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BUILDING AN ENVIRONMENTAL POWERHOUSE

VOLUME 3

# Basis for the proposal of a 2nd NDC for Brazil 2030-2035

Technical Note
August 2024

OBSERVATÓRIO DO CLIMA
SEEG

Brasil 2045

**Building an environmental powerhouse**
**Volume 3**

# Basis for the proposal of a 2nd NDC for Brazil (2030-2035)

**Technical Note**
**August 2024**

OBSERVATÓRIO DO **CLIMA**

SEEG

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# SUMMARY

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# 1

# CONTEXT OF THE PROPOSED EMISSIONS TARGET

## 1.1 Introduction: past NDCs

In 2015 and 2020, the Climate Observatory (OC) presented proposals for Nationally Determined Contributions (NDCs) for Brazil. The first one, published in June 2015, followed the guidelines for NDCs from the "Lima Call for Climate Action", the main decision of COP20, the 2014 climate conference. Based on a series of analyses on fair sharing of mitigation efforts, and on global emissions trajectories up to 2030 that would give humanity at least a 66% chance of limiting global warming to below 2°C, OC proposed that Brazil adopt an emissions cap of 1 $GtCO_2e$ for the year 2030, for the entire economy[1]. Brazil's NDC, published by the government in September, set an absolute target for the entire economy: a 37% reduction in emissions by 2025 compared to 2005 (consistent with 1.3 $GtCO_2e$ net emissions). It also presented an indicative target for 2030 (43% reduction, consistent with 1.2 $GtCO_2e$ net).

Decision 1/CP.21, which adopted the Paris Agreement at COP21 in December 2015, required Parties with targets for 2025 to submit targets for 2030 by 2020, and Parties with targets for 2030 to update them in that same year. There was, therefore, a need to transform Brazil's indicative target into a commitment – and align it with the latest science. In 2018, the IPCC (Intergovernmental Panel on Climate Change) published its special report "Global Warming of 1.5°C"[2], enumerating the much more serious climate change impacts that would follow a global warming of 2°C above the pre-industrial era compared to 1.5°C. The report was the turning point for the goal of stabilizing the Earth's temperature at the most ambitious limit of the Paris Agreement to become the one to be pursued by the nations who signed the treaty.

In December 2020, at the end of the deadline set by decision 1/CP.21, Brazil made its first update to its NDC. The government ratified the indicative target for 2030 of 43% reduction, but not only did it not align it with the most recent science, but it also failed to adjust the percentage of reductions in light of the Third National Inventory, published in 2016. As a result, the country reduced the ambition of its target, in absolute terms, up to 400 $MtCO_2e$[3].

On the eve of the government's presentation of the updated NDC, the Climate Observatory presented an NDC proposal aligned with 1.5°C for 2030[4]. Again, the request was for an emissions cap that year of 400 $MtCO_2e$ net, a reduction of 83% compared to 2005.

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[1] Climate Observatory, *Climate Observatory Proposal for Brazil's Intended Nationally Determined Contribution*. June 2015. Available at https://oc.eco.br/wp-content/uploads/2015/06/proposta-indc-oc.pdf

[2] IPCC, *Special Report: Global Warming of 1.5oC*. Summary for Policymakers. https://www.ipcc.ch/sr15/chapter/spm/

[3] See Climate Observatory, *NDC and carbon "pedaling": how Brazil reduced the ambition of its goals in the Paris Agreement* (2020). https://www.oc.eco.br/wp-content/uploads/2020/12/ANA%CC%81LISE-NDC-1012FINAL.pdf and Unep, Emissions Gap Report 2021. https://www.unep.org/pt-br/resources/emissions-gap-report-2021

[4] https://www.oc.eco.br/wp-content/uploads/2020/12/Prposta-OC-NDC-2030-Final.pdf

OC's first NDC proposal took into account historical responsibility and national capability criteria included in several equity calculators. This type of initiative seeks to divide the global mitigation effort among countries in a "top-down" approach, in which, roughly speaking, the emissions limit in a given target year is divided among countries according to their level of development, their population and their share of historical greenhouse gas emissions, starting from a baseline that assumes that no emissions reduction policy is adopted[5]. Although imperfect, this effort-sharing approach is widely adopted by civil society because it more accurately reflects the needs of the atmosphere and the responsibilities of countries. It contrasts with the bottom-up approach of the Kyoto Protocol and the Paris Agreement, in which mitigation efforts are defined by countries and – in the case of Paris – later compared to the needs of the climate.

After a benchmarking exercise, the Climate Observatory network chose to base its initial proposal on Cerf (Climate Equity Reference Framework Calculator)[6], an initiative of an international consortium led by the Stockholm Environmental Institute and Eco-Equity.

The first NDC adopted the following assumptions:

- The country would meet the goals of the National Policy on Climate Change by 2020.
- National emissions would decrease between 2020 and 2030.
- Brazil's per capita emissions average would be lower than the world average.
- The country would eliminate deforestation in the Amazon by 2030, recover forests and store carbon in agricultural soils of degraded pasture areas.

The 2020 update network's proposal to make the NDC 1.5°C-compatible was based on parameters established by Unep (United Nations Environment Programme) in the Emissions Gap Report 2019. According to Unep, to have a significant chance of limiting global warming to below 1.5°C by 2100, global emissions should be limited to 25 $GtCO_2e$ in 2030[7] (39% lower than the emissions scenario compatible with global warming below 2°C by 2100 and 54% lower than the scenario of full implementation of the NDCs) and carbon neutrality achieved by 2050. The calculation of the target was therefore based on the following equation:

$$\mathbf{M_{oc}1.5°C = (M_{oc}2.0°C - RemAP2015) * 0.61}$$

Where:

*Moc1.5°C – Proposed 2030 OC Target compatible with 1.5°C global warming limit, expressed in $MtCO_2e$;*

[5] See https://climateequityreference.org/calculator-information/gdp-and-emissions-baselines/

[6] https://calculator.climateequityreference.org/

[7] Adjusted to 33 billion tons in later versions of the report. (N.A.)

*Moc2.0°C - OC Target Proposal presented in 2015 for 2030 compatible with global warming limit of 2.0°C, expressed in* $MtCO_2e$;

*RemAP2015 – Carbon removals from the atmosphere by protected areas in Brazil in 2015, expressed in* $MtCO_2e$;

*0.61 – ambition increase factor, equivalent to a 39% reduction, according to IPCC scenarios and the 2019 Emissions Gap Report.*

The fair-share target for Brazil to limit its net greenhouse gas emissions in 2030 within a global trajectory that offers the highest chance (66% probability) of limiting global warming to 1.5°C by 2100 would therefore be 400 $MtCO_2e$ in 2030. **Included in this calculation are projections of carbon removals from the atmosphere by forests within protected areas.**

## 1.2. Equity and historical responsibility

According to Cait/WRI, Brazil is the seventh largest emitter of greenhouse gases on the planet, sixth when the European Union is excluded. The SEEG (OC's Greenhouse Gas Emissions Estimation System) shows that Brazil's per capita emissions are consistently above the world average: in 2022, gross per capita emissions were 11.4 tons, and net emissions[8], 8.3 tons, compared to a global average of 6.1 tons. Excluding deforestation, however, the country's per capita emissions fall to 5.3 tons[9].

Because it only takes into account fossil fuel emissions, the Climate Equity Reference Calculator does not capture the role of deforestation in a country's current emissions, nor in its historical emissions. It is therefore overly generous to countries that derive most of their emissions from land use, land-use change and forestry (LULUCF), such as Brazil, Indonesia and the Congos. Although there have been studies since 2014 indicating that Brazil is among the five largest historical emitters of greenhouse gases[10] (due to deforestation in the Atlantic Forest in the 19th and 20th centuries and in the Amazon and Cerrado from the second half of the 20th century), analyses of the Brazilian NDC from the point of view of fair share – that is, how much the country would have to increase the ambition of its goals considering its historical responsibility for observed global warming and the country's capacity – end up underestimating Brazil's just contribution by neglecting emissions from deforestation. For 2030, an analysis that used Cerf and two other equity benchmarks showed that Brazil's fair contribution in 2030 would be a per capita emission of 2.86 tons (compared to 5.3 tons currently)[11]. For comparison, the US fair share would be a negative emission of 14.37 tons per capita, and Germany's would be a negative emission of 8.82 tons. This bias,

[8] Here considering removals from protected areas.

[9] SEEG/Climate Observatory, *Analysis of greenhouse gas emissions and their implications for Brazil's climate goals (1970-2022)*. 2023.

[10] Mathews, H. D. *et al.*, 2014. National contributions to observed global warming. *Environ. Res. Lett.*9 014010

[11] Holz C., *Are G20 countries doing their fair share of climate mitigation?* Oxfam discussion papers, sep. 2023.

less evident in 2015 when carbon budgets were larger and NDCs were aligned with the looser 2°C temperature limit, becomes critical in 2024 when the world needs to make dramatic emissions reductions of 43% by 2030 and 60% by 2035, compared to 2019, if it is to have a 50% or greater chance of limiting global warming to 1.5°C[12].

## 1.3. The mandate of the Global Stocktake

The Emissions Gap report, published annually by Unep, measures the distance between national policies to reduce greenhouse gas emissions (mitigation) and the need for a world with stabilized global warming, as recommended by the Paris Agreement. In its latest edition, in 2023, the report estimated global emissions in 2022 (including LULUCF) at 57.4 billion tons of carbon dioxide equivalent ($GtCO_2e$). In 2035, the emissions level consistent with stabilization at 1.5ºC is about 25 $GtCO_2e$. Therefore, the emissions gap by 2035 is about 32 billion tons[13].

According to the UNFCCC, the United Nations Framework Convention on Climate Change, the sum of all countries' NDCs submitted and/or updated by September 2023 (excluding LULUCF) would reduce the emissions gap by only 5.3% in 2030 compared to 2019, at best (compare with the need for a 43% reduction in that period indicated by the IPCC). This value is consistent with global warming of 2.1°C to 2.8°C by the end of the century, a far cry from 1.5°C[14].

The Paris Agreement is based on a pledge-and-review approach: countries define their mitigation offers (pledges) nationally and the sum of national pledges is periodically compared with reality (review) in order to guide the aggregate effort towards the objective of the agreement. Each year, synthesis reports of the aggregate ambition of the NDCs are published by the UNFCCC. And every five years a global stocktake, or global assessment (hereinafter GST), is carried out to identify gaps in ambition and implementation and to guide the new cycle of NDCs, which should be valid for the period 2030-2035.

The first GST was concluded in 2023 in Dubai at COP28, under the shadow of an NDC synthesis report that showed little joint ambition and little implementation of targets – and in the wake of extreme weather events in what was to date the hottest year on record. Outlined in decision 1/CMA.5, it recognizes the need to accelerate mitigation efforts in this decade, and calls on countries to adopt a series of measures, including:

- Transition away from fossil fuels from energy systems in a fair, orderly and equitable man-

[12] IPCC AR6, Synthesis Report - Summary for Policymakers. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf

[13] Unep, *Emissions Gap Report 2023 - Broken record*. Disponível em https://www.unep.org/interactives/emissions-gap-report/2023/

[14] UNFCCC, NDC Synthesis Report 2023. Available at https://unfccc.int/ndc-synthesis-report-2023#Projected-GHG-Emission-levels

ner, accelerating action in this critical decade to achieve net zero emissions by 2050, in line with science;

- Triple renewable energy and double the annual energy efficiency rate by 2030;
- Halt and reverse deforestation by 2030;
- Accelerate the reduction of non-$CO_2$ emissions, especially methane, by 2030.

Furthermore, all countries are encouraged to present, in the next cycle, NDCs with absolute targets for the entire economy, which until now had been the obligation of only developed countries, as well as urged to increase, in 2024, the ambition of their NDCs for 2030.

GST 1 has also established, in paragraph 4 of Decision 1/CMA.5, that the 1.5°C target, the “aspirational” objective of the Paris Agreement, becomes the target to be pursued by the international community in the multilateral effort to combat the climate crisis. Until then, this temperature objective had been expressed only in cover decisions (at COPs 26 and 27), political preambles to the COPs’ negotiating decisions.

The message from GST for the 2030-2035 NDCs, therefore, is one of renewed urgency and maximum ambition, since the window to keep 1.5°C on the horizon is closing fast – and even now the costs of mitigation and adaptation measures are high, a price to pay for decades of inaction. For this reason, the Climate Observatory has chosen, once again, to make an NDC proposal that starts from the needs of the atmosphere and seeks to establish what Brazil’s fair contribution is to meet them.

Brasil 2045

# 2

# UPDATED PROPOSAL

**for Brazilian emissions target in 2035 compatible with 1.5°C limit for global warming by 2010**

## 2.1. Defining Brazil's fair share: a new approach

In order to maintain consistency with previous NDC proposals, OC chose to use Cerf as the benchmark for historical equity and accountability. However, the problem remained of how to reflect the country's actual accountability in an equity calculator that accounted for LULUCF emissions in 2015 but stopped doing so for a number of reasons[15].

The solution found was to develop a "customized" version of the Climate Equity Reference Calculator. It would habilitate historical data on emissions from land use, well known for Brazil (although with uncertainties for other tropical countries), and then calculate the mitigation effort for 2035 in the other sectors, assuming that in 2030 the country zeroes its emissions from deforestation, as per the national commitment expressed in the Plan for the Prevention and Control of Deforestation in the Amazon (Brazil, 2023), in the speech of President Luiz Inácio Lula da Silva during COP27, in Egypt, and in the Glasgow Leaders' Declaration on Forests, of which Brazil is a signatory. The full description of the methodology applied is in the memorandum accompanying this technical note (Holz, 2024).

To facilitate these calculations, the calculator's central database was fed with time series of historical LULUCF emissions. The Global Carbon Project[16] recently began reporting time series of historical national LULUCF emissions from multiple sources (Gasser et al. 2020[17]; Hansis et al. 2015[18]; Houghton and Castanho 2023[19]). For Brazil specifically, a high-quality domestic data source is available through SEEG. However, its temporal scope is limited to the years 1990-2022.

[15] See: https://climateequityreference.org/calculator-information/the-climate-equity-reference-calculator-database/

[16] Friedlingstein, Pierre; Michael O'Sullivan; Matthew W. Jones; Robbie M. Andrew; Dorothee C. E. Bakker; Judith Hauck; Peter Landschützer; et al. (2023) "Global Carbon Budget 2023" in *Earth System Science Data*, , *15*(12), 5301–5369. [doi: 10.5194/essd-15-5301-2023]

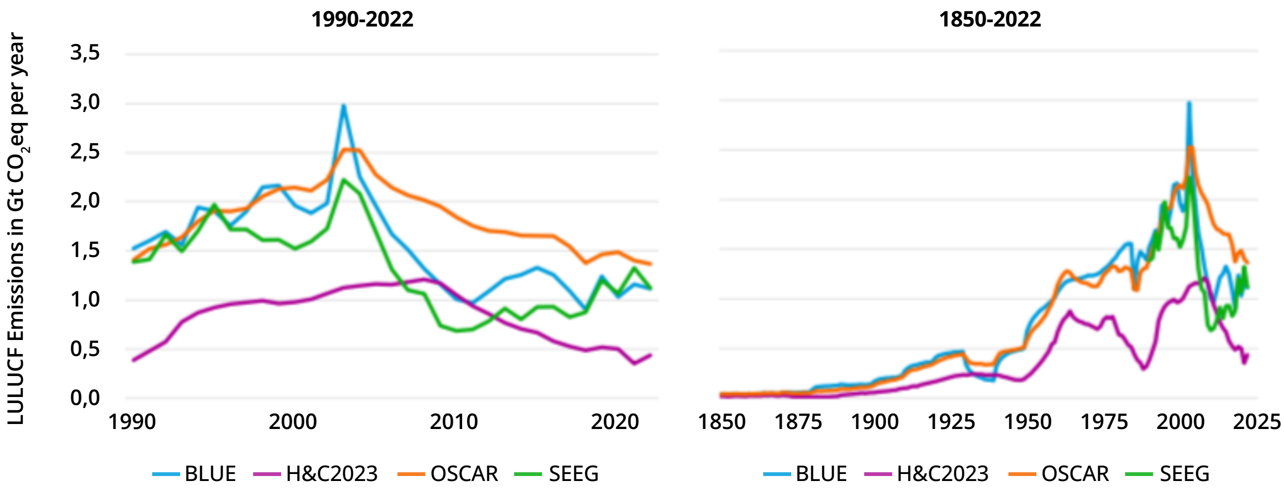
[17] Gasser, Thomas; Léa Crepin; Yann Quilcaille; Richard A. Houghton; Philippe Ciais and Michael Obersteiner (2020) "Historical $CO_2$ emissions from land use and land cover change and their uncertainty" in *Biogeosciences*, , *17*(15), 4075–4101. [doi: 10.5194/bg-17- 4075-2020]

[18] Hansis, Eberhard; Steven J. Davis and Julia Pongratz (2015) "Relevance of methodological choices for accounting of land use change carbon fluxes" in *Global Biogeochemical Cycles*, , *29*(8), 1230–1246. [doi: 10.1002/2014GB004997]

[19] Houghton, Richard A. and Andrea Castanho (2023) "Annual Emissions of Carbon from Land Use, Land-Use Change, and Forestry from 1850 to 2020" in *Earth System Science Data*, *15*(5), 2025–2054. [doi: 10.5194/essd-15-2025-2023]

Thus, while SEEG data were used for Brazil for the period 1990–2022, data for other countries and years were taken from the Blue database (Hansis et al. 2015), and the Global Carbon Project (Friedlingstein et al. 2023). Blue was selected over the other two data sources because it provides the closest match to SEEG for 1990–2022. A comparison of Brazil's LULUCF emissions data between the SEEG dataset and the three GCB data sources is also shown in the figure below.

***Figure 1: Comparison between historical land use emissions databases (Source: Holz, 2024)***




To calculate Brazil's fair share consistent with 1.5°C in its non-LULUCF sectors, the global mitigation effort first needs to be defined. In the exercise that gave rise to this NDC proposal, it is defined as the mitigation between the reference projections (baseline, fixed, where a global counterfactual scenario without any mitigation policy is drawn up[20]) and the mitigation pathways (for non-LULUCF sectors) of two global emissions scenarios: the Low Energy Demand (LED) pathway – included in the IPCC's Sixth Assessment Report (IPCC 2023) – and also the Climate Action Tracker's "Median 1.5°C Pathway" (CAT 2023). Figure 2 below (panels a and c) shows these global mitigation pathways in the context of baseline projections – the CAT pathway requires emissions cuts of 28 $GtCO_2eq$ by 2030 and 37 $GtCO_2eq$ by 2035, while the LED pathway requires 31 $GtCO_2eq$ and 39 $GtCO_2eq$, respectively.

[20] See https://climateequityreference.org/calculator-information/gdp-and-emissions-baselines/

***Figure 2: Global mitigation pathways and Brazil's fair shares (Source: Holz, 2024)***

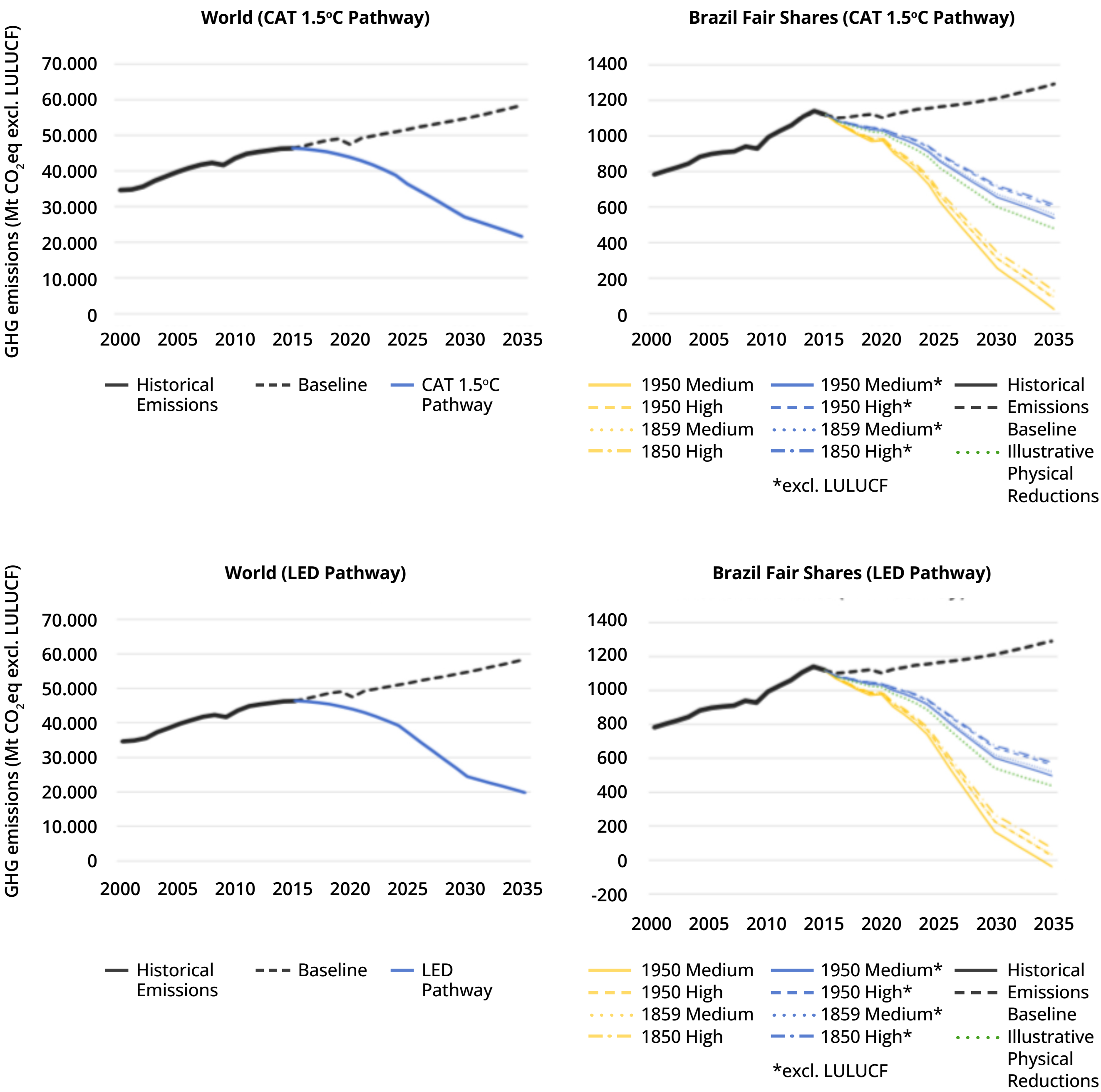



Figure 2 also shows the results of Brazil's fair contribution calculations (panels b and d) on these two pathways. Each set of blue and yellow lines shows four different combinations of specific perspectives on how capacity and responsibility should be defined in the context of equitable effort sharing (four "equity milestones"). The captions for the lines show the starting date for the historical responsibility calculation (1950 and 1850) as well as the version of "progressivity" (medium and high) used when calculating capacity (and responsibility). Measures of capacity to act are given by Cerf based on an income threshold of US$7,500 per person per year. The larger the population of a country with income below this threshold, the lower that country's capacity to take climate action. "Low progressivity" means that all income above this threshold is counted as national capacity. "High progressivity" includes a second threshold, set at US$50,000 per person per year, to further differentiate the treatment of incomes at different levels in the context of capacity. Above this threshold, 100% of income counts as national capacity; there is a gradient between the two thresholds.

When historical land-use emissions are included, Brazil's responsibility changes significantly. The set of blue lines in each of panels b and d show the fair share without LULUCF, while the yellow lines include deforestation. The country's historical responsibility changes, respectively, from the range of 1.8% to 2% of global efforts to 3.1% to 3.3%.

Crossing historical responsibility with the different global mitigation pathways, and considering scenarios in which "history" begins in 1950 or 1850, or "progressivity" (country capacity, defined by income) is medium or high, Holz (2024) estimated a range of "fair shares" for Brazil in other sectors of the economy that go from negative emissions as early as 2035, in the most ambitious scenario, to 117 $MtCO_2e$, in the conservative scenario. In 2035, for the 1.5°C CAT pathway and depending on the equity framework chosen, Brazil's fair share of mitigation implies a reduction in non-LULUCF sectors of between 87% and 98% below 2005 levels, while for the LED pathway fair share reductions would be between 93% and 106% below 2005 levels.

With the figures at hand, the SEEG team carried out a scenario exercise, broken down into each of the sectors of the economy (land use change and forests, agriculture, energy, industrial processes and waste), with sectoral targets for reducing emissions and increasing removals that would need to be adopted to get as close as possible to the country's share of the global effort. Brazil's fair share was therefore used as a benchmark for a calculation effort that looks at the real economy and tries to get as close as possible to it by considering existing and scalable mitigation options. The result is the mitigation target now proposed by OC: to reach 2035 with net emissions of 200 million tons of $CO_2$ equivalent ($MtCO_2e$).

## 2.2. Premises of this NDC

The Climate Observatory's proposal for a 2030-2035 NDC consistent with Brazil's fair share to a 1.5°C world is based on some assumptions, some of which were also adopted in previous exercises:

a) Brazil will achieve zero deforestation and combat degradation in all its biomes by 2030.

b) The Forest Code's target for recovery of vegetation cover will be fully met.

c) The carbon stored in agricultural soils, currently not accounted for in national emissions inventories but estimated by SEEG since 2015, will be included in Brazil's National Communications.

d) Brazil will follow the International Energy Agency's (2021) recommendation in its NZE (net zero emissions) scenario and refrain from licensing new oil, fossil gas and coal projects.

e) The reported emissions will be net, including carbon in agricultural soils and removals by secondary forests, as in the 2015 and 2020 proposals, but, unlike the latter, excluding removals by protected areas.

Premises "a" and "e" will be detailed below. Premises "a" and "b" have already been partially or fully adopted by the current government.

## ZERO DEFORESTATION

There is no agreed definition of zero deforestation (ZD) in public policies in Brazil. In the annex to the iNDC, the Intended Nationally Determined Contribution that became the country's first NDC, the commitment was to achieve "zero illegal deforestation by 2030 and offset greenhouse gas emissions from legal vegetation suppression by 2030"; that is, the Forest Code was complied with, but the possibility of losing surplus native vegetation that amounts to 43 million hectares in the Amazon and Cerrado alone was admitted.

In 2023, the PPCDAm (Action Plan for the Prevention and Control of Deforestation in the Legal Amazon) adopted in its fifth phase a definition of ZD similar to that of the NDC, speaking of "eliminating illegal deforestation and compensating for the legal suppression of native vegetation and greenhouse gas emissions resulting from it, through strengthening the implementation of forestry legislation and the recovery and increase of native vegetation stocks through economic incentives for conservation and sustainable forest management"[21].

In order to escape the conceptual trap of "zero illegal deforestation", this NDC proposes a total ban on deforestation in the country – through a combination of law enforcement and economic incentives – while allowing for a residual suppression of native vegetation of a maximum of 1,000 square kilometers per year through interventions of social interest or public utility, declining further after 2035. The horizontal expansion of the agricultural frontier is therefore ended.

[21] Brasil, 2023. *Action Plan for the Prevention and Control of Deforestation in the Legal Amazon, 5th phase* (2023-2027). https://www.gov.br/mma/pt-br/assuntos/combate-ao-desmatamento/amazonia-ppcdam-1/5a-fase-ppcdam.pdf

## REMOVALS BY PROTECTED AREAS

Brazil's National Communication to the UNFCCC reports net greenhouse gas emissions, discounting removals by secondary forests and removals by protected areas (conservation units and indigenous lands). The latter amounted to 386 million tons in the Fourth National Inventory, a value that has remained constant since the Third Inventory.

Brazil considers protected areas and indigenous lands to be "managed" forests, since there is a public policy effort to keep them protected. Thus, it is authorized by the IPCC to claim removals by these mature forests as "anthropogenic", deducting them from the national accounting. OC replicates this methodology in the SEEG annual reports, in order to make its data comparable with those of the government. Thus, in 2022, there are gross emissions of 2.3 billion tons of $CO_2$e and net emissions of 1.7 billion tons of $CO_2$e. However, OC disagrees with these removal figures by protected areas: first, because it is not known what the actual removals made by these mature forests are, although the literature indicates that forests in the Amazon can remove up to 1.3 tons of $CO_2$ per hectare/year.[22] Then, protected areas are being invaded, deforested and degraded, which reduces their capacity to remove carbon[23].

Achieving zero deforestation in Brazil also poses a philosophical difficulty for removals by protected areas: at the moment when a public policy effort eliminates all loss of native vegetation cover in the country, it could be argued that all 500 million hectares of native vegetation in Brazil would be "under management", therefore actively practicing anthropogenic removals (since all of them would be under the umbrella of a set of public policies aimed at zero deforestation) and leading the country to an unrealistic level of negative emissions. Such reasoning *ad absurdum* illustrates the difficulty of the concept of removal by protected areas, which, in OC's view, should be eliminated from national communications.

For illustration purposes only, the table below shows what the NDC proposed by the Climate Observatory would be if the "discount" for protected areas were applied in the years 2030 and 2035, even assuming that no other protected areas would be created between now and 2030.

[22] Phillips, O., et al., "Carbon uptake by mature Amazon forests has mitigated Amazon nations' carbon emissions". *Carbon Balance and Management*, Volume 12, article number 1, (2017)

[23] Lapola, D M, Pinho, P, Barlow, J, Aragão, L E, Berenguer, E, Carmenta, R, ... & Walker, W S (2023) "The drivers and impacts of Amazon forest degradation" in *Science, 379* (6630), eabp8622. [doi: 10.1126/science.abp8622]

***Table 1 - NDC targets accounting for removals by protected areas***

| | 2030 | 2035 |
|---|---|---|
| Target ($MtCO_2e$) | 400 | 200 |
| Removals by protected areas ($MtCO_2e$) | -386 | -392 |
| Total with protected areas ($MtCO_2e$) | -14 | -192 |

It follows, therefore, that adding removals by protected areas in an NDC scenario compatible with Brazil's fair share in a 1.5°C world could lead the country to negative emissions as early as 2030. Although such a scenario would clearly be desirable, the Observatory does not consider it scientifically appropriate.

Brasil 2045

# 3

# EMISSIONS AND REMOVALS SCENARIO

## to achieve the proposed NDC target

This section presents a scenario of greenhouse gas (GHG) emissions and removals broken down by sector, which indicates a path to achieving the level of net emissions compatible with the target proposed by the Climate Observatory for Brazil's NDC.

The exercise of developing this scenario was based on the emissions estimates from the SEEG collection 11.2 and, like SEEG, was carried out by the following organizations that are part of OC: the Amazon Environmental Research Institute (Ipam), for the Land Use Change and Forestry sector, the Forest and Agricultural Management and Certification Institute (Imaflora), for the Agriculture sector, the Energy and Environment Institute (Iema), for the Energy and Industrial Processes and Use of Products sectors, and Local Governments for Sustainability in South America (ICLEI), for the Waste sector.

Section 3.1 presents the main mitigation actions considered in the scenario. Section 3.2 presents the emissions and removals of the scenario summarized. Sections 3.3 to 3.6 present, for each of the emission sectors, the main assumptions, methodology and results.

## 3.1. Main mitigation actions considered

Here are listed the mitigation actions considered in the scenario, for each of the emission sectors, until 2035.

### 3.1.1. Land Use Changes and Forests

- Elimination of deforestation in all biomes, restricting the annual deforested area in the country to a maximum of 1,000 $km^2$ from 2030 onwards.
- Recovery of all the country's vegetation deficit[24], of 21 million hectares according to the Forest Code, by 2035, leading to the growth of secondary vegetation.

### 3.1.2. Agriculture

- Recovery of 22.5 million hectares of soil with signs of degradation [25];

[24] Vegetation deficit, within the scope of the Forest Code (Law 12.651/2012), refers to areas that were converted from their natural state without authorization for their removal. They must, therefore, be recovered by the responsible party for the purposes of environmental regularization of the rural property.

[25] Mitigation action quantified by accounting for emissions and removals due to carbon in the soil, not accounted for in the Brazilian Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases (NCI emissions and removals - Not Accounted for in the Inventory).

- Further expansion[26] of 18 million hectares of Integrated Crop-Livestock-Forestry (ICLF) systems;
- Implementation of 1 million additional hectares of Agroforestry Systems (AFS);
- Further expansion of 5 million hectares of Planted Forests (PF);
- Adoption of No-till System (NTS) practices in 80% of the agricultural area, of which at least 80% with No-till (NT) and 20% with complete NTS, considering the expansion of the planted area destined for agriculture (approximately 24.3 million hectares);
- The slaughter of 7.5 million cattle with Intensive Termination (IT), with the adoption of confinement, semi-confinement and with supplementation;
- For Animal Waste Treatment (AWT), achieve expansion to 40.5% of biodigester use in relation to other animal waste management systems, with the total conversion of anaerobic lagoons to biodigesters in pig farming, totaling the national average of 46.4% of biodigester adoption;
- Further expansion of 19 million hectares with the use of Biological Nitrogen Fixation (BNF).

### 3.1.3. Energy and Industrial Processes and Product Use

- **Transportation:** Increased energy efficiency in new conventional vehicles following the historical trend. Gradual increase in hybrid, battery-electric and hydrogen vehicles in total new sales, reaching a cumulative value of 5.2 million hybrid vehicles, 7.6 million battery-electric vehicles and 51.5 thousand hydrogen vehicles sold between 2025 and 2035. Availability of 3.5 billion liters of green diesel in 2035. Growth in the share of biodiesel in commercial diesel oil until reaching 20% in 2030. Increased use of ethanol to replace gasoline, reaching 100% of flex-fuel vehicles by 2035. Improvement of urban passenger mobility, with a decrease in the use of individual motorized transportation and an increase in the use of public and active modes. To this end, four thousand kilometers of roads dedicated to BRT (bus rapid transit) systems, one thousand kilometers of subway tracks and another 95 thousand kilometers of bike paths will be built in addition to the 2015 figures. Thus, the growth in the number of kilometers traveled by automobiles will be limited to 15% between 2015 and 2035, while that traveled by urban buses will more than double in the same period. Air transport will include the addition of SAF (sustainable aviation fuel) to aviation kerosene from 2027 (reaching 8% of the volume of kerosene consumed in 2035).

[26] In the agricultural sector, the expression "further" refers to what existed in the year 2022.

- **Industry:** Increased use of electricity and biomass already used (sugarcane bagasse, lye and charcoal). In 2035, consumption of biogas and biomethane will represent 3.9 million tons of oil equivalent. Start of use of green hydrogen in 2030. Reduction in consumption of petroleum derivatives between 2022 and 2035 by more than 50%. Gradual retirement of the use of coal and derivatives for the manufacture of steel and other metallurgical products. Fossil fuels limited to supplying approximately 15% of direct industrial energy demand in 2035. Increase in average industrial efficiency by 3% between 2022 and 2035. Control of the use and emissions of HFCs (refrigerant gases), complying with the Kigali Amendment of the Montreal Protocol.

- **Fuel production:** Production of oil, fossil gas, coal and their derivatives will be limited to meeting estimated domestic demand.

- **Electricity generation:** Installed hydroelectric power capacity will be frozen from 2022 (110 GW). All coal-fired power plants will be completely retired by 2027, while the total capacity of other fossil fuel-fired power plants will be set at 26.5 GW (2022 value). Wind and solar photovoltaic power plant capacities will reach 70 GW and 95 GW, respectively, in 2035 (in 2022, both wind and solar power plants totaled 24 GW of capacity). Biomass power plants will continue to grow, reaching an increase of more than 50% in installed capacity between 2022 and 2035.

- **Buildings:** Elimination of the use of firewood for residential cooking in urban areas by 2030, as well as a gradual reduction in rural demand. Direct solar heating will represent 20% of residential energy consumption in 2035.

- **Agriculture:** 4% annual gain in energy efficiency until 2030. Increase in electricity use by approximately 25% between 2022 and 2035, replacing the burning of diesel oil. Use of biodiesel, added to petroleum diesel, in the same proportions adopted in the transport activity (15% of the volume of the mixture between biodiesel and petroleum diesel in 2025, reaching the limit of 20% in 2030).

### 3.1.4. Waste

- Universal coverage of the domestic wastewater collection service;
- Closure of dumpsites by 2028;
- Increase in the recovery rate of recyclables - 24% by 2035;
- Increase in the recovery rate of organic waste through composting and anaerobic digestion, 18% by 2035;
- Percentage of biogas used for energy in landfills and anaerobic digestion - 58% by 2035;

- Installation of domestic wastewatert treatment plants with aerobic processes and anaerobic reactors focused on capturing biogas, in addition to optimizing existing systems, whether to increase treatment efficiency or burner efficiency;

- Exclusion of thermal treatment routes in solid waste management.

## 3.2. Overall scenario emissions and removals results and proposed emissions and removals targets for the NDC horizon

Table 2 summarizes the total emissions and removals of the scenario developed for the years 2025, 2030 and 2035, also presenting the historical estimates for 2005, 2010, 2015 and 2020. The results of the scenario consisted of net emissions of 368 $MtCO_2e$ in 2030 and 171 $MtCO_2e$ in 2035. It is worth noting that, in the Land Use Change and Forestry sector, removals by protected areas were not considered, due to the great uncertainties involved (see section 2.2). In the Agriculture sector, $CO_2$ emissions and removals related to managed soils were considered, sources that are not yet accounted for in the National Inventory but that are relevant in the total carbon balance, being reported by SEEG (see section 3.4).

***Table 2: General table of emissions and removals by year (scenario)***

| Values in $MtCO_2e$ (GWP AR-5) | 2005 | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|---|---|
| **Emissions** | **2769** | **1832** | **2201** | **2289** | **1992** | **1279** | **1244** |
| LUCF | 1697 | 684 | 928 | 1064 | 725 | 61 | 61 |
| Energy | 318 | 372 | 452 | 387 | 389 | 312 | 249 |
| IPPUIPUP | 76 | 85 | 92 | 88 | 89 | 93 | 96 |
| Waste | 61 | 70 | 82 | 91 | 89 | 81 | 66 |
| Agriculture | 519 | 534 | 552 | 576 | 646 | 693 | 743 |
| Agriculture NCI* (soil carbon) | 100 | 86 | 95 | 82 | 54 | 39 | 29 |
| **Removals** | **-329** | **-426** | **-518** | **-614** | **-750** | **-911** | **-1073** |
| LUCF | -138 | -178 | -213 | -239 | -312 | -412 | -511 |
| Agriculture NCI* (soil carbon) | -191 | -248 | -305 | -376 | -438 | -500 | -562 |
| **Net emissions** | **2440** | **1405** | **1682** | **1674** | **1242** | **368** | **171** |

*$CO_2$ emissions and removals from soil carbon variations through soil management are considered. Such emissions and removals are not accounted for in the Brazilian Inventory of Anthropogenic Greenhouse Gas Emissions and Removals (NCI emissions and removals - Not Accounted for in the Inventory).

Table 3 summarizes the total emissions and removals of the scenario prepared for each five-year period.

***Table 3: General table of emissions and removals per five-year period (scenario)***

| Values in $MtCO_2e$ (GWP AR-5) | 2006 a 2010 | 2011 a 2015 | 2016 a 2020 | 2021 a 2025 | 2026 a 2030 | 2031 a 2035 |
|---|---|---|---|---|---|---|
| **Emissions** | **10363** | **10325** | **11083** | **11420** | **7828** | **6274** |
| LUCF | 4896 | 4126 | 4893 | 5017 | 1632 | 304 |
| Energy | 1725 | 2182 | 2048 | 2048 | 1717 | 1367 |
| IPPUIPUP | 386 | 461 | 440 | 455 | 459 | 474 |
| Waste | 330 | 383 | 438 | 451 | 434 | 354 |
| Agriculture | 2584 | 2717 | 2825 | 3121 | 3370 | 3613 |
| Agriculture NCI* (soil carbon) | 443 | 456 | 439 | 329 | 216 | 162 |
| **Removals** | **-1941** | **-2413** | **-2864** | **-3429** | **-4235** | **-5042** |
| LUCF | -809 | -999 | -1138 | -1365 | -1860 | -2357 |
| Agriculture NCI* (soil carbon) | -1132 | -1414 | -1726 | -2064 | -2375 | -2685 |
| **Net emissions** | **8422** | **7912** | **8219** | **7991** | **3593** | **1232** |

*$CO_2$ emissions and removals from soil carbon variations through soil management are considered. Such emissions and removals are not accounted for in the Brazilian Inventory of Anthropogenic Greenhouse Gas Emissions and Removals (NCI emissions and removals - Not Accounted for in the Inventory).

Based on the results of the scenario, the targets of the Climate Observatory's NDC proposal for 2030 and 2035 are established - maximum emission values and minimum removal values by sector and totaled, in Table 4. Likewise, the targets for accumulated emissions and removals are established in the five-year periods 2026 to 2030 and 2031 to 2035.

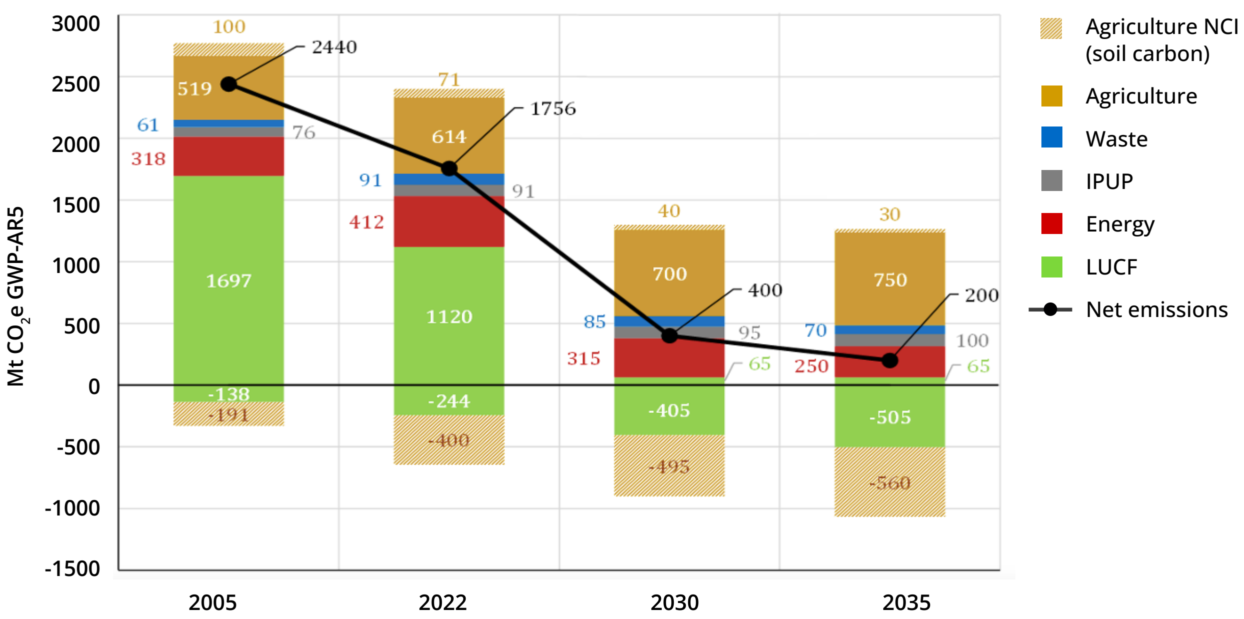
***Table 4: Emissions and removals targets for 2030 and 2035 and for the five-year periods 2026 to 2030 and 2031 to 2035***

| Values in $MtCO_2e$ (GWP AR-5) | 2030 | 2035 | 2026 a 2030 | 2031 a 2035 |
|---|---|---|---|---|
| **Emissions** | **1300** | **1265** | **8200** | **6600** |
| LUCF | 65 | 65 | 1700 | 400 |
| Energy | 315 | 250 | 1800 | 1400 |
| IPPUIPUP | 95 | 100 | 500 | 500 |
| Waste | 85 | 70 | 500 | 400 |
| Agriculture | 700 | 750 | 3400 | 3700 |
| Agriculture NCI* (soil carbon) | 40 | 30 | 300 | 200 |
| **Removals** | **-900** | **-1065** | **-4100** | **-4900** |
| LUCF | -405 | -505 | -1800 | -2300 |
| Agriculture NCI* (soil carbon) | -495 | -560 | -2300 | -2600 |
| **Net emissions** | **400** | **200** | **4100** | **1700** |

*$CO_2$ emissions and removals from soil carbon variations through soil management are considered. Such emissions and removals are not accounted for in the Brazilian Inventory of Anthropogenic Greenhouse Gas Emissions and Removals (NCI emissions and removals - Not Accounted for in the Inventory).

Figure 1 illustrates emissions and removals in 2005 (reference year for establishing the targets of the 1st Brazilian NDC), in 2022 (data from the latest SEEG collection, except for NCI emissions from Agriculture, whose estimate was updated for the current exercise), in 2030 and 2035 (years for which the current exercise establishes emissions and removals targets).

***Figure 1: Emissions and removals in 2005 and 2022 and emissions and removals targets by sector and net total for 2030 and 2035***




## 3.3. Energy and Industrial Processes and Product Use (IPPU)

### 3.3.1. Scenario assumptions

In the Energy and Industrial Processes sectors, Brazil must make efforts to meet the growing demand for energy while promoting an ambitious energy transition, replacing fossil fuels with renewable sources. To this end, there must be clear commitments, translated into public and private incentives and investments, with effective public policies, debated with society and the sectors involved, avoiding errors in projects that disregard basic socio-environmental safeguards.

In response to the need for transition, to the GST mandate and to the International Energy Agency's net zero scenario, Brazil must halt the expansion of fossil fuel exploration, reducing massive incentives (OC, 2024) for this sector and avoiding the opening of any new exploration frontiers. The energy transition is gaining speed across the world and should result, in the coming years, in a lower global demand for oil, which will affect Brazilian exports and jeopardize expensive investments in new areas. To overcome these risks and promote a complete decarbonization of the Brazilian energy matrix by 2045, Petrobras' investment portfolio must change so that the oil company increasingly becomes an energy company focused on renewable sources.

However, the advancement of renewable energy alone is not enough in a country marked by profound social, regional and racial inequalities. In Brazil, investments in infrastructure and technological modernization must necessarily come hand in hand with the fight against poverty, which must definitively enter the government's agenda and be a parameter for public policies.

It is also crucial to reconfigure cities in the quest for territorial and housing justice, which should translate into more social housing in central areas, reduced trips and distances traveled, and zero fares on public transport combined with the electrification of fleets. These issues are directly related to the passenger transport sector, which should focus on the introduction of more efficient zero-emission vehicles while prioritizing public transport — buses, subways, light rail, among others — over individual transport. In addition, the electrification of fleets should be combined with a paradigm shift in urban planning, focusing on more compact cities that prioritize short trips on foot or by bicycle. Fewer cars, less air and noise pollution, and better health for the population.

However, freight transport, which is mostly road-based and intensive in the use of fossil fuels, is the largest source of greenhouse gas emissions in the Energy and Industrial Processes sectors. The challenges to mitigating these emissions are enormous, so it is essential to embrace a range of alternatives that include different types of heavy vehicles that need to travel long distances at a moderate cost. Fossil-based diesel should be replaced by biofuels — biodiesel and green diesel produced in a sustainable way — in addition to synthetic fuels, green hydrogen and hybrid or electric engines.

In the electricity subsector, there must be, first and foremost, a focus on equitable and affordable energy supply, with a continuous guarantee of clean and quality energy throughout the country, including alternatives for remote areas without supply via the National Interconnected System (NIS). This must be combined with clear goals for reducing energy poverty, such as ending the precarious use of traditional biomass for the subsistence of poorer families, in addition to making distributed generation accessible to low-income families.

In decarbonizing this subsector, the distance to be covered is shorter, given that the Brazilian electricity mix is already mostly renewable. However, it is necessary to move towards a complete transition with the decommissioning of coal-fired thermal power plants by 2027 and reversing of the contracting of inflexible gas-fired thermal plants, maintaining the existing ones in a flexible manner in response to system crises, only as a capacity reserve.

In parallel with decarbonization, Brazil should not make new investments in nuclear energy for electricity generation, either due to the high environmental risks associated with radioactive material or due to the major economic disadvantages for the population. In 2024, the Angra 1 and 2 plants will sell their energy at a rate of R$355/MWh, without considering charges and taxes (ANEEL, 2023); If completed, Angra 3 will cost R$43 billion more than other alternatives, which would represent a 2.9% impact on energy tariffs, according to the Federal Court of Accounts (TCU) (EPBR, 2024). For comparison, 31 wind and solar energy projects won an Aneel auction in 2021 with an average tariff of just over R$160/MWh, to operate from 2026 (EPE, 2021).

The construction and operation of new Small Hydroelectric Power Plants should also be restricted, with their operation in the Amazon region completely banned, in addition to prohibiting new megaprojects and evaluating the decommissioning of existing ones. Medium-sized hydroelectric projects can continue to be considered together with wind and solar generation projects, as long as a series of safeguards are observed to avoid socio-environmental impacts. This means starting from the premise that **the Brazilian energy transition must be fair and popular**, with broad participation of the communities affected by the new projects, a robust regulatory framework and rigorous environmental licensing processes, in order to protect preserved and socially sensitive areas.

Industry is known to be a difficult activity to reduce emissions, but there are already alternatives for its decarbonization, such as investment in energy efficiency, recycling and the use of renewable energy. In this subsector, fossil fuels must be progressively replaced by electricity, biomass and other renewable energy sources. To this end, it will be necessary to implement public policies and invest in new energy transition fronts aimed at industry, such as green hydrogen, biomethane and charcoal.

There are initiatives aimed at reindustrializing Brazil, especially through public policies such as the Ecological Transformation Plan and the New Industry Brazil, which provide guidelines for both economic and productive activity development. The Brazilian industrial sector must be guided by technological innovation, green investments for its modernization and a change of focus to low-carbon production, which is focused on its progressive, effective and ambitious decarbonization, with incentives for those who produce in a more sustainable way and are seeking solutions to combat the climate crisis.

Brazil must limit its greenhouse gas emissions in the Industrial Processes and Product Use sector with the appropriate public and private financial contributions to ensure technological changes and the acquisition of the necessary, climate-friendly inputs.

As for hydrofluorocarbons (HFCs), the country must reduce its imports by 10% in 2029, 30% in 2035; 50% in 2040; and 80% in 2045, compared to the baseline of 79.5 million tons of $CO_2e$ (average of 2020, 2021 and 2022), according to the schedule for reducing the production and consumption of HFCs approved by the Kigali Amendment of the Montreal Protocol.

Finally, mineral extraction and production for the industry must also follow the parameters of climate and social responsibility, with attention to good practices, contributing to the decarbonization agenda of the Brazilian economy, focusing on the best location alternatives for projects (with respect to local communities and protected and especially sensitive areas), as well as on the best production arrangements. The extraction of strategic or critical minerals, which serve as raw materials for the production of essential items for the energy transition, such as batteries and solar panels, should not put action against the climate emergency and the fundamental rights of society on opposite sides. Therefore, the extraction and production methods of the mining sector must be adapted to the reality of the global climate crisis, changing the focus of investments and projects currently in place or in the future.

Brazilian industry must also be concerned with reducing social inequalities and combating environmental racism, including the search for climate justice on its agenda. This is especially important when making decisions about projects and their implications in protected and sensitive areas, territories of traditional peoples and communities, and areas that interfere with the well-being of the local population. Once again, it is necessary to focus on broad participation of affected communities, as well as organizations and civil society itself.

### 3.3.2. Scope of Energy and IPPU emissions and overall results

The Energy sector includes greenhouse gas emissions from the burning of fuels for final energy consumption, such as the combustion of gasoline in automobiles, or for energy transformation, such as the burning of natural gas in thermoelectric plants to generate electricity. In addition, this sector also includes fugitive emissions, which occur due to intentional or unintentional escapes of gasses during fuel production, such as methane ($CH_4$) leaks during oil exploration. The Energy sector was responsible for the emission of 412.5 million tons of $CO_2e$ (GWP-AR5) in 2022, equivalent to 18% of Brazil's total gross emissions.

The Industrial Processes and Product Use (IPPU) sector includes emissions that occur due to physical-chemical transformations inherent to the manufacture of materials and/or industrial products, such as the processing of iron ore into steel. In this sector, there are also emissions associated with the use of products, such as refrigerant gasses, used in refrigerators, air conditioning units, etc. In 2022, 90.8 million tons of $CO_2e$ were estimated within IPPU, corresponding to 4% of the national total.

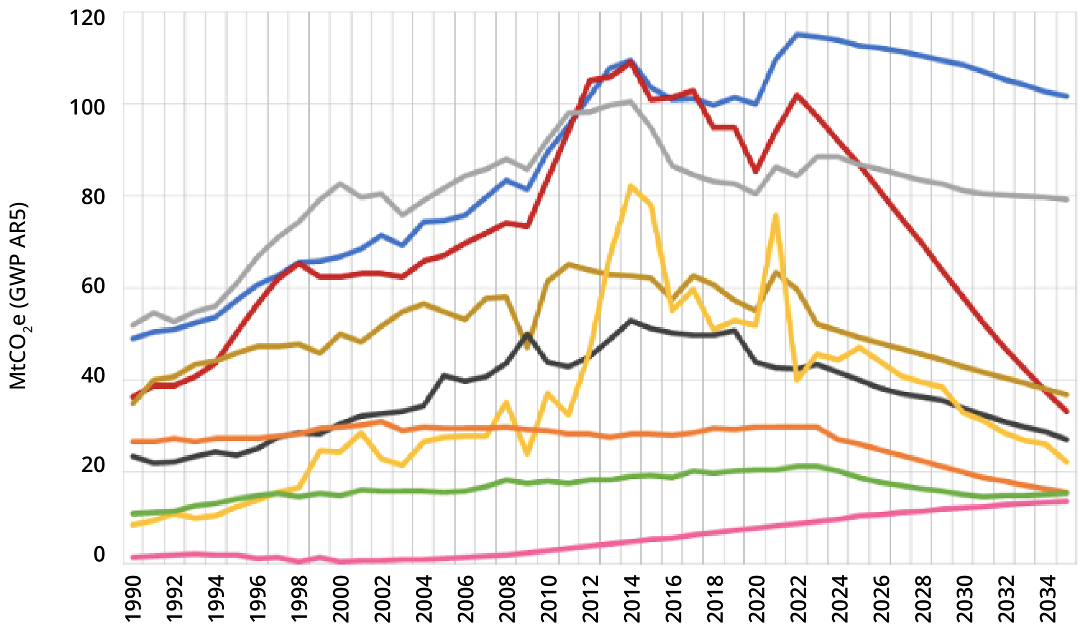
These two sectors have similar emissions dynamics, which are strongly correlated with the country's Gross Domestic Product (GDP) and technical-industrial development. In addition, there are industrial activities that emit both due to the burning of fuels (Energy sector) and physical-chemical transformations (IPPU), such as cement production, or that use energy sources as part of industrial processes, such as the use of coal coke to manufacture pig iron and steel.

For these reasons, the Energy and Industrial Processes sectors will be treated here jointly, aggregated through nine major emitting activities: (i) Freight transportation; (ii) Passenger transportation; (iii) Cement, chemicals, other raw materials and industries; (iv) Pig iron and steel and other metallurgical industries; (v) Fuel production; (vi) Electricity generation; (vii) Buildings; (viii) Agriculture; and (ix) Production and use of HFCs.

Broadly speaking, data related to industrial production or energy use in these activities were projected from 2023 to 2035 through their correlations with Brazil's GDP. Future GDP growth rates (growth of 2.1% per year between 2023 and 2035 for General GDP and 1.9% for Industrial GDP) were calculated based on the average between the linear trend of historical data (1960-2022) and the average growth projection of EPE (2024). In addition, the historical relationship (1970-2022) of GDP results with variables of industrial or energy activities was observed and a future trend relationship (2023-2035) was assumed; then, already having future GDP values (2023-2035), it was possible to determine future values for these variables as well.

Finally, for each general Energy and IPPU activity, actions were defined that would meet the projected demands, but that would also mitigate emissions: reduction in the intensity of use of emitting technologies, increase in the use of renewable energy sources, technological improvement, increase in energy efficiency, etc. The methods, premises and guiding actions adopted will be better explained in the next subtopics, and the general results achieved in the scenario can be seen in the figures and table below.

***Figure 2: Historical and projected emissions of Energy and IPPU by general activities***



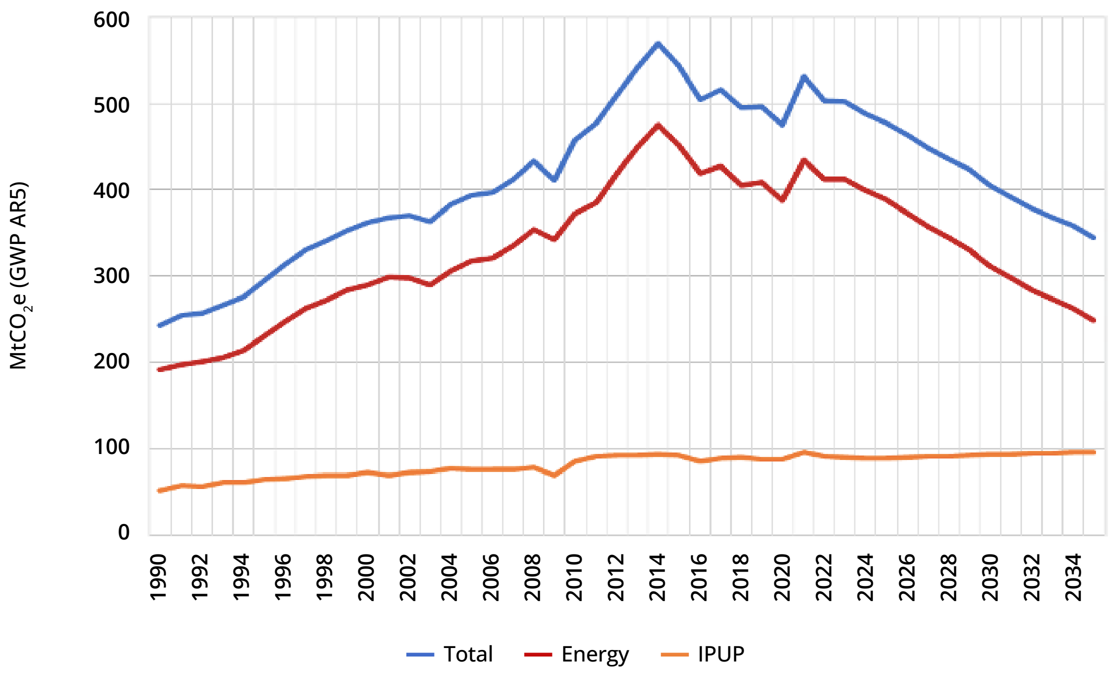

Emissions from Energy and Industry in 2035: 344,8 $MtCO_2e$

- Freight transport: 101,6 $MtCO_2e$ (29%)
- Cement, chemical and other materials and industries: 79,3 $MtCO_2e$ (23%)
- Pig iron and other metallurgies: 36,8 $MtCO_2e$ (11%)
- Passenger transport: 33,2 $MtCO_2e$ (10%)
- Fuel production: 27,1 $MtCO_2e$ (8%)
- Electricity generation: 22,1 $MtCO_2e$ (6%)
- Buildings: 15,6 $MtCO_2e$ (5%)
- Agriculture: 15,3 $MtCO_2e$ (4%)
- HFCs: 13,8 $MtCO_2e$ (4%)

***Table 5: Historical estimates (2005, 2010, 2015 and 2020 to 2022) and projections (2023 to 2035) of emissions, in millions of tons of $CO_2$e, from Energy and IPPU by sectors and general activities***

| | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cargo transport | 74,6 | 89,6 | 103,7 | 100,1 | 109,8 | 115,0 | 114,7 | 113,9 | 112,8 | 112,1 | 111,4 | 110,5 | 109,6 | 108,4 | 107,1 | 105,5 | 104,2 | 102,7 | 101,6 |
| Passengers transport | 67,0 | 83,6 | 100,9 | 85,4 | 94,2 | 101,8 | 97,3 | 92,1 | 86,8 | 81,2 | 75,4 | 69,6 | 63,8 | 58,0 | 52,4 | 47,1 | 42,1 | 37,5 | 33,2 |
| Cement, chemical, other raw materials and industries | 81,7 | 92,2 | 94,9 | 80,6 | 86,3 | 84,4 | 88,6 | 88,6 | 86,9 | 85,9 | 84,7 | 83,5 | 82,6 | 81,2 | 80,5 | 80,2 | 80,0 | 79,9 | 79,3 |
| Pig iron, steel and other metallurgies | 54,8 | 61,5 | 62,3 | 55,1 | 63,3 | 59,8 | 52,2 | 50,7 | 49,3 | 48,1 | 46,9 | 45,6 | 44,3 | 43,1 | 41,8 | 40,6 | 39,3 | 38,0 | 36,8 |
| Fuel production | 41,1 | 44,0 | 51,3 | 44,0 | 42,6 | 42,5 | 43,4 | 41,8 | 40,0 | 38,4 | 37,1 | 36,4 | 35,7 | 34,0 | 32,5 | 31,0 | 29,8 | 28,9 | 27,1 |
| Electricity generation | 27,7 | 37,0 | 78,0 | 51,9 | 75,9 | 40,0 | 45,5 | 44,5 | 47,0 | 44,1 | 41,0 | 39,5 | 38,6 | 33,0 | 31,3 | 28,5 | 26,9 | 26,2 | 22,1 |
| Buildings | 29,4 | 29,0 | 28,2 | 29,8 | 29,8 | 29,8 | 29,9 | 27,2 | 26,0 | 24,8 | 23,6 | 22,4 | 21,2 | 20,0 | 18,8 | 18,0 | 17,2 | 16,4 | 15,6 |
| Agriculture | 15,7 | 18,2 | 19,3 | 20,5 | 20,6 | 21,2 | 21,2 | 20,2 | 18,9 | 17,7 | 17,1 | 16,4 | 15,8 | 15,2 | 14,7 | 14,8 | 15,0 | 15,1 | 15,3 |
| HFC production and use | 1,2 | 2,8 | 5,4 | 7,8 | 8,2 | 8,7 | 9,3 | 9,9 | 10,4 | 10,8 | 11,1 | 11,5 | 11,9 | 12,3 | 12,6 | 12,9 | 13,2 | 13,5 | 13,8 |
| **Total (energy and IPPU)** | **393,2** | **457,8** | **544,1** | **475,1** | **530,8** | **503,3** | **502,0** | **488,7** | **478,1** | **463,2** | **448,3** | **435,5** | **423,5** | **405,2** | **391,5** | **378,4** | **367,7** | **358,3** | **344,8** |
| **Total (energy)** | **317,6** | **372,4** | **451,9** | **387,4** | **434,3** | **412,5** | **412,2** | **399,4** | **389,2** | **372,8** | **357,1** | **344,1** | **330,9** | **312,1** | **297,8** | **284,2** | **272,8** | **262,9** | **249,2** |
| **Total (IPPU)** | **75,6** | **85,4** | **92,2** | **87,7** | **96,5** | **90,8** | **89,8** | **89,3** | **88,9** | **90,4** | **91,2** | **91,4** | **92,6** | **93,1** | **93,7** | **94,2** | **94,8** | **95,4** | **95,6** |

*Figure 3: Historical and projected emissions of Energy and IPPU by sector*




### 3.3.3 Freight transport

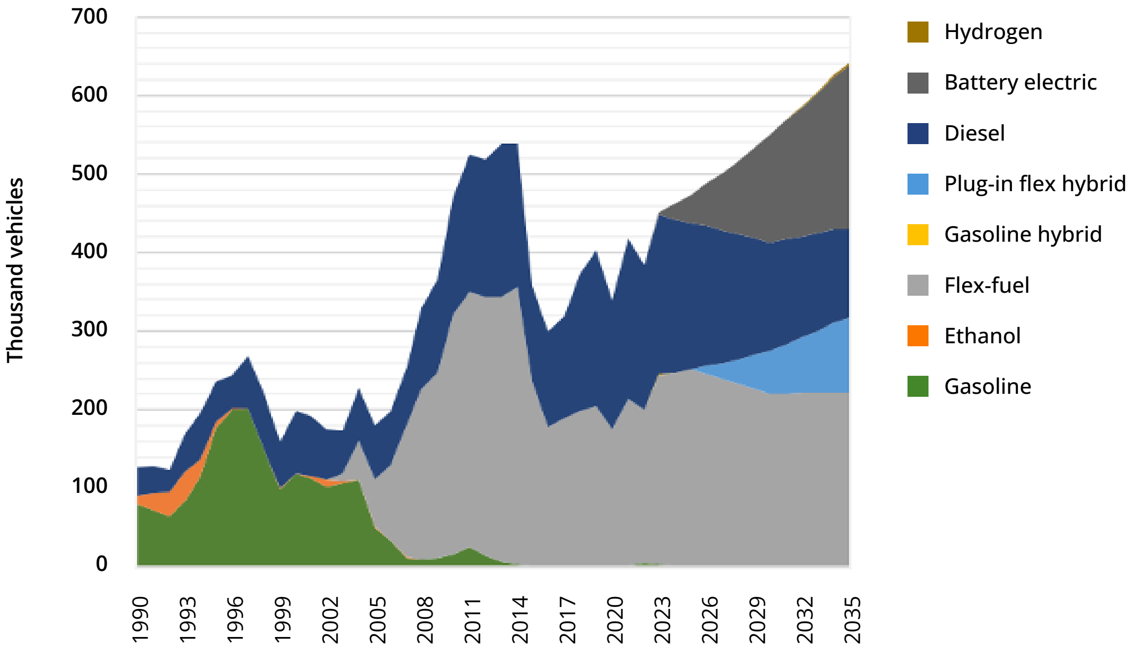
**The methodology for estimating historical and projected emissions from road transport was based on the National Inventory of Atmospheric Emissions by Road Motor Vehicles 2013 Base Year 2012 (MMA, 2014).**

Initially, historical statistics were gathered on annual sales of new trucks and light commercial vehicles, which were considered entirely as freight vehicles. For each of these categories, the shares of different propulsion technologies – diesel, battery-electric, hydrogen, gasoline, ethanol, flex fuel, gasoline hybrid and flex fuel plug-in hybrid – in relation to the total number of units sold were also raised year by year (ANFAVEA, 2023).

Future sales (2023 to 2035) of these two vehicle categories (trucks and light commercial vehicles) were projected according to the trend in the relationship between the annual number of units sold and Brazil's per capita GDP, with the country's population growth forecasts available on the IBGE portal (2018), while the GDP projection adopted is explained in the previous topic of this report. The São Paulo State Energy Plan 2050 (SEMIL, 2023) provided the share of each propulsion technology in sales in 2030 and 2040, allowing the technological profiles to also be determined for the years between 2023 and 2029, as well as between 2031 and 2035, linearly interpolating the values for 2022 (verified sales), 2030 and 2040 (projected sales). The scenario described here only disregarded the future sales shares of biogas vehicles indicated by Semil (2023), since the option was made to direct this fuel to other purposes (electricity generation and industry). Therefore, the market share predicted by the SP Energy Plan for new biogas units was, here, attributed to combustion vehicles.

This resulted in the figures of 149,000 trucks and 642,000 light commercial vehicles being sold in 2035, with 20% and 32.5% of these sales being battery-electric models, respectively. Cumulative sales of battery-electric vehicles will reach 202,000 trucks and 1.4 million light commercial vehicles by 2035. The following figure illustrates the technological sales profile obtained in this exercise for the light commercial vehicle category.

***Figure 4: Historical (1990 to 2022) and projection (2023 to 2035) of annual sales of new light commercial vehicles by propulsion technologies***




Scrapping curves are applied to the accumulated sales values, determining the number of vehicles that, according to category (truck or light commercial vehicle) and age, remain in the fleet over the years. New curves are then applied, this time for intensity of use, relating the annual mileage traveled by each vehicle to its category and age. Finally, the mileage obtained is multiplied by the energy demand (J/km) of the vehicles in the fleet (MMA, 2014), obtaining the final energy consumption of freight transportation. It is worth mentioning that the energy demand values per kilometer traveled were considered progressively lower over the years, extrapolating the historical trend observed, which is reflected in energy savings and reduced emissions by 2035.

In order to reduce emissions, part of the demand for diesel-powered vehicles must be met by biodiesel and green diesel. This takes into account that biodiesel will represent 15% of the volume of diesel oil sold in 2025 and 20% in 2030 – using Bill No. 528 of 2020, currently under consideration in the Federal Senate (2024), as a reference. It is also considered that the supply of green diesel, to be used both in freight transportation (most of it) and in passenger transportation, will be 700 million liters in 2031, reaching 3.5 billion in 2035 – values defined by assuming a linear growth in the production of this biofuel between 2030 and 2040, the year for which Cebri (2023) projected the production of 7 billion liters of green diesel in its ambitious scenario.

For light flex commercial vehicles, priority was given to the use of ethanol, adopting an annual supply, projected between 2023 and 2035 based on information from Conab (2024) and EPE (2023b), which allows the fleet of these vehicles to be fully fueled by biofuel in 2035.

In a less detailed way, given its lower relevance in terms of emissions, the energy demand for rail and waterway transport (with the exception of oil cabotage), fully allocated in the freight classification, was projected based on the historical trend of the relationship between the use of energy in vessels or locomotives and the country's GDP (EPE, 2023a; World Bank, 2023). In waterway transport, it was also estimated, in simplified terms, that 48% of its energy consumption in 2017 was due to oil cabotage, making it possible to calculate an average fuel consumption index for oil cabotage per number of barrels produced (EPE, 2023a; EPL, 2021; ICCT, 2024). With this index, the reduction in energy consumption of this portion of waterway transport was projected due to the decrease in demand for oil pursued in the scenario described here (see topic 3.3.7, on fuel production).

Thus, with the annual fuel consumption in freight transportation already estimated, emission factors from SEEG were applied, obtaining a result of 101.6 million tons of $CO_2$e emitted in 2035. This is a reduction of 13.4 Mt$CO_2$e (-12%) in relation to the emissions verified for the year 2022. The emissions curve for the freight transportation activity can be seen in figure 2 and the detailed results by mode (road, rail and waterway) are presented in the table below.

***Table 6: Historical estimates (2005, 2010, 2015 and 2020 to 2022) and projections (2023 to 2035) of emissions, in millions of tons of $CO_2$e, from Freight transport by travel mode***

| | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Road** | 68,1 | 81,9 | 96,3 | 93,1 | 102,9 | 108,2 | 107,9 | 107,0 | 105,9 | 105,3 | 104,6 | 103,7 | 102,7 | 101,6 | 100,2 | 98,7 | 97,3 | 96,0 | 94,7 |
| **Water** | 3,6 | 4,5 | 4,2 | 3,7 | 3,7 | 3,6 | 3,6 | 3,6 | 3,6 | 3,5 | 3,6 | 3,5 | 3,6 | 3,5 | 3,7 | 3,5 | 3,6 | 3,4 | 3,5 |
| **Railway** | 2,8 | 3,2 | 3,1 | 3,3 | 3,2 | 3,3 | 3,3 | 3,3 | 3,3 | 3,2 | 3,2 | 3,2 | 3,2 | 3,2 | 3,2 | 3,3 | 3,3 | 3,4 | 3,4 |
| **Total** | **74,6** | **89,6** | **103,7** | **100,1** | **109,8** | **115,0** | **114,7** | **113,9** | **112,8** | **112,1** | **111,4** | **110,5** | **109,6** | **108,4** | **107,1** | **105,5** | **104,2** | **102,7** | **101,6** |

### 3.3.4 Passenger transport

Estimates of greenhouse gas emissions generated by road passenger transport activity followed the same methodological approach applied to freight transport.

Therefore, as a first step, the sales history of new vehicles were collected, according to the three passenger categories: cars, buses and motorcycles. Sales by category were projected until 2035, incorporating the circumstances of the modal shift scenario in compact cities developed by ITDP and UC Davis (2024), which considers a significant increase in the number of urban trips made on foot, by bicycle and/or by public transport. As a result, on the one hand, there was a decrease in the growth rate of car and motorcycle sales and, on the other, a greater increase in the growth rate of buses. The number of cars sold rose from 1.6 million units in 2022 to 2.1 million in 2035 (+30%) and the number of motorcycles fell from 1.4 million to 1.2 million in the same period (-8%). However, bus sales went from 17.3 thousand units in 2022 to 43.6 thousand in 2035 (+152%), a significantly higher percentage growth.

According to projections prepared in the São Paulo State Energy Plan 2050 (Semil, 2023), annual sales of automobiles, buses and motorcycles were distributed among the different engine technologies: gasoline, ethanol, flex fuel, gasoline hybrid, flex fuel hybrid, plug-in flex hybrid, diesel, gas, battery electric, and H2. It should be noted that the SP Energy Plan considers that a fraction of the new bus market will be made up of biogas vehicles; however, this portion of gas bus sales was, in the scenario described here, entirely directed to diesel vehicles, understanding that biogas would have a more strategic use in electricity generation and industry activities.

The table below shows the shares of different propulsion technologies in the case of automobile sales. The values for the year 2022 refer to statistics verified by Anfavea (2023), while the percentages for 2030 and 2040 come from Semil (2023). The fractions for the intermediate years (2023 to 2029 and 2031 to 2035) were obtained by linearly interpolating the figures for 2022, 2030 and 2040.

***Table 7: New car sales and shares of different motorization technologies***

| | 2022 (Anfavea, 2023) | 2030 (Projection Observatório do Clima) | 2035 (Projection Observatório do Clima) |
|---|---|---|---|
| **Sales of new automobiles** (millions of cars) | 1,6 | 2,1 | 2,1 |

| **Share of sales** (by technology) | 2022 (Anfavea, 2023) | 2030 (Semil, 2023) | 2035 (Interpolation Observatório do Clima) | 2040 (Semil, 2023) |
|---|---|---|---|---|
| Gasoline | 3% | 0% | 0% | 0% |
| Ethanol | 0,002% | 0% | 0% | 0% |
| Flex fuel | 91% | 60% | 49,5% | 39% |
| Gasoline hybrid | 3% | 0% | 0% | 0% |
| Flex-fuel hybrid | 0% | 15% | 17,5% | 20% |
| Plug-in flex hybrid | 0% | 10% | 12,5% | 15% |
| Diesel | 3% | 0% | 0% | 0% |
| Fossil gas | 0% | 0% | 0% | 0% |
| Battery EV | 0% | 15% | 20% | 25% |
| H2 | 0% | 0% | 0,5% | 1% |

By multiplying accumulated sales and scrapping/retirement rates (according to year of manufacture and vehicle category), the fleet in circulation in a given year was obtained. It is now possible to find the total mileage traveled by the different vehicles in circulation by multiplying, this time, the usage intensity rates (km/vehicle/year) by the fleet that was estimated (MMA, 2014).

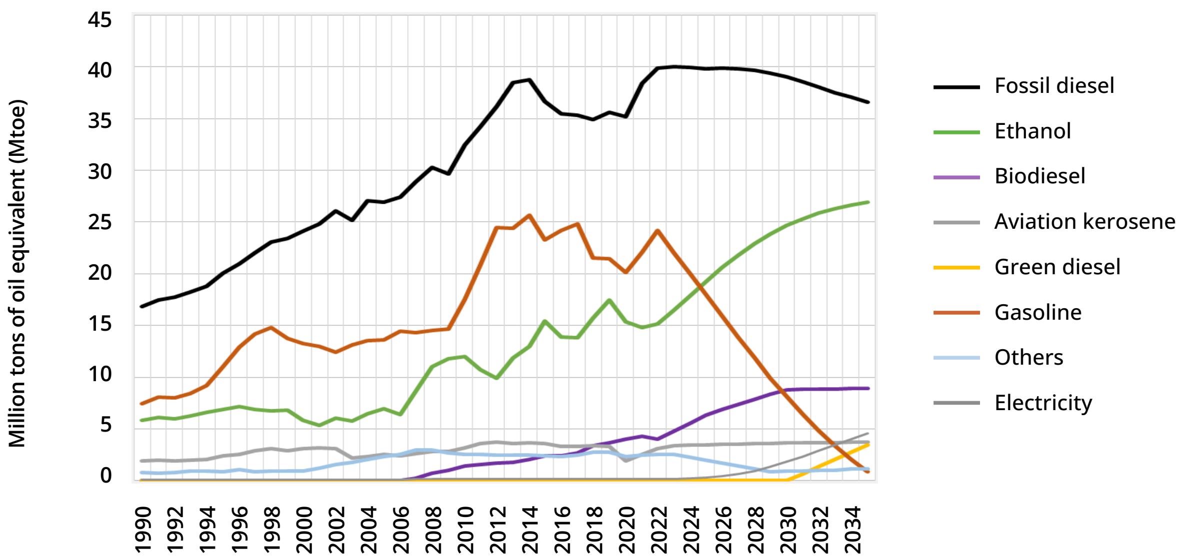
The mileages obtained were further adjusted based on the scenario of prioritizing collective and active mobility of ITDP and UC Davis (2024). In this way, the mileage traveled by individual motorized transport grew less sharply than that traveled by urban buses.

Given the annual mileage traveled by the combination of vehicle category (car, bus or motorcycle) and propulsion/motorization technology, it was possible to calculate, using autonomy indexes (energy consumed per mileage traveled), the energy demand for road passenger transport.

This result was complemented by the energy demand for air transport, which, for the sake of simplicity, is here considered entirely as passenger transport. The demand for aviation fuels was projected following the trend of its relationship with Brazilian GDP. It was also adopted that SAF (sustainable aviation fuel) will be mixed with aviation kerosene from 2027, when it will replace 1% of the demand for this fossil fuel. Advancing one percentage point per year, SAF will replace 8% of the demand for aircraft kerosene in 2035 (Federal Senate, 2024).

Segmented by source, the next figure illustrates the sum of energy demand for passenger transport and that for freight transport (see previous topic). The significant drop in gasoline consumption is noteworthy, as a result of greater penetration of low-emission technologies in the light vehicle fleet, as well as the increase in trips made by active and public transport.

***Figure 5: Historical (1990 to 2022) and projection (2023 to 2035) of fuel consumption in all transport activities (passengers and freight)***



Applying the appropriate emission factors to energy consumption in passenger transportation, we finally find emissions from the burning of fuel in cars, buses, motorcycles and aircraft. In 2035, according to the table below, these vehicles are projected to emit 33.2 million tons of $CO_2$e. This figure is 67% lower than the total emitted by the movement of people in 2022, representing the highest percentage of emissions reduction among all activities in the Energy and IPPU sectors.

***Table 8: Historical estimates (2005, 2010, 2015 and 2020 to 2022) and projections (2023 to 2035) of emissions, in millions of tons of $CO_2$e, from Passenger transport by travel modes***

| | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Road | 59,2 | 73,8 | 89,9 | 79,6 | 86,5 | 92,3 | 86,8 | 81,5 | 76,2 | 70,4 | 64,6 | 58,6 | 52,7 | 46,9 | 41,2 | 35,8 | 30,8 | 26,1 | 21,8 |
| Air | 7,8 | 9,8 | 11,0 | 5,8 | 7,7 | 9,5 | 10,5 | 10,5 | 10,7 | 10,8 | 10,8 | 11,0 | 11,1 | 11,1 | 11,2 | 11,2 | 11,3 | 11,4 | 11,4 |
| **Total (passenger transport)** | **67,0** | **83,6** | **100,9** | **85,4** | **94,2** | **101,8** | **97,3** | **92,1** | **86,8** | **81,2** | **75,4** | **69,6** | **63,8** | **58,0** | **52,4** | **47,1** | **42,1** | **37,5** | **33,2** |

### 3.3.5 Cement, chemicals, other raw materials and industries

The general activity of "Cement, chemicals, other raw materials and industries" includes emissions from both Energy and Industrial Processes and Product Use (IPPU) related to the following eight industrial segments: cement, chemicals, food and beverages, pulp and paper, ceramics, mining and pelletizing, textiles, and other industries. In total, this activity was responsible for the emission of 84.4 million tons of $CO_2$e in 2022.

These eight industrial segments are grouped under this same general activity because they were treated using the same methodological approach for projecting emissions. It should be noted, however, that carbon from the combustion of fuels in self-producing power plants associated with these industries was classified as belonging to the "Electricity generation" activity and is therefore not accounted for here.

As the first step of the methodology, the future energy demands (2023-2035) of each of the industrial categories mentioned in the first paragraph of this topic were determined. This calculation was possible through the respective trends in the evolution of the relationship between energy demand (EPE, 2023a) and industrial GDP results (MAPA, 2024; WORLD BANK, 2023). Thus, having in hand these trends (toe/R$) and projections of the country's industrial GDP until 2035 (R$), the future energy demand curves (toe) are found.

As information was available and given the greater weight of this industry in emissions, a specific analysis was used for the case of energy use in cement plants: the relationship between cement production (Snic, 2023) and energy demand (EPE, 2023a) was considered, instead of the relationship between the GDP of the entire Brazilian industry and the energy demand of cement manufacturing alone.

Since the projections adopted for both industrial GDP and cement production are upward, with an average growth of 1.9% per year between 2023 and 2035 for the former and 2.5% for the latter, the total energy demanded by the "Cement, chemicals, other raw materials and industries" activity increased accordingly. Therefore, in order to reduce this energy demand and, consequently, emissions, an indicative average efficiency gain was assumed, in terms of energy consumed per unit of industrial GDP produced (toe/R$), of 1% between 2023 and 2035.

For the remaining demand, the energy matrix of each of the eight industries mentioned above was analyzed, seeking, according to observed trends or information from the literature, to increase the use of electricity and biomass while reducing the use of fossil fuels. For the cement, chemical, food and beverage, and pulp and paper industries, the decarbonization plan for the United States industry prepared by the Renewable Thermal Collaborative - RTC (2022) group was adopted as a reference.

As a result, the following examples of decarbonization premises could be adopted: (i) zero consumption of petroleum derivatives and coal by 2030 and natural gas by 2035 in the food and beverage, cement, and pulp and paper industries; (ii) reduction in natural gas consumption and start using green hydrogen in the chemical industry by 2035 (RTC, 2022).

Finally, the appropriate emission factors were applied to the estimated annual consumption for the different fuels, resulting in emissions related to fuel combustion (Energy sector). Future emissions related to the IPPU sector of the "Cement, chemicals, other raw materials and industries" activity were estimated, in a simplified manner, through the historical relationship of these emissions with the industrial GDP or with cement production. Therefore, no actions were assumed here to reduce emissions related specifically to industrial processes.

Thus, as illustrated in figure 2 and organized in the table that concludes this topic, the total emission achieved in 2035 was 79.3 $MtCO_2e$, a value 6% and 3% lower than that verified for this activity in 2022 and 2005, respectively.

The cement production category is the only one that does not show a decrease in emissions between 2035 and 2022; on the contrary, it is possible to note an increase of 26%. Although emissions related to the burning of fuels in cement plants have been reduced through the actions mentioned above, the same did not happen with those related to industrial processes in this industry, causing such an increase. $CO_2$ emissions from IPPU in cement plants are inherent to the transformation of raw materials that culminate in the manufacture of cement (final product), and the only technology currently envisaged to reduce them is CCS (carbon capture and storage). However, the Climate Observatory has as a premise the non-use of CCS as a mitigation solution, since the promise of using this mechanism has not yet proven to be technically and economically viable and has, in practice, been used as a justification for the inaction of emitting sectors.

***Table 9: Historical estimates (2005, 2010, 2015 and 2020 to 2022) and projections (2023 to 2035) of emissions, in millions of tons of $CO_2$e, from Cement, chemicals, other raw materials and industries by production categories***

| | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cement | 23,6 | 36,0 | 38,7 | 35,5 | 37,4 | 34,2 | 38,4 | 38,5 | 38,8 | 39,2 | 39,6 | 40,1 | 40,6 | 40,9 | 41,4 | 41,8 | 42,3 | 42,9 | 43,1 |
| Chemical | 24,4 | 18,0 | 17,5 | 14,9 | 16,3 | 15,8 | 15,4 | 15,1 | 14,8 | 14,5 | 14,1 | 13,5 | 13,0 | 12,5 | 12,3 | 12,1 | 11,9 | 11,7 | 11,5 |
| Other raw materials and industries | 33,7 | 38,1 | 38,7 | 30,1 | 32,6 | 34,4 | 34,8 | 35,0 | 33,3 | 32,2 | 31,1 | 30,0 | 28,9 | 27,8 | 26,8 | 26,3 | 25,8 | 25,3 | 24,7 |
| **Total** | **81,7** | **92,2** | **94,9** | **80,6** | **86,3** | **84,4** | **88,6** | **88,6** | **86,9** | **85,9** | **84,7** | **83,5** | **82,6** | **81,2** | **80,5** | **80,2** | **80,0** | **79,9** | **79,3** |

## 3.3.6 Pig iron and steel and other metallurgical industries

The main source of emissions in the “Pig iron and steel and other metallurgical industries” activity is the industrial process of chemical reduction of ores to manufacture metals (final products), using reducing fuels that are currently mostly fossil fuels. In 2022, 74% of emissions from metallurgy came from the consumption of fossil reducing fuels, which is equivalent to 44.5 $MtCO_2$e. Of this amount, 88% occurs in the pig iron and steel industry. Therefore, reducing emissions from “Pig iron and steel and other metallurgical industries” necessarily involves the implementation of technological alternatives that enable the reduction of the use of fossil fuels in steel mills (essentially coal and derivatives).

To retire the steel production route using fossil reducing fuels in so-called steel blast furnaces, there are already options: (i) blast furnaces dedicated to the use of charcoal as a reducing fuel; (ii) direct reduction using natural gas and/or hydrogen; (iii) new smelting reduction processes; and (iv) recycling using an electric arc furnace (a route already used in Brazil) (E+, 2022; Hebeda *et al*, 2023).

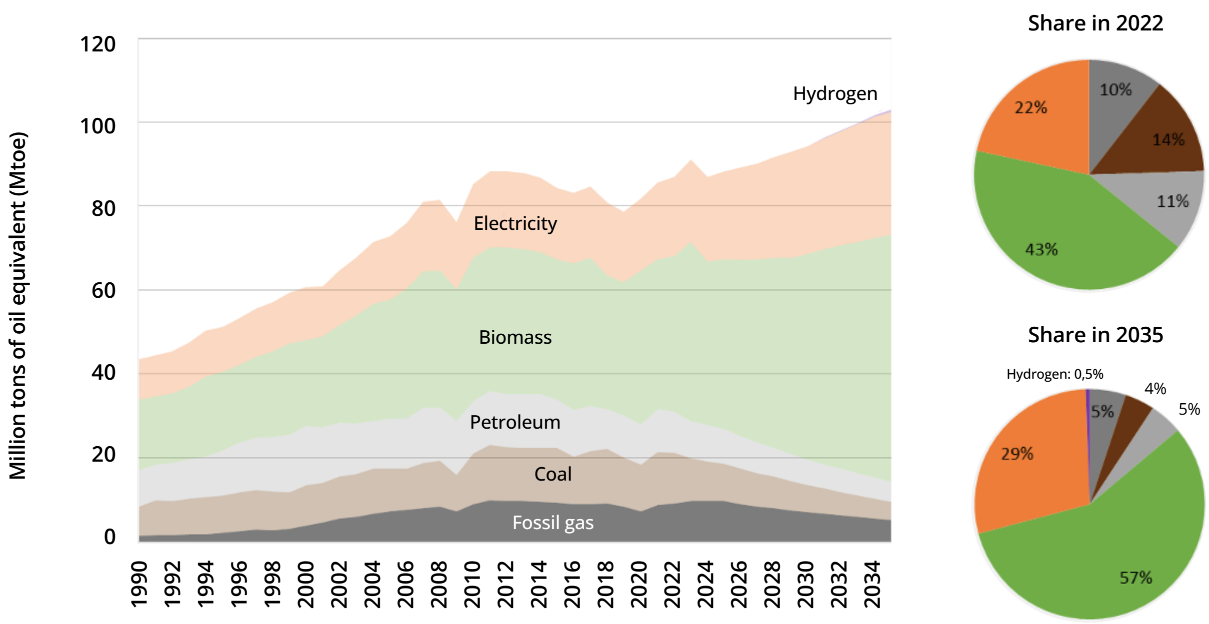
The article “Pathways for deep decarbonization of the Brazilian iron and steel industry” (HEBEDA et al, 2023) presents scenarios for adopting different technological routes for iron and steel production, with a view to reducing the carbon intensity of this industry. In the so-called “scenario of deep sustainable development” for the steel industry, the authors project a significant drop in steel production using blast furnaces using coal and derivatives, while the use of other less emitting routes (mentioned in the previous paragraph) increases. Thus, while the scenario predicts a growth of around 35% in the quantity (in mass) of steel produced in the country as a whole between 2022 and 2035, the amount of steel coming specifically from the blast furnace and coal route would see a reduction of approximately 65% in the same period (HEBEDA *et al*, 2023).

The annual consumption of energy sources indicated in the article as necessary to achieve the “deep sustainable development scenario” was then fully adopted in this NDC proposal from the Climate Observatory – it should be noted that such consumption includes both the final use of energy (Energy sector) and the use of inputs for the transformation of materials/chemical reduction of iron ore (IPPU sector). Regarding this consumption, emission factors from SEEG were applied. As a result, a 30% reduction in Energy and IPPU emissions from the steel industry was obtained between 2022 and 2035.

For other metallurgical activities (production of aluminum, magnesium, ferroalloys, non-ferrous metals and others), the total future demand for energy was considered to increase in line with industrial GDP, in a manner analogous to the approach described in the previous topic on “Cement, chemicals, other raw materials and industries”. From this, a linear curve of reduction in the use of fossil fuels was applied, so that such consumption would reach zero in 2050 and be gradually replaced by charcoal, biomethane and electricity. The emissions associated with the use of this fuel mix were then calculated; and complemented with the projection, according to the industrial GDP, of the IPPU emissions in metallurgy not related to the use of reducing fuels (such as those resulting from the use of $SF_6$ in the production of magnesium).

The next figure, the result of the methodologies described in this and the previous topic, shows the energy matrix used in the industry as a whole (“Cement, chemicals, other raw materials and industries” and “Pig iron and steel and other metallurgical industries”). It is worth noting that fossil fuels, which represented 35% of the industrial matrix in 2022, will account for only 14% in 2035.

***Figure 6:*** *History (1990 to 2022) and projection (2023 to 2035) of energy consumption in industry, highlighting electricity, hydrogen and the primary sources of fuels used*




Returning to the general activity of “Pig iron and steel and other metallurgical activities”, the following table presents the results of $CO_2e$ emissions obtained. Finally, it is worth noting that indirect emissions related to the generation of electricity used in metallurgy are not considered here, but rather within the activity of “Electricity generation”.

***Table 10: Historical estimates (2005, 2010, 2015 and 2020 to 2022) and projections (2023 to 2035) of emissions, in millions of tons of $CO_2e$, from pig iron and steel and other metallurgical industries by production categories***

| | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Production of pig iron and steel | 43,5 | 47,6 | 49,1 | 43,9 | 50,9 | 48,2 | 41,2 | 40,1 | 39,0 | 38,1 | 37,1 | 36,1 | 35,1 | 34,0 | 33,0 | 32,0 | 31,0 | 30,0 | 29,0 |
| Other metallurgy | 11,3 | 13,9 | 13,2 | 11,1 | 12,4 | 11,6 | 11,0 | 10,6 | 10,3 | 10,0 | 9,8 | 9,5 | 9,3 | 9,0 | 8,8 | 8,5 | 8,3 | 8,0 | 7,8 |
| **Total** | **54,8** | **61,5** | **62,3** | **55,1** | **63,3** | **59,8** | **52,2** | **50,7** | **49,3** | **48,1** | **46,9** | **45,6** | **44,3** | **43,1** | **41,8** | **40,6** | **39,3** | **38,0** | **36,8** |

## 3.3.7 Fuel production

Greenhouse gas emissions from fuel production are related to the processes of exploration and refining of oil and fossil gas, as well as the production of other fuels, such as coal, charcoal and ethanol. To calculate the trajectories of emissions in the coming years, the model considered the domestic demand for these fuels to meet other sectors'. Based on the consumption required to meet demand, the associated emissions for the production and exploration of fuels were calculated.

The demand calculation is based on the country's internal needs, with a forecast reduction in exports and imports in the coming years. In this sense, the model assumes production only considering the supply of the Brazilian domestic market, without considering an expansion in exploration for export purposes.

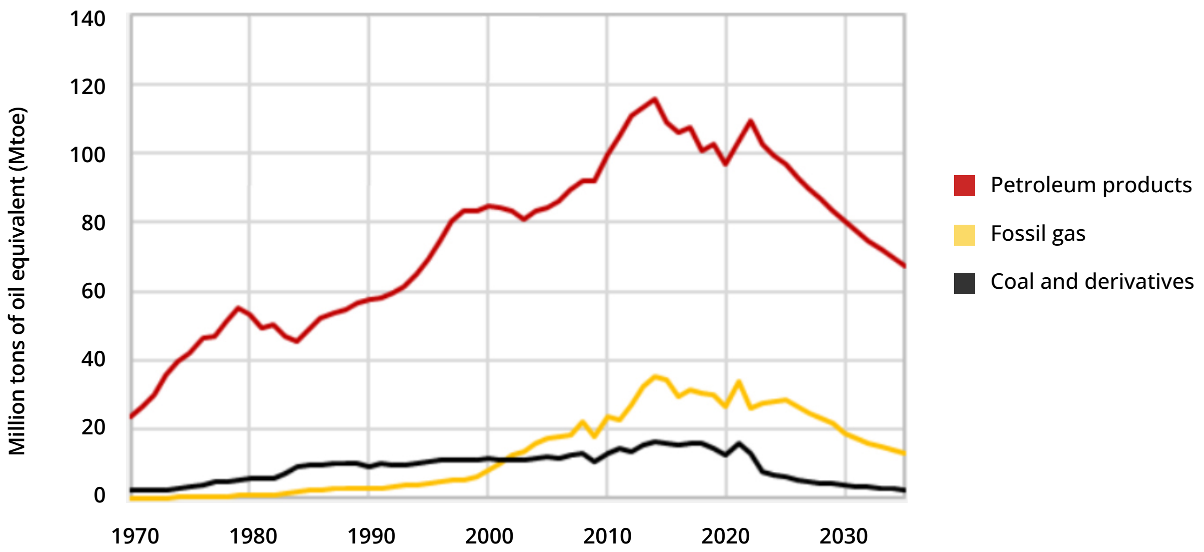
Even with the total growth in domestic energy demand, resulting from the economic and population growth projected for Brazil, premises were adopted that aim to reduce emissions, such as prioritizing fuels with lower emissions and evaluating the growth of national production capacity from other sources.

Thus, the calculation of fossil fuel production is an output from the model linked to the calculation of the consumption of these fuels, so that the assumptions adopted in other sectors, such as modal changes in transport, increased energy efficiency and replacement by other energy sources, directly impact the estimate of the production of these fuels.

The estimate for biofuel production, which is desirable to expand, was made based on assumptions of production capacity and trends in productivity indicators. With the aim of ensuring energy security and meeting demand amid the reduction in fossil fuel production, the model indicates significant growth in ethanol production. This increase is mainly to meet demand in the passenger transportation sector. Sugarcane ethanol production is expected to double by 2035, reaching approximately 60 million cubic meters.

With this proposed scenario, the model predicts a reduction in the total demand for oil and its derivatives in the coming years, indicating a decrease in the production of these fuels and, consequently, in the associated emissions. The total consumption of fossil fuels, coal, oil, fossil gas and derivatives, will have a reduction of 42%, with coal being the energy source with the greatest reduction compared to 2022, reaching almost 80%.

***Figure 7: History (1970 to 2022) and projection (2023 to 2035) of total consumption of oil, natural gas, coal and derivatives***




Thus, emissions from fuel production are estimated at around 27 $MtCO_2e$ in 2035, a value 36% lower than emissions in 2022, the base year for the calculations. The table below shows the results achieved for the other projected years (2023 to 2034).

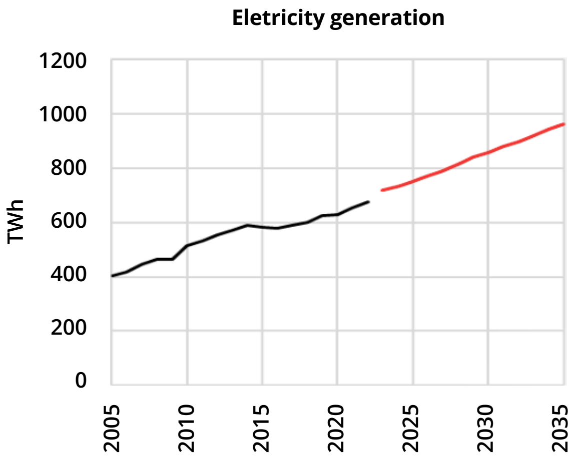
***Table 11: Historical estimates (2005, 2010, 2015 and 2020 to 2022) and projections (2023 to 2035) of emissions, in millions of tons of $CO_2e$, from fuel production***

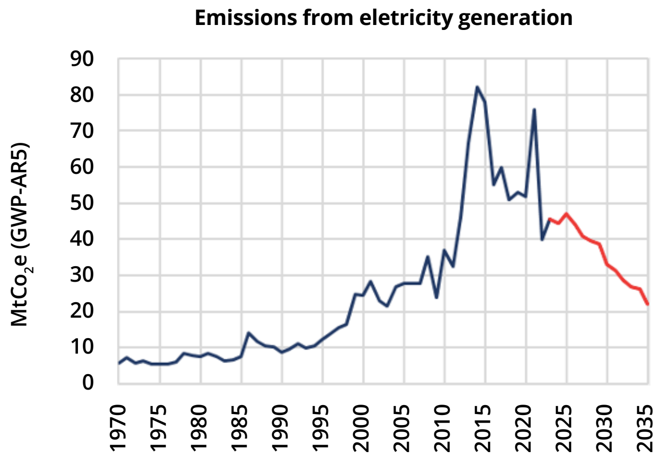
| | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exploitation, transport and refining of oil, gas and derivatives | 37,4 | 39,6 | 47,8 | 40,7 | 39,1 | 39,1 | 40,6 | 39,1 | 37,6 | 36,2 | 35,1 | 34,3 | 33,5 | 31,7 | 30,1 | 28,5 | 27,2 | 26,3 | 24,4 |
| Production of coal and others | 2,0 | 2,7 | 1,8 | 1,6 | 1,7 | 1,7 | 1,1 | 0,8 | 0,5 | 0,3 | - | - | - | - | - | - | - | - | - |
| Production of renewable fuels | 1,6 | 1,7 | 1,7 | 1,7 | 1,7 | 1,6 | 1,7 | 1,8 | 1,9 | 2,0 | 2,0 | 2,1 | 2,2 | 2,3 | 2,4 | 2,5 | 2,5 | 2,6 | 2,7 |
| **Total (fuel production)** | **41,1** | **44,0** | **51,3** | **44,0** | **42,6** | **42,5** | **43,4** | **41,8** | **40,0** | **38,4** | **37,1** | **36,4** | **35,7** | **34,0** | **32,5** | **31,0** | **29,8** | **28,9** | **27,1** |

### 3.3.8 Electricity generation

To project the trajectory of emissions from electricity generation, the first step was to model the country's total demand, resulting from the electricity needs of various sectors, for the coming years. The projected growth of electric vehicle fleets, the increase in electricity use in industry and other usage trends directly influence the total generation demand, the increase of which is linked to GHG emissions. In addition, GDP growth projections also contribute to this demand being even higher.

***Figure 8: History (2005 to 2022) and projection (2023 to 2035) of electricity generation and History and projection of associated emissions, in millions of tons of $CO_2e$***

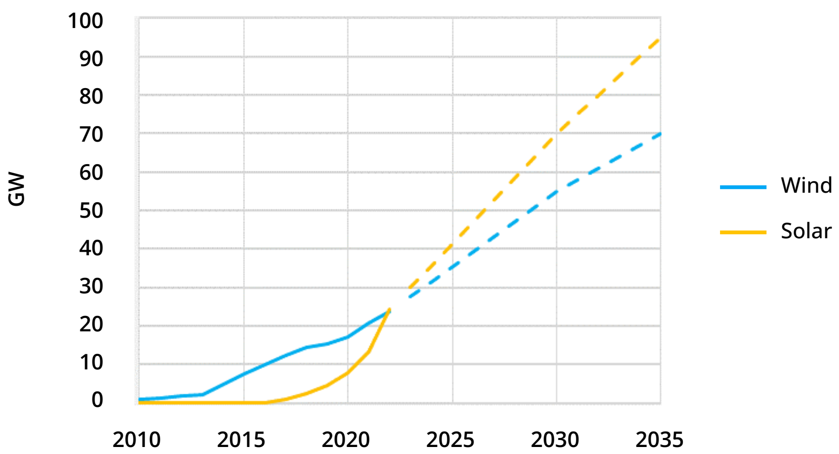



To meet this projected demand, technological prioritization criteria were applied, with fossil fuels, such as natural gas, being added last. Thus, the following assumptions were considered to calculate the necessary electricity supply and the resulting emissions trajectory: (i) growth in the share of renewable energy; (ii) average capacity factor of recent years for hydroelectric plants; and (iii) decommissioning of coal-fired power plants by 2027, together with the reduction/freezing of power plants dependent on other fossil fuels.

In recent years, there has been significant growth in electricity generation from wind and solar sources, which could increase even further in the next decade, according to analyses presented in documents by EPE (2023b), Absolar (2023) and other organizations. Based on these projections and a prospective assessment of new incentives for these sources, the model predicts a significant increase in installed capacities by 2035, reaching 70 GW for wind power and 95 GW for solar power.

***Figure 9: History (2010 to 2022) and projection (2023 to 2035) of the potential for generating electricity from wind and solar sources***

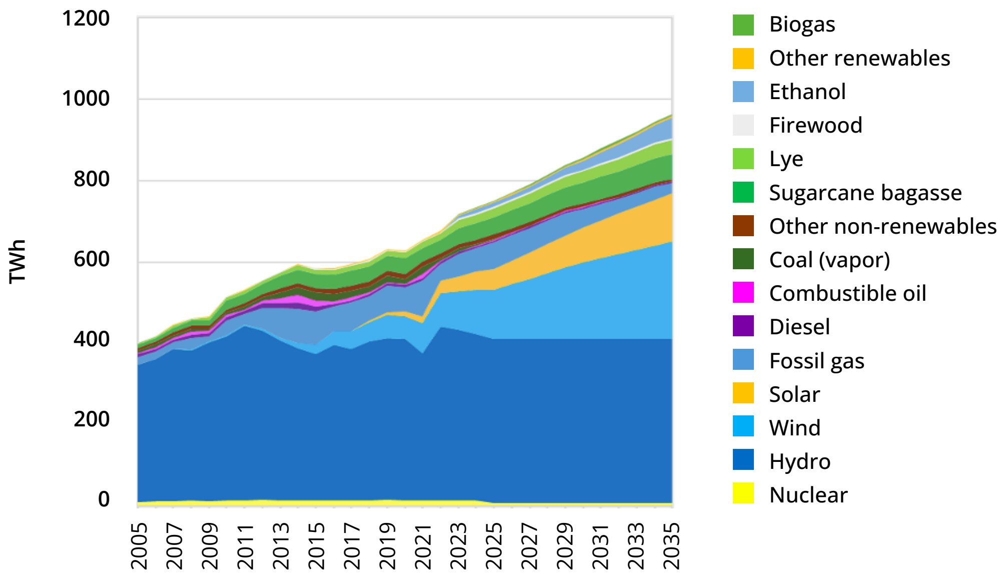


Conservatively, an average capacity factor based on recent years was adopted for hydroelectric plants (EPE, 2023a), seeking to take into account a scenario of climate change unfavorable to rainfall patterns - in the period considered, the 2021 water crisis stands out. Bearing in mind the risks and environmental damages for new hydroelectric projects, the total installed capacity was kept constant without the inclusion of future projects. Thus, it is expected that such plants will decrease their share in electricity generation from 63% in 2022 to 42% in 2035, since there is a diversity of other sources expanding.

Regarding the use of fossil fuels, such as coal, fuel oil and diesel, actions were taken to reduce and/or eliminate them. Given the high intensity of greenhouse gas emissions and local air pollutants, the retirement of coal use by 2027 was considered. In addition, a gradual reduction in the use of fuel oil and diesel was assumed, until they were zero by 2050. On the other hand, an increase in the use of biomass, such as sugarcane bagasse, was assumed as a trend in electricity generation, reaching 61 TWh by 2035, double the amount in 2022. Furthermore, considering the projected surplus of ethanol (already discounting the uses in transportation and other subsectors), it was assumed that the biofuel could also be used in thermoelectric parks. Finally, generation by natural gas thermoelectric plants was calculated to cover the total growing demand discovered by other sources, which resulted in a generation level with a downward trajectory in the projected period.

It is worth mentioning that, in the coming years, greater use of biogas in electricity production is expected, as a result of technological implementations to use treated landfill gasses, as assumed in the waste sector (section 3.6). The model also indicates an increase in the production of this biofuel, stimulated by estimates of growth in sugarcane production to meet the demand for ethanol in transportation. This growth then drives the production of biogas associated with the sugarcane industry, which also makes it possible to use this biofuel in electricity generation, replacing a portion of the natural gas currently used. The figure below shows electricity generation by source.

***Figure 10: History (2005 to 2022) and projection (2023 to 2035) of electricity generation by source***



Thus, according to the premises established for electricity generation, the table below details the emissions from the use of non-renewable fuels and biomass. The emission projection for 2035 is 22.1 million tons of $CO_2$e, representing a reduction of almost 45% compared to 2022 emissions.

***Table 12: Historical estimates (2005, 2010, 2015 and 2020 to 2022) and projections (2023 to 2035) of emissions, in millions of tons of $CO_2$e from electricity generation***

| | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Non-renewables | 27,5 | 36,6 | 77,5 | 51,3 | 75,4 | 39,5 | 44,9 | 43,8 | 46,3 | 43,4 | 40,2 | 38,8 | 37,8 | 32,2 | 30,4 | 27,7 | 26,1 | 25,3 | 21,2 |
| Biomass | 0,2 | 0,4 | 0,5 | 0,6 | 0,5 | 0,5 | 0,6 | 0,6 | 0,7 | 0,7 | 0,7 | 0,8 | 0,8 | 0,8 | 0,8 | 0,9 | 0,9 | 0,9 | 0,9 |
| **Total (electricity generation)** | **27,7** | **37,0** | **78,0** | **51,9** | **75,9** | **40,0** | **45,5** | **44,5** | **47,0** | **44,1** | **41,0** | **39,5** | **38,6** | **33,0** | **31,3** | **28,5** | **26,9** | **26,2** | **22,1** |

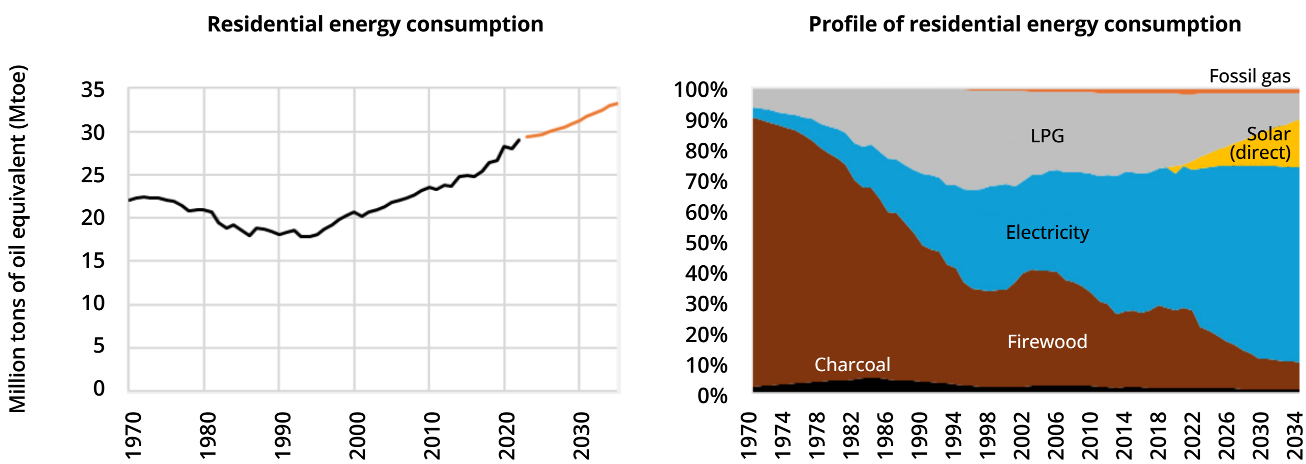
### 3.3.9 Buildings

Emissions from building activities are mainly linked to the consumption of fuels for residential use, such as LPG, firewood and charcoal, used for heating and food preparation. In 2022, residential use activities accounted for more than 90% of emissions from the building sector (27.2 $MtCO_2$e). Emissions from energy use in commercial and public establishments complete the total emitted by buildings, with, respectively, 2.1 and 0.8 $MtCO_2$e estimated for 2022.

For future projections of buildings emissions, assumptions were considered that restrict the use of fuels that emit more, such as LPG, which is expected to be phased out by 2045, and the elimination of the use of firewood in urban areas by 2030. Despite a reduction observed until 2013 in Brazil, in recent years, due to economic factors, the use of firewood has increased. This is reflected in higher $CO_2$e emissions since the precarious use of this fuel, despite being renewable, is associated with high rates of methane ($CH_4$) emissions, a gas with a global warming potential dozens of times greater than carbon dioxide ($CO_2$). Considering GDP growth projections and a favorable economic scenario, a reduction in the use of firewood and other sources with higher emissions is assumed, in addition to an increase in the use of electricity in cooking activities, reducing the sector's total emissions. Regarding the use of solar heating, which has been growing in recent years, it was estimated that this will represent 20% of residential energy consumption by 2035.

As an illustration, the figure below shows the growth in residential energy consumption projected based on GDP growth (on the left) and the profile of this consumption by energy source (on the right).

***Figure 11: Historical (1970 to 2022) and projected (2023 to 2035) residential energy consumption and historical (1970 to 2022) and projected residential energy consumption profile (% based on toe)***




Thus, total emissions from the sectors in 2035 will be 15.6 Mt $CO_2e$, representing a reduction of more than 48% in the sector's total emissions (see figure and table below). This reduction is driven by the projected assumptions, especially for residential activities, which account for the largest share of the sector's emissions.

***Figure 12: History (1970 to 2022) and projection (2023 to 2035) of emissions from buildings***

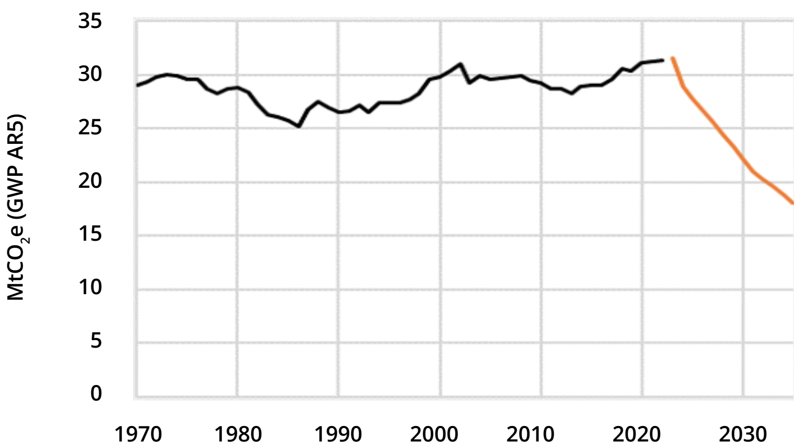



***Table 13: Historical estimates (2005, 2010, 2015 and 2020 to 2022) and projections (2023 to 2035) of emissions, in millions of tons of $CO_2e$, in buildings***

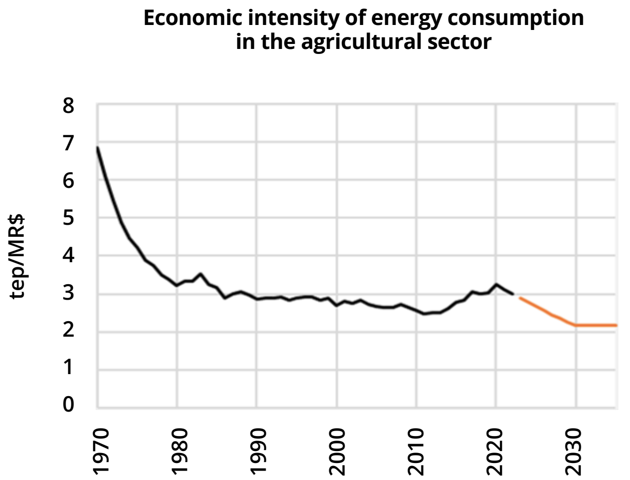
| | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Residential | 25,7 | 26,2 | 25,8 | 27,7 | 27,4 | 27,2 | 27,2 | 24,5 | 23,3 | 22,0 | 20,8 | 19,5 | 18,2 | 16,9 | 15,7 | 14,8 | 13,9 | 13,1 | 12,2 |
| Commercial | 2,0 | 1,6 | 1,5 | 1,3 | 1,6 | 1,8 | 1,8 | 1,9 | 1,9 | 1,9 | 2,0 | 2,0 | 2,1 | 2,1 | 2,2 | 2,2 | 2,3 | 2,3 | 2,4 |
| Public | 1,7 | 1,2 | 0,8 | 0,8 | 0,8 | 0,8 | 0,8 | 0,8 | 0,8 | 0,8 | 0,9 | 0,9 | 0,9 | 0,9 | 0,9 | 1,0 | 1,0 | 1,0 | 1,0 |
| Total | 29,4 | 29,0 | 28,1 | 29,8 | 29,8 | 29,8 | 29,9 | 27,2 | 26,0 | 24,8 | 23,6 | 22,4 | 21,2 | 20,0 | 18,8 | 18,0 | 17,2 | 16,4 | 15,6 |

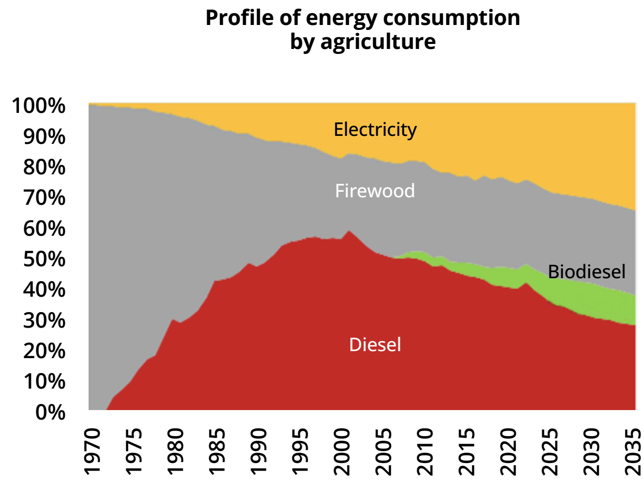
### 3.3.10 Agriculture

The projection of energy demand in agricultural activity was carried out by relating GDP growth and historical variations in energy growth in this subsector, as observed in the National Energy Balance (EPE, 2023a).

To construct the emissions scenario, the shares of the fuels used were assessed, considering the premise of increasing electricity use, accompanied by a reduction in the share of firewood and diesel use. In addition, as in transportation, the increase in the percentage of biodiesel was considered, in line with the Fuel of the Future Bill, according to which by 2030 the share of biofuel should represent 20% of the total volume of the diesel blend. An increase in overall energy efficiency of 4% per year between 2022 and 2030 was also considered.

***Figure 13: History (1970 to 2022) and projection (2023 to 2035) of the economic intensity of agricultural energy consumption and history (1970 to 2022) and projection (2023 to 2035) of the profile of agricultural energy consumption (% based on toe)***




With the established premises, the agricultural sector, responsible for 21.2 Mt $CO_2e$ emitted in 2022, will emit 15.3 Mt $CO_2e$ in 2035, representing a reduction of approximately 28% of emissions in the sector, as can be seen in the figure below.

***Figure 14: History (2000 to 2022) and projection (2023 to 2035) of agricultural emissions within the Energy sector***

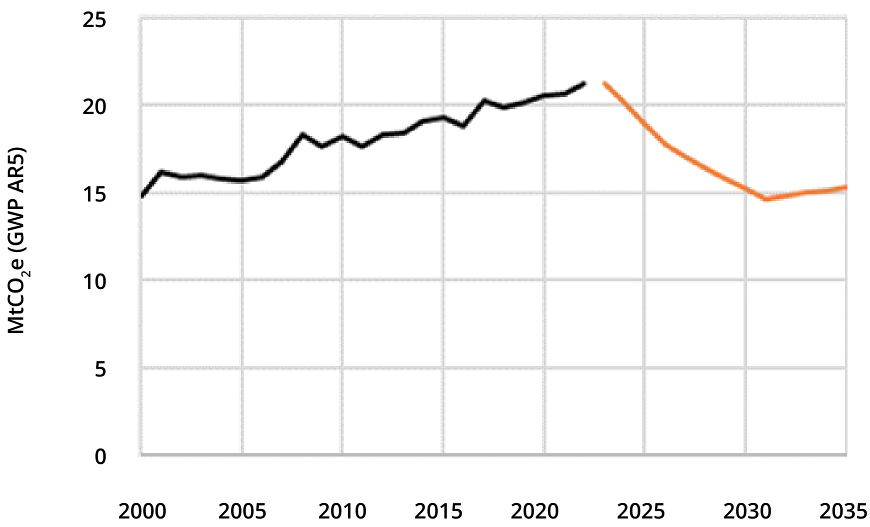



***Table 14: Historical estimates (2005, 2010, 2015 and 2020 to 2022) and projections (2023 to 2035) of emissions, in millions of tons of $CO_2$e in the agricultural sector***

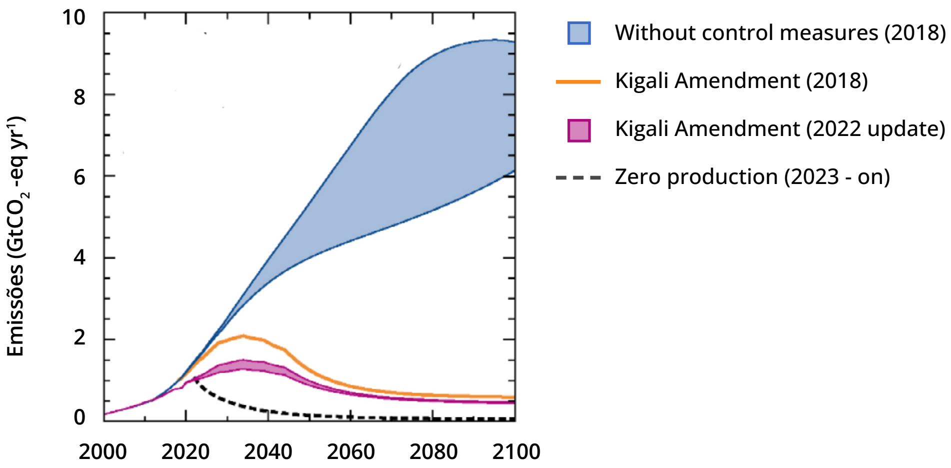
| | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total (Agriculture) | 15,7 | 18,2 | 19,3 | 20,5 | 20,6 | 21,2 | 21,2 | 20,2 | 18,9 | 17,7 | 17,1 | 16,4 | 15,8 | 15,2 | 14,7 | 14,8 | 15,0 | 15,1 | 15,3 |

### 3.3.11 Production and use of HFCs

Hydrofluorocarbons (HFCs) are gasses widely used in refrigeration that have a much higher global warming potential than $CO_2$. To project HFC emissions, a simplified method was adopted in relation to that used to estimate historical emissions in the National Inventory and SEEG, due to the lack of available data to replicate the method, mainly the lack of historical information on the import of these gasses. This made it impossible to conduct a complete bottom-up assessment. Therefore, to construct the present scenario, based on Brazil's historical values and the global total, the trend of Brazil's participation in these emissions in the future was estimated. Then, global emissions projections for the use of these gasses from the WMO (World Meteorological Organization) and NOAA (National Oceanic and Atmospheric Administration) were used, considering compliance with the Kigali amendment (figure 3.3.10.1).

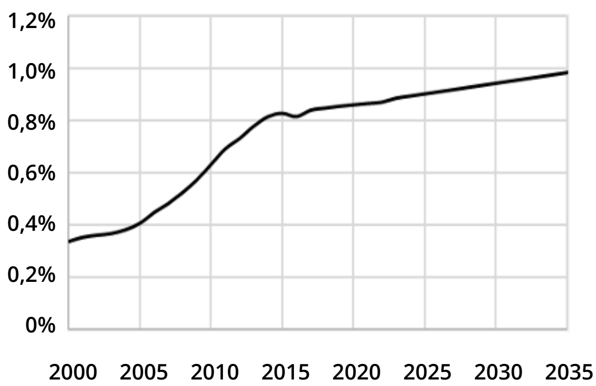
The Kigali amendment, signed by Brazil and other countries in 2016, establishes gradual targets for reducing the import of HFCs by 2045. In the initial years, the targets are more conservative, progressively evolving until reaching a reduction of around 85% by 2045 (BRASIL, 2023; REDE KIGALI, 2023).

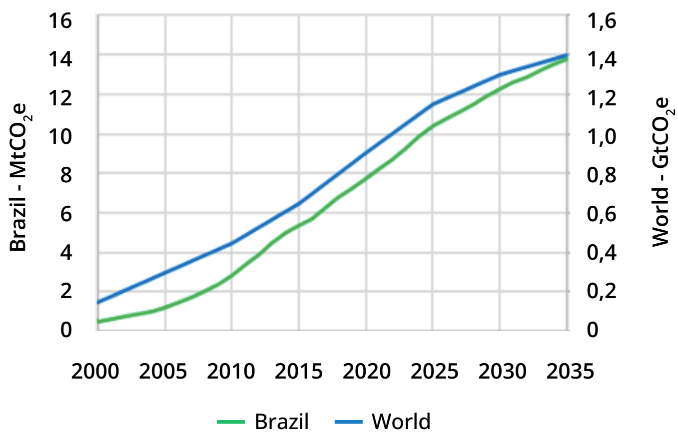
***Figure 15: History (2000 to 2021) and projection (2022 to 2050) of emissions, in millions of tons of $CO_2e$, related to the global use of HCFs (WMO, 2022)***




Using these projected global data, the future trend of Brazil's share in the global total to be emitted annually was applied, considering historical data between 2015 and 2020 (figure 3.3.10.2). Thus, it is projected that Brazil will be responsible for approximately 1% of total emissions from the use of HFCs by 2035.

***Figure 16: History (2000 to 2021) and projection (2022 to 2035) of Brazil's share in global HFC emissions (left); and history (2000 to 2021) and projection (2022 to 2035) of emissions, in millions of tons of $CO_2e$, related to global and Brazilian use of HCFs***




According to projections prepared by the WMO (2022), even with the Kigali measures, the model indicates a global growth in emissions until 2035, followed by a more significant reduction in subsequent years. Thus, for the general activity of "Production and use of HFCs", the table below presents the $CO_2e$ emissions results obtained. In Brazil, the scenario estimates that total emissions from the consumption of these gases will reach almost 14 $MtCO_2e$ in 2035.

***Table 15: Historical estimates (2005, 2010, 2015 and 2020 to 2022) and projections (2023 to 2035) of emissions, in millions of tons of $CO_2$e, from the production and use of HFCs***

| | 2005 | 2010 | 2015 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total (production and use of HFCs) | 1,2 | 2,8 | 5,4 | 7,8 | 8,2 | 8,7 | 9,3 | 9,9 | 10,4 | 10,8 | 11,1 | 11,5 | 11,9 | 12,3 | 12,6 | 12,9 | 13,2 | 13,5 | 13,8 |

## 3.4. Agriculture

The agricultural sector was responsible for 27% of GHG emissions generated by Brazil in 2022, as estimated by the latest SEEG collection, released at the end of 2023. These emissions come from livestock production and agriculture activities, accounting for emissions of methane, nitrous oxide and carbon dioxide, resulting from enteric fermentation, management of animal waste, cultivation of irrigated rice, burning of sugarcane residues and the way in which agricultural soils are managed.

The transformation of agriculture and food systems represents a unique opportunity for mitigation, adaptation, resilience, food and nutrition security, and livelihoods. Brazil should prioritize approaches with high mitigation and adaptation potential, such as transitioning away from fossil fuels in food systems and transitioning to mitigating emissions from agriculture, expanding food production through family, organic and ecologically-based farming, conserving and restoring ecosystems.

Given this scenario and the importance of agribusiness in the Brazilian socioeconomic context, the State needs to adopt concrete measures to promote low-carbon agriculture and livestock farming and assess the hidden costs of the current production and consumption model. First, subsidies need to be reviewed, prioritizing small producers, family farming, and emissions reduction initiatives. Above all, subsidies for agricultural commodities in general need to be redirected to agriculture in areas with some level of degradation.

The resources from the Safra Plan should be transferred, as far as possible, exclusively to low-carbon actions and initiatives, aiming at a balance in access to resources between family farming and agribusiness. The 2024/2025 Safra Plan was launched with financing of R$400.59 billion, an amount 10% higher than the previous Safra Plan. However, the amount allocated to Renovagro (the new name for the ABC Program) was R$7.68 billion, which is equivalent to less than 2% of the total amount.

The current rules of the Safra Plan need to change so that it becomes a program to finance low-carbon agriculture initiatives. By 2030, all rural credit intended for financing (planting) and transition (area recovery) must be linked to the ABC+ Plan (especially with the increase in areas for pasture recovery, integrated systems and agroforestry). Likewise, financing for equipment and infrastructure for agriculture can be done with a focus on reducing emissions. The ModerFrota Line, of the Safra Plan, must have a plan to focus on electric or low-emission vehicles.

Robust rural credit lines must be established that include mandatory reductions in greenhouse gas emissions and strict control of deforestation in all biomes, including the integration of databases (Ibama, state environmental agencies, Brazilian Forest Service and Central Bank) to detect illegalities and prevent public credit lines from being used to fuel the destruction of forests and biomes.

It is also necessary to train technicians and financial institutions to facilitate access to resources. Current rules make access difficult for family farming, and the valorization and strengthening of family farming should be a priority. Equivalence between programs such as the National Program for Strengthening Family Farming (Pronaf) and Renovagro are essential to guarantee equitable access to resources.

It is essential that financing systems be more transparent, especially that of the Central Bank. Mandatory fields on emission reduction gains should be implemented, which can be made available to the entire society and provide greater transparency on how financing systems are supporting the achievement of targets. The Safra Plan should also make available details of its resources so that it is possible to monitor what is being financed.

In parallel, other actions need to be taken to encourage the reduction of emissions and the sustainable use of resources, such as eliminating the burning of agricultural waste, investing in technologies such as early slaughter (via a national policy to reduce the slaughter age of cattle to 24 months), precision agriculture and the use of soil conservation techniques. Reducing dependence on pesticides and encouraging the use of bioinputs would also minimize the environmental impact of agricultural activities. By 2035, it is ideal that there will be a significant increase in the bioinputs market, linked to the reduction in the use of pesticides and synthetic fertilizers. Furthermore, subsidies for products that reduce enteric fermentation should be increased, expanding policies aimed at diversified production systems such as ILPF and SAF to improve sustainable production systems, ensure food security and reduce the application of agrochemicals and synthetic fertilizers.

At COP26 in Glasgow, Brazil signed the Global Methane Pledge, which aims to reduce emissions of this gas by 30% by 2030. Methane ($CH_4$) is the second largest contributor to global warming. Each molecule of this gas heats the planet 28 times more than a molecule of carbon dioxide ($CO_2$) over a period of one hundred years. In 20 years, this warming potential is even greater: 80 times. Brazil is able to adopt a 36% cut target for itself, as indicated by calculations prepared by SEEG/Climate Observatory, therefore indicating that the government should adopt this more ambitious target. By 2035, this reduction should be even more significant, with robust monitoring of the reduction of these emissions.

In addition to these points, it is necessary to address the issue of recovering degraded areas. At the end of 2023, the Federal Government instituted the National Program for the Conversion of Degraded Pastures into Sustainable Agricultural and Forestry Production Systems (PNCPD), which aims to recover up to 40 million hectares of low-productivity pastures and convert them into arable areas within ten years.

Finally, the government needs to establish a National Traceability Policy, integrating public and private traceability systems, defining clear goals to ensure the traceability of all agricultural commodities and improving, by 2025, the monitoring of production chains provided for within the scope of PPCDAm and PPCerrado.

### > LOW-EMISSION FOOD SYSTEMS AND DIETS

Brazil's climate policies should include actions aimed at reducing demand for foods whose production results in high greenhouse gas emissions. It is also recommended that the Brazilian government establish a national research network to assess the hidden costs of the food system and that this process, including climate justice and equity criteria, then create subsidies for evaluating transition pathways and reducing demand for foods whose production results in high greenhouse gas emissions, especially animal products.

The country must also consider:

- Revise dietary guidelines in line with human and planetary health, including through quantitative guidance in line with the recommendations of the EAT-Lancet Commission on Food, Planet and Health;
- Evaluate and realign agricultural subsidies to support shifts towards healthy and sustainable diets;
- Promote public awareness of the importance of healthy and sustainable diets (in particular, increasing consumption of fresh fruits, vegetables and legumes and reducing consumption of animal products) through incorporation of the topic into school curricula and public awareness campaigns;
- Promote plant-based alternatives to animal products by increasing public investment in research and development, as well as creating public policies to stimulate the sector that include tax, financial and credit benefits;
- Update PNAE guidelines to promote the supply of legumes as plant-based protein alternatives;
- Introduce tax incentives to align consumption with healthy and sustainable diets, including tax and credit measures;

- Increase investment in reducing food waste, especially of resource-intensive foods such as animal-based foods.

- The measures described above are fully aligned with the commitments made in Brazil during COP28, as co-leader of the Alliance of Champions for Food Systems Transformation and signatory of the United Arab Emirates Declaration on Sustainable Agriculture, Resilient Food Systems and Climate Action.

### 3.4.1. Mitigation of emissions from agriculture and livestock farming

The methodology used to project emissions from the agricultural sector up to 2035 is based, like the SEEG, on the 4th National Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases (MCTI, 2020a), which uses the methodological bases and guidelines for national inventories developed by the Intergovernmental Panel on Climate Change (IPCC, 2006, 2019). For this purpose, activity data are projected.

Thus, the projected emissions in the sector result from all activities and emitting sources related to the country's livestock and agricultural production. These emissions were estimated according to the calculations provided for the subsectors of i) Enteric Fermentation (MCTI, 2020b), with emissions coming from the digestion process carried out by herds of ruminant animals; ii) Animal Waste Management (MCTI, 2020c), resulting from the treatment and disposal of animal waste; iii) Rice Cultivation (MCTI, 2020d), referring to rice cultivation under the irrigated regime; iv) Burning of Agricultural Residues (MCTI, 2020e), referring to the burning of agricultural residues from sugarcane and cotton cultivation, and lastly; v) Managed Soils, Liming and Urea Application (MCTI, 2020f), which considers the increase in nitrogen through the use of inputs and the form of management of the soils in which agricultural activities are practiced.

In addition to emissions from agricultural production, the sector also accounts for carbon emissions and removals from managed soils. The current National Inventory does not yet account for these sources of emissions and removals from soil, so this balance of emissions from the sector is not yet reported in official data. **Thus, seeking to account for these sources for the sector's emissions balance, SEEG replicates the National Inventory methodology and adds, in a complementary manner, estimates of emissions and removals from the soil.**

All activity data collected and used to estimate greenhouse gas emissions from the agricultural sector up to 2022 followed the same methodology as the 4th National Inventory (MCTI, 2020a). For the remaining years, up to 2035, it was necessary to collect data already projected and expected for the sector's production, together with projections for data for which estimates were not made.

According to Mapa projections, the sector is expected to reach new growth records by the 2032/2033 harvest year. Regarding agriculture, the grain sector is expected to produce 389.4 million tons of grain, covering a total area of 92.3 million hectares, representing an increase of approximately 24.1% and 19.1%, respectively. The total agricultural area is expected to reach 105.8 million hectares, corresponding to an increase of approximately 11.3% compared to the 2022/23 harvest year. The production of soybeans and corn stands out, reaching a production of 189.7 million tons (2.4%) and 159.8 million tons (2.6%), together with the increase in the planted area, reaching 55.9 million hectares (2.4%) and 25.7 million hectares (1.5%), respectively. An increase in the production and planted area of sugarcane is also projected, reaching a total of 717.9 million tons (1.9%) and a total area of 9.6 million hectares (1.5%). Rice and bean crops, on the other hand, show a reduction in production and planted area.

Meat production from beef cattle, pig and poultry farming is expected to increase by around 6.6 million tons compared to the 2022/23 crop year, representing a 22.4% increase in total animal protein production. Beef production is expected to reach 10.2 million tons, representing a 12.4% increase over the next decade. Chicken and pork meat are expected to show increases of 28.1% and 23.2%, respectively, being the protein sources that indicate the greatest growth in the coming years. Milk production is expected to increase by around 18.5%, from 34.2 million liters to 40.5 million liters. For all these agricultural products, national consumption is projected to increase by 0.4%, 2.2%, 2.2% and 1.7% for beef, chicken, pork and milk, respectively (MAPA, 2023).

To project greenhouse gas emissions up to 2035, activity data were used – the quantity produced and area planted – of the main products in the sector, published by the Brazilian Agribusiness Projections (2022/23 to 2032/33), a study carried out by the Ministry of Agriculture (Mapa) that indicates future trends and possible trajectories of production and area used by the main products in the sector for the next decade (MAPA, 2023).

For the period between the 2022/2023 and 2032/2033 harvest years, the values reported by Mapa on the planted area, agricultural and livestock production were used, based on the average annual growth or decrease rates. These same rates were used for the activity data for the years 2034 and 2035 (MAPA, 2023).

For all other agricultural products without Mapa projections (e.g. oats and tomatoes), data on planted area and production were estimated based on average annual increase or decrease rates between 2012 and 2022, based on data from the IBGE's Municipal Agricultural Survey (IBGE, 2023a). The same was done for data related to livestock farming, based on data from the IBGE's Municipal Livestock Survey (IBGE, 2023b).

### 3.4.2. Agricultural activity and agricultural inputs data

Below is a breakdown of how the other activity data required to calculate emissions from the sector's agricultural activity were estimated.:

- For the production and planted area data for rice, beans, corn, soybeans, wheat, sugarcane, sugar, cotton, tobacco, potatoes, cassava and melon, the projected values between the 2022/2023 and 2032/2033 harvest years were used, using the same average growth or decrease rates of planted area and production until the year 2035 (MAPA, 2023). Then, the total estimated values were allocated to each state according to the percentage of participation presented in the year 2022, based on PAM data (IBGE, 2023a);

- For all other agricultural products, the average annual growth or decrease rates of production and planted area were calculated, estimated based on data from the last ten years (2012-2022) for each state. Data regarding the harvested area of each crop were estimated based on its proportion in relation to the planted area for the year 2022, with this proportion being used up to the year 2035 on the projected planted area (IBGE, 2023a);

- The area of rice production under irrigated conditions was estimated based on the proportion between the irrigated rice data and total rice (considering rainfed and irrigated). This proportion was obtained by dividing the irrigated rice data for the state of Rio Grande do Sul (IRGA, 2023) and for the other states (EMBRAPA ARROZ E FEIJÃO, 2023) by the total rice data for the year 2022 (IBGE, 2023a). Finally, these proportions were applied to the values obtained based on the projected values between the 2022/2023 and 2032/2033 harvest years, using the same average growth or decrease rates of planted area and production up to the year 2035 (MAPA, 2023);

- The same values estimated for the Energy sector were used to project ethanol production data (see section 3.1);

- The total consumption of nitrogenous synthetic fertilizers was obtained based on the values reported by the sector's statistics, which indicate possible fertilizer demands until 2050, using the value of 65.1 million tons until 2050 (MAPA, 2022). The projected consumption values in tons for the years 2030, 2040 and 2050 were multiplied by 13.9%, which according to Anda was the amount of nitrogen ($N_2$) there was in the average composition consumed in 2022. Immediately afterwards, the state proportions of 2022 were used to obtain the amount at the state level.;

- The consumption of agricultural limestone was obtained through the National Mining Plan 2030, which provides the estimated value for the year 2030 of agricultural limestone, and the rate of increase between 2022 and the projected value for 2030 was used to project up to 2035, resulting in an annual addition of approximately 4.6 million tons of agricultural limestone per year (MME, 2011);

- The percentage of planted area where sugarcane residues are still burned was estimated based on the annual rate of increase or reduction over the last 10 years (2012-2022) for each state, using data from Conab (2023);

- The area of organic soils was kept constant, based on the total indicated by the method for the agricultural sector of the 4th National Inventory (MCTI, 2020f);

- To calculate the removal of organic carbon from the soil by agricultural areas with the adoption of Direct Planting System (DPS) practices and for emissions by areas under Conventional Planting, a discount was made for the planted areas of crops that are produced by 2nd harvest (corn, beans, peanuts and potatoes) and by 3rd harvest (beans and potatoes), according to PAM data (IBGE, 2023a).

### 3.4.3. Livestock activity data

Below is a breakdown of how the other activity data required to calculate emissions from the sector's livestock activity were estimated:

- For data on beef and milk production, the projected values between the 2022/2023 and 2032/2033 harvest years were used, using the same average production growth rates up to 2035 (MAPA, 2023). Then, the total estimated values were allocated to each state according to the percentage of participation presented in 2022, grouped based on data from the Quarterly Animal Slaughter Survey (IBGE, 2023c) and the Municipal Livestock Survey (PPM), respectively, for meat and milk (IBGE, 2023b);

- The country's total cattle herd was estimated based on the average annual rate of increase over the last ten years (2012-2022) for each state, based on PPM herd data (IBGE, 2023b);

- For the confined cattle herd, the herd of 10.3 million animals in confinement in 2030 was adopted (COE et al., 2015). Then, the average annual increase rate was estimated and applied until the year 2035, based on the 2022 data available for the confined cattle herd;

- The dairy cow herd was estimated based on the average annual increase rate of milk production per cow over the last ten years (2012-2022) for each state, based on PPM data (IBGE, 2023a). This rate was then applied up to the year 2035, with these data being multiplied by the projected milk production between the 2022/2023 and 2032/2033 harvest years and extended until 2035. (Mapa, 2023);

- For the slaughter of beef cattle, the average yield per carcass per slaughtered animal was used, using the yield for 2022 (263 kg of carcass/animal). This yield was used to divide the projected beef production, and for each state, the total value was allocated according to its relative share in 2022 (IBGE, 2023c);

- For the pasture area and its respective vigor levels (low, medium and high), the data were obtained based on MapBiomas collection 8. For the period up to 2035, the areas and vigor level were projected based on the following calculation steps: i) calculation of the stocking rate per area (animals/ha) for each state between the years 2000 and 2022, by dividing the beef cattle herd by the pasture area; ii) projection of the animal stocking rate per area up to the year 2035 based on the average annual growth or decrease rate of each state between 2000 and 2022; iii) calculation of the estimated total pasture area of each state, by dividing the beef cattle herd by the projected animal stocking rate per area; iv) then, the percentages of areas classified between vigor types were estimated linearly, based on the behavior trend between the years 2000 and 2022; and v) calculation of the pasture area by vigor type by multiplying the percentages of participation of each vigor class by the total pasture area obtained until 2035;

- For the total herds of pigs, buffaloes, horses, goats, sheep, poultry (total), chickens (hens), quails, mules and donkeys, the annual growth or decrease rate resulting from the last 10 years (2012-2022) was used, with the allocation at the state level being made based on the relative participation of each state in the year 2022 (IBGE, 2023b);

- The herd of breeding pigs was estimated based on the relative share of the total herd of pigs for the year 2022, with the allocation at the state level being made based on the relative share of each state in the year 2022. (IBGE, 2023b).

### 3.4.4. GHG emissions balance

The trend towards increased production and area of agricultural activity indicates an increase in emissions by the sector and, although an increase in the efficiency of production of various agricultural crops and livestock is achieved, the trend for the agricultural sector in Brazil will still be for an increase in greenhouse gases until 2035.

At the same time, the agricultural sector has great potential in its low-emission practices and technologies and in soil conservation to remove carbon dioxide ($CO_2$), as well as strategies to reduce emissions of methane and other gases. The promotion and implementation of these sets of low-emission systems, practices and technologies must be widely adopted and scaled up in all contexts of agricultural production, contributing to the mitigation of the sector, as well as ensuring more productive, sustainable and resilient systems in the face of the impacts of climate change on production (MAPA, 2021).

The main sink in the sector is the soil, which, depending on its type of management and use, can emit or remove $CO_2$ from the atmosphere. Removals and emissions due to the way agricultural soils are managed are not yet reported in the current national inventory, requiring overcoming the challenge of obtaining data on the practices used in production areas, together with the more precise and representative application of emission and removal factors to perform this calculation, as well as factors linked to the aspect of permanence of this carbon stock over the years (IPCC, 2006).

Precisely because of its importance in the sector's emissions and removals balance, presenting contributions to compliance with the Brazilian NDC, this exercise estimates this contribution of soils to mitigating emissions from the sector and the main practices adopted and possible to be scaled up for this purpose. In addition, the contributions that the reduction of greenhouse gas (GHG) emissions can generate by promoting practices and technologies that emit less than those usually employed were estimated.

Thus, the sector's net emissions were estimated up to 2035, taking into account four components: i) trend GHG emissions from agricultural production, ii) carbon emissions from soil, iii) carbon removals from soil and iv) emission reductions through the adoption of low-emission practices and technologies. For soil carbon emissions, pasture areas with signs of loss of vigor were counted, being considered as elements for soil degradation, as well as agricultural cultivation areas that are managed under conventional cultivation systems. Soil carbon removals were counted from areas with degraded and well-managed pasture recovery (high vigor), with integrated ILPF (Crop-Livestock-Forest Integration) and SAF (Agroforestry Systems) systems, by agricultural cultivation areas managed under No-till Planting System (NTS) practices and by areas of Planted Forests (PF). Emission reductions were accounted for by Intensive Termination (IT) of beef cattle, improved management of animal waste treatment from livestock production (AWT) and the use of Biological Nitrogen Fixation (BNF).

Thus, the proposed trajectory for the agricultural sector until 2035 is a reduction in net emissions of 25.7% compared to 2020, reaching 210.5Mt$CO_2$e net in 2035 (Table 16). These net emissions comprise the sum of emissions by subsectors, carbon emissions from soil, carbon removals from soil and emission reductions from IF and AWT.

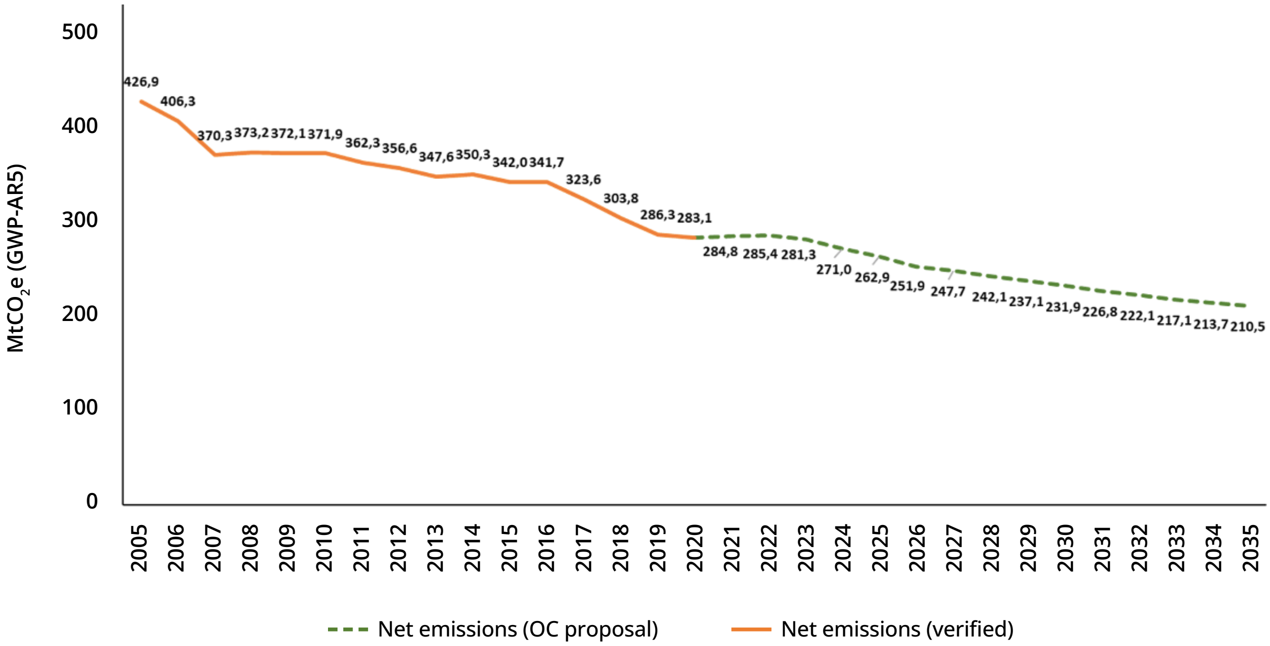
***Table 16: Trajectory of GHG emissions, removals and reductions in the agricultural sector between 2020 and 2035.***

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Agricultural sector** | MtCO₂e (GWP-AR5) | | | | | | | | | | | | | | | |
| **Net GHG emissions** | **283,1** | **284,8** | **285,4** | **281,3** | **271,0** | **262,9** | **251,9** | **247,7** | **242,1** | **237,1** | **231,9** | **226,8** | **222,1** | **217,1** | **213,7** | **210,5** |
| **Total GHG emissions** | 576,3 | 598,1 | 616,9 | 630,9 | 639,3 | 650,0 | 658,7 | 669,7 | 679,2 | 689,4 | 699,4 | 709,3 | 719,6 | 729,6 | 740,6 | 751,6 |
| Enteric fermentation | 372,0 | 382,5 | 398,4 | 404,5 | 409,6 | 414,7 | 419,9 | 425,2 | 430,5 | 435,9 | 441,3 | 446,8 | 452,3 | 457,8 | 463,4 | 469,0 |
| Management of animal waste | 27,3 | 28,0 | 28,9 | 29,4 | 29,9 | 30,4 | 30,9 | 31,4 | 32,0 | 32,5 | 33,1 | 33,6 | 34,2 | 34,8 | 35,4 | 36,1 |
| Managed soils | 166,3 | 176,6 | 178,8 | 187,1 | 190,5 | 196,0 | 199,6 | 205,3 | 209,6 | 214,5 | 219,0 | 223,5 | 228,3 | 232,8 | 237,6 | 242,4 |
| Rice cultivation | 10,4 | 10,6 | 10,5 | 9,7 | 9,0 | 8,6 | 8,0 | 7,4 | 6,8 | 6,3 | 5,7 | 5,1 | 4,5 | 3,9 | 3,9 | 3,9 |
| Burning of agricultural residue | 0,4 | 0,4 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 |
| **Soil carbon emissions - total** | 82,4 | 76,7 | 71,4 | 66,1 | 60,4 | 54,4 | 47,6 | 45,4 | 43,1 | 40,9 | 38,7 | 36,4 | 34,2 | 32,0 | 30,4 | 28,9 |
| Low-vigor pastures | 33,3 | 28,0 | 21,9 | 15,5 | 10,2 | 5,5 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| Medium-vigor pastures | 7,5 | 7,5 | 7,5 | 7,5 | 7,5 | 7,5 | 7,6 | 7,1 | 6,6 | 6,2 | 5,7 | 5,2 | 4,8 | 4,3 | 3,8 | 3,2 |
| Crops under conventional farming | 41,6 | 41,3 | 42,0 | 43,2 | 42,7 | 41,5 | 40,0 | 38,3 | 36,5 | 34,8 | 33,0 | 31,2 | 29,4 | 27,7 | 26,7 | 25,7 |
| **Soil carbon removals - total** | -375,7 | -388,1 | -400,5 | -412,9 | -425,3 | -437,7 | -450,1 | -462,5 | -474,9 | -487,3 | -499,8 | -512,2 | -524,6 | -537,0 | -549,4 | -561,8 |
| High-vigor pastures | -138,7 | -142,0 | -145,4 | -148,8 | -152,1 | -155,5 | -158,8 | -162,2 | -165,5 | -168,9 | -172,3 | -175,6 | -179,0 | -182,3 | -185,7 | -189,1 |
| Crop-Livestock-Forest Integration | -96,0 | -102,6 | -109,2 | -115,8 | -122,4 | -129,0 | -135,6 | -142,2 | -148,8 | -155,4 | -162,0 | -168,6 | -175,2 | -181,8 | -188,4 | -195,1 |
| Agrofoerstry systems | -109,1 | -109,6 | -110,1 | -110,6 | -111,1 | -111,6 | -112,0 | -112,5 | -113,0 | -113,5 | -114,0 | -114,5 | -115,0 | -115,5 | -116,0 | -116,4 |
| Forest plantations | -6,9 | -7,1 | -7,4 | -7,7 | -8,0 | -8,2 | -8,5 | -8,8 | -9,0 | -9,3 | -9,6 | -9,8 | -10,1 | -10,4 | -10,6 | -10,9 |
| Crops under no-till planting system | -25,0 | -26,7 | -28,4 | -30,1 | -31,8 | -33,5 | -35,2 | -36,8 | -38,5 | -40,2 | -41,9 | -43,6 | -45,3 | -47,0 | -48,7 | -50,3 |
| **Reduced or avoided GH emissions - total** | 0,0 | 2,0 | 2,4 | 2,9 | 3,3 | 3,8 | 4,3 | 4,8 | 5,3 | 5,9 | 6,4 | 6,8 | 7,1 | 7,5 | 7,9 | 8,3 |
| Intensive termination | 0,0 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 |
| Treatment of animal waste | 0,0 | 1,6 | 2,1 | 2,6 | 3,0 | 3,5 | 4,0 | 4,5 | 5,0 | 5,5 | 6,1 | 6,5 | 6,8 | 7,2 | 7,6 | 8,0 |
| Biological nitrogen fixation | 66,2 | 69,5 | 73,0 | 77,8 | 80,7 | 83,1 | 85,3 | 87,3 | 89,2 | 91,2 | 93,1 | 95,1 | 97,0 | 99,0 | 101,4 | 103,8 |

*Note: the historical values of carbon emissions and removals from soil estimated for the agricultural sector in the current fiscal year differ from those found in the SEEG platform (Collection 11), due to the update of emission and removal factors, together with the inclusion of $CO_2$ removals from areas with Agroforestry Systems (SAF) and estimates of possible emission reductions. Currently, these sources of emissions and removals are not accounted for in the 4th National Inventory (MCTI, 2020a), and are referred to as NCI emissions and removals (Not Accounted for in the Inventory) in the SEEG platform (Collection 11).*

* *Mitigation promoted by Biological Nitrogen Fixation (BNF) is an emission avoided by not using synthetic nitrogen fertilizers, so the avoided emissions shown in the table would be those that would occur if this action had not been applied.*

***Figure 17: Net greenhouse gas emissions in the agricultural sector between 2020 and 2035***




Thus, considering the expansion of the adoption of production systems, practices and technologies with low emissions and high capacity to remove carbon, and considering that the expansion of the area destined for agriculture will occur over areas that are currently unproductive and with indications of degradation, it is suggested that the following commitments for the sector be made in order to reach net emissions of 210.5 $MtCO_2e$ in 2035:

- *The recovery of 22.5 million hectares of soils with signs of degradation;*
- *The additional expansion of 18 million hectares of Integrated Crop-Livestock-Forestry (ICLF) systems;*
- *The implementation of 1 million additional hectares of Agroforestry Systems (AFS);*
- *The additional expansion of 5 million hectares of Planted Forests (PF);*
- *Adoption of No-till Planting System (NTS)practices in 80% of the agricultural area, of which at least 80% with No-till Planting and 20% with complete No-till planting system, considering the expansion of the planted area destined for agriculture (approximately 24.3 million hectares), totaling 35.2 million hectares with additional adoption;*
- *The slaughter of 7.5 million cattle with Intensive Termination, finished with the adoption of*

*confinement, semi-confinement and with supplementation, as long as animal welfare and resilience are not compromised;*

- *For Animal Waste Treatment (AWT), achieve expansion to 40.5% of biodigester use in relation to other animal waste management systems, with the total conversion of anaerobic lagoons to biodigesters in pig farming, totaling the national average of 46.4% of biodigester adoption;*
- *Additional expansion of 19 million hectares using Biological Nitrogen Fixation (BNF);*

In addition to these commitments, there are other important strategies and actions that can be promoted and expanded throughout the productive sector to contribute to the reduction or removal of GHG emissions. Due to limitations in terms of activity data and emission/removal factors, these were not considered quantitatively[27].

However, it is important to identify these practices and seek methodological advances that allow their accounting, such as strategies in beef and dairy farming such as animal breeding (MGA), improvement and manipulation of animal diet, manipulation of ruminal fermentation through the use of additives and other practices and technologies that contribute to reducing the period of animal slaughter and greater milk production. For beef farming, these good practices and the adoption of technologies contribute to animals being slaughtered earlier, reducing the slaughter age and resulting in reduced emissions due to the better level of technical, environmental and productive performance (Gomes *et al.*, 2023).

Therefore, it is strongly recommended that there be investment in technologies that lead to a reduction in the slaughter age of beef cattle (early steers), with this strategy being incorporated via a national policy or plan. An example of practices that result in a reduction in the slaughter time of beef cattle is the “Boi China” (China Cattle), in which the herd slaughtered for meat export to China must be up to 30 months old until slaughter, compared to the estimated national average of 36 months. This strategy estimates a reduction in emissions of approximately 5.8 $MtCO_2e$ for the year 2022, demonstrating the potential for adopting this action on a national scale[28].

[27] In 2022, SEEG published the report on the “Challenges and Opportunities for Reducing Methane Emissions in Brazil”, for which the potential for reducing methane ($CH_4$) by 30% was estimated, compared to 2020, through the adoption of mitigation strategies for livestock and agricultural activities. Some of these strategies do not have targets defined by regulations at the federal level, so there are currently no specific national targets to encourage and monitor the adoption of these mitigation strategies. Therefore, for the calculations of this NDC, some of the strategies previously analyzed were not included to estimate the reduction of GHG emissions from the agricultural sector.

[28] Considering GHG emissions of 156.1 kg $CO_2e$/animal/month based on emissions from beef cattle by enteric fermentation, animal waste management and managed soils from SEEG Collection 11 and the beef cattle herd in 2022 based on data from the IBGE Municipal Livestock Survey (PPM) (IBGE, 2023b). The carcass yield per slaughter in the country in 2022 was 267.5 kg carcass/animal slaughtered based on data from the Quarterly Animal Slaughter Survey (PTAA) (IBGE, 2023c). To estimate the meat yield generated per carcass, a conversion of approximately 75% was considered, based on the division of beef exports from AgroStat (Brazilian Agribusiness Foreign Trade Statistics) (MAPA, 2023) by carcass exports from CONAB (2023).

In agriculture, the expectation is to completely eliminate the use of burning to clear sugarcane agricultural residues, and to use precision agriculture to optimize the use of agricultural inputs such as fertilizers and limestone. The expansion of the use of BNF and other bioinputs for other crops, together with the full application of the defining concepts of the No-tillPlanting System. Table 18 shows the emission and removal factors used in the estimates, as well as the data sources on which they were based.

***Table 18: Projection of area expansion and adoption of soil carbon emissions mitigation strategies by 2035***

| | Carbon Emission/ Removal and GHG Emissions Reduced/ Avoided | 2020 | 2035 | Reference | Emission/Removal/ Reduction/ Avoided Factor | Reference |
|---|---|---|---|---|---|---|
| | | Mha | | | $tCO_2e$/ha/year | |
| Soil Carbon Emissions | Low Vigor Pastures | 32,4 | 0,0 | MapBiomas Col.8 (2023) | 1,03 | Maia et al., (2009) |
| | Medium Vigor Pastures | 67,8 | 29,4 | MapBiomas Col.8 (2023) | 0,11 | Maia et al., (2009) |
| | Crops under Conventional Planting | 28,4 | 17,5 | FEBRAPDP (2018); Agricultural Census (2006-2017); PAM (IBGE) | 1,47 | Costa Junior et al., (2013) |
| Soil Carbon Removals | High Vigor Pastures | 61,9 | 84,4 | MapBiomas Col.8 (2023) | -2,24 | Maia et al., (2009) |
| | Crop-Livestock-Forest Integration | 17,4 | 35,4 | Rede ILPF (2015); Polidoro et al., (2020) | -5,51* | Oliveira et al., (2024) |
| | Agroforestry Systems | 14,9 | 15,9 | Agricultural Census (2006-2017) | -7,33 | GHG Protocol Florestas (2020) |
| | Planted Forests | 8,5 | 13,5 | MapBiomas Col.8 (2023) | -0,81 | Lima et al., (2006) |
| | Crop under Direct Planting System | 7,0 | 14,0 | FEBRAPDP (2018); Agricultural Census (2006-2017); PAM (IBGE) | -1,84 | Cerri et al., (2007) |
| | Crop under Direct Planting | 27,8 | 56,0 | FEBRAPDP (2018); Agricultural Census (2006-2017); PAM (IBGE) | -0,44 | Costa Junior et al., (2013) |
| GHG Emissions Reduced/Avoided | Intensive Termination | 0[1] | 7,5 | PPM (IBGE); PTAA (IBGE) | 33,1%[4] | Cardoso et al., (2016) |
| | Animal Waste Treatment | 4,8%[2] | 51,2%[3] | MCTI (2020c); MAPA (2021) | 74,1 $MtCO_2e$[5] | IPCC (2006); MCTI (2020c) |
| | Biological Nitrogen Fixation | 33,9 | 53,2 | PAM (IBGE); ESTEVAM et al., 2022 | 1,95[6] | Sá et al., (2017) |
| | | | | | 1,83[7] | MAPA (2012) |

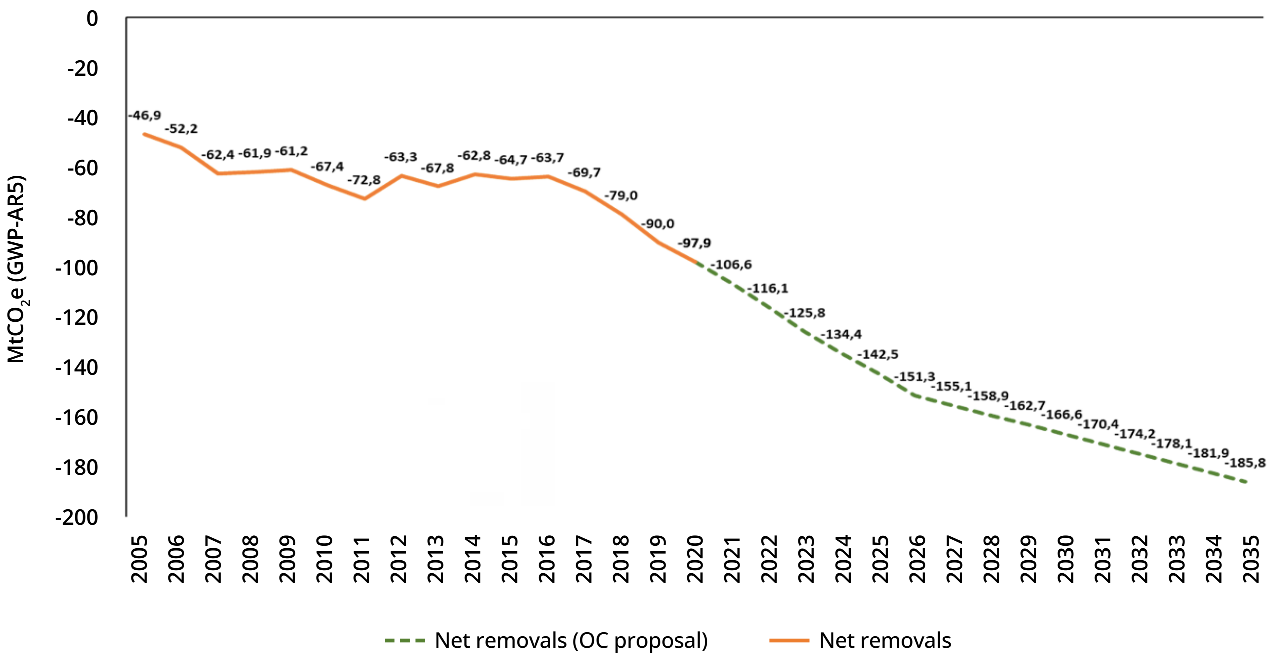
** the emission factor is considering the ILP system, with the forestry component (F) already accounted for in Planted Forests (PF)*
*[1] there is no official data reporting how much of the beef cattle herd was actually slaughtered with IF;*
*[2] is the national average percentage in which a biodigester was used as a system for treating animal waste in pig farming;*
*[3] is the national average percentage projected for the use of biodigesters as a system for treating animal waste in pig farming;*
*[4] is the percentage of reduction in GHG emissions by carrying out IF in the slaughtered beef cattle herd compared to those that do not receive IF;*
*[5] is the expected total cumulative mitigation in millions of tons of $CO_2e$ for AWT;*
*[6] is the emission factor calculated for the soybean crop in which BNF is used;*
*[7] é o fator de emissão default para as demais culturas em que é empregado BNF;*

### 3.4.5 Pasture Areas

To ensure high levels of animal productivity, with the necessary amount of feed to meet the volume and nutritional demand on an ongoing basis, the goal is to recover degraded pastures. In 2022, according to data from MapBiomas, approximately 38% of the pasture area in the country had high vigor, totaling 62 million hectares, while the remainder showed some level of loss of vigor (62%), with approximately 100 million hectares.

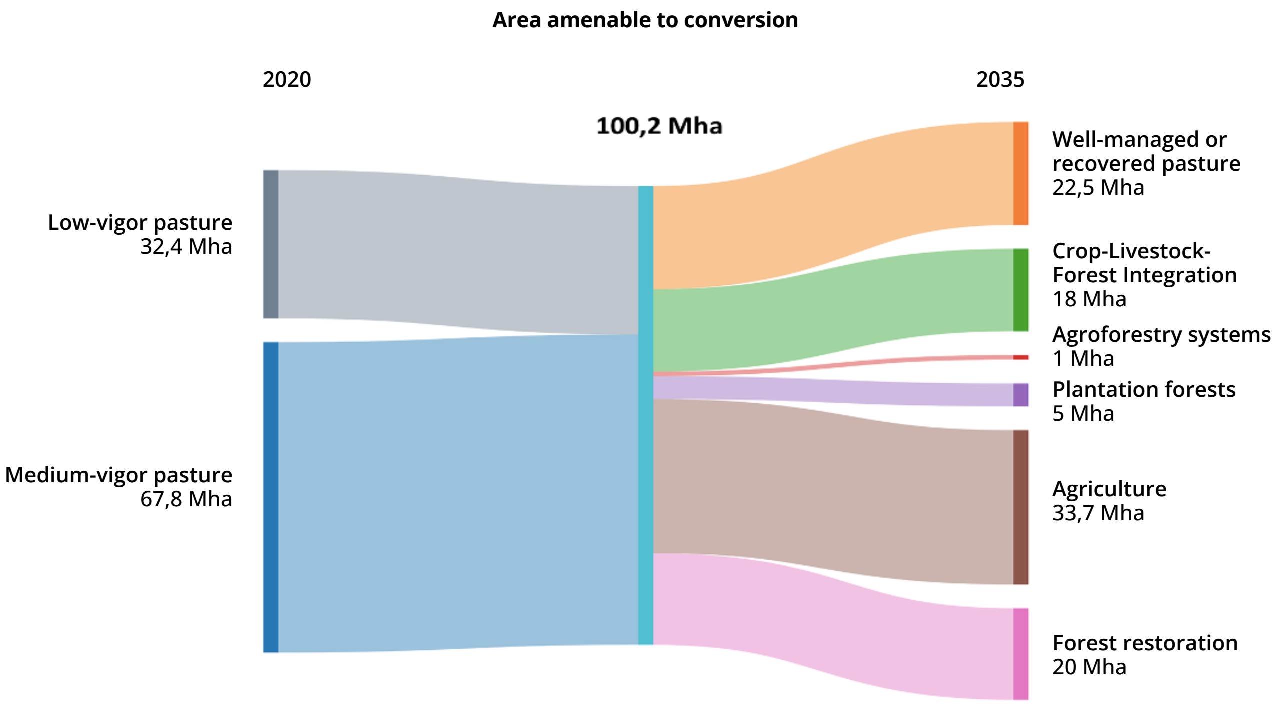
Considering carbon emissions and removals due to the decrease and increase in soil carbon stocks in pastures, respectively, the carbon balance trajectory indicates a net removal of 185.8 $MtCO_2e$ in 2035, with an increase of 87.9 $MtCO_2e$ in net removal between 2020 and 2035, representing a 90% increase in net removals. To achieve this, it will be necessary to recover 22.5 million hectares of pasture. In the end, it is expected that 84.4 million hectares of well-managed pasture will be available by 2035, with signs of high vigor (carbon removal for up to 20 years).

***Figure 18: NDC proposal for net emissions from pastures between 2020 and 2035***



For the remaining pasture area with indications of degradation due to loss of vigor, the conversion of its use to a projected area for agricultural expansion with DPS practices (24.3 million hectares), area planted with other crops (9.4 million hectares), ILPF (18 million hectares), AFS (1 million hectares) and PF (5 million hectares) was considered, resulting in approximately 20 million hectares destined for the restoration of native vegetation by 2035. Figure 19 below shows the land use conversions up to the year 2035 based on data from 2022.

***Figure 19: Land use conversions to productive and GHG mitigating systems between 2020 and 2035***



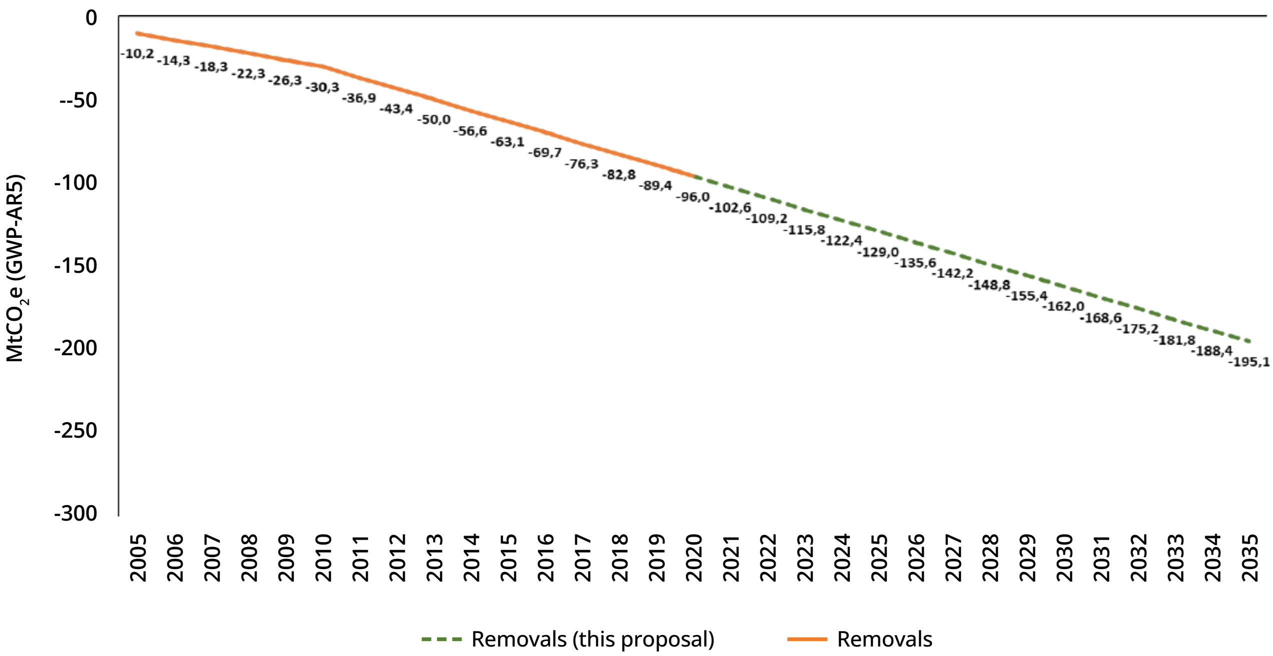

## 3.4.6 Integrated Crop-Livestock-Forestry Systems (ICLF)

In addition to the area for the recovery of degraded pastures, the implementation of Crop-Livestock-Forest Integration systems will also make up part of the area designated for grazing, while also producing wood and grains.

According to data from the ILPF Network, in 2020 the total area with ILPF adoption was 17.4 million hectares. In 2022, it is estimated that the area will have been approximately 19.8 million hectares, and may reach an area greater than 28.1 million hectares by 2030 (POLIDORO et al., 2020).

The removal trajectory estimated by expanding the adoption of ILPF areas over pasture areas with signs of degradation due to loss of vigor results in a total removal of 195.1 $MtCO_2e$ in 2035, with an increase in removal of 99.1 $MtCO_2e$ between 2020 and 2035, representing an increase of 103%. To this end, it is recommended that an additional 20 million hectares of ILPF systems be implemented, reaching a total area of 35.4 million hectares in 2035.

***Figure 20: NDC proposal for net ILPF emissions between 2020 and 2035***



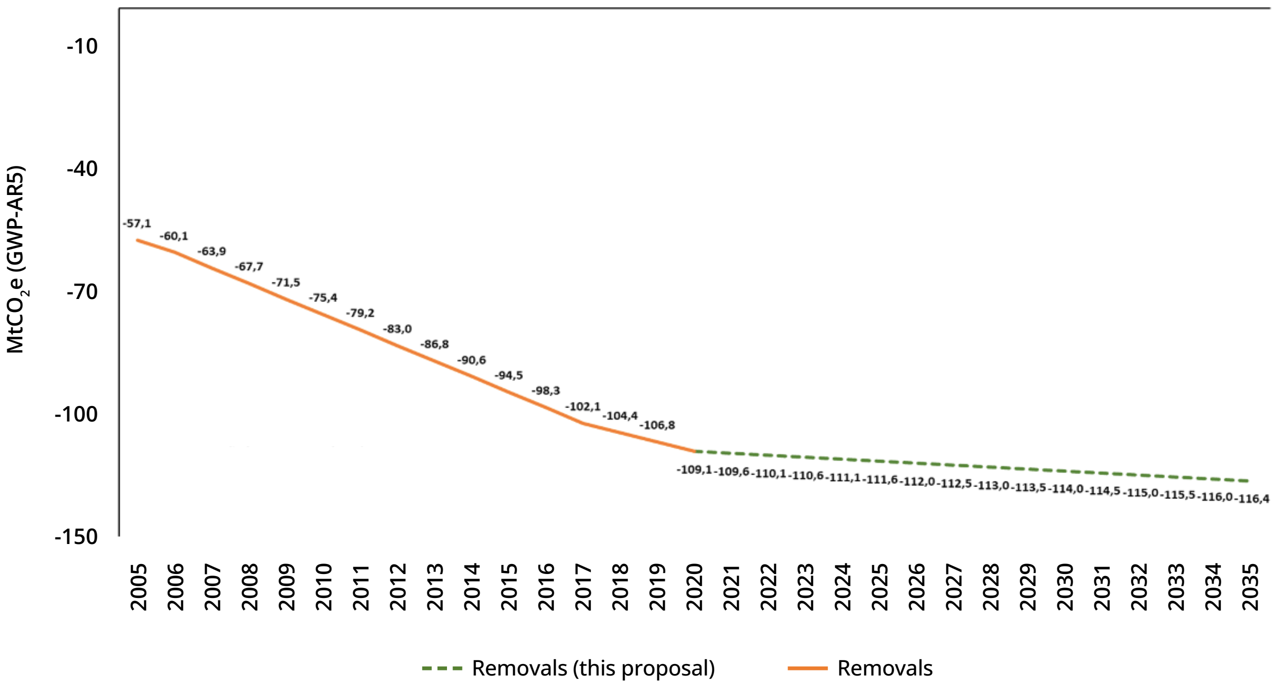

### 3.4.7 Agroforestry Systems (AFS)

Agroforestry Systems (AFS) are productive systems that are based on the ecological succession of natural ecosystems. They combine exotic or native trees with agricultural crops and even livestock, providing a great diversity of species and interactions between them.

According to official data from the 2017 Agricultural Census, the total AFS area was 13.9 million hectares, representing an increase of 70% since 2006, when the 2006 Agricultural Census indicated an area of 8.2 million hectares, with an increase of more than 5.7 million hectares. Thus, considering the trend of increasing AFS areas and this same increase occurring again by 2035, it is estimated that in 2020 there was an area with approximately 14.9 million hectares of AFS.

The removal trajectory through the adoption of AFS considers that by 2035 there will be an increase of 1.0 million hectares, resulting in an area of 15.9 million hectares. This results in the total removal of 116.4 $MtCO_2e$ in 2035, representing an increase in removal of 7.3 $MtCO_2e$ between 2020 and 2035, totaling a 7% increase in removals.

***Figure 21: Trend trajectory and proposed NDC for net AFS emissions between 2020 and 2035***

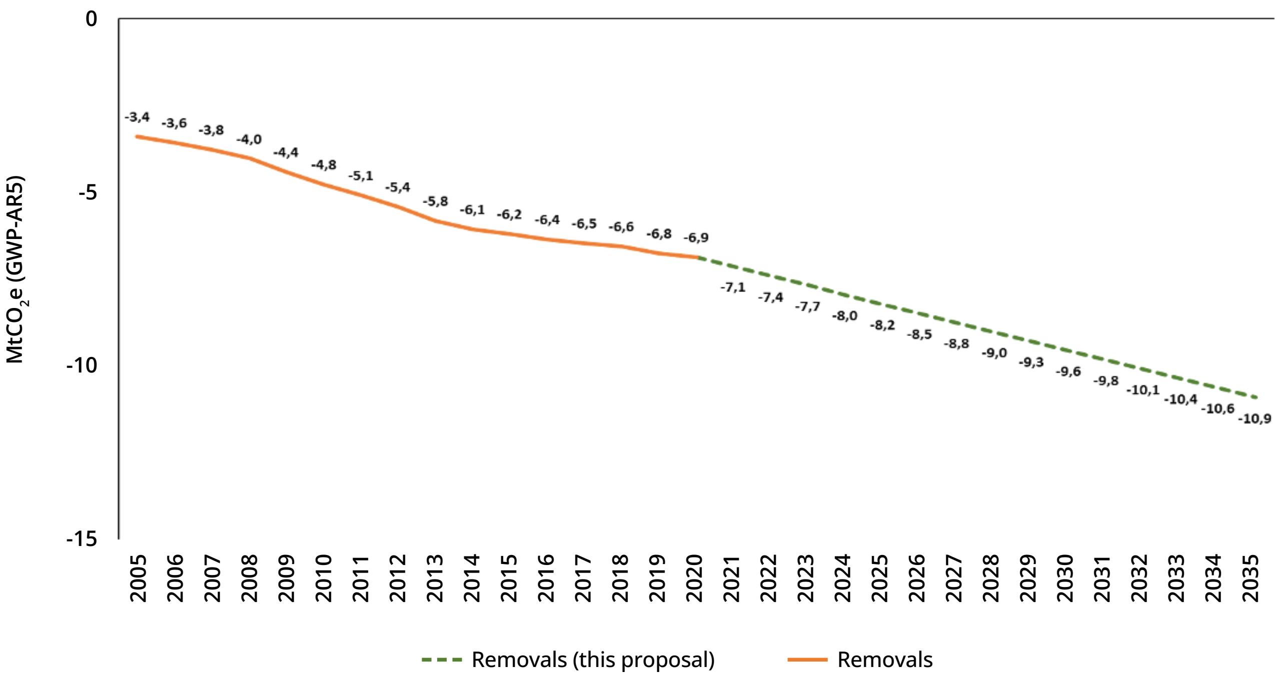



## 3.4.8 Planted Forests (PF)

Planted forests, mainly pine and eucalyptus, are plantations aimed at the production of wood, pulp and paper, being a solution for degraded areas and composing a fundamental part of ILPF, as they contribute to the removal of carbon by biomass and soil. According to data from MapBiomas Collection 8 (2023), the total area in the country in 2022 was 8.5 million hectares, following an increasing trend.

The removal trajectory through the adoption of FP considers that by 2035, there will be an increase of 5.0 million hectares, resulting in an area of 13.5 million hectares. This results in a total removal of 10.9 $MtCO_2e$ in 2035, with an increase in removal of 4.0 $MtCO_2e$ between 2020 and 2035, representing a total of 59%.

***Figure 22: Trend trajectory and NDC proposal for net forest plantations emissions between 2020 and 2035***




## 3.4.9 Crops grown under the No-till Planting System (NTS) and under Conventional Planting

The use of the Direct Planting System is a conservationist method of soil management, contributing to better soil quality and protection, water retention and greater increase in organic matter. When carried out in its entirety, that is, with soil preparation being carried out only in the sowing or planting lines, with permanent maintenance of soil cover with organic matter and with diversification of the variety of species through crop rotation and/or intercropping, this practice results in an increase in soil carbon stocks, generating removals.

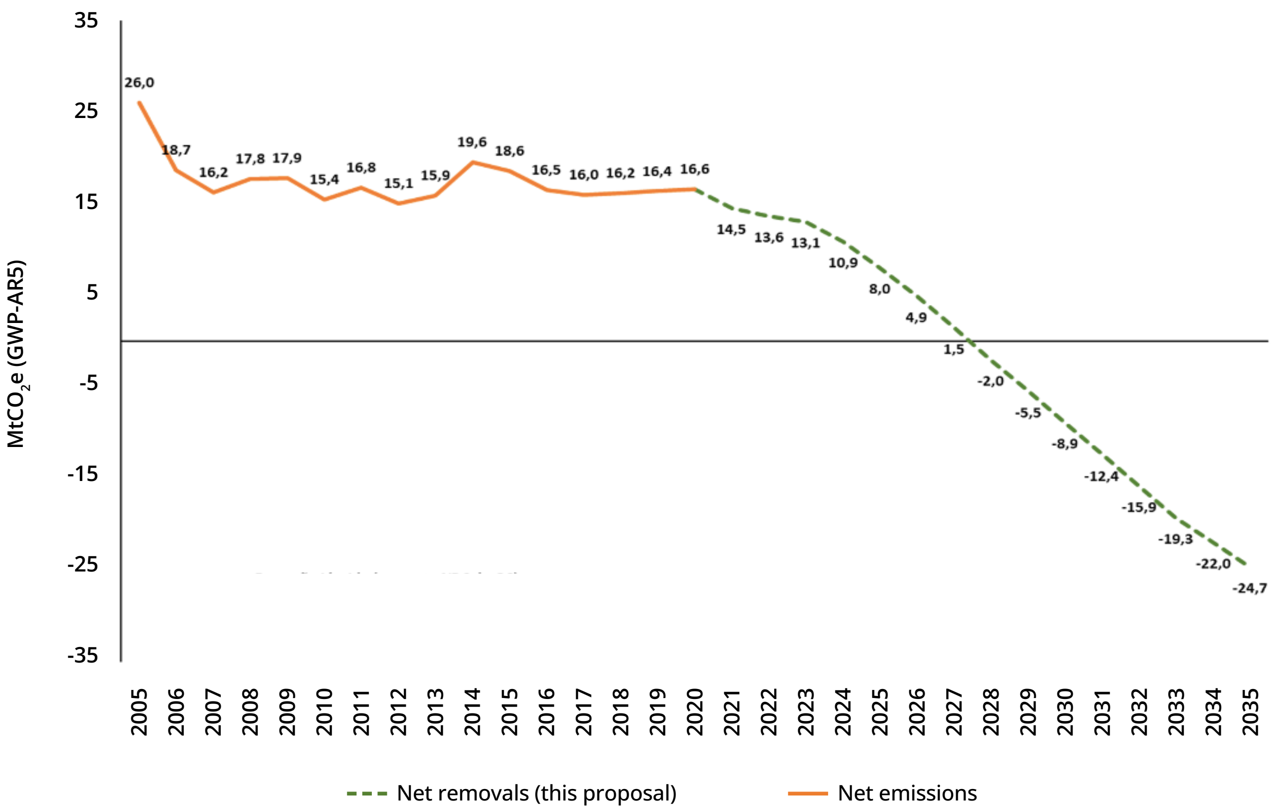
According to official data from the 2017 Agricultural Census, the total area with practices that make up the DPS was 32.9 million hectares, which corresponded to approximately 44.6% of the grain area cultivated for that year, while data from FebraPDP (2018) indicated 33.1 million hectares for the year 2018.

The trajectory of removals through the adoption of DPS practices considers that, by 2035, approximately 80% of the agricultural area cultivated with grains will have adopted it, with at least 20% of this area with complete no-till planting systems and the remainder with no-till planting (80%), totaling an increase of 35.2 million hectares compared to 2020. Compared to 2020, the estimated area with NtPS practices was approximately 34.8 million hectares, corresponding to 55.1% of the total agricultural area.

This increase in area under NtPS practices results in a total removal of 50.3 $MtCO_2e$ in 2035, with an increase in removal of 25.3 $MtCO_2e$ between 2020 and 2035, representing a total of 101%. The remaining grain cultivation areas under conventional planting practices will result in the emission of 25.7 $MtCO_2e$ by 2035, representing a reduction in emissions of 16 $MtCO_2e$, approximately 38% less than in 2020. Thus, soils cultivated with grains go from a net emission of 16.6 $MtCO_2e$ in 2020 to a net removal of 24.7 $MtCO_2e$ in 2035.

By 2035, a total expansion of 33.7 million hectares of agriculture was estimated, with 24.3 million hectares for crops with the adoption of NtPS and 9.4 million hectares for the expansion of other crops[29], totaling an area of 96.9 million hectares, of which 70 million hectares are covered by NtPS and NtP practices, 9.4 million hectares are used for other crops, and the remainder, 17.5 million hectares, are managed in a conventional planting manner.

***Figure 23: Trend trajectory and proposed NDC for net NtPS emissions between 2020 and 2035***




[29] These crops include avocado, açaí, olives, bananas, rubber, cocoa, coffee, persimmon, cashew nuts, tea, coconut, palm oil, yerba mate, fig, guava, guarana, orange, lemon, apple, papaya, mango, passion fruit, quince, walnut, palm heart, pear, peach, black pepper, sisal or agave, tangerine, tung, annatto and grapes. These crops do not present GHG emissions from agricultural waste according to the national inventory for the agricultural sector.

### 3.4.10 Intensive Termination (IT)

Mitigation promoted by Intensive Finishing is achieved through intensified feed management, which provides more energy to beef cattle during the rearing and fattening phases. This allows animals to reach ideal slaughter weight more quickly, reducing fattening time with the use of confinement, semi-confinement and supplementation on pasture.

A reduction of up to 33.1% in the emission of kg$CO_2$e/kg of carcass can be estimated when comparing the emission intensity of 40.9 kg$CO_2$e/kg of carcass between less productive systems with the average mitigation of 13.5 kg$CO_2$e/kg of carcass of systems that employ IT, based on data from Cardoso et al., (2016). Thus, considering that 7.5 million cattle will be slaughtered with intensive termination by 2035, an accumulated emission reduction of 4.7 Mt$CO_2$e is estimated. It is difficult to obtain data to understand the current scenario of cattle properly finished with IT.

### 3.4.11 Animal Waste Treatment (AWT)

Animal waste treatment (AWT) is a step in waste management that includes collection, storage, treatment and agricultural use of by-products. It is a strategy to mitigate methane and nitrous oxide, using technologies such as biodigestion and composting, which reduce the conversion of organic matter into methane.

Thus, replacing waste management systems with more efficient ones results in mitigation. Thus, considering the pig farming chain, a reduction of 8.0 Mt$CO_2$e is estimated by 2035, from the expansion of the use of biodigesters to the detriment of the Liquid/Slurry portion by 2035, achieving an expansion of 40.5% for the national average of waste treated by this system. In addition, it accounts for the mitigation of the total conversion of anaerobic lagoons to biodigesters, resulting in a total expanded national average of 46.4% with the use of biodigesters. The jump in the percentage of adoption of this technology stands out, which through data from the 4th National Inventory, presented a national average of 4.8% (MCTI, 2020c).

### 3.4.12 Biological Nitrogen Fixation (BNF)

The use of BNF contributes to increased agricultural productivity, along with reducing dependence on the use of synthetic nitrogen fertilizers for fertilization, being an important measure for mitigation as it avoids GHG emissions by carrying out fixation through the biological process by bacteria that transform the nitrogen present in the atmosphere ($N_2$) into forms assimilable by plants, especially legumes.

The mitigation promoted by the use of BNF results from the avoided GHG emissions from the use of synthetic nitrogen fertilizers. It is estimated that in 2020 the use of BNF avoided the emission of approximately 68 Mt$CO_2$e (Estevam et al., 2022).

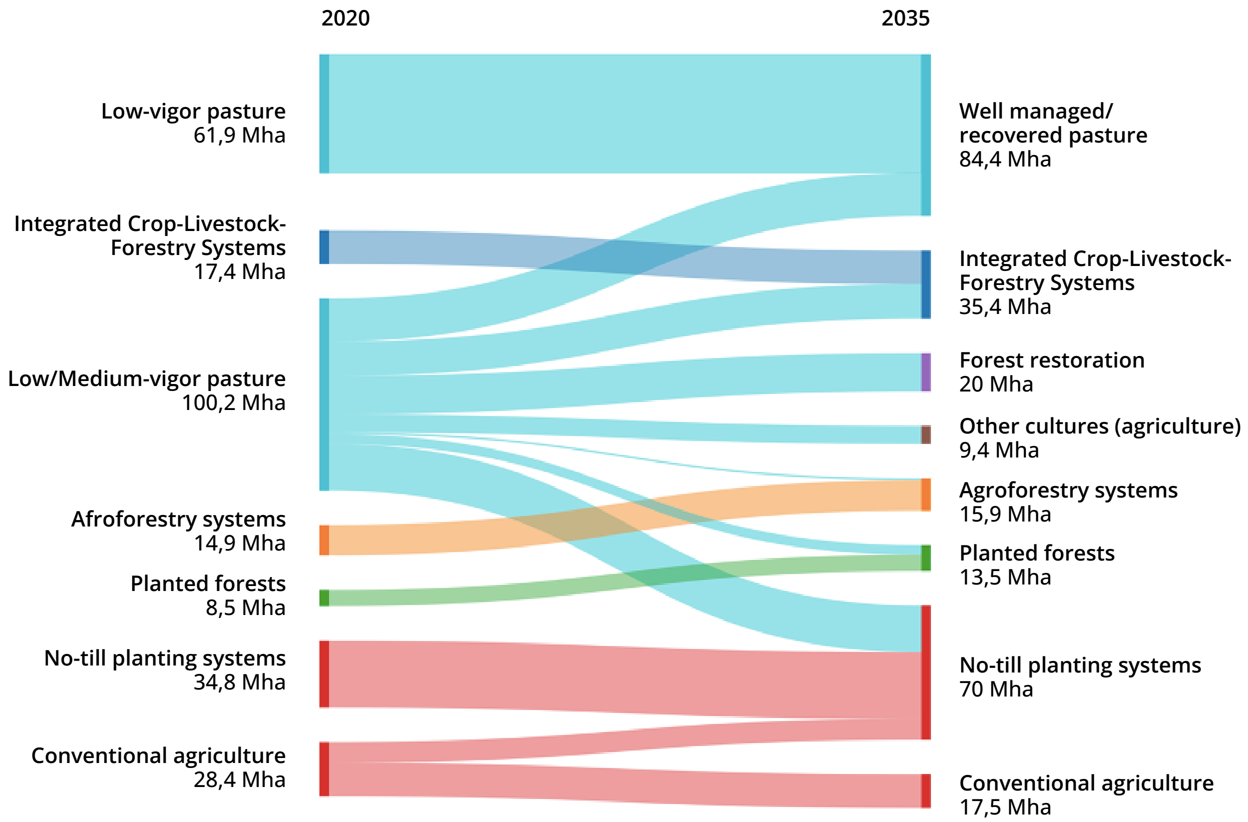
Thus, it is estimated that the emission of 103.8 $MtCO_2e$ can be avoided in 2035, representing an increase of 57% compared to the mitigation promoted in 2020, which was 66.2 $MtCO_2e$, totaling an increase of 37.7 $MtCO_2e$. To achieve this level of avoided emissions, the stipulated target was to expand to an additional 19 million hectares by 2035, reaching a total area of 53.2 million hectares, which results in a 57% increase in the total area with BNF use.

Its use should be considered for legumes, especially soybeans and beans, in addition to other crops, together with other species that can avoid the demand for synthetic nitrogen, such as grasses (corn, rice and wheat), requiring investment in research and production of inoculants.

### 3.4.13 Land conversions and uses by the agricultural sector

Finally, considering the areas with livestock, agriculture and forestry activities, from 2020 onwards, the expansion of the adoption of production systems based on the goals proposed until 2035, results in the total conversion of pastures classified as low and medium vigor to more efficient uses and production systems, capable of promoting the removal and storage of carbon by the soil, as well as its portion destined for forest restoration.

***Figure 24: Land use and management conversions by the agricultural sector between 2020 and 2035***



## 3.5. Land-use change and forestry

The protection and preservation of standing forests, as well as their recovery, must be priority measures for compliance with the Brazilian NDC, bringing together measures to combat deforestation and degradation, combat and control fires and burning in biomes, expansion of protected areas and areas of vegetation recovery. As a general guideline, there must be due appreciation of the means of life and production of traditional peoples and communities, as well as the bioeconomy and means of using natural resources in a sustainable and responsible manner. Furthermore, there must be the correct and sufficient allocation of financial and personnel resources so that the measures can be long-lasting and implemented in their entirety by the competent bodies/entities, with due focus on climate justice and combating environmental racism.

Brazil is committed to achieving the goal of zero deforestation in all biomes by 2030, considered as such when the maximum rate of 100,000 hectares per year is reached, with the maintenance of this situation after 2030 and the increase in the regeneration and recovery of degraded areas in 21 million hectares in legal reserve and permanent preservation areas by 2035, which represents the entire deficit of the Forest Code. The restoration of biomes must be accompanied by economic incentives for environmental preservation, whether in the form of tax/fiscal benefits or economic incentives through external resources (funds, credit lines or asset trading, for example). Furthermore, a system for monitoring the status of forest recovery and native vegetation in Brazil must be implemented, as well as monitoring, verification and validation of the compliance of authorizations for vegetation suppression and compliance with their requirements.

Land regularization is essential to curb the advance of deforestation, with the commitment to complete it on 100% of rural properties by 2035. Another measure should be the analysis and due regularization of rural properties registered in the Rural Environmental Registry (RER) and that have joined the Environmental Regularization Program (ERP), with the goal of 100% of rural properties in Brazil having completed the RER analysis and, by 2035, having duly complied with the ERPs (or proven compliance), with the Sicar operational and public data updated periodically. This objective must be accompanied by the implementation of a system that integrates data and information from Brazilian rural properties, so that there is effective monitoring of biomes and, consequently, their protection and improvements or implementation of specific public policies.

To combat the adverse effects of fire (whether legal or not), permanent plans must be drawn up for all Brazilian biomes, to be implemented and renewed regardless of the government context, with a sufficient budget allocated and transferred to the agencies/entities responsible for preventing and controlling such events. Such plans must contain quantitatively defined goals with specific deadlines. Special attention should be paid to prescribed burning activities, the application of which should be expanded through programs such as Prevfogo. Furthermore, data and information systems on burning authorizations and forest firefighting should be integrated, and these systems should be freely accessible to the public, with ongoing updates and on an official government database.

Brazil is committed to having at least 30% of protected areas in each biome by 2030 (in compliance with the United Nations Convention on Biological Diversity), in addition to finalizing the demarcation of indigenous lands and carrying out the removal of intruders from these areas, as well as the recognition and titling of *quilombola* territories and traditional communities. Specifically in relation to protected areas, in addition to the creation of new ones, 100% of the processes for developing management plans will be completed, with the consolidation of the boundaries of the created protected areas, with special attention to their buffer zones and the embargo of 100% of the illegally deforested areas within their boundaries, in compliance with the SNUC and related legislation. Although this NDC does not address the creation of protected areas beyond 2030, since it is based on the premise of ending deforestation of the biomes in that year, the creation of these areas is a fundamental condition for zero deforestation. Finally, 100% of federal public lands in all biomes that have not yet been allocated must be allocated, as well as the forest concession of 100 million hectares for restoration purposes, so that the management of such territories can be effective, also contributing to the reduction of illegal deforestation.

Projections of emissions and removals from the Land Use Change and Forestry (LUC) sector are based on three main assumptions: (1) the progressive elimination of deforestation, (2) the addition of new areas of recovering native vegetation (secondary vegetation) and (3) the addition of new areas of planted forest and agroforestry systems.

### 3.5.1. Progressive elimination of deforestation

From 2030 onwards, the annual deforestation area in the country will be capped at 100,000 ha (1,000 $km^2$). Between 2022 and 2030, a linear decrease in deforestation was considered. This refers to practically zero deforestation in Brazil, as promised by the government, but considering a small portion of new deforestation that can still be licensed (see chapter 2).

### 3.5.2. Re-vegetation

The linear growth of additional secondary vegetation was considered, assuming environmental regularization, by 2035, of all forest deficit under the Forest Code, which is currently estimated at 21 million hectares (Forest Code Thermometer, 2023), including: 11.3 million hectares in the Amazon, 5.1 million hectares in the Cerrado, 460 thousand hectares in the Caatinga, 3.8 million hectares in the Atlantic Forest, 341 thousand hectares in the Pampa and 94 thousand hectares in the Pantanal. Regarding these additional areas of secondary vegetation, a removal factor per biome was applied, according to SEEG collection 11.2, of: -17.8 $tCO_2$/ha in the Amazon, -6.3 $tCO_2$/ha in the Cerrado, -3.6 $tCO_2$/ha in the Caatinga, -5.8 $tCO_2$/ha in the Atlantic Forest, -6.3 $tCO_2$/ha in the Pampa and -7.8 $tCO_2$/ha in the Pantanal.

### 3.5.3. Planted forests and agroforestry systems

The goals for implementing planted forests and agroforestry systems (AFS), considered in the agricultural sector (see section 3.2), also impact the LUC sector, since emissions and removals from these systems in the agricultural sector refer only to the organic carbon component of the soil. It was therefore up to the LUC sector to measure the impact of these goals with the components of the carbon stock of the associated vegetation. The implementation of these systems in already open areas promotes carbon removals. For removals from new silvicultural systems, the removal factor used by SEEG of -20.4 $tCO_2$/ha was applied to the additional area of planted forest of 333 thousand hectares per year between 2023 and 2035, as seen in the agricultural sector. For agroforestry systems there is no specific removal factor in the SEEG, so the average removal factor for secondary native vegetation (-7.3 $tCO_2$/ha) was applied to the additional AFS area of 66.6 thousand hectares per year between 2023 and 2035, and this area is considered part of the 21 million hectares to be recovered.

### 3.5.4. Other land use changes

In this exercise, the emissions and removals table for the LUC sector is completed by emissions and removals from other land use changes. The projections for emissions and removals from other land use changes consisted of the average of the last five years of the historical series and represent a small part of the emissions and removals of the sector (3% and 0.43%, respectively).

### 3.5.5. Removals due to primary vegetation in protected areas

When considering, according to the National Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases, removals in protected areas would represent a substantial part of the sector's removals, with 386 million tons of $CO_2$ in 2022 (59% of removals). However, since the simple delimitation of new protected areas does not in fact imply changes in the processes of carbon emissions and sequestration in such areas, this component of removals was not considered quantitatively in this exercise, which aims to propose Brazilian targets in the NDC that seek a fair contribution from the country to the global mitigation effort.

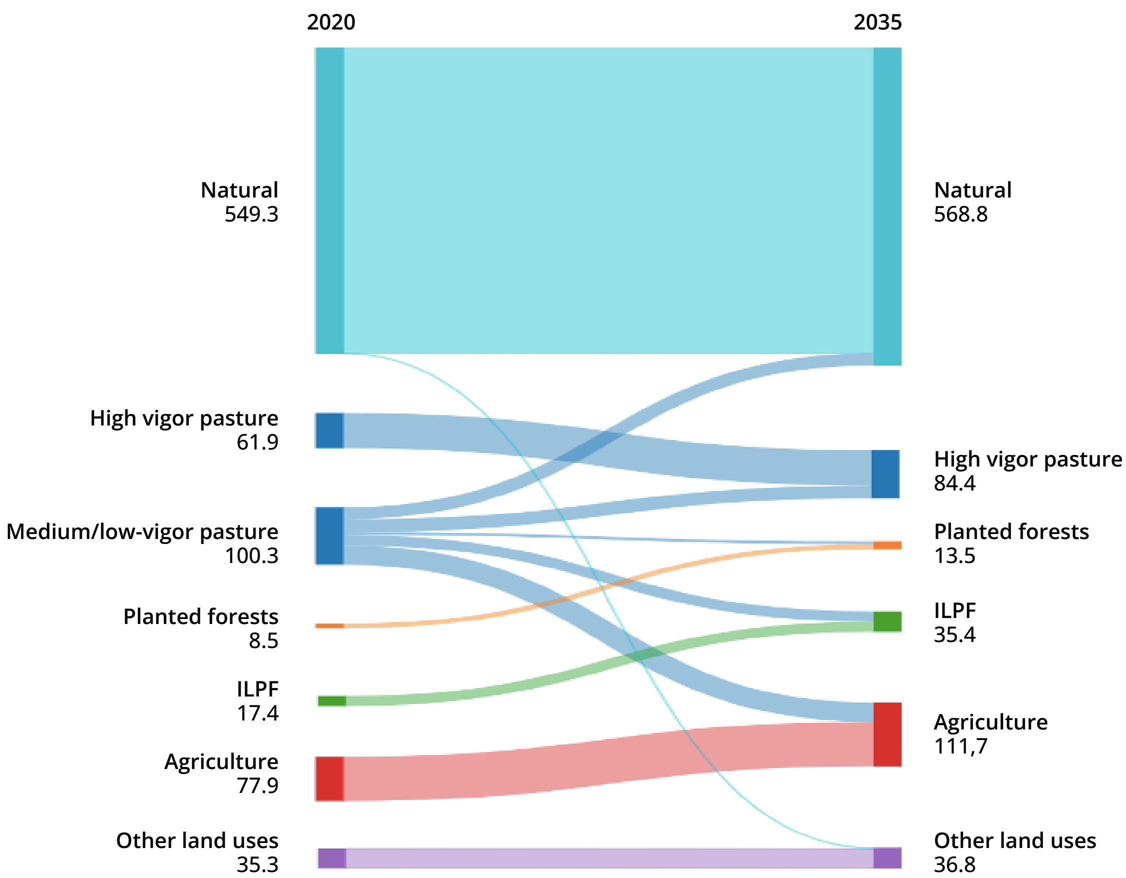
### 3.5.6. Fires in areas of native vegetation

The LUC sector presents in the SEEG emissions not accounted for in the Inventory (NCI) related to fires in areas of native vegetation. This component represented approximately 2% of the sector's total gross emissions in 2022 and was not considered in the current exercise. Although fighting forest fires and the use of integrated fire management are mentioned in current public policies, we were unable to identify targets in public policies related to the total area where integrated fire management will be used.

### 3.5.7. Changes in land cover and use in Brazil

When analyzing the panorama of the Brazilian territory, considering together the targets of the LUC and agricultural sectors for 2035, an expansion of native vegetation coverage, including Agroforestry Systems (AFS), of 3.5% can be observed in relation to the base year of 2020 (Figure 4). The entire area of low and medium vigor pasture, of 100.3 million hectares in 2020, should be converted into agricultural areas (35%), high vigor pasture (23%), integrated forest-crop-livestock systems (18%), planted forest (5%) and destined for the recovery of native vegetation and implementation of AFSs (20%). The proportion of deforestation that will still occur until 2035, of 100,000 hectares per year, resulting in 1.5 million hectares in the period, was projected to be allocated to other land use classes other than agricultural areas (Figure 25).

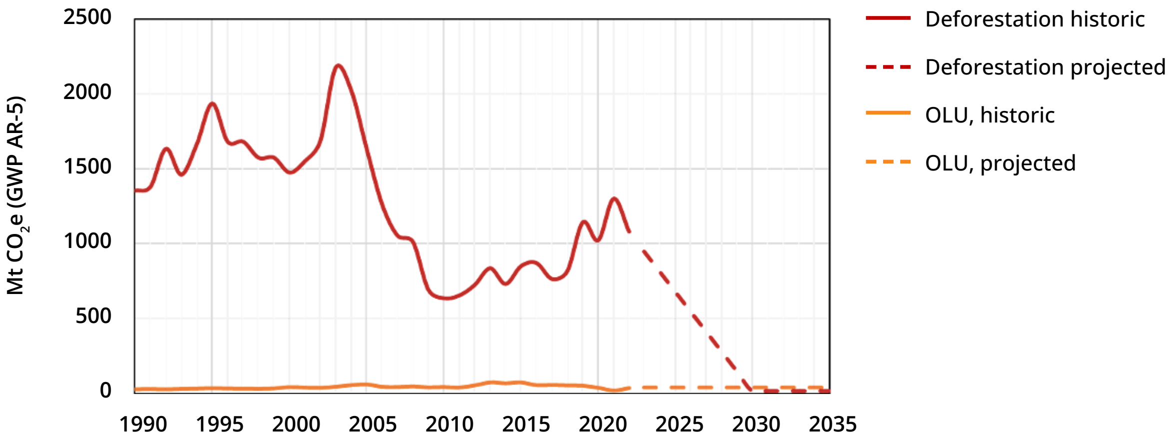
***Figure 25: Conversions of land cover and use in Brazilian territory, totaling 8.5 million hectares, considering the targets of the Agriculture and Land Use Change and Forestry sectors for 2035 and the base year of 2020***




### 3.5.8. LUC sector emissions balance

Regarding gross emissions, deforestation was projected to 42.1 million tons of $CO_2$e emitted annually between 2030 and 2035. Other land use changes were projected to be constant and contribute 18.7 million tons of $CO_2$e in both 2030 and 2035 (Figure 26). Projections from the LUC sector total 60.8 million tons of $CO_2$e constant between 2030 and 2035 (Figure 27).

***Figure 26: History and projections of gross emissions related to deforestation and other land use change (OLUC)***




Regarding removals, -400 and -500 million tons of $CO_2$e were estimated in 2030 and 2035, respectively, due to the growth of secondary vegetation. Due to the implementation of planted forests and agroforestry systems, -7 million tons of $CO_2$e were projected in both 2030 and 2035. Removals due to other types of land use changes were projected to remain constant, with -4.6 million tons of $CO_2$e in 2030 and 2035 (Figure 2). Total removals estimates are -411 million tons of $CO_2$e in 2030 and -511 million tons in 2035 (Figure 3). Combining gross emissions and estimated removals results in total net emissions of -351 million tons of $CO_2$e in 2030 and -450 million tons in 2035 from the LUC sector (Figure 27).

***Figure 27: History and projections of removals related to the growth of secondary vegetation, the implementation of planted forests (PF) and agroforestry systems (AFS), and other land use changes (OLUC). The targets related to the implementation of new planted forests and agroforestry systems are additive from 2022 onwards and, therefore, do not have a historical curve***

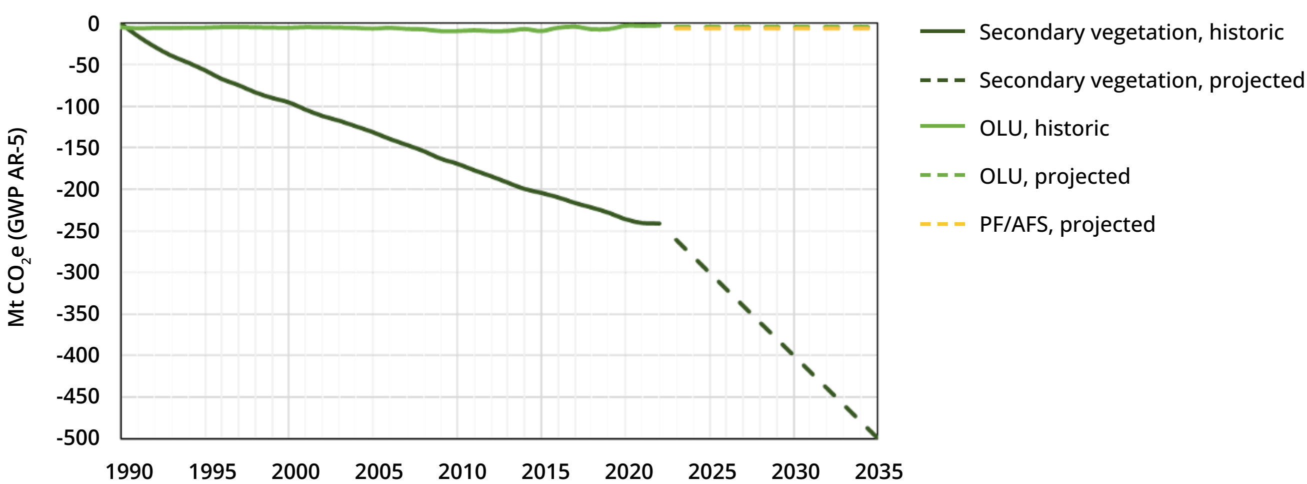
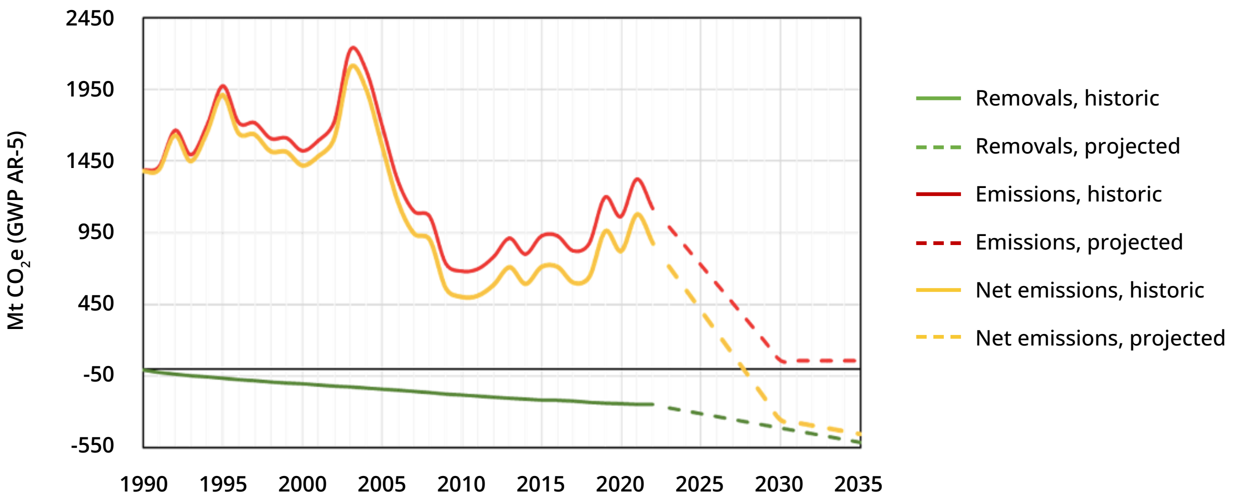


***Figure 28: History and projections of gross emissions and removals and the net total for the Land Use Change and Forestry sector***




## 3.6. Waste

The waste sector covers greenhouse gas (GHG) emissions from sanitation services related exclusively to the treatment of solid waste and wastewater.According to the guidelines of the Intergovernmental Panel on Climate Change (IPCC), emissions from the sector are disaggregated into: solid waste disposal, incineration and open burning, biological treatment and the treatment and discharge of domestic and industrial wastewater.

The solid waste disposal produces significant amounts of methane ($CH_4$) through the decomposition of the organic fraction. The estimate of the $CH_4$ generation potential of solid waste is made based on the analysis of the gravimetric composition, the type of management adopted at the final disposal sites – dumps, controlled landfills or sanitary landfills – precipitation rates, temperature and the amount of material sent to each type of destination.

Waste decomposition can occur aerobically or anaerobically (methanogenic). Aerobic decomposition occurs in the initial phase of waste deposition in the soil, when oxygen is still available. Subsequently, with the reduction of oxygen present in the waste, the anaerobic decomposition phase begins, during which biogas, rich in methane and carbon dioxide, is formed.

Incineration is a thermochemical process considered as a technological alternative for the intermediate treatment of waste. This process consists of the complete combustion of solid and liquid waste in controlled environments, promoting the reduction of volume and hazardous characteristics. The $CO_2$ and

$N_2O$ emissions resulting from the solid waste incineration process were estimated. For this purpose, data such as quantity, composition of the incinerated waste and incineration technology are used. The scarcity of these data increases the uncertainty of the emission estimate.

Open burning refers to a portion of the total amount of solid waste generated that is destined for uncontrolled burning. This practice is adopted by the fraction of the population that does not have access to the municipal solid waste collection system, and occurs more frequently in rural areas than in urban areas. Emissions of $CH_4$, $CO_2$ and $N_2O$ resulting from the combustion process in open air or in open dumps, in which greenhouse gasses are released directly into the atmosphere, without passing through a filtering chimney, have been estimated (IPCC, 2006).

Biological treatment consists of the degradation of organic carbon through processes such as composting and anaerobic digestion. Composting is an aerobic process in which a large fraction of the degradable organic carbon in the waste is converted to $CO_2$, $CH_4$ (in the anaerobic sections of the compost) and a small fraction of $N_2O$. Anaerobic digestion of organic waste accelerates the natural decomposition of organic matter without oxygen, generating $CH_4$ while $N_2O$ emissions from this type of process are not considered relevant. Digestion provides an environment in which it is possible to recover energy from the biogas generated.

Wastewater are generated from a variety of activities, which can be domestic, commercial or industrial. The type of activity from which the effluent is generated directly impacts the composition of the wastewater and, therefore, its GHG emission potential.

Domestic wastewater have a high organic load content, which, when degraded, can generate significant $CH_4$ emissions. These emissions vary according to the type of treatment applied, reaching higher amounts with treatments in anaerobic environments. Domestic wastewater treatment also emits nitrous oxide ($N_2O$), resulting from the degradation of nitrogen components (such as urea, nitrates and proteins).

Industrial wastewater present different loads of organic material depending on the industrial process sector. To analyze the sector estimates, strategic industries that generate a large volume of biochemical oxygen demand (BOD) were classified, related to the production sector of: cellulose, beef, pork, poultry, raw milk, pasteurized milk and beer.

The construction of the scenarios was based on the methodology and results of SEEG collection 11 and the emissions projections consider the implementation of the sector's main mitigation strategies, using as a basis different instruments of national sectoral policies, literature and knowledge of experts from the institutions that make up the Climate Observatory.

The main premise considered was to guarantee universal access to sanitation services, especially with regard to coverage of solid waste and wastewater collection systems, as well as the end of waste disposal considered environmentally inadequate. These are central aspects that permeate the important instruments of the sector, such as the National Solid Waste Plan (Planares), the National Basic Sanitation

Plan (Plansab) and the Basic Sanitation Legal Framework. Regarding the burning of household waste, it is considered that this route will no longer be adopted after the universalization of collection.

Another important aspect for the experts consulted is that thermal treatment routes, such as waste to energy incineration plants, should not be prioritized in solid waste management in Brazil.

### 3.6.1 Solid waste

The disposal of organic waste in landfills is the main source of greenhouse gas emissions in the sector. Measures aimed at diverting municipal solid waste must follow the National Solid Waste Policy, which sets out the order of priority for actions such as: non-generation, reduction, reuse, recycling, treatment of solid waste, environmentally appropriate solid waste disposal and adoption of energy recovery technologies. Therefore, in this context, premises were considered that incorporate the increase in the amount of waste sent for biological treatment, an increase in the recycling rate and an increase in the energy use of biogas generated in landfills.

***Table 18: Main premises adopted to mitigate the sector's GHG emissions in relation to solid waste treatment***

| | | Intensity of action over time (%) | | |
|---|---|---|---|---|
| **Subsector** | **Premise** | **2028** | **2032** | **2035** |
| Waste disposal | Recovery of recyclable materials | 9 | 17 | 24 |
| | Total mass with inadequate waste disposal | 0 | 0 | 0 |
| | Percentage of biogas used for energy (landfills and anaerobic digestion) | 26 | 50 | 58 |
| Biological treatment | Mass destined for biological treatment | 5 | 11 | 18 |

### 3.6.2 Wastewater

Regarding domestic wastewater treatment, the main reference was considered to be the universalization of the collection and treatment, with a focus on installing new aerobic treatment plants and installing new anaerobic reactors, with the aim of increasing the biogas capture rate in wastewater treatment

plants (WWTPs). Furthermore, optimization of existing systems should be encouraged with a focus on increasing burner efficiency and developing design criteria/guidelines that minimize emissions (e.g., limiting sludge accumulation; ensuring appropriate water level; dynamic aeration control).
The table below consolidates the main qualitative and quantitative assumptions adopted in the projections of emissions related to waste treatment by subsector related to the different sectoral instruments.

***Table 19: Main premises adopted to mitigate the sector's GHG emissions in relation to the treatment of domestic liquid effluents***

| | | Intensity of action over time (%) | | |
|---|---|---|---|---|
| **Subsector** | **Premise** | **2028** | **2032** | **2035** |
| Domestic effluents | Universalization of collection service coverage | 100 | 100 | 100 |
| | Install new aerobic treatment plants and install new anaerobic reactors focused on biogas capture, increase the adoption of these types of routes by 5% by 2035 | | | |
| | Optimization of existing systems with a focus on increasing burner efficiency | | | |

### 3.6.3 Waste sector emissions balance

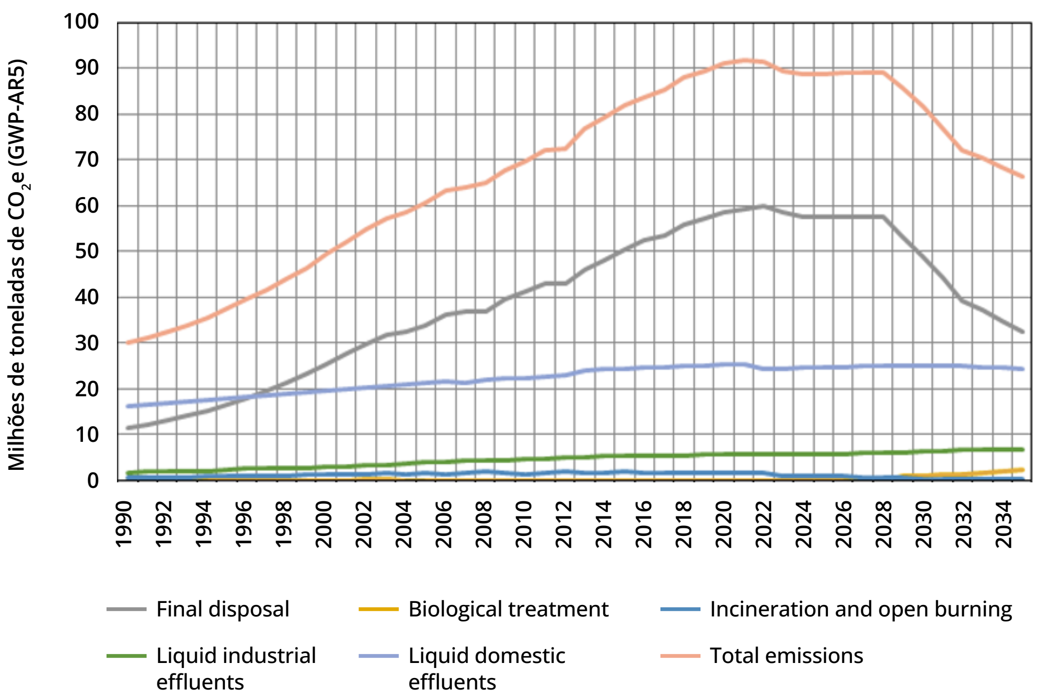
Regarding total emissions for the Waste sector, a decrease of around 11% (9.8 mt $CO_2e$) was projected for the period 2022-2030, and 19% for 2030-2035 - which is equivalent to 15.2 mt $CO_2e$). Thus, based on the scenarios presented, a decrease of approximately 27% is expected in the next 11 years, with waste disposal being the main driver for this situation. This scenario is related to the diversion of waste from landfills and, mainly, to the increase in the rates of capture and use of biogas at final disposal sites.

Still within this range, emissions related to biological treatment are expected to increase by more than 30 times by 2035, as this will become a widely used route in the country. Emissions related to industrial wastewater treatment, which is related to the increase in GDP, also follow the upward trend; and domestic, the latter being a considerably low value for their proportions (around 200 thousand $tCO_2e$ in a universe of around 24 mt $tCO_2e$), related to the increase in population, accompanied by the implementation of mitigation measures. All the above information is included in Table 21, as well as in Figure 29.

***Table 21: Overview and projections for the Waste sector***

| | Reference Year (in $tCO_2e$ - GWP AR-5) | | |
|---|---|---|---|
| **Subsector** | **2022** | **2030** | **2035** |
| Final Disposal | 9.861.105 | 48.855.917 | 32.426.034 |
| Biological Treatment | 73.834 | 1.048.278 | 2.369.450 |
| Incineration and Open Burning | 1.492.641 | 351.646 | 103.947 |
| Industrial Liquid Effluents | 5.588.679 | 6.280.348 | 6.876.538 |
| Domestic Liquid Effluents | 24.317.130 | 24.949.931 | 24.465.148 |
| Total Emissions | **91.333.389** | **81.486.120** | **66.241.118** |

***Figure 29: Historical overview and projections for the Waste sector in Brazil (1990-2035)***



Brasil 2045

# 4

# ADAPTATION

The Climate Adaptation Plan will form the basis for the adaptation actions and targets to be implemented by Brazil in its second Nationally Determined Contribution, seeking to respect and implement environmental, climate and human rights legislation in all sectors, in particular the rights of communities at climate risk, combating environmental racism and promoting policies, measures and actions that are sensitive to racial and gender equity.

In line with Decision 2/CMA.5, the plan will develop targets and indicators for adaptation and resilience building, taking into account the fight against environmental racism and the identification of the most vulnerable areas in cities, rural areas and terrestrial and coastal ecosystems. By proposing new adaptation and resilience-building measures for these territories and ecosystems, including the management, creation, consolidation and expansion of terrestrial and marine protected areas, which respect the territories and rights of traditional peoples and communities and incorporate the recommendations of the most recent available scientific knowledge, These indicators should consider the breakdown by race, gender, age, disability status, income and territory, especially with a view to necessary changes in the urban territorial arrangement and the guarantee of the Right to the City. Through a National Adaptation Strategy, the federal government will guarantee technical, operational and financial support to states and municipalities, with the inclusion, training and full participation of local communities and subnational governments.

- Brazil is committed to developing new scenarios for assessing climate risk to infrastructure (including power generation and transmission, public roads, basic sanitation equipment, ports, airports, hospitals, schools and other strategic buildings), agriculture, human settlements and terrestrial, coastal and marine ecosystems by 2026. These scenarios will be based on regionalized climate models, participatory risk identification methods and analyses already carried out, such as those of the Brazil 2040 initiative, AdaptaClima, and the Brazilian Panel on Climate Change.

- Brazil is committed to including climate impact and risk analysis in the entire public budget through Annual Budget Laws and directing public budgets towards adaptation measures and financial incentives for initiatives that ensure greater resilience to climate events, compatible with the size of the crisis.

- It also commits to incorporating new scientific evidence, indigenous traditional knowledge and local knowledge into all policies and plans aimed at:

a) the promotion of urban and regional development;
b) the implementation of infrastructure projects;
c) the expansion of electricity generation;
d) the use and occupation of urban and rural land;
e) the promotion of agriculture and livestock farming;
f) the promotion of improved public health;
g) the guarantee of food and nutritional security;

h) industrial development;
i) water resources management;
j) ocean and coastal zone management;
k) and conservation of biodiversity and ecosystems.

- All the aforementioned public policies and the plans and actions related to them will be aligned with the objectives, guidelines, strategies and indicators of the Climate Adaptation Plan and the National Adaptation Strategy, as determined by law 14.904/2024.

- The resilience of national industry must be strengthened in the face of the impacts of climate change, prioritizing the modernization and adaptation of industrial infrastructures to face climate events, ensuring the continuity of operations.

- Brazil will invest in infrastructure adapted to climate change, including a public transport system with operational quality to attract users, with systematic investments in fleet renewal with more sustainable technologies, restructuring of contracts and regulatory instruments that allow for greater quality in the provision of services and greater control by the public authorities.

- Active mobility will be encouraged through the structuring of walkable and cycleable cities, with improvements in the quality of paving and signage, an increase in green corridors, an increase in the cycle path network, an increase in the possibilities of short travel connections, investments in public lighting and infrastructure for bicycle parking, bringing more accessibility, safety and quality to people's basic mobility.

- The country will adopt targets, strategies and indicators to reduce areas at risk of climate disasters and increase resilience, especially in coastal regions and on hillsides in urban areas.

- Policies, measures and actions will be established aimed at qualified urbanization and protection of communities and populations in risk areas, with a view to ensuring their permanence in their territories, provided that it is technically feasible in view of local conditions. When relocations are extremely necessary, adequate resettlement must be guaranteed, always in dialogue with local leaders and the population.

- Investments should be directed towards reinforcing structures in critical areas and areas at climate risk, as well as in the infrastructure needed to avoid adverse effects in such situations. Furthermore, studies and investments in urban arrangements adapted to the climate crisis should be prioritized, avoiding urban densification in valley bottoms.

- In addition to infrastructure works, adaptation actions based on ecosystems and nature will be promoted, using biodiversity and ecosystem services as part of the adaptation strategy.

- The Union, States, Federal District and Municipalities must expand and implement incentives for the preservation and expansion of urban green areas as a potential for the use of ecosystem services and encourage the use of nature-based solutions to increase the resilience of cities and ensure greater safety for the urban and peri-urban population in relation to the impacts of climate change.

- By 2027, Brazil will have established multi-hazard early warning systems, climate information services for risk reduction and systematic observation to support improved climate-related data, information and services, and will have invested resources in the preparedness stage, with the promotion of territorialized disaster action plans to improve the response capacity of populations living in risk areas.

- Responses and investments in adapting territories to disasters must include strengthening state and municipal civil defense and protection agencies, through the allocation of resources, the valorization of civil defense professionals, adequate training, according to the conditions and specificities of each territory, the improvement of communication and governance, thus fostering social and intersectoral participation, including constant dialogue with health and social assistance policies in a preventive manner.

- Climate-resilient, sustainable and regenerative agricultural production must be fostered;

Aware that some adaptation actions have synergies with mitigation actions, Brazil:

- Will develop decentralized energy generation, especially small wind and solar farms, with priority given to community management and ensuring the necessary social safeguards.

- Will map the structural integrity and safety of existing energy infrastructures in relation to damage associated with climate risks, proposing solutions, as well as the effects on the energy efficiency rates of power generation plants with higher temperatures, adjusting the models according to these new parameters.

- Will consider climate change scenarios and water resource modeling and will assess the impacts in terms of electricity production and ensuring clean energy generation.

- Will use Nature-based Solutions to reduce heat waves in urban environments associated with passive environmental comfort strategies to reduce the internal temperature in buildings.

- Will direct budget and efforts towards enabling public health services to fully care for the Brazilian population regarding the adverse effects of climate change, such as heat stress, arboviruses and waterborne diseases.

Brasil 2045

# 5

# CLIMATE JUSTICE

Climate justice is transversal to all agendas, bringing with it several structuring discussions of the national climate agenda, which must be one of the main assumptions for the elaboration and implementation of public policies with human rights and the fight against environmental racism. National, sectoral and territorial plans must focus on the pursuit of climate justice, aiming to reduce social, racial, ethnic, class and gender inequalities, establishing clear, objective and ambitious goals. Climate justice must also be achieved through strict compliance with existing legislation, especially standards guaranteeing fundamental and structural rights, as well as the formulation and implementation of public policies.

Progress must be made in implementing climate (and anti-racist) education for society, public and private agents, with an essential focus on children and adolescents.

Brazil must complete all open and unfinished processes for demarcating indigenous lands and granting titles to quilombola territories. In addition to mitigating measures to protect against deforestation, the integrity, protection and proper management of traditional territories helps to strengthen the country's adaptive capacity, and is also an urgent measure to ensure climate justice for these populations. The country must also guarantee the protection of the rights and cultures of traditional and indigenous peoples and communities, in compliance with what is determined in Brazilian legislation, highlighting the Brazilian Federal Constitution, ILO Convention 169, the Indigenous Statute (Federal Law 6,001/1973) and the National Policy for the Sustainable Development of Traditional Peoples and Communities (Federal Decree 6,040/2007).

Furthermore, the participation of communities most impacted by the climate emergency in the processes of discussion, financing and implementation of measures and actions to adapt to climate change must be guaranteed.

Public budgets must be directed towards adaptation measures, as well as towards strengthening the climate justice agenda and financial incentives for better socio-environmental and climate practices. Whether from domestic or foreign sources, financial resources must be applied correctly to situations and realities that truly require such investments, such as disaster prevention and strengthening family farming. It is important to emphasize the importance of a local perspective on territorial problems, that is, for regionalizing problems and directing investments. It is necessary to create specific policies for those affected by climate change.

In this context, a "participatory climate budget" should be considered at the local level, with rules for the correct application of resources and greater participation from society (especially from vulnerable/affected communities) to discuss its use with transparency. Within this context, it is worth highlighting the need to include society and those affected/vulnerable in the activities and discussions related to the transfer of financial resources for prevention actions in disaster risk areas provided for in Federal Decree 11.219/2022.

In Brazil, extreme weather events have been increasing in a way that brings concern and significant economic impacts, such as crop losses and extraordinary outlays from public coffers to mitigate the negative effects of climate change, as seen in 2024 in Rio Grande do Sul – according to Datafolha, 47% of people who earn up to two minimum wages report having suffered economic losses due to flooding, and 52% of black people suffered losses, compared to 26% of white people[30].

In disaster management, it is essential to direct efforts and budgets towards reducing risk areas, especially coastal areas, city outskirts and areas near hillsides, in order to implement the adaptation agenda and not just the mitigation of effects. Urban infrastructure projects aimed at ensuring the permanence of the population living in risk areas, through qualified urbanization of their territories, if technically feasible in view of local conditions, studies developed and the prospect of extreme events, with the guarantee of life safety for the population living there. Such a measure involves the review and implementation of Brazilian legislation, especially those related to civil defense activities and the transfer of resources to municipalities. Public monitoring and follow-up of such measures is essential.

Still on the territorial issue, there must be progress in the instruments for managing land and water spaces for traditional peoples and communities, with prioritization in the allocation of territories (Sustainable Use Authorization Term - TAUs - and Real Right of Use Concession Contract - CCDRU) to direct measures beyond the demarcation/recognition of territories, but also the maintenance of sustainable economic activities.

Relating the energy agenda to climate adaptation, decentralized energy generation must be developed, especially small wind and solar farms, with their management by communities, aiming at full energy access for traditional peoples and communities, including for the maintenance of their basic activities.

[30] https://www1.folha.uol.com.br/cotidiano/2024/06/enchentes-do-rs-atingiram-proporcao-maior-de-pobres-negros-e-menos-escolarizados.shtml

Brasil 2045

# 6

# OCEAN AND COASTAL AREAS

In Decision 1/CMA.5 (Global Stocktake), Parties were invited to conserve and restore oceans and coastal ecosystems and to scale up ocean-based mitigation actions. It was also recognized that ocean-based adaptation actions and measures to increase resilience through ecosystem-based approaches reduce the risk posed by climate change and provide multiple co-benefits. Finally, it was encouraged to strengthen ocean-based adaptation and mitigation actions.

The largest continuous strip of mangroves in the world is in northern Brazil, representing 80% of the country's mangrove cover. Most of the country's mangrove and apicun area is within conservation units (ICMBio, 2018) of the Brazilian Coastal Zone. Despite the importance of these numbers, we have already recorded a 25% loss of the original coverage of this ecosystem since the beginning of the 20th century, and in the Northeast this percentage could reach 40% due to infrastructure projects and shrimp farms (ICMBIO, 2018). Mapbiomas highlights that direct human actions were the main responsible for the changes in the coverage of mangroves and apicuns between the years 2000 and 2020.

Mangroves are even more important because they contribute to both adapting to the impacts of climate change and to carbon sequestration. Studies indicate that the highest concentrations of carbon in the soil of the Amazon are in mangrove areas. It is estimated that Brazilian mangroves have the potential to sequester 468.3 tons of carbon per hectare[31], a potential that needs to be considered in the development of a national strategy for the use of blue carbon, and that, once initiated, can generate an inventory for quantification, understanding and shareable data. These ecosystems are fundamental both for coastal communities — where mangroves are a source of livelihood and protection against natural disasters — and for the rest of the world, which has mangroves as an ally against global warming.

In this sense, Brazil must restore 27 thousand hectares of mangroves and apicuns. In addition to the restoration goals, it is necessary to identify areas critical to climate change that already show projections and/or symptoms of impact (areas of saline intrusion, areas with projected sea level rise and recurrent areas of bleaching), with a specific goal of restoring 30 thousand hectares of arboreal restinga by 2035. These areas should be prioritized for the development of adaptation, mitigation and emergency action plans.

The World Meteorological Organization's "State of the Global Climate 2023" report[32] emphasizes that in 2023 the increase in ocean temperature reached its peak in 65 years of analysis. This effect significantly alters ocean dynamics, impairing the ability to reduce atmospheric temperature and increasing the potential for water acidification. The process of ocean acidification has raised attention as it affects organisms and ecosystem services, with the potential to reduce biodiversity and reinforce food insecurity.

[31] https://www.nature.com/articles/s41467-024-45459-w

[32] World Meteorological Organization (WMO). State of the Global Climate 2023. *Geneva, Switzerland, 2024* (https://library.wmo.int/viewer/68835/download?file=1347_Statement_2023_en.pdf&type=pdf&navigator=1o.int)]

More than 54% of the ocean's coral reefs are experiencing the fourth global bleaching event[33], monitored by the National Environmental Satellite through "Coral Reef Watch" (NOAA). Bleaching has occurred especially in Florida, the Caribbean, Brazil, as well as several countries in the South Pacific, the Middle East, Indonesia and Africa. The vulnerability of coral reefs is a cause for great concern, since it is one of the most biodiverse ecosystems on the planet, home to approximately 25% of marine species, including those of great ecological and commercial importance.

We know, however, that this scenario tends to worsen, because when we reach an average temperature increase of 1.5ºC, the projection is that 70% to 90% of the world's corals will be lost, which would be extinct with a warming of 2ºC. In Brazil, the Costa dos Corais EPA has already suffered 18.1% loss (PEREIRA et al., 2022)[34], while in the Abrolhos region another study identified 89% mortality of fire corals in the 2019 heat wave (DUARTE et al., 2019)[35].

In addition to reducing fish stocks and harming tourism activities, the deterioration of coral reefs increases coastal vulnerability, especially during extreme events such as storm surges and storms, resulting in significant material and non-material damage. By preventing the effects of storm surges and other extreme weather events, reefs protect public and private infrastructure, also avoiding costs for construction of artificial barriers that are increasingly necessary in coastal regions.

The Coral Reef Breakthrough, launched at COP28, sets out four action points to save coral reefs: 1) Stop the causes of loss - Mitigate land-based pollution sources, destructive coastal development and overfishing; 2) Double the area of protected reefs - Strengthen reef conservation efforts aligned with global targets, including 30x30 (30% of areas protected by 2030); 3) Accelerate restoration - Support innovative solutions and climate-responsive designs to adapt 30% of degraded reefs by 2030; 4) Secure investments of at least US$12 billion by 2030 to conserve and restore these crucial ecosystems. Brazil should respond to this call by creating an adaptation goal aimed at developing and implementing a plan for sustainable use, conservation and restoration of coral reefs based on an ecosystem-based approach.

Many coastal municipalities have large estuarine systems that are related to oceanic and continental processes that coexist. Changes in the hydrological regime that are common in extreme events and directly affected by climate change are not yet part of the adaptation equation for coastal areas. It is therefore necessary to develop adaptation policies that consider estuaries at their core, highlighting the relationship between 'interventions on the continent x responses in the coastal zone' and vice-versa. – in order to prevent or reduce the social and environmental impacts of disasters such as the one currently being observed in the State of Rio Grande do Sul. It is therefore suggested that water resource management programs dialogue with coastal management in order to protect these environments and adapt, as necessary, to protect biodiversity and populations affected by climate events.

[33] https://www1.folha.uol.com.br/opiniao/2024/04/o-oceano-em-preto-e-branco.shtml

[34] https://www.frontiersin.org/articles/10.3389/fmars.2022.725778/full

[35] https://www.frontiersin.org/articles/10.3389/fmars.2020.00179/full

There is also concern about real estate expansion in coastal cities, especially with regard to urban restoration in coastal areas, whether in mangroves, apicuns or even restinga areas, which are of significant importance for the local ecosystem and for containing the adverse effects of climate change in these regions. As a global goal, it is important to have zero degradation of mangroves, apicuns and restingas and to achieve the target of 30% of marine protected areas by 2035.

Strengthening the economies of coastal and marine sociobiodiversity, as well as the allocation of marine lands of social interest, including housing spaces and access to work environments and natural resources, are also important instruments for inducing the preservation and conservation of coastal and marine ecosystems. Furthermore, public policies in these regions should focus on populations directly affected by extreme events, such as environmental and climate disasters, in addition to rising sea levels, including local fishermen and traditional communities and peoples who live and carry out their activities in these regions.

Marine Protected Areas (MPAs) and other conserved areas, recognizing territories of traditional peoples and communities, are one of the main means for the participatory and fair conservation of marine biodiversity, which is why they are addressed in Target 3 of the Global Biodiversity Framework. In the era of climate change[36], protected areas take on new roles and should be considered in NDCs as they also increase the resilience of biodiversity and coastal communities, serve as adaptation measures and help mitigate the pace and extent of climate change impacts. The effectiveness of MPAs in reducing the decline of marine systems, enabling mitigation and adaptation to climate change and socio-ecological resilience has been consistently reported in practical and scientific experiences[37].

Currently, Brazil has 26.1% of Marine Protected Areas. However, the assessment of 96% of Marine Conservation Units identified that less than a third of them can be considered fully effective (SAMGe, 2020). Furthermore, we are not close to forming a connected network of Conservation Units, in a representative and effective way, which would certainly guarantee the persistence of marine biodiversity in the long term (Magris et al., 2020)[38]. Therefore, it is essential that this percentage increases to at least 30% of marine protected areas by 2030, strengthening the MPA system by ensuring connectivity, habitat representation and equitable governance.

It is important to advance information bases that provide models, scenarios and data on the coastal and marine zone of Brazil, both for the formulation of public policies for mitigating and adapting to climate change and for developing specific goals.

[36] https://ocean-climate.org/wp-content/uploads/2022/11/Policy-Brief_Adaptation_MPA.pdf

[37] https://www.cell.com/one-earth/pdfExtended/S2590-3322(22)00480-8
https://www.pnas.org/doi/full/10.1073/pnas.1701262114
https://www.iucn.org/resources/issues-briefs/marine-protected-areas-and-climate-change

[38] https://onlinelibrary.wiley.com/doi/full/10.1111/ddi.13183

Brasil 2045

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