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The transition to electric vehicles in Brazil's automotive industry and its effects on jobs and income

ANDRÉ CIEPLINSKI (ICCT), PEDRO ROMERO MARQUES (MADE/USP), AND LUIZA NASSIF PIRES (MADE/USP & IE/UNICAMP)

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Edited by Tomás Francisco Husted

International Council on Clean Transportation
1500 K Street NW, Suite 650
Washington, DC 20005

communications@theicct.org | www.theicct.org | @TheICCT

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EXECUTIVE SUMMARY

Transitioning Brazil's road vehicle fleet to battery electric vehicles (EVs) has the potential to combine the development of a new domestic industry, both in vehicle assembly and battery manufacturing, with substantial reductions in greenhouse gas emissions. Established by Law № 14.902, in June 2024, the Green Mobility and Innovation Program (MOVER, from *Programa Mobilidade Verde e Inovação*), which regulates vehicle emissions and provides incentives for producing low-emission vehicles, has triggered the announcement of an unprecedented round of investments in the Brazilian automotive industry. Given the history of Brazil's production of biofuels, which represent one of the primary energy sources for combustion engine vehicles in the country, MOVER envisions the decarbonization of road transportation based on the coexistence EVs and biofuels.

The development of a national EV industry will depend on its capacity to create high-quality new jobs and to foster the expansion of a domestic industry for main components such as electric motors and batteries. Evaluating the job and income creation potential from the production of EVs is complex and requires a comprehensive analysis. Analyses with a specific sectoral focus that consider only the production of vehicles and auto parts, for example, ignore that the vast majority of new jobs created stem from changes throughout the whole productive structure of the economy. In other words, the economic impacts depend on the direct production of vehicles and the sectors (such as auto parts and tires) that directly supply inputs to the automotive value chain, in addition to the sectors that supply goods and services to the latter. For example, the sale of an EV requires the production of its battery, and that requires both research and development services and raw materials.

This report develops two distinct scenarios for the evolution of Brazil's national vehicle fleet until 2050. The aim is to compare the effects, on the level of jobs and income, of an ambitious increase in EVs (the Electrification scenario) with a scenario in which combustion vehicles dominate sales until 2050 (the Baseline scenario). The two scenarios consider the production of light- and heavy-duty vehicles, divided into five segments: passenger cars, light commercial vehicles, medium-duty trucks, heavy-duty trucks, and buses.

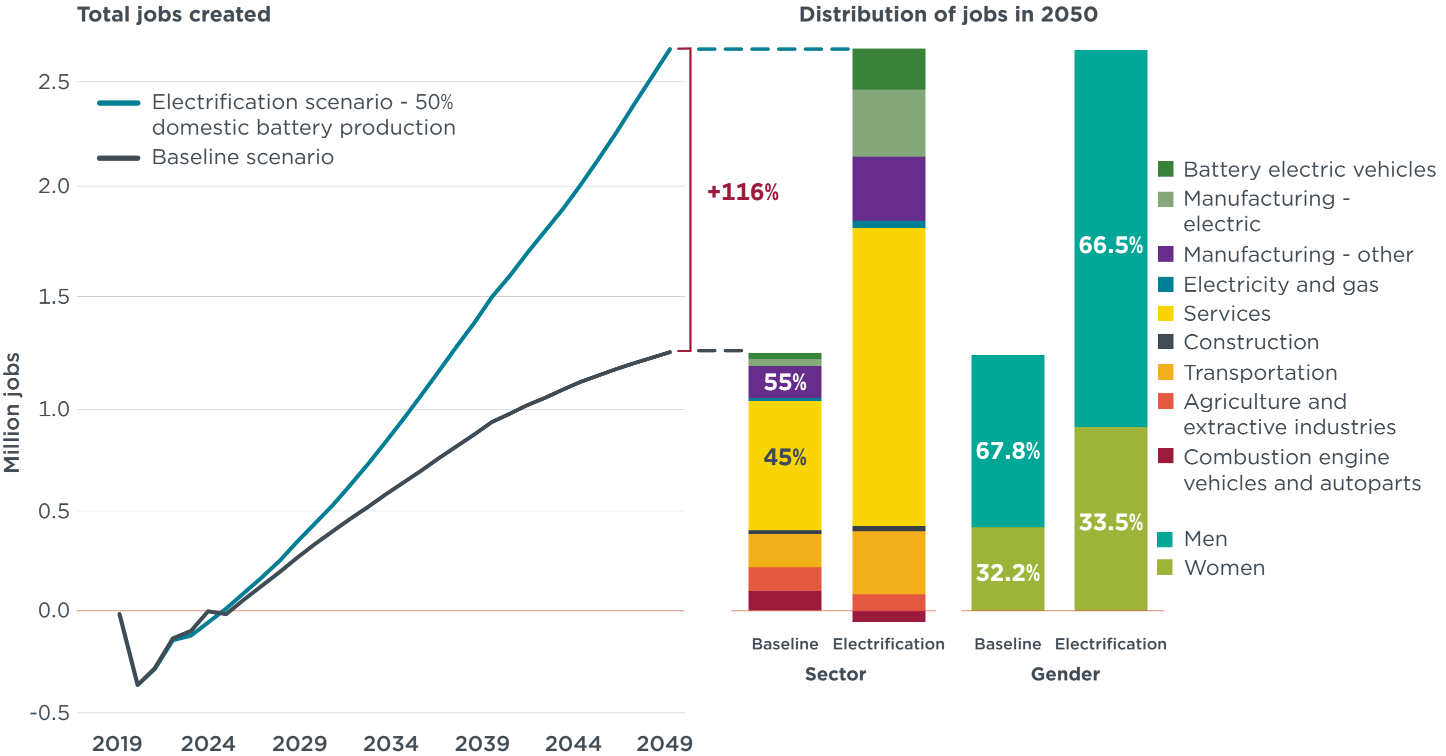
To estimate the economic consequences of remodeling the vehicle fleet, we chose to use a specific methodology—an input-output analysis—that allows us to consider the links between all sectors of an economy and identify the impacts of potential changes in its structure. A synthetic sector representative of the EV industry was included in the Brazilian input-output matrix in order to specify the goods and services required by this industry. This synthetic sector enables an assessment of the effects generated by changes in demand for its final goods: light and heavy EVs.

This report then assesses the impacts on employment and income from the production of vehicles and from the associated consumption of fossil fuels, biofuels, and electricity. To do this, we estimate the evolution of sales of vehicles produced in Brazil, fuel demand, and electricity demand and then convert the results into monetary value that is used to project the gross value of production, the value added (the sum of wages and profits), and the number of new jobs created between 2019 and 2050 in both the Baseline and Electrification scenarios. Jobs related to vehicle maintenance, the production of spare parts, and electrical distribution and charging infrastructure for EVs are beyond the scope of this analysis.

Figure ES1 summarizes our results. The left panel shows the evolution of the total new jobs potentially created from the sale of EVs, fuels, and electricity in the Baseline (brown) and Electrification (blue) scenarios. The two panels on the right illustrate the distribution of jobs created at the end of the simulations (in 2050) by sector and gender.

Figure ES1

Evolution and distribution of new jobs created in the Baseline and Electrification scenarios



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The results show that, assuming labor productivity and the amount of inputs required for production remain fixed at current levels, the Electrification scenario would generate more than twice as many jobs as the Baseline scenario by 2050, thanks to more ambitious targets. This potential for job creation is due to an increase in aggregate demand that results from growth in EV sales and the expansion of the domestic production of automotive batteries. The Electrification scenario estimates a notable expansion of industrial jobs, both in EV manufacturing and in other manufacturing industries. This is especially true of electrical machinery and equipment manufacturing, which includes batteries and electric powertrain components. On the other hand, the Electrification scenario estimates an absolute reduction in jobs in the production of combustion vehicles and a relative reduction in jobs in the production of auto parts compared with the Baseline scenario. The Electrification scenario also projects moderate reductions in the fuels, biofuels, and agriculture sectors relative to the Baseline. The largest job-creation potential in both scenarios is in services, a category composed of 23 relatively labor-intensive sectors that together accounted for 64% of all jobs in Brazil at the start of the simulations (2019).

In both scenarios, assuming the current gender distribution of jobs in each sector remains fixed until 2050, about two-thirds of new jobs would be occupied by men. This is a more unequal gender distribution than the one observed for the total Brazilian economy in 2019, when 60% of employees were men. This is mainly due to the expansion of sectors that currently employ mostly men, such as the production of electric and combustion engine vehicles (in which men comprise 89% of the workforce), truck transportation (83%), electrical equipment manufacturing (71%), and other types of manufacturing (70%).

The simulations also evaluated changes in the distribution of labor income and profits. The share of wages and income generated by vehicle and fuel sales is higher in the Electrification scenario (53%) than in the Baseline scenario (45%) as the expansion of EV production results in greater demand for goods and services from sectors with higher wages.

The international competitiveness of Brazil's automotive industry also plays a key role in the results, as observed in our sensitivity analyses. By replicating a declining exports trajectory in the Electrification scenario equal to the one assumed in the Baseline scenario, the number of jobs generated in the Electrification scenario is reduced by 14% in 2050. This means that the number of new jobs created in the Electrification scenario only surpasses the Baseline scenario after 2032. Still, even when considering a decline in exports, 88% more jobs are created in the Electrification scenario than in the Baseline scenario.

Considering the current context of Brazil's national automotive industry, and its position in the transition to zero-emission vehicles, this analysis supports the following conclusions.

Establishing more ambitious corporate-average vehicle emission reduction targets and introducing industrial policies to develop the national production capacity for key EV components, especially batteries, could be part of an effective policy mix to support EV production. The new MOVER program presents opportunities to set more ambitious corporate vehicle emissions reduction targets and stimulate the Brazilian EV industry. Setting more ambitious emission reduction targets than those implemented in the last cycle of the Rota 2030 program has the potential to direct investments toward EV production. Increasing the scale of EV sales and domestic production can, in turn, support the competitive domestic production of key electric powertrain components, especially batteries, increasing the domestic content of these vehicles.

Strengthening export-promotion policies to leverage the production of low-emission vehicles in Brazil can help mitigate the impacts of the transition on exports and strengthen Brazil's competitiveness in the long term. Fleet electrification targets in some of Brazil's main vehicle export destinations, such as Chile, Colombia, and Mexico, put current Brazilian exports of combustion engine vehicles at risk. On the other hand, the growth of EV demand in Latin America and the availability of lithium and other raw materials in the region can benefit Brazilian exports, especially to markets without developed automotive industries. The government could consider export financing instruments (trade finance), export tax incentives, and financial assistance in foreign markets. In contrast, a continued focus on the production of combustion engine vehicles or a late start of national production of EVs and batteries may result in the loss of international markets, a deepening of the current trend of increasing import content in domestically assembled vehicles, and increased vehicle imports. For Brazil, such processes could result in a change in the country's position concerning the trade balance with important partner economies in Latin America.

If promoting gender parity in the transition to EVs is a government objective, training and professional inclusion programs, with a particular focus on women in the workforce, could help avoid worsening the existing wage differential between men and women in EV production and other sectors. The remodeling of Brazil's vehicle fleet will have implications for gender equity in the sectors directly and indirectly involved in vehicle production. Anticipating the gender impacts of the transition will be crucial for designing policies aimed at ensuring that the development of a EV industry in Brazil does not create new inequalities in the labor market or reproduce existing ones, and for promoting greater gender inclusion in the Brazilian labor market.

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WHAT DO WE KNOW ABOUT JOB CREATION IN THE ELECTRIC VEHICLE INDUSTRY?

There is no consensus regarding the impacts of battery electric vehicle (EV) production on job creation. Studies, opinion surveys, and statements from manufacturers tend to reach conflicting conclusions—ranging from significant job losses to moderate increases in the employed workforce—as a result of changes in the vehicle fleet. There are several reasons for such differences. One of them is the lack of a consistent definition of the sectors and jobs involved in this transformation: Are we referring to automakers, auto parts suppliers, or all industries within the automotive value chain? Another reason is variation in the geographic distribution of production of key components for EVs: Where are batteries manufactured? What effects does this geographic distribution have on the export and import of vehicles?

A study commissioned by the European Association of Automotive Suppliers (Rennert et al., 2021) concluded that the transition to fully electric vehicles could result in a net loss of 275,000 jobs in Europe by 2040. However, this estimate considered only jobs related to the production of powertrain[1] components such as internal combustion engines, traction batteries, and electric motors. Harrison et al. (2019, p. 5) estimated that the rapid adoption and production of EVs could lead to a net increase of up to 590,000 jobs in Europe by 2030 across the entire automotive value chain. Meanwhile, though Kuhlman et al. (2021) found only a small net change in total employment by 2030 due to the transition to EVs in Europe, they highlighted significant sectoral job losses in traditional vehicle assembly and auto parts manufacturing, which tended to be offset by job gains in the EV-specific auto parts, charging infrastructure, and electricity generation sectors.

Amid the industry's transition to new technologies, the domestic production of key components such as electric motors and batteries becomes crucial to determining the employment impacts of the transformation of the fleet. According to Barret and Bivens (2021), considering only the assembly and auto parts manufacturing industries, if EVs accounted for 50% of vehicle sales by 2030, 74,000 jobs would be lost in the United States if there were no increase in domestic content in EVs. Alternatively, the same sales scenario would result in a gain of 150,000 new jobs in the United States if there were an increase in local production of batteries and EVs.

Another commonly cited argument is that job losses in vehicle production are inevitable due to the lower number of parts and components in EVs. However, according to McElroy (2019), assembling two similar vehicles, one electric and one combustion-powered, would require a comparable number of stations and workers on the assembly line, as the automotive battery contains nearly as many components as a combustion engine. In a study commissioned by the United States Environmental Protection Agency (EPA), two similar vehicles—an EV and a gasoline-powered vehicle—were dismantled and all their components were cataloged. In the end, the total number of components in the EV was 1,584, compared to 1,307 in the gasoline-powered counterpart. Even after excluding all components related to the battery and combustion engine, the EV still had more parts: 1,475 in total (FEV Consulting, 2023).[2] Automakers themselves are not in agreement on this point (Levin, 2022). BMW has stated it will not cut jobs due to the transition to EVs, but other factors—such as competition with rival automakers and changes in workforce composition—may still reduce the number of job positions (Charette, 2023). A survey of 197 industry

1 The term *powertrain* refers to the components of a vehicle responsible for propulsion, including combustion engines, electric motors, and batteries in EVs, the transmission, and axles.

2 The study treated the combustion engine as a single component.

executives and managers indicated that 85% expected to maintain or expand their workforce due to the adoption of new technologies (Rockwell Automation, 2023).

The results briefly summarized above indicate that a study of the consequences of the transition to electric vehicles for the structure of employment would benefit from an analysis capable of capturing effects across various parts of the value chain. Such a broad analysis is essential, given the numerous factors that can influence job creation within the EV production chain. These factors, in turn, may be shaped by the mix of public policies, such as those related to local content of production and the import and export of vehicles.

This study develops and presents a scenario for the electrification of Brazil's vehicle fleet. We compare the impacts generated by this scenario on the employment structure with those of a Baseline scenario, characterized by the continued dominance of internal combustion engine vehicles (ICEVs) in sales, alongside the expansion of biofuel use. The effects on economic activity and employment in each scenario are estimated by converting projections of vehicle and fuel sales into monetary values and applying a national input-output matrix to assess the impact of this final demand across all sectors involved in the production chain—such as auto parts, electrical machinery and equipment, metals, glass, and rubber.

The following section provides a brief overview of the expansion of EV sales globally, in Latin America, and in Brazil. It then outlines the characteristics of EV production, using ICEV production as a point of comparison. The following section describes the methodology used to develop the two aforementioned scenarios—detailing the evolution of vehicle sales by segment and powertrain, imports and exports of vehicles, and domestic production of traction batteries—and adapts the Brazilian input-output matrix to enable scenario projections through 2050. Finally, the results section presents estimates of greenhouse gas emissions associated with each scenario, total job creation and its distribution across economic sectors and by gender, the generation of value added and its distribution between wages and profits, and sensitivity analyses regarding local battery content and variations in vehicle exports. The report concludes with public policy recommendations derived from the findings.

CHARACTERISTICS OF THE GLOBAL TRANSITION TO EVS

SALES, MODELS, AND SEGMENTS IN MAJOR MARKETS

The transition to zero-emission vehicles is underway in the world's largest automotive markets. Driven by targets to ban the sale of ICEVs and by incentives for both consumers and manufacturers, EV sales have scaled up since 2020. In 2022, more than 10 million EVs were sold globally—a 54% increase compared to the previous year. Of these, 99% were light-duty vehicles. Approximately 73% were fully battery-electric vehicles, while the remaining 27% were composed almost entirely of plug-in hybrids. Around 59% of EVs were sold in China, and 25% in Europe (Chu & Cui, 2023).

In the European Union, and more recently in Canada, bans on the sale of new light-duty ICEVs starting in 2035 (Sen & Miller, 2023; Government of Canada, 2023) are being supported by incentive policies aimed at promoting the adoption of zero-emission vehicles. In Europe, for example, France and Germany have offered subsidies of up to €5,000 and €4,500, respectively (Chu & Cui, 2023). These targets and incentive policies have been accompanied by increases in the market share of EVs in the largest light-duty vehicle markets. In 2022, EV sales accounted for 27% of the market in China, 21% in the European Union, 7% in the United States, and 20% in the United Kingdom (Chu & Cui, 2023).

Increased production of EVs and batteries, along with the development of battery chemistries that rely less on high-cost raw materials (such as cobalt), have led to reductions in the price of EVs. According to Chen et al. (2024), electric passenger cars, SUVs, and pickup trucks are expected to reach price parity with comparable ICEVs as early as 2028–2029. In a pessimistic scenario involving rising prices for key raw materials such as lithium, nickel, and cobalt, this parity is projected to be reached by 2032.

Batteries account for a large share of EV production costs. Technological advancements and economies of scale in the production of batteries will play a key role in achieving cost parity between EVs and ICEVs. In 2023, the production costs of lithium-ion batteries returned to their historical downward trajectory after a slight increase in 2022 (Bloomberg NEF, 2023), and this downward trend is expected to continue in the coming years. Estimates suggest that reductions in the price of raw materials and innovations in manufacturing processes—such as changes in battery chemistries and streamlining of production—could lower battery costs by up to 40% in 2025 and 60% in 2030, relative to 2023 levels (Goldman Sachs, 2024).

ELECTRIFICATION TARGETS IN LATIN AMERICA

The ambition to decarbonize road transportation is not limited to the world's largest markets. Latin America accounted for 7% of global new vehicle sales in 2020 and its motorization rates continue to rise (Kohli et al., 2022). In this context, several countries in the region—including some of Brazil's key trading partners—have established targets related to EV adoption. For example, Chile's goals call for 100% of new sales to be zero-emission vehicles for passenger cars and urban buses by 2035, and for trucks and intercity buses by 2045. Colombia projects that its electric car fleet will reach 600,000 units by 2030, and that all new urban buses will be zero-emission by 2035.[3] Other targets include exclusive sales of zero-emission light-duty vehicles in Costa Rica by 2050 and significant increases in EVs in Ecuador by 2040 (Barassa et al., 2022).

3 Ecuador's targets aim for zero-emission vehicle sales of 60%–70% for urban buses, 20%–25% for light-duty vehicles, and 30%–40% for trucks by 2040.

In June 2022, the Mexican government announced that 50% of all vehicles produced in the country would be zero-emission by 2030. Mexico is also a signatory of the non-binding COP26 declaration, which proposes the adoption of 100% zero-emission cars and vans by 2040 (Pineda, 2022). Brazil and Argentina, however, do not yet have official targets for the adoption of zero-emission vehicles.

EV PENETRATION IN BRAZIL

EV penetration in Brazil remains modest but is growing: in 2023, battery electric light-duty vehicles accounted for 0.9% of total sales, and 2.6% when combined with plug-in hybrids. In the first half of 2023, 3,778 battery EVs were sold, while between July and December of the same year, there was a notable surge in sales, which totaled 15,532 units, or 1.25% of light-duty vehicle sales during that period (ABVE, 2024). In the first half of 2024, EVs represented 3% of light-duty vehicle sales in Brazil, totaling around 31,000 units, a figure that already exceeded total EV sales for all of 2023.

This increase is linked to a greater availability of models and, more recently, to EVs with less prohibitive prices. According to the Brazilian Vehicle Labeling Program (INMETRO, 2023), the Brazilian market offered 101 electric models in 2023, representing 9% of all models available in the country—a 600% increase compared to the 14 models available in 2020 (INMETRO, 2020). By the end of 2023, five models were available for under R$150,000 (Schaun, 2023). Although this is still significantly higher than the price of the most affordable ICEVs, which cost around R$60,000 to R$70,000, the R$150,000 price point is not far from the average price of cars sold in Brazil in 2022 (Rodriguez, 2023), especially when the lower operating costs of EVs are taken into account (Morrison & Wappelhorst, 2023, p. 13).

Despite the recent increase in demand, domestic production of EVs and their components remains limited. Currently, electric buses and medium-duty trucks are already produced in Brazil, as are some electric motors. Battery electric passenger cars and light commercial vehicles sold in Brazil are still imported, but recently-announced investments are expected to enable the domestic manufacturing of EVs starting in 2025 (Cesar, 2024), with an initial production capacity of 150,000 units per year—equivalent to about 7% of national light-duty vehicle sales in 2023. In terms of battery production, only the final assembly of packs using imported cells and lithium extraction are currently performed in the country. Although there are some national initiatives aimed at developing the technological capacity to produce anodes, cathodes, and cells (Chaves et al., 2023), domestic production of the stages with the highest value added in the battery value chain depends on the scale of local demand.

The manufacturing of EVs differs from that of ICEVs. Replacing internal combustion engines with electric motors and batteries entails changing several of the major parts and components of the vehicles, as well as the industrial sectors that supply them. Other key components, such as the chassis, axles, and suspension system, although retained, require new designs and adaptations to support greater weight and accommodate battery packs. These characteristics also necessitate changes in the workforce and in the organization of assembly lines. The following section presents the cost structure associated with EV production. It highlights the industrial sectors involved in manufacturing each component and, consequently, the number of jobs directly generated by EV production.

THE EV VALUE CHAIN

To examine EV production, the relative costs of their main components were compiled across four vehicle segments. Using relative costs enables the modeling of simulation scenarios: as these costs are held constant over time, it is not necessary to account for changes in sectoral technical coefficients. The construction of the synthetic EV sector and the role of relative prices between EVs and ICEVs are explained in detail in the "Input-Output Analysis: Calculating the Impact on the Employment Structure" section.

Figure 1 summarizes the relative costs of batteries; other powertrain components such as electric motors, converters, drive units, and the chassis and bodywork; accessories; and indirect costs, which include transportation, sales, wages, and profit margins. These estimates are based on the international literature and draw from various countries. The data present the percentage distribution of these costs for passenger cars (Slowik et al., 2022; FEV Consulting, 2023), light commercial vehicles (Mulholland, 2022), buses (EY Parthenon, 2023), and trucks (Xie et al., 2023; EY Parthenon, 2023).

Figure 1

Average production costs of EVs by segment and for the average EV according to the international literature

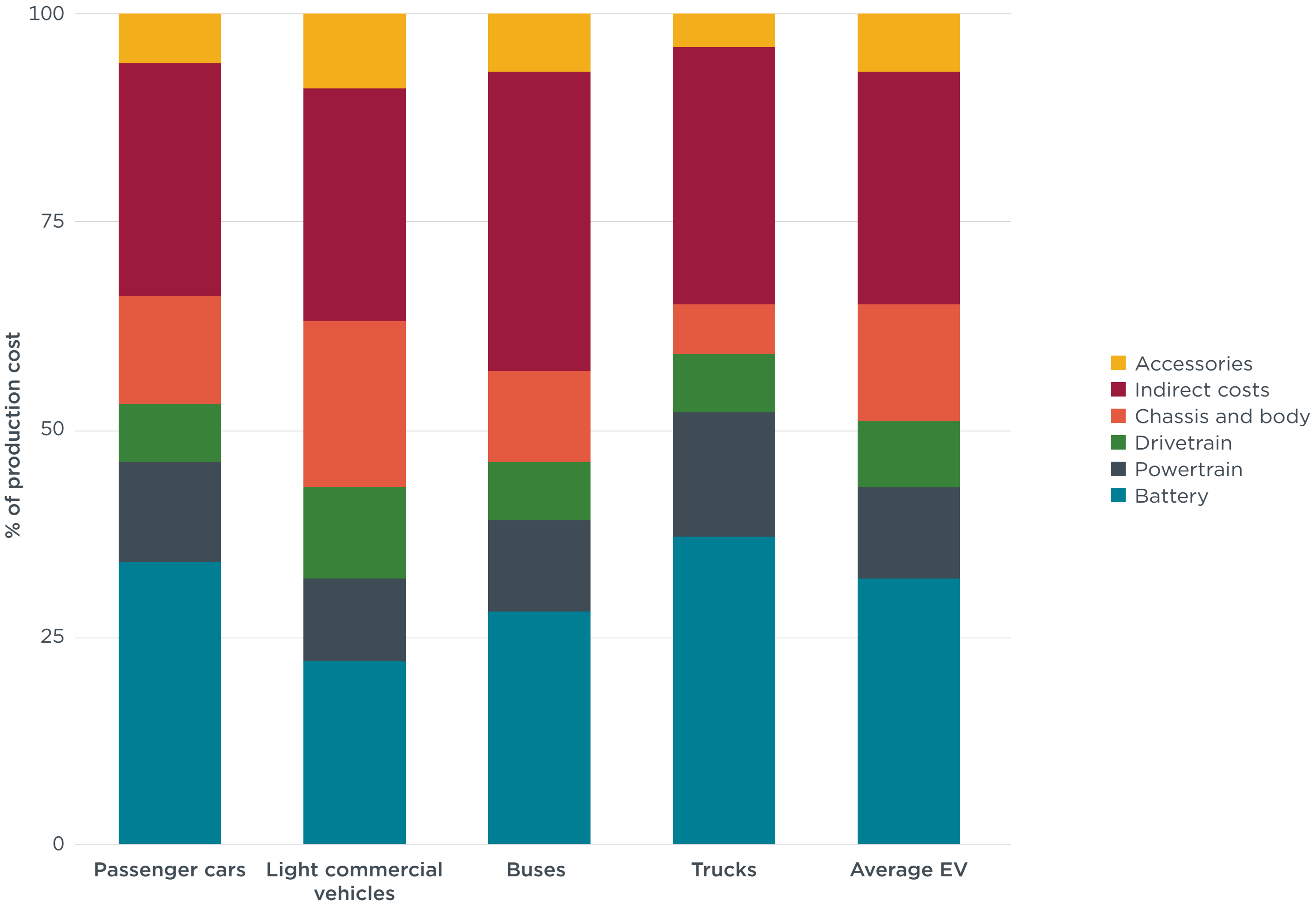

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Figure 1 highlights the importance of batteries in the overall cost structure. They account for 32% of the total cost of the average EV, ranging from 22% for light commercial vehicles to 37% for trucks. When combined with the costs of other powertrain components (that is, the parts unique to EVs) batteries and the powertrain together make up 43% of total production costs and 59% of direct costs.

One of the methodological strategies used to quantify the economic importance of EV production is the association of EV components with their corresponding economic sectors in national input-output matrices. Below, we apply this approach for the case of Brazil. To do so, 13 groups of components were mapped to sectors represented in the System of National Accounts (SCN/IBGE). The correspondence between components and sectors is presented in Table A2 of the Methodological Appendix.[4] Based on this mapping, it is possible to construct a synthetic sector representative of EV production in Brazil, which enables the estimation of the value of intermediate demand for goods and services produced by other sectors. This process begins by differentiating vehicle components into two groups: primary and secondary. Primary components include batteries, electric powertrain components, the body and chassis, suspension, brakes, drive axles, tires, and wheels. For secondary components, such as metals for the body, plastics, and services, we assumed that an ICEV and an EV require the same value of intermediate inputs for their production.

This approach is similar to the one adopted by Tamba et al. (2022, p. 3). We acknowledge that there are differences in components between ICEVs and EVs. For example, EVs tend to feature more onboard technology, meaning their demand for microchips, screens, and software may be higher than that of ICEVs. However, since the majority of production costs are concentrated in core industries, we expect this simplification to have a limited impact on the results.

To determine the intermediate demand for primary components, we used the relative costs (as percentages) between secondary components and each of the EV's primary components. For example, for an average EV, if we know that accessories account for 8% of the total cost and correspond to R$1,000,000, and the battery represents 32% of the cost, the value of the batteries would be 0.32/0.08 × 1,000,000 = R$4,000,000. This procedure is repeated for all major components and for value added. For more information, see the first section of the Methodological Appendix.

After defining the total costs by sector, we applied the same proportions between domestic and imported content observed in Brazil's traditional ICEV sector in the 2019 base year—except for the domestic content of batteries, whose trajectory is part of the simulated scenarios and will be described in the next section. Finally, a ratio of 0.84 was assumed between the value added by the EV and ICEV sectors, in line with international literature (Tamba et al., 2022; FEV Consulting, 2023). This figure was used to adjust the value added by the ICEV sector in the base year of the analysis (11.6%), such that the value added per EV corresponds to 9.7% of the gross production value. This amount is distributed between wages and profits, following the same proportion observed in the ICEV sector.

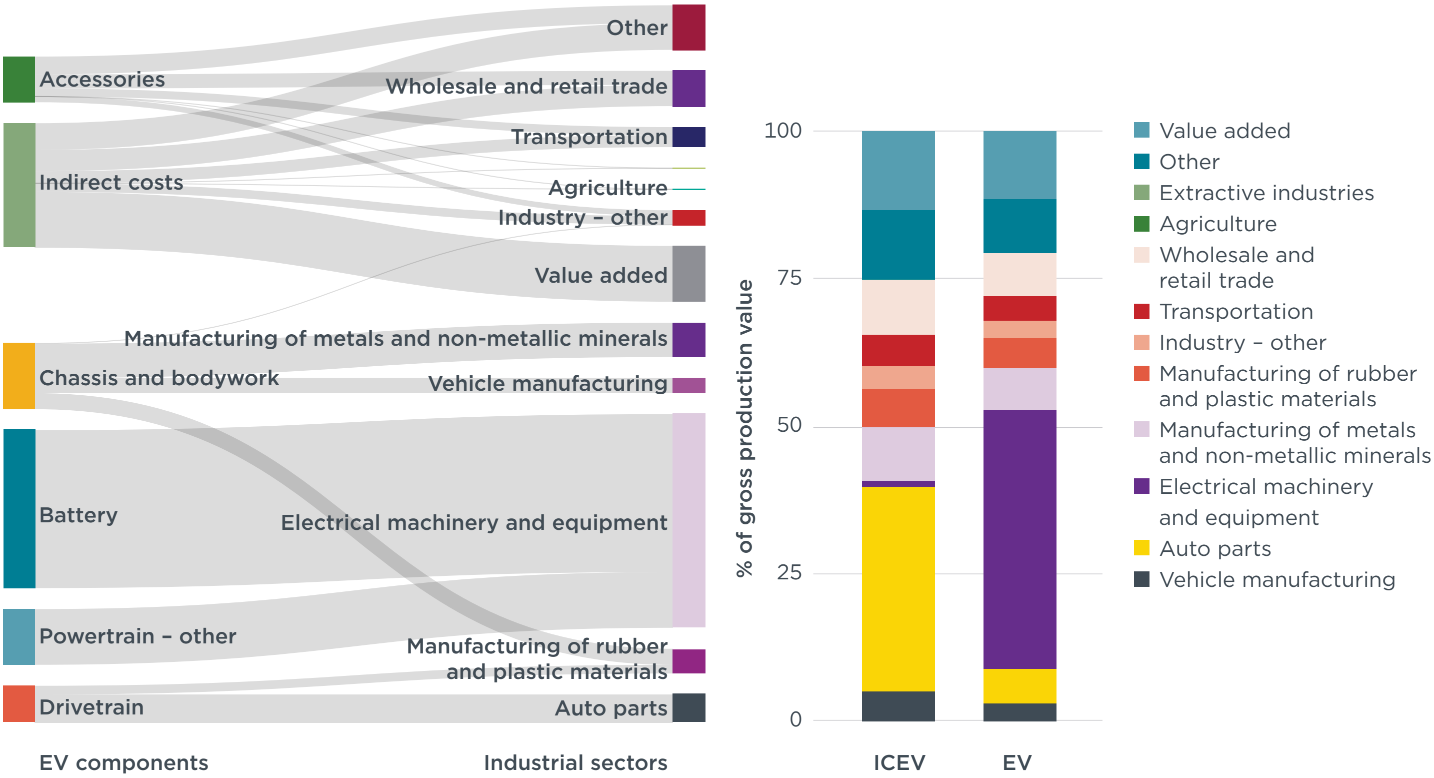
The results of this allocation of components to sectors are presented in the left panel of Figure 2. Due to the costs associated with batteries, electric motors, inverters, and other powertrain components, approximately 40% of production costs are linked to the electrical machinery and equipment sector. Other sectors responsible for a significant share of total costs include wholesale and retail trade (7.2%), the manufacture of metals and non-metallic minerals (7%),[5] the traditional auto parts sector (6%), and plastics and transportation materials (4.2%).

4 The Methodological Annex is available for download at www.theicct.org on the same page as this report.

5 The manufacturing of metals and non-metallic minerals includes the following sectors in the national accounts system: (1) the manufacture of metal products, except machinery and equipment; (2) metallurgy of non-ferrous metals and metal casting; (3) production of pig iron/ferroalloys, steelmaking, and steel tubes; and (4) manufacture of non-metallic mineral products.

Figure 2

Allocation of EV components to industrial sectors (left) and comparison of production costs between ICEVs and EVs (right)



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The right panel of Figure 2 compares the sectoral cost composition of an EV to that of an ICEV. A substantial increase in costs related to electrical machinery and equipment is observed in the case of EVs, along with a reduction in demand for traditional auto parts. However, it is important to note that this reduction, in absolute terms, is smaller than what is represented proportionally in the figure, since EVs tend to be more expensive. In total, 68% of EV manufacturing costs correspond to demand for industrial goods—a share higher than for ICEVs (60%).

METHODS

The methodology used to estimate the impact of the expansion of Brazil's EV fleet is explained in two parts. The first outlines the assumptions behind the two scenarios developed in this study: the Baseline and Electrification scenarios. The second describes the methodology adopted to simulate the number of jobs created and the corresponding value of production in each scenario. A more detailed description of the method, along with the code used, can be found in the Methodological Appendix.

SCENARIOS

The evolution of Brazil's national vehicle fleet through 2050, by segment and powertrain type, was simulated using the ICCT Roadmap model (ICCT, 2022). The model uses projections of vehicle demand, energy efficiency of combustion and electric engines, scrappage curves, and emission factors for fossil fuels, biofuels, and the electricity grid to calculate the fleet composition, fuel demand, greenhouse gas emissions, and local air pollutants. To project the two scenarios described below, the model was run with different distributions of EV and ICEV sales—while keeping the total number of vehicle sales constant—and different uses of fossil fuels, biofuels, and electricity. These assumptions are summarized in panels 1.a and 1.b of Box 1, below.[6] Two representative scenarios were thus constructed to contrast the economic effects of a continued focus on ICEV production alongside increased biofuel consumption (the Baseline scenario), with a transition to EV production that also considers greater biofuel use among the smaller share of ICEVs (the Electrification scenario).

The simulation of these scenarios projects the evolution of Brazil's national vehicle fleet from 2019 to 2050, by segment and powertrain type. It also accounts for emissions associated with the national road transportation sector and its corresponding consumption of fossil fuels, biofuels, and electricity. The main difference between the Baseline and Electrification scenarios lies in the share of new vehicle sales by powertrain type (electric or internal combustion engine) across five representative segments: passenger cars, light commercial vehicles, medium-duty trucks (gross vehicle weight [GVW] < 15 tons), heavy-duty trucks (GVW > 15 tons), and buses. The growth rates of vehicle sales, and therefore of the total fleet, are the same in both scenarios.

With regard to the domestic content of battery production, the same trajectory was assumed for both scenarios, starting at 21% in 2019, equivalent to the share of the battery's value corresponding to the assembly of battery packs, battery management systems, and battery thermal management (FEV Consulting, 2023; Ricardo, 2021; UBS, 2017).[7] These are the stages of production that already take place within the country. The national content of batteries increases over the course of the analysis, reaching 50% by 2050. This trajectory is shown in panel 3 of Box 1.

The scenarios project the sales and use of all vehicles within the national territory. However, the economic impacts linked to vehicle production depend not on total sales, but on domestic vehicle production. Therefore, after simulating the scenarios, we also consider the evolution of vehicle imports and exports of domestically produced vehicles. The scenarios simulated in the Roadmap model project national vehicle sales and fleet composition, which include imports and exclude domestically produced vehicles that are exported. However, since domestic manufacturing jobs depend on national production, it is necessary to exclude the share of imported vehicles and include exports in the scenarios.

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6 Other applications of the Roadmap model for fleet projections, energy demand, and emissions at global and national levels include Sen et al. (2023), Sen and Miller (2022), and Jin et al. (2021).

7 Therefore, this initially excludes the manufacturing of battery cells.

To do this, when converting domestic vehicle sales into monetary values, we excluded the percentage of imported vehicles in each segment. Next, the percentage of light- and heavy-duty vehicle exports in final demand was added. Section 3 of the Methodological Appendix details the conversion of Roadmap model outputs into values associated with the number of vehicles and fuel consumption, as well as the adjustments related to excluding imports and including exports in domestic production. The evolution of exports and imports is projected in alternative scenarios presented in Box 1, below, and discussed in the "Sensitivity Analyses" section.

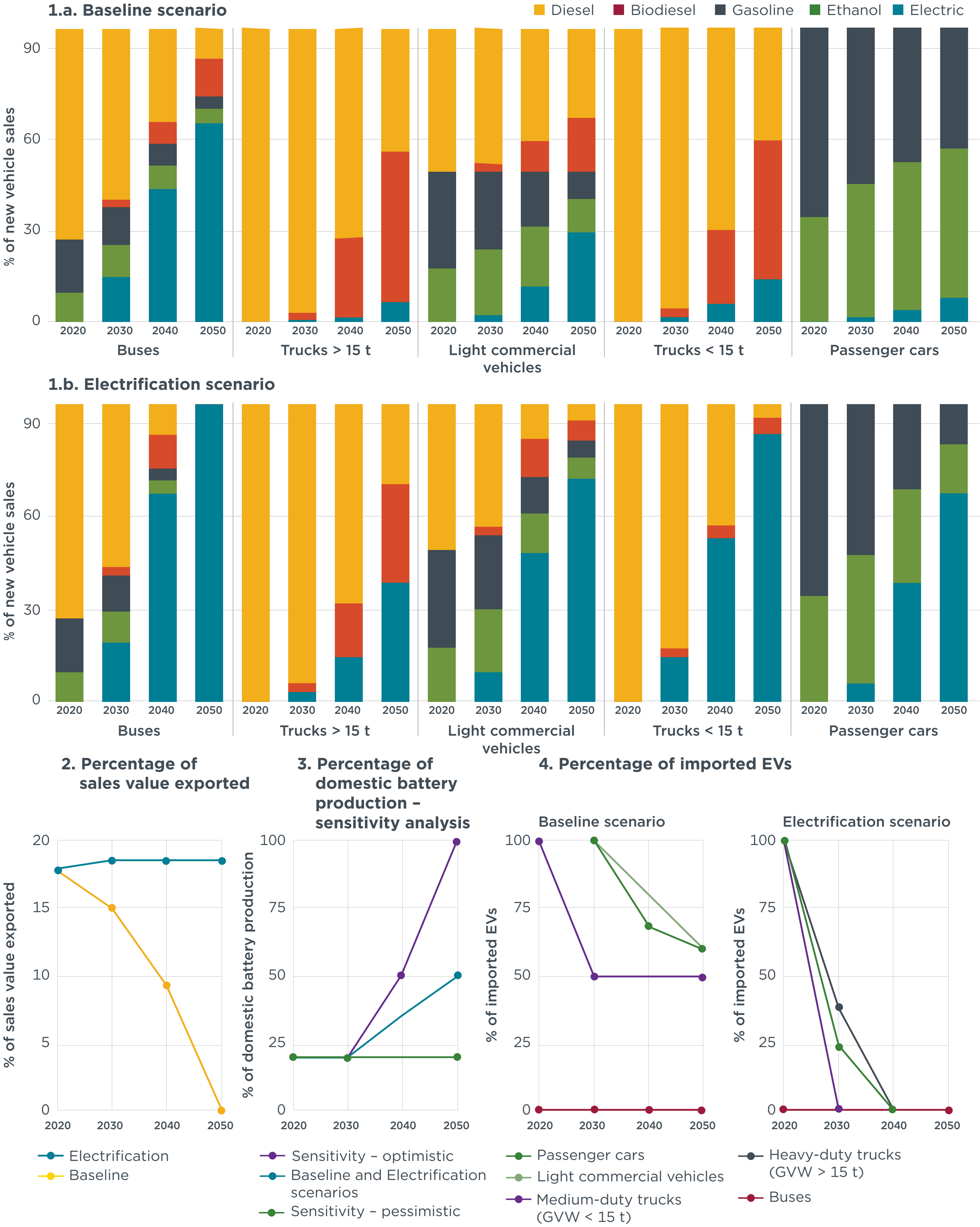
To ensure the robustness of the results, sensitivity analyses were performed following the main simulations to quantify the impact of uncertainties in the assumptions adopted. These analyses were based on replications of the Electrification scenario, using alternative assumptions—one pessimistic and one optimistic—regarding the evolution of domestic battery content, as well as alternative assumptions for the trajectory of vehicle exports.

The scenarios developed for this study do not consider hybrid or plug-in hybrid vehicles. Hybrids, even when equipped with flex-fuel engines, offer limited emissions mitigation potential (Mera et al., 2024) and can be regarded, at best, as a transitional step toward vehicles aligned with Brazil's national climate neutrality targets for 2050. Even plug-in hybrids, which are capable of operating in electric mode, deliver real-world emissions reductions far below their technical potential (Isenstadt et al., 2022; Plötz et al., 2022). Additionally, the comparison between battery EVs and ICEVs is the most relevant for understanding the impact of the energy transition on employment, as it contrasts technologies and production processes that are fundamentally different. Hybrid vehicles, on the other hand, combine both combustion and electric technologies, resulting in greater demand for parts and components and, according to Bauer et al. (2018), a higher labor demand than that required for assembling either electric or combustion-only vehicles.

The assumptions adopted in the projections of the Baseline and Electrification scenarios, as well as those used in the sensitivity analyses, are summarized in Box 1 below and described in detail in the sections that follow.

Box 1

Summary of Baseline and Electrification scenarios



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Baseline scenario

The Baseline scenario represents a continuation of current trends in vehicle production and fuel consumption in Brazil. In this scenario, ICEVs account for the vast majority of sales through 2050, with only moderate increases in EV sales.

Panel 1.a of Box 1 shows the evolution of vehicle sales by segment in this scenario. By 2050, ICEVs still represent 92% of passenger car sales, 70% of light commercial vehicle sales, 86% of medium-duty truck sales, 93% of heavy-duty truck sales, and 33% of bus sales. The remaining sales in all segments are EVs, in line with projections for Brazil under the Stated Policies Scenario (STEPS) modeled by the International Energy Agency (2022).

Fuel consumption by ICEVs in the Baseline scenario results in an increase in biofuel use. The use of hydrous ethanol in light-duty vehicles rises from 35.6% in 2020 to 46% in 2030, 52.4% in 2040, and 55.4% in 2050 (Ministry of Mines and Energy & The Energy Research Office [EPE, from the Portuguese *Empresa de Pesquisa Energética*], 2020; EPE, 2022). The share of anhydrous ethanol blended in gasoline (Gasoline C) is held constant at its current level of 27.5%. Among ICEVs, it was assumed that the evolution of biofuel consumption in heavy-duty vehicles reaches the same percentage levels as in light-duty vehicles by 2050. However, heavy-duty vehicles running on 100% biofuels must be fueled with HVO (hydrotreated vegetable oil), which is different from the biodiesel currently produced in Brazil and not yet commercially available at scale. Therefore, the Baseline scenario projects the use of HVO in heavy-duty vehicles beginning only in 2030. The biodiesel content in B-diesel is also held constant at 12% through 2050.

The dominance of ICEV production in the Baseline scenario stands in contrast to the electrification targets of both developed countries and Brazil's major trading partners in the automotive sector. As a result, the Baseline scenario projects a loss of competitiveness for the national automotive industry, with gradual reductions in exports and increasing penetration of imported EVs. The projected trajectories for vehicle exports and imports in the Baseline scenario are shown in panels 3 and 4.a of Box 1.

Electrification scenario

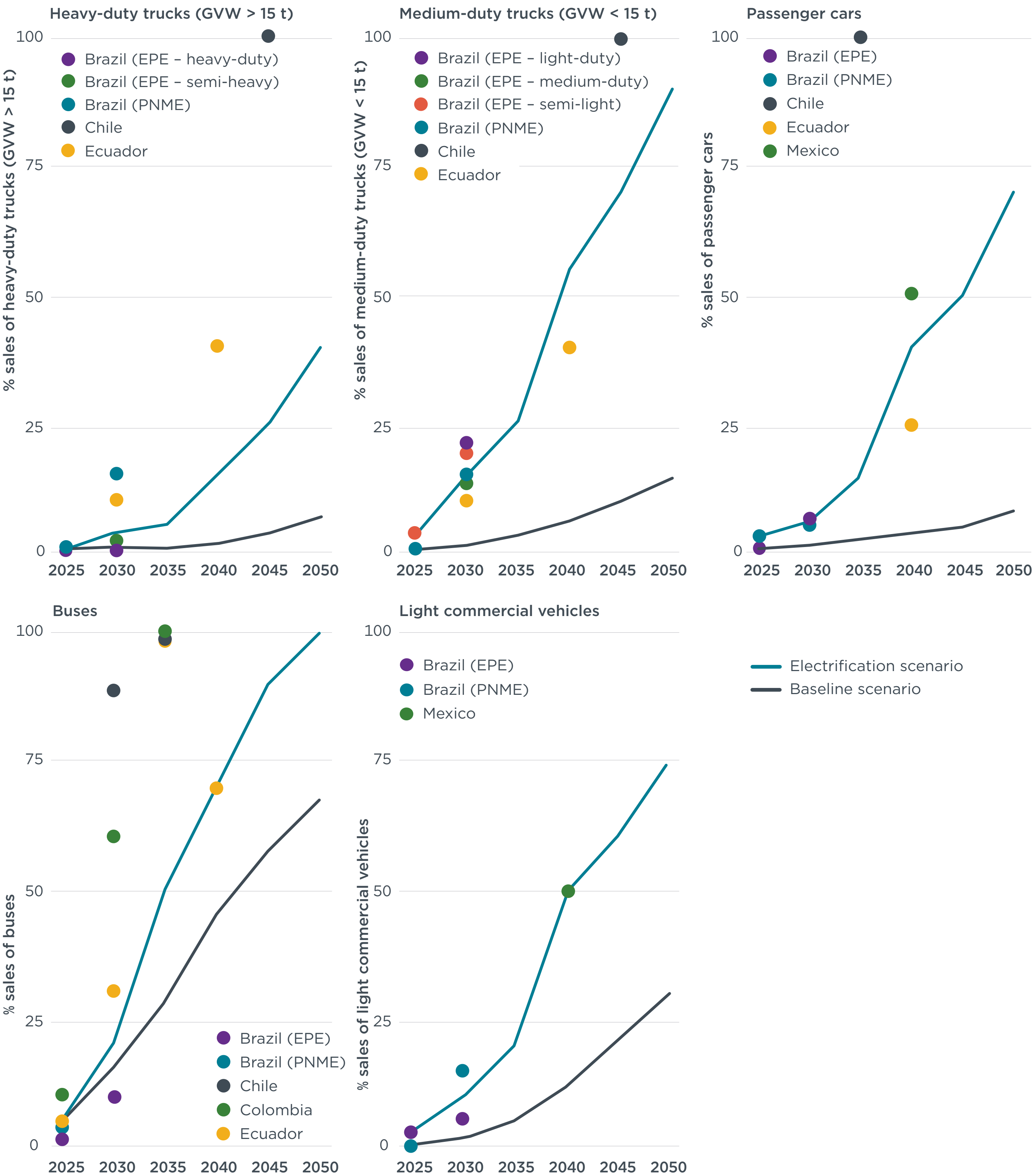
The Electrification scenario reflects an ambitious increase in EV sales through 2050. For ICEVs, the same percentage increase in biofuel consumption used in the Baseline scenario is applied. However, this increase affects a smaller fleet of ICEVs due to the projected rise in EV sales.

Projections of EV sales in the Electrification scenario, compared with the Baseline scenario, are presented in Figure 3 for the five representative segments. These projections are based on studies conducted for Brazil by EPE (2023) and the National Electric Mobility Platform (PNME, from the Portuguese *Plataforma Nacional de Mobilidade Elétrica*; Barassa et al., 2022), as well as on declared targets from other Latin American countries (Pineda, 2022; Barassa et al., 2022; Kohli et al., 2022). Since Brazil has not yet established any defined electrification targets, we used these other Latin American countries for reference. Despite projecting increases in EV sales, especially after 2035, the values used here are below the targets set by Chile, Mexico, Colombia, and, in some cases, Ecuador.

In the Electrification scenario, electric passenger car sales reach 6% in 2030, 40% in 2040, and 70% in 2050. Light commercial vehicles follow a similar trajectory, reaching 75% EV sales by 2050. Among heavy-duty vehicles, buses are the only segment to achieve 100% electrification by 2050, while medium-duty electric trucks—primarily used in urban areas—account for 16% of sales in 2030, 55% in 2040, and 90% in 2050. Finally, the heavy-duty truck segment faces greater barriers to the adoption of EVs, particularly due to the need for public highway charging infrastructure. Even in the Electrification scenario, EVs in this segment are projected to represent only 40% of total sales by 2050.

Figure 3

Projected EV sales in the Baseline and Electrification scenarios



Note: Data for Brazil are from EPE (2023) and PNME (Barassa et al., 2022). Data for the other countries are from Pineda (2022), Barassa et al. (2022), and Kohli et al. (2022).

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Another difference between the two scenarios is the projected behavior of foreign trade. The evolution of these assumptions is shown in panels 3 and 4.b of Box 1. In the Electrification scenario, it is assumed that the scale of EV sales enables competitive domestic production. Therefore, the level of vehicle exports remains constant at around 18% of national industry revenue through 2050.[8] On the other hand, this level of production also replaces initial imports of EVs. Domestic production accounts for 100% of medium-duty truck sales beginning in 2030. By that year, about one-quarter of passenger cars and light commercial vehicles and 35% of heavy-duty trucks sold are still imported. Starting in 2040, 100% of EVs sold in the Electrification scenario are produced locally.

Sensitivity analyses

The assumptions underlying the two scenarios involve uncertainties that may affect the results of this study. Two sensitivity analyses were conducted to quantify the influence of key uncertainties on the scenario outcomes: the domestic content of automotive batteries and the evolution of exports. Since these assumptions primarily affect the Electrification scenario, the sensitivity analyses focus exclusively on their effects within this scenario, in comparison with the Baseline scenario.

The first analysis highlights the importance of domestic battery production for job and income generation from EV sales, since imported components account for about one-third of the production cost of the average vehicle (see Figure 1). In this analysis, the Baseline and Electrification scenarios are simulated assuming the same domestic battery content, starting at 21% and reaching 50% by 2050. Additionally, we assume a pessimistic hypothesis (holding at 21% throughout the period) and an optimistic one (reaching 100% by 2050) for domestic battery production in the Electrification scenario. The trajectories of domestic content in the main scenarios and sensitivity analyses are shown in panel 3 of Box 1. The assumptions regarding import reductions, shown in panel 4, have a smaller impact on the Baseline scenario, since they affect only imports of EVs, which make up a smaller share of total sales in that scenario.

The second sensitivity analysis highlights how the reduction in exports projected in the Baseline scenario contributes to changes in Brazil's occupational structure. In this analysis, the Electrification scenario is simulated again, this time incorporating the same decline in exports projected for the Baseline scenario.

INPUT-OUTPUT ANALYSIS: CALCULATING THE IMPACT ON EMPLOYMENT STRUCTURE

The analysis presented in this study is limited to evaluating the employment effects stemming from vehicle manufacturing and the inputs required for production, as well as from the demand for fossil fuels, biofuels, and electricity. Therefore, the results do not include jobs related to electric charging and distribution infrastructure, nor those associated with vehicle use, such as maintenance and spare parts.

To estimate the long-term economic implications of the Baseline and Electrification scenarios, an input-output model was developed. In simplified terms, this framework identifies which sectors are responsible for producing goods and services (output) and which sectors consume them, either as inputs for the production of other goods and services or as final consumption by institutional sectors (households, governments, and businesses). This approach makes it possible to map out the intersectoral relationships within an economy. Input-output analysis relies on matrices that organize these flows, constructed from observed economic data. In many countries, these matrices are

8 This value corresponds to the average vehicle exports from 2010 to 2019, prior to the COVID-19 pandemic.

published by public institutions, although with varying frequency. As the matrices are built using annual data, they represent snapshots of a given year's economic structure, which limits the model's analytical flexibility. As will be discussed below, this is an important limitation for the current study. However, it does not diminish the value of the method for simulating, albeit in simplified form, the trends associated with different scenarios for expanding Brazil's EV fleet.

In Brazil, official input-output matrices are published by the Brazilian Institute of Geography and Statistics (IBGE) every five years, with some delay. The simulations proposed in this study are based on Brazil's 2019 input-output matrix, which was constructed by Passoni-Alves and Freitas (2020) using the 2015 matrix and supply and use tables for 2019. The matrix used includes 67 productive sectors (disaggregated into 126 activities), in addition to institutional sectors.

Three limitations of the input-output analysis used here warrant special attention. First, because it represents a country's productive structure in a specific year, the input-output matrix is a limited tool for simulating future changes in the production structure. In this study, the original productive structure for all other sectors in the matrix was held constant throughout the entire simulation period, from 2019 to 2050. As a result, the analysis assumes technological rigidity—that is, it does not account for potential structural changes in production arising from the adoption of new technologies over time. This also affects the labor force employed in each sector, as labor productivity is assumed to remain fixed. Finally, the analysis does not account for intertemporal changes in relative prices, which would be expected as the production structure evolves.

The second limitation concerns the variation in relative prices between EVs and ICEVs. The simulations in the Roadmap model assume that only the composition, and not the volume, of vehicle sales between electric and combustion powertrains varies between the two scenarios. In other words, a one-to-one substitution between the two types of powertrains is assumed. Additionally, the higher cost of EVs in the base year is taken into account when converting sales figures into monetary values. The ratio between the price of an EV and an ICEV is 1.45 for passenger cars, 1.32 for light commercial vehicles, 1.43 for medium-duty trucks, 2.47 for heavy-duty trucks, and 3.39 for buses (Xie et al., 2023; Slowik et al., 2022; Lutsey & Nicholas, 2018).

Therefore, producing the same quantity of EVs corresponds to a higher level of final demand than producing ICEVs. The assumption of keeping relative prices fixed throughout the simulations while varying only quantities is consistent with the decision to maintain the productive structure observed in the input-output matrix for the base year (2019). Applying projected reductions in the relative price of EVs over time would be equivalent to imposing reductions in labor intensity in the EV manufacturing sector and across all sectors that supply intermediate goods to it. In other words, it would imply assuming that the entire price reduction of EVs results from new, less labor-intensive technologies—an assumption that would be incompatible with price variations driven by battery raw material costs or changes in manufacturers' profit margins.

In summary, when projecting scenarios using the productive structure observed in the base year, it is also necessary to keep initial relative prices fixed. In this way, the projected changes in EV and ICEV sales reflect the employment intensity per vehicle across the two value chains as observed in the base year. It is worth noting that, due to the higher unit price of EVs, the total number of jobs generated per vehicle may be higher for EVs than for ICEVs, even though the number of jobs per unit of production value is lower.

The third limitation is that, like other input-output matrices, the Brazilian matrix does not include a specific sector for the manufacturing of EVs. Therefore, the information presented in the section on the characteristics of the EV industry in Brazil was used to construct a synthetic sector representative of EV production. This information makes it possible to map a cost structure for the synthetic sector, which was incorporated as the 68th sector in the Brazilian input-output matrix. This, in turn, allows us to determine the intermediate consumption links of the synthetic sector (i.e., how much and from which sectors it demands inputs), and thereby estimate the impact of this sector's production on output in other sectors. This is a fundamental premise of input-output analysis, and it is what makes it possible to calculate the economic impacts of changes in demand, such as how many new jobs will be created in each sector and across the economy as a whole.

However, it is important to acknowledge that the synthetic sector method only allows for the assumption of a demand structure for the EV sector, and not a supply structure. In other words, it is not possible to determine how much the 67 original sectors in the input-output matrix demand from the new EV sector. Nonetheless, approximately 94% of the total demand for the ICEV sector originates from institutional sectors representing final demand (household consumption, government consumption, gross fixed capital formation, inventory changes, and exports). Therefore, it can be inferred that the EV sector, like the ICEV sector, is not significant as a supplier of intermediate inputs.

In year 1 of the simulation (2019), it is assumed that the EV sector's contribution to national output is negligible. This assumption does not compromise the results and, in fact, ensures consistency within the input-output model when incorporating a synthetic sector. Further details on these procedures are described in Kim et al. (2017; 2019), who propose the method, and in Marques et al. (2024), who apply it to the case of the Brazilian Amazon.

Once the synthetic EV sector is incorporated into the matrix, the procedures for estimating economic impacts follow the traditional calculation of output and employment multipliers applied to the input-output model, which uses the Leontief inverse matrix (Miller & Blair, 2009, ch. 6). As the goal is to simulate changes in demand for EVs over time, it is these changes which, interacting with the cost structure of the synthetic sector, determine the magnitude and sectoral distribution of the impacts on the economy. As mentioned earlier, the procedure involves replicating the 2019 input-output matrix for subsequent years and incorporating demand shifts based on the previously-described Baseline and Electrification scenarios. These changes are introduced through adjustments to the original input-output matrix.

The impact of production on the number of people employed depends not only on a sector's cost structure but also on the employment coefficients associated with each sector in the input-output matrix. These coefficients are calculated as the ratio between the total number of people employed in a sector and the gross value of its production. The challenge, however, is that EV production is not typically distinguished as a specific sector within the input-output matrix, so it must be defined using predetermined criteria.

Thus, in addition to a complete cost structure for the new EV sector—which allows us to identify the inputs used in EV production—it is also necessary to know the number of people directly employed in the sector. Several recent studies have sought to quantify the potential employment impacts resulting from the substitution of ICEVs with EVs. These studies have aimed to examine the anecdotal hypothesis that the production structure associated with EVs leads to a reduction in the number of jobs required by the automotive industry. Table 1 summarizes the findings of some of these studies, which show considerable variation. Two of them suggest that the ratio of direct employment in EV production to ICEV production, for the same value of output, is around 60% (Küpper et al., 2020; Suehiro & Purwanto, 2020). The other two indicate a ratio of around 80% (Bauer et al., 2018; Jaeger et al., 2021). For the purposes of this analysis, we selected four out of ten studies that allow for the identification of direct labor intensity in EV and ICEV production, using different methodologies.

Table 1
Ratio of direct employment in EV versus ICEV production for the same gross production value

Reference	Proportion of direct employment in the EV sector relative to the ICEV sector
Bauer et al. (2018)	80.1%
Küpper et al. (2020)	80.1%
Jaeger et al. (2021)	59.0%
Suehiro and Purwanto (2020)	63.3%
Average	**70.4%**

Based on these values, this study defines in advance the direct employment coefficient for the EV sector. By treating it as a separate synthetic sector in the input-output matrix and identifying it through the cost structure previously described, we also assumed that its direct employment coefficient is a fraction of the direct employment coefficient for the ICEV sector. To determine this, we multiplied the ICEV sector's coefficient—identifiable in the input-output matrix—by the average ratio of direct employment in the production of EVs and ICEVs, as listed in Table 1. The calculated direct employment coefficient for EV production in Brazil is 0.55 jobs per million in gross production value, compared with a coefficient of 0.78 for ICEV production.

Finally, to estimate the gender distribution of employment impacts, it is necessary to disaggregate employment by sector, which is only available in aggregated form within the input-output matrices. In this case, we used gender proportions from Brazil's formal labor market based on official data from the Annual Report of Social Information (RAIS), published by the Ministry of Labor and Employment (2022), which is available for all sectors in the official matrix. Since there are no gender-specific data for the EV sector, we used the gender distribution of the ICEV sector for the first year as a proxy.

With the cost structure and direct employment coefficient of the new EV sector, and the gender distribution of employment across all sectors, we can proceed to the scenario simulations. Since the Baseline and Electrification scenarios assume changes in demand for EVs and ICEVs, the effects captured by the model stem exclusively from these sectors and their input suppliers. This means that any other changes in demand (or in prices) associated with sectors unrelated to vehicle, fuel, or electricity production over the analyzed period are excluded from consideration.

Finally, it is important to emphasize that the results obtained from the multiplier analysis account for both direct and indirect effects—that is, effects resulting from changes in demand related to the production within the sectors themselves, and from the production in sectors that supply inputs. In the specific case of the EV manufacturing sector, for example, the multiplier captures both the direct jobs created within the EV sector itself and the indirect jobs generated in all sectors supplying inputs for EV production, such as batteries, electric motors, metals, and glass. Induced effects—that is, those resulting from the impact of increased consumption on economic activity—are not included.

RESULTS

This section presents the simulation results for the Baseline and Electrification scenarios. First, it compares life-cycle greenhouse gas emissions (from well to wheel) for Brazil's national vehicle fleet. Next, the main results describe the generation of jobs and income (wages and profits). Finally, sensitivity analyses quantify the impact of domestic battery production and vehicle exports on job creation under the Electrification scenario.

GREENHOUSE GAS EMISSIONS IN ROAD TRANSPORT

We estimated greenhouse gas emissions for each scenario using the methodology of the Roadmap model (ICCT, 2022). Life-cycle (well-to-wheel) emissions were assessed to ensure a comprehensive analysis of the emissions resulting from vehicle and transport demand. This includes both tailpipe emissions (tank-to-wheel) and upstream emissions from the extraction, cultivation, transport, and production of fossil fuels, biofuels, and electricity (well-to-tank).

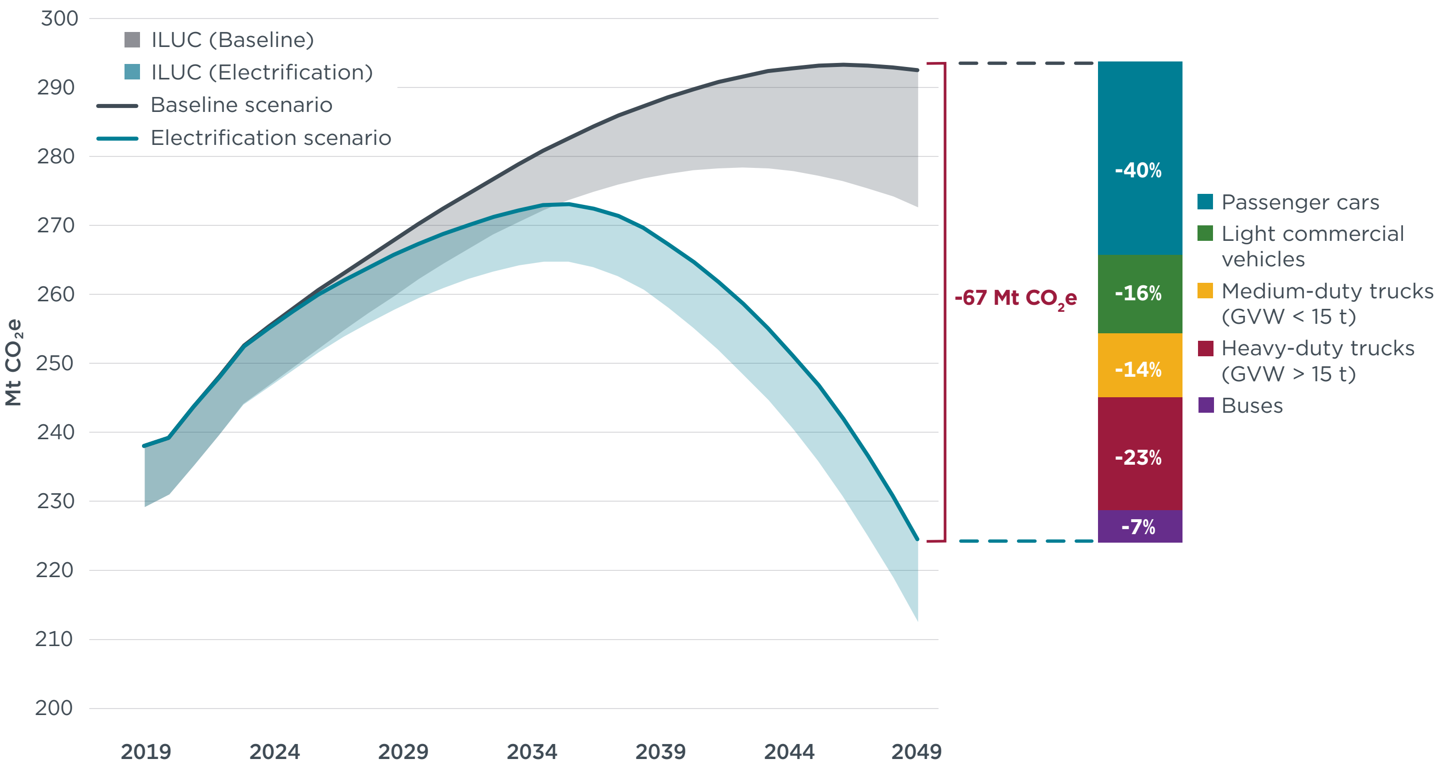
The results are presented in Figure 4. The left panel shows the variation in emissions from 2019 to 2050 under the Baseline and Electrification scenarios. The shaded areas beneath each scenario indicate the share of emissions resulting from indirect land use change (ILUC) associated with the cultivation of energy biomass. The right panel of the figure breaks down the emissions reduction between the two scenarios across the five vehicle segments considered in the analysis.

The results indicate a reduction of 67 megatons of CO_2 equivalent emissions in the Electrification scenario compared with the Baseline scenario by 2050. In both scenarios, emissions initially rise due to an increase in vehicle sales and, consequently, in the size of the national fleet. For example, annual passenger car sales increase from 2.2 million vehicles in 2019 to 5.1 million in 2050. Sales by segment and powertrain are shown in Figure 3 and in panels 1.a and 1.b of Box 1.

The emission reductions in the Electrification scenario, projected to begin in 2036, occur alongside a significant increase in EV sales across all segments (see Figure 3). The largest share of the mitigation potential is attributed to passenger cars, which make up the majority of the national fleet, followed by heavy-duty trucks, light commercial vehicles, primarily urban medium-duty trucks, and finally, buses.

Figure 4

Life-cycle emissions (well-to-wheel) in the Baseline and Electrification scenarios (left) and composition of greenhouse gas mitigation by vehicle segment (right)



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EMPLOYMENT

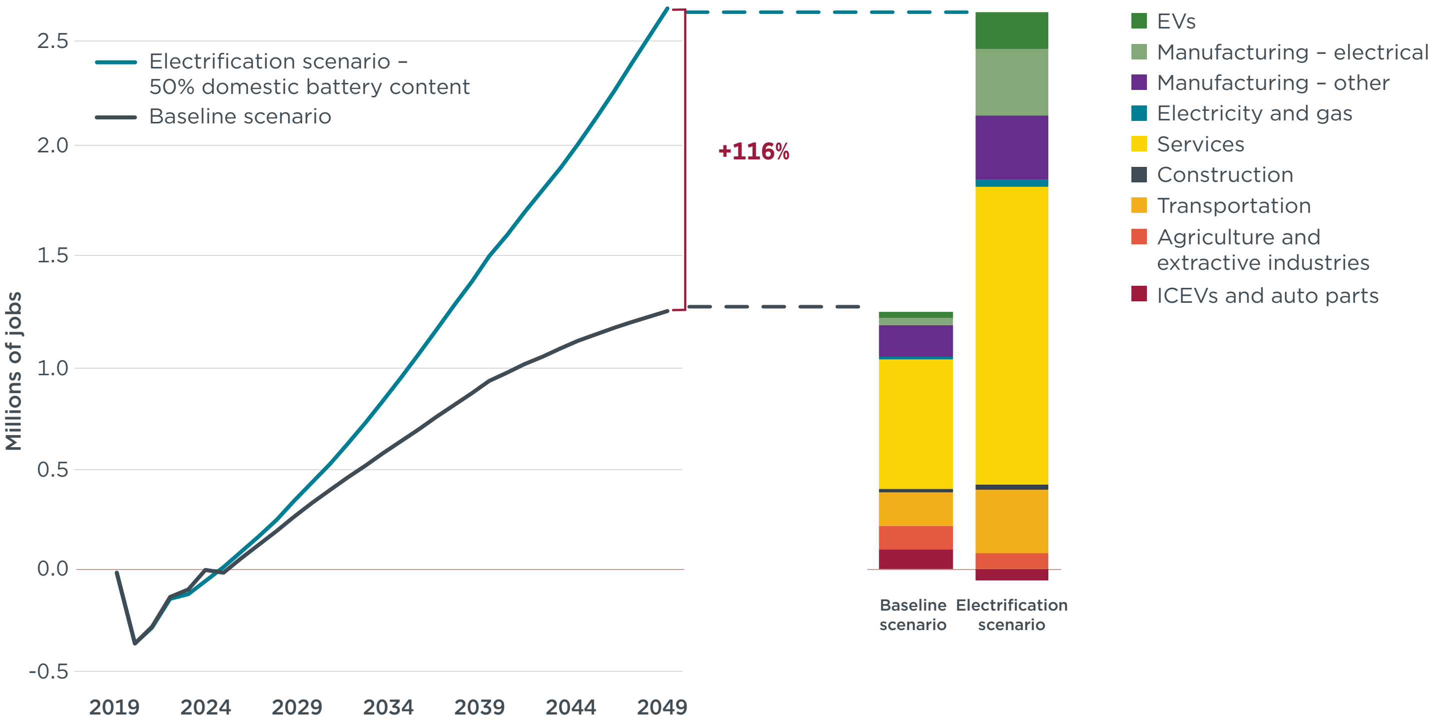
Figure 5 illustrates the trajectories of the two simulated scenarios in terms of the quantity and type of occupations potentially created over the period. The Electrification scenario diverges from the Baseline starting in 2026, resulting in a job creation potential that is 2.1 times greater by 2050, a 116% increase.[9] The projection therefore suggests that more ambitious electrification targets can expand the job-generating capacity of Brazil's automotive industry when compared to more conservative pathways (in this case, the Baseline scenario). As the simulation assumes a lower number of jobs generated per million in gross production value for EVs than for ICEVs (i.e., EVs have a smaller multiplier), this result stems from an electrification strategy that foresees a significant increase in demand for EVs.

The total number of jobs generated in the final year (2050) is grouped into nine categories that encompass the 68 sectors in the input-output matrix. The correspondence between the 68 sectors and these aggregate categories is listed in Table A2 of the Methodological Appendix. The distribution across scenarios shows that job growth is not uniform: some categories benefit relatively more than others when shifting from the Baseline to the Electrification scenario. For example, both EV production and the manufacturing of electrical machinery and equipment represent a higher share of total employment in the Electrification scenario (9.5% and 10.8%, respectively) compared with the Baseline scenario (2.4% and 2.9%).

9 The initial drop in both trajectories reflects the impact of the COVID-19 pandemic.

Figure 5

Total jobs generated across all sectors as a result of sales of EVs, ICEVs, fossil fuels, biofuels, and electricity (left), and distribution of jobs generated at the end of the simulations by sector (right)



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A similar dynamic is observed in the production of ICEVs and auto parts, but in this case, there are job losses when moving from one scenario to the other. Specifically, the Electrification scenario implies a reduced relative share for these categories.[10] Another notable aspect of the Electrification scenario is the relative contraction (slower growth) of the agriculture sector, highlighting the effects of electrification on biofuel production: while in the Baseline scenario this sector accounts for 9.8% of total employment, in the Electrification scenario that figure falls to just 3%.

Nonetheless, it is important to emphasize that 78.8% of the new jobs generated in the Electrification scenario are due to other categories indicated in the figure, especially the one encompassing the services sectors. As shown in Table A2, this category includes 23 sectors from the input-output matrix, such as financial intermediation and insurance, real estate and legal activities, wholesale and retail trade, and professional and scientific activities, including research and development (R&D). In this case, there is no significant difference compared with what occurs in the Baseline scenario, where 77.9% of the jobs generated are also allocated to services. In the initial year of the analysis (2019), the services category accounted for 64% of the total employment in the country. In this sense, the substantial increase in jobs allocated to services in both scenarios reflects the size of these sectors within the Brazilian economy, as well as their higher labor intensity compared to the average of manufacturing sectors. The jobs generated, therefore, are largely due to the effect of increased demand associated with EVs. Since direct effects (the impact on occupations exclusively linked to the EV sector) are smaller than indirect effects (the impact on occupations resulting from input demand by the EV sector), these results highlight not only the importance of EV production to the broader economy, but also outline the sectors most affected by the expansion in demand for these vehicles.

10 This can be seen in Figure 5 by the fact that the number of jobs in the ICEV sector under the Electrification scenario is negative.

Figure 6 provides further details on the distribution of the employment differential between the two scenarios in 2050. It highlights the importance of the services sector in accounting for the additional jobs generated in the Electrification scenario, followed by electrical equipment manufacturing, EV production, and other types of manufacturing. In contrast, job growth in auto parts manufacturing, ICEV production, and agriculture is lower in the Electrification scenario than in the Baseline scenario. It is worth noting, however, that this reduction is less pronounced in the biofuels and oil refining sectors (now presented separately), which are directly related to the production of ICEVs.

Figure 6

Relative change in employment by sector between the Electrification and Baseline scenarios at the end of the simulations (2050)

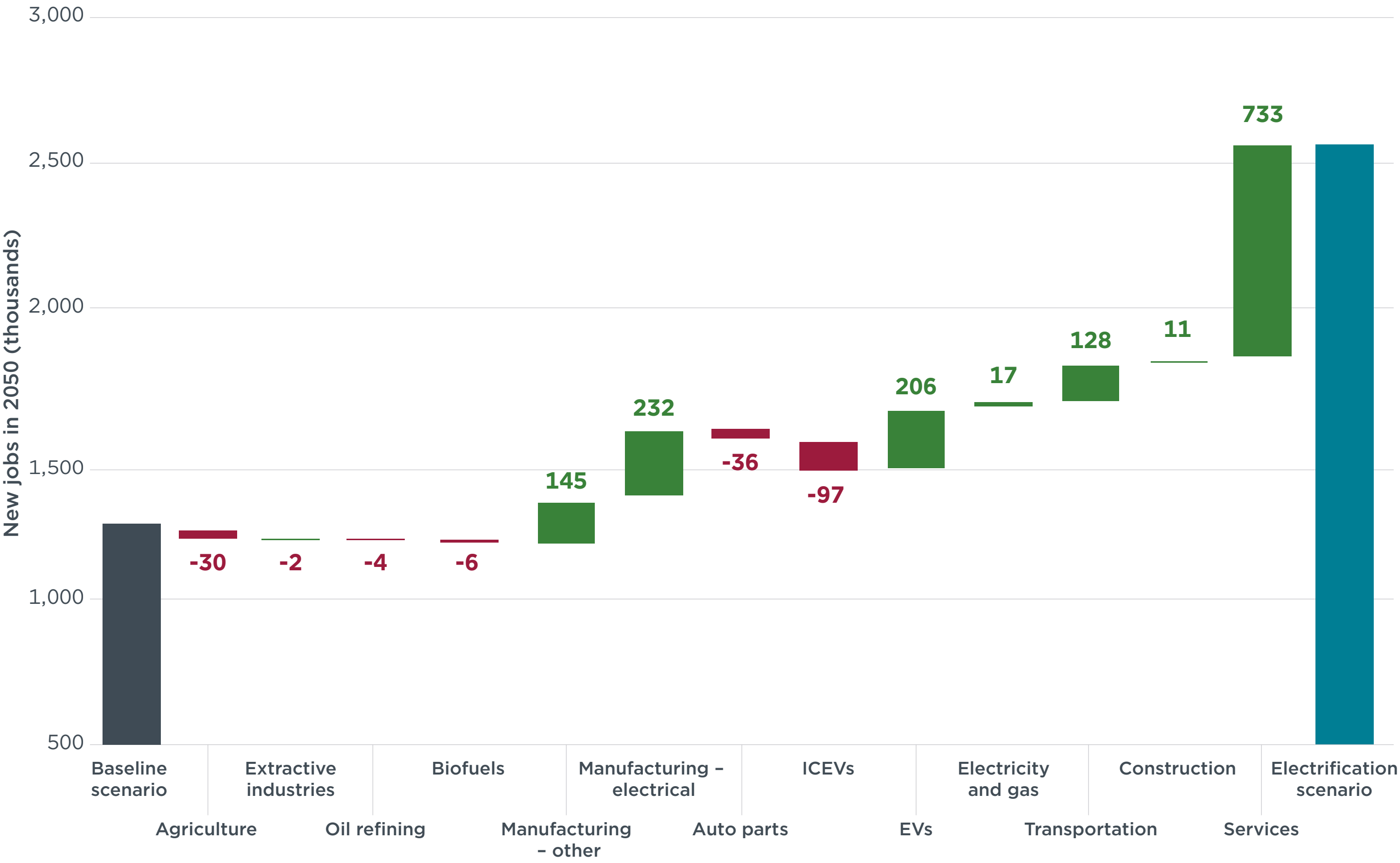

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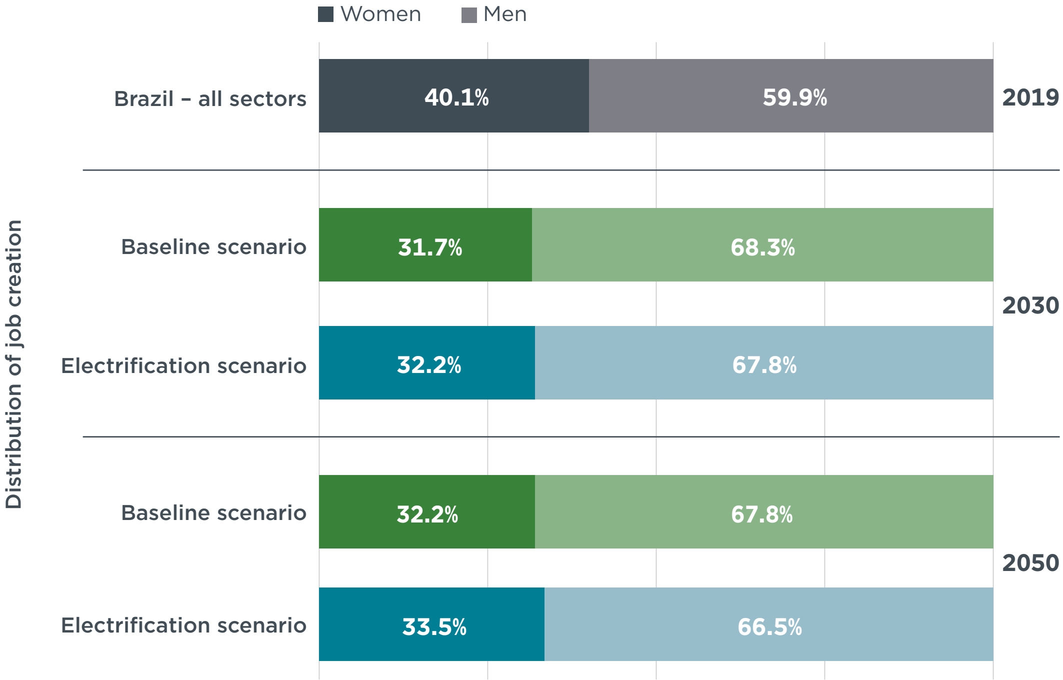
Figure 7 presents the distribution of new jobs by gender. The first horizontal bar in the chart illustrates the gender distribution of total employment in the Brazilian economy in 2019. Next, the gender distributions of new jobs generated in the Baseline and Electrification scenarios are shown for 2030 and 2050. Due to the nature of this analysis, the jobs generated in the scenarios and the changes in their gender distribution are limited to the dynamics analyzed and, therefore, do not reflect changes across the entire Brazilian economy. As such, they are not directly comparable with the bar showing the total employment distribution in Brazil in 2019.

Figure 7

Gender distribution of projected jobs in the Baseline and Electrification scenarios in 2030 and 2050, compared with the distribution in the Brazilian economy in 2019



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The results suggest that around two-thirds of all new jobs projected in both scenarios will be filled by men. Although the share of jobs for women is slightly higher in the Electrification scenario than in the Baseline scenario, in both cases the projected new jobs exhibit a worse gender distribution than the national average. This unequal outcome is mainly due to the expansion of categories that currently employ mostly men, such as EV and ICEV production (growth of 89%), electrical equipment manufacturing (29%), other types of manufacturing (21%), and transportation (16%). On the other hand, the significant expansion of the services sector, which has a more balanced gender distribution than the national average (54% men, 46% women), partially offsets this trend.

The projected gender inequality in new jobs suggests that policies aimed at increasing female employment in sectors stimulated by vehicle sales—particularly in emerging industries such as EV and battery manufacturing—may be necessary if gender parity is to be achieved in the industrial transition to EVs. Nonetheless, it is important to acknowledge the limitations of this analysis. We assume that the gender distribution in the EV sector is the same as in the ICEV sector, and that the gender distribution across all sectors remains fixed until 2050, except for changes generated by the scenarios. Even with these limitations, the results are relevant in indicating that, in both scenarios, job creation is concentrated in sectors that currently employ a relatively higher proportion of men.

INCOME GENERATION AND VALUE ADDED

The job creation discussed in the previous section is directly linked to the projected increase in the value of production of ICEVs and EVs, as well as fuels and electricity, in the two scenarios. Figure 8 shows the evolution of income generation (value added) in the economy (left) and its division between wages and profits (right).[11]

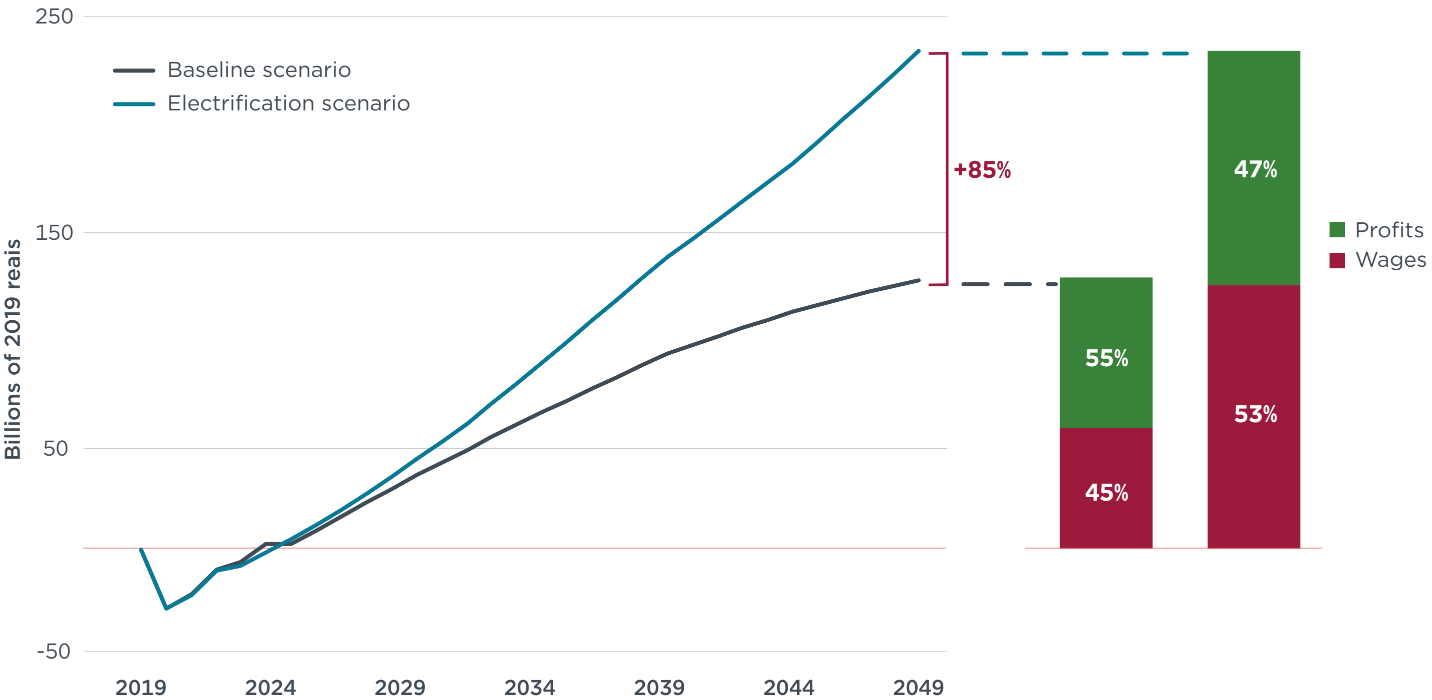
Both scenarios project significant increases in income from the automotive sector following an initial decline due to the COVID-19 pandemic. However, as with job creation, the Electrification scenario projects 85% higher value added than the Baseline scenario by 2050.

To disaggregate income generation into wages and profits, we assumed that the proportion of wages to profits in the value added of each of the 68 sectors studied remains fixed over time—that is, no changes were estimated in the functional distribution of income within each sector. Therefore, the projected variations in the wage share are a function of changes in the composition of the sectors that grow most in each scenario.

Of the total income generated in the Electrification scenario, 53% is allocated to wages, while in the Baseline scenario this share is 45% (in the 2019 input-output matrix, it was 52%). The difference between the scenarios is due to the relative increase in employment in industrial sectors with higher average wages. In particular, the expansion of the EV production sector, electrical equipment manufacturing (which includes batteries), and other types of manufacturing accounts for the larger wage share projected in the Electrification scenario. It is important to highlight that, under the conditions analyzed here, an expansion that favors jobs currently held disproportionately by men would widen the gender wage gap, since these jobs have higher average wages.

Figure 8

Total income (value added) generated across all sectors as a result of sales of EVs, ICEVs, fossil fuels, biofuels, and electricity (left), and functional distribution of income between wages and profits at the end of the simulations (right)



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11 Wages are considered as total compensation, which includes wages and effective social contributions - (FGTS (a Brazilian government managed severance reserve) and private pension plans. Profits include gross operating surplus and gross mixed income.

SENSITIVITY ANALYSES

The results discussed above project greater potential for job and income generation in the Electrification scenario, as well as a larger share of that income being allocated to wages. However, these results depend on the assumptions adopted in each scenario (see Box 1). In particular, the share of batteries produced domestically and the reduction in exports in the Baseline scenario have a direct impact on the results. This section evaluates how changes in these two assumptions affect the results of the Electrification scenario.

Domestic battery production and employment multipliers

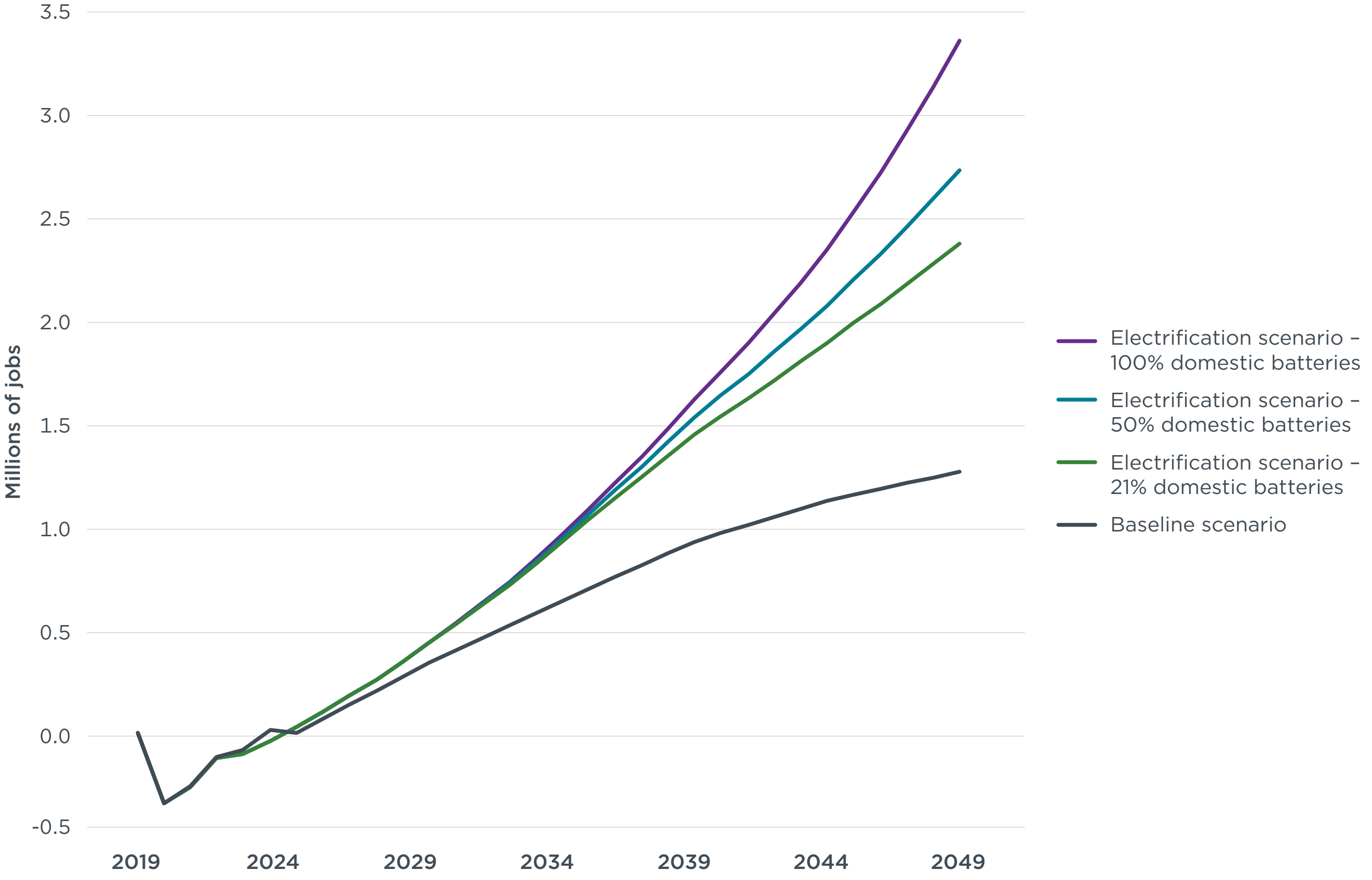
Figure 9 presents total job creation in the scenarios, adding two different trajectories for the evolution of domestic battery content in the Electrification scenario: one pessimistic and the other optimistic (the trajectories are shown in panel 3 of Box 1). The pessimistic case assumes that only 21% of batteries will be of domestic origin by 2050, corresponding to the share of total cost associated with assembling battery packs in the country using imported cells. The optimistic case assumes a faster expansion of domestic production of traction batteries, reaching 100% by 2050, compared with 50% in both the Baseline and Electrification scenarios.

The scenarios shown in Figure 9 demonstrate that increased domestic battery production leads to significant changes in the trajectory of the Electrification scenario. Even in the pessimistic case, where battery packs are only assembled in Brazil, the Electrification scenario still outperforms the Baseline scenario, generating 1.9 times more jobs, 13% less than the Electrification scenario with 50% domestic batteries.

The projection for the Electrification scenario under the optimistic case of 100% domestic battery production estimates the creation of 2.6 times more new jobs compared with the Baseline scenario, 23% more than the Electrification scenario with 50% domestic batteries.

Figure 9

Sensitivity analysis: Total jobs generated across all sectors under different trajectories for the domestic content of batteries (see Box 1, panel 3)



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Changes in domestic content directly affect the number of jobs generated in vehicle production. To assess this impact, the employment multipliers for the ICEV and EV production sectors are presented in Table 2. The multipliers represent the number of jobs associated with each additional R$1 million (in 2019 values) of final demand spent on vehicle production. They include jobs not only in the EV and ICEV production sectors themselves, but also in the sectors that supply intermediate inputs for vehicle production, such as auto parts, metals, batteries, and tires.

The results indicate that the ICEV sector generates more jobs (8.0) per million reais of demand than the EV production sector (7.0), when 50% of batteries are produced domestically. This finding is supported by the literature, which points to a reduction in the size of the workforce used by the electric automotive industry compared with that of the ICEV industry, both directly and indirectly. As highlighted above, the superior performance of the Electrification scenario is primarily the result of increased aggregate demand driven by higher EV sales. It is therefore not surprising that fully domestic battery production raises the employment multiplier of the EV sector (to 8.3), surpassing that of the ICEV sector. Finally, in the pessimistic case in which only 21% of battery production is domestic, approximately 6.2 new jobs are generated per million reais.

Table 2
Employment multipliers

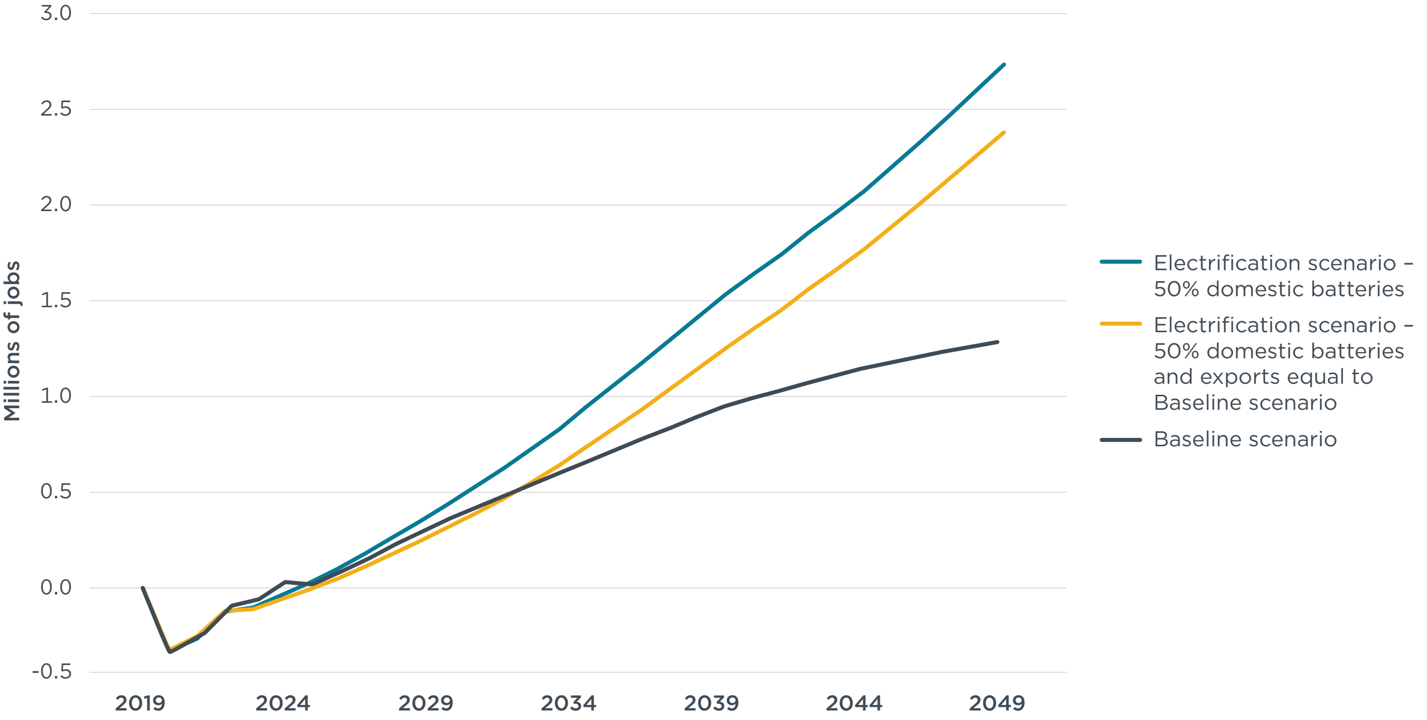
	Jobs per R$1,000,000 of gross production value
ICEVs	8,0
EVs – 21% domestic batteries	6,2
EVs – 50% domestic batteries	7,0
EVs – 100% domestic batteries	8,3

Imports and exports

Another question related to the expansion of the EV fleet concerns the impact on the external sector. As previously discussed, the Baseline scenario assumes a downward trajectory for vehicle exports (see panel 2 of Box 1), reflecting the loss of competitiveness of the Brazilian automotive sector abroad and the decline in demand for ICEVs among Brazil's main trading partners. In Figure 10, this same export trajectory from the Baseline scenario is applied to the Electrification scenario. This means assuming that the Electrification scenario is not able to prevent a loss of international market share, thereby limiting the consumption of EVs to the domestic market by 2050.

In this simulation, a declining export trajectory in the Electrification scenario reduces the number of jobs generated in that scenario, with a 13% decrease by the end of the period (2050). Although the total number of jobs generated in 2050 is still 88% higher than in the Baseline scenario, the reduction in exports causes job creation in the Electrification scenario to remain below that of the Baseline until 2032. Therefore, maintaining competitiveness and the ability to export vehicles also has a significant impact on job creation, particularly in the short term.

Figure 10
Sensitivity analysis: Total jobs generated across all sectors under different trajectories for vehicle exports (see Box 1, panel 2)



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CONCLUSION AND RECOMMENDATIONS

This study developed and simulated two scenarios for the evolution of the Brazilian vehicle fleet toward a larger share of EVs. It compared an ambitious yet feasible increase in EV adoption in Brazil (Electrification scenario) with a Baseline scenario in which ICEVs make up the vast majority of sales through 2050. In both cases, an increase in the use of biofuels in ICEVs was projected, in line with official forecasts (Ministry of Mines and Energy & EPE, 2020; EPE, 2022). Estimated sales of vehicles produced in Brazil, along with fuel and electricity demand in the Electrification and Baseline scenarios, were converted into monetary values, generating final demand projections used to estimate production value, value added (wages and profits), and the number of new jobs created between 2019 and 2050. A synthetic sector representing the intersectoral demands of EV production was constructed and added to the Brazilian input-output matrix.

The results suggest higher job creation and value added (income) in the Electrification scenario compared with the Baseline scenario. Assuming that labor productivity and technology remain constant, the number of new jobs projected was 116% higher while value added was 85% higher in the Electrification scenario. This stronger performance is due to the evolution of domestic battery content, better export performance when domestic EV production keeps pace with electrification targets in Brazil's major trading partners, and the increased value of final demand resulting from higher EV sales, which generates effects throughout the entire EV production chain.

In the sectoral composition of jobs generated, the services category stands out. This category encompasses 23 service-providing sectors and, in addition to being more labor-intensive, accounted for 64% of total employment in Brazil in 2019. Services represented nearly 80% of the jobs generated in both scenarios. The Electrification scenario resulted in a notable expansion of industrial employment, both in EV manufacturing and in the broader manufacturing industry, with particular emphasis on the electrical machinery and equipment sector, which includes batteries and electric powertrain components. On the other hand, the Electrification scenario projected an absolute reduction in jobs in ICEV production and a relative reduction in auto parts compared to the Baseline scenario. Moderate relative declines in employment were also observed in the fuels, biofuels, and agriculture sectors in the Electrification scenario.

The simulations also assessed the functional distribution of income between wages and profits in the increase of value added. In particular, due to greater job creation in industrial sectors, the share of wages in value added was higher in the Electrification scenario (53%) compared with the Baseline scenario (45%). However, assuming that the current gender distribution of employment across all sectors remains fixed until 2050, it was estimated that in both scenarios, about two-thirds of the new jobs will be held by men—a more unequal gender distribution than that observed in the total Brazilian economy in 2019.

The study also included sensitivity analyses to assess how certain assumptions, when incorporated into the scenarios, differently affect the results. First, we examined the effect of increasing the domestic content of battery production. We found that the national production of automotive batteries has a significant impact on job creation. The difference in new jobs between the optimistic case (in which 100% of batteries are domestic) and the pessimistic case (in which only battery pack assembly occurs in Brazil) is 42%. We also analyzed the impact of a decline in vehicle exports, hypothetically driven by a loss of competitiveness in international markets. As a result, we found that applying the same declining export trajectory from the Baseline scenario to the Electrification scenario reduces the number of jobs generated in the latter by 13% in 2050. This reduction caused the number of new jobs in the Electrification scenario to remain below that of the Baseline scenario until 2032.

Given these results and the current context of the national automotive industry, this analysis supports the following conclusions and considerations for public policy:

Setting more ambitious corporate vehicle emission reduction targets and introducing industrial policies to develop national production capacity for key components, especially batteries, could be part of an effective policy mix to support EV production. The new MOVER program presents opportunities to establish more ambitious emission reduction targets than those implemented in the last cycle of the Rota 2030 program (Cieplinski, 2024) and to stimulate the Brazilian EV industry. This, in turn, has the potential to direct investment toward battery electric vehicles. Increasing the scale of EV sales and domestic production could enable competitive production of key electric powertrain components, such as batteries, thereby increasing the domestic content of these vehicles. Concrete examples of industrial policies include investments and loans for new entrants (seed capital and seed loans), specialized support services in marketing, management, and technology, and the provision of guarantees, along with a trade policy that allows for a gradual transition toward greater domestic battery production.

Strengthening export-promotion policies to leverage the potential for low-emission vehicle production in Brazil could help mitigate the impacts of the transition on exports and strengthen Brazil's long-term competitiveness. The global shift toward EVs and the fleet electrification targets of some of Brazil's main trading partners represent an opportunity for domestic firms to integrate into this global value chain or attract foreign investment. On the other hand, exclusive production of ICEVs or a delayed start to domestic EV and battery manufacturing could result in the loss of international markets, a deepening of the current trend of increasing imported content in domestically assembled vehicles, and even a rise in vehicle imports. In Brazil's case, such developments could worsen the country's balance of trade with key partner economies in Latin America. If promoting export competitiveness is a government objective, export financing instruments (trade finance), export tax incentives, and financial assistance in foreign markets could be considered as ways of supporting the development of new industries (Juhász et al., 2023).

If promoting gender parity in the transition to EVs is a government objective, training and professional inclusion programs—particularly those focused on women in the workforce—could help prevent a worsening of the existing wage gap between men and women in this and other sectors. The restructuring of Brazil's vehicle fleet will have implications for gender equity in sectors directly and indirectly involved in vehicle production. Anticipating the gender impacts of the transition will be essential for designing gender-inclusive public policies aimed at ensuring that the development of the EV industry in Brazil does not create new labor market inequalities or reproduce existing ones, and for promoting greater gender inclusion in the Brazilian labor market.

The results of this study are subject to methodological limitations and assumptions inherent to the use of the input-output matrix as an analytical tool. By holding constant variables such as labor productivity, technology, relative prices between EV and ICEVs, and the gender distribution of employment across sectors, among other variables, this study presents simulations based on the current productive structure of the Brazilian economy. Future research that models the impacts of changes in these factors—and examines in greater detail the socioeconomic impacts of the transition, such as those related to gender equity—could contribute to a more comprehensive understanding of the economic effects of the transition to EVs in Brazil.

REFERENCES

ABVE. (2024, January 3). 94 mil eletrificados: 2023 bate todas as previsões [94,000 electrified: 2023 beats all forecasts]. https://abve.org.br/2023-supera-todas-as-previsoes-94-mil-eletrificados/

Alves-Passoni, P., & Freitas, F. (2020). *Estimação de matrizes insumo-produto anuais para o Brasil no Sistema de Contas Nacionais: Referência 2010* [Estimation of annual input-output matrices for Brazil in the national accounts system: 2010 benchmark]. Instituto de Economia/IE, UFRJ. https://repositorio.ipea.gov.br/bitstream/11058/13345/5/PPE_v53_n1_Artigo4_estimacao_de_matrizes.pdf

Barassa, E., Cruz, R. F., Bermúdez-Rodrígues, T., Chaves, A. F., Navarro, A. C. L., Consoni, F. & Tenure, T. M. P. (2022). *Segundo anuário brasileiro da mobilidade elétrica: o Brasil em direção ao mix de tecnologias para descarbonização e digitalização dos transportes* [Second Brazilian electric mobility yearbook: Brazil moving toward a mix of technologies for transport decarbonization and digitalization]. Plataforma Nacional de Mobilidade Elétrica. https://www.pnme.org.br/biblioteca/2o-anuario-brasileiro-da-mobilidade-eletrica-pnme/

Barret, J., & Bivens, J. (2021, September 22). *The stakes for workers in how policymakers manage the coming shift to all-electric vehicles.* Economic Policy Institute. https://files.epi.org/uploads/232751.pdf

Bauer, W., Riedel, O., Herrmann, F., Borrmann, D., Sachs, C., Schmid, S., & Klötzke, M. (2018). ELAB 2.0. *Wirkungen der Fahrzeugelektrifizierung auf die Beschäftigung am Standort Deutschland. 2. Auflage.* [Effects of vehicle electrification on employment in Germany. 2nd edition]. Fraunhofer IAO. https://publica.fraunhofer.de/entities/publication/dd906cb2-3a8e-45bc-ac15-393b0642034f

BloombergNEF. (2023, November 26). Lithium-ion battery pack prices hit record low of $139/kWh. https://about.bnef.com/blog/lithium-ion-battery-pack-prices-hit-record-low-of-139-kwh/

Castro, M. (2023, December 21). Nove estados e o DF já dão isenção ou reduzem IPVA para carros elétricos. Veja a lista. [Nine states and the Federal District already offer exemptions or reductions of IPVA for electric cars. See the list]. *O Globo*. https://oglobo.globo.com/economia/noticia/2023/12/20/nove-estados-e-df-ja-dao-isencao-ou-reduzem-ipva-para-carros-eletricos-veja-a-lista.ghtml

Cesar, L. (2024). BYD confirma início de obras da fábrica de carros elétricos no Brasil [BYD confirms start of construction on electric vehicle factory in Brazil]. *InsideEVs*. https://insideevs.uol.com.br/news/711266/byd-obras-fabrica-carros-brasil/

Cieplinski, A. (2024). *Metas viáveis para a descarbonização dos veículos leves no programa MOVER* [Viable targets for decarbonizing light-duty vehicles in the MOVER program]. The International Council on Clean Transportation. https://theicct.org/publication/o-potencial-de-descarbonizacao-do-programa-mover-explorando-variacoes-nas-vendas-de-veiculos-de-diferentes-tecnologias-ate-2027-jul24

Charette, R. (2023, January 17). How EVs are reshaping labor markets. *IEEE Spectrum*. https://spectrum.ieee.org/the-ev-transition-explained-2658797703

Chaves, A. F., Barassa, E., Paula, R. A., Cruz, R. F. & Wolffenbüttel, R. (2023). *3º Anuário Brasileiro da Mobilidade Elétrica: Rumo à expansão do mercado, políticas e tecnologias no Brasil* [3rd Brazilian electric mobility yearbook: Toward the expansion of the market, policies, and technologies in Brazil]. Plataforma Nacional de Mobilidade Elétrica. https://pnme.org.br/wp-content/uploads/2023/12/3o-Anuario-Brasileiro-de-Mobilidade-Eletrica.pdf

Chen, C., Slowik, P., & Beach, A. (2024). *Investigating the U.S. battery supply chain and its impact on electric vehicles costs through 2032.* The International Council on Clean Transportation. https://theicct.org/publication/investigating-us-battery-supply-chain-impact-on-ev-costs-through-2032-feb24/

Chu, Y., & Cui, H. (2023). *Annual update on the global transition to electric vehicles: 2022.* The International Council on Clean Transportation. https://theicct.org/publication/global-transition-electric-vehicles-update-jun23/

Empresa de Pesquisa Energética. (2022). *Descarbonização do setor de transporte rodoviário: Intensidade de carbono das fontes de energia* [Decarbonization of the road transport sector: Carbon intensity of energy sources]. https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-708/NT-EPE-DPG-SDB-2022-03_Intensidade_de_carbono_Transporte_Rodoviario.pdf

Empresa de Pesquisa Energética. (2023). *Estudos do plano decenal de expansão de energia 2032: Eletromobilidade* [Studies for the 2032 ten-year energy expansion plan: Electromobility]. https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-689/topico-640/Caderno%20de%20Eletromobilidade_PDE%202032_rev2.pdf

EY Parthenon. (2023, April 13). *Zero emission trucks cost estimation – India.* https://theicct.org/wp-content/uploads/2024/08/ICCT-Final-Report_EY-Parthenon.pdf

FEV Consulting. (2023, April 18). *Cost and technology evaluation, conventional powertrain vehicle compared to an electrified powertrain vehicle, same vehicle class and OEM.* https://www.regulations.gov/document/EPA-HQ-OAR-2022-0829-0422

Goldman Sachs. (2024, February 29). Lower battery prices are expected to eventually boost EV demand. https://www.goldmansachs.com/intelligence/pages/even-as-ev-sales-slow-lower-battery-prices-expect.html.

Government of Brazil. (2022, March 21). *Nationally determined contribution (NDC).* https://unfccc.int/sites/default/files/NDC/2022-06/Updated%20-%20First%20NDC%20-%20%20FINAL%20-%20PDF.pdf

Government of Brazil. (2023, October 27). *Nationally determined contribution (NDC).* https://unfccc.int/sites/default/files/NDC/2023-11/Brazil%20First%20NDC%202023%20adjustment.pdf

Government of Canada. (2023, December 19). *Canada's electric vehicle availability standard (regulated targets for zero-emission vehicles).* https://www.canada.ca/en/environment-climate-change/news/2023/12/canadas-electric-vehicle-availability-standard-regulated-targets-for-zero-emission-vehicles.html

Harsdorff, M., Montt, G., Rius, A., Bonnet, A., & Luu, T. (2020). *Jobs in green and healthy transport: Making the green shift.* International Labour Organization. https://www.ilo.org/publications/jobs-green-and-healthy-transport-making-green-shift

Harrison, P., Hill, N., Kollamthodi, S., Varma, A., Cerbron, S., Wells, P., . . . & Ward, T. (2019). *Fuelling Europe's future: How auto innovation leads to EU jobs.* Cambridge Econometrics. https://www.camecon.com/wp-content/uploads/2016/10/Fuelling-Europes-Future-How-auto-innovation-leads-to-EU-jobs.pdf

INMETRO. (2020). *Programa Brasileiro de Etiquetagem Veicular: Veículos leves 2020* [Brazilian Vehicle Labeling Program: Light-duty vehicles 2020*].* Instituto Nacional de Metrologia, Brasília. https://www.gov.br/inmetro/pt-br/assuntos/avaliacao-da-conformidade/programa-brasileiro-de-etiquetagem/tabelas-de-eficiencia-energetica/veiculos-automotivos-pbe-veicular/veiculos-leves-2020/view

INMETRO. (2023). *Programa Brasileiro de Etiquetagem Veicular: Veículos leves 2023 – 15º ciclo* [Brazilian Vehicle Labeling Program: Light-duty vehicles 2023 – 15th cycle]*.* Instituto Nacional de Metrologia, Brasília. https://www.gov.br/inmetro/pt-br/assuntos/avaliacao-da-conformidade/programa-brasileiro-de-etiquetagem/tabelas-de-eficiencia-energetica/veiculos-automotivos-pbe-veicular/pbe-veicular-2023.pdf/view

International Council on Clean Transportation. (2022). *Roadmap model documentation.* https://theicct.github.io/roadmap-doc/

International Energy Agency. (2022). *World energy outlook 2022.* https://www.iea.org/reports/world-energy-outlook-2022

Isenstadt, A., Yang, Z., Searle, S., & German, J. (2022). *Real world usage of plug-in hybrid vehicles in the United States.* The International Council on Clean Transportation. https://theicct.org/publication/real-world-phev-us-dec22/

Jaeger, J., Walls, G., Clarke, E., Altamirano, J. C., Harsono, A., Mountford, H., … & Tate, A. (2021). *The green jobs advantage: how climate-friendly investments are better job creators.* World Resources Institute. https://doi.org/10.46830/wriwp.20.00142

Juhász, R., Lane, N. J., & Rodrik, D. (2023). *The new economics of industrial policy.* National Bureau of Economic Research. https://www.nber.org/papers/w31538

Kohli, S., Khan, T., Yang, Z., & Miller, J. (2023). *Zero-emission vehicle deployment: Latin America.* The International Council on Clean Transportation. https://theicct.org/wp-content/uploads/2022/04/EMDE-Latin-America-briefing-A4-v2.pdf

Kuhlmann, K., Küpper, D., Schmidt, M., Wree, K., Strack, R., & Kolo, P. (2021). *Is e-mobility a green boost for European automotive jobs?* Boston Consulting Group. https://web-assets.bcg.com/82/0a/17e745504e46b5981b74fadba825/is-e-mobility-a-green-boost.pdf

Küpper, D., Kuhlmann, K., Tominaga, K., Arora, A., & Schlageter, J. (2020). *Shifting gears in auto manufacturing*. Boston Consulting Group. https://www.bcg.com/publications/2020/transformative-impact-of-electric-vehicles-on-auto-manufacturing

Levin, T. (2022, August 23). Ford is slashing thousands of jobs as it goes electric. Experts say a tidal wave of layoffs will rock the industry as it undergoes a seismic shift. *Business Insider.* https://www.businessinsider.com/ev-electric-car-auto-industry-jobs-layoffs-employment-ford-2022-8#:~:text=Both%20Ford%20and%20Volkswagen%20have,than%20an%20engine%20and%20transmission

Lutsey, N. & Nicholas, M. (2018). *Electric vehicle costs and consumer benefits in Colorado in the 2020–2030 time frame.* The International Council on Clean Transportation. https://theicct.org/wp-content/uploads/2021/06/ev_Colorado_cost_2020_20190613.pdf

Marlins, C. S., Searle, S. & Baral, A. (2014). *A guide for the perplexed to the indirect effects of biofuels production.* The International Council on Clean Transportation. https://theicct.org/publication/a-guide-for-the-perplexed-to-the-indirect-effects-of-biofuels-production/

Marques, P. R., Nassif-Pires, L.N., Taioka, T., Bergamin, J., & Lima, G.T. (2024). *Amazon green recovery and labour market in Brazil: Can green spending reduce gender and race inequalities?* Levy Economics Institute. https://www.levyinstitute.org/pubs/wp_1041.pdf

McElroy, J. (2019, April 3). EVs not easier to build, but will cut jobs. *Wards Auto.* https://www.wardsauto.com/ideaxchange/evs-not-easier-build-will-cut-jobs

Ministério de Minas e Energia & Empresa de Pesquisa Energética. (2020). *Plano nacional de energia 2050* [National energy plan, 2050]. https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/Plano-Nacional-de-Energia-2050

Ministério do Trabalho e do Emprego. (2022). *RAIS – 2022* [Database]. https://www.gov.br/trabalho-e-emprego/pt-br/assuntos/estatisticas-trabalho/rais/rais-2022

Morrison, K. & Wappelhorst, S. (2023). *Are battery electric vehicles cost competitive? An income-based analysis of the cost of new vehicle purchase and leasing for the German market.* The International Council on Clean Transportation. https://theicct.org/publication/cost-ownership-battery-electric-gasoline-car-germany-oct23/

Mulholland, E. (2022). *Cost of electric commercial vans and pickup trucks in the United States through 2040.* The International Council on Clean Transportation. https://theicct.org/publication/cost-ev-vans-pickups-us-2040-jan22/

Mulholland, E. (2023). *Europe's new heavy-duty CO_2 standards, explained.* The International Council on Clean Transportation. https://theicct.org/eu-co2-hdv-standards-explained-feb23/

OICA. (2023). *Registrations or sales of new vehicles − passenger cars* [Database]. https://www.oica.net/wp-content/uploads/pc_sales_2022.pdf

Pineda, L. (2022, October 7). *What's missing in Mexico's EV strategy?* The International Council on Clean Transportation. https://theicct.org/whats-missing-mexicos-ev-strategy-oct22/

Plötz, P., Link, S., Ringelschwendner, H., Keller, M., Moll, C., Bieker, G., Dornoff, J., & Mock, P. (2022). *Real world usage of plug-in hybrid vehicles in Europe: a 2022 update on fuel consumption, electric driving and CO_2 emissions.* The International Council on Clean Transportation. https://theicct.org/publication/real-world-phev-use-jun22/

Rennert, H., Gasser, K., Rose, P., van Arsdale, S. J., Hertle, L., & Frauenknecht, P. (2021). *Electric vehicle transition impact assessment report 2020−2040: A quantitative forecast of employment trends at automotive suppliers in Europe.* European Association of Automotive Suppliers. https://clepa.eu/wp-content/uploads/2021/12/Electric-Vehicle-Transition-Impact-Report-2020-2040.pdf

Ricardo plc. (2021). *E-truck virtual teardown study: Final report.* https://theicct.org/wp-content/uploads/2022/01/Final-Report-eTruck-Virtual-Teardown-Public-Version.pdf

Rockwell Automation. (2023). *Eighth annual state of smart manufacturing report: Automotive edition.* https://www.rockwellautomation.com/content/dam/rockwell-automation/documents/pdf/campaigns/state-of-smart-2023/8th-State-of-Smart-Manufacturing-Report-Automotive.pdf

Rodriguez, H. (2023, January 30). Por que preço dos carros vendidos no Brasil aumentou 85% em 5 anos? [Why did car prices in Brazil increase by 85% in 5 years?] *Quatro rodas.* https://quatrorodas.abril.com.br/noticias/por-que-preco-dos-carros-vendidos-no-brasil-aumentou-85-em-5-anos

Schaun, A. (2023, October 24). 5 carros elétricos novos de até R$ 150 mil para você comprar [5 new electric cars under R$150,000 you can buy]. *Autoesporte.* https://autoesporte.globo.com/mercado/noticia/2023/10/5-carros-eletricos-novos-por-ate-r-150-mil-para-voce-comprar.ghtml

Sen, A., & Miller, J. (2023). *Vision 2050: Update on the global zero-emission vehicle transition in 2023.* The International Council on Clean Transportation. https://theicct.org/publication/vision-2050-global-zev-update-sept23/

Sen, A., Miller, J., Hillman-Alvarez, G., & Rodrigues, P. F. (2023). *Vision 2050: Strategies to align global road transport with well below 2°C.* The International Council on Clean Transportation. https://theicct.org/publication/vision-2050-strategies-to-reduce-gap-for-global-road-transport-nov23

Slowik, P., Isenstadt, A., Pierce, L., & Searle, S. (2022). *Assessment of light-duty electric vehicles costs and consumer benefits in the United States in the 2022−2035 time frame.* The International Council on Clean Transportation. https://theicct.org/publication/ev-cost-benefits-2035-oct22/

Suehiro, S., & Purwanto, A. J. (2020). *The influence on energy and the economy of electrified vehicles penetration in ASEAN.* Economic Research Institute for ASEAN and East Asia. https://www.eria.org/uploads/media/Research-Project-Report/2020-14-Electrified-Vehicle-ASEAN/The-Influence-on-Energy-and-the-Economy-of-Electrified-Vehicle-Penetration-in-ASEAN.pdf

Tamba, M., Krause, J., Writzel, M., Raileano, I., Duboz, L., Grosso, M., & Vandyck, T. (2022). *Economy-wide impacts of road transport electrification in the EU.* Technological Forecasting & Social Change, 182, 121803.

UBS. (2017). *UBS evidence lab electric car teardown – Disruption ahead?* https://neo.ubs.com/shared/d1ZTxnvF2k/

Uyarra, E., Zabala-Iturriagagoitia, J.M., Flanagan, K., Magro, E. 2020. Public procurement, innovation and industrial policy: Rationales, roles, capabilities and implementation. *Research Policy, 49(1),* 103844.

Xie, Y., Basma, H., & Rodríguez, F. (2023). *Purchase costs of zero-emission trucks in the United States to meet future Phase 3 GHG standards.* The International Council on Clean Transportation. https://theicct.org/publication/cost-zero-emission-trucks-us-phase-3-mar23/

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communications@theicct.org

@theicct.org

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