

Recommendations to develop a Brazilian Maritime National Action Plan

Prepared by: Francielle Carvalho

Background

Action plans are a useful tool in strategic policy planning and help to set a methodology to achieve an established policy goal. In addition to identifying the main actions required, such plans also attribute responsibilities, define budgets, and establish monitoring processes so that best results can be achieved. Figure 1 presents the structure commonly seen in policy action plans.

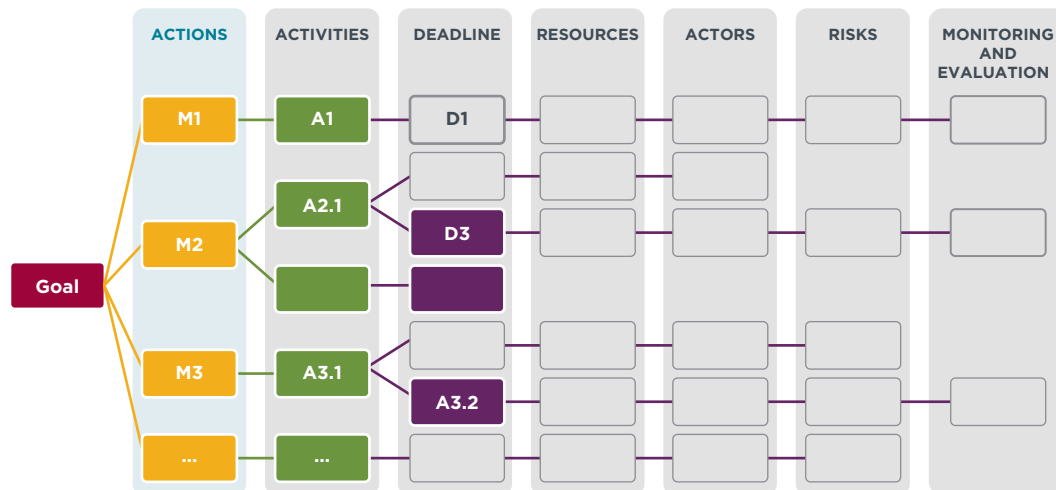


Figure 1. Common Action Plan structure

National action plans (NAPs) guide countries in the development and implementation of national policies or strategies. Because NAPs generally involve the participation

Acknowledgments: We would like to thank Instituto Clima e Sociedade for hosting the webinar, "Recommendations to develop a Brazilian Maritime National Action Plan." We'd also like to thank the webinar panelists D.Sc Paula Pereda (USP), Capitain Fernando Alberto da Costa (Brazilian Navy), and Mrs. Sveinung Oftedal (Norwegian Ministry of Climate and Environment) for their participation and valuable contributions.

The information presented in this workshop report is derived from the webinar, "Recommendations to develop a Brazilian Maritime National Action Plan," hosted by the Instituto Clima e Sociedade on August 22, 2022. Webinar speakers and participants discussed topic surrounding how Brazil could shape a national action plan for maritime decarbonization.

www.theicct.org

communications@theicct.org

[twitter @theicct](https://twitter.com/theicct)

of many stakeholders, their creation and implementation can be challenging. Their application is relatively new and unsuccessful experiences with such plans can be related to the lack of resources, political support, and effective coordination. Alternately, such plans may be poorly prioritized or not adapted to local contexts. Successful and impactful NAPs should include outside experts in their development; be designed to fit local priorities; clearly identify roles, responsibilities, and timelines; and include monitoring and evaluation plans.

The “Initial IMO Strategy for the Reduction of GHG Emissions from Ships” includes as a possible short-term measure the development of national action plans to encourage the uptake of policy and strategies to facilitate the reduction of greenhouse gas (GHG) emissions from ships at national level. During the International Maritime Organization’s (IMO’s) 75th meeting of the marine environment protection committee in 2020, the resolution MEPC 75-18-Add.1 was published to encourage member states to develop and present voluntary national action plans to address GHG emissions (International Maritime Organization, 2020):

“The Resolution suggests that National Action Plans could include (not limited to):

1. *Improving domestic institutional and legislative arrangements for the effective implementation of existing IMO instruments;*
2. *Developing activities to further enhance the energy efficiency of ships;*
3. *initiating research and advancing the uptake of alternative low-carbon and zero-carbon fuels;*
4. *Accelerating port emission reduction activities, consistent with resolution MEPC.323(74);*
5. *Fostering capacity-building, awareness-raising and regional cooperation; and*
6. *Facilitating the development of infrastructure for green shipping.”*

As of 2022, seven member states have submitted NAPs to the IMO. These plans do not follow a common methodology, thereby greatly differing in terms of scope, structure, and ambition. A summary of the NAPs submitted to the IMO, including content comparisons and suggestions presented in IMO’s resolution, can be found in the appendix.

ICCT presentation: Recommendations for the establishment of a NAP for maritime decarbonization in Brazil

The following is a summary of a presentation given by Francielle Carvalho, Brazil Marine Associate Researcher, ICCT, based on a project that aimed to characterize the Brazilian maritime sector with a view to providing recommendations for a future action plan for maritime decarbonization in the country.

National action plans actions can be used to encourage the uptake of policy and strategies to facilitate the reduction of GHG emissions from ships. Aiming to understand how Brazil could shape its own action plan for maritime decarbonization, ICCT researchers undertook a project to:

1. Understand the current state of international and national maritime transportation in Brazil.
2. Identify promising decarbonization pathways for the sector.
3. Identify possible actions to decarbonize maritime transport in the country.

The analyses performed in the project is described in more detail below.

Current state of maritime transport in Brazil

According to the Agência Nacional de Transportes Aquaviários (ANTAQ), Brazil's National Agency of Waterway Transportation, around 1.2 billion tonnes of cargo were transported in Brazil in 2021 (Agência Nacional de Transportes Aquaviários, 2022). Long haul transportation represented most of the maritime activity and moved approximately 71% of the total cargo transported, followed by cabotage (24%) and inland waterway activity (5%). Dry bulk cargo (58%) represented the major cargo type transported, followed by liquid bulk (26%), container (11%) and general cargo (5%). Iron ore was the main product transported, totaling 340 million tonnes and making up 33% of the total mass transported. Crude oil, containerized cargo, soybeans, and oil products are the other main products transported, collectively accounting for 43% of the total. Figure 2 presents a summary of maritime transportation in Brazil in 2021.

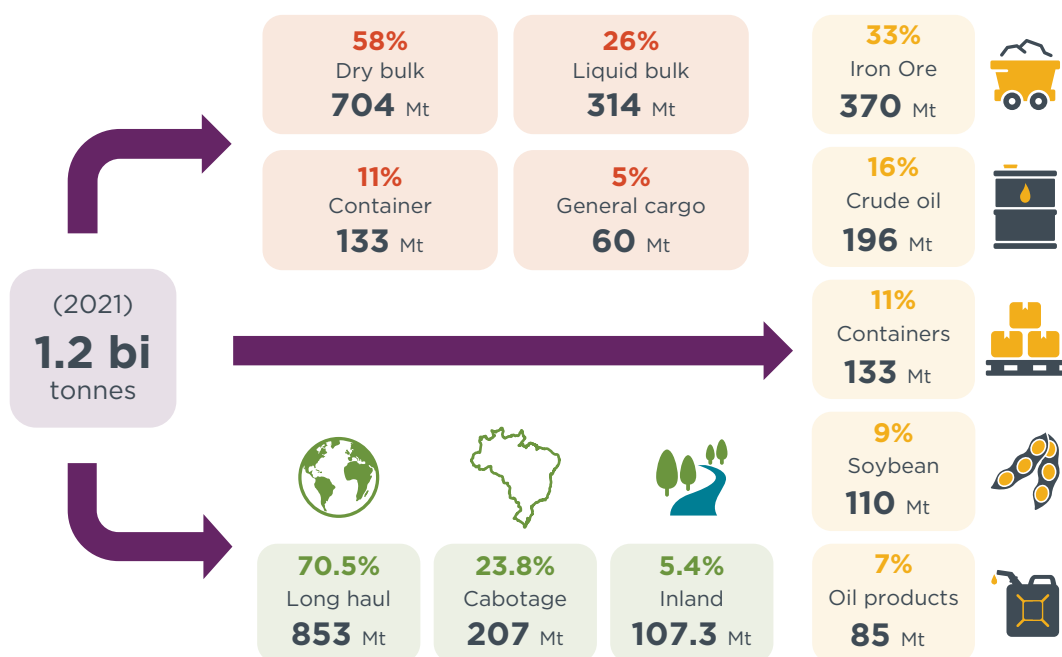


Figure 2. Maritime transport in Brazil in 2021.

Maritime transport and economic activity

Long-haul

Figure 3 shows the share of Brazilian exports in 2022, expressed in both monetary value and mass. The data show that the main export products (iron ore, soy, oil, sugar, and beef) represent about 77% of exports in mass terms, and only 47% in monetary terms. This indicates that Brazilian international trade is based on the export of low value-added commodities.

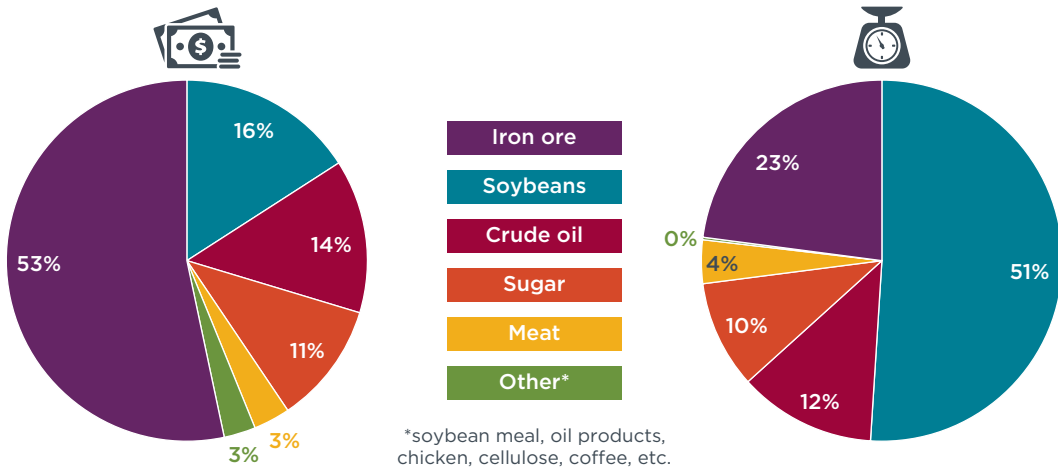


Figure 3. Brazil exports share in 2021

For imports, the scenario is quite different (Figure 4). The main imported products (fertilizers, oil products, medicines, and others) do not make up the majority of imports in terms of mass or monetary value. Brazilian imports are based on manufactured products, which are generally higher value-added products.

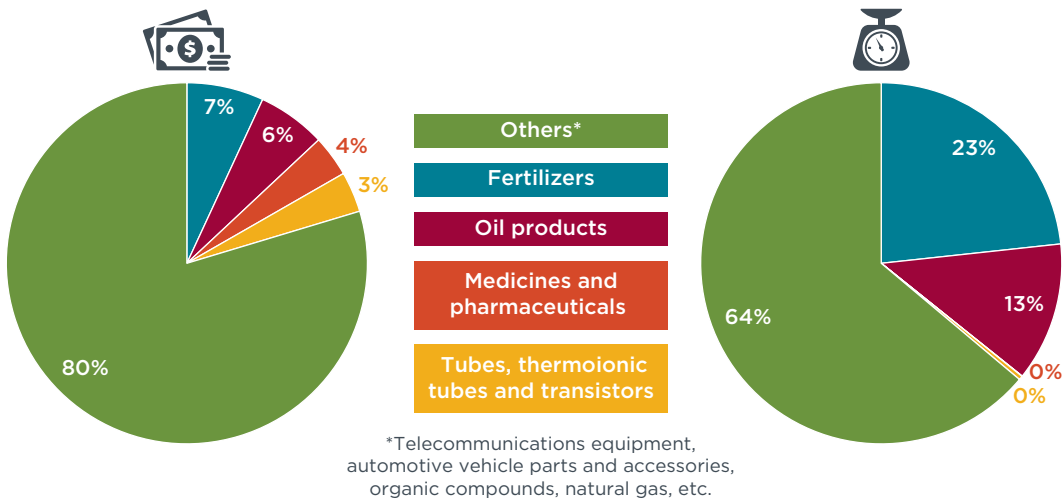


Figure 4. Brazil import share in 2021

The main Brazilian trade partners in terms of exports and imports are China, the United States, Russia, and Argentina which, except for the latter, are geographically distant from Brazil (Figure 5). Thus, it can be concluded that Brazilian foreign trade is characterized by (1) long-haul maritime transport; (2) the export of low value-added commodities; and (3) the import of manufactured products, which are higher value-added. This indicates that any changes in maritime transport that imply a cost increase may have significant impacts on the Brazilian trade balance and affect national industry.

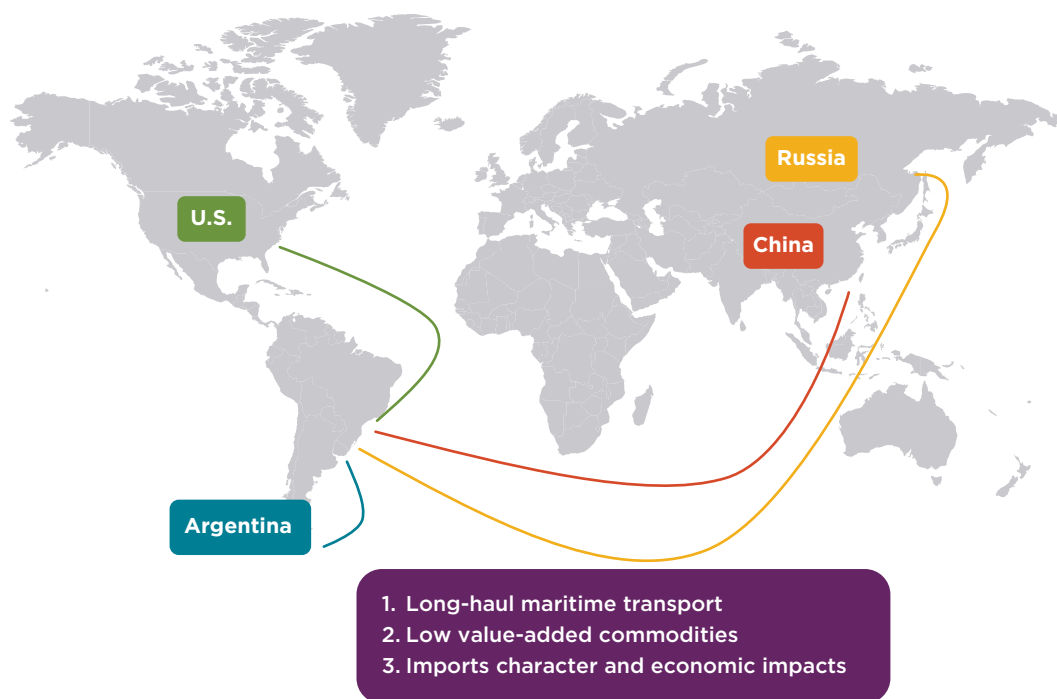


Figure 5. Brazil main trade partners and characteristics of maritime trade

Cabotage

Regarding cabotage, maritime transport is quite concentrated in both mass and economic terms, being led by crude oil transport (almost 80% in mass and economic terms), followed by ore and containerized cargo transport (Figure 6).

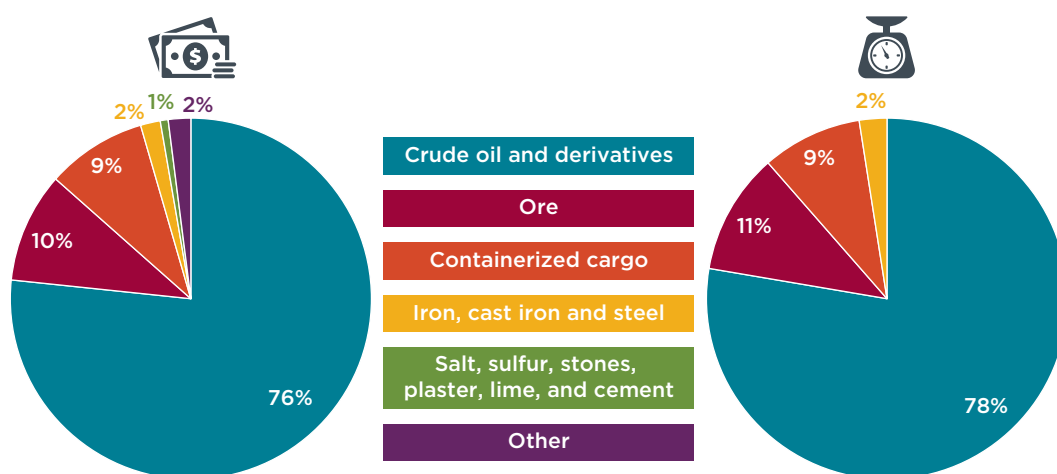


Figure 6. Products share in cabotage transport in 2021

Inland Waterways

In inland navigation, a more distributed profile is observed (Figure 7). The main products handled are seeds and oilseeds, ores, oil, cereals, containerized cargo, chemicals, and fertilizers.

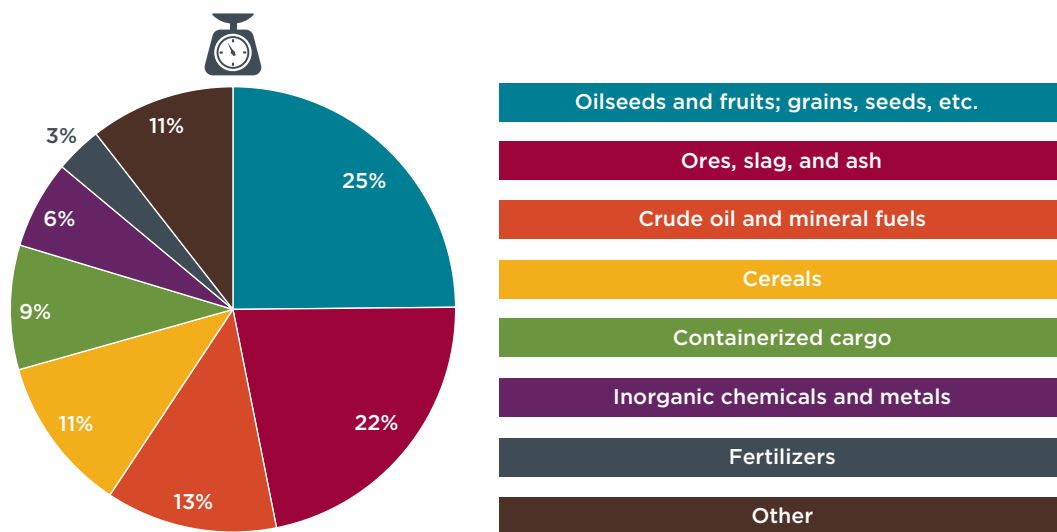


Figure 7. Products share in inland waterway transport in 2021

Fleet identification and emission estimates

The analysis of the fleet operating in Brazilian maritime transport was divided into two stages. First, vessels were classified according to their operations and were identified as long haul, cabotage, or supply vessels. To this end, the fleet database from ANTAQ was used (Agência Nacional de Transportes Aquaviários, 2022). Second, the fleet was characterized in terms of capacity, ship class, and GHG emissions. The capacity represents the sum of all variable weights that a ship is capable of safely carrying, including fuel, water, provisions, consumables, crew, passengers, luggage, and cargo.

The ANTAQ database lists the number of ships operating in each segment as follows: 66 vessels operating in long haul transport, 187 in cabotage, 640 in maritime supply, and 1759 in port supply (Figure 8). It is noteworthy the link between the fleet serving the long haul and cabotage; only one vessel operating in long haul does not operate in cabotage. However, the ship type profile is quite different between cabotage and long haul. Barges represent the main ship type operating in cabotage, while containers are more significant in the long-haul fleet (Figure 7).

Long-haul	66
Cabotage	187
Maritime supply	640
Port supply	1,759
Cabotage & Long-haul	188

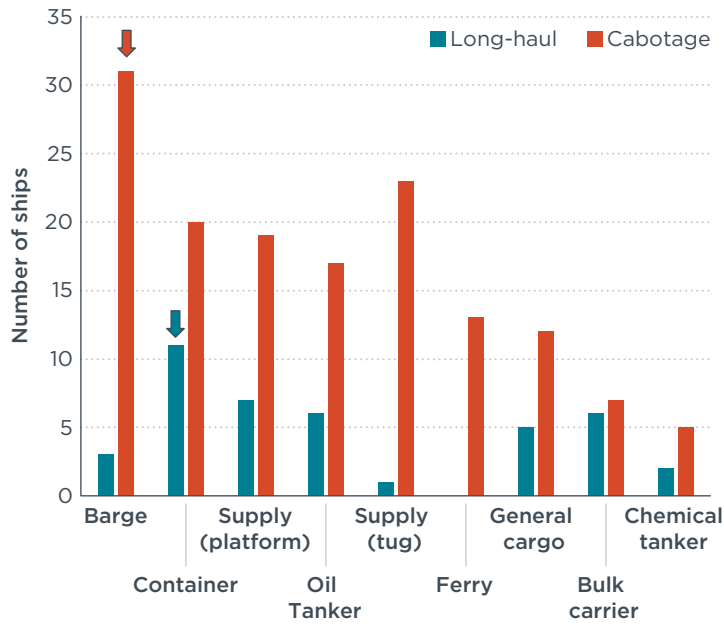


Figure 8. Ships operating in different maritime transport segment (right) and ships profile operating in long-haul and cabotage (left).

Of the 2215 registered vessels in the fleet database, the class with the highest number of ships is tugboats (almost 500), followed by oil platform supply vessels, ferries, and barges. In terms of capacity, oil tankers stand out, representing more than 40% of the total capacity (Figure 9).

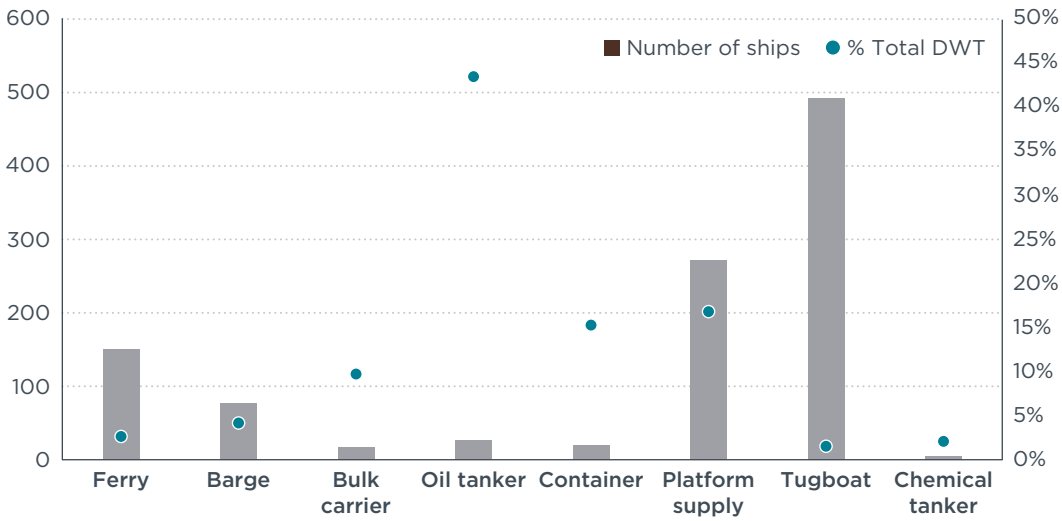


Figure 9. Composition of the fleet operating in Brazil (only vessels registered in ANTAQ).

Each vessel's IMO number was then identified where available. The IMO number is a permanent identification number for ships whose capacity (in deadweight) exceeds 300 tonnes for cargo vessels and 100 tonnes for passenger vessels. Of the 2215 vessels under analysis, only 430 were found to have an IMO number, including 357 supply vessels (tugboats and oil platform supply vessels), 20 container ships, and 20 oil tankers. Vessels without an IMO number were mostly speedboats, motorboats, tugboats, boats, and ferries.

Next, the age of the fleet under analysis was identified to determine the share of ships that may be approaching their end of useful life, assumed to be approximately 30 years. By analyzing the fleet age composition (Figure 10), it was found that the fleet operating in Brazil is relatively new, as most ships were built in the last 15 years.

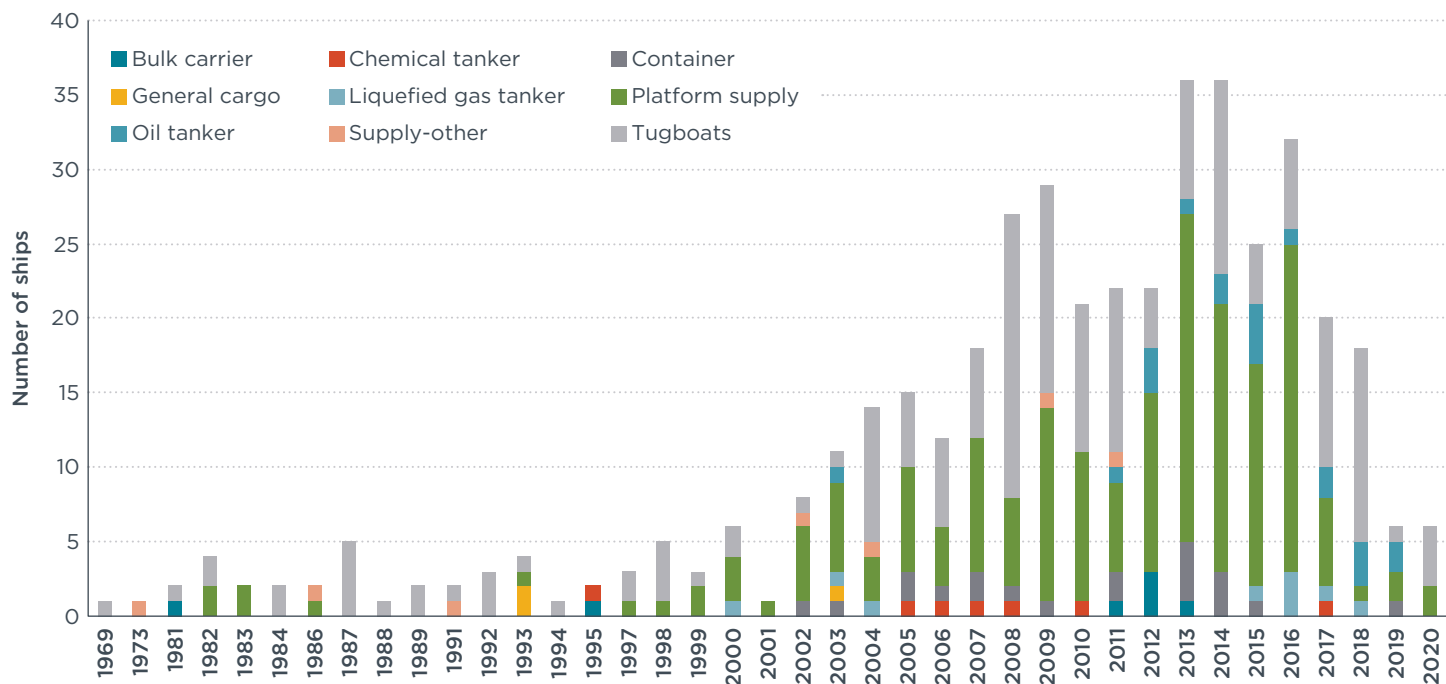


Figure 10. Age of the ships operating in Brazil

To estimate the GHG emissions from the fleet operating in Brazil, ICCT’s SAVE model was used. SAVE integrates AIS and IHS datasets to estimate ship-specific power consumption hour by hour for each ship (Olmer et al., 2017). AIS reports each ship’s location as frequently as every few seconds, in addition to the ship’s speed over ground and draught, while the IHS dataset provides key technical characteristics for each ship. The SAVE model uses a bottom-up emissions inventory to estimate the spatial-temporal energy consumption of each individual ship at a fine resolution. Emissions of CO₂, CH₄, and N₂O were converted to CO₂ equivalent (CO₂e) using the 100-year global warming potential from the Sixth Assessment Report from the IPCC (Intergovernmental Panel on Climate Change, 2021).

The total emissions from the fleet under analysis were determined to be 2.3 MtCO₂e (Figure 11). These emissions are not limited to the national territory, but represent the total emissions associated with ships belonging to the fleet under analysis.

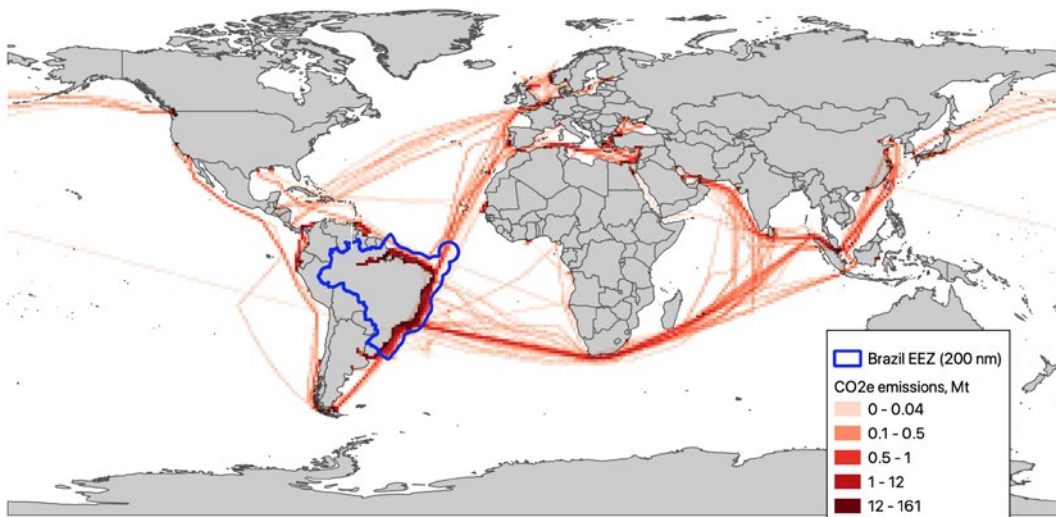


Figure 11. Emissions of the fleet under analysis in 2019

Emissions inside the exclusive economic zone (EEZ), outlined in blue in Figure 11, totaled 1.7 Mt CO₂e. As shown, these emissions are concentrated near the southeastern coast of Brazil. This is explained by the intense oil transport activity from the oil platforms to the continent in the Southeast region, which hosts the major oil refineries in the country (black rectangles in Figure 12).

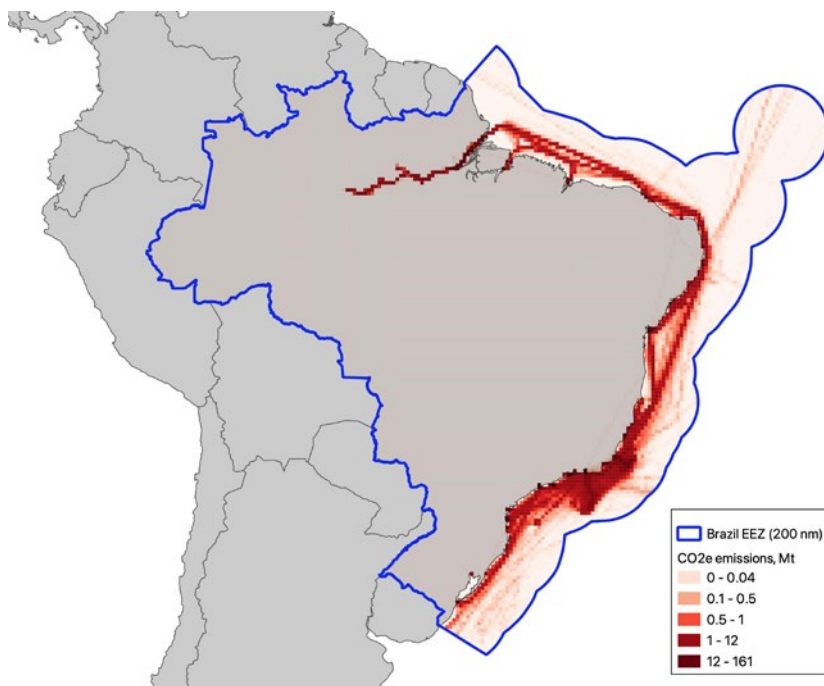


Figure 12. Emissions of the fleet under analysis inside of EEZ.

Emissions inside the EEZ (1.7 MtCO₂e) were a very small share of both national emissions (2160 MtCO₂e) and transport sector emissions (185 MtCO₂e) in 2020 (Observatorio do Clima, 2021). However, with the expected growth for maritime activities in Brazil and globally (Carvalho, 2022; Empresa de Pesquisa Energética, 2021; Faber et al., 2020; United Nations Conference on Trade and Development, 2021), and the similarities between national transport (cabotage) and international transport in terms of ships and infrastructure, decarbonization of national maritime transport is necessary to achieve international maritime decarbonization.

Emissions inside the EEZ per ship type were also determined. Offshore supply vessels, container ships, and oil tankers were found to contribute the most emissions, representing 28%, 27%, and 27%, respectively. Tugboats, chemical tankers, and bulk carriers represent 11%, 4%, and 3% of the total (Figure 13).

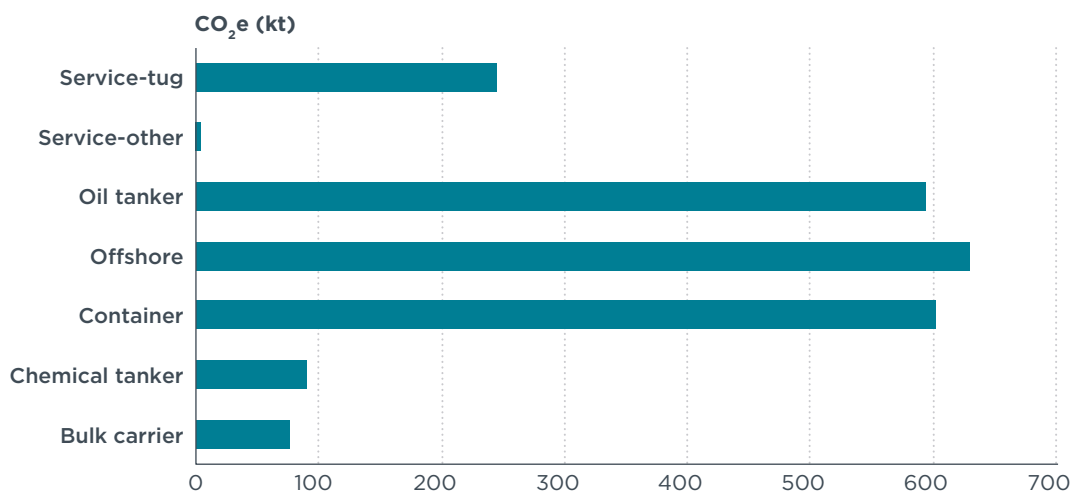


Figure 13. Emissions inside of Brazil EEZ per ship type

Promising decarbonization pathways for the sector

Around 90% of international trade is carried out by ships, which makes the decarbonization of maritime transport quite complex. To comply with the IMO Greenhouse Gas Strategy (International Maritime Organization, 2023), countries will have to invest in locally available resources and new technologies to promote sustainable shipping. Brazil's commercial profile poses additional challenges, as exports are mostly composed of low value-added products sold to distant markets. This means that decarbonization measures and new energy sources must be carefully evaluated for potential economic impacts and consequences for a ship's autonomy. In this context, the analysis presented here is intended to illustrate how Brazil could contribute to the decarbonization of the maritime sector.

With an understanding of the Brazilian maritime trade profile (presented in the previous section), it is possible to identify feasible decarbonization pathways for the country in the short-, mid-, and long-term and to define priority actions. Required measures to reduce maritime transport emissions have been extensively studied and are composed mainly of technical and operational measures, in addition to the use of low-emission fuels (Figure 14) (Bouman, Lindstad, Riialand, & Strømman, 2017). Among operational and technical measures are the application of energy efficiency indexes (IMO, 2022b, 2022a; Rutherford, Mao, & Comer, 2020), slow steaming (Cariou, 2011; Faber, Nelissen, Hon, Wang, & Tsimplis, 2013; Glujić, Kralj, & Dujmović, 2022), and hull cleaning and lubrication (Comer, Chen, Stolz, & Rutherford, 2019). When considering the use of low GHG emission fuels, they should be assessed according to their life-cycle emissions (Comer, O'Malley, Osipova, & Pavlenko, 2022; Gilbert et al., 2018; Law, Foscoli, Mastorakos, & Evans, 2021; Zhou, Pavlenko, Rutherford, Osipova, & Comer, 2020; Carvalho, O'Malley, Osipova, & Pavlenko, 2023). Other alternatives include wind-assisted propulsion and onshore power for ships at berth (Comer et al., 2019; Comer, Georgeff, Stolz, Mao, & Osipova, 2022).

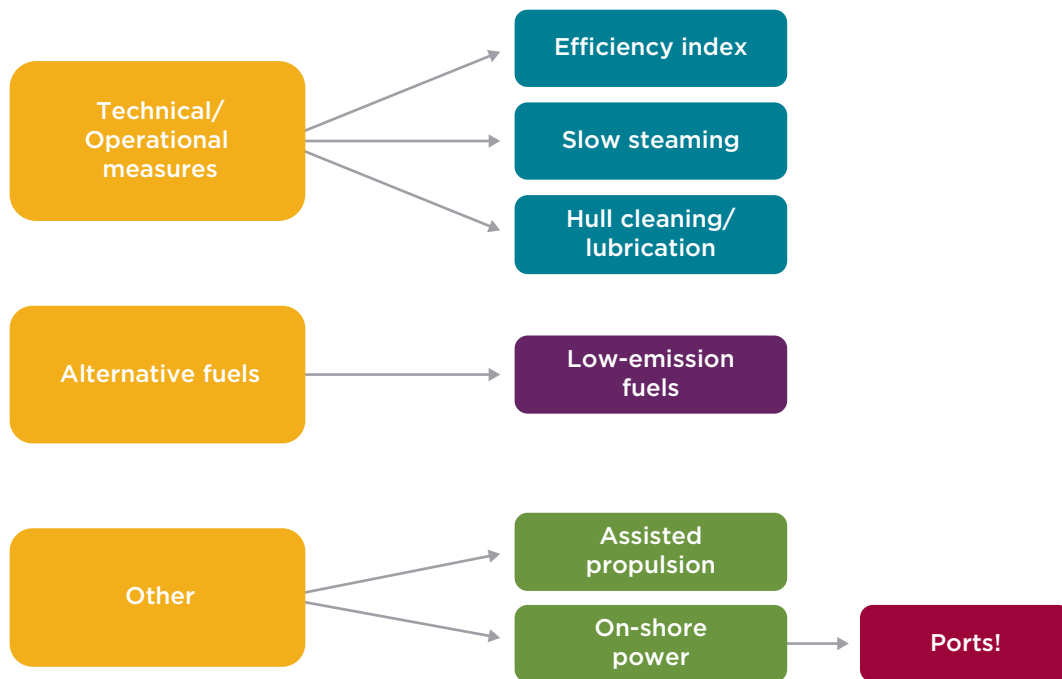


Figure 14. Measures to reduce maritime transport emissions.

Some technical and operational measures have already been implemented by the international maritime organization, such as the energy efficiency index for new ships (EEDI), the energy efficiency index for existing ships (EEXI) and the carbon Intensity indicator (CII) (IMO, 2022a, 2022b).

For fuels, potential alternatives are liquefied natural gas (LNG), green methanol, biofuels, green hydrogen, green ammonia, and electrofuels (e-fuels). As shown in Figure 15, each of these fuels involve tradeoffs, and challenges of different natures exist for all alternatives, such as lower energy density than conventional fuels, costs, technological maturity, and risk of secondary impacts, such as indirect land use changes, safety, or fossil electricity displacement.

	LNG	Green methanol	Biofuels	Green hydrogen	Green ammonia	E-fuels
Energy density	+	-	+	-	-	+ -
Life cycle emissions	- (slip)	+ (renewable)	+	+ (renewable)	+ (renewable)	+ (renewable)
Secondary impacts		- (add. RE*/ safety)	- (iLUC/food)	- (add. RE*/ water)	- (add. RE*/ water/ fertilizers)	- (add. RE*/ CO ₂ capture)
Costs	+	+	-	-	-	-
Technological maturity	+	+	+	+	-	-

*additional renewable electricity

Figure 15. Alternative marine fuel benefits and challenges

Further, ports are key pieces for the decarbonization of maritime sector (Alamouch, Ölçer, & Ballini, 2022; International Association of Ports and Harbours, 2021). In addition to on-shore electricity for ships on berth, ports will need to provide the infrastructure to supply new low- or zero-emission fuels. However, such transformations require intensive investments in capital. These investments in infrastructure and port facilities are generally demand-driven, but shipping companies are unlikely to invest in alternative fuels or on shore power if there is no infrastructure available in ports.

Possible actions to decarbonize maritime transport in Brazil

To design a decarbonization action plan for maritime transportation in Brazil, it is necessary to identify the main target actions. The analysis presented shows:

- » The Brazilian international trade profile, characterized by exports of commodities to distant markets, requires the use of alternative fuels with high energy density in order to optimize the cargo space on the ship and guarantee its autonomy.
- » The age of the fleet, which is relatively young (around 15 years), indicates that it is necessary to prioritize technical and operational measures and the use of drop-in alternative fuels, given that they would not imply changes in the propulsion and supply system.
- » Because the fleet is predominantly associated with the oil and gas industry, decarbonization of national maritime transportation will require the participation of that sector.
- » The high number of supply vessels means special attention should be paid to this category of ships, which operate only in short-distance transport and represent 37% of emissions in the EEZ.

Audience poll

During the webinar, whose audience was mainly composed by stakeholders from the maritime sector, a poll was performed to rank priority actions for the Brazilian Action Plan on maritime decarbonization (Figure 16).

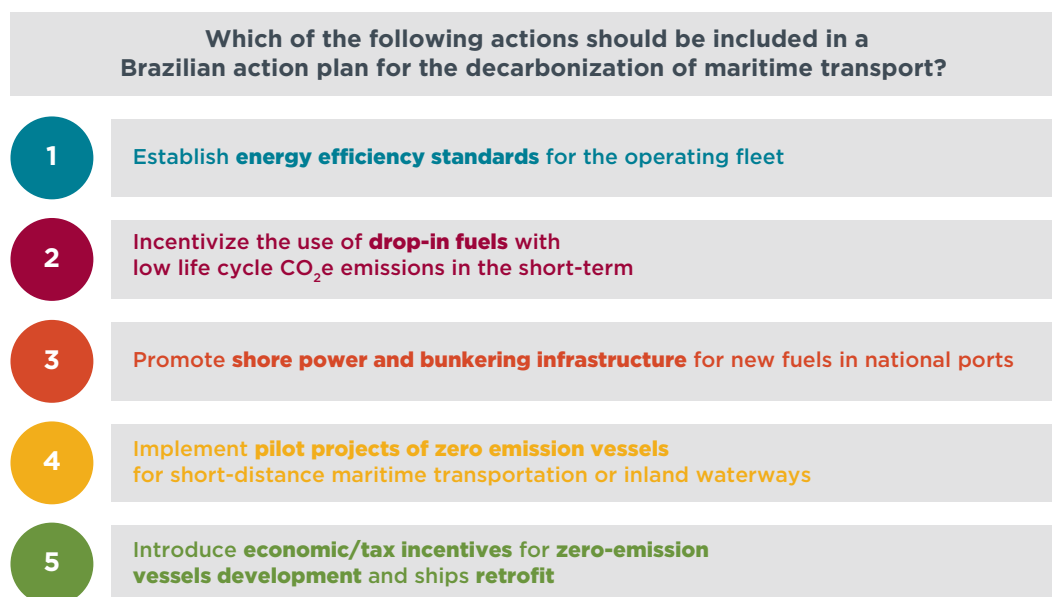


Figure 16. Poll to identify priority actions for the Brazilian Action Plan for maritime decarbonization.

The poll results showed a higher preference for incentivizing the use of drop-in fuels (option 2), followed by establishing energy efficiency standards for the operating fleet (option 1), promoting onshore power and bunkering infrastructure for new fuels (option 3), introducing economic incentives for zero-emission vessels (option 5), and implementing pilot projects for short distance maritime transportation (option 4). Possible outcomes from these actions are presented in Figure 17.

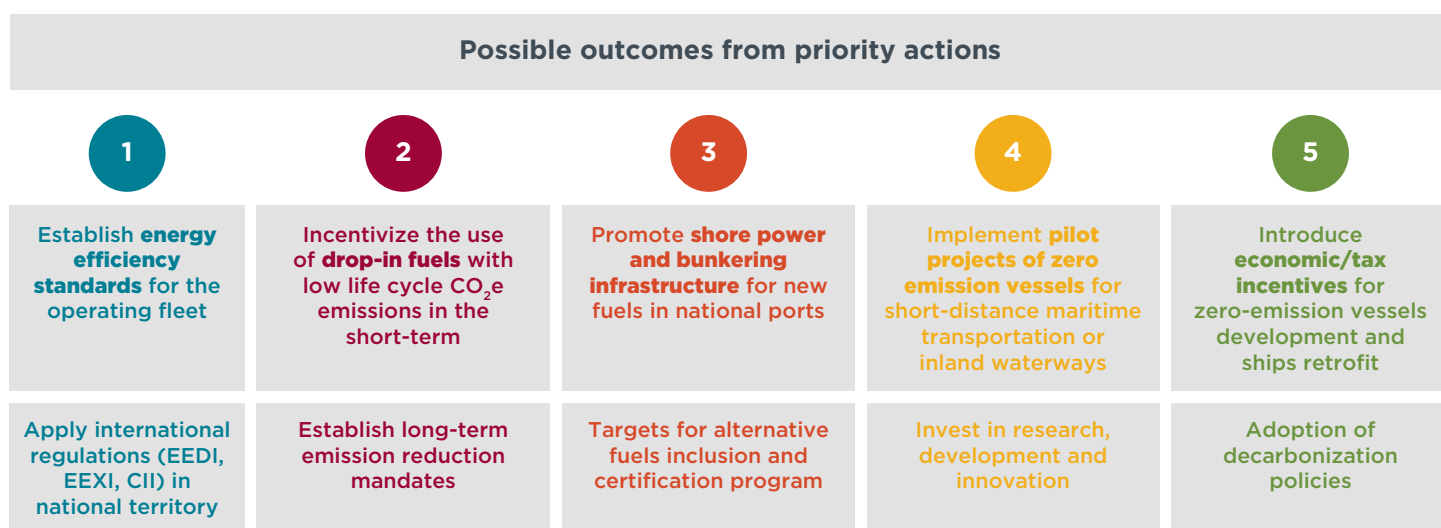


Figure 17. Possible outcomes from the identified priority actions

Discussion panel

A panel discussion was held after the primary presentation. Speakers on the panel were:

- » Captain of Sea and War Fernando Alberto da Costa, Coordinator of the Brazilian delegation on matters relating to the Marine Environment Protection Committee of the International Maritime Organization.
- » D.Sc. Paula Pereda, Professor at the Department of Economics at the University of São Paulo. She conducts research in climate economics (among other areas) and was co-author of the Fourth IMO GHG Study
- » Mrs. Sveinung Oftedal, Director Specialist at the Norwegian Ministry of Climate and Environment with focus on international negotiations on environmental requirements for the maritime sector and chair of the IMO Working Group on greenhouse gas emissions.

The panelists provided their views on the decarbonization of the maritime sector, which was followed by a round of questions from the audience. Themes covered included national perspectives on maritime decarbonization, the economic feasibility of mitigation alternatives, and the experience of the Norwegian National Action Plan.

Initially, the ongoing actions in the Brazilian maritime sector and recommendations for future actions were presented. Although not directly focused on the decarbonization, some initiatives already established in Brazil that focus on operational and logistic efficiency and in infrastructure development would help to reduce maritime-related emissions in the country. Panelists recommended future national actions should be consistent with IMO guidelines and inspired by ongoing international initiatives. In addition, the identification of national stakeholders and existing initiatives in the country would be the first step toward future coordinated actions.

Concerning the economic perspective of maritime sector decarbonization, links were made to the global challenges faced by the energy sectors to produce viable clean energy sources. Additionally, specificities of the maritime sector make decarbonization challenging, including the use of fuel with high carbon and sulfur content, the long lifespan of ships, and the long-established fueling infrastructure. Moreover, the characteristics of maritime transport in Brazil would require a decarbonization strategy and that might not be similar to international initiatives.

From an economic perspective, the panel expressed that the cost of alternative should not be the only consideration because they are an investment for the future. It was suggested that technologies to decarbonize maritime transport and their cost should be evaluated considering the social cost of carbon, including the non-commercial impacts on the environment and human health. In this way, all the impacts of climate change would be taken into account to maximize the net benefits for the society.

Finally, the challenges and successful outcomes from the Norwegian experience with the country's NAP were discussed. Key recommendations identified for effective NAPs include: they should be implemented at the governmental level and contain clear targets; the focus must be on the climate goals and its potential economic benefits; key stakeholders should participate; and administrative coordination and political will is crucial. The relevance of robust scientific work was also highlighted, in addition to the necessary participation of diverse stakeholders, including industry and civil society.

Questions from the audience and a summary of answers from the panelists are presented below.

1. What is the perspective for the effective elaboration of the NAP in Brazil with all the necessary elements commented on before, such as governance, political will, clear targets, etc.? Is there any intention from the Brazilian authorities and organizations to do it?

- » Chances of effective collaboration are high, given that Brazil's structure to deal with IMO matters involve government participation.
- » Actions already underway in the country would help to reduce maritime emissions.
- » There is a need to identify stakeholders, prioritize actions, and encourage coordinated participation.
- » Brazil does not yet have a clear decarbonization target for the maritime sector, given that it is expected to be in line with the Paris Agreement goals, but it would follow all the rules applied by the IMO.
- » In summary, Brazil requires administrative and governmental efforts to gather stakeholders, identify actions, and plan ongoing monitoring and follow up.

2. How can decarbonization initiatives be used to result in an economic advantage? Where are these greatest opportunities in the maritime sector?

- » Economic benefits are expected to come mainly from operational and technical efficiency improvements on ships and port operations.
- » Other initiatives could be identified by considering the social cost of carbon in the assessments of cost-effectiveness.
- » It is expected that technological progress reduces the costs of decarbonization measures over time, favoring their cost-effectiveness.

3. The Norwegian plan had a strong government leadership and governance structure, which allowed for its successful implementation. If initiatives are developed in absence of established goals, do you believe in the possibility of success for a Brazilian plan?

- » The first step is always important. That is, it doesn't matter if we begin with simple actions or those with a limited scope. The important thing is to start.
- » Brazil does not necessarily need to copy other successful plans but should instead find a way to make its own, even if it's modest or less ambitious.
- » National opportunities and synergies need to be identified to capture financial support from private investments, public-private partnerships, and other entities.

4. What necessary knowledge and research is required to compose an ambitious Brazilian plan. What is missing?

- » There is a need to understand the national context to identify vocations (resources) and potential impacts.
- » A diagnosis of the sector should be followed by impact assessments of the selected mitigation measures.
- » Monitoring and evaluation activities should be established.
- » Links with decarbonization efforts in other energy-related sectors should be identified.

5. How can it be ensured that the Brazilian national plan is coherent with the plans of other countries? Would it be important to consider the need for global standardization?

- » Avoiding unilateral actions is recommended by the IMO, given that there is a danger of too much specificity within the regional mitigation effort.

- » National plans should facilitate standardization.
- » Green corridors can be established for certain routes, ships, and products with similar infrastructure requirements.
- » Technical standardization and security challenges should be addressed, as there is no one-size-fits-all solution for the industry.
- » When government-derived actions are established to reduce emissions, industries will move towards finding adequate solutions.

Conclusions

To promote the decarbonization of maritime transport, the adoption of relevant and timely policy measures at the national level are crucial. The research presented at the webinar aimed to provide preliminary recommendations for a Brazilian action plan for the decarbonization of maritime transport and stimulate discussion among national stakeholders. It was identified that, even though some initiatives already underway in the country could contribute to reducing emissions, governmental will and support is needed to set a decarbonization agenda for the sector. For the objective of this mobilization to be successful, government leadership and governance are necessary to create a maritime decarbonization action plan, with the collaboration of regulators, private sector, civil society, research institutions, and other stakeholders.

References

- Alamouh, A. S., Ölçer, A. I., & Ballini, F. (2022). Ports' role in shipping decarbonisation: A common port incentive scheme for shipping greenhouse gas emissions reduction. *Cleaner Logistics and Supply Chain*, 3, 100021. <https://doi.org/10.1016/j.clscn.2021.100021>
- Agência Nacional de Transportes Aquaviários. (2022). Estatístico Aquaviário [Waterway statistics]. <http://ea.antaq.gov.br/QvAJAXZfc/opendoc.htm?document=painel%5Cantag%20-%20anu%C3%A1rio%202014%20-%20v0.9.3.qvw&lang=pt-BR&host=QVS%40graneleiro&anonymous=true>
- Bouman, E. A., Lindstad, E., Riiland, A. I., & Strømman, A. H. (2017). State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review. *Transportation Research Part D: Transport and Environment*, 52, 408–421. <https://doi.org/10.1016/j.trd.2017.03.022>
- Cariou, P. (2011). Is slow steaming a sustainable means of reducing CO₂ emissions from container shipping? *Transportation Research Part D: Transport and Environment*, 16(3), 260–264. <https://doi.org/10.1016/j.trd.2010.12.005>
- Carvalho, F. (2022). *Brazilian coastal shipping: New prospects for growth with decarbonization*. International Council on Clean Transportation. <https://theicct.org/publication/brazil-marine-brazil-coastal-shipping-new-prospects-growth-decarbonization-jul22/>
- Carvalho, F., O'Malley, J., Osipova, L., & Pavlenko, N. (2023). Key issues in LCA methodology for marine fuels. International Council on Clean Transportation. <https://theicct.org/publication/marine-lca-fuels-apr23/>
- Comer, B., Chen, C., Stolz, D., & Rutherford, D. (2019). *Rotors and bubbles: Route-based assessment of innovative technologies to reduce ship fuel consumption and emissions*. International Council on Clean Transportation. https://theicct.org/sites/default/files/publications/Rotors_and_bubbles_2019_05_12.pdf
- Comer, B., Georgeff, E., Stolz, D., Mao, X., & Osipova, L. (2022). *Decarbonizing bulk carriers with hydrogen fuel cells and wind-assisted propulsion: A modeled case study analysis*. International Council on Clean Transportation. <https://theicct.org/publication/hydrogen-and-propulsion-ships-jan22/>
- Comer, B., O'Malley, J., Osipova, L., & Pavlenko, N. (2022). *Comparing the future demand for, supply of, and life-cycle emissions from bio, synthetic, and fossil LNG marine fuels in the European Union*. International Council on Clean Transportation <https://theicct.org/publication/lng-marine-fuel-sep22/>
- Empresa de Pesquisa Energética. (2021). Plano Decenal de Expansão de Energia 2031 [Ten-Year Energy Expansion Plan 2031]. <https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decena-de-expansao-de-energia-2031>
- Faber, J., Hanayama, S., Zhang, S., Pereda, P., Comer, B., Hauerhof, E., ... Yuan, H. (2020). *Fourth IMO greenhouse gas study*. International Maritime Organization. <https://docs.imo.org/>
- Faber, J., Nelissen, D., Hon, G., Wang, H., & Tsimplis, Mi. (2013). Regulated slow steaming in maritime transport. International Council on Clean Transportation. <https://theicct.org/publication/regulated-slow-steaming-in-maritime-transport/>
- Gilbert, P., Walsh, C., Traut, M., Kesieme, U., Pazouki, K., & Murphy, A. (2018). Assessment of full life-cycle air emissions of alternative shipping fuels. *Journal of Cleaner Production*, 172, 855–866. <https://doi.org/10.1016/j.jclepro.2017.10.165>
- Glujčić, D., Kralj, P., & Dujmović, J. (2022). Considerations on the Effect of Slow-Steaming to Reduce Carbon Dioxide Emissions from Ships. *Journal of Marine Science and Engineering*, 10(9), 1277. <https://doi.org/10.3390/jmse10091277>
- International Association of Ports and Harbours. (2021). *IAPH Annual Report 2020-2021* (p. 12). https://www.iaphworldports.org/n-iaph/wp-content/uploads/2021/10/IAPH_annual_report_2020-2021.pdf
- International Maritime Organization. (2018). RESOLUTION MEPC.304(72). https://unfccc.int/sites/default/files/resource/250_IMO%20submission_Talanoa%20Dialogue_April%202018.pdf
- International Maritime Organization. (2020). RESOLUTION MEPC.324(75). <https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Air%20pollution/MEPC.324%2875%29.pdf>
- International Maritime Organization. (2022a). Energy Efficiency Measures. <https://www.imo.org/en/ourwork/environment/pages/technical-and-operational-measures.aspx>
- International Maritime Organization. (2022b). *Rules on ship carbon intensity and rating system enter into force*. <https://imopublicsite.azurewebsites.net/en/MediaCentre/PressBriefings/pages/CII-and-EEXI-entry-into-force.aspx>
- International Maritime Organization. (2023). RESOLUTION MEPC.377(80). [https://wwwcdn.imo.org/localresources/en/MediaCentre/PressBriefings/Documents/Resolution%20MEPC.377\(80\).pdf](https://wwwcdn.imo.org/localresources/en/MediaCentre/PressBriefings/Documents/Resolution%20MEPC.377(80).pdf)
- Intergovernmental Panel on Climate Change. (2021). *Climate Change 2021: The Physical Science Basis* [Sixth Assessment Report of the Intergovernmental Panel on Climate Change]. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_07_Supplementary_Material.pdf

- Law, L. C., Foscoli, B., Mastorakos, E., & Evans, S. (2021). A Comparison of Alternative Fuels for Shipping in Terms of Lifecycle Energy and Cost. *Energies*, 14(24), 8502. <https://doi.org/10.3390/en14248502>
- Observatorio do Clima. (2021). System of Estimates of Emissions and Removals of Greenhouse Gases: Download [database]. <http://seeg.eco.br/download>
- Rutherford, D., Mao, X., & Comer, B. (2020). *Potential CO₂ reductions under the Energy Efficiency Existing Ship Index*. International Council on Clean Transportation. <https://theicct.org/publication/potential-co2-reductions-under-the-energy-efficiency-existing-ship-index/>
- United Nations Conference on Trade and Development. (2021). *Review of Maritime Transport 2021*. https://unctad.org/system/files/official-document/rmt2021_en_0.pdf
- Zhou, Y., Pavlenko, N., Rutherford, D., Osipova, L., & Comer, B. (2020). *The potential of liquid biofuels in reducing ship emissions*. International Council on Clean Transportation. <https://theicct.org/publication/the-potential-of-liquid-biofuels-in-reducing-ship-emissions/>

Appendix: National action plans submitted to the International Maritime Organization

Table A1. Summary of national action plans to address maritime emissions.

Member state	NAP summary
<p>Marshall Islands</p> 	<p>Micronesian Center for Sustainable Transport (MCST) - A Catalyst for Change (2015)</p> <p>Directs parties to prepare and implement a strategy to transition the country to a low carbon transport future and serve as a pilot and catalyst for other Micronesian and Small Island States.</p>
<p>Norway</p> 	<p>The Government's action plan for green shipping (2019/2021)</p> <p>Government's policy for cutting domestic GHG emissions, strengthening the Norwegian maritime industry. The main approach in the action plan is to consider possible measures and policy instruments for different categories of vessels.</p>
<p>UK</p> 	<p>Clean Maritime Plan (2019)</p> <p>Presents a roadmap of the Maritime 2050 strategy focused on zero emissions shipping and explores how UK can address AP and GHG emissions to reach zero emissions from shipping.</p>
<p>Japan</p> 	<p>Roadmap to Zero Emission from International Shipping (2020)</p> <p>Presents a study that modeled emission pathways to achieve IMO 2030/2050 targets and a roadmap that identifies the required actions that would need to be taken by industrial, academic, and public sector.</p>
<p>India</p> 	<p>Maritime India Vision 2030 (MIV 2030) (2021)</p> <p>Presents a blueprint to ensure coordinated and accelerated growth of India's maritime sector in the next decade. Sets 10 key themes for India to be at the forefront of the global maritime sector.</p>
<p>Finland</p> 	<p>Resolution on reducing GHG emissions from maritime and inland waterway transport (2022)</p> <p>Government Resolution to confirm national measures and priorities for exerting influence internationally to reduce GHG emissions from maritime and inland waterway transport.</p>
<p>Singapore</p> 	<p>Decarbonization Blueprint Working towards 2050 (2022)</p> <p>Developed by the Maritime and Port Authority of Singapore in consultation with industry partners, the blueprint charts long-term strategies to build a sustainable maritime industry by focusing in seven areas of action.</p>

Table A2. Comparison of national action plans to address maritime emissions

	Marshal Islands	Norway	UK	Japan	India	Finland	Singapore
NAP characteristics							
Year published	2015	2019/2021	2019	2020	2021	2022	2022
Timeframe	2025	2030	2035	(2050?)	2030	n/a	2030/2050
Primary goal	Reduce 16% emission from transport by 2025 and 27% in 2030 (2015 RMI INDC)	Reduce 50% emissions from domestic shipping/fisheries by 2030	Built clean maritime clusters and consolidate as a global leader in clean shipping	Research followed by a roadmap that details actions required to meet IMO GHG Strategy	A blueprint that identifies over 150 initiatives to foster the growth of India's maritime sector till 2030	Proposes measures to facilitate the transition to alternative fuels and propulsion technologies and to support energy efficiency	Blueprint that charts concrete long-term decarbonization strategies and sets emission reduction targets in 7 focus areas
International shipping focus				x			
Domestic shipping focus	x	x	x		x	x	x
IMO call for NAPS suggestions							
Improve domestic institutional and legislative arrangements	x	x	x		x	x	x
Develop activities to further enhance EE of ships	x	x	x	x	x	x	x
Initiate research and advancing the uptake of alternative low- and zero-carbon fuels	x	x	x	x	x	x	x
Accelerate port emission reduction activities		x	x		x	x	x
Foster capacity building, awareness raising and regional cooperation	x	x	x		x	x	x
Facilitate the development of infrastructure for green shipping		x	x	x	x	x	x
Features common in NAPS							
Promotes diverse stakeholder engagement	x	x	x	x	x		x
Defines goals		x	x		x		x
Defines actions/activities	x	x	x	x	x	x	x
Identifies actors/responsibilities	x	x	x		x		x
Monitoring and reporting	x	x	x		x	x	
Other							
Mentions IMO strategy		x	x	x	x	x	x
Shipping decarbonization focus		x	x	x		x	x
Document length	20p	70p	47p (60p)	38p (135p)	265p (300p)	33p	64p