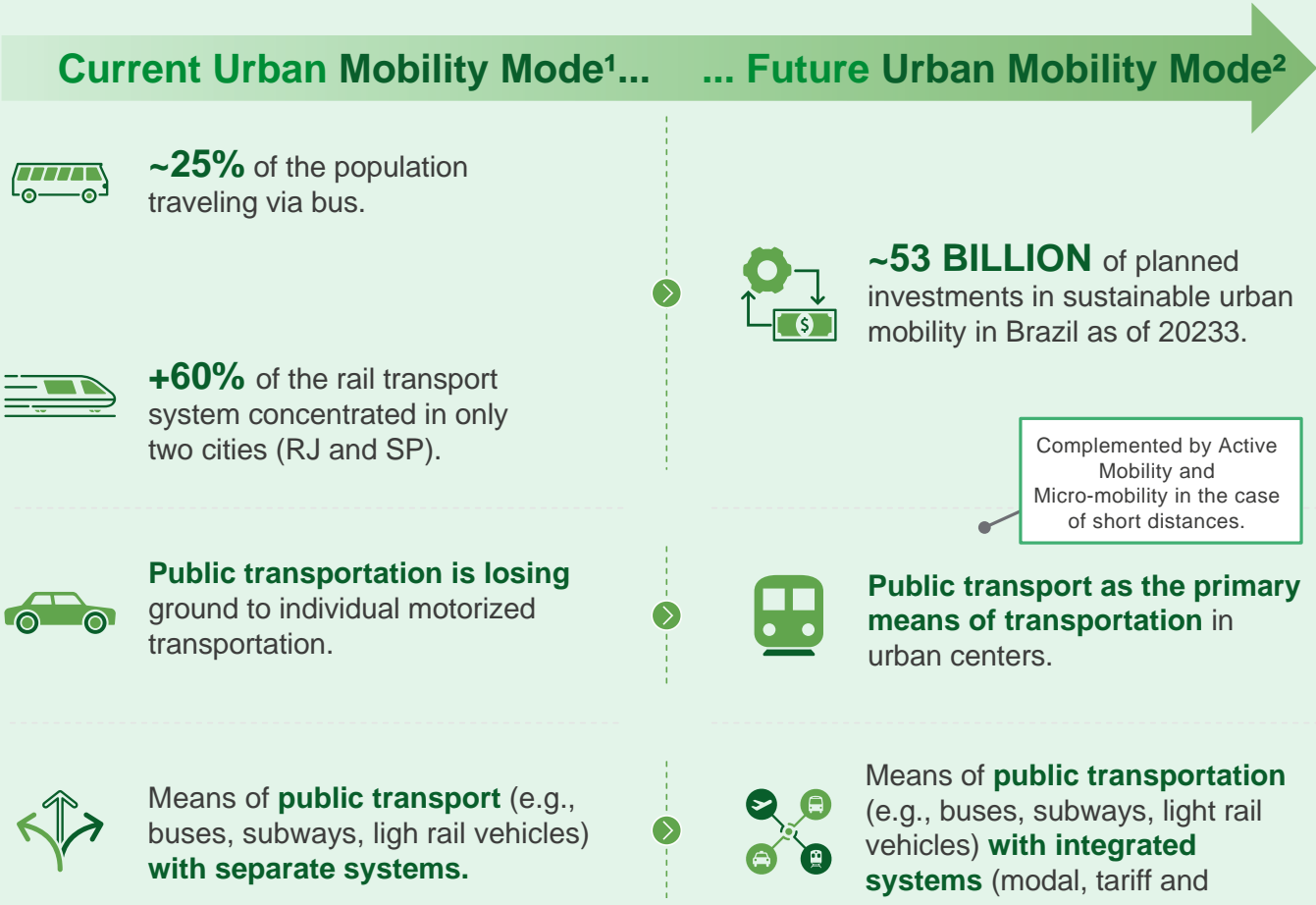
### ✓ Sustainable economic financing and incentives

- **Financing with public and/or private funds to subsidize public transport fares** | The government has invested €3.4B since 2022 in the public transport subsidy, resulting in a 33% increase in its use in Spain 
- **Corporate economic incentives** | Some Brazilian companies have already adopted mobility plans and corporate benefits aimed at reducing CO<sub>2</sub>e emissions in commutes made by their employees 

- ✓ **Monitoring and Inspection for the Sake of Legality** | Implementation of surveillance mechanisms using cameras that verify the environmental badges of vehicles for monitoring Low Emission Zones in Bilbao. 

1. Law No. 12.587, of January 3, 2012; 2. Intercity train (*Trem Intercidades*); 3. Made up of the Brazilian company Comporte and the Chinese company CRRC; 4. São Paulo Metropolitan Trains Company (*Companhia Paulista de Trens Metropolitanos*). Sources: National Mobility Policy; Planalto; Globo; ViaMobilidade; Investment Partnerships Program of São Paulo; Exame; Ministerio de Transportes y Movilidad Sostenible; City of São Paulo website; Mobility Estadão; Legislative Assembly of the State of Paraná.

# We aim for sustainable growth in the Brazilian Urban Mobility mode



1. 2023; 2. 2050; 3. Investments in projects provided for by the New PAC.

## SUMMARY | URBAN MOBILITY



Urban Mobility emissions are highly relevant to Brazil's climate goals, considering that ~87% of the population lives in cities and ~45% of the potential for urban emissions reduction by 2050 comes from transport.

Emissions related to individual motorized transport are much higher than those of public transportation (127 gCO<sub>2</sub> / pkm in cars vs. 16 gCO<sub>2</sub> / pkm in buses<sup>1</sup>), reinforcing the thinking that **expanding public transportation and emphasizing the importance of maintaining connections between different modes of transport is fundamental for the decarbonization** of the transport sector as a whole and for achieving net-zero emissions in urban mobility.

In order to mitigate emissions growth and play an even more active role in the climate agenda, the **23 entities<sup>2</sup>** participating in the Coalition's Urban Mobility vertical came together to exchange ideas and listed 21 decarbonization levers, which were divided into three main areas of focus:

- **AVOID:** Application of planning instruments aimed at minimizing trip frequency and optimizing route length. The following stand out:
  - › Urban densification based on mixed land use, allowing the population to have access to various services within short distances;
  - › Route optimization through systems and technologies that optimize the operation of urban modes of transport.
- **SHIFT:** Changing the current matrix to strengthen and expand sustainable public transport, active mobility and micro-mobility. The following stand out:
  - › Expansion and improvement of public transport infrastructure (e.g., buses, meters, urban trains, etc.);
  - › Expansion of the bicycle network and its integration with public transport;

- › Promotion of fare moderation and alternative sources of revenue (e.g., "charge for the time gained").

- **IMPROVE:** Decarbonization of the different urban modes to optimize the levels of emissions generated by the different vehicles. The following stand out:
  - › Use of less GHG-emitting solutions and technologies<sup>3</sup>;
  - › Eco-efficient and assisted driving aimed at greater fuel consumption efficiency.

Given the tremendous challenge, a series of enablers will be required to materialize such levers. Some concrete examples below illustrate how enablers can help progress the decarbonization agenda in the Urban Transport mode:

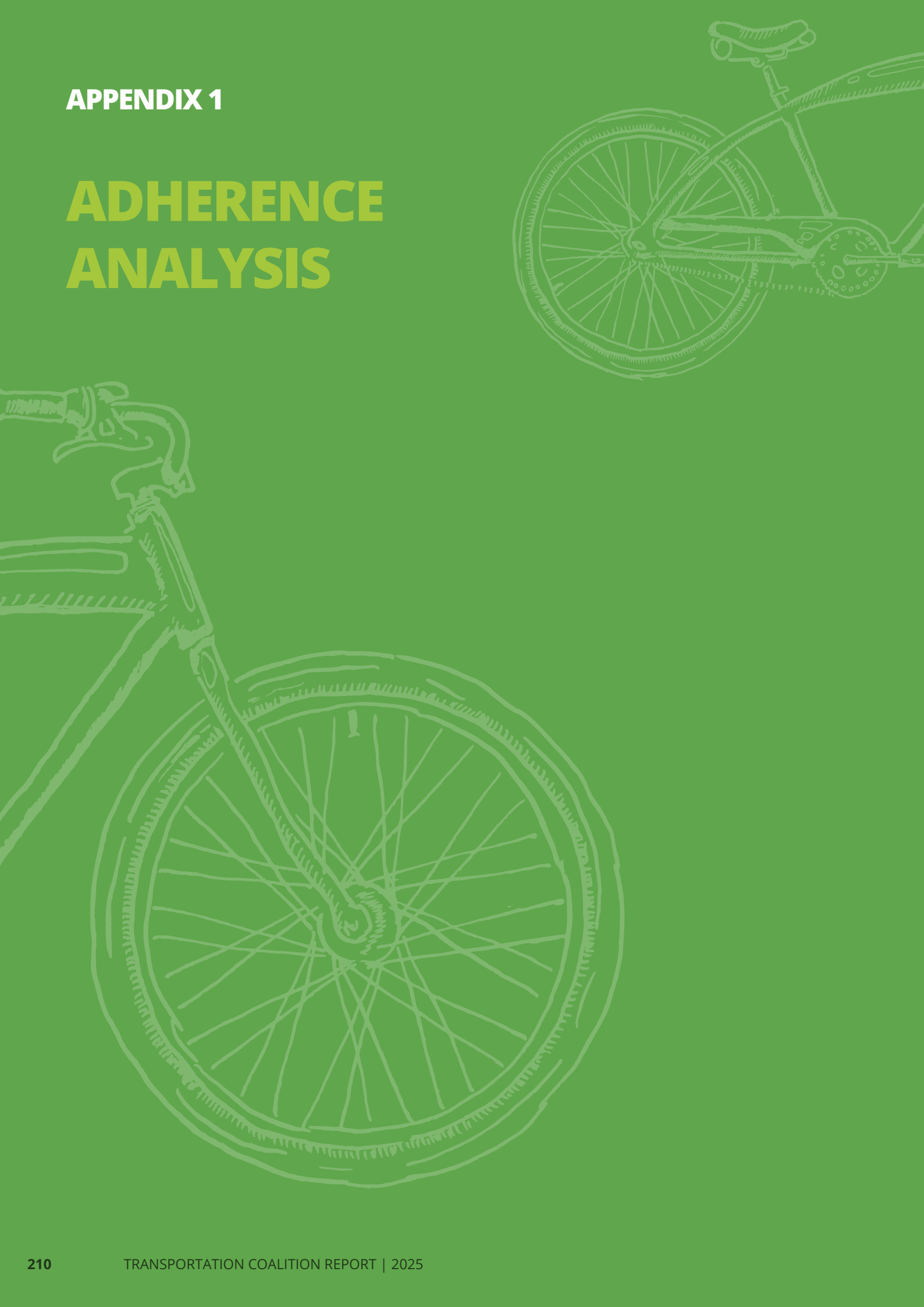
- **Regulation | Urban Mobility Law<sup>4</sup> |** Defines guidelines for urban mobility infrastructure and services to be developed in a systemic and coordinated manner, encouraging multi and intermodality.
- **Incentives | TIC5 North Axis: São Paulo – Campinas |** In May 2024, the Government of SP signed the concession rights to the consortium C2 Mobilidade sobre Trilhos, which provides for investments of R\$14.2 billion to operate trains with speeds up to 140 km/h.

Reducing Urban Mobility<sup>6</sup> emissions is challenging, but implementing the AVOID, SHIFT and IMPROVE levers represents a **major step towards the transformation of Brazilian cities, in which sustainable, inter- and multimodal public transport prevails as the main means of locomotion, reducing the use of individual motorized transport.** The entities participating in the Coalition should continue the discussions in order to promote progress towards net-zero emissions by 2050.

Notes: 1. PKm = Passenger-kilometer; Values of the city of São Paulo; 2. In addition to the 23 specific entities, CEBDS, Motiva, CNT and Inspere Mobility Observatory also coordinated the discussions across the different verticals of the coalition; 3. Greenhouse Gas; 4. Law No. 12.587, 01/03/12; 5. Intercity train; 6. The largest share of urban mobility emissions was covered by the road sector quantification.

## APPENDIX 1

# ADHERENCE ANALYSIS





**AVOID:** Use of planning tools to avoid travel and/or reduce distances

## STEP 1

# LEVERS SHOW DIFFERENT LEVELS OF ADHERENCE, DEPENDING ON THE CITY PROFILE

Non-exhaustive

### Analysis of adherence<sup>1</sup> - AVOID

	>= ~3M inhabitants	~1M-3M inhabitants	~300K –1M inhabitants	Up to ~300K inhabitants
Adoption of route optimization mechanisms	●	●	●	●
Digitalization of public services	●	●	◐	◐
Transit-Oriented Development (TOD)	●	◐	◐	○
Urban densification based on mixed land use	●	◐	◐	○

Lower cost and easier implementation in all profiles.

Adherence grows with the demand, complexity of the services offered and ability to invest.

Adherent to larger cities, where planning can be applied in urban revisions.

Adherent to larger cities, where planning can be applied in urban revisions.

Legend | ● The greener, the more adherent.

1. Qualitative, considers the criteria of ease of implementation and availability of resources.



**SHIFT:** Replacement of the current matrix with the strengthening of sustainable public transportation between the different modes (e.g., subways, light rail vehicles, buses, BRTs), active mobility (e.g., on foot) and micro-mobility (e.g., scooters)

## STEP 2

Non-exhaustive

### Analysis of adherence<sup>1</sup> - SHIFT

	>= ~3M inhabitants	~1M-3M inhabitants	~300K –1M inhabitants	Up to ~300K inhabitants
Investment in improving public transport infrastructure	●	◐	◐	◐
Optimization of the urban train and LRV network	●	◐	◐	○
Implementation of exclusive corridors for buses	●	◐	◐	○
Promotion of fare moderation and alternative sources of revenue	●	◐	◐	◐
Creation of low-emission zones	●	●	●	●
Creation of restriction policies for the circulation of private vehicles	●	◐	○	○

Larger cities have greater demand, ability to invest and physical infrastructure.

Larger cities have greater demand, ability to invest and physical infrastructure.

Larger cities have greater demand, ability to invest and physical infrastructure.

More adherent in larger cities, where heavy traffic justifies the effort.

Lower cost and easier implementation in all profiles.

Applicable to cities with a high number of vehicles and congestion.

Proper supervision and disincentive rules are necessary for efficient implementation, impeding, for example, the purchase of more than one car by the same individual.

Legend | ● The greener, the more adherent.

1. Qualitative, considers the criteria of ease of implementation and availability of resources.

Non-exhaustive

Analysis of adherence<sup>1</sup> - SHIFT

	>= ~3M inhabitants	~1M-3M inhabitants	~300K –1M inhabitants	Up to ~300K inhabitants
Implementation of parking management policies	●	●	◐	◐
Promotion of micro-mobility solutions	●	●	◐	◐
Promotion of active mobility solutions (e.g., hiking)	●	●	●	●
Creation of incentives for intermodality	●	◐	◐	◐
Combating clandestine transport	●	◐	◐	◐

More adherent to larger cities, where the number of parking lots is higher.

Adherent to all profiles, but larger cities have greater infrastructure and resources.

Lower cost and easier implementation in all profiles.

Larger cities have greater demand and ability to invest.

Larger cities have greater demand and ability to invest.

Legend | ● The greener, the more adherent.

1. Qualitative, considers the criteria of ease of implementation and availability of resources.



**IMPROVE:** Decarbonization of the different urban mobility modes

**STEP 3**

**LEVERS SHOW DIFFERENT LEVELS OF ADHERENCE, DEPENDING ON THE CITY PROFILE**

Non-exhaustive

Analysis of adherence<sup>1</sup> - IMPROVE

	>= ~3M inhabitants	~1M-3M inhabitants	~300K –1M inhabitants	Up to ~300K inhabitants
Adoption of mandatory environmental vehicle inspection systems	●	●	●	●
Eco-efficient and assisted driving	●	●	●	●
Enhancing the use of ethanol in light vehicles	●	●	●	◐
Intensification of the use of biofuels in urban buses	◐	◐	◐	◐
Conversion of diesel bus engines to gas (e.g., Biomethane)	◐	◐	◐	◐
Intensification of solutions that promote vehicle emissions close to zero	●	◐	◐	◐

Access may be more difficult in very small cities

Lower cost and easier implementation in all profiles.

Lower cost and easier implementation in all profiles.

Easier implementation in all profiles, at an affordable cost.

Larger cities have higher demand and ability to invest in newer technologies.

Larger cities have higher demand and ability to invest in newer technologies.

Higher costs and infrastructure limitations make it more adherent in larger cities.

Legend | ● The greener, the more adherent.

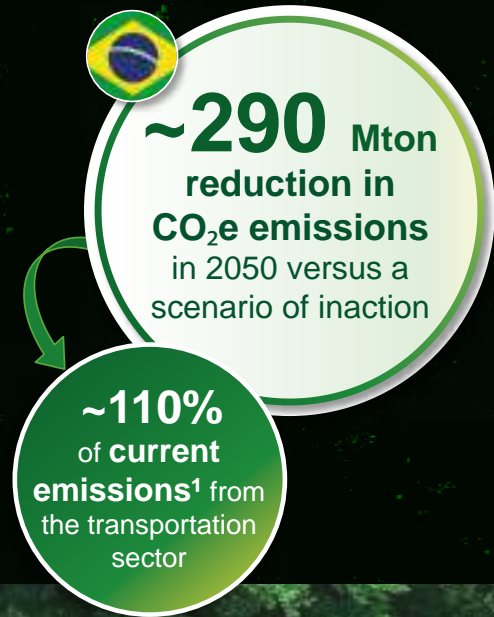
1. Qualitative, considers the criteria of ease of implementation and availability of resources; 2. Emission standards for motor vehicles established by Brazil and the European Union, respectively, set strict limits on the amount of pollutants vehicles are allowed to emit.

# CONCLUSIONS OF TRANSPORTATION COALITION



# We aim for sustainable growth in the Brazilian transportation sector

Target impact in 2050



## Current Brazil<sup>1</sup>...

## ... Future Brazil<sup>2</sup>



**~2.4 Trillion TKM** transported, representing **58%** of total emissions.



**~4.2 trillion TKM** transported, growth of **2.2% p.a.** (+79% vs. '23).



**~30%** of the freight matrix in lower relative emission modes (such as gCO<sub>2</sub>e/TKM).



**~55%** of the freight transport uses modes with relatively lower emissions (rail and water transport).



**~25%** of the population travels via bus and **+60%** of the rail system is concentrated in RJ and SP.



**~R\$53 Billion** of investments in sustainable urban mobility in Brazil from 2023.



**+30 BILLION LITERS** of biofuels consumed<sup>4</sup>, representing **23%**<sup>5</sup> of the energy matrix.



**~55 B L** of biofuels consumed, **+25 B L** of demand vs. '23 of SAF, Green Diesel and others.



**<1%** of the light vehicle fleet<sup>6</sup> is electrified<sup>7</sup> in 2023 (BEV and PHEV).



**+50%** of the electrified light vehicle fleet<sup>7</sup> and **~300,000** electric buses in circulation.



**H2 routes only in pilot** projects testing **Power-to-X (PtX) solutions** and other alternatives.



**15%** of vessels using **synthetic fuels (PtX)** (applications also used in other modes).

1. 2023; 2. 2050 Transformational; 3. Investments in projects provided for by the New PAC; 4. Between road and rail transport modes; 5. Considering the total energy matrix; 6. Light vehicle fleet; 7. Electric and plug-in hybrid vehicles. Source: Infra SA 2021, Thesis on Social Impact on Mobility; EPE 2024, NTU 2025, CNT.

# SUMMARY | MAIN CONCLUSIONS

The announcement of **Brazil's new NDC and the milestone of COP30** present a **unique opportunity for the country** to position itself globally as a hub for decarbonization solutions. In this context, **the transportation sector is of critical importance**, currently **accounting for ~11% of the country's CO<sub>2</sub>e emissions**, of which **+90% are emitted by road transport**.

Expected **growth of the transportation sector** by 2050 is a **tremendous challenge**. It is estimated that, in a **Scenario of Inaction<sup>1</sup>**, total **emissions from the sector could reach 424 Mton CO<sub>2</sub>e in 2050<sup>2</sup>** (+63% vs. 2023). Despite the significant increase, by way of global comparison, **Brazil is expected to emit in 2050 ~1.9 Ton CO<sub>2</sub>e/per capita**, still lower than **countries such as the US and France**, which emitted 5.6 and 2.5 in 2023, respectively.

The scale of this challenge makes mobilization and debate among the transportation sector critical. To this end, **Motiva, CEBDS, CNT, and Insper's Mobility Observatory** mobilized the formation of a **coalition composed of +50 entities from 6 transport verticals**: urban mobility, road transport, air transport, water transport, rail transport, infrastructure and transversality.

Based on the solutions and technologies known at the time of the discussions, supported by the intense contribution of the entities that made several studies available, **~90 levers for the decarbonization of the sector were mapped, with 3 vectors responsible for ~60% of the emission reduction potential**:

## 1 .Implementation of the change in the transport matrix, focusing on cleaner modes:

- › Increase in the share of **rail transport from 16% to 33%** in freight handling. There is an estimated need of **+R\$270 billion** in investments;
- › Expansion of the share of **water transport from 15% to 22%**, also in freight handling. Estimate of investments still under definition;

- › Reduction of the share of the **Road transport mode from 70% to 45%**, due to the expansion of the rail and water transport modes;
- › Emission reduction potential of **65 Mton CO<sub>2</sub>e** (-15% vs. Scenario of Inaction).

## 2.Expansion of the use of biofuels:

- › Expansion of the use of cleaner fuels (e.g. SAF, green diesel) – **Adoption must be preceded by tests that prove technical feasibility<sup>3</sup>**;
- › Estimated **investments of around R\$225 billion** to satisfy an **additional demand of 25 billion liters of biofuels** in 2050;
- › Potential impact of **45Mton CO<sub>2</sub>e in reducing emissions** (-10% vs. Scenario of Inaction)

## 3. Electrification and Power-to-X:

- › Use of **Brazil's clean energy matrix for electrification**, especially for **individual road transport**;
- › Potential to reduce emissions by **145 Mton CO<sub>2</sub>e** (-35% vs. scenario of inaction);
- › Electrification of **light vehicles represents a reduction of 70 Mton CO<sub>2</sub>e** (~48% of the 145). Requires investments of **~R\$40 billion in recharging infrastructure alone**;
- › Use of **low-carbon H<sub>2</sub> routes** as a solution for **hard-to-abate transport modes**, especially maritime shipping.

**The other levers** are also of paramount importance and have been widely debated in each mode. As much as the impact on reduction is an important metric, **the levers with high feasibility of implementation in the short term need to be highlighted**. As an example, some mentioned below:

1. Demand for the sector in 2050 is projected with growth aligned with the growth of the country's economic activity of 2.4% p.a.; Maintenance of the current profile of the Brazilian transportation matrix, lack of advances in new technologies and expansion of the use of clean fuels); 2. Estimates based on PSTF (Rail Transport Sector Plan) and the PNL; 3. In addition to respecting the diversity of matrices and considering regional specificities.

- › Urban mobility: **inter and multi-modal integration, with expansion of public transport to the detriment of the individual motorized transport;**
- › Road transport: **renewal of the current fleet and improvement in road pavement/infrastructure;**
- › Rail transport: **improvement and renewal of the current fleet, optimization of routes and improvement in the maintenance/infrastructure of the railways;**
- › Water transport: **improvements in the hydrodynamic performance of vessels and viability of infrastructure and facilitation of port access;**
- › Air transport: **renewal of the current fleet and improvement of the operational management of airports.**

Given the dimensions of the challenge, **a series of enablers<sup>1</sup> will be required** to materialize such levers. **Some concrete examples below** illustrate how enablers can help progress the decarbonization agenda in the transportation sector:

**New Legal Framework for Railways | Regulation:** Mechanism to promote private investments to expand the capacity of the mode;

**Fuel of the Future Law | Regulation:** Guidelines for the expansion of the use of biofuels;

**REFROTA ("Re-fleet") Program | Incentives:** Federal Government program that provides financing for the purchase of 2,296 electric buses.

Considering all these efforts, the **potential reduction is estimated at up to ~50% of current emissions** (~70% of the inaction baseline in 2050) and **~70% of relative emissions<sup>5</sup> in 2050** (vs.

2023). Even so, there will still be some remaining residual emissions of **137 Mton CO<sub>2</sub>e by the year 2050, concentrated in the remaining use of fossil diesel**, especially for road transport (~25 billion liters in 2050 vs. ~50 billion liters in 2023). This situation brings attention to the significant **challenge of achieving net-zero emissions by 2050 in the sector, without relying to some extent on offsets.**

There are some alternatives with the potential to minimize residual emissions: i. **Even more accelerated adoption of mapped levers** ii. **Pioneering new technologies** iii. **Compensation tools.** Sustained exploration of decarbonization options remains vital, as the sector upholds its role in advancing Brazil's climate agenda and unlocking its **associated social benefits.**

Finally, the sector plays a crucial role in making **sustainable growth** attainable as part of moving towards a **future vision for Brazil, where in 2050 it is envisaged:**

- › **A reduction of up to ~290Mton CO<sub>2</sub>e<sup>2</sup>** (reduction of ~110% of the current emissions volume of ~260 Mton CO<sub>2</sub>e), despite the **growth of the sector<sup>3</sup>;**
- › **55% of the freight matrix** handled via **lower-emission modes**, such as rail and water transport;
- › **+75% growth** in the use of biofuels (i.e. additional demand of 25 billion liters) and **+40% of the current fleet of electrified vehicles<sup>4</sup>;**
- › **~R\$53 billion invested by the New PAC in sustainable urban mobility projects in Brazil** (from 2023), contributing to the greater share of public transport to the detriment of individual motorized transport.

1. Several other examples of enablers are listed in the documents of each of the verticals; 2. In relation to a scenario of inaction in 2050; 3. Growth rate of the transportation sector (~2% p.a.) estimated in line with the growth of the country's economic and demographic activity; 4. Number should exceed 50% for electric and plug-in hybrid light vehicles and reach about 40% for heavy vehicles; 5. Emissions by TKM; Sources: Gov BR - Civil House.

# TRANSPORTATION COALITION

HOW THE TRANSPORTATION SECTOR CAN BECOME AN ACTIVE CONTRIBUTOR TO THE REDUCTION OF BRAZILIAN EMISSIONS

## COALITION FOR THE DECARBONIZATION OF TRANSPORTATION: A MOVEMENT FOR THE GLOBAL CLIMATE AGENDA.

This study is the result of the engagement of more than 50 entities and associations, whose leaders and associated companies formed a coalition to identify initiatives aimed at decarbonizing the modes of the Brazilian transportation sector.

Mobilized by the Brazilian Business Council for Sustainable Development (CEBDS), the National Transport Confederation (CNT), Motiva and Insper's National Observatory for Sustainable Mobility, the movement was structured based on an invitation from the ambassador and president of COP30, André Corrêa do Lago, materializing in this study, which seeks to expand the discussions around the Climate Plan and the Nationally Determined Contributions (NDCs) of Brazil. It also presents the sector's recommendations to contribute to Brazil's achievement of the goals of the Paris Agreement and the UN Sustainable Development Goals (SDGs).

In 2023, the transport sector accounted for approximately 11% of absolute carbon dioxide (CO2) emissions in the country and the study by the Transportation Coalition identified 90 levers to promote the decarbonization of the sector, grouping those with the highest impact in critical vectors with a potential for a 60% reduction in emissions. Together, these measures will represent an investment of R\$530 billion by 2050 in areas such as biofuels, green fuels, fleet electrification, railways, waterways and highways.

The engagement of the Brazilian transport sector in sustainable development and its willingness to innovate make us optimistic about the messages we will bring to Belém (PA) during the Conference of the Parties/COP30, which takes place in November 2025.



Scan the QR Code to view the Coalition for Transportation Decarbonization materia

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