The decarbonization path for the Auto sector in Brazil

ANFAVEA

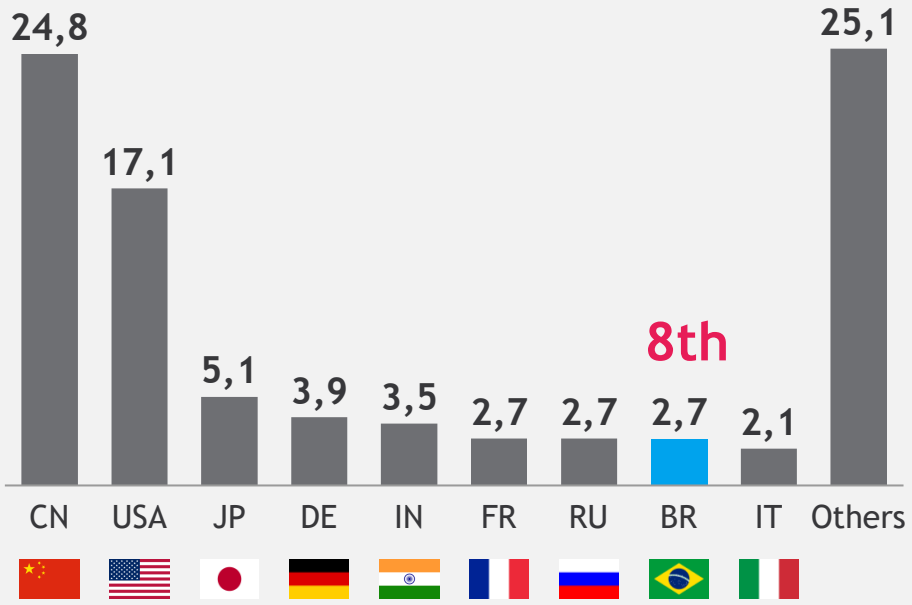
AUGUST 10, 2021

Context

Brazil is among the 10 largest automotive markets

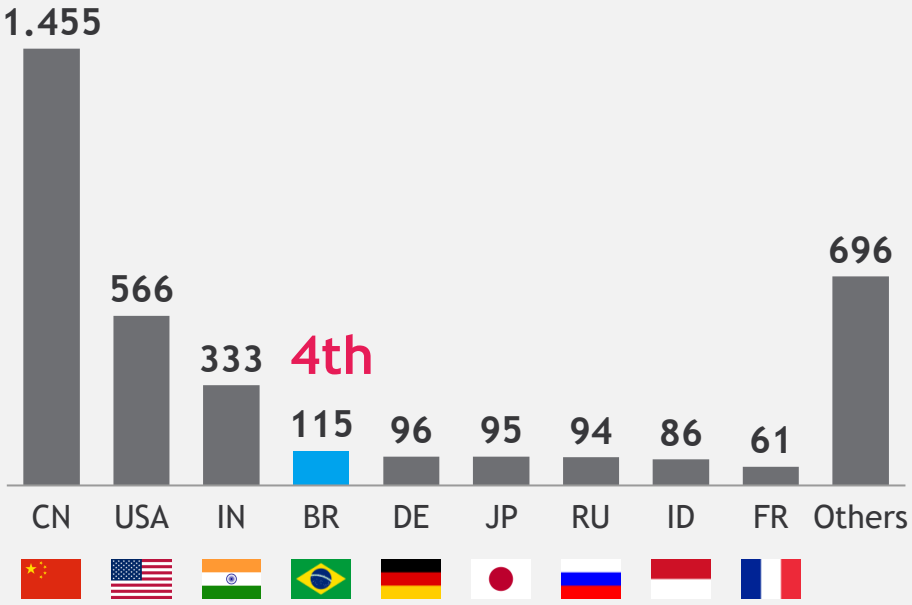
Light vehicles

Light vehicle sales in 2019 (millions)



Heavy vehicles

Heavy vehicle sales in 2019 (thousand)

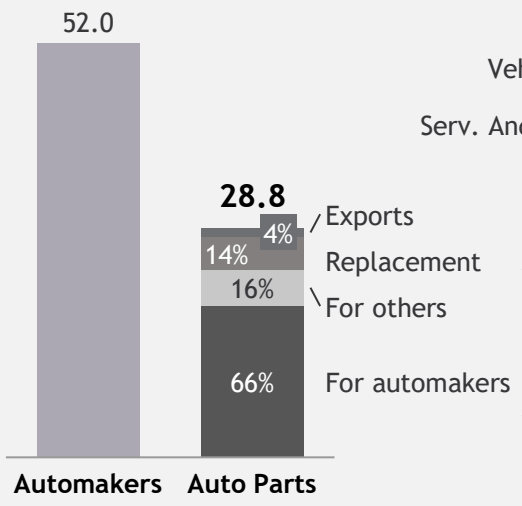


Note: Light vehicles include passenger vehicles and light commercial vehicles. Heavy vehicles include medium (6-15T), heavy (>15T) and Buses.
Source: includes content supplied by IHS Markit; Copyright © IHS Markit, Dec 2020.

Contribution of industry and the automotive chain to the Brazilian economy

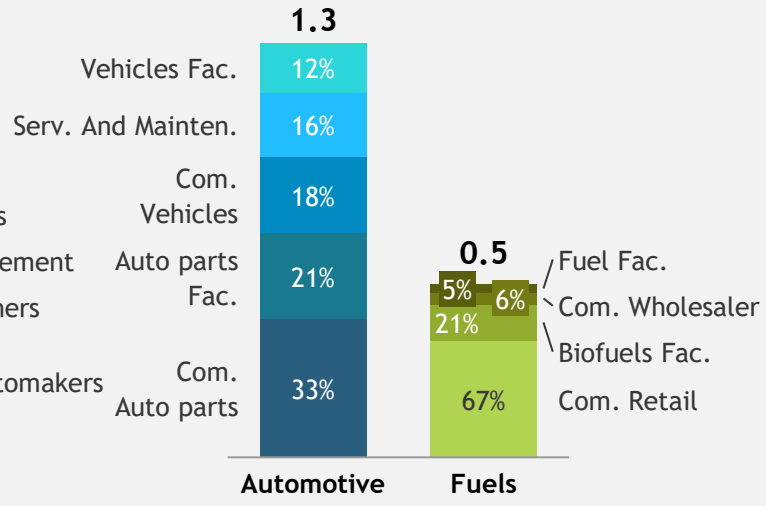
Direct revenue of >USD 80 billion

Net income
(US$ billion, 2019)



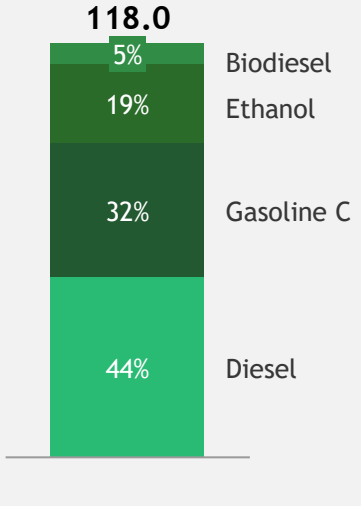
Generation of 1.8 million jobs

Formal jobs[1]
(million, 2019)



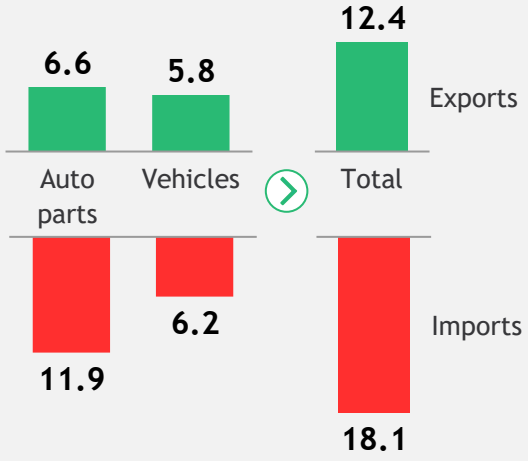
Consumption of 118 billion L fuel

Fuel consumption
(billion liters, 2019)



Expressive role in the trade balance

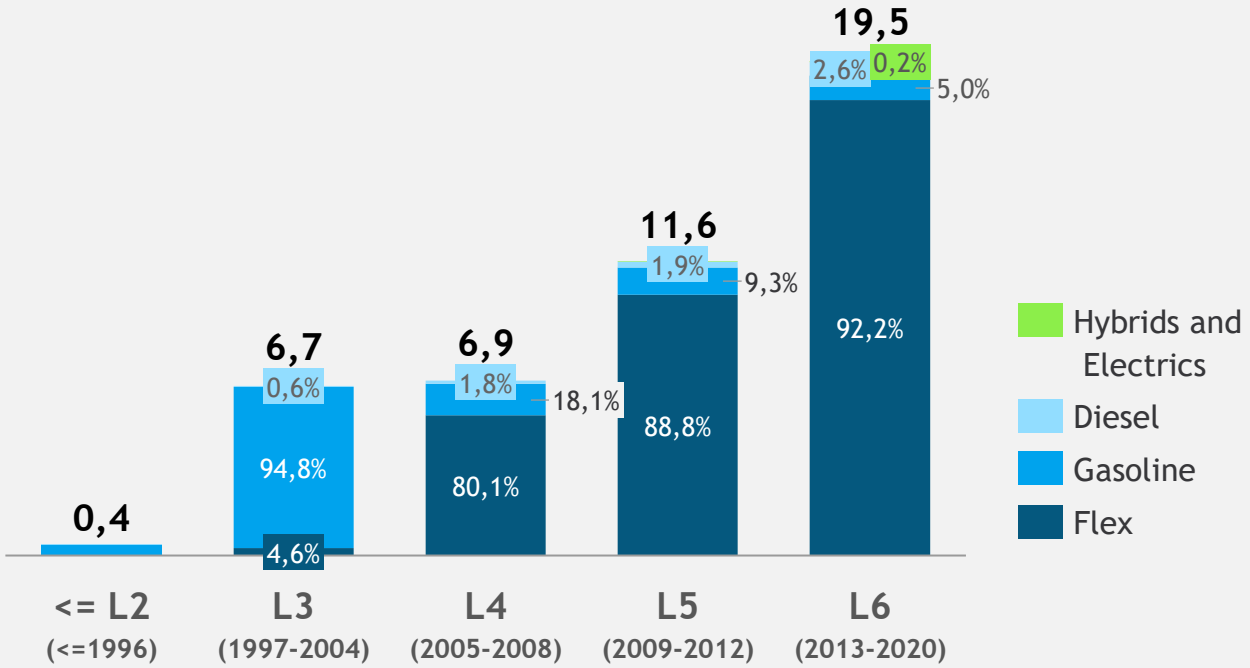
Global trade in goods[2] (USD billion, 2019)



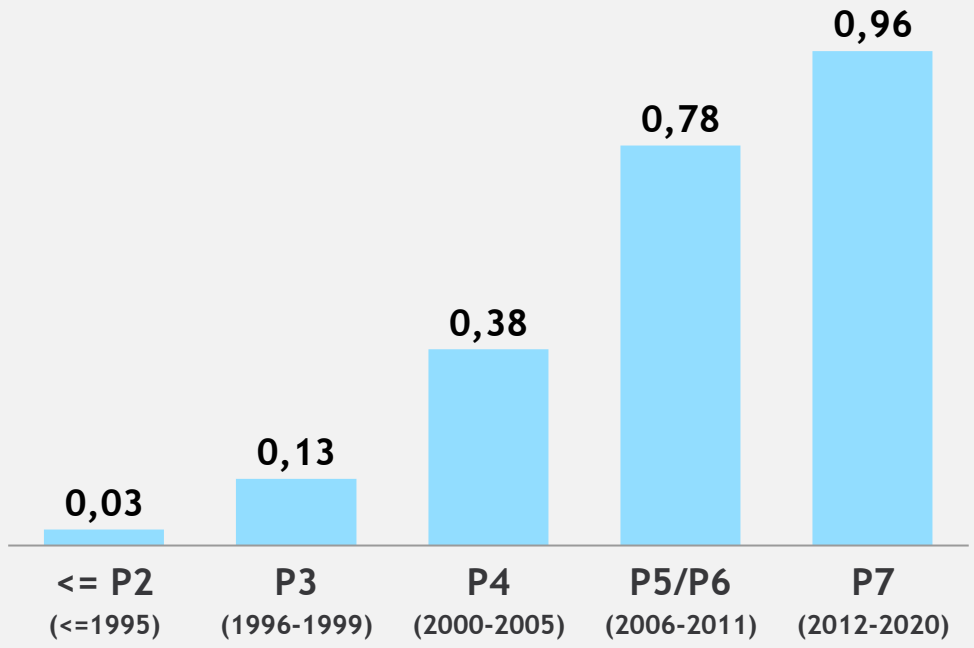
Note: Values refer to 2019. 1. includes jobs in vehicle manufacturing and MCI-related auto parts, and service & maintenance. 2. automotive sector represented 6% of Brazil's exports and 10% of imports in 2019.
Sources: Anfavea, Sindipeças, RAIS, ANP, Global Trade Atlas, Ministry of Economy

Brazilian fleet by Proconve phase

Light vehicles | Fleet in 2020 ~45 million



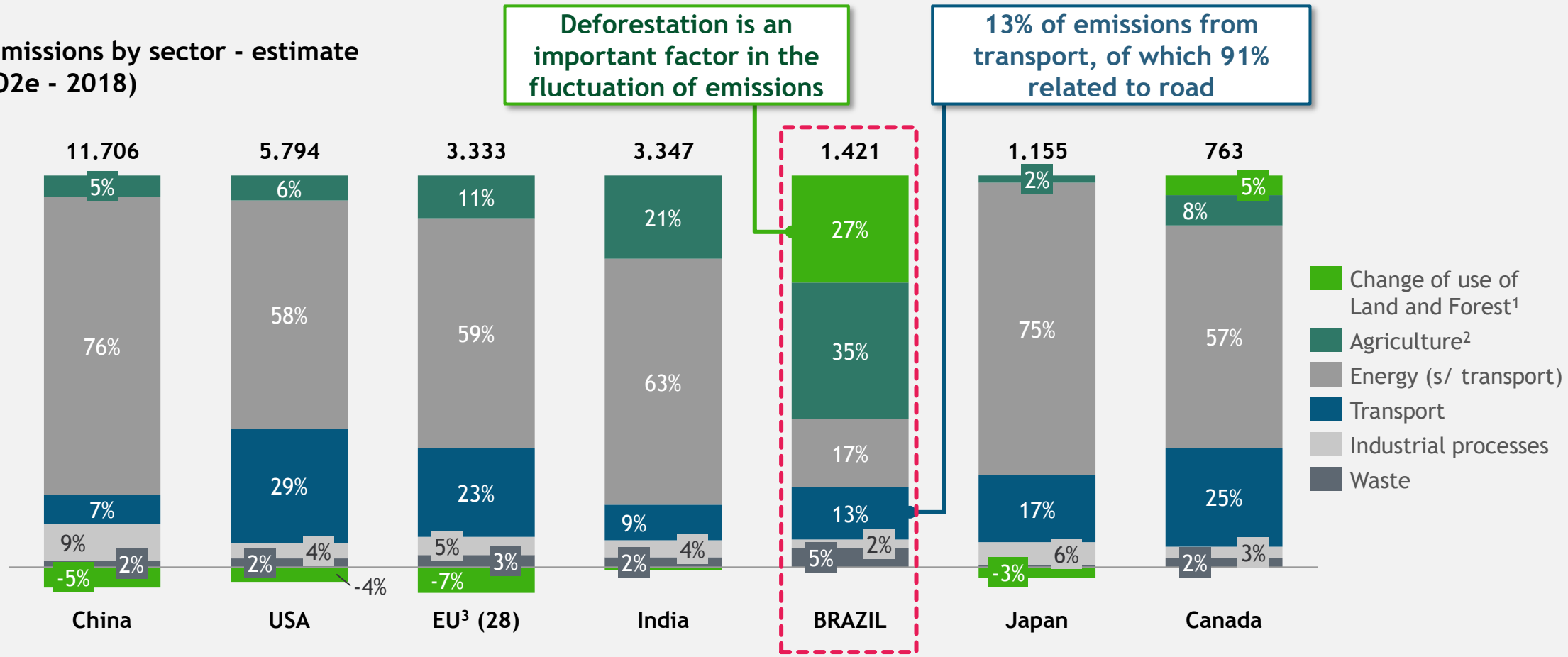
Heavy vehicles | 2020 Fleet ~2.0 million



Note: Light vehicles include passenger vehicles and light commercial vehicles; Heavy vehicles include MDT, HDT and Bus
Source: Anfavea; Sindipeças

CO2 emissions and participation of the transport sector

Net emissions by sector - estimate (MtCO2e - 2018)



1. Considers the capture and release of atmospheric CO2 by changes in land use (e.g. forest area transformed into an agricultural area). Negative values may exist by changes in land use that capture atmospheric CO2. 2. Includes livestock emissions and related to agricultural soils (fertilizers, manure, etc...) 3. Includes UK in the EU.
Source: CAIT, SEEG

Influences on Technology Routes

In a context of decarbonization, several technological routes compete for medium-long-term space

Non-Exhaustive

 Fossil Fuels	**- Petrol**	. Most common fuel for light vehicles in Brazil
	- Diesel	. Most common fuel for heavy vehicles in Brazil
	- Compressed Natural Gas (CNG)	. Natural gas solution; lower energy density
	- Liquefied Natural Gas (LNG)	. Latest solution with higher energy density
 Biofuels	**- Bioethanol**	. Mixed with gasoline or consumed individually
	- Biodiesel	. Mixed with Brazilian diesel; does not replace diesel[1]
	- Renewable/Green Diesel (HVO)	. Can be used without restrictions on current engines[2]
	- Biogas/Biomethane	. Fuel produced by biological decomposition[3]
 Electrified (xEV)	**- MHEV (Mild hybrid, 48V)**	. Low-voltage electric motor with limited power
	- HEV (Hybrid)	. Medium power, with low-speed support
	- PHEV (Plug-in hybrid)	. High power, allowing high speed.; w/ charger
	- BEV (Pure battery)	. Purely electrical solution; external charger
 Cell a Comb.	**- Fuel cell**	. Hydrogen used to generate electricity
	- Fuel cell with ethanol	. Ethanol transformed into hydrogen to power battery

Note: There are several other energy sources being researched/developed globally (e.g. Synthetic fuels, SOFC, DMFC, etc.). List contains some of the most widely used or under discussion technologies/energy sources; 1. On account of glycerin, it cannot completely replace fossil diesel (currently ~10% of diesel); 2. Molecules equal to that of mineral diesel oil; 3. Biological decomposition of organic matter in the absence of oxygen.

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Several forces influencing the evolution of technological routes

Regulation and Incentives

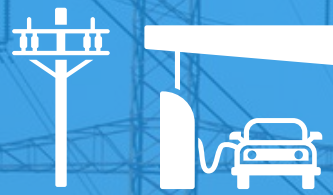
Government positioning and stimulus

Investors and Clients

Focus of investors and clients on ESG

Industry and Technology

Technological feasibility and industry development



Infrastructure

Availability of Production and Distribution Infrastructure

TCO

Total Cost of Vehicle Ownership

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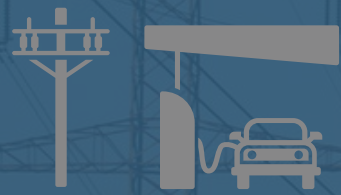

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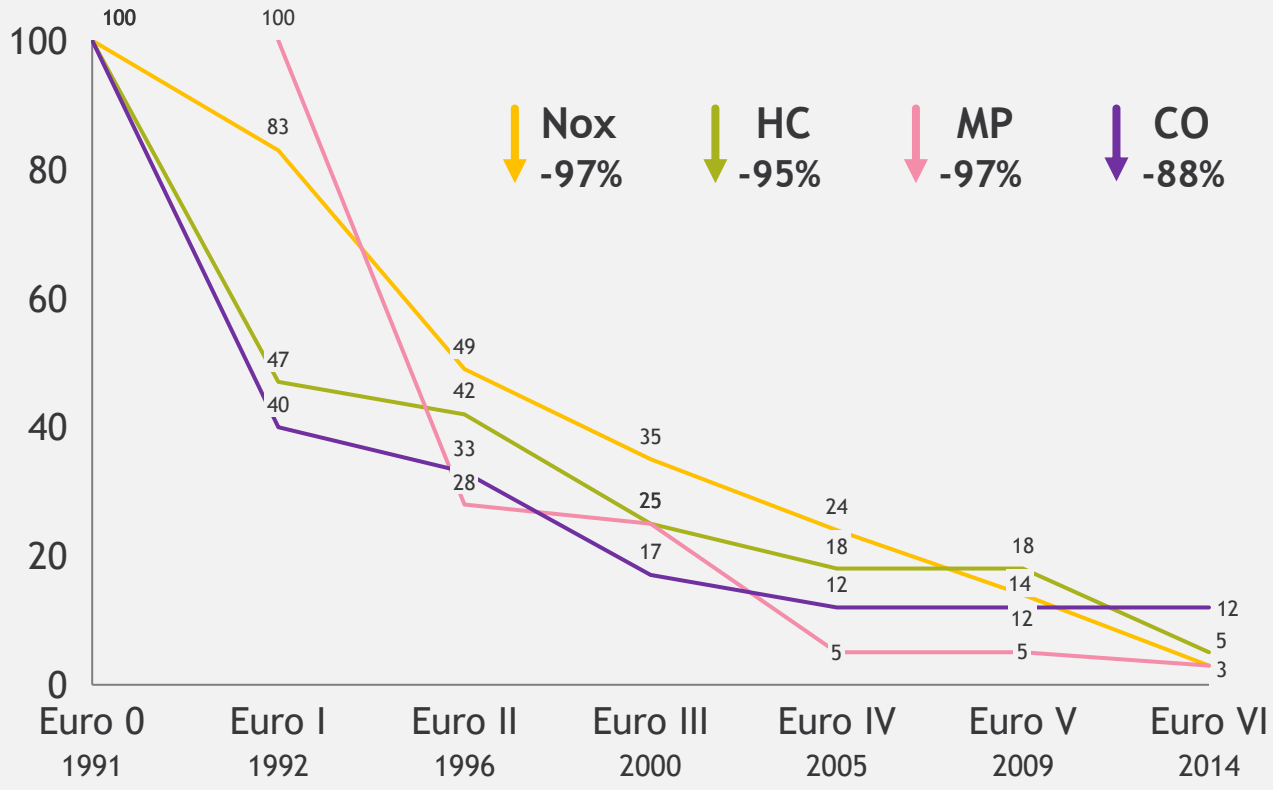
International regulations are increasingly strict, calling into question the future of combustion engines

European regulation has imposed increasingly strict limits



Note: CO = Carbon monoxide, MP = Particulate matter, HC = Hydrocarbons, NOx = Nitrogen Oxides
Source: VDA, Dieselnet, European Commission

Reactions to Euro VII proposal

France says EU push for tougher emissions rules goes too far -Le Figaro
Reuters

> *European standards should encourage and not destroy our (automotive) industry*
> *Bruno Le Maire - Minister of Finance*

EU environmental requirements for cars must be "feasible" – German transport minister
Clean Energy Wire

> *One should be bold in goals, but keep in mind the principle of what is technically possible*
> *Andreas Scheuer - Minister for Transport*

German engineers warn new EU emission rules could spell end of combustion engine
Clean Energy Wire

> *Current regulatory plans represent a ban on MCIs by the "back door" [...] an abrupt end to MCIs*
> *VDMA (Engineering Federation)*

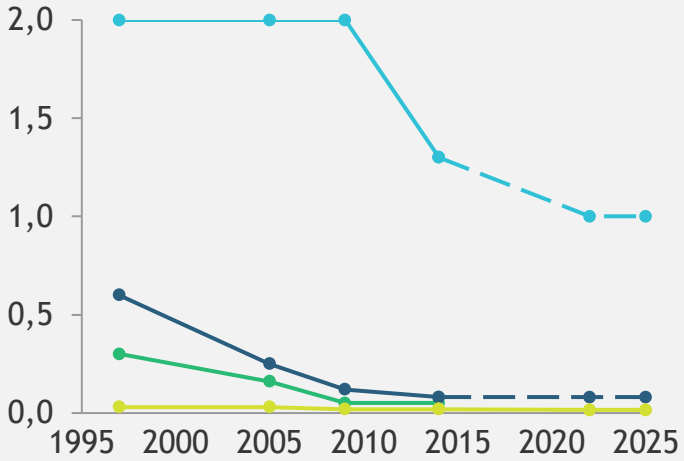
Brazilian regulation follows international references, but without direct link to greenhouse gases

Examples

Proconve: Progressive reduction of pollutant limits in several phases

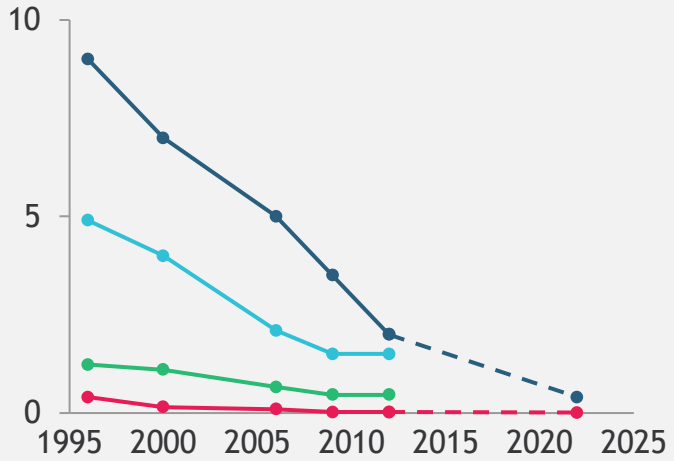
Light

Emission limits (g/km)



Heavy

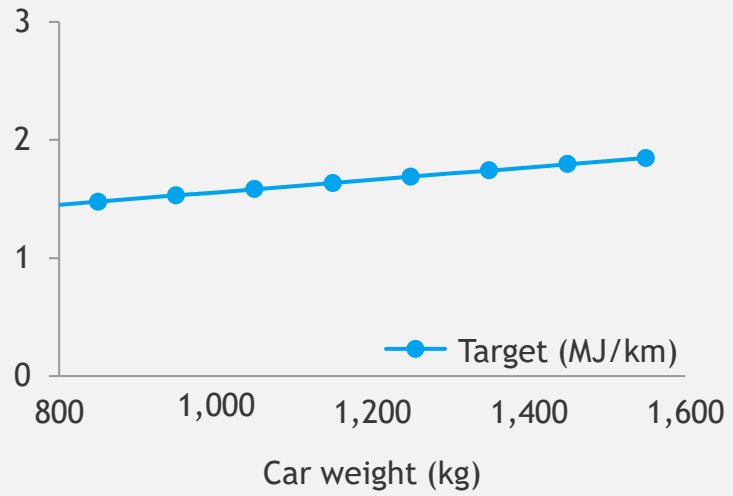
Emission limits (g/kWh)



CO HC NOx Aldehydes MP

Route 2030: Control of energy efficiency levels

Example: Energy efficiency target for cars (1,564 kg) (MJ/km) from Oct/2022



Note: CO = Carbon monoxide, HC = Hydrocarbons, NOx = Nitrogen Oxides, MP = Particulate Matter
Source: Anfavea

In parallel to emission regulation, several routes are encouraged by public policies

Examples

Politics		Encouraged Route	Launch	Leadership
RenovaBio	National Biofuels Policy (Renovabio)	Biofuels (e.g. Ethanol, Biodiesel, etc.)	2016	MME
BIODIESEL	National Biodiesel Production and Use Program (PNPB)	Biodiesel	2004	MAPA
NOVO MERCADO DE GÁS	New Gas Market	Natural Gas / Biogas	2019	MME
	Discounts on Import Tariffs for xEVs	Electric	2015	Ministry of Economy
	IPI discount for xEVs	Electric	2020	MDIC
	DISCOUNT ON IPVA for xEVs	Electric	-	State Governments
COMBUSTÍVEL DO FUTURO	Fuel Program of the Future	Shaft on cycle Otto, Diesel, Hydrogen, etc.	2021	MME
	National Hydrogen Program	Hydrogen	In preparation	MME

Note: MME - Ministry of Mines and Energy; MAPA - Ministry of Agriculture, Livestock and Supply; MDIC - Ministry of Industry, Foreign Trade and Services; xEVs - electrified vehicles

External references point to the need to focus on specific objective and stimuli for the development of new routes

	Europe	USA	China	India
Goal	Control of greenhouse gas emissions	Control of greenhouse gas emissions	Emission control Technological leadership	Urban pollution Energy security Exports[2]
Route prioritized[1]	Electrification	Electrification	Electrification	Electrification (2W) Gas/Biocomb. (short term in 4W)
Examples of regulation and stimuli	Maximum vehicle emission 95 g CO2/km	Minimum number of ZEVs (unissued vehicles) sold per year by OEMs	Implementation of China VI (equivalent to Euro VI)	Implementation of BS VI for internal combustion vehicles
	Reduction of up to € 5 K to 6 K of the value of electric vehicles	Up to $7.5K in electric vehicle tax credit	Credit program for EVs has been replacing subsidies in the value of the vehicle[3]	FAME[4] Grant Program

Note: ZEV - Zero Emission Vehicle; 2W = 2-wheel vehicles (motorcycles and scooters); 4W = 4-wheel vehicles (passengers)
1. Other routes have received stimulus in these regions; 2. Indian production must adapt to the need for electrification observed in other parts of the world; 3. Subsidies granted to OEMs according to BEV autonomy. As much as 50% of vehicle value in 2018; 4. Promoted $130 M in subsidies for 2W and 3W electric, hybrid, e-cars and e-buses in 2015. FAME II, starting in 2019, will promote $1.4 B in incentives for EV purchases and charging infrastructure development; Source: Press search; Expert interviews; Brokers' reports; BCG analysis

Methodology of measurement and reporting of emissions will be important in the definition of the Brazilian route

Measurement methodology		Emissions (g CO2 /km)	Average emission[1] (g CO2 /km)
Tank to wheel *Only the emission co2 in the exhaust*	Gasoline C[2]	149	144
	Ethanol	136	
Well to wheel *Including production, refining and distribution*	Gasoline C[2]	151	112
	Ethanol	46	

-22%

Estimate including carbon capture (sugarcane-based ethanol)

Ethanol in the Brazilian mix generates variation in the measurement of CO2 emissions, depending on the measurement methodology

1. Considering proportion of the national consumption of gasoline and ethanol 2019 (63% gasoline, 27% ethanol); 2. Petrol values A of 153 g/km wheel ed if and ~185 g/km well by wheel

Notes: Emissions for Hyundai IONIQ and Hyundai i30, similar attributes, ethanol emissions buoyed According to Embrapa study; Brazilian energy matrix emits 88g/CO2/kWh; Gasoline considers 27% ethanol;. Source: press search, Embrapa, "Synthesis Report, 2019" - EPE

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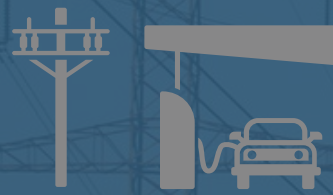


Infrastructure

Availability of Production and Distribution Infrastructure

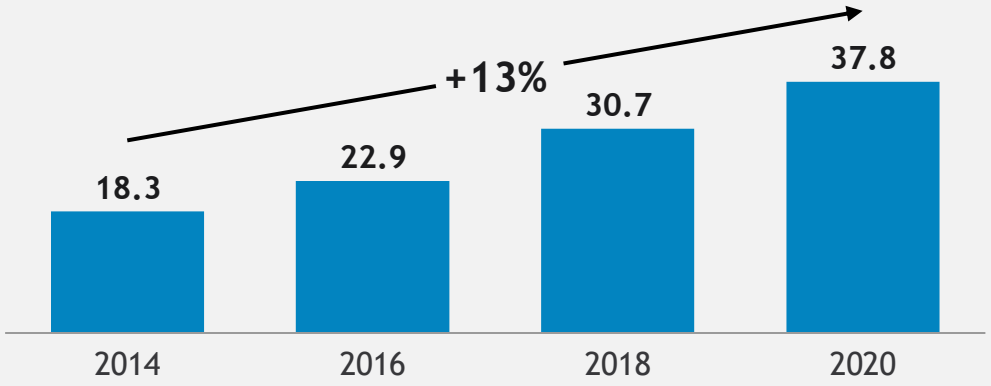
TCO

Total Cost of Vehicle Ownership

Investments in sustainable funds have grown rapidly

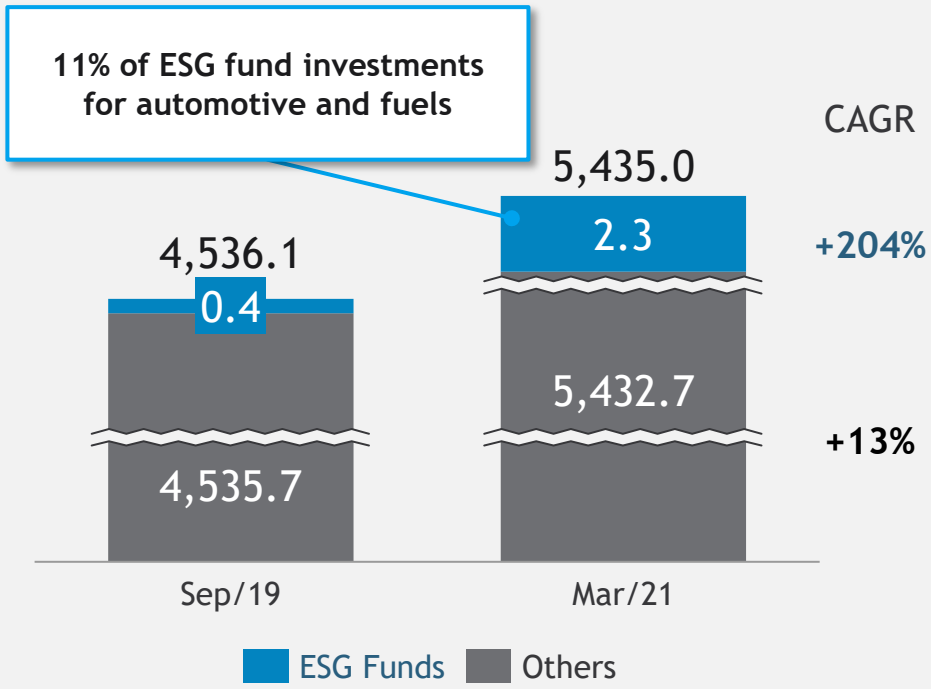
Equity invested in sustainable funds grows globally

Net Worth of ESG Funds worldwide (US$ trillion)



ESG funds are still a small share of investments but growing rapidly

Shareholders' Equity of Investment Funds in Brazil (R$ billion)

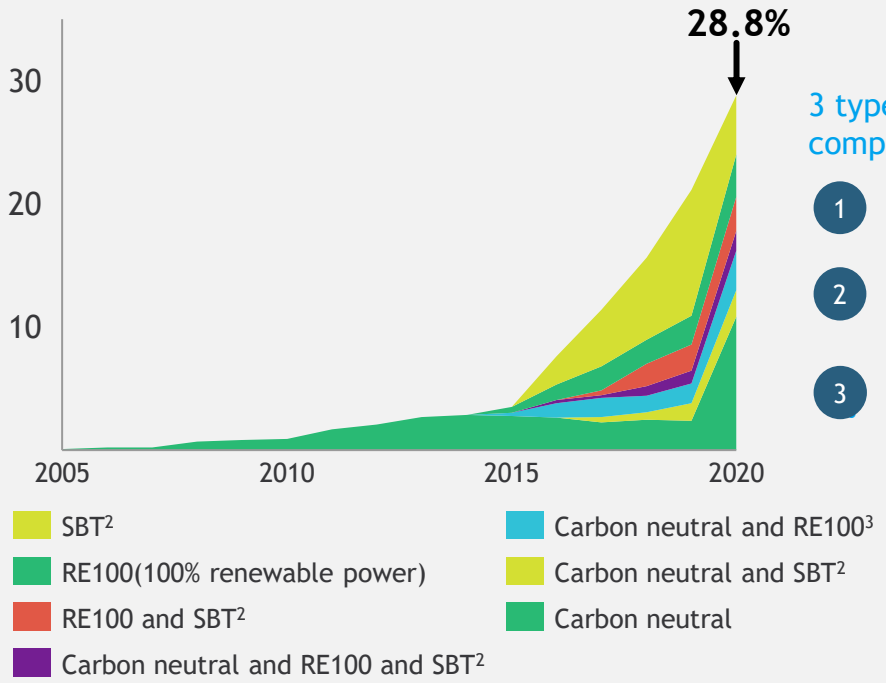


Note: ESG - Environmental, Social and Governance; CAGR - compound annual growth rate
Source: Companies websites; Interviews; ANBIMA; ESG Fund Portfolio

Brazilian companies follow global trend and start to announce targets for reducing emissions

Globally, companies are increasingly announcing targets for reducing emissions

Percentage of Fortune 500 Global[1] companies



3 types of compromises:

1. Carbon neutral
2. Use of 100% renewable sources[3]
3. SBT[2] Service

Ambitious emission reduction targets - some examples

- ambev: Target of reducing carbon emissions in your chain by 25% by 2025
- JBS: Zero the balance of your greenhouse gas emissions by 2040
- L'ORÉAL: Be carbon neutral by 2025, with the possibility of achieving it in 2021 (BR)
- Uber: Fully electric and carbon-free platform by 2040

1. 2020 data. 2. SBT (Science-Based Targets) Science-based emission reduction targets 3. RE100 (Renewable Electricity 100%): Targets for the use of electricity from renewable sources. Source: News; Deeds Not Words: The Growth of Climate Action in the Corporate World, September 2019 – Natural Capital Partners

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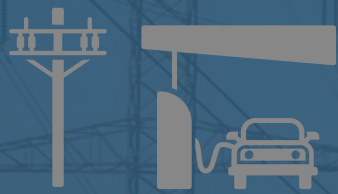

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Availability of Production and Distribution Infrastructure

TCO

Total Cost of Vehicle Ownership

Several alternative routes have been evaluated in Brazil

Examples

Light vehicles

Heavy vehicles

Biofuels

"Licensing of second generation technology can be essential for ethanol to be a global commodity" - *Jun.21*

"Scania launches trucks and road buses powered by CNG and/or biomethane in Brazil" - *Feb.21*

"Bosch studies investments in HVO for buses and trucks in Brazil" - *Dec.19*

Electric

"Automakers announce new models of electric cars that will be launched in Brazil" - *Apr.21*

"Companies prepare for the production of electric trucks, moving towards the electrification of their portfolio of commercial vehicles" - *Feb.21*

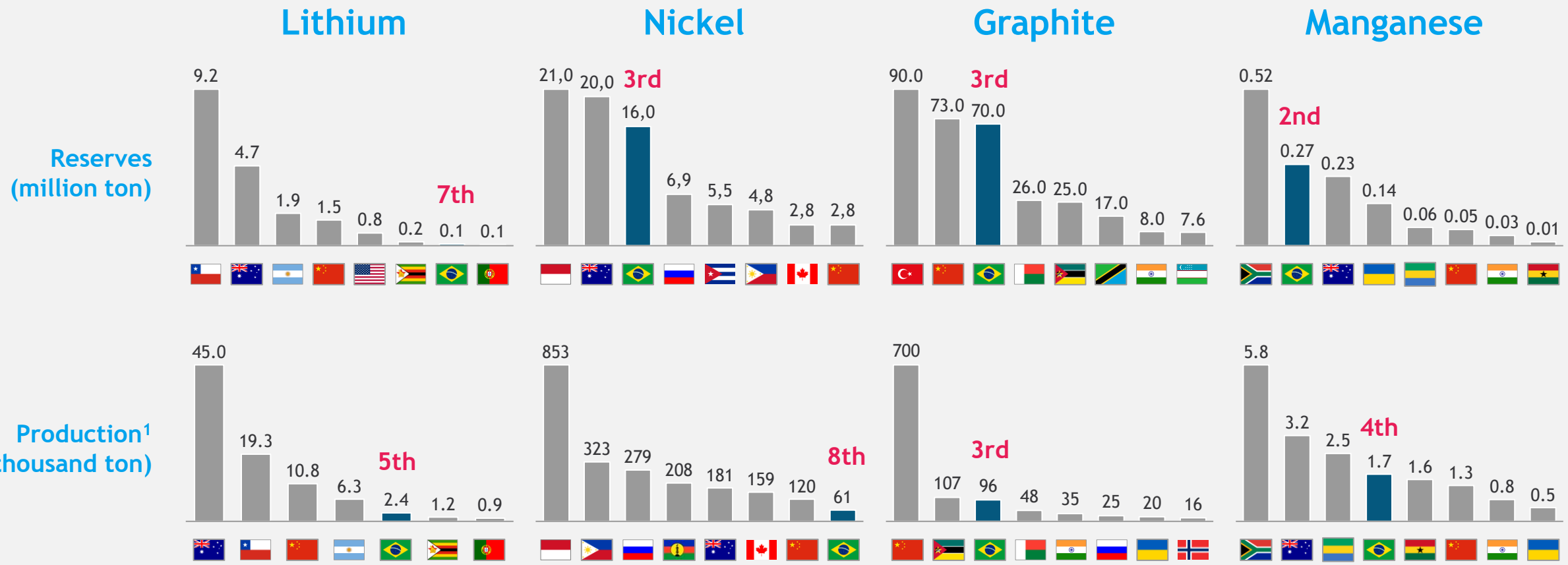
Fuel Cell

"Companies focus on the development of fuel cell technology powered by ethanol" - *Feb.21*

"Volvo and Daimler partner for the development, production and marketing of fuel cell systems" - *Mar.21*

Source: News; Company websites

Brazil and neighboring countries have vast reserves of raw materials used in the production of batteries...



1. 2019 data. Note: Lithium may be present in the battery button and as dissolved salt in the liquid electrolyte. Graphite is the main material used in lithium ion battery anodes. Nickel, manganese and cobalt are the main materials used in the core of EVs batteries, in different proportions. Cobalt was produced in Brazil by Votorantim until 2016, when production units were paralyzed. In 2015, Brazil produced 3.8 k ton of cobalt and had 70 k ton of reserves. Source: Statista; Mineral Commodity Summaries 2021; InnoEnergy; BCG analysis

… but local production of xEVs requires billion-dollar investments

Examples

Research & Development

"**invests US$ 185M in** a research and development center for EVs batteries." - *Apr.2021*

"Plans to **invest US$ 11.8B (R$ 60.4B)** by 2025 to develop and manufacture hybrid and electric vehicles." - *Nov.2017*

"**will invest US$ 11B** in 10 new all-electric models by 2022." - *Mar.2017*

Batteries

"Nissan will invest **more than US$1.8B** (US$9.2B) in new EVs battery factories in Japan and UK." - *May 2021*

"GM and LG to **invest $2.3B (R$** 11.8B) in a lithium-ion battery cell plant in the USA." - *Apr.2021*

"Announcements of factories for the production of lithium ion cells in Europe are between **€ 900 M to € 2 B (R$ 6B to 12B).**" - *Dec.2019*

Vehicles

"GM announced that **it will invest US$1B** in an electric vehicle plant in Mexico." - *Apr.2021*

"GM announced investment **of US$ 2.2B (R$** 11.3B) in factory for EVs production." - *Apr.2021*

"Mercedes plans **to invest US$1B in** factory for electric SUVs and batteries in Alabama (USA)." - *Sep.2017*

Note: Considering the Dollar = R$5.12 and Euro = R$6.19.
Source: News and website of companies

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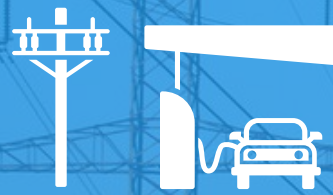

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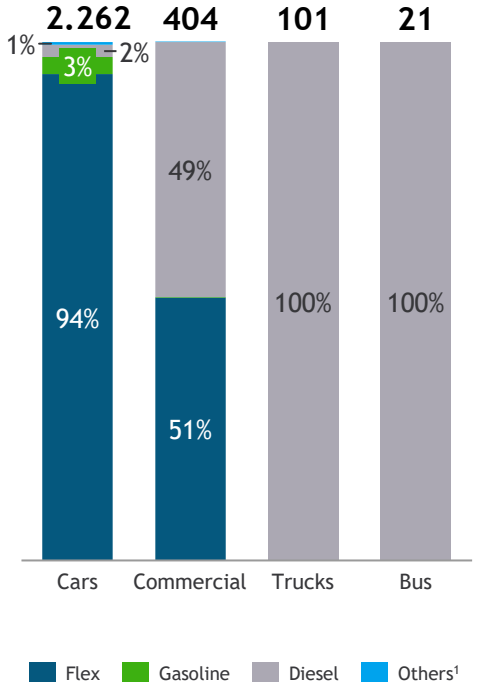
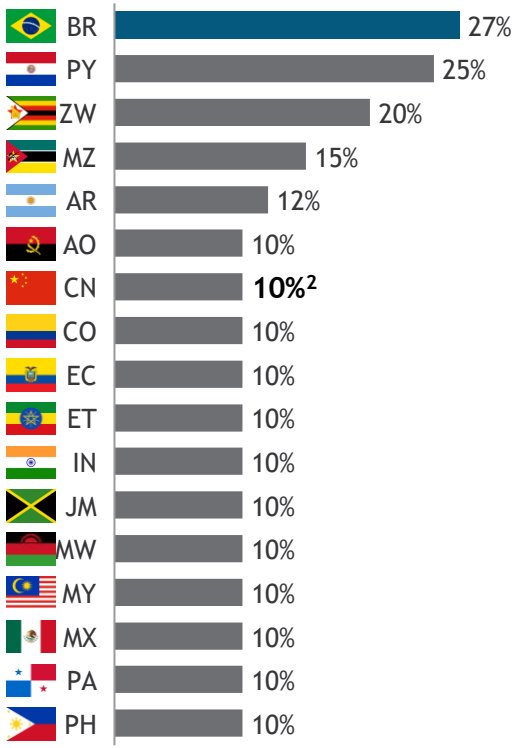
Total Cost of Vehicle Ownership

Widespread availability of flex cars and ethanol production allow greater biofuel relevance in Brazil vs. other countries

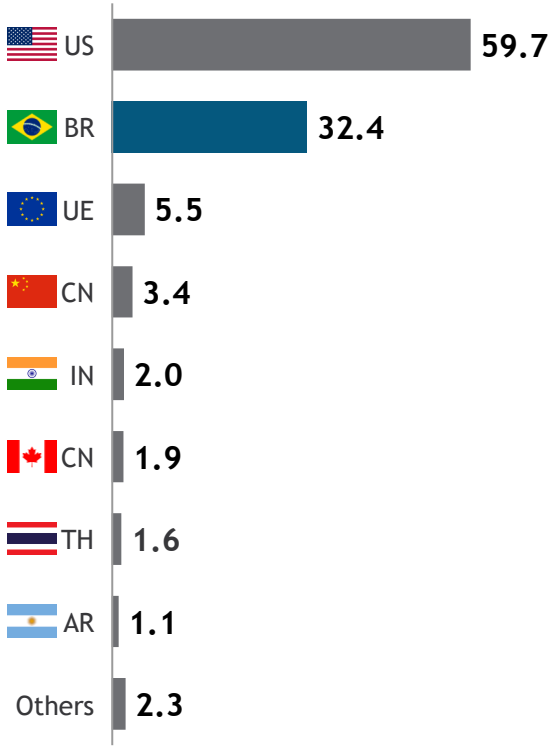
Licensed vehicles in 2019 (k)



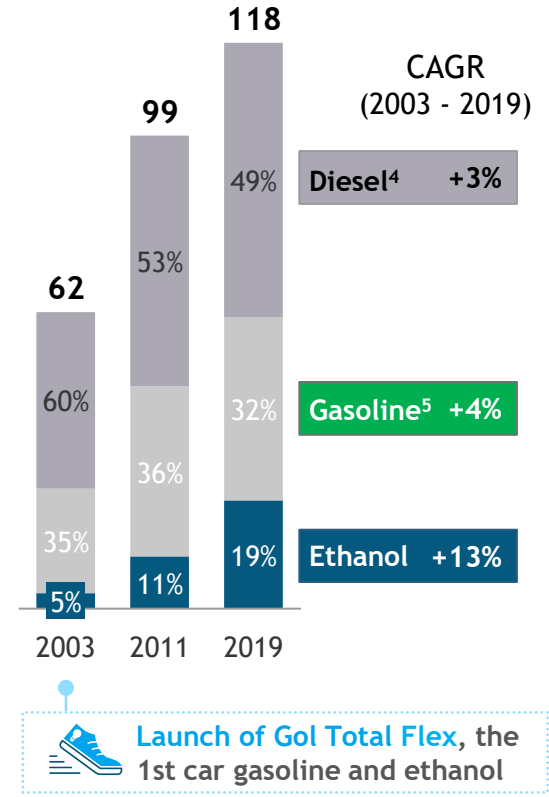
Amount of ethanol required in gasoline (%)



World ethanol production in 2019³ (billion liters)



Sale of fuels by distributors (millions of m³)



1. "Other" includes Electric, Hybrid and an insignificant number of vehicles that only use ethanol. 2. In 15 regions. 3. World ethanol production of 109.9 Billion liters in 2019. 4. Includes biodiesel. 5. Gasoline C Note: USA does not have a national requirement of the amount of ethanol in gasoline - but on average, gasoline consumed has 10% ethanol by volume. Source: Anfavea; ANP; Renewables 2020 - Global Status Report; ETENE Sector Notebook 2020

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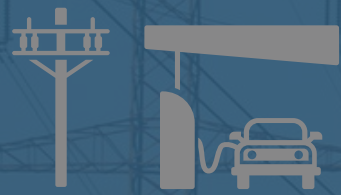


Infrastructure

Availability of Production and Distribution Infrastructure

TCO

Total Cost of Vehicle Ownership

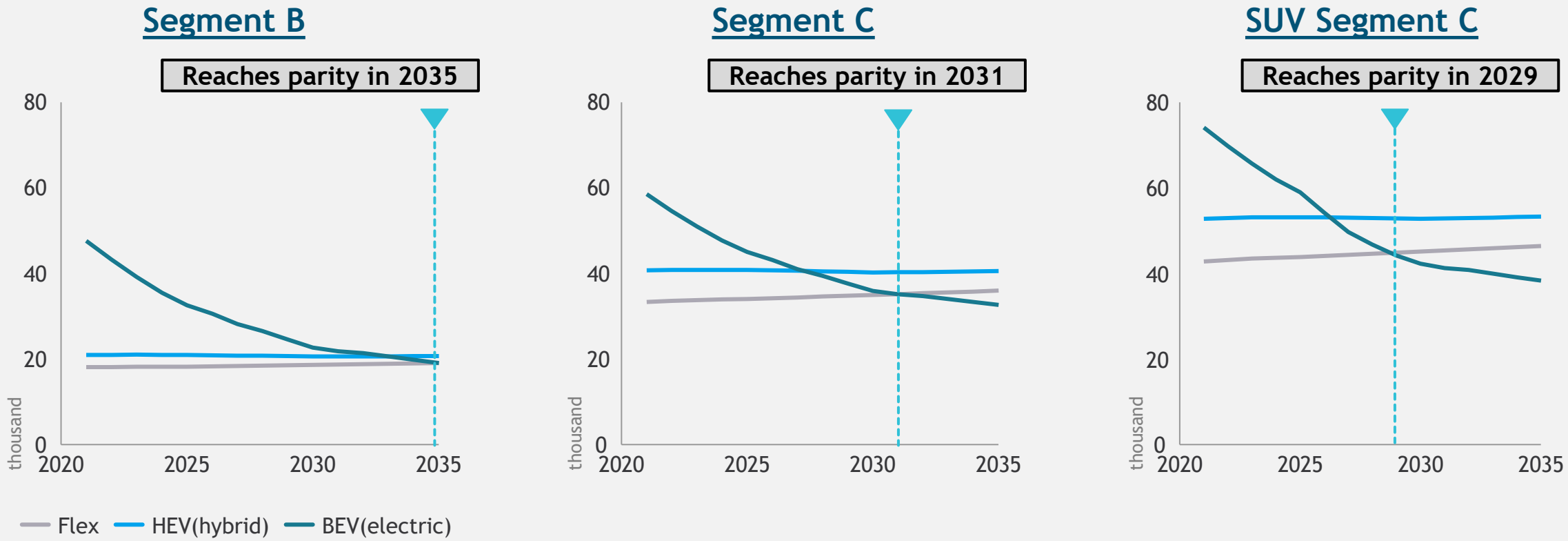
Main factors influencing the analysis of TCO

Dimension	Approach
Acquisition cost	• Current acquisition cost based on market price/external references • Projections follow global references
Financing cost	• Cost of financing based on average market rates
Replacement cost battery	• Estimated cost for battery replacement by wear and tear
Fuel cost	• Based on efficiencies, autonomies, fuel prices and mileage • MCI and xEV performance improvement projections follow global benchmarks
Maintenance cost	• Cost for MCI and flex vehicles based on market references • Costs for HEVs and BEVs estimated from international references
IPVA	• Cost of IPVA in the state of São Paulo used as a reference
Residual value	• Residual value assessed on the basis of market references and vehicle mission

Light vehicles | For personal use, BEV to ICE parity reached around 2030 onwards, varying according to segment

Total cost of ownership for light passenger vehicles (12,000 km/year - R$/year)

ESTIMATES



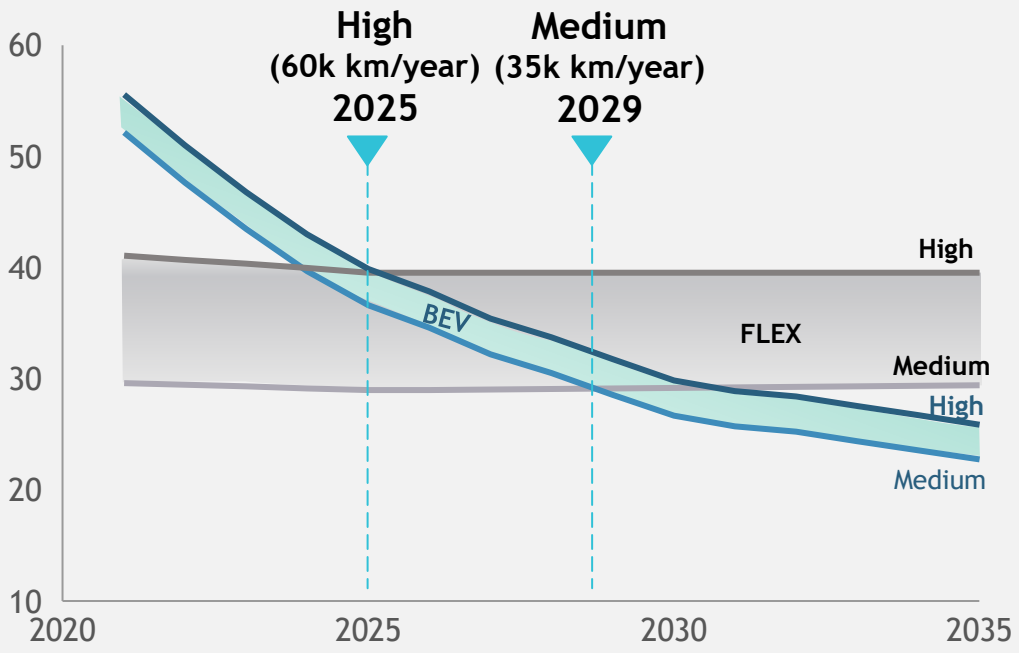
Note: Segment B: Includes Onix, HB20; Segment C: Includes Civic, Corolla; Segment SUV C: Includes Compass, HEV - Hybrid Electric Vehicle; BEV - Battery Electric Vehicle
Sources: Anfavea, Inmetro, automakers' websites, FIPE, ANP, ANEEL, BCG global projections, Bacen, BCG analysis and estimates

For specific missions such as ride hailing, parity could be reached in the middle of this decade

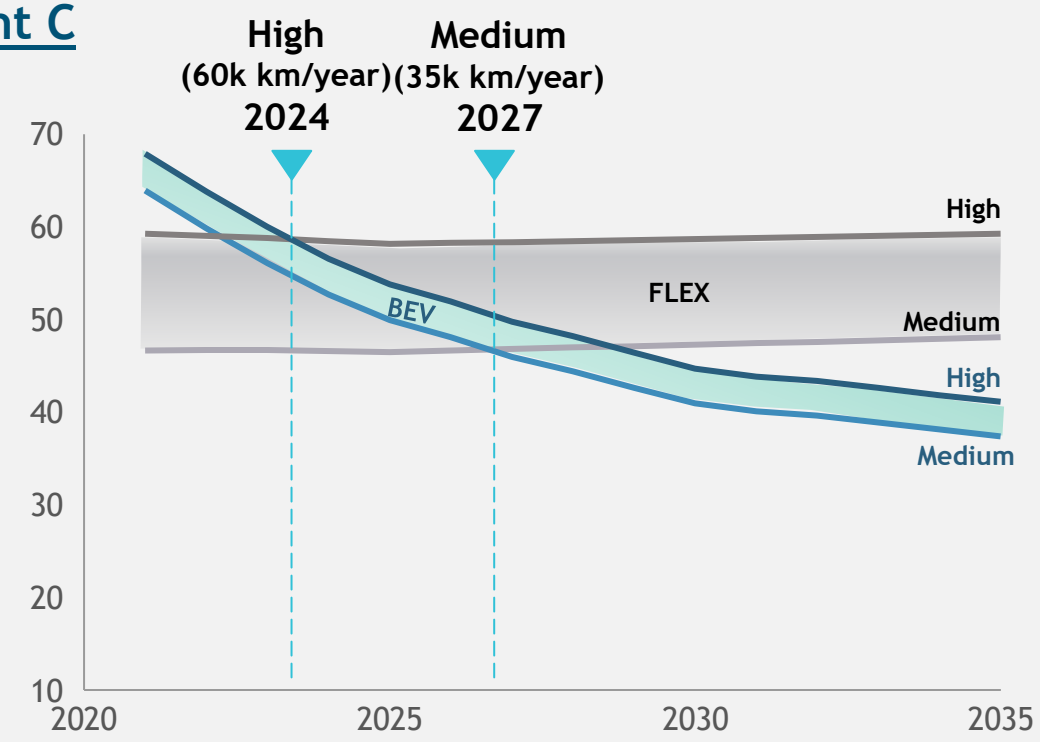
ESTIMATES

Total cost of ownership for professional light vehicles, per level of use (R$ thousand/year)

Segment B



Segment C

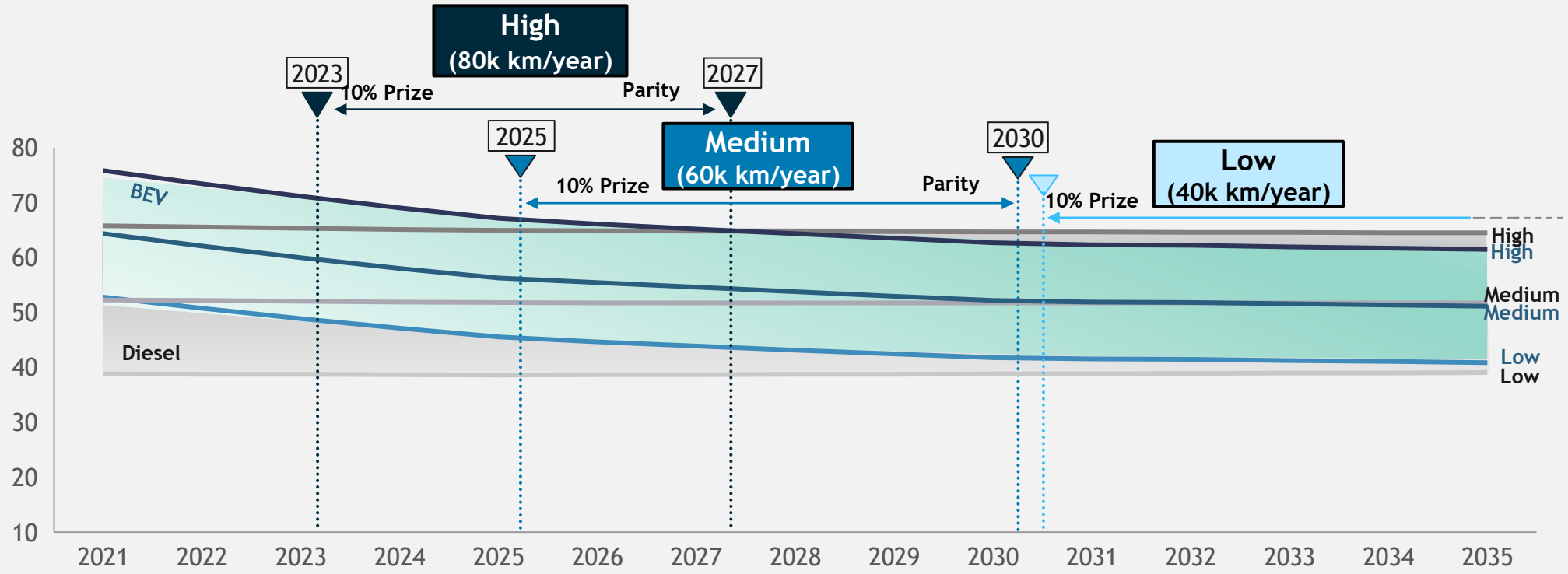


Note: Includes financing cost; BEV - Battery Electric Vehicle
Source: Anfavea, Inmetro, automakers' websites, FIPE, ANP, ANEEL, BCG global projections, Bacen, BCG Analysis

Urban light trucks | Willingness to pay premium may anticipate transition, particularly in cases of heavy use

ESTIMATES

Total cost of ownership for 11 years for urban trucks, per level of use (R$ thousand/year)



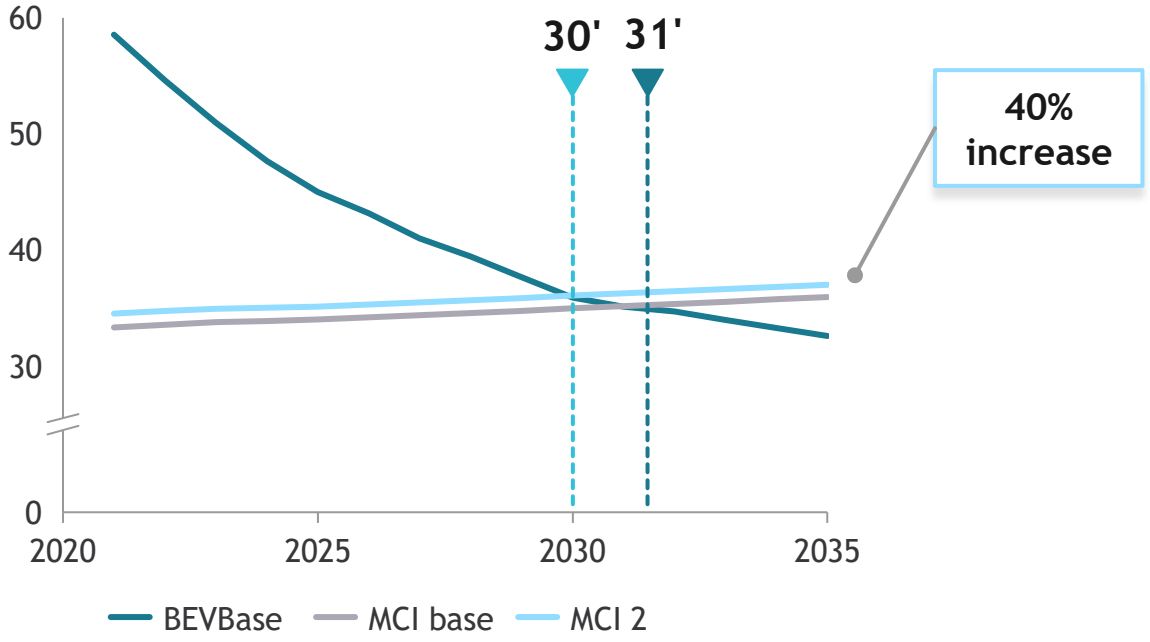
Note: Includes cost of financing, acquisition, battery replacement for BEV, fuel, maintenance, IPVA and residual value. Acquisition cost of Diesel vehicle increases in the period, but is offset by the improved efficiency of the engine; BEV - Battery Electric Vehicle
Source: Anfavea, Inmetro, automakers' websites, FIPE, ANP, ANEEL, BCG global projections, Bacen, BCG Analysis

Higher fuel prices or faster reduction in battery cost can accelerate adoption of xEVs

Examples of light vehicles

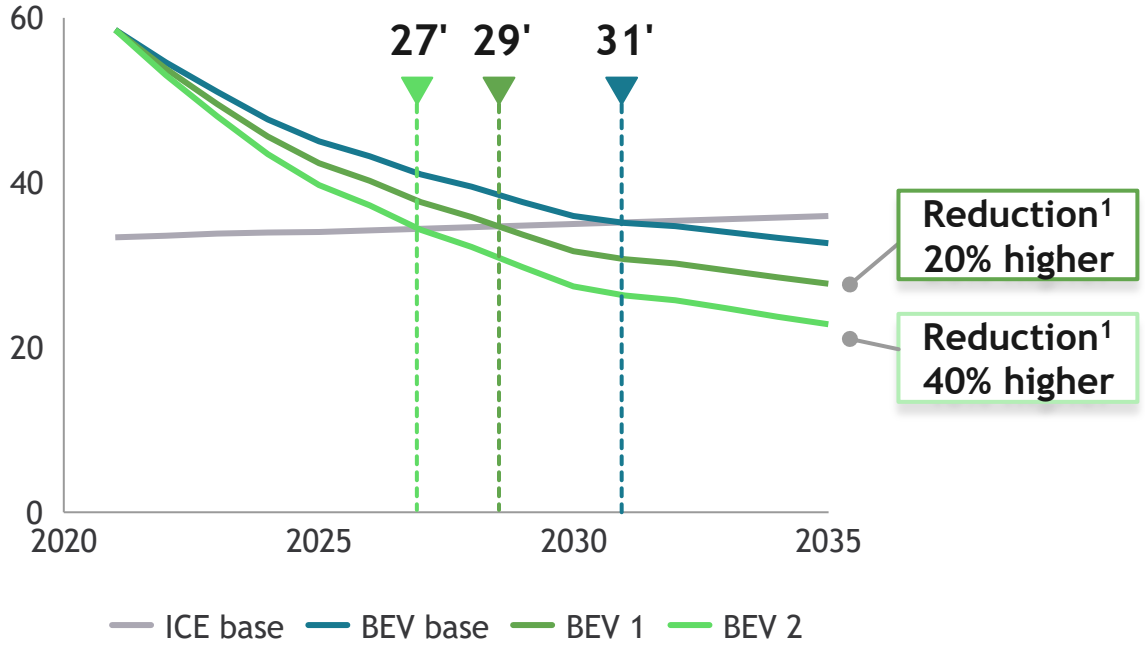
Increase in gasoline price by 40% can anticipate parity in a year

TCO segment C ride (12,000 km/year) with different values price of gasoline (R$ thousand)



Faster drop in electric powertrain cost can anticipate TCO parity significantly

TCO segment C ride (12,000 km/year) with different reductions of the cost of the electric powertrain (R$ thousand)



1. Reductions refer only to the specific cost of the electric powertrain, not the complete cost of the vehicle.
Sources: Anfavea, Inmetro, OEMs' websites, FIPE, ANP, ANEEL, BCG global projections, Bacen, BCG analysis

Development scenarios

BCG ANFAVEA

BCG Study: The decarbonization path for the Auto sector in Brazil

Context and local forces

Industry context in Brazil

Forces that influence the evolution of technological routes

- Regulation
- Cost and technology
- Infrastructure
- ...

Development scenarios

What are possible future scenarios of electrification and decarbonization in Brazil?

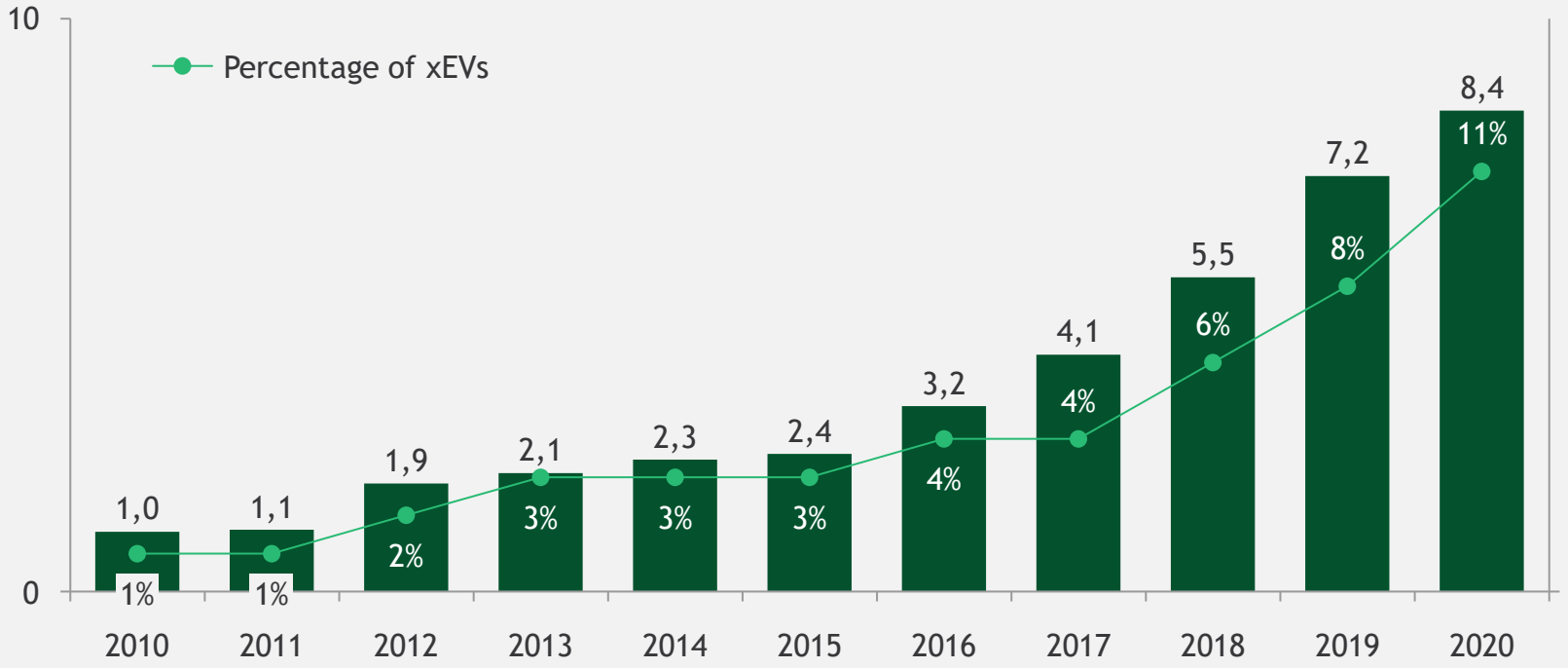
What implications and externalities in each scenario?

International trends and case studies

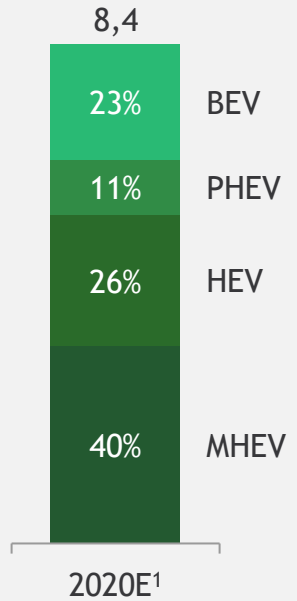
References and learnings from other markets

Globalsales of electrified vehicles (xEVs) has been growing in a relevant way

Global production electrified vehicles (M)



Participation of xEVs by type (%)



Note: xEV including: BEV = battery electric; PHEV = plug-in hybrid electric; HEV = full hybrid electric; MHEV = mild hybrid electric
1. 2020 forecast based on actual sales figures through October with estimates for November and December
Source: Includes content supplied by IHS Markit Alternative Propulsion Plus Data; Copyright © IHS Markit, Dec 2020; IHS Markit LV sales; Copyright © IHS Markit, Dec 2020; MarkLines; national vehicle registrations; BCG Analysis

Electrification is being driven by various forces

1

Increasingly strict regulation

Increasingly stringent CO2 emission standards across geographies, incentives for electric vehicle sales

2

Battery costs falling faster than expected

Technological advances and scale gains contributing to reduced battery costs

3

Global automakers expanding xEVs offering

Announcements of 400+ hybrid electric and plug-in models by 2025

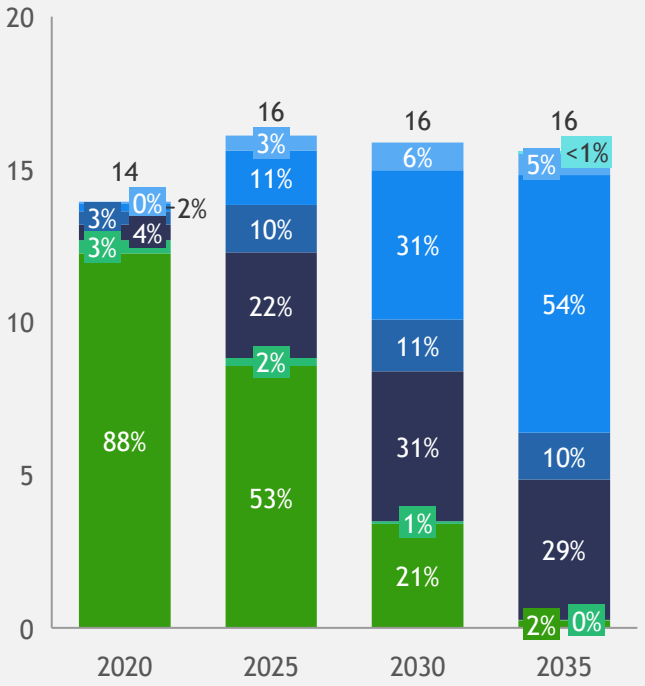
4

Pressure from investors and customers

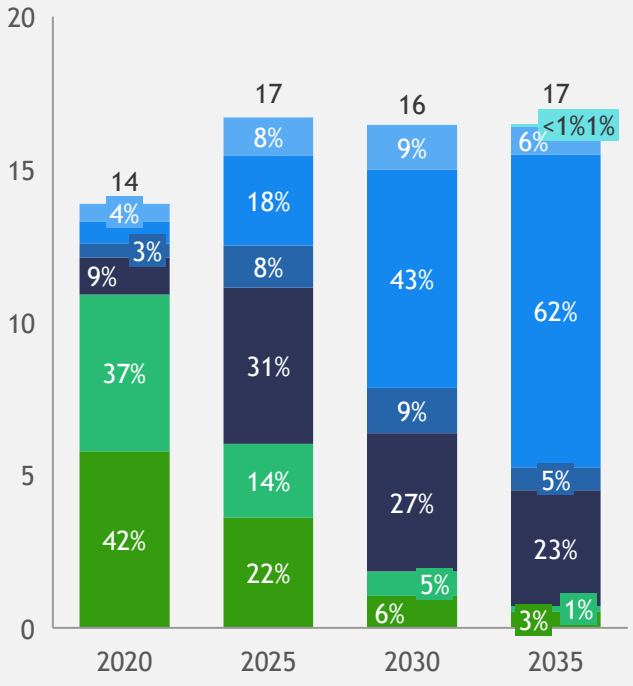
Clients, investors and society exerting pressure for decarbonization in order to meet the requirements to achieve a net-zero world by 2050

USA, Europe and China lead adoption of electrified vehicles

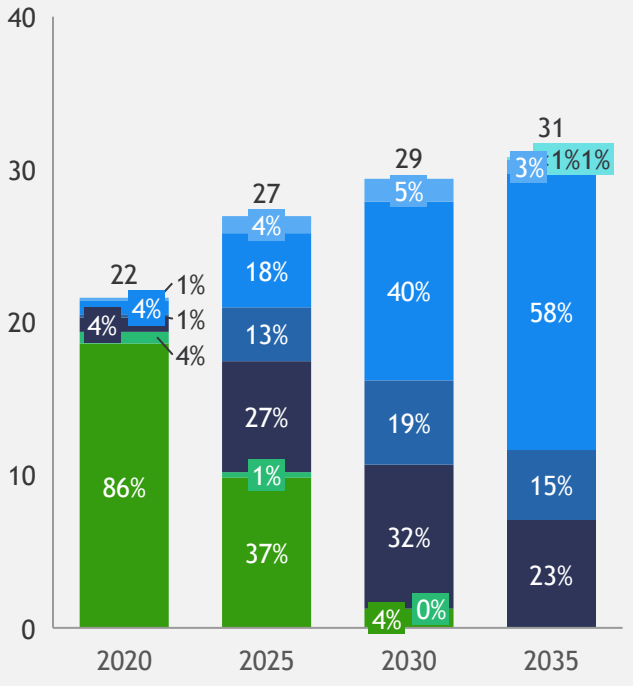
USA Volume Projections (M units)



EU volume projections (M units)



China volume projections (M units)



FCEV PHEV BEV HEV MHEV Diesel Gasoline

Note: Forecast includes all light vehicles except vans;
Source: BCG Projections (April 2021 - www.bcg.com/publications/2021/why-evs-need-to-accelerate-their-market-penetration)

In Brazil, local forces also influence evolution of the routes

Regulation and Incentives

Current regulation without direct link with CO_2 and other greenhouse gases, as well as policies and incentives acting on multiple fronts

TCO (total cost of ownership)

Cost parity of electric vehicles vs. more distant internal combustion vs. more advanced markets, due to factors such as acquisition cost, fuel cost and usage profile

Portfolio and installed capacity

Portfolio more focused on the segments of lower added value (e.g. compact), excess installed capacity and the need for high investments for local production of xEVs

Biofuels as an alternative

Extensive availability and existing infrastructure of biofuels in the country, especially ethanol, which has a more favorable CO2 emission profile than fossil fuels

The interaction of forces can shape different decarbonization routes in Brazil in the next 10-15 years

Light Vehicles

Heavy vehicles

Scenario 1	Scenario 2	Scenario 3
L1	L2	L3
Inertial	Global convergence	Biofuel protagonism

1. Inertial scenario

In this scenario, combustion engines sustain still high penetration over the next 15 years, particularly in the volume segments

Electrification aimed at serving specific segments, meeting emission requirements and demands of corporate customers, leading to a low level of electrification of the higher volume segments

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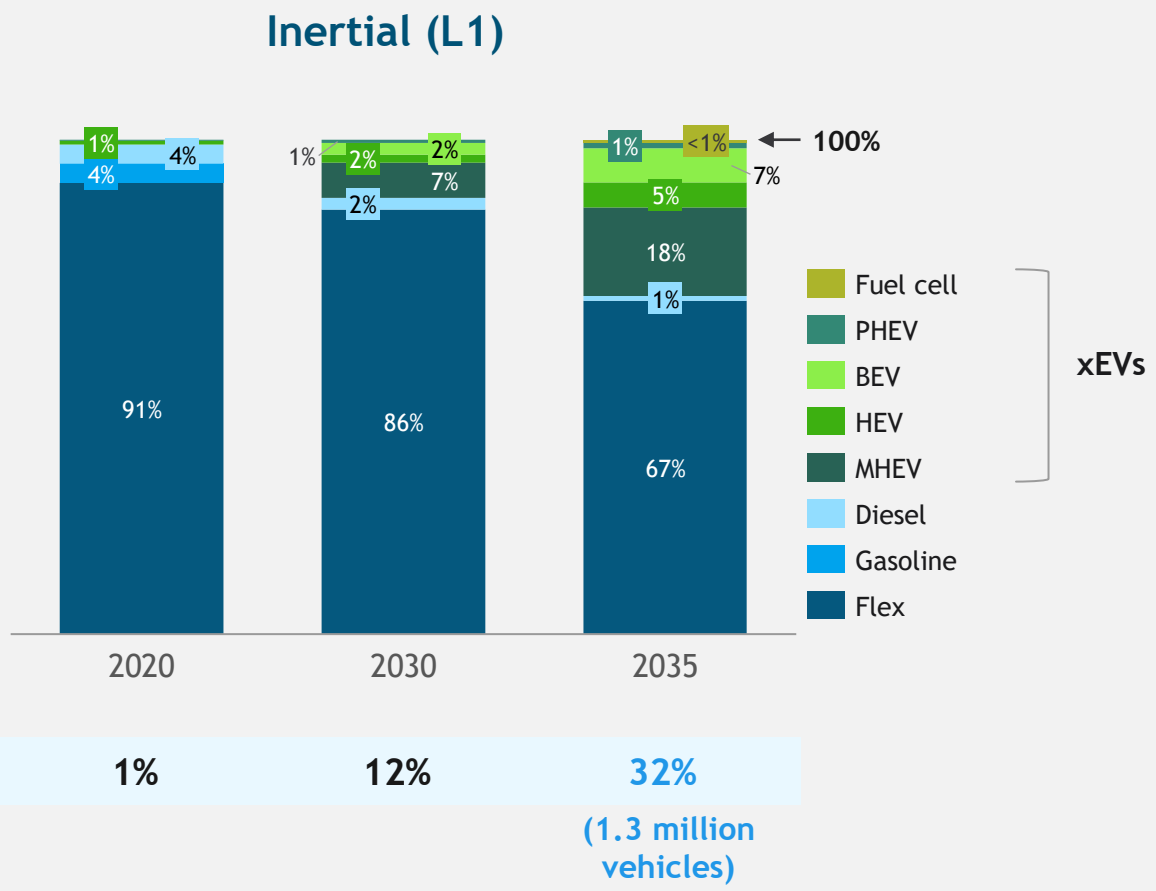
Electrification aimed at serving specific segments, meeting emission requirements and demands of corporate customers, leading to a low level of electrification of the higher volume segments

Annual sales mix

ESTIMATES



	2020	2030	2035
xEVs (%)	1%	12%	32% (1.3 million vehicles)

Note: Light-duty vehicles, including Passenger Cars and Light Commercial Vehicles; xEVs - electrified vehicles; PHEV - Plug-in Hybrid Electric Vehicle; BEV - Battery Electric Vehicle; HEV - Hybrid Electric Vehicle; MHEV - Mild Hybrid Electric Vehicle.
Source: BCG analysis and projections

2. Global Convergence Scenario

In this scenario, technological evolution and adoption rate allow xEVs to gain scale in Brazil in the period, reaching in 2035 levels of penetration per segment similar to those in Europe in 2030

Brazil approaches electrification levels of more advanced markets, automakers follow global electrification strategies

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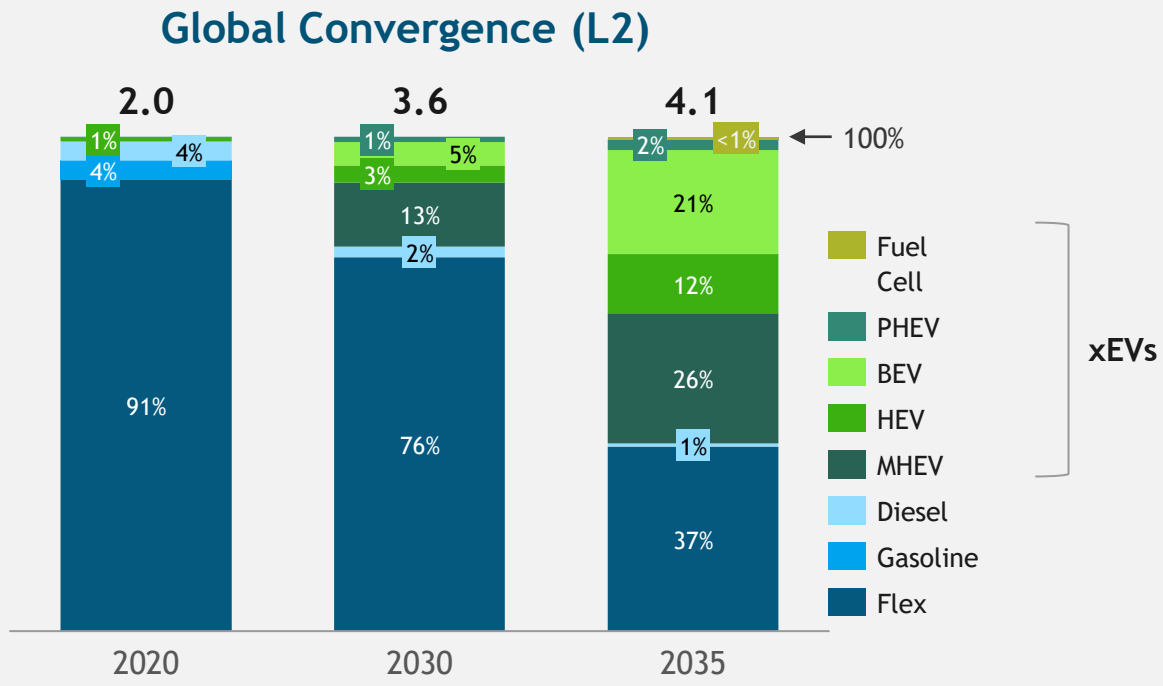
Annual sales mix - millions of vehicles

ESTIMATES



	2020	2030	2035
xEVs (%)	1%	22%	62% (2.5 million vehicles)

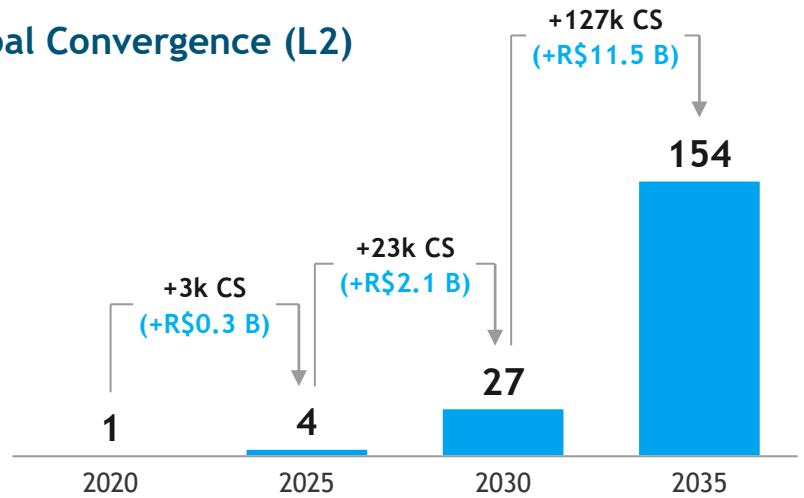
Note: Light-duty vehicles, including Passenger Cars and Light Commercial Vehicles; xEVs - electrified vehicles; PHEV - Plug-in Hybrid Electric Vehicle; BEV - Battery Electric Vehicle; HEV - Hybrid Electric Vehicle; MHEV - Mild Hybrid Electric Vehicle.
Source: BCG analysis and projections

Convergence scenario points to the need to install 150,000 chargers and investments of R$ 14B until 2035

Estimated charging stations (CS) needed to meet fleet of xEVs[1]

Estimates

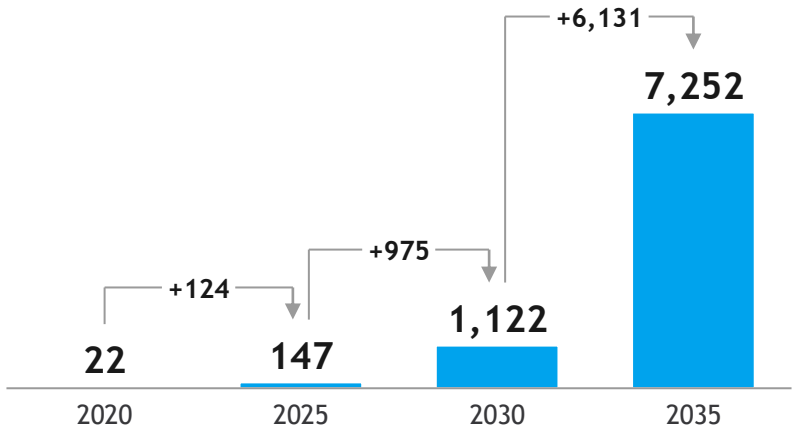
Global Convergence (L2)



	2020	2025	2030	2035
Tram fleet[3] (000)	10	68	507	3.230

Estimated impact on electricity consumption[2] (GWh)/year

Global Convergence (L2)



Total in the period

R$ 14 billion[4]

investments in charging points
penetration of BEVs/PHEVs in the convergence scenario

~1.5% of electricity consumed by the country (2019)

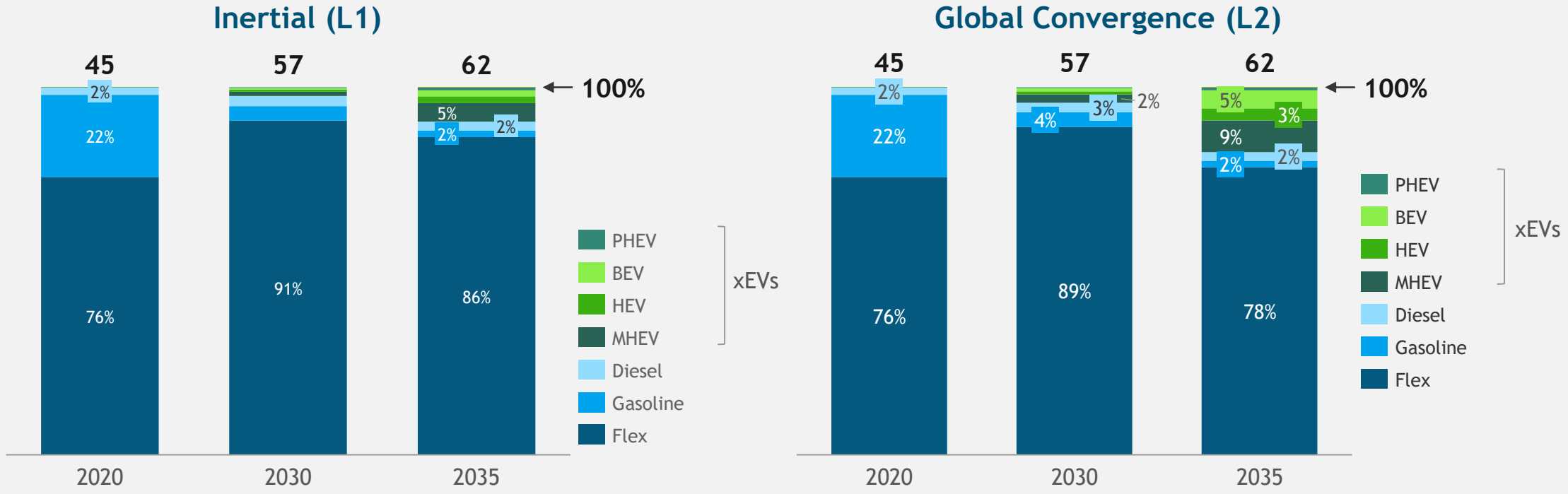
represents the demand for electricity to supply BEVs/PHEVs in 2035 in the convergence scenario

1. Energy efficiency of 3.54 km/kWh for PHEVs and 5.27 km/kWh for BEVs, average travel distance of 12,000 km/year and 61% of km driven by PHEVs on battery electrics according to Europe; 2. 21 EV/CP in 2020, 12 EV/CP in 2025, 15 EV/CP in 2030 and 21 EV/CP in 2035; 3. BEVs and PHEVs. Includes hardware and installation cost only. Grid connection costs can vary between €2k and €40k in Europe. Average cost R$ 10k per slow charging station, R$ 55k for fast charging stations and R$ 300k for ultra fast charging stations. Hardware price drops with annual rate varying linearly from 5% in 2021 to 0.7% in 2035. Note: ~75% of Brazilian power plants driven by renewable sources. Source: Press search, ICCT; ANEEL; Anuário Estatístico de Energia Elétrica 2020; BCG Analysis

Current fleet | Flex vehicles are still expected to represent most of the fleet by 2035, assuming current renewal rates

Fleet per year and powertrain - millions of vehicles

ESTIMATES



xEVs (%)	-	2%	10%	-	4%	18%

Note: Light-duty vehicles, including Passenger Cars and Light Commercial Vehicles;
xEVs - electrified vehicles; PHEV - Plug-in Hybrid Electric Vehicle; BEV - Battery Electric Vehicle; HEV - Hybrid Electric Vehicle; MHEV - Mild Hybrid Electric Vehicle.
Source: Anfavea, BCG Analysis

3. Biofuel protagonism

In this scenario, ethanol gains more prominence as a path to decarbonization, made possible by favorable regulation, flex fleet and extensive production and distribution infrastructure

Scenario assumes an increase of +15 p.p. of ethanol in the fuel mix, reaching 61% of consumption, and for comparison purposes, penetration of xEV in sales equal to the inertial scenario

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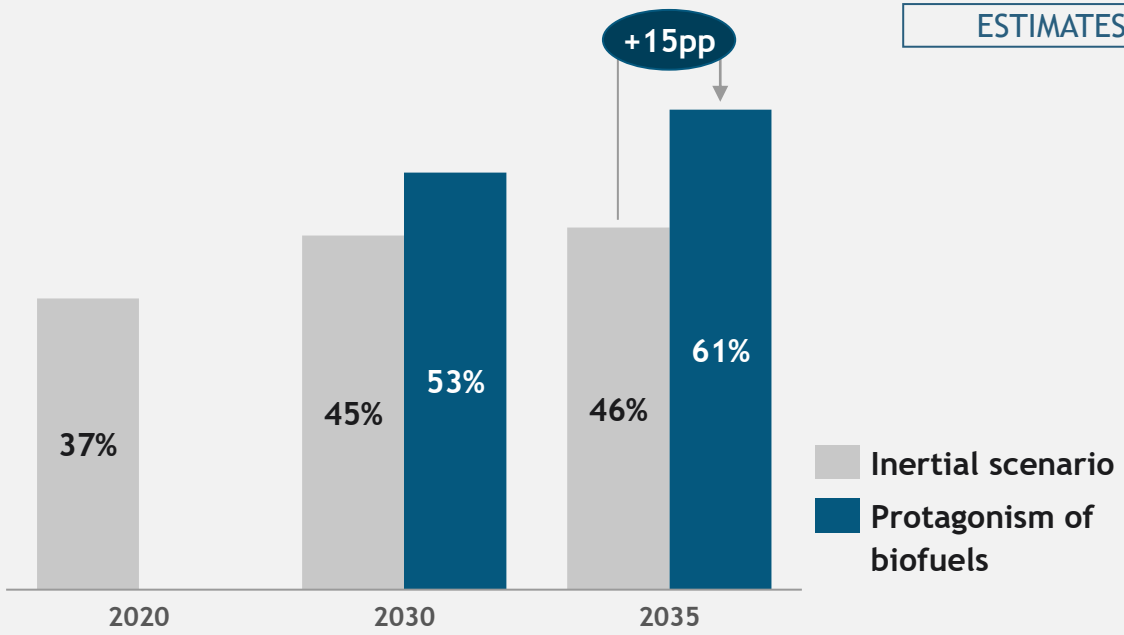
Light vehicles (% ethanol / total fuel)



Effects of increased penetration of ethanol

- CO2 emissions (well to wheel)
- Emission of local pollutants
- Gasoline consumption

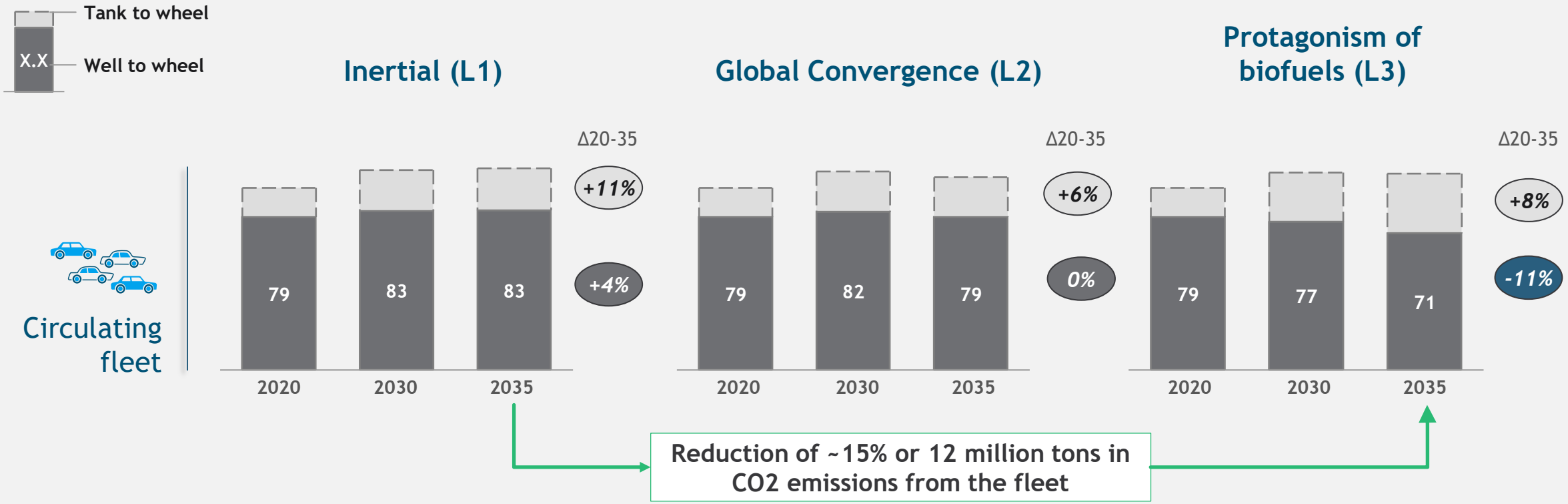
+18 B of liters	Additional ethanol consumption in 2030 vs 2020
R$ 55 billion	Potential investment demanded in the next 15 years for additional ethanol production
1-2 millions of ha	Additional planted area to meet ethanol demand

Note: Light vehicles, including passenger cars and light commercial vehicles
Source: Anfavea, epe, Ministry of Agriculture, Livestock and Supply; IBGE; BCG Analysis

CO2 - light vehicles | Increased use of ethanol can accelerate short-term decarbonization by reducing circulating fleet emissions

ESTIMATES

CO2 emissions - million tonnes CO2 / year



Note: Assumes growth of 37% in the current fleet between 2020 and 2035; emission factors (Kg/l exhaust and well to wheel, resp.) of 2.01 and 2.04 for gasoline, 1.2 and 0.4 for ethanol and 2.4 and 2.7 for diesel. Passenger vehicles only.
Source: Anfavea; Sindipeças; CBCS; BCG Analysis

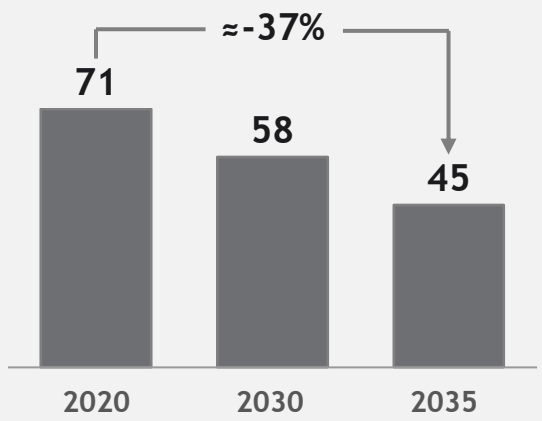
Local pollutant emissions - light vehicles | Significant reduction in all scenarios due to fleet renewal

ESTIMATES

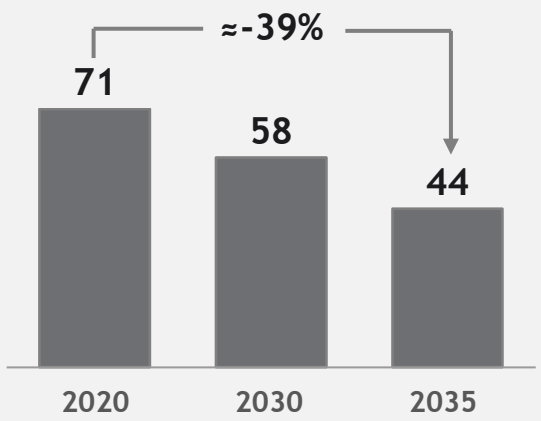
NMOG + NOx emissions - thousands of tons / year

Circulating fleet

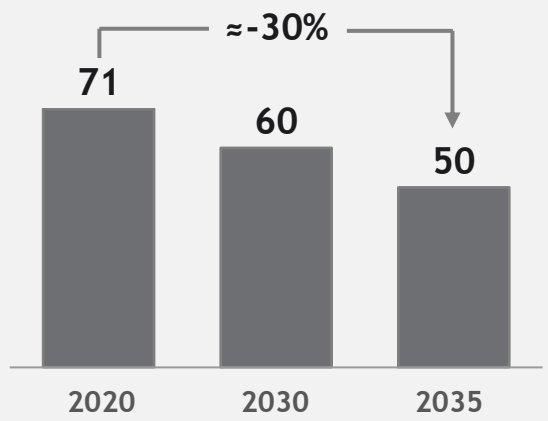
Inertial (L1)



Global Convergence (L2)



Protagonism of biofuels (L3)



Note: Passenger vehicles only; 54% growth in the new fleet between 2019 and 2035, and 37% in the circulating fleet between 2020 and 2035.
Source: Anfavea; CETESB; CONAMA; INMETRO; BCG Analysis

The interaction of forces can shape different decarbonization routes in Brazil in the next 10-15 years

Light vehicles

Heavy vehicles

Scenario 1	Scenario 2	Scenario 3
P1	P2	P3
Inertial	Global convergence	Biofuel protagonism

1. Inertial Scenario

In this scenario, new engine technologies (NEVs) are focused on specific applications and to meet the demands of large customers

Diesel engine remains dominant

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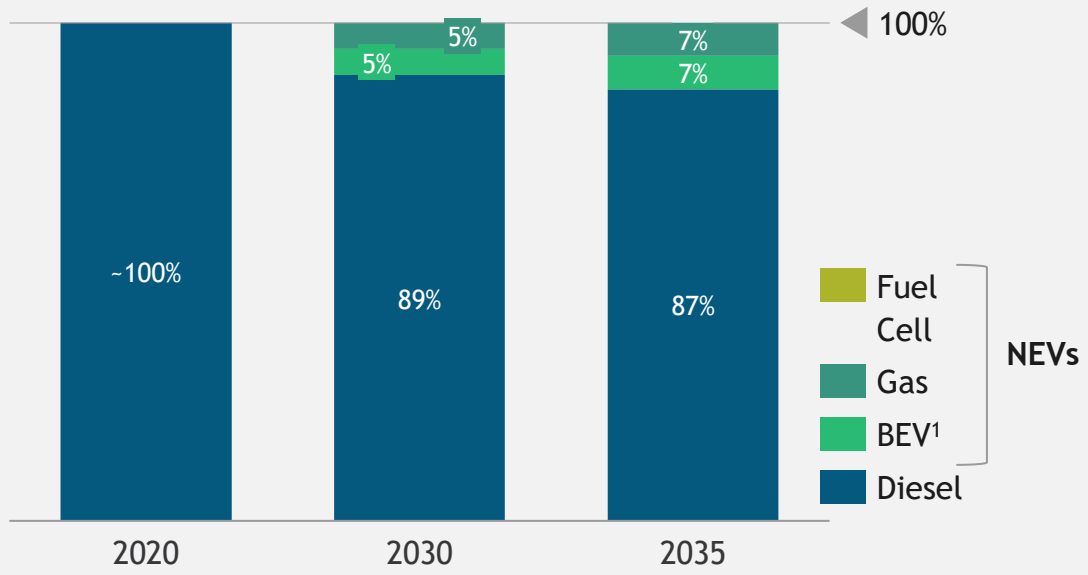
Diesel engine remains dominant

Annual sales mix - thousands of vehicles

ESTIMATES

Inertial (P1)



NEVs[1] (%)	0%	10%	14%

Note: Includes medium and heavy trucks and buses;
1. NEV - New Energy Vehicle; BEV - Battery Electric Vehicle
Source: BCG analysis and projections

2. Global Convergence Scenario

In this scenario, technological developments and the pace of adoption allow new technologies to gain scale in Brazil, reaching 2035 penetration levels similar to those in Europe in 2030

Brazil approaches levels of new engines of more advanced markets, and automakers follow global strategies for NEVs

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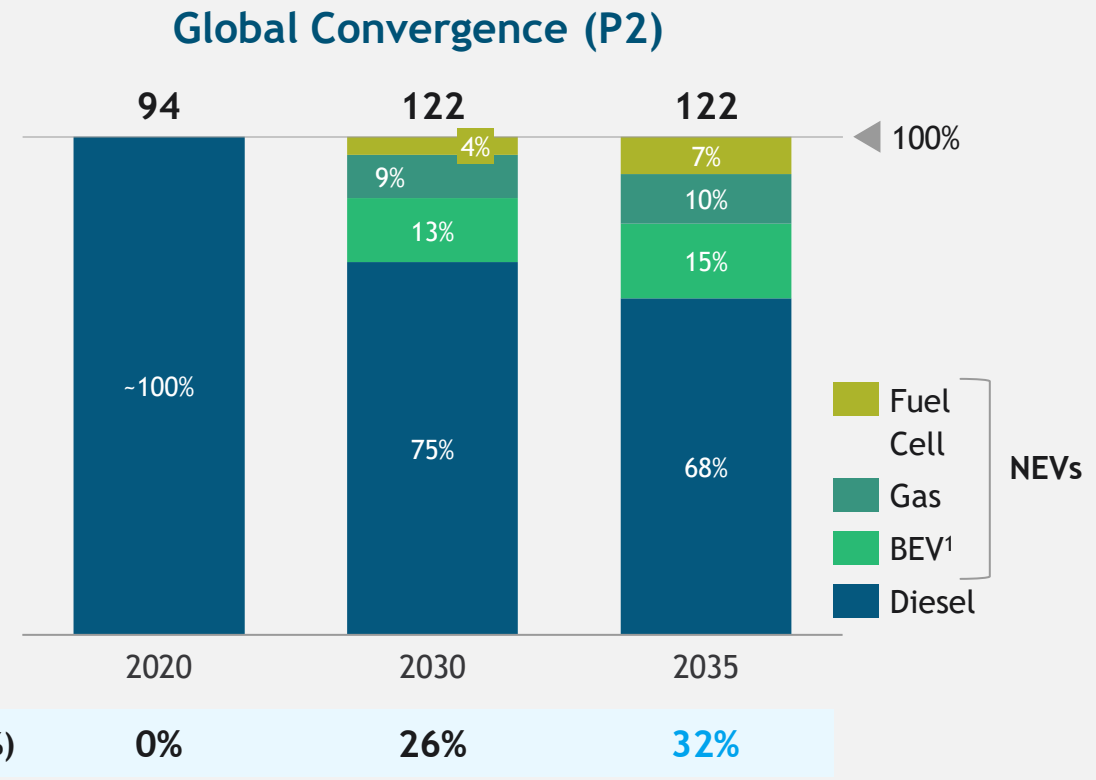


NEVs[1] (%)	0%	26%	32%

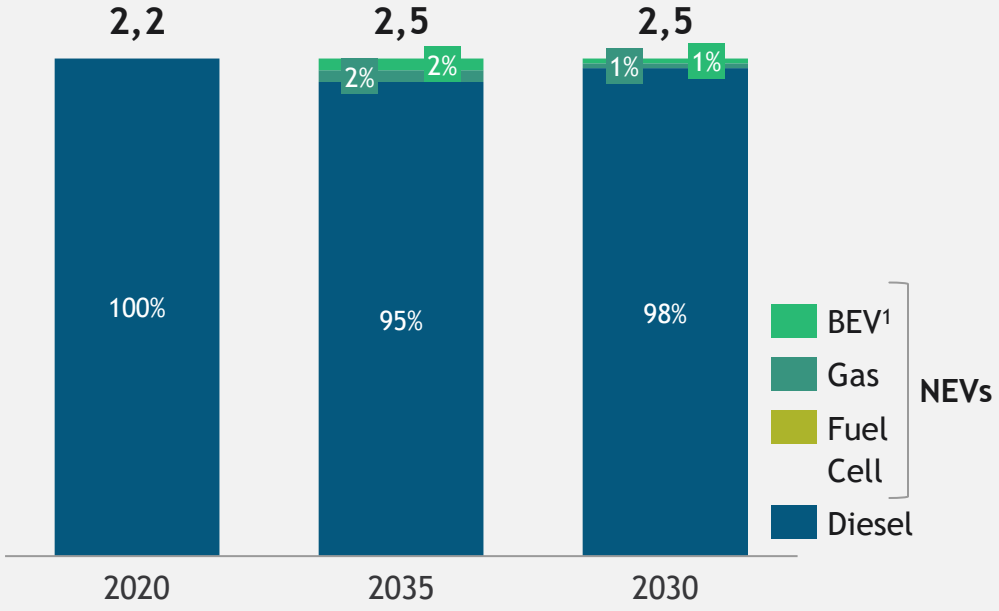
Note: Includes medium and heavy trucks and buses;
1. NEV - New Energy Vehicle; BEV - Battery Electric Vehicle
Source: BCG analysis and projections

Fleet - heavy vehicles | Diesel-powered internal combustion engine expected to remain dominant in fleet in period, assuming current renewal rate

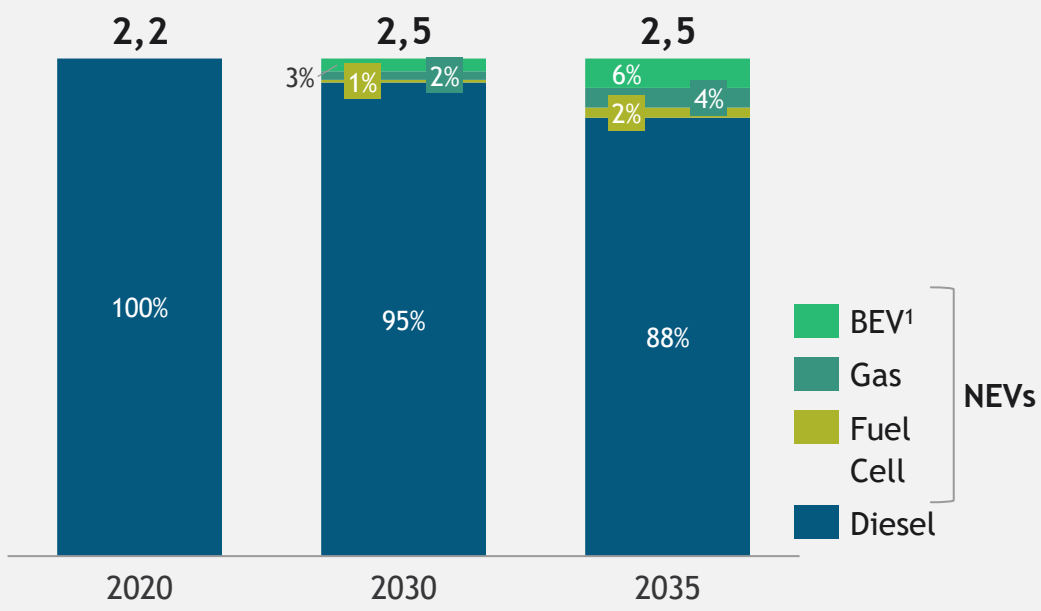
Fleet per year and motorization - millions of vehicles

ESTIMATES

Inertial (P1)



Global Convergence (P2)



NEVs[1] (%)	0%	2%	4%	0%	5%	12%

Note: Includes medium and heavy trucks and buses;
1. NEV - New Energy Vehicle; BEV - Battery Electric Vehicle
Source: BCG analysis and projections

3. Biofuel protagonism

In this scenario, Biodiesel/HVO and other biofuels gain prominence as a path to decarbonization, made possible by favorable regulation and investments

Scenario assumes as premise, increase of relevance of HVO to 15% of the mix, vs. 3% in the inertial scenario (and 15% of biodiesel)...

... and for comparison purposes, nev penetration into new sales equal to the inertial

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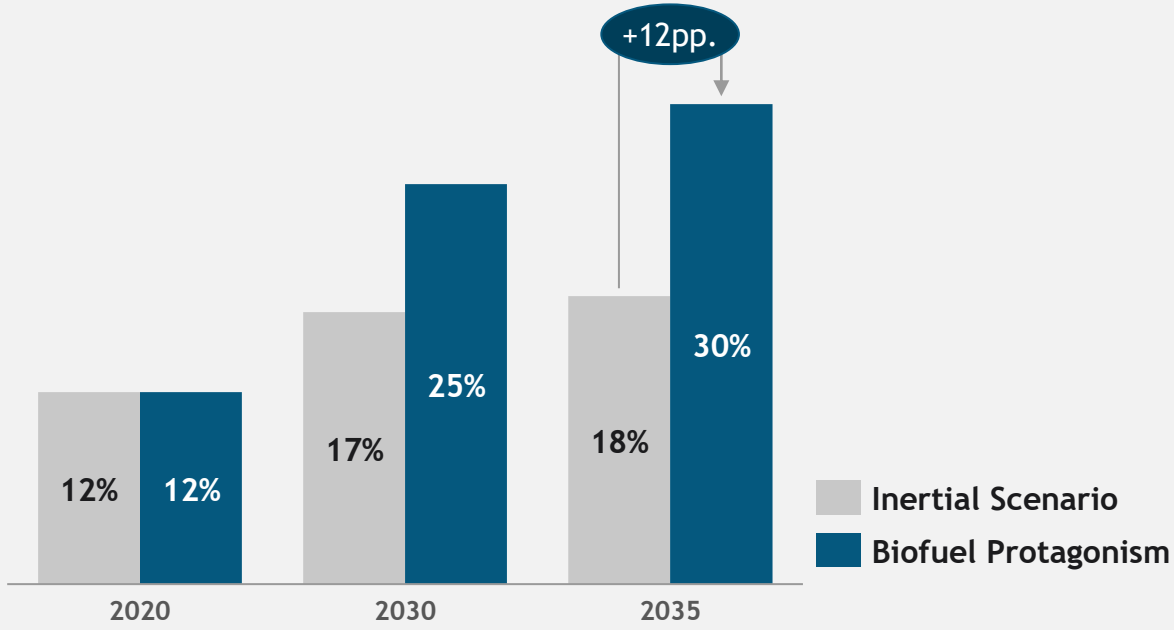
Heavy vehicles (% biofuels / fuels)

ESTIMATES



Impacts of increased biofuel penetration

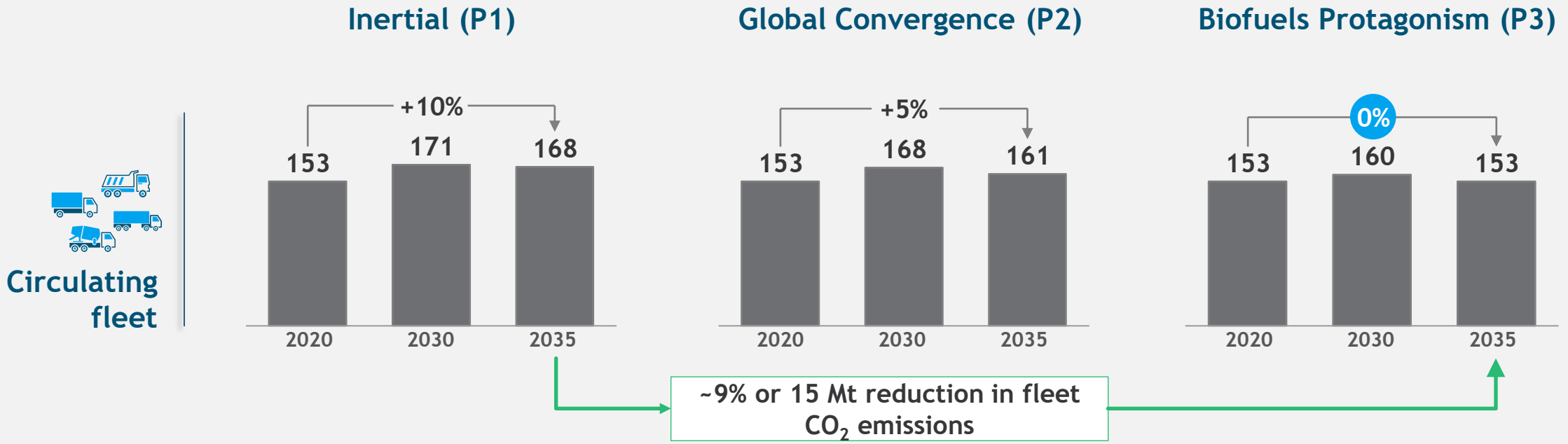
- CO_2 emissions (well to wheel)
- Pollutants (HVO)
- Diesel Consumption

Note: Includes medium and heavy trucks and buses; HVO - hydrotreated vegetable oil ("green diesel")
Source: Anfavea; BCG analysis

CO_2 - heavy vehicles | Increased application of biofuels can help reduce CO2 by reducing current fleet emissions

CO_2 emissions - millions of tons CO2 / year, well to wheel[1]

ESTIMATES



1. Considers carbon capture

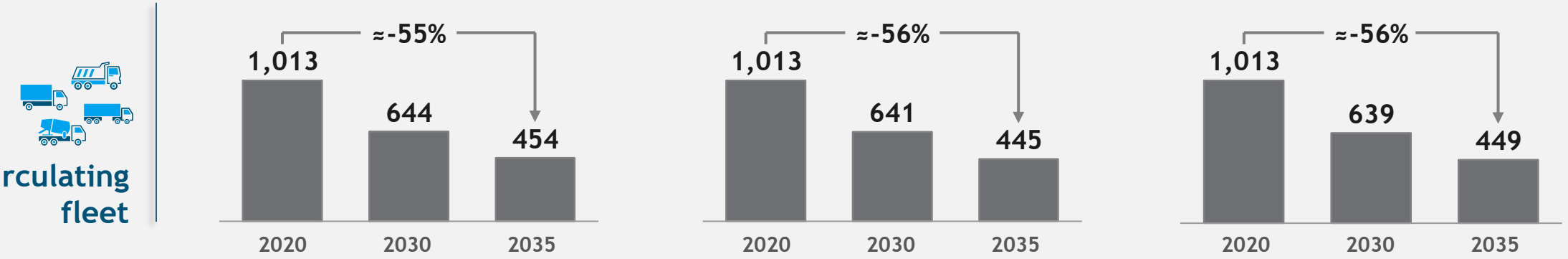
Note: New fleet growth of 12% between 2019 and 35, and of 14% of the circulating fleet between 2020 and 35; Emission factors (Kg/l exhaust and well-to-wheel, resp.) of 2.01 and 2.04 for gasoline, 1.2 and 0.4 for ethanol, 2.4 and 2.7 for diesel, 1.4 and 0.7 for HVO and 2.0 and 2.3 for NG. Considers only medium and heavy trucks

Source: Anfavea; BCG Analysis

Local pollutant emissions - heavy vehicles | Significant reduction in all scenarios given fleet renewal

ESTIMATES

NOx emissions - thousands of tons / year



Note: Considering medium and heavy trucks only; NOx emissions from HVO 10% lower than from Diesel; 2% increase in emissions from Biodiesel for each 20ptos of concentration in Diesel; Growth of the new fleet 12% between 2019 and 35, and 14% of the circulating fleet between 2020 and 35.
Source: Anfavea; CETESB; CONAMA; INMETRO; BCG Analysis

Final considerations

Final considerations

1 - Impacts on the automotive sector

Final considerations

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2 - Government Stimuli

Final considerations

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3 - Reflections on fuels

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Final considerations

1 - Impacts on the automotive sector

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4 - Investments in energy and infrastructure

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Final considerations

1 - Impacts on the automotive sector

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4 - Investments in energy and infrastructure

5 - Reduction of CO_2 emissions and pollutants

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Final considerations

1 - Impacts on the automotive sector

2 - Government Stimuli

3 - Reflections on fuels

4 - Investments in energy and infrastructure

5 - Reduction of CO_2 emissions and pollutants

6 - Unique opportunity: avalanche of investments in Brazil

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Public policies

	Europe	USA	China	India
Goal	Control of GHG emissions	Control of GHG emissions	Emission control Technological leadership	Urban pollution Energy security Exports
Route prioritized1	Electrification	Electrification	Electrification	Electrification (in 2W) Gas/Biocomb. (short term in 4W)
Examples of regulation and stimuli	Maximum vehicle emission 95 g CO2/km	Minimum number of ZEVs sold per year by OEMs	Implementation of China VI (equivalent to Euro VI)	Implementation of BS VI for MCI vehicles
	Reduction of up to €5-6K from the value of BEVs	Up to $7.5K in tax credit for BEVs	Credit program for EVs has been replacing subsidies in the value of the vehicle	FAME4 Grant Program

Public policies

	Europe	USA	China	India	Brazil
Goal	Control of GHG emissions	Control of GHG emissions	Emission control Technological leadership	Urban pollution Energy security Exports	
Route prioritized1	Electrification	Electrification	Electrification	Electrification (in 2W) Gas/Biofuels (short term in 4W)	
Examples of regulation and stimuli	Maximum vehicle emission 95 g CO2/km	Minimum number of ZEVs sold per year by OEMs	Implementation of China VI (equivalent to Euro VI)	Implementation of BS VI for MCI vehicles	
	Reduction of up to €5-6K from the value of BEVs	Up to $7.5K in tax credit for BEVs	Credit program for EVs has been replacing subsidies in the value of the vehicle	FAME[4] Grant Program	