

CO₂ standards for heavy-duty vehicles: VECTO governance framework in the European Union and recommendations for Brazil

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INTRODUCTION

Recently, the Brazilian government released a timeline for the regulation of CO₂ emissions from heavy-duty vehicles (HDVs), with the first CO₂ emissions targets to be established in 2029 and enforced in 2033.¹ The world's leading economies, such as Canada, China, the European Union (EU), India, Japan, the United Kingdom, and the United States, have implemented similar policies, although these differ in terms of regulation type (e.g., fuel economy or CO₂ emissions), target magnitude, vehicles regulated, and compliance testing methods (e.g., laboratory testing or simulation tools). Latin American countries such as Chile, Colombia, and Mexico are considering implementing energy efficiency and emission regulations.²

In 2018, Brazil's Ministry of Development, Industry, Trade, and Services (MDIC) published a plan and timeline for the implementation of the Rota 2030 Program, which included fuel economy targets for HDVs³ and a plan to select a computational simulation tool for calculating the fuel consumption of new vehicles.⁴ Although

- 1 André Cieplinski et al., *The Regulation of Brazil's Green Mobility and Innovation (MOVER) Vehicle Emission Program* (International Council on Clean Transportation, 2025), <https://theicct.org/publication/regulation-of-brazil-green-mobility-and-innovation-mover-vehicle-emissions-program-oct25/>.
- 2 Hussein Basma, "Latest Iterations of HDV Fuel Economy Standards" (presentation at the Hybrid GRPE Workshop on the Global Harmonization of Heavy-duty Fuel Economy, Energy Consumption and Range Determination, Geneva, Switzerland, May 23, 2024), https://unece.org/sites/default/files/2024-05/HDV_FE_Session1_ICCT.pdf.
- 3 Lei No. 13.755, de 10 de dezembro de 2018 [Law No. 13.755, of December 10, 2018], https://www.planalto.gov.br/ccivil_03/_ato2015-2018/2018/lei/L13755.htm.
- 4 Portaria No. 2.200-SEI, de 27 de dezembro de 2018 [Ordinance No. 2.200-SEI, of December 27, 2018], https://www.in.gov.br/materia/-/asset_publisher/Kujrw0TZC2Mb/content/id/57220399.

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no formal decision was made at the time, participants in discussions involving the government, industry, and academia suggested using the Vehicle Energy Consumption calculation TOol (VECTO)—which is used to certify the CO₂ emissions and fuel economy of HDVs in the EU—due to similarities between the Brazilian and EU fleets.⁵

In 2024, Brazil established the Green Mobility and Innovation (MOVER) Program, which replaced the Rota 2030 Program.⁶ MOVER will set mandatory requirements for new vehicles sold, including fuel economy and CO₂ emission targets. The program also officially adopted VECTO as the vehicle simulation tool for emissions certification. However, implementing VECTO for the Brazilian context requires a governance framework that has not yet been clearly outlined. Specifically, it will require clear procedures and institutional allocations related to the tool's maintenance and updates, data requirements, oversight and certification of information, and communication and transparency mechanisms. Thus while Brazil has officially adopted VECTO under the MOVER Program, the critical question of how to operationalize the tool within Brazil's institutional structures remains unanswered.

This policy brief provides recommendations for establishing a governance framework for the use of VECTO to support the MOVER Program for HDVs. First, we detail the governance structure of VECTO in the European Union, outlining the institutions involved and their respective roles. Second, drawing on the European experience and the roles of Brazilian institutions, we provide recommendations for the development of a governance structure for the use of the tool, aiming to ensure transparency and effective policy implementation. The proposed guidelines may also be helpful for other countries seeking to adopt VECTO as a tool to support the regulation of HDV CO₂ emissions.

REGULATION OF CO₂ EMISSIONS IN THE EUROPEAN UNION

Discussions regarding the regulation of CO₂ emissions from HDVs in the European Union began in 2009, with the European Commission indicating that it would implement strategies in the following years.⁷ As a part of the rollout, the first public version of VECTO was released in 2012. Later, Regulation (EU) 2017/2400 established procedures for calculating the CO₂ emissions and fuel consumption of HDVs, making VECTO the official tool for certifying and monitoring HDV emissions in the European Union.⁸

Under Regulation (EU) 2017/2400, first-stage manufacturers (i.e., the companies producing the base vehicle) must certify the CO₂ emissions of new vehicles before their registration, sale, or entry into circulation. Regulation (EU) 2018/956 then introduced mandatory annual reporting requirements of CO₂ emissions and fuel consumption

5 The proposal to use VECTO in Brazil was raised during discussions of the Heavy-Duty Vehicle Energy Efficiency Steering Committee, established in 2018 under the Rota 2030 Program, which included representatives from the government, industry, and academia. On HDVs in Brazil, see Thiago Rodrigues, *Evolução do Mercado de Veículos Pesados no Brasil* [Evolution of the heavy-duty vehicle market in Brazil] (International Council on Clean Transportation, 2025), <https://theicct.org/publication/evolucao-do-mercado-de-veiculos-pesados-no-brasil-apr25>.

6 Lei No. 14.902, de 27 de junho de 2024 [Law No. 14.902, of June 27, 2024], https://www.planalto.gov.br/ccivil_03/_Ato2023-2026/2024/Lei/L14902.htm.

7 European Commission, "A European Strategy on Clean and Energy Efficient Vehicles" (2010), <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52010DC0186>.

8 Commission Regulation (EU) 2017/2400 of 12 December 2017 implementing Regulation (EC) No 595/2009 of the European Parliament and of the Council as Regards the Determination of the CO₂ Emissions and Fuel Consumption of Heavy-Duty Vehicles and Amending Directive 2007/46/EC of the European Parliament and of the Council and Commission Regulation (EU) No 582/2011 (Text with EEA Relevance), OJ L 349 (2017), 1-247, <https://eur-lex.europa.eu/eli/reg/2017/2400/oj/eng>.

data.⁹ Member States are required to report registration data for all new vehicles, while manufacturers submit vehicle-specific simulation results generated by VECTO in accordance with Regulation (EU) 2017/2400. These reports must be submitted annually.

After a decade of studies and public consultations, the European Union implemented CO₂ emissions regulations for the HDV segment with the publication of Regulation (EU) 2019/1242 in 2019.¹⁰ This regulation set CO₂ emission targets for manufacturers, applicable to specific groups of new trucks based on their technical characteristics.¹¹ While annual compliance monitoring was already in place, the first target of a 15% reduction went into effect in 2025, using 2019 emission levels as the baseline and considering the weighted average emissions of vehicles registered. Further reductions are scheduled in 5-year intervals; specifically the regulation mandates a reduction of 43% by 2030, 64% by 2035, and 90% by 2040.¹²

GOVERNANCE OF VECTO

This section describes the governance of VECTO as regards the institutions and processes involved in the verification of simulation results, data transparency, and tool updates. As a publicly available simulation software developed and owned by the European Commission,¹³ VECTO's governance framework distributes responsibilities across multiple institutions to ensure data integrity, regulatory compliance, and transparency. Understanding how VECTO operates in the EU is particularly relevant for Brazil, as it provides lessons on institutional coordination and regulatory design that can inform the development of a Brazilian governance framework. Figure 1 shows the institutions involved in VECTO governance and summarizes their respective roles.

9 Regulation (EU) 2018/956 of the European Parliament and of the Council of 28 June 2018 on the Monitoring and Reporting of CO₂ Emissions from and Fuel Consumption of New Heavy-Duty Vehicles (Text with EEA Relevance), OJ L 173 (2018), 1–15, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018R0956>.

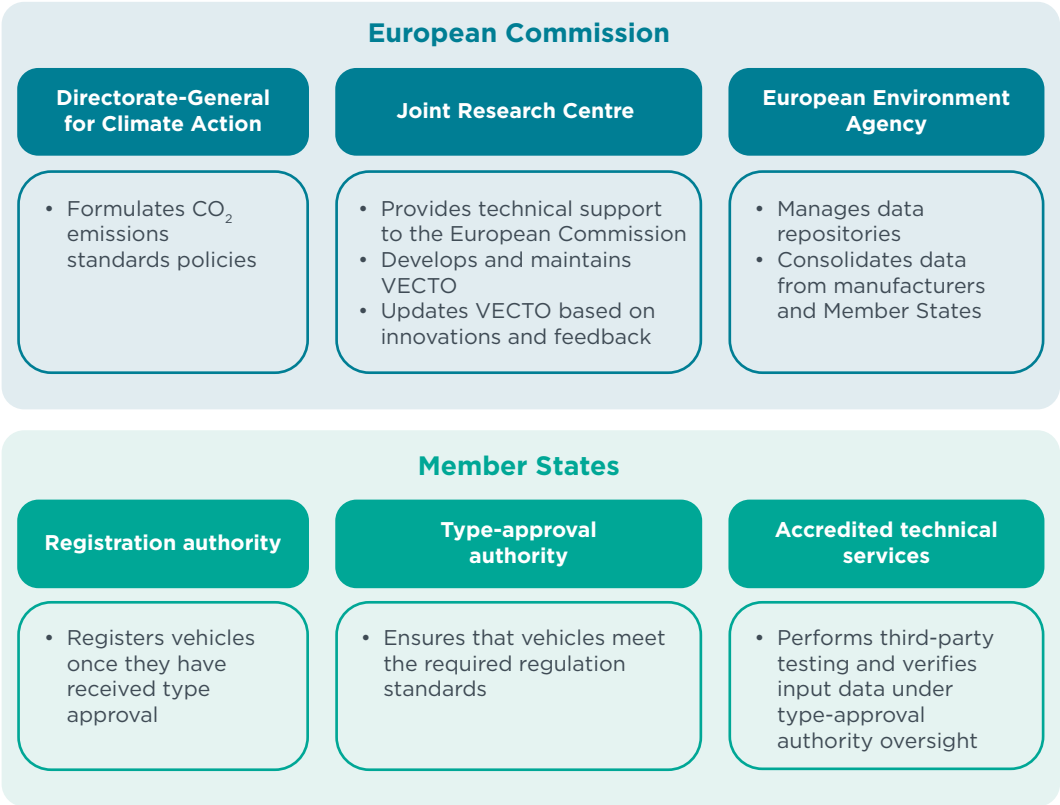
10 Regulation (EU) 2019/1242 of the European Parliament and of the Council of 20 June 2019 Setting CO₂ Emission Performance Standards for New Heavy-Duty Vehicles and Amending Regulations (EC) No 595/2009 and (EU) 2018/956 of the European Parliament and of the Council and Council Directive 96/53/EC (Text with EEA Relevance), OJ L 198 (2019), 202–240, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R1242>.

11 The first vehicle groups subject to the regulation included rigid trucks and tractor-trailers with 4x2 or 6x2 axle configurations.

12 Eamonn Mulholland, *The Revised CO₂ Standards for Heavy-duty Vehicles in the European Union* (International Council on Clean Transportation, 2024), <https://theicct.org/publication/revised-co2-standards-hdvs-eu-may24/>.

13 VECTO was developed by the Institute of Thermodynamics and Sustainable Propulsion Systems (ITnA) of Graz University of Technology (TUG), in collaboration with the consultancy Ricardo AEA, commissioned by the Directorate-General for Climate Action (DG CLIMA) and the Joint Research Centre (JRC) of the European Commission.

Figure 1
Key institutions involved in the governance of VECTO



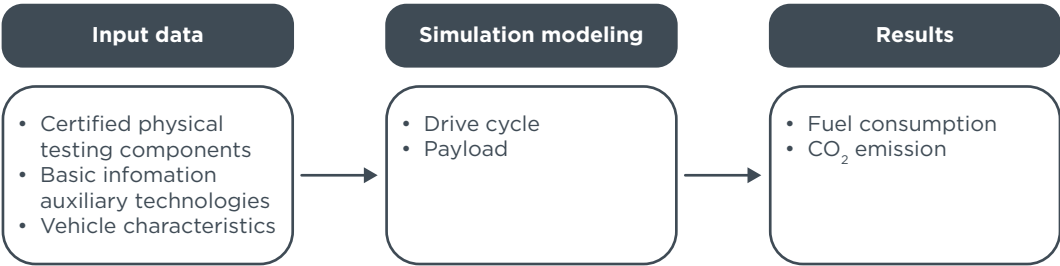
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THE TOOL PACKAGE

The VECTO software package includes three components: the simulation tool (VECTO Sim), pre-processing tools (VECTO AirDrag, VECTO Engine, and VECTO Trailer), and the hashing module (VECTO Hash).

VECTO Sim calculates fuel consumption and CO₂ emissions based on technical data provided by the user. Included in these data are component-level characteristics—such as engine maps, aerodynamic drag, rolling resistance, and auxiliary systems—that are typically derived from standardized physical tests conducted by manufacturers. To reduce compliance costs associated with physical testing, Regulation (EU) 2017/2400 allows manufacturers to use predefined default values for specific components. These default values are likely designed conservatively to promote the use of test-based values. Figure 2 shows the schematic structure of the simulation tool.

Figure 2
Schematic structure of VECTO’s certification process



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The pre-processing tools prepare key inputs for the simulation. VECTO Engine processes engine performance curves from laboratory tests. VECTO AirDrag calculates aerodynamic drag using data from track tests. Finally, VECTO Trailer inputs parameters for semi-trailers. The processed data are then fed into VECTO Sim, which performs the complete vehicle simulation.

VECTO offers two operating modes to serve both compliance and innovation needs. Declaration mode is used for regulatory purposes and requires that input values be based on certified tests or regulatory references, while development mode is used for research and development and allows users to freely modify parameters.

Under declaration mode, the manufacturer must enter information about the vehicle's axle configuration, curb weight, and gross vehicle weight (GVW). Based on these inputs, VECTO automatically assigns the appropriate vehicle segment, drive cycles, payloads, and other parameters. The simulation generates several measures of fuel consumption and CO₂ emissions.

To ensure data integrity, VECTO generates an XML file at the end of each simulation conducted in declaration mode. The VECTO Hash module applies a cryptographic algorithm to the XML file, producing a unique digital fingerprint. Any change to the data generates a new hash, which enables regulatory authorities to verify that the reported results match the original simulation.¹⁴

RESULTS VERIFICATION

According to Regulation (EU) 2017/2400, manufacturers must perform CO₂ and fuel consumption simulations using VECTO before registering a new vehicle. To access VECTO, manufacturers must obtain a license. Type-approval authorities in each Member State oversee the simulation process to ensure compliance with the regulatory requirements.

The accuracy of these simulations depends on technical data about the vehicle components. Regulation (EU) 2025/35 mandates a procedure for in-service verification of the VECTO-generated data.¹⁵ This procedure includes physical testing performed under real-world driving conditions. Accredited technical services, designated by Member States, provide independent oversight throughout this process, and the type-approval authorities confirm compliance.

Under Regulation (EU) 2020/1079, the European Commission verifies the quality of reported data by randomly selecting between 2% and 10% of registered vehicles from each manufacturer. Selected manufacturers must submit original records and type-approval certificates, and the Commission cross-checks reported values, cryptographic hash codes, and homologation data. Manufacturers must correct data if discrepancies are identified and, in the case of systematic discrepancies, revised data must be submitted for the entire reporting period. The Commission may apply a correction factor to the reported CO₂ emissions if manufacturers fail to comply. All corrections are flagged in the public dataset to ensure transparency.

¹⁴ Directorate-General for Climate Action, "VECTO Data Integrity Measures" (presentation at the VECTO Workshop of the European Commission, Ispra, Italy, November, 2018), https://climate.ec.europa.eu/document/download/78b3d698-e4e9-4720-a241-e2aa1153600f_en?filename=201811_integrity_en.pdf.

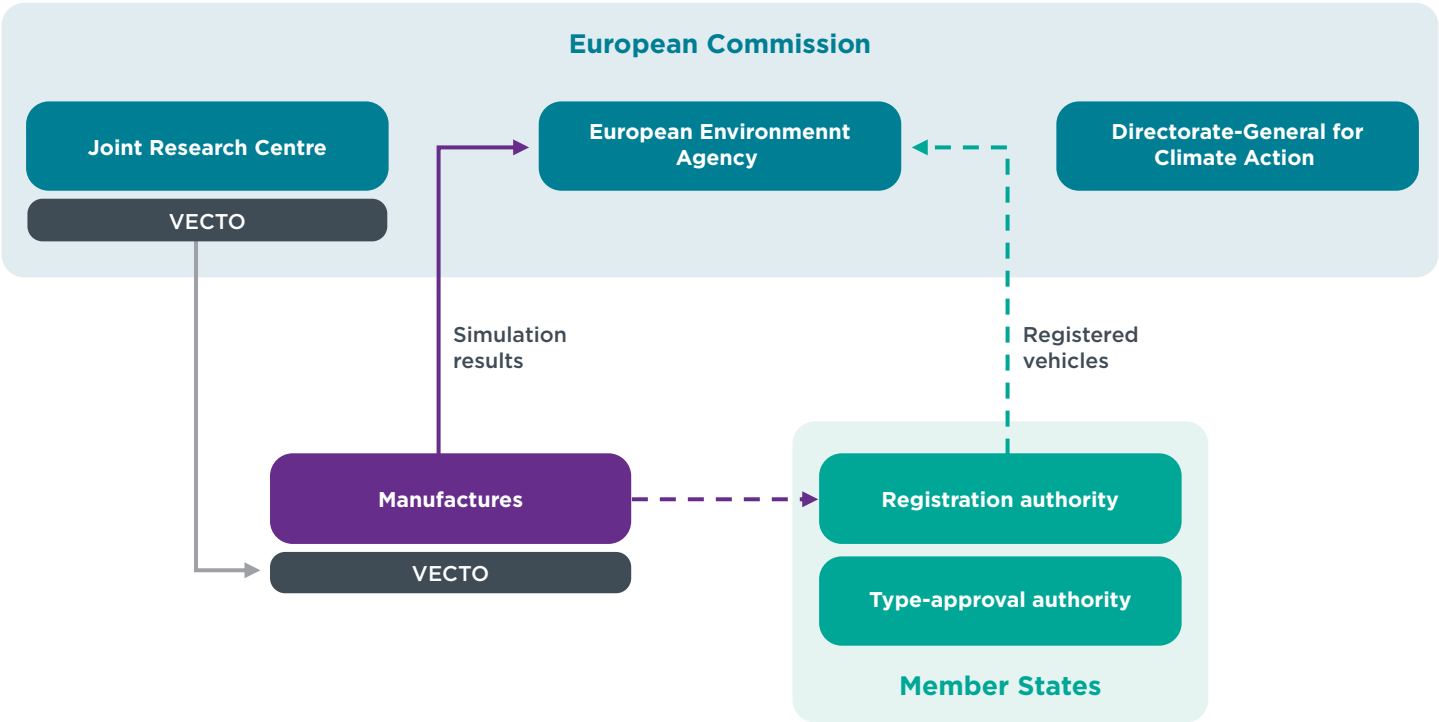
¹⁵ Commission Implementing Regulation (EU) 2025/35 of 13 January 2025 Implementing Regulation (EU) 2019/1242 of the European Parliament and of the Council by Determining the Procedures for the In-Service Verification of the CO₂ Emissions of Heavy-Duty Vehicles, OJ L 14.1.2025 (2025), https://eur-lex.europa.eu/eli/reg_impl/2025/35/oj.

If reported data diverge from type-approval certificates or are not submitted within the established deadlines, the European Commission may impose sanctions.¹⁶ Manufacturers must also retain original record files and type-approval documents for at least 20 years after the vehicle’s production, making them available to both type-approval authorities and the Commission upon request.

TRANSPARENCY

Manufacturers send VECTO simulation outputs to the European Environment Agency (EEA), the European Commission’s designated institution for collecting, validating, and disseminating environmental data. Within the framework of HDV regulation, the EEA acts as the central repository for information submitted by Member States and manufacturers.¹⁷ Figure 3 illustrates the flow of data transmission.

Figure 3
VECTO governance and data transmission flow



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Registration authorities in each Member State are responsible for licensing vehicles and collecting detailed information, including brand, model, and vehicle category. These data are consolidated and transmitted annually to the EEA via the Central Data Repository, a data repository integrated into the European Environment Information and Observation Network (Eionet).¹⁸

Simultaneously, manufacturers submit their simulation results to the Business Data Repository, which the EEA also manages within Eionet. To safeguard commercially sensitive information, access to this repository is restricted. The EEA merges the

16 Regulation (EU) 2025/35.
17 Regulation (EU) 2018/956.
18 Eionet is a partnership network of the EEA and its 38 member and cooperating countries; its task is to gather and develop data, knowledge, and advice for policymakers on European environmental matters.

datasets from manufacturers and Member States to verify consistency and data integrity. If discrepancies are identified, either party must submit an error notification report to the relevant repository.

After completing validation and analysis, the EEA publishes vehicle-level processed data.¹⁹ Additionally, the European Commission releases annual reports presenting average CO₂ emissions by manufacturer, vehicle group, and Member State, based on data from the previous year.²⁰

TOOL UPDATES

VECTO is periodically updated to integrate new technologies, address flaws, and reflect regulatory changes. The Joint Research Centre (JRC)—specifically the Sustainable, Smart and Safe Mobility unit of the Energy, Mobility, and Climate Directorate—is responsible for the tool’s maintenance, updates, and public availability. The institution coordinates the software development, promoting technical reviews and periodic updates based on technological advancements, regulatory changes, and contributions from the industry and Member States.

The update process begins with the release of the VECTO Candidate version, a preliminary edition of the software made available by the JRC for testing and validation by manufacturers and other stakeholders. This version has no regulatory value but allows for the technical evaluation of proposed changes and adjustments. After the testing period and approval of the updates, the new VECTO Official version is released, which becomes mandatory for regulatory use after a 3-month transition period.

VECTO’s source code is publicly available through CODE EU, the European Commission’s official open-source software platform. CODE EU facilitates technical scrutiny for tools like VECTO by providing public access to software developed or funded by EU institutions; researchers, regulators, and other stakeholders can then examine, use, and adapt the tool according to regulatory or analytical needs.²¹

Regarding new technologies that required updates to VECTO, Regulation (EU) 2022/1379 amended Regulation (EU) 2017/2400, extending its scope to include additional vehicle categories, such as medium and heavy lorries and heavy buses.²² Subsequently, Regulation (EU) 2025/258 further broadened the scope to cover new propulsion technologies, including vehicles running on hydrogen.²³

19 European Environment Agency, *Monitoring of CO₂ Emissions from Heavy-duty Vehicles*, dataset, accessed October 22, 2025, <https://www.eea.europa.eu/data-and-maps/data/co2-emission-hdv>.

20 The ICCT also monitors published results through periodic analyses and reports to support transparency and independent oversight. See, for example, Hussein Basma et al., *CO₂ Emissions from Trucks in the European Union: An Analysis of the 2021 Reporting Period* (International Council on Clean Transportation, 2024), <https://theicct.org/publication/eu-co2-emissions-trucks-manufacturers-2021-reporting-dec24/>.

21 “About code.europa.eu,” European Commission, accessed October 14, 2025, <https://code.europa.eu/info/about>.

22 Commission Regulation (EU) 2022/1379 of 5 July 2022 Amending Regulation (EU) 2017/2400 as Regards the Determination of the CO₂ Emissions and Fuel Consumption of Medium and Heavy Lorries and Heavy Buses and to Introduce Electric Vehicles and Other New Technologies (Text with EEA Relevance), OJ L 212 (2022), 1-290, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022R1379>.

23 Commission Regulation (EU) 2025/258 of 7 February 2025 Amending Regulation (EU) 2017/2400 as Regards the Determination of the CO₂ Emissions and Fuel Consumption of Medium and Heavy Lorries and Heavy Buses and the Inclusion of Vehicles Running on Hydrogen and Other New Technologies and Amending Regulation (EU) No 582/2011 as Regards the Applicable Rules on the Determination of CO₂ Emissions and Fuel Consumption in Order to Obtain an Extension to an EU Type-Approval, OJ L 20.02.2025 (2025), <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32025R0258>.

THE BHARAT VECTO PROJECT

India was the first country outside of Europe to express the intention of adapting VECTO to its national context. While India has regulated CO₂ emissions for HDVs based on constant speed tests since 2017,²⁴ in 2018 Indian authorities announced the intention to incorporate energy efficiency standards based on computational simulations, leading to the Bharat VECTO project. However, the tool has not yet been implemented.

The Standing Committee on Implementation of Emission Standards (SCOE), a government technical committee responsible for guiding the implementation of emissions regulations in India, drove the development of the tool. The Committee tasked the Automotive Research Association of India, an automotive research and certification association, with leading the adaptation project. To develop Bharat VECTO, the association formed a consortium with the Society of Indian Automobile Manufacturers and vehicle manufacturers.²⁵

The project also involves other government institutions. The Bureau of Energy Efficiency, an agency within the Ministry of Energy, leads the formulation of vehicle efficiency standards, while the Ministry of Road Transport and Highways, which is responsible for road transport policy, is involved in integrating Bharat VECTO into the national regulatory framework for HDVs. The Central Pollution Control Board, an agency within the Ministry of Environment, provides technical support on the environmental impacts of the implemented policies. Together, these institutions coordinate activities such as collecting operational data, defining local simulation parameters, and standardizing testing methodologies.²⁶

As part of the international technical support for the project, the ICCT developed a proof-of-concept version of Bharat VECTO. This version includes simplifications to serve as a learning exercise to guide the development of a more comprehensive version of the tool, and to identify best practices that could be useful to other countries interested in adopting VECTO.

Based on this experience, the ICCT put forth several recommendations for countries adapting VECTO:

1. Prioritize standardized component and full-vehicle testing using established international methodologies (e.g., from the EU and United States), focusing on critical inputs such as engine maps, rolling resistance, and aerodynamic drag;
2. Complement laboratory testing with real-world operational data to adjust drive cycles and payload assumptions to local conditions;
3. Develop domestic technical capacity in the VECTO software and its source code to ensure long-term autonomy and adaptation;
4. Involve industry stakeholders early on in the process to improve data access, modeling accuracy, and regulatory acceptance; and
5. Promote transparency in VECTO inputs and the certification process through public disclosure and audit mechanisms to foster trust and accountability.²⁷

These recommendations reflect the technical, institutional, and stakeholder engagement challenges inherent in adapting VECTO beyond its original European context, offering guidance for other countries pursuing similar regulatory tools.

²⁴ International Energy Agency, *Transitioning India's Road Transport Sector* (2023), <https://www.iea.org/reports/transitioning-indias-road-transport-sector>.

²⁵ "ARAI and MoRTH Launch Bharat VECTO Project: A Calculation Tool for Estimating Emissions Through Simulation," *Mobility Outlook*, January 17, 2025, <https://www.mobilityoutlook.com/news/arai-and-morth-launch-bharat-vec-to-project-a-calculation-tool-for-estimating-emissions-through-simulation/>.

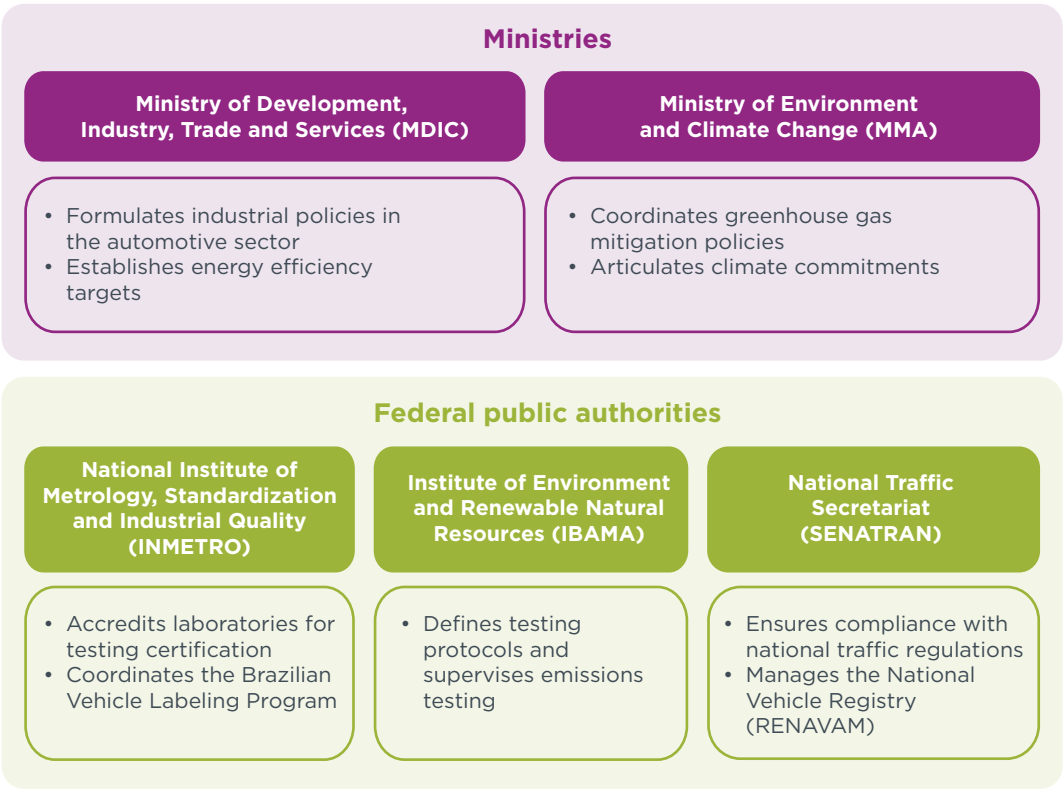
²⁶ International Energy Agency, *Transitioning*.

²⁷ Ben Sharpe et al., *Adapting the Vehicle Energy Consumption Calculation Tool (VECTO) for Use in India and Other Countries* (International Council on Clean Transportation, 2019), <https://theicct.org/publication/adapting-the-vehicle-energy-consumption-calculation-tool-vec-to-for-use-in-india-and-other-countries/>.

GOVERNANCE OF ENVIRONMENTAL REGULATIONS FOR ROAD VEHICLES IN BRAZIL

The governance of environmental and energy policies for vehicles in Brazil—including policies relating to energy efficiency, control of local pollutants, and greenhouse gas emissions—involves multiple ministries and public authorities. Figure 4 shows the federal institutions involved and summarizes their respective roles. Compared with the EU, Brazil’s framework has similar functions—splitting responsibilities across ministries and agencies for industrial policy, environmental oversight, vehicle registration, and technical certification.

Figure 4
Key federal institutions involved in automotive policies in Brazil



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MDIC formulates and coordinates Brazil’s industrial policies. Similar to the Directorate-General for Climate Action in Europe, MDIC is responsible for vehicle energy efficiency policies. Before the MOVER Program, MDIC implemented a series of successive programs: the Inovar-Auto program (2013–2017) and the Rota 2030 (2018–2023).²⁸ These policies established mandatory energy efficiency targets for new vehicles, combining industrial incentives with technical regulatory standards. Within MDIC, the Secretariat for Industrial Development, Innovation, Commerce, and Services (SDIC) plays a central role in designing and implementing these programs, coordinating inter-ministerial efforts, engaging with the private sector, and aligning industrial and environmental objectives.

The National Institute of Metrology, Standardization, and Industrial Quality (INMETRO) is a federal agency linked to MDIC responsible for quality control of products and services. In the context of vehicle policies, INMETRO accredits the laboratories that

²⁸ Inovar-Auto was established by Law No. 12.715/2012; Rota 2030 was established by Law No. 13.755/2018.

carry out local pollutant emissions tests required by the Institute of Environment and Renewable Natural Resources (IBAMA) for vehicle type approval. Additionally, the Brazilian Vehicle Labeling Program (PBEV), coordinated by INMETRO, regulates vehicle energy efficiency labeling.

The Ministry of the Environment and Climate Change (MMA) is the leading authority responsible for coordinating Brazil's federal climate policy and ensuring compliance with the country's Nationally Determined Contribution under the Paris Agreement.²⁹ The MMA is tasked with leading the development and implementation of the National Climate Plan, including monitoring greenhouse gas emissions targets.³⁰ Furthermore, the MMA is responsible for the national inventory of atmospheric emissions by road vehicles, which provides an assessment of pollutant emissions from road transport in Brazil.³¹

Finally, IBAMA, a federal agency under the MMA, is the implementing body for environmental policy and plays a central role in vehicle environmental licensing, emissions certification, and enforcement under the Program for the Control of Air Pollution from Motor Vehicles (PROCONVE). IBAMA is responsible for defining the testing protocols and overseeing the local pollutant emissions tests required for certification in laboratories accredited by INMETRO. IBAMA validates the results submitted by manufacturers during the type-approval process. In addition, IBAMA manages INFOSERV, a digital platform used to monitor environmental compliance in the automotive sector. IBAMA maintains formal relationships with other agencies through interministerial committees and joint regulatory instruments.

The National Traffic Secretariat (Senatran) is the highest executive body of Brazil's National Traffic System and operates under the Ministry of Transport.³² It is responsible for overseeing and ensuring compliance with national traffic legislation. Senatran also manages the National Motor Vehicle Registry (RENAVAM), a centralized database that compiles administrative and technical information on vehicles registered in Brazil. Supporting this system, Serpro (the Federal Data Processing Service), a public company linked to the Ministry of Finance, develops and maintains information technology and integrates RENAVAM with other governmental databases.

These institutions form the governance framework within which Brazil's HDV energy efficiency policy operates. The MOVER Program, launched in 2024, represents the policy mechanism through which these agencies will coordinate their efforts to implement VECTO-based regulations for HDVs.

MOVER PROGRAM

The MOVER Program establishes mandatory requirements for the commercialization of new vehicles, including fuel economy and CO₂ emission targets for light-duty vehicles and HDVs. Under the MOVER Program, Decree 12.435/2025 establishes that the commercialization of HDVs will be conditional upon manufacturers and importers submitting energy efficiency reports to MDIC to monitor compliance with energy

29 Government of Brazil, *Brazil's NDC: National Determination to Contribute and Transform*, November 13, 2024, <https://unfccc.int/documents/643337>.

30 For more details on the National Climate Plan, see MMA, *Plano Clima* [Climate Plan], accessed October 22, 2025, <https://www.gov.br/mma/pt-br/composicao/smc/plano-clima>.

31 MMA, *Inventário Nacional de Emissões Atmosféricas por Veículos Automotores Rodoviários* [National inventory of atmospheric emissions from road motor vehicles] (January 2013), http://antigo.mma.gov.br/images/arquivo/80060/Inventario_de_Emissoes_por_Veiculos_Rodoviaros_2013.pdf.

32 The Ministry of Transportation is also responsible for quantifying CO₂ emissions from long-haul HDVs within the National Climate Plan (*Plano Clima*), which sets the guidelines and actions necessary to reduce emissions and fulfill Brazil's commitments under the Paris Agreement, as outlined in the country's Nationally Determined Contribution. See Government of Brazil, *Brazil's NDC*.

efficiency targets.³³ Ordinance GM/MDIC No. 176/2025 sets the policy timeline, with targets set for 2019 and compliance verification scheduled for 2033.³⁴

Implementation of the MOVER Program requires a simulation tool for certification. Ordinance GM/MDIC No. 176/2025 mandates using VECTO adapted to national conditions. Technical groups from the Brazilian Association of Automotive Engineering (AEA) have been supporting MDIC in carrying out these adaptations since 2024. The ordinance also states that the regulated segments will be defined based on axle configuration, usage, weight, and payload or passenger transport capacity. The first regulated segment (Group 1) includes tractor-trailers with (1) a GVW over 12 tons, (2) axle configurations of 6x2 or 6x4, and (3) long-haul applications.

VECTO simulates fuel consumption from the tank to the wheel, focusing solely on the emissions produced during vehicle operation. In contrast, the MOVER Program sets energy efficiency targets based on the well-to-wheel cycle, which considers emissions from energy extraction, production, and distribution. Future regulations are needed to address this adjustment and incorporate input from additional authorities, such as the Ministry of Mines and Energy (MME) and the Energy Research Office (EPE).

The Heavy-Duty Vehicle Energy Efficiency Management Committee, established by the same ordinance, will technically advise MDIC. The committee will comprise representatives from INMETRO, the AEA, the National Association of Motor Vehicle Manufacturers, the Brazilian Electric Vehicle Association, and the ABC Metalworkers Union. Although not a formal member, IBAMA may participate as a permanent guest in the committee's meetings. The Committee is the main institution for recommending the governance framework of the policy and for defining new segments to regulate, with a 2-year interval between the inclusion of each new segment.

The implementation of the energy efficiency program for HDVs in Brazil is structured in three cycles, as shown in Figure 5. The first cycle (2025–2026) focuses on regulatory preparation. Regulations related to test procedures and the definition of trailer types to be used in simulations must be published by March 2026. The regulatory drive cycle should be defined by June 2026, and the adaptation of the VECTO model should be finalized by December 2026.

33 Decreto No. 12.435, de 15 de abril de 2025 [Decree No. 12.435, of April 15, 2025], https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2025/decreto/D12435.htm.

34 Ordinance GM/MDIC No. 176/2025 establishes the schedule for the implementation of the energy efficiency program for heavy-duty vehicles and the publication of results, in compliance with Law No. 14.902/2024 and Decree No. 12.435/2025, <https://www.in.gov.br/en/web/dou/-/portaria-gm/mdic-n-176-de-7-de-julho-de-2025-641610640>.

Figure 5**Implementation timeline of the heavy-duty vehicle energy efficiency policy**

	2025	2026	2027	2028	2029	2030	2031	2032	2033
First cycle (2025–2026)									
Publication of regulations									
Finalization of the simulation tool									
Second cycle (2027–2028)									
Validation of the simulation tool									
Submission of the energy efficiency report									
Definition of baseline values									
Third cycle (2029–2033)									
Setting of targets									
Submission of the energy efficiency report									
Publication of results (label)									
Verification of target compliance									

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The second cycle (2027–2028) involves establishing the energy efficiency baseline. To this end, the committee must validate the adapted version of VECTO by June 2027. Based on this version, manufacturers and importers will be required to submit to MDIC by November 1, 2028, the simulated results of fuel consumption and CO₂ emissions for Group 1 vehicles produced between October 1, 2027, and September 30, 2028. These data will be used to calculate the national baseline, which must be finalized by December 31, 2028. At this stage, the governance framework for VECTO should be fully consolidated to ensure the integrity, interoperability, and transparency of the data system.

The third cycle (2029–2033) introduces mandatory CO₂ efficiency targets. By April 2030, targets for Group 1 vehicles must be set, with compliance verification beginning in October 2033. During this period, manufacturers and importers must submit simulated results to MDIC by November 1 of each year, covering the previous 12 months of production. Starting January 2030, these results must be publicly disclosed through the Brazilian Vehicle Labeling Program. To support this effort, Decree 12.435/2025 mandates that key institutions involved in the labeling process (MDIC, INMETRO, SENATRAN, and SDIC) collaborate closely to integrate and unify all HDV-related data, including simulation tool results.³⁵

Ordinance GM/MDIC No. 176/2025 establishes that any delays in adapting or validating the simulation tool will automatically postpone the implementation schedule.³⁶ This makes the first cycle (until 2026) the main potential bottleneck of the policy. However, the challenge extends beyond VECTO adaptation. Establishing a credible certification framework also requires the definition and implementation of standardized testing procedures for vehicle components, as these are essential inputs for vehicle simulation.

³⁵ Decree No. 12.435.

³⁶ Ordinance GM/MDIC No. 176/2025.

This emphasizes the necessity of establishing the VECTO governance before reaching this stage.

In addition, creating a vehicle labeling system presents further complexity in the case of HDVs, where labeling practices are less consolidated and more challenging to standardize due to the heterogeneity of configurations and applications. Hence, there is structural risk associated with linking regulatory deadlines to complex and interdependent milestones. The establishment of a strong and well-coordinated governance framework—leveraging MDIC’s coordination capacity, INMETRO’s laboratory accreditation and coordination of the PBEV, IBAMA’s environmental expertise, and SENATRAN’s vehicle data—can ensure timely implementation and mitigate institutional and technical delays.

RECOMMENDATIONS FOR BRAZIL

The implementation of VECTO within the MOVER policy framework requires a governance structure that assigns institutional responsibilities for the validation of simulation results, data transparency, and the ongoing maintenance and update of the tool. This structure must also ensure the integration of market information—including the volume and specifications of registered vehicles—with environmental information, such as fuel economy and CO₂ emissions.

Given that the major HDV manufacturers operating in Brazil have their headquarters in Europe and already comply with the European Commission’s vehicle certification procedures, Brazil has an institutional and technical advantage in adopting a governance model inspired by the EU framework.

Building on this alignment, we propose five key recommendations for the Brazilian government. First, Brazil may consider establishing formal cooperation with the European Commission to support the adaptation of VECTO to the national context. Second, it is essential to clearly define the roles and responsibilities of the government institutions involved in overseeing tools and data. Third, to address the main potential bottleneck for the policy (the first cycle), the government can prioritize the creation of a robust data infrastructure. Fourth, based on the definition of roles and the establishment of the data infrastructure, the policy can promote transparency to enable public monitoring of compliance and progress. Finally, from the outset, the government should lead efforts to build local technical capacity—both within public institutions and across the automotive industry. These recommendations are presented in more detail below.

ESTABLISH COOPERATION WITH THE EUROPEAN COMMISSION

Brazil could consider establishing a cooperation agreement with the European Union, particularly with the Directorate-General for Climate Action, the body responsible for CO₂ emissions policy and overseeing the use of VECTO in the EU. While authorization from the European Commission is not required to use VECTO, such an agreement could facilitate the adaptation and implementation of VECTO in Brazil and enable technical cooperation arrangement with the JRC, which develops and maintains the software.

This is particularly feasible given the European Commission’s openness to supporting countries interested in adapting VECTO to their own regulatory context. Through such cooperation, Brazil can benefit from the European Union’s infrastructure and distribution platform, ensuring access to the tool and continuous updates. Additionally, Brazil could link the adapted tool with the European version, creating a network for sharing updates, addressing bugs, and resolving software issues. This collaboration

could enhance the tool's functionality and ensure that Brazil and the European Union benefit from improvements. Such cooperation could also support a more streamlined integration of VECTO into Brazil's regulatory framework.

DEFINE ROLES FOR GOVERNMENT INSTITUTIONS EARLY ON

As noted in the timeline analysis, the policy's first cycle (2025–2026) represents the main potential bottleneck of the framework. Defining institutional roles early can prevent delays in the tool's adaptation, data infrastructure development, and certification procedures, ensuring that all technical and administrative processes are in place before manufacturers submit efficiency reports in 2028. Implementing VECTO also requires defining the institutions responsible for data processing, the audit mechanism, and tool maintenance and updates. The governance structure outlined in this paper addresses this by recommending technical responsibilities and management mechanisms to support effective implementation.

Based on the governance of vehicle environmental policies, the public institutions involved in MOVER, and the expertise developed under PROCONVE, the key federal institutions for VECTO's governance in Brazil would be MDIC, SERPRO, SENATRAN, INMETRO, and IBAMA. As the general coordinator of the MOVER program, MDIC will implement the policy and adapt VECTO-related regulations from the European context to the Brazilian environment. SERPRO would be well suited to integrate technological systems and databases from SENATRAN with the output results from VECTO sent by manufacturers. Building on the institutional framework and technical procedure already established under PROCONVE, INMETRO and IBAMA could strengthen and extend their collaboration to the implementation of HDV efficiency standards. This partnership could encompass test criteria, laboratory accreditation, conformity checks, and in-service verification.

The governance network could also designate a technical entity responsible for managing VECTO in Brazil. This entity could provide operational support to users, coordinate the tool's adaptation to the national context, and promote integration between existing technical, regulatory, and environmental systems. Ideally, this institution would be public, given the government's capacity to finance and sustain the policy over time.

CREATE A DATA INFRASTRUCTURE

Under the MOVER Program, manufacturers will calculate fuel economy and CO₂ emissions using VECTO. These simulation results must be cross-referenced with new vehicle registration data to verify compliance with efficiency targets by regulated segment.

Ordinance GM/MDIC No. 176/2025 defines regulated segments primarily by axle configuration and GVW.³⁷ Manufacturers will input this information, among others, into VECTO. For compliance verification, the RENAVAM database must contain equivalent technical information. Alignment between VECTO outputs and RENAVAM fields is necessary to enable monitoring and compliance verification.³⁸

A data infrastructure can be established to integrate vehicle registration data, technical specifications, energy consumption, and emissions. VECTO simulation results can also be incorporated into this system for regulatory and transparency purposes. According to the policy timeline, manufacturers must submit their energy efficiency reports to

³⁷ Ordinance GM/MDIC No. 176/2025.

³⁸ For example, if the RENAVAM database records only the number of axles, a three-axle vehicle could correspond to either a 6x2 or 6x4 configuration, making it difficult to accurately identify regulated segments.

MDIC by 2028; therefore, the data infrastructure would ideally be fully operational by that deadline. To ensure integrity and unauthorized modifications, data transmission could follow the European model, using XML files with hash codes. Protocols can also be established for data security, confidentiality, and authenticity.

Institutions such as MDIC, SERPRO, SENATRAN, and IBAMA could work together to construct and manage the integrated database, consolidating the data declared by manufacturers and harmonizing national systems. It would be important to define a reporting model, leveraging the European Commission's experience, and ensure interoperability between the systems of SENATRAN, IBAMA, and other involved public platforms, guaranteeing the secure and reliable flow of technical and environmental information.

PROMOTE TRANSPARENCY

The non-sensitive VECTO output, when combined with vehicle registration data from RENAVAL, ideally would be made publicly available. This transparency would enable manufacturers and civil society to monitor the policy effectively. Making this information accessible could also support more informed purchasing decisions by reducing information asymmetry. Additionally, while the federal government would already have access to these data, extending access to state and local governments would provide them with a robust basis for designing complementary measures—such as tax incentives or fleet renewal programs—to promote the adoption of energy-efficient vehicles.

Vehicle-level results could be disclosed through a dedicated platform in multiple file formats, following the example of the European Commission. This approach would avoid unnecessary delays to the MOVER program's implementation. Ordinance GM/MDIC No. 176/2025 proposes creating a labeling system. However, as discussed above, given the heterogeneity of the HDV segment and the need for specific data processing requirements that differ significantly from those used in light-duty vehicle labeling systems, this could pose a barrier to effective policy implementation.

BUILD LOCAL TECHNICAL CAPACITY

Implementing VECTO in Brazil necessitates technical training for professionals from the government (e.g., MDIC, INMETRO, IBAMA, and SENATRAN) and the automotive industry. The training program could consider existing international practices and involve key institutions such as universities and research centers. Ideally, this training would begin immediately, during the ongoing adaptation of VECTO, to support the timely development of the mandatory VECTO regulations required by March 2026.

Institutions that have contributed to developing VECTO in Europe, like the JRC and the Graz University of Technology, could support these training programs. Furthermore, establishing partnerships between Brazilian and European universities could enhance research and development related to the tool's use and improve its functionalities.

CONCLUSIONS

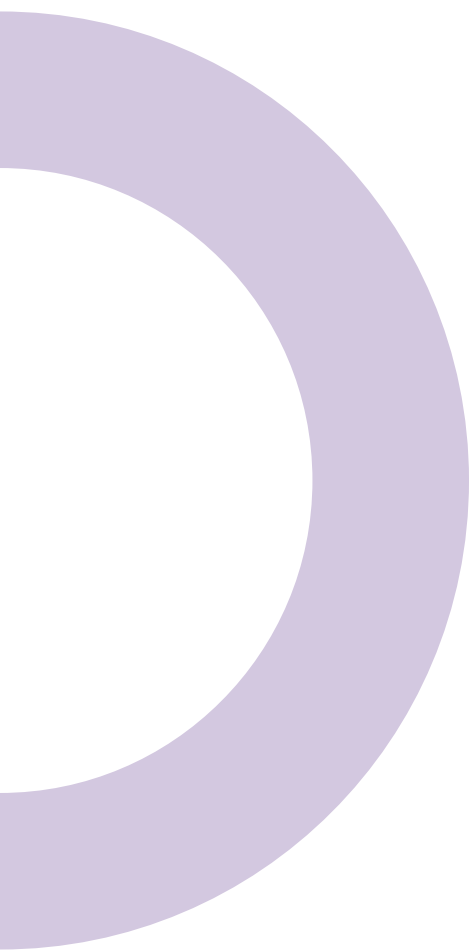
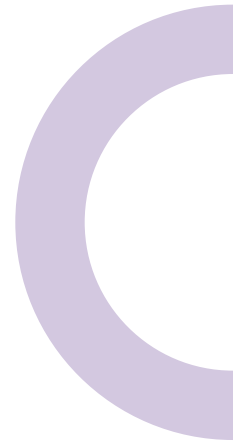
VECTO, the European Union's simulation tool for calculating HDV fuel consumption and CO₂ emissions, offers Brazil a proven regulatory approach for addressing emissions from HDVs. Successful implementation of VECTO in Brazil will depend on effective institutional coordination and the development of a robust technical and governance infrastructure suited to the national context. The European Union's regulatory framework can serve as a key reference for Brazil, offering lessons on implementing a governance structure for use of the simulation-based tool.

The current MOVER regulatory framework sets a lengthy timeline and a limited scope of regulated vehicles. Although this gradual approach may reduce the initial risks associated with implementing VECTO, it also delays broader environmental benefits. The first regulatory cycle of MOVER (through 2026) risks becoming a bottleneck that inhibits implementation. Because any delays in adapting VECTO will automatically delay the policy's rollout, it is imperative that clear procedures and institutional responsibilities are established and operational well before manufacturers submit their first energy efficiency reports in 2028; this includes clarifying responsibilities for the tool's maintenance and updates, data requirements, oversight, and certification of information, and communication and transparency mechanisms. Establishing a well-coordinated governance framework can provide the regulatory certainty and operational clarity required for effective implementation.

Importantly, the challenge of implementing the MOVER Program for HDVs extends beyond software implementation. Building a reliable certification framework will require standardized testing procedures for key vehicle components, such as aerodynamics, engines, and tires, which are the primary inputs to the simulation tool and the main sources of CO₂ reduction potential. Advanced actions of the regulatory institutions involved can ensure that the necessary procedures are in place before 2027, when manufacturers will first be required to develop energy efficiency reports.

Lastly, public access to data, along with the involvement of researchers and independent civil society organizations, can allow for external monitoring of the policy. This approach can strengthen environmental accountability and guarantee that the use of public resources, such as financial incentives, can be monitored independently.

If implemented effectively, Brazil's VECTO-based HDV efficiency policy can serve as a model for other Latin American countries while demonstrating how simulation tools can support ambitious yet achievable climate targets in the transport sector.



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