Corporate Inventory of Greenhouse Gases

Year 2023

Irani Papel e Embalagem SA

This report presents the results of the Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases not Controlled by the Montreal Protocol from the operations of Irani Papel e Embalagem SA, in the year 2023. The inventory follows international standards developed by the International Organization for Standardization (ISO) and the World Resources Institute (WRI), covering all Direct Emissions (Scope 1) and Indirect Emissions due to Energy Consumption (Scope 2), in addition to Indirect Emissions from other Sources (Scope 3).

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summary

1. General Information

This document was prepared in accordance with the principles and requirements of the international standard ISO 14.064:2022 - Part 1: Specification and guidance for organizations for quantifying and preparing reports on greenhouse gas emissions and removals. The Brazilian standard may also be used as a reference NBR ISO 14.064:2022.

2. Company Description

Irani Papel e Embalagem SA produces cellulose, Kraft paper, corrugated cardboard sheets and packaging and resins. In its activities, it reaffirms its commitment to sustainability. Currently, Irani has the following business units: Paper-SC, Packaging-SC and Florestal-SC in Vargem Bonita-SC, Resins-RS and Forestry-RS in Balneário Pinhal-RS, Packaging-SP in Indaiatuba-SP, Paper-MG in Santa Luzia-MG, and administrative office in Joaçaba-SC.

Irani produces brown and white Kraft paper, from 30 to 200 g/m2, in the FineKraft, FlashKraft and FlexiKraft lines, in addition to EnveloKraft, in brown and gold. It also produces 100% virgin fiber paper, suitable for direct contact with food. For the production of corrugated cardboard sheets and packaging, Irani manufactures KraftLiner, Recycled, Core and Cape paper. Irani supports its customers from the indication to the development of the Kraft paper best suited to the needs of each process. Provides support and monitoring through technical assistance.

Irani is one of the main industries in the corrugated cardboard packaging segment. In its production, it uses paper of various weights with excellent performance and cardboard sheets in single, double or triple waves with recognized resistance to humidity and impacts. The product line comprises normal boxes, cutting and die-cutting. For the development of customized packaging, Irani provides its research, development and technical assistance structure to produce packaging that meets and optimizes the specific logistics of each client.

The company also produces turpentine and pitch from the extraction of natural pine resin. The resining process at Irani is carried out in accordance with the best environmental forestry management practices.

The FSC Seal certifies responsible forest management and the acquisition of raw materials of appropriate origin by Irani. Chain of Custody Certification guarantees that, in the Paper (SC and MG), Packaging (SC and SP) and Resin-RS units, the entire process is followed by certified raw materials and monitored from the forest to the product sold, in addition to other wood of controlled origin, in accordance with FSC requirements. The company is also certified in its Quality Management System according to the NBR ISO 9001 standard in all operational units.

Irani's Environmental Management certified through the NBR 14001 standard in the Packaging business units is structured to enable a balance between production activities and environmental performance. Through its Environmental Policy, Irani is committed to maintaining an Environmental Management System that seeks to comply with current legislation, promote continuous improvement and avoid pollution. With this, the company identifies, analyzes and monitors all environmental impacts of its production activity, such as liquid effluents, gaseous emissions, solid waste and their final disposal. The Environmental Management coordination works integrated with the company's management, helping to identify and deal with environmental aspects and impacts, constantly seeking participatory action that encourages everyone involved. Included in the company's strategic map, the next steps to improve the company's environmental management are certification of the NBR 14001 standard in the Paper-MG, Paper-SC and Resins-RS business units.

2.1 Operational Frontiers

In this document, removals and emissions from the following operational and controlled units of Irani Papel e Embalagem SA were accounted for, listed in table 01 below:

Table 01– Operating and controlled units

Operating Units	Location	Holding
Paper SC	Vargem Bonita- SC	Unidade
Packaging SC	Vargem Bonita- SC	Unidade
Forestry SC	Vargem Bonita- SC	Unidade
Packaging SP	Indaiatuba- SP	Unidade
Habitasul Florestal RS	Balneário Pinhal- RS	Controlada
Resins RS	Balneário Pinhal- RS	Unidade
Administrative	Joaçaba- SC | Porto Alegre RS	Unidade
Paper MG	Santa Luzia- MG	Unidade

The administrative office in Porto Alegre RS was transferred to Habitasul in 2022, with only the fuel consumption of its own fleet being counted, since the vehicles are from Irani.

2. 2 Emission Sources

The operational boundaries were not expanded in the inventory in relation toto 2013. The identification of emission sources was carried out by the company itself and the necessary adjustments to the data collection spreadsheets were made.

Below, in table 02, we have the emission sources for each activity in the manufacturing units.

Table 02- Identification of GHG Emission Sources in operation during the year

Category	Activity	Substance	Removal Sinks/Emission Source	GHG	Operating Units
Direct Removals	Forest growth	Biomass	Forests planted with pine and eucalyptus	CO_2	Forestry/SC e Forestry/RS
Direct Removals	Crescimento florestal	Biomass	Native Forests	CO_2	Forestry/SC
Direct Emissions	Fuels	Diesel	Own fleet of heavy vehicles	CO_2; CH_4; N_2O	Paper/SC; Forestry/RS; Resins/RS; Packaging/SP; Administrative
		Gasoline	Own fleet of light vehicles	CO_2; CH_4; N_2O	Paper/SC; Packaging/SP; Forestry/RS; Resins/RS; Paper/MG; Administrative
		LPG gas	Forklifts	CO_2; CH_4; N_2O	Paper/SC; Packaging/SP; Resins/RS; Paper/MG
		Natural gas	Boiler	CO_2; CH_4; N_2O	Packaging/SP; Paper/MG
		GMP Oil	Boiler	CO_2; CH_4; N_2O	Paper/SC; Packaging/SC; Paper/MG
		Ethanol	Own fleet of light vehicles	CH_4	Paper/SC; Packaging/SP
		Biomass	Boiler	CH_4	Paper/SC; Resins/RS
		Black Liquor	Recovery Furnace	CH_4	Paper/SC
	Reagents	Solvents and Paints	Painting Process	CO_2	Paper/SC; Packaging/SC; Packaging/SP;
		Acetylene	Oxy-cutting and welding processes	CO_2	Paper/SC; Packaging/SC; Packaging/SP; Resins/RS
		Kerosene	Maintenance Cleaning	CO_2	Paper/SC; Packaging/SC; Packaging/SP; Paper/MG
		Chemicals containing organic solvents	Polymers and Antifoam	CO_2	Paper/SC; Paper/MG
		Flexographic inks	Packaging Painting	CO_2	Packaging/SP; Paper/MG
		Nutrients/Osmocote	Forest Nursery	N_2O	Forestry/SC
	Waste treatment	Industrial Waste (own landfill)	Disposal of solid waste in its own industrial landfill or disposal in a forest	CH_4	Paper/SC; Packaging/SC; Packaging/SP;
	Wastewater treatment	Industrial Effluents	Biogenic emissions resulting from the burning of methane gas in flares	CO_2	Paper/ MG
	Wastewater treatment	Domestic effluents	Anaerobic treatment of domestic effluents	CH_4	All Units
Indirect Emissions - ENERGY - Location-Based Approach	Energy	Electricity	GRID Power Acquisition	CO_2	Paper/SC; Forestry/SC; Paper/MG Packaging/SP; Packaging/SC Resins/RS; Joaçaba's Office
Indirect Emissions - Purchasing Choice-Based Approach	Energy	Electricity	IREC Acquisition	CO_2	Packaging/SP
Indirect Emissions - Other sources	Fuels	Diesel	Outsourced fleet of heavy vehicles	CO_2; CH_4; N_2O	Paper/SC; Forestry/SC; Forestry/RS; Packaging/SP; Resins/RS
		Gasoline	Outsourced fleet of light vehicles	CO_2; CH_4; N_2O	Paper/SC; Forestry/SC; Forestry/RS
		Airplane Kerosene	Air travel	CO_2	All Units
		LPG gas	Restaurants	CO_2; CH_4; N_2O	Paper/SC; Packaging/SP; Resins/RS; Paper/MG
		Lubricant	Chainsaw; brushcutters	CO_2; CH_4; N_2O	Forestry/SC e Forestry/RS
	Waste treatment	Solid Waste (private landfill)	Disposal of solid waste in private industrial/domestic landfill	CH_4	Paper/SC; Packaging/SC; Packaging/SP; Resins/RS; Paper/MG

Therefore, the categories of sources/sinks considered in this document can be summarized as follows:

a) Direct Removals: own planted forests and forests planted in partnerships (Pinus and Eucalyptus), where removals of the bole were recorded – aerial part trunk, branches and needles, litter and roots. Remnants of forests planted with species no longer used by the company were also considered (Araucária, Liquidambar, Cupressus, Cryptomeria and Cunninghamia). In addition to native forests, which had their successional stages defined and removals accounted for.

b) Direct Emissions: fuel consumption, reagent consumption, effluent treatment and solid waste treatment;

c) Indirect Emissions – Energy: electricity consumption from the National grid;

d) Indirect Emissions from Other Company Sources.

2.3 Neutral sources excluded, neutral sources accounted for and irrelevant emission sources excluded

Some sources of GHG emissions identified in the organization have different treatments, which are listed below:

Excluded Neutral Sources:

- The PCHs' own energy production is not accounted for as they are renewable sources, therefore excluded, as there are no GHG emissions;
- The emission related to the burning of methane gas in flares in the industrial effluent of the Paper unit – MG is calculated and reported, but not accounted for as it is a biogenic emission.

Neutral Sources Accounted for:

- Emissions from the biomass boiler HPB (High Pressure Boiler) and Black Liquor were calculated, and emissions related to CH4 and N2O are calculated and accounted for in the spreadsheet and report;
- Emissions related to biodiesel fuels, gasoline with added alcohol and ethanol were only recorded as CH4 and N2O in the report and spreadsheet.

Excluded Irrelevant Emission Sources:

- Fugitive refrigerant emissions: gasses used by Irani Papel e Embalagem SA for this purpose, they are from the "R-22" and "R-410 A" specifications of the HCFC family. Such gasses are not regulated by the United Nations Framework Convention on Climate Change nor by ISO 14.064:2022 Part 1;
- Emissions related to CO2 from fire extinguishers from all units were disregarded, as the percentage relative to the company's total emissions is below 5%, which can be observed with a base year of 2021, which was 0.002%.
- Process CO2 used in the 4th washer filter to control the pH of the washed cellulose from the Papel SC unit. Emissions associated with this source are presumably insignificant when compared to those from other identified sources.
- Sources related to maintenance paints and thinners were excluded, as the percentage relative to total emissions is less than 5%, and can be observed with a base year of 2021, which was 0.005%.

As we are not counting Biomass (chips, wood) and Black Liquor, table 03 below shows information relating to each source, as well as GHG emissions. The calculations for Biomass, Black Liquor, Biodiesel, Gasoline and Ethanol are in the GHG calculation spreadsheet "Calculation – Scope 1 and Scope 3". The justification for exclusion as a source of greenhouse gas emissions is because they are biogenic sources, thus there is compensation between emission and removal.

Table 03– Calculated sources considered neutral emissions

Emissions from Biogenic Sources - t/CO2e	
Biodiesel and Gasoline (Mobile Fuel) - Scope 1	277.45
Biodiesel (Stationary Fuel) - Scope 1	0.01
Ethanol (Mobile Fuel) - Scope 1	6.18
Biodiesel and Gasoline (Mobile Fuel) - Scope 3	1,160.34
Black Liquor (Stationary Fuel) -Scope 1	203,350.32
Biomass (Stationary Fuel) - Scope 1	606,544.33
Industrial Effluent - Scope 01	1,673.56
Total:	**813,012.19**

2.4 Reference Period and Base Year

This is the eighteenth greenhouse gas inventory prepared and monitored by the company. The first survey was carried out in 2006, and served as a base year for the company's environmental monitoring over time. With the expansion of units, the base year was changed to 2013, however, some comparisons will remain. All conclusions documented in this inventory make reference to results found in 2006 to 2023, in order to build a historical series of results that reflect the company's climate performance. The reference period covered by this document, therefore, corresponds to the fiscal year whose range extends from 01/01/2023 to 12/31/2023.

The structured documentation system for building the inventory in the base year has been improved and used to collect, store and communicate information relevant to the company's GHG Inventory. The databases were consolidated and standardized, and the information comes from the following sources: Invoices; Financial posting system (SAP); Logistics reports; People Development Reports; Production reports; Georeferenced registration of forestry projects through: ArcView 8 (ESRI) and F sign 2.0 (Brisa); and Laboratory reports.

The procedureGEE-001 - Greenhouse Gas information management was implemented to better manage information relevant to the company's emissions and removals. The company's employees involved in this procedure were trained by the Team.Manages Health, Safety, Quality and Sustainability was responsible for the critical analysis of the information.

The review of organizational and operational boundaries, as well as emission sources and removal sinks, was carried out by Health, Safety, Quality and Sustainability Managementof the company. The review of the quantification methodologies was carried out by the Environmental Management Team, before the consolidation of this Emissions Inventory, referring to the 2023 financial year.

2.5 Base Year Recalculation

In 2023 there was no recalculation because there were no changes in emission sources or changes in operational boundaries. In mid-2019, the Vila Maria/SP Packaging unit was deactivated, but the operational boundaries did not change.

2.6 Inventory Verification by External Parties

This inventory was verified by an external body in accordance with the NBR ISO 14.064:2022 Part 1 standard. This document corresponds to the Company's Declaration on Greenhouse Gases and contains information related to their emissions and removals.

The objective of verifying this inventory by external bodies is to obtain an independent statement on the quality of the inventory, in order to ensure that its users have a consistent assessment of the company's emissions standard. The scope of the verification must include the boundaries established by the inventory and the emission sources and removal sinks identified, as well as the quantification of GHG emissions and removals considering the information from the period covered by this report.

After verifying this document, a declaration must be presented containing, at a minimum:

a) description of the scope, objectives and criteria used in the verification;

b) clarifications regarding the level of precision used in the verification;

c) conclusion on the qualification or limitation of the inventory, considering the requirements of the standardNBR ISO 14.064:2022 Part 1.

2.7 Information Responsibilities

Responsibility for providing information in each operational unit is according to the Responsibility Column, Source of Information and Comments in the data sheet.

3. Terms and Definitions

3.1 Terms used

For the purposes of this document, the following terms and definitions will apply:

a) **Greenhouse Gas (GHG)**: atmospheric constituent, of natural or anthropogenic origin, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, atmosphere and clouds. GHGs include Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulfur Haxafluoride (SF_6).

b) **Source of GHG**: physical unit or process that releases GHG into the atmosphere.

c) **GHG sink**: physical unit or process that removes GHG from the atmosphere.

d) **GHG reservoir**: physical unit or component of the biosphere, geosphere or hydrosphere with the capacity to store or accumulate GHGs removed from the atmosphere by a sink or GHGs captured from a source. The total mass of carbon contained in a GHG reservoir over a specific period of time can be referred to as the carbon stock of the reservoir. A GHG reservoir can transfer GHGs to another GHG reservoir. Collecting a GHG from a source before that GHG enters the atmosphere and storing it in a reservoir can be referred to as GHG capture and storage.

e) **GHG emissions**: total mass of a GHG released into the atmosphere in a specific period.

f) **GHG Removals**: total mass of a GHG removed from the atmosphere in a specific period.

g) **GHG emission or removal factor**: factor that relates activity data to GHG emissions and removals.

h) **Direct GHG emissions**: GHG emissions from sources owned or controlled by the company. To establish the company's operational boundaries, the concepts of financial and operational control will be used in this document.

i) **Indirect GHG emissions related to energy consumption**: GHG emissions from the generation of electrical energy, heat or steam, imported/consumed by the company.

j) **Other indirect GHG emissions**: GHG emissions, different from those indirect emissions related to energy consumption, which are a consequence of the company's activities, but come from sources whose ownership or control is carried out by other organizations.

k) **GHG emissions inventory**: document in which GHG sources and sinks are detailed, and GHG emissions and removals are quantified during a given period.

l) **Global warming potential**: factor that describes the impact of the radiative force of a unit mass of a given GHG, in relation to a unit mass of carbon dioxide in a given period.

m) **Equivalent carbon dioxide (CO_2e)**: unit for comparing the radiative force of a given GHG to that of CO_2.

n) **Base year**: historical period specified for the purpose of comparisons of GHG removals and emissions, and other related information, over time.

o) **Company**: company, corporation, enterprise, authority or institution, or part or combination thereof, whether incorporated or not, public or private, that has its own functions and administration. In this report, it is restricted to Irani Papel e Embalagem SA and its forestry and industrial operations.

3.2 GHG Inventory Principles

For the purposes of this document, the following principles will apply:

a) **Generalities**: The application of principles is essential to ensure that GHG-related information is accounted for truthfully and fairly. The principles are the basis for and will guide the application of the requirements in this document.

b) **Relevance**: Selection of FSR, data and GHG methodologies appropriate to the needs of the intended user.

c) **Completeness**: Inclusion of all relevant GHG emissions and removals. Inclusion of all pertinent information to support criteria and procedures.

d) **Consistency**: Possibility of meaningful comparisons of GHG-related information.

e) **Precision**: Reduction of variances and uncertainties to the extent feasible.

f) **Transparency**: Disclosure of sufficient and appropriate GHG-related information to permit the intended user to make decisions with reasonable confidence.

g) **Conservatism:**Use of conservative assumptions, values and procedures to ensure that emission reductions or GHG removal improvements are not overestimated.

4. Methodologies

4.1 Methodologies for quantifying GHG emissions

4.1.1 GHG emissions due to fuel consumption

CO2 emission due to fuel consumption - Biomass

To calculate COtwo emissions for consumption of renewable fuels, the following formula was used:

(1) $$Em^{CO_2}_{comb,y} = \sum_c \left(Q^c_y \cdot NCV^c \cdot EF^c\right)$$

Where:

$Em^{CO_2}_{comb,y}$ COtwo emission by fuel consumption, in year y (tCO2);

Q^c_y Amount of type c fuel consumed in the year *y* (t);

NCV^c Net calorific value of fuel *w* (TJ.Gg-1) (IPCC, 2006);

EF^c COtwo emission factors by burning fuel c (kg CO2.TJ-1) (IPCC, 2006).

CO2 emission from fossil fuel consumption

To calculate COtwo emissions for consumption of non-renewable fuels, the following formula was used:

(2) $$Em^{CO_2}_{comb,y} = \sum_c \left(Q^c_y \cdot NCV^c \cdot EF^c\right)$$

Where:

$Em^{CO_2}_{comb,y}$ COtwo emission by fuel consumption, in year y (tCO2);

Q^c_y Amount of type c fuel consumed in the year *y* (t);

NCV^c Net calorific value of fuel *w* (TJ.Gg-1) (IPCC, 2006);

EF^c COtwo emission factors by burning fuel c (kg CO2.TJ-1) (IPCC, 2006).

N2O emission due to fuel consumption

In addition to the type of fuel used, N20 emissions depend on the technology used to burn the fuel. Therefore, to calculate N2O emissions due to fuel consumption, the following formula was used:

$$Em_{comb,y}^{N2O} = GWP_{N2O} \cdot \sum_{c,t} (Q_y^{c,t} \cdot NCV^c \cdot EF_{N2O}^{c,t}) \qquad (3)$$

Where:

$Em_{comb,y}^{N2O}$ Ntwo emission O by fuel consumption, in year y (tCO2e);

GWP_{N2O} Global warming potential of NtwoO (IPCC, 2006);

$Q_y^{c,t}$ Fuel quantity *w* consumed through technology t, in year y (t);

NCV^c Net calorific value of fuel *w* (TJ.Gg-1) (IPCC, 2006);

$EF_{N2O}^{c,t}$ Ntwo emission factors O by fuel consumption c through technology t (kg N2O.TJ-1) (IPCC, 2006).

CH4 emission due to fuel consumption

Just like N2O emissions, CH4 emissions from fuel consumption depend on the technology used in burning. Therefore, to calculate CH4 emissions due to fuel consumption, the following formula was used:

$$Em_{comb,y}^{CH4} = GWP_{CH4} \cdot \sum_{c,t} (Q_y^{c,t} \cdot NCV^c \cdot EF_{CH4}^{c,t}) \qquad (4)$$

Where:

$Em_{comb,y}^{CH_4}$ — CH_4 emission by fuel consumption, in year y (tCO2e);

GWP_{CH_4} — Global warming potential of CH_4 (IPCC, 2006);

$Q_y^{c,t}$ — Fuel quantity *w* consumed through technology t, in year y (t);

NCV^c — Net calorific value of fuel c (TJ.Gg-1) (IPCC, 2006);

$EF_{CH_4}^{c,t}$ — CH_4 emission factor by fuel consumption c through technology t (kg N2O.TJ-1) (IPCC, 2006).

4.1.2 Estimation of fuel consumption by vehicles or machinery

Ideally, to calculate GHG emissions from burning fossil fuels, the amount of fossil fuel used by own or outsourced vehicles or machinery should be monitored in absolute values, in tons. However, these data were not readily available and were estimated as below.This formula is applied when we do not have the amount of fuel in volume (liters), but the vehicle's mileage:

Fuel consumption by vehicles

(5) $$Q_y^c = \frac{10^{-3} \cdot km_y^m \cdot D^c}{Ce^{m,c}}$$

Where:

Q_y^c — Amount of type c fuel consumed in the year *y* (t);

km_y^m — Total distance traveled by model vehicles *m*, in year y (km);

$Ce^{m,c}$ — Specific fuel consumption *w* for model m vehicles (km/L);

D^c Fuel density *w* (kg/L)

Note: To estimate the average vehicle consumption (km/liters), the GHG Protocol reference values were used.

Fuel consumption by machinery

(6) $$Q_y^c = \frac{10^{-3} \cdot h_y^m \cdot D^c}{Ce^{m,c}}$$

Where:

Q_y^c Amount of type c fuel consumed in the year *y* (Gg);

h_y^m Total hours worked by model machinery *m*, in year y (h);

$Ce^{m,c}$ Specific fuel consumption *w* per model m machinery (h/L);

D^c Fuel density *w* (kg/L)

4.1.3 Estimation of consumption by reagents

CO2 emission due to acetylene consumption

To calculate CO2 emissions due to the consumption of acetylene, the formula below was used:

(7) $$AC_y = Q_y^{AC} \cdot \frac{24}{26} \cdot \frac{44}{12}$$

Where:

AC_y	COtwo emissions due to the consumption of acetylene (tCO2e);
Q_y^{AC}	Amount of acetylene used (t);
$\frac{24}{26}$	Carbon content in acetylene;
$\frac{44}{12}$	Molecular mass conversion factor from C to COtwo.

CO2 emission due to the use of organic solvents

The use of solvents manufactured from fossil fuels, or the use of products containing such solvents (eg paints, varnishes, kerosene, etc.), through evaporative losses, leads to the emission of several NMVOC (non-methane volatile organic compounds) which are oxidized to CO2 in the atmosphere (IPCC, 2006).

To calculate the emissions resulting from 80% of the consumed volume of organic solvents, formula 7 was used. The final result obtained, referring to 80% of consumption, was extrapolated to 100% by linear regression.

$$Em_{solv}^{CO_2} = \frac{44}{12} \cdot 10^{-6} \cdot FF^{solv} \cdot \sum_{prod} Q_y^{prod} \cdot VOC^{prod} \qquad (8)$$

Where:

$Em_{solv}^{CO_2}$	COtwo emissions from the use of organic solvents (tCO2e);
FF^{solv}	Fraction of fossil carbon in solvents (w/w) (IPCC, 2006);
Q_y^{prod}	Quantity of product used *product* (L);
VOC^{prod}	Content of volatile organic compounds in the product *product* (g/L).

$\frac{44}{12}$ Molecular mass conversion factor from C to CO_{two}.

4.1.4 CO2 emission due to electricity consumption

Indirect CO2 emissions from electricity consumption were calculated taking into account the network emission factor in each month of the period considered. Therefore, indirect emissions due to energy consumption were calculated according to the following formula:

(9) $$Em_{ee,y}^{CO_2} = \sum_m CE_m \cdot EF_m^{rede}$$

Where:

$Em_{ee,y}^{CO_2}$ CO_{two} emission by electricity consumption, in year y (tCO2);

CE_m Electricity consumption, in month m (MWh);

EF_m^{rede} CO_{two} emission factors, from month m, through the electricity grid serving the operational unit (tCO2.MWh-1). The calculation of monthly network emission factors is explained in detail in Appendix IX.

4.1.5 CH4 emission from liquid effluent treatment

Septic tank, sinkholes and disposal into water bodies

To calculate CH_4 emissions due to anaerobic decomposition of effluents treated by septic tanks or discarded through sinks or directly into bodies of water, the following formula was used:

(10) $$Em_y^{CO2e} = GWP_{CH4} \cdot B_o \cdot MCF \cdot \sum_m V_m \cdot [BOD_m].313.10^{-6}$$

Where:

$Em_{y}^{CO_2e}$ CH_4 emissions by treatment/disposal of domestic sewage, in year y (tCO2e);

GWP_{CH_4} Global warming potential of methane (IPCC, 2006);

B_o Maximum CH_4 production (IPCC, 2006) (kg CH4.kg BOD-1);

MCF Correction factor for methane production (IPCC, 2006) (table 04);

$Em_{m}^{CO_2e}$ CH_4 emissions by treatment/disposal of domestic sewage, in month m (tCO2e);

V_m Monthly pretreatment effluent flow (m^3);

$[BOD_m]$ Biochemical oxygen demand in pre-treatment effluent – monthly measurement (kg $BOD.m^{-3}$);

313 Number of days worked in the year.

Table 04– Correction factor for methane production – MCF

DEFAULT MCF VALUES FOR INDUSTRIAL WASTEWATER			
Type of treatment and discharge pathway or system	Comments	MCF[1]	Range
Untreated			
Sea, river and lake discharge	Rivers with high organics loadings may turn anaerobic, however this is not considered here.	0,1	0 - 0,2
Treated			
Aerobic treatment plant	Must be well managed. Some CH4 can be emitted from settling basins and other pockets	0	0 - 0,1
Aerobic treatment plant	Not well managed. Overloaded	0,3	0,2 - 0,4
Anaerobic digester for sludge	CH_4, recovery not considered here	0,8	0,8 - 1,0
Anaerobic reactor (e.g. UASB, Fixed Film Reactor	CH_4, recovery not considered here	0,8	0,8 - 1,0
Anaerobic shallow lagoon	Depth less than 2 metres, use expert judgment	0,2	0 - 0,3
Anaerobic deep lagoon	Depth more than 2 metres	0,8	0,8 - 1,0
[1] Based on expert judgment by lead authores of this			

Source:IPCC 2006 Volume 05, Chapter 6 - Wastewater, pg. 6.21

Estimation of daily organic load from septic tank systems

In the absence of measurements of the flow and BOD parameters required by the formula above, typical values found in technical literature were assumed. Based on the number of users of each system or the number of meals served, it is possible to estimate these parameters.

To estimate the flow, Von Sperling (2007) stipulates the consumption of80 L.day-1.user-1 for septic tank systems in industrial sectors, with a return rate of 80%. NBR 9649 also defines a sanitary sewage return coefficient of 80%. For systems that receive effluents from industrial kitchens, NBR 7229 defines the flow rate of95L.day-1.user-1.

To estimate the BOD concentration, the parameters observed by Giansante (2009) were used, from 260 mg.L-1 ranging from 130 mg.L-1 to 400 mg.L-1.

4.1.6 GHG emissions from solid waste disposal

CH4 emissions due to waste disposal in controlled landfill without methane capture

Once solid waste has been disposed of in a controlled landfill, within the operational boundaries, methane emissions arising from this practice must be counted as direct emissions. To calculate CH_4 emissions due to waste disposal in controlled landfills, without methane capture, the following formula was used:

$$MB_y = GWP_{CH_4} \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot \left(1 - e^{-k_j}\right) \quad (11)$$

Where:

MB_y Potential for methane generation in the year *y*, through anaerobic decomposition of type j waste, at the disposal site (tCOtwoe);

GWP_{CH_4} Global warming potential of methane (IPCC, 2006);

$\frac{16}{12}$ C to CH_4 molecular mass conversion factor;

F Fraction of methane in biogas (IPCC, 2006);

DOC_f Fraction of total degradable carbon disseminated into biogas (IPCC, 2006);

MCF Methane correction factor (IPCC, 2006). O*MCF* expresses the proportion of waste disposed of on site that will be degraded anaerobically. This fraction will partly decompose (DOCf) to generate CH_4 and CO_{two} from biogas;

$W_{j,x}$ Quantity of waste j generated in year y (t);

DOC_j Fraction of degradable carbon (w/w) in waste type j (IPCC, 2006);

y Year for which emissions are calculated;

x Year in which the waste was disposed of;

k_j Decomposition rate of type j residue.

It is worth noting that according to this first-order decay model, GHG emissions due to the disposal of waste in controlled landfills in the current year will be distributed in subsequent years (emissions liability). Such distribution will occur depending on the degree of degradability of the materials disposed under environmental conditions that favor anaerobic decomposition. In each year of the inventory, waste deposited in the industrial landfill suffered degradation over time, generating greenhouse gases. For example, if it was the first time that a quantity of waste was deposited in 2019, and in 2020 nothing was deposited, as well as in the coming years, greenhouse gas emissions will still occur due to the degradability of that quantity of waste. .

To calculate emissions, an Excel© spreadsheet was created, in which the people responsible for data collection entered the GHG information. The technical team checks the data and verifies the calculations, evaluating the GHG emissions results.

4.1.7 N_{two} emission o by use of nitrogenous compounds

Nitrous oxide ($N_{two}O$) is naturally produced in soils through the processes of nitrification and denitrification. Nitrification is the microbiological oxidation of ammonia (NH3) to nitrate, while denitrification is the microbiological reduction of nitrate to nitrogen gas (N_{two}). $N_{two}O$ is a gaseous intermediate of denitrification and a byproduct of nitrification that can eventually be released into the atmosphere. One of the main factors controlling this reaction is the availability of inorganic nitrogen in the soil. Therefore, in the present study, nitrogen additions to the soil resulting from Irani's forestry activities were taken into account. (ie synthetic fertilizer additions) (IPCC, 2006).

$N_{two}O$ emissions that result from anthropogenic additions of nitrogen to soils occur through direct pathways ($N_{two}O$ is formed directly in the soil to which fertilizers have been added) and through two indirect pathways (1) volatilization/emission of nitrogen in the form of NH3 and NOx and the subsequent deposition of these nitrogenous species in the form of NH+4 or nitrogen oxides in soil or water bodies, and the (2) leaching of nitrogenous species to surface waters, wetlands or the ocean coast (IPCC, 2006).

Therefore, $N_{two}O$ emissions due to the use of fertilizers were calculated according to the formulas below.

(11)

$$E_{N_2O} = GWP_{N_2O} * CF_{N_2O-N,N} * 10^{-3} * \left(E_{N_2O,land} + E_{N_2O,runoff} + E_{N_2O,vol}\right)$$

(12)

$$E_{N_2O,land} = EF_1 * \sum_{fert} Q_y^{fert} \cdot [N]^{fert}$$

(13)

$$E_{N_2O,runoff} = EF_5 * F_{leach} * \sum_{fert} Q_y^{fert} \cdot [N]^{fert}$$

(14)

$$E_{N_2O,vol} = EF_4 * F_{gasf} * \sum_{fert} Q_y^{fert} \cdot [N]^{fert}$$

Where:

ENO_{two} $N_{two}O$ emissions due to fertilizer applications, (Mg CO2e);

$GWP\ N_{two}O$ global warming potential of $N_{two}O$;

CF_{N2O-NN} molecular mass conversion factor from N to $N_{two}O$ (44/28);

$EN_{twoO,land}$ direct N_{two} emissions O due to fertilizer application (kg $N_{two}ON$);

$EN_{twoO,runoff}$ N_{two} emissions O due to fertilizer leaching (kg $N_{two}ON$);

$EN_{twoO,vol}$ N_{two} emissions due to volatilization of nitrogen as $NH_{3\ and}$AT THE_X(kg $N_{two}ON$);

EF_1 factor for direct N_{two} emission due to the application of fertilizers to soils (kgN_{two}ON/kg N) (IPCC, 2006);

EF_5 factor for indirect emission of $N_{two}O$ due to leaching of fertilizers applied to soils (kg N2O-N/kg N) (IPCC, 2006);

EF_4 N_{two} emission factor O through nitrogen deposition in the atmosphere [kg N-$N_{two}O$ /(kg NH_{3}-N + volatilized NOx-N)] (IPCC, 2006);

F_{leach} fraction of the nitrogen content of applied fertilizers that is lost through leaching (IPCC, 2006);

Fgasf nitrogen content of applied fertilizers which volatilizes as NH_3 and no_x(kg NH_3-N and NO_x-N per kg of N) (IPCC, 2006);

Q fert-y amount of fertilizer used (kg);

[N]fert nitrogen content in fertilizer (m/m).

4.2 Calculation of carbon stock and CO2 removals due to forest growth

In 2021 we made changes to the methodology for calculating removals. We hired the Federal University of Paraná – UFPR, with the aim of reviewing forest removal calculations, covering pine and eucalyptus planted forests and also developing the calculation model for native forests. Under the coordination of Professor Carlos Roberto Sanquetta Forestry Engineer, Ph.D. in Forest Management and Ecology from the United Graduate School of Agricultural Sciences, Japan. He has expertise in climate change and carbon sequestration, being a member of the Intergovernmental Panel on Climate Change and Roster of Experts from the UN Framework Convention on Climate Change. Full Professor at UFPR. Coordinator of the BIOFIX Center for Biomass and Carbon Research at UFPR.

For the calculations carried out, the methodology established in the greenhouse gas emissions inventory guides published by the Intergovernmental Panel on Climate Change (IPCC) was used. Registration data and the company's latest consolidated forest inventory, provided by Irani, were used.

To assess the climate impact of forestry operations in the*Irani Papel e Embalagem SA* In the year 2023, the total standing carbon stock of the last 04 (four) years was calculated and the moving average was constructed to define the current removal. The moving average premise was adopted due to the oscillation of stock differences caused by the silviculture process, thus establishing a condition of stability in the removal calculation process. The difference in carbon stock between 01/01/2020 and 12/31/2023, and the total CO_2 removals in industrial forests, according to the formulas below:

To calculate the carbon stock and its CO_2 equivalent, both in biomass above and below ground (AGB + BGB), mathematical growth models were used. These models were built to estimate the stock in tons of carbon (tC/ha) depending on the age of the stand.

A model was adjusted for the data of each genus with data from the forest inventory carried out in 2018. From the registered planting date, the last day of the year in the analyzed period was considered to determine age.

The mathematical formulation of the model is presented below:

(2)

$$C = \left(\beta_0 . exp\frac{-\beta_1}{I}\right).TC$$

On what:

W= carbon stock (in tC/ha);

β_0e = parameters to be estimated by regression;β_1

I= age of the stand (in years);

TC= carbon content (in decimal values).

The result of adjusting the growth model for Pinus and Eucalyptus can be seen in figures 01 and 02, respectively, as will be discussed below.

To calculate the carbon stock of Pinus forests, the following equation was adjusted (R^2 = 0.8145 and Syx% = 22.0%):

(3) $C = \left(541{,}1039.\, exp\frac{-13{,}7855}{I}\right).\,0{,}4536$

There was no differentiation between Pinus *taeda* and Pinus *elliottii* for this modeling. Although it was desirable to make estimates for each species, there were no data available that would allow specific equations to be adjusted.

For Eucalyptus, the adjustment resulted in the following growth equation (R^2 = 0.8085 and Syx% = 26.9%):

(4)

$C = \left(580{,}9470.\, exp\frac{-10{,}2181}{I}\right).\,0{,}4630$

On what:

W= carbon stock (in tC/ha);

I= age of the stand (in years).

The determination of the carbon stock before adjusting the equation followed a sequence of calculations presented below. To this end, data from the continuous forest inventory carried out by Irani in planted forests were used. The database used was that of the inventory carried out during 2018, the last inventory with consolidated data made available by the company.

The first step consisted of using an individual biomass equation, in which the diameter at breast height (dbh) and the total height (h) of each tree measured served as independent variables.

For Pinus, the equation published by LIMA (2014) was used, namely:

(5)

$agb = 0{,}0225.\, dap^{1{,}8759}.\, h^{0{,}7800}$

For Eucalyptus, equation 6 was adopted:

(6)

$$agb = -5{,}9515 + 1{,}18123.ln\, ln\, (\, dap^2.h)$$

On what:

agb= individual biomass above ground (in t);

dap= diameter at chest height (in cm);

H= total height (in m).

Next, a root expansion ratio, also known as root-to-shoot ratio (R), was used. The default value of 0.17 obtained in publications by Sanquetta et al. (2011) and Sanquetta et al. (2018). The use of a root expansion ratio consists of multiplying the above-ground biomass (abg) by the R value to determine the underground living biomass (bgb), as shown below:

(7)

$$bgb = agb.R$$

On what:

agb= biomass above ground (in t);

R= root ratio (dimensionless).

From the sum of the live biomass above (agb) and below the ground (bgb), the live biomass stock in each plot was determined. In this step, all dead trees were disregarded, as follows:

(8)

$$ABG_i + BGB_i = \sum_{i=1}^{n} \left(abg_{ij} + bgb_{ij}\right)$$

On what:

ABG= above-ground biomass of the ith plot (in t/ha);

BGB= below-ground biomass of the ith (in t/ha);

abg= above-ground biomass of the j-th tree of the ith plot (in t);

bgb= biomass below ground of the j-th tree of the ith plot (in t).

To calculate the carbon stock of each stand in each year (2015 to 2022), the living biomass above and below ground per hectare were multiplied by the carbon content (TC) of each genus, as shown below.

(9)

$$C = AGB.TC$$

CT values were extracted from the publication by Sanquetta et al. (2018), 0.4536 for Pinus and 0.4630 for Eucalyptus.

Using the equation applied to each age/year of planting, it was possible to estimate the carbon stock per hectare of Pinus and Eucalyptus forests throughout the rotation, as shown in figures 01 and 02.

With the estimates per hectare in each stand with different ages and areas, the total carbon stocks (in tC and tCO2e) were calculated for each unit (plot/project/farm). When the values were added for each year of analysis (2015 to 2022), the values of the total stocks were obtained for each gender and their respective sums.

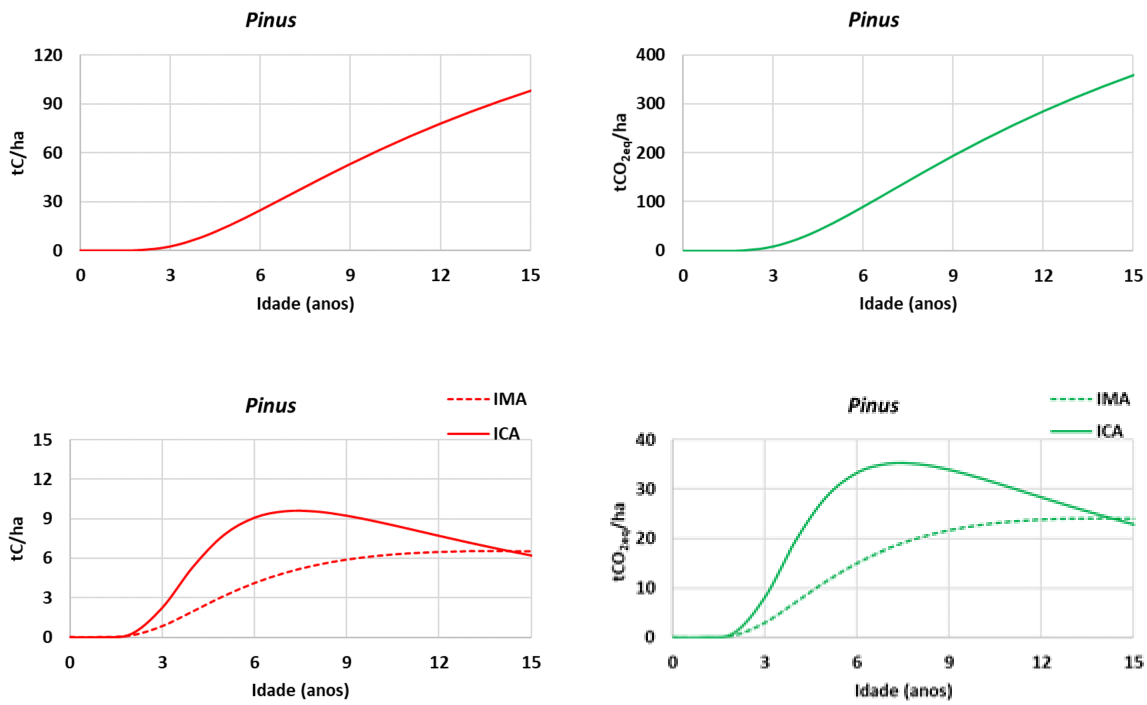

Figure 01-Stock curves in C (a) and CO2e (b) and annual stock increments in C (c) and CO2e (d) for Pine forests. ICA = current annual increment; IMA = average annual increment

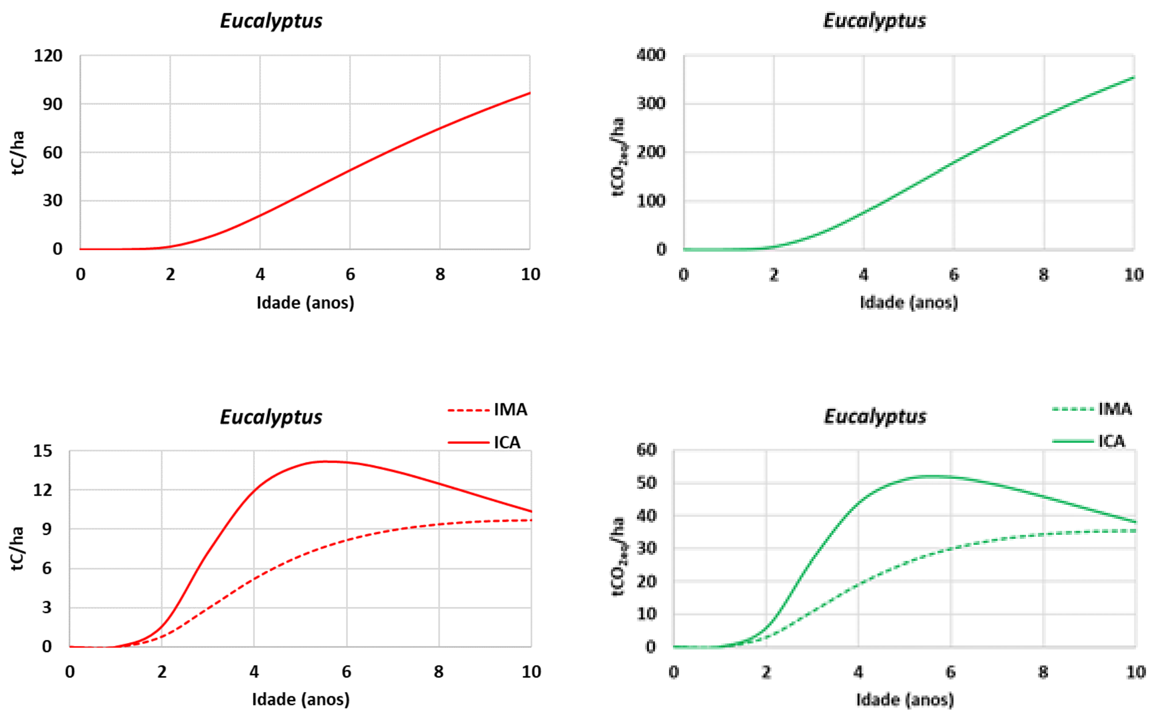

Figure 02-Stock curves in C(a) and CO2e. (b) and annual stock increments in C (c) and CO2e. (d) for Eucalyptus forests. ICA = current annual increment; IMA = average annual increment

To the values of carbon stock in biomass (AGB and BGB) of each stand, the values corresponding to non-woody necromass (LTR) or litter (table 05) were added, which were taken from the literature. Carbon stocks in woody necromass (DWR) and soil organic carbon (SOC) were not considered in this analysis, as data were not available.

Table 05– Default values of carbon stock in litter in planted forests

Age years)	*Pine*(tC/ha)	*Eucalyptus*(tC/ha)
1	1.54	0.83
two	3.09	1.65
3	4.63	2.14
4	6.18	2.62
5	7.72	3.70
6	7.81	4.78
7	7.90	5.14
8	8.00	5.14
9	8.09	5.14
10	8.18	5.14

11	8.27	5.14
12	8.37	5.14
13	8.46	5.14
14	8.55	5.14
15	8.64	5.14
>15	8.64	5.14

4.3 Carbon and CO2e Stock in Native Forests

Irani does not carry out forest inventory in areas covered by native forests. Therefore, there is no availability of primary dendrometric data for farms. For this reason, average carbon stock values per hectare obtained in the literature were adopted.

The average carbon stock in aerial (AGB) and underground (BGB) living biomass was calculated based on studies developed by SANQUETTA et al. (2002). AGB is made up of bole (trunk), branches, leaves and miscellany (flowers, fruits, shoots, etc.), while BGB corresponds to the roots.

An average carbon stock value was assigned to each hectare of native forest, considering the two classes of ecological succession stage: 1. Initial and 2. Medium/Advanced:

• Forests in the initial stage: AGB + BGB = 28.84 tC/ha;

• Medium/advanced stage forests: AGB + BGB = 117.63 tC/ha.

Where tC/ha = tons (or megagrams) of carbon per hectare.

Forests in the initial stage of succession, as they are less developed, have lower carbon stocks. The most developed forests (in the medium/advanced stage) have a greater stock.

Furthermore, carbon stocks in woody (DWR) and non-woody (LTR) necromass were counted. These reservoirs also store carbon and should be accounted for in the corresponding calculations as much as possible, as defined by the IPCC. Another carbon reservoir in forests to be considered is soil organic carbon (SOC). However, as there are no specific data on SOC, this reservoir was excluded from the analyses.

Thus, average DWR and LTR stock values were assigned for each hectare of forest. The studies developed by MAAS (2015) and DEUS et al. (2018) were consulted and the values presented in these publications were used as default. For DWR, a single stock value was assigned, regardless of the succession stage, which was equal to 5.74 tC/ha. The following values were assigned to LTR:

• Forests in the initial stage: LTR = 7.90 tC/ha;

• Medium/advanced stage forests: LTR = 8.10 tC/ha.

This technical report therefore included the following components: aerial living biomass (AGB), underground living biomass (BGB), woody necromass (DWR) and non-woody necromass – litter (LTR). The soil (SOC) was not included.

Then, carbon stocks were converted to the CO2 equivalent unit. The CO2 equivalent measurement is nothing more than a metric to equalize emissions of various GHGs (greenhouse gasses) based on the relative importance of each gas. The composition of the carbon dioxide molecule consists of two oxygen atoms and a single carbon atom. Carbon has a molar mass of 12, while oxygen has a molar mass of 16. Therefore, each mass unit of carbon fixed in plant material corresponds to 3.6666... mass units of CO2.

The conversion of carbon stock to CO2 equivalent is carried out using the following equation:

$$(1)$$

$$CO2eq.=C.4412$$

Where: CO2e = mass unit of CO2 equivalent (in t); C = carbon mass unit (in t); 44 = sum of the molecular weight of one Carbon molecule (C) + two Oxygen molecules (O2); 12 = molecular weight of a Carbon atom (C).

5. Results

5.1 Recalculation of Emissions or Removals

For the year 2023, there were no changes in the methodology for calculating removals compared to 2022. For the calculations carried out, the methodology established in the greenhouse gas emissions inventory guides published by the Intergovernmental Panel on Climate Change (IPCC) was used. Registration data and the company's latest consolidated forest inventory, provided by Irani, were used.

5.2 Comparative Results – Base Year

The analysis of the final balance between removals and emissions from Irani Papel e Embalagem SA in 2023 revealed that removals exceeded emissions by 37,892 tCO2e,figure 03. Regarding greenhouse gas emissions, we reduced by 29% compared to the first base year – 2006, and 40% compared to the second base year – 2013.

Removals suffered large variations when compared to the base years due to the change in calculation methodology, as reported in item 4.2.

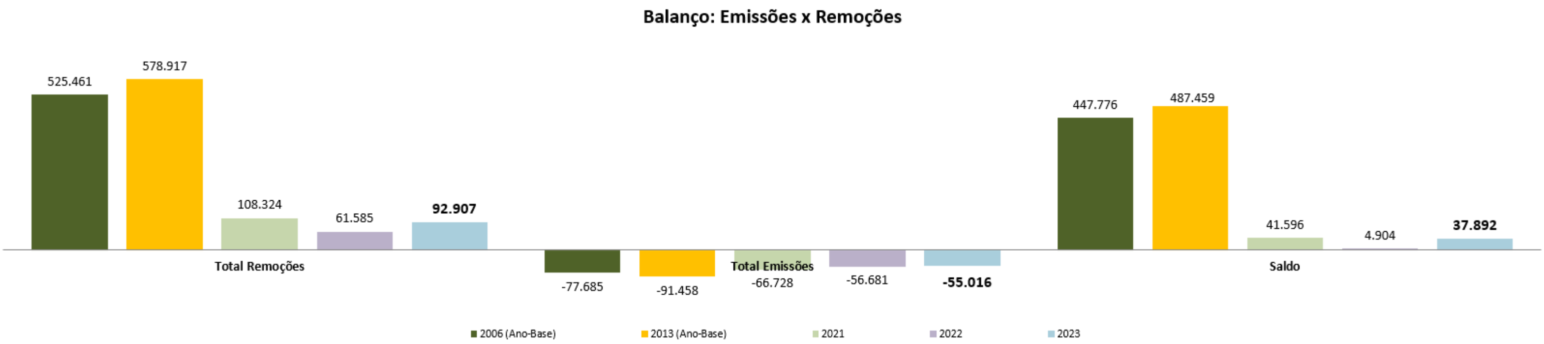

Figure 03 -Total balance of emissions and removals

5.3 Removals

In 2023, net carbon removals totaled 92,907 tCO2e, being attributed to planted pine and eucalyptus forests in the states of Santa Catarina and Rio Grande do Sul, as well as to native forests located in Santa Catarina, when compared to the previous year. removals increased by 51%. Additionally, we observed a significant increase in our total carbon stock, which reached 10,493,211.6 tCO2e, representing an increase of 10% compared to the previous year, distributed over 32,700 hectares. This increase in stock is primarily the result of the incorporation of 1,970 hectares of native forests and the increase in the pine planted area in Rio Grande do Sul.

Table 06– Total Liquid Removal

FINAL RESULT - IRANI S.A				
Place	**Unit:**	**Net Removals - Stock Difference**		
		Pinus	*Eucalipto*	*Nativas*
Planted (own + partners)	SC	-19.106	-24.079	57.015
Planted (Own)	RS	79.076	2	
Total in tCO:		59.970	-24.077	57.015
		92.908		

NOTE: Negative values mean a reduction in carbon stock, occurring mainly in reforestation areas, where silvicultural management takes place.

Irani's largest carbon stock is located in the native forests of Santa Catarina, representing 63.4% of the total, followed by the planted forests in Santa Catarina, which correspond to 25.27%, and the planted forests in Rio Grande do Sul, with 11.32% of the total. Shown in table 07 and figure 04.

Table 07– Carbon Stock

Carbon stock by species and region				
Species/Location	**Stock tCO**	**%**	**Area (ha)**	**% Area**
Pinus - SC	2,464,018	23.48%	12,998	39.75%
Eucalyptus - SC	187,787	1.79%	1,273	3.89%
Natives - SC	6,653,083	63.40%	14,519	44.40%
Pine - RS	1,188,324	11.32%	3,910	11.96%
Total	**10,493,212**	**100%**	**32,700**	**100.00%**

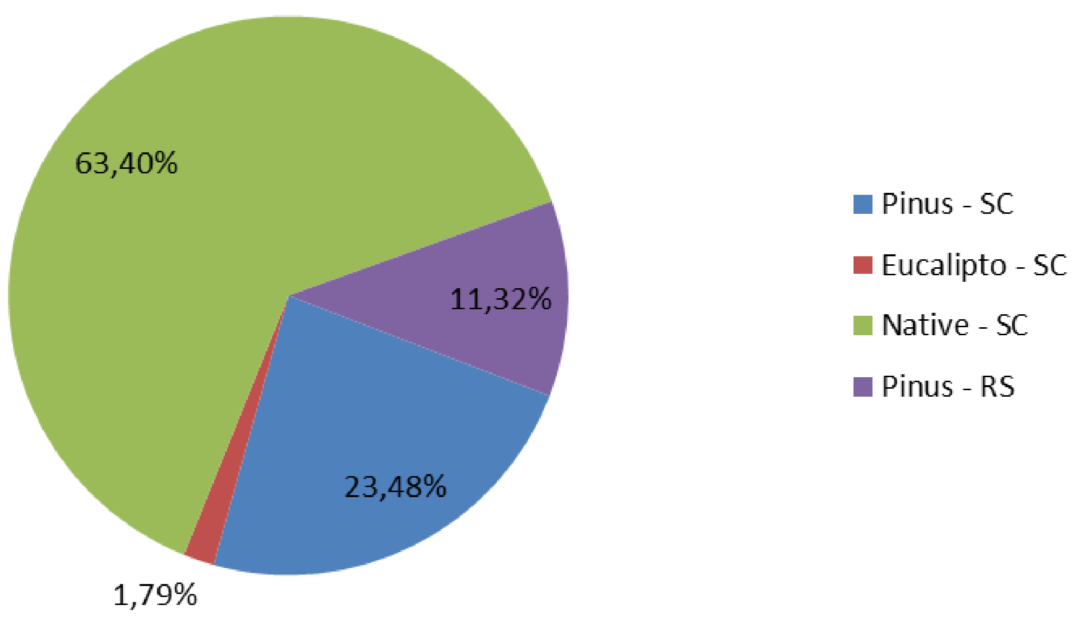

Figure 04– Percentage of Carbon Stock

In table 08, it is possible to observe the net removals, highlighting that the planted forests in Santa Catarina remove less carbon than those in the Florestal RS unit. Although the area (ha) of planted forest (pine and eucalyptus) in Santa Catarina is 71% larger than that in Rio Grande do Sul, the activity of extracting wood to be sent to the Papel SC industrial plant results in a considerable difference. This process means that the planted forests in Santa Catarina are considered biogenic, with low levels of removal, depending on silvicultural planning; that is, we are constantly planting new stock while harvesting old stock.

On the other hand, the base of native forests is only removed, without loss of stock, resulting only in an increase in carbon, as they do not suffer any type of interference. A similar situation occurs with the pine forests of the RS Forestry Unit, which are used for resin extraction, suffering only occasional cuts. This means that inventory loss is low or zero, depending on the year.

In 2023, the successional stage of 1970.7 hectares of native forests was defined, which were incorporated as a new source of carbon sink to the forest base of Santa Catarina.

Table 08– Liquid Removals

Carbon stock by species and region				
Species/Location	**Stock tCO**	**%**	**Area (ha)**	**% Area**
Pinus - SC	2.464.018	23,48%	12.998	71,49%
Eucalipto - SC	187.787	1,79%	1.273	7,00%
Pinus - RS	1.188.324	11,32%	3.910	21,50%
Total	**3.840.129**	**37%**	**18.181**	**100,00%**

5.4 Emissions

The company's emissions totaled 55,016 tCO_2e. This result represents a reduction of 39.85% compared to 2013 and a decrease of 2.9% compared to the previous year, as detailed in table 09 and illustrated in figure 05.

Table 09– Emission Categories - tCO2e

Year	E1 Direct Emissions	E2 Indirect emissions - Energy	E3 Indirect emissions - Other Sources	Total
2006	71.850	1.188	4.647	**77.685**
2007	42.557	1.013	5.741	**49.311**
2008	8.441	2.480	5.945	**16.866**
2009	10.846	1.400	6.927	**19.173**
2010	10.823	2.432	9.315	**22.570**
2011	13.003	1.520	10.414	**24.936**
2012	17.454	695	9.910	**28.058**
2013	72.515	7.279	11.665	**91.458**
2014	103.383	12.172	11.029	**126.584**
2015	90.007	12.959	12.719	**115.686**
2016	87.876	13.723	12.461	**114.060**
2017	50.689	10.167	12.926	**73.782**
2018	49.855	8.047	11.082	**68.985**
2019	45.611	7.979	10.325	**63.916**
2020	43.320	6.702	10.359	**60.380**
2021	41.827	13.946	10.955	**66.728**
2022	43.255	4.282	9.143	**56.681**
2023	41.684	4.060	9.272	**55.016**
Comparison				
Base Year 2006	**-41,98%**	**241,71%**	**99,53%**	**-29,18%**
Base Year 2013	**-42,52%**	**-44,23%**	**-20,51%**	**-39,85%**
Year 2022	**-3,63%**	**-5,21%**	**1,41%**	**-2,94%**

note:E1= Scope 01; E2= Scope 02; E3= Scope 03

From 2007 onwards, with the modernization of the effluent treatment station at the Paper SC unit, there was a reduction in direct emissions (scope 01), which were impacted in 2013 due to the company's new business units, the Paper MG and Embalagem Vila units. Maria SP. In 2017, direct emissions reduced significantly at the Resina RS unit, which stopped carrying out anaerobic biological treatment of its effluents and releasing it into water bodies to use it for irrigation in the planting of pine trees in the Florestal RS area. There was also a significant reduction in emissions at the Paper MG unit due to the correction in the calculation of natural gas consumption. Indirect Emissions from Energy reduced as a result of the Grid's average emission factor, justified by the greater use of renewable energy in the country in 2017 due to excessive rainfall, with little use of thermoelectric plants. Indirect Emissions from Other Sources increased, mainly due to the accounting of diesel consumption for the transport of waste from the Indaiatuba - SP unit. Another important factor to be considered in the company's history was the closure of the activities of the Vila Maria Packaging unit – SP, in 2019, directly impacting the reduction of total emissions.

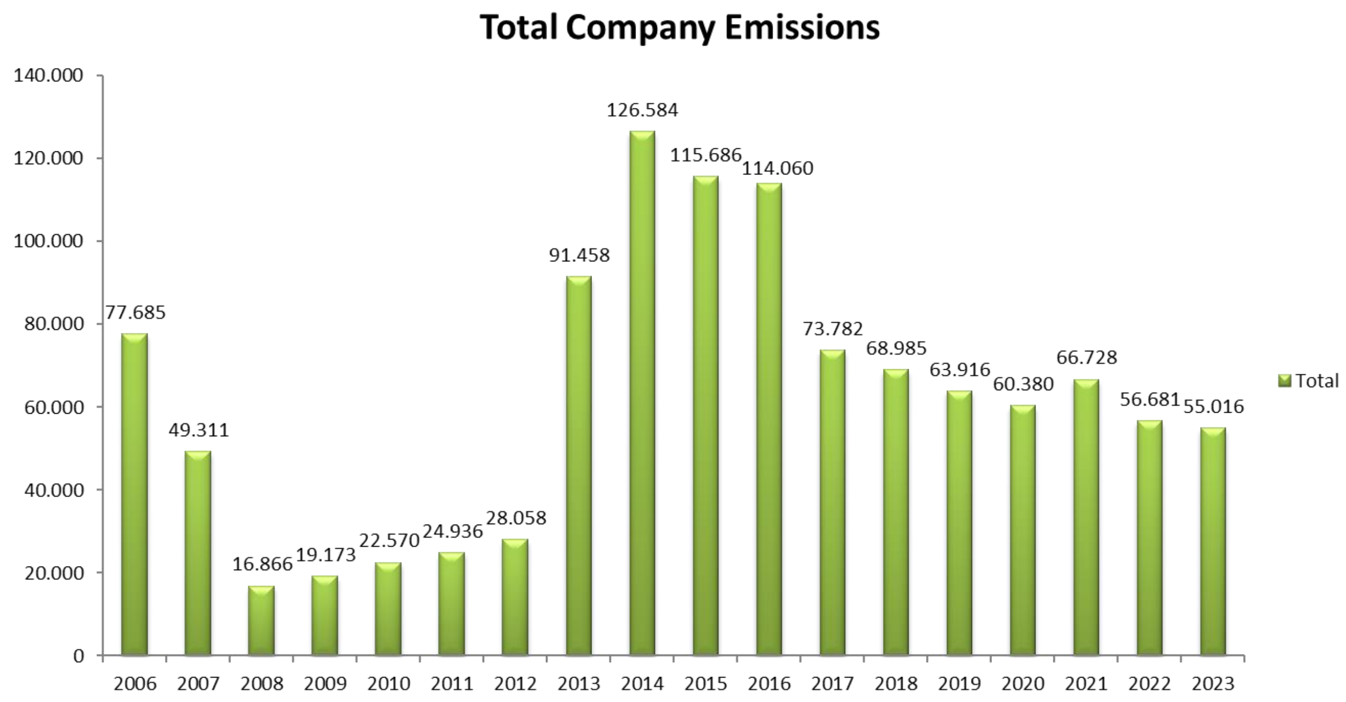

Figure 05– Evolution of Emissions over time – tCO2e

The categories, fuel consumption by outsourced fleets, energy consumption and solid waste treatment showed a significant increase in relation to 2006. Variation of each of the emission categories is shown in table 10 and figure 06.

Table 10– Emissions by Activity – tCO2e

Categories	Base Year: 2006	Year						Base Year: 2013	Year										Variation % 2006 and 2023	Variation % 2013 and 2023	Variation % 2022 and 2023
		2007	2008	2009	2010	2011	2012		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023			
Effluent Treatment (domestic)	58.761	28.966	222	187	509	1.383	5.012	14.391	31.135	15.323	24.244	790	788	276	237	266	224	257	-99,56%	-98,21%	14,54%
Energy consumption	1.188	1.013	2.480	1.400	2.432	1.520	695	7.279	12.172	12.959	13.723	10.167	8.047	7.979	6.702	13.946	4.282	4.060	241,71%	-44,23%	-5,21%
Fuel Consumption (own)	9.282	7.811	4.589	5.700	4.062	4.480	4.856	49.162	63.241	65.433	56.319	42.034	40.108	39.941	38.312	37.070	38.624	37.509	304,11%	-23,70%	-2,89%
Fuel Consumption (Third Party)	4.647	5.742	5.945	6.927	9.246	10.361	9.882	11.302	10.884	12.523	12.312	12.763	10.950	9.824	10.123	10.677	8.888	9.038	94,50%	-20,03%	1,69%
Reagent Consumption	2.289	3.275	174	199	453	857	756	2.044	2.060	1.880	1.137	1.238	900	994	924	1.343	1.354	1.155	-49,55%	-43,51%	-14,69%
Treat. Solid Waste (industrial landfill)	1.518	2.504	3.456	4.760	5.799	6.282	6.830	6.917	6.947	7.371	6.176	6.626	7.004	4.401	3.847	3.147	3.053	2.763	82,02%	-60,05%	-9,49%
Solid Waste Treatment (private landfill)	0	0	0	0	69	53	28	363	145	196	148	163	133	502	236	278	255	234	*	-35,56%	-8,29%
Total	**77.685**	**49.311**	**16.866**	**19.173**	**22.570**	**24.936**	**28.058**	**91.458**	**126.584**	**115.685**	**114.060**	**73.782**	**67.928**	**63.916**	**60.380**	**66.728**	**56.681**	**55.016**	**-29,18%**	**-39,85%**	**-2,94%**

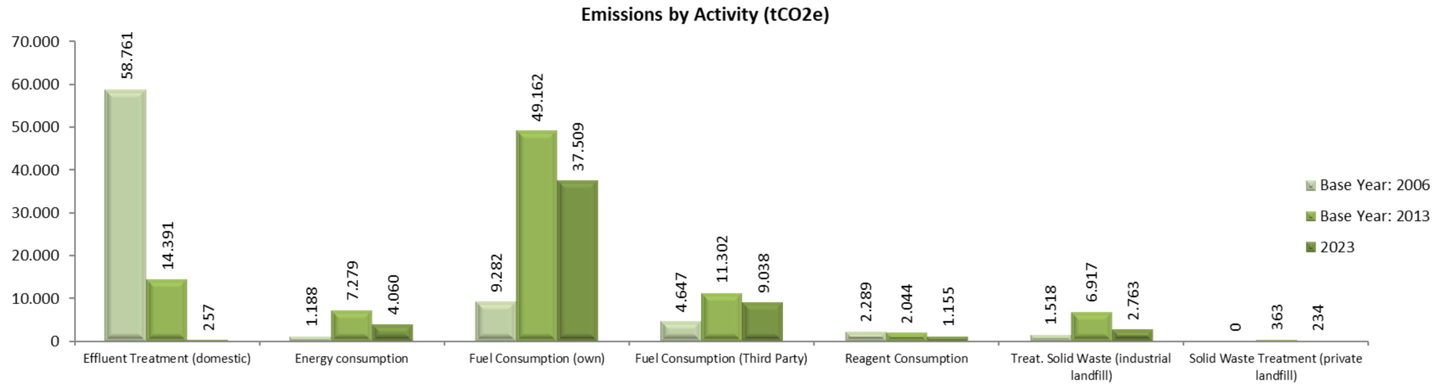

Figure 06– Comparison between categories

In table 11, the general analysis of the main reasons for significant changes in emissions in relation to the previous year.

Table 11– Analysis of causes for the variation observed in emissions.

Activities	Causes
Mobile Fuel - Business Travel - Scope 03	The reduction in the number of air travel by the company resulted in a decrease in emissions of 162 tons of carbon dioxide equivalent (tCO2e) compared to the year 2022.
Stationary Fuel - Scope 01	At the SP Packaging unit, we observed a lower consumption of Natural Gas in the boiler, mainly due to the reduction in production. Meanwhile, at the Paper MG unit, the decrease in Natural Gas consumption occurred due to the general shutdown of the factory in April. Furthermore, there was a reduction in the consumption of BPF oil at the SC Packaging unit, which contributed to a reduction of 581 tCO2e in emissions. On the other hand, at the Paper SC unit, we recorded an increase in emissions due to the use of BPF oil during the start-up of the recovery boiler, which required a large quantity of this fuel for testing.
Energy - Scope 2	The emission of equivalent carbon dioxide (CO2e) derived from energy consumption decreased compared to the previous year, due to the reduction in the emission factor of the National Interconnected System. Additionally, we recorded the acquisition of Renewable Energy Certificates (I-RECs) by the Packaging Indaiatuba SP unit.
Waste - Scope 03	The reduction in waste being sent to third-party landfills had a direct impact on reducing emissions from this factor.

In table 12 and figure 07, we list the five largest sources of emissions for the year, compared to the base years. In 2006 we did not consume Natural Gas.

Table 12– Five biggest sources of emissions – tCO2e

Unidade Operacional	Fonte de Emissão	Base Year 2006	Base Year 2013	2023	% variation between 2013 and 2023
Paper - MG	Natural gas	0	28.604	13.345	-53,35%
Packaging Indai - SP	Natural gas	0,06	3.516	3.733	6,20%
Paper - SC	Biomass Boiler	11.937	12.823	10.183	-20,59%
Paper - SC	GMP Oil	0	575	5.216	807,66%
Forestry SC	Diesel (Third Fleet)	868	4.855	5.103	5,11%

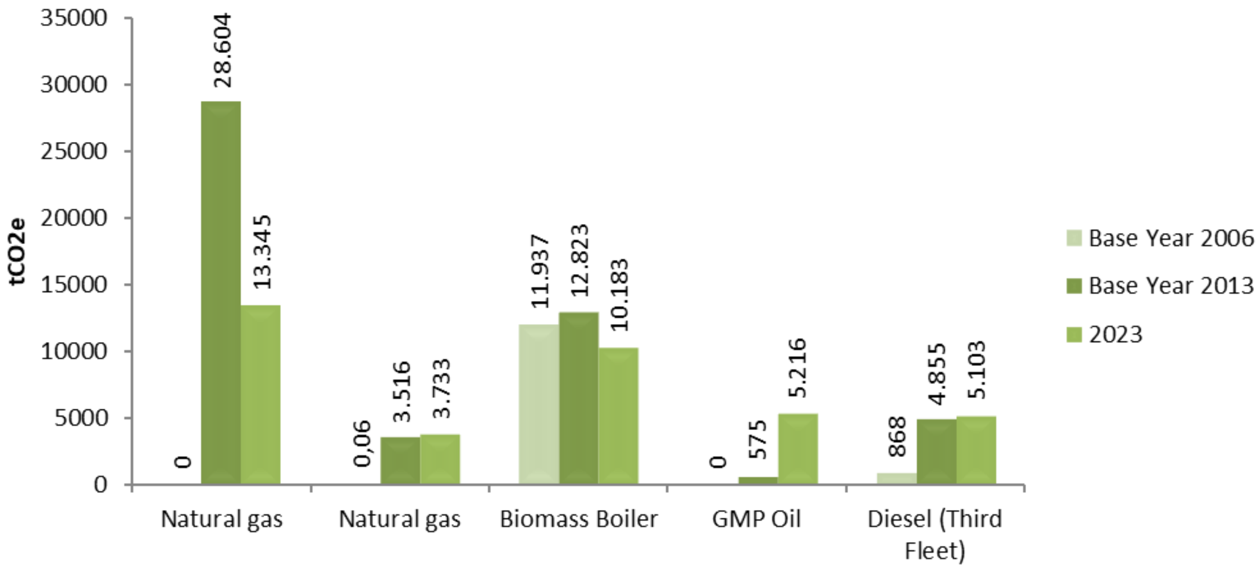

Figure 07 –Comparison between emission categories (tCO2e)

5.4.1 By type of Gas

Carbon Dioxide (CO2) was the main greenhouse gas emitted by the company's activities. The activities that most contributed to such emissions were: Transport by Outsourced Fleets, Fuel Consumption and Energy Consumption. Methane was the second main gas emitted in the period, mainly due to Solid Waste Treatment and Effluent Treatment activities. Nitrous Oxide emissions accounted for a small part of the company's total emissions and came from Fuel Consumption activities. In table 13 and figure 08, we have the three main gasses in each operational unit.

Table 13– Quantity of GHG per unit depending on the type of gas emitted

Quantity in tCO2e				
Units:	**Carbon Dioxide - CO2**	**Methane - CH4**	**Nitrous Oxide - N2O**	**Emission Per Unit (tCO2e)**
Paper	11.152	7.565	6.856	25.574
Pack_SC	1.565	182	3	1.751
Forestry SC	5.997	10	95	6.102
Forestry RS	348	1	6	354
Resins RS	491	166	67	725
Adm	78	345	1	425
Pack_SP	4.569	89	9	4.667
Paper_MG	15.365	36	17	15.418
TOTAL	39.566,34	8.394,76	7.054,55	55.015,64
	Percentage of Gases			
	71,92%	**15,26%**	**12,82%**	

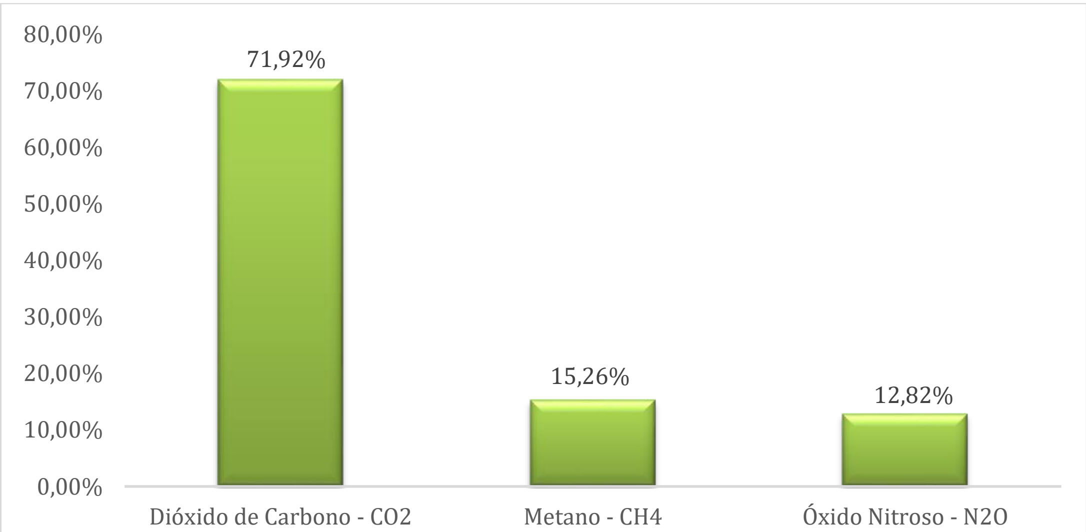

Figure 08– Percentage of the performance of each GHG gas

Table 14 presents a list of all sources of emissions, detailed by scope.

Table 14– Total Emissions

EMISSIONS													
Scope	CATEGORY	TYPE OF ACTIVITY	OBJECT	OPERATIONAL UNITS								RESULT	
				PAPER SC	PACK. SC	FORES. SC	FORES. RS	RESINS-RS	ADM	PACK. SP	PAPER MG	SUBTOTAL	TOTAL (tCO_{2e})
Scope 1	DIRECT EMISSIONS	MOBILE FUEL	DIESEL	161,45	0,00	857,10		89,14	4,44		9,73	1.121,85	41.684,20
			GASOLINE	85,24	50,89	73,96		24,00	26,74	91,48	6,93	359,22	
			ETHANOL		0,00	0,0003			0,00	0,04	0,01	0,06	
			LGP	397,21	398,10			1,06		317,51	181,14	1.295,03	
			Lubricant Oil							0,001	0,01	0,01	
		STATIONARY FUEL	NATURAL GAS							3.733,50	13.344,86	17.078,36	
			DIESEL		0,05					0,00	61,50	61,55	
			GMP OIL	5.216,39	777,00							5.993,39	
			BIOMASS	10.182,80				106,79				10.289,59	
			BLACK LIQUOR	1.310,15								1.310,15	
		REAGENTS [1]	Chemicals; Acetylene; Kerosene; Paints	578,06	69,99	0,69		24,44		143,05	338,60	1.154,83	
		TREATMENT SOLID WASTE	WASTE GENERATED 2014	249,07	3,29							252,37	
			WASTE GENERATED 2015	260,50	2,79							263,29	
			WASTE GENERATED 2016	289,75	3,98							293,73	
			WASTE GENERATED 2017	309,03	5,00							314,03	
			WASTE GENERATED 2018	275,64	4,05							279,69	
			WASTE GENERATED 2019	305,95	4,82							310,78	
			WASTE GENERATED 2020	344,84	7,54							352,38	
			WASTE GENERATED 2021	243,76	45,03							288,79	
			WASTE GENERATED 2022	210,71	30,01							240,72	
			WASTE GENERATED 2023	153,04	14,19							167,23	
		TREATMENT SANITARY LIQUID EFFLUENT	DOMESTIC EFFLUENT	110,45	39,54			34,68		49,43	23,04	257,14	
Scope 2	INDIRECT EMISSIONS - ENERGY	ENERGY - Location Based Approach	ELECTRICITY	2.909,98	283,04	0,94		19,65	0,34		845,55	4.059,51	4.059,51
Scope 2	INDIRECT EMISSIONS - ENERGY	ENERGIA - Abordagem Baseada na Escolha de Compra	ELECTRICITY							0,00		0,00	0,00
Scope 3	INDIRECT EMISSIONS - OTHER SOURCES [3]	TREATMENT SOLID WASTE	Waste (Private landfill)	111,43	10,59			83,25		27,79	0,61	233,68	9.271,94
		MOBILE FUEL - EMPLOYEE TRANSPORTATION	DIESEL	1010,26			270,16			128,01	40,18	1.448,62	
			GASOLINE	62,88						1,84	5,36	70,07	
		MOBILE FUEL - BUSINESS TRIP	DIESEL						48,51			48,51	
			GASOLINE						0,00			0,00	
			AIRPLANE KEROSENE						344,86			344,86	
		MOBILE FUEL - FORESTRY AND TRANSPORTATION EQUIPMENT	DIESEL	780,02	1,00	5.102,93	79,55	341,67		151,98	549,99	7.007,14	
			GASOLINE			3,64	4,45			1,30	0,49	9,89	
			LUBRICANT OIL			62,55	0,00			0,09		62,63	
		STATIONARY FUEL	LGP	15,36						21,07	10,12	46,54	
			TOTAL	25.573,97	1.750,90	6.101,79	354,17	724,70	424,89	4.667,09	15.418,13		55.015,64

Note[1]: Consumption of Reagents includes the following products: Acetylene; Kerosene; Polymers; Anti-foam; Paints; Diluents, Dispersants, etc.
Note[2]: The company is obliged to follow the standards of ISO 14064 and GHG Protocol to account for Scope 1 and 2 emissions. Scope 3 is not mandatory, but over the years we have been counting and increasing the mapping of sources emission

5.4.2 Scope 1 – Direct Emissions

The company's direct emissions represented 75% of total emissions recorded. Table 15 below shows all scopes with their percentages.

Table 15– Percentage of Emission by Scope

Scope of Emissions	Representativeness by Scope																	
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Scope 1	92,49%	86,30%	50,05%	56,57%	47,95%	52,14%	62,20%	79,29%	81,67%	77,80%	77,04%	68,70%	72,27%	71,36%	71,74%	62,68%	76,31%	75,77%
Scope 2	1,53%	2,05%	14,70%	7,30%	10,78%	6,09%	2,48%	7,96%	9,62%	11,20%	12,03%	13,78%	11,66%	12,48%	11,10%	20,90%	7,56%	7,38%
Scope 3	5,98%	11,64%	35,25%	36,13%	41,27%	41,76%	35,32%	12,75%	8,71%	10,99%	10,92%	17,52%	16,06%	16,15%	17,16%	16,42%	16,13%	16,85%

5.4.3 Scope 2 – Indirect Emissions from Energy

We monitor energy consumption in all operational and administrative units. There was a reduction in emissions in 2023 compared to 2013 (base year) of 44%, and compared to the previous year of 5.21%, also considering units that use incentivized energy sources. The significant reduction occurred when compared to the previous year due to the increase in clean energy added to the National Interconnected System-SIN, causing the average CO2 emission factors to reduce.

Another company initiative was the acquisition of Renewable Energy Certificates – I'RECs for the Embalagem SP industrial unit, with this we seek to contribute to the increase in renewable energy production in the country and mitigate our emissions related to scope 02 and offset emissions of the unit in question.

Future studies are being planned within the company, with the aim of making the operational units self-sufficient and thus eliminating the purchase of energy from GRID.

Table 16– GHG Emissions by Energy and Grid Emission Factor

Year	tCO2e	Average- tCO2e /MWh
2006	1,188.00	0.03
2007	1,013.00	0.03
2008	2,480.00	0.05
2009	1,400.00	0.02
2010	2,432.00	0.05
2011	1,519.53	0.03
2012	694.86	0.07
2013	7,278.54	0.10
2014	12,171.95	0.14
2015	12,959.30	0.13
2016	13,723.30	0.14
2017	10,167.20	0.09
2018	8,047.06	0.08
2019	7,979.45	0.08
2020	6,701.97	0.06
2021	13,945.79	0.13
2022	4,282.44	0.043
2023	4,059.51	0.039
% 2013 - 2023	**-44.23%**	
% 2022 - 2023	**-5.21%**	

In table 17 we have the emissions detailed by operational and administrative units. In figure 9, a comparison between the units, it is worth highlighting that the SC Paper Unit is the largest consumer and the smallest is the SC Forestry Unit.

Table 17– Emissions by Operational Unit

UNIT	tCO2e
Paper	2909,98
Packaging SC	283,04
Forestry SC	0,94
Resins RS	19,65
Administrative	0,34
Paper MG	845,55
Total	**4.059,51**

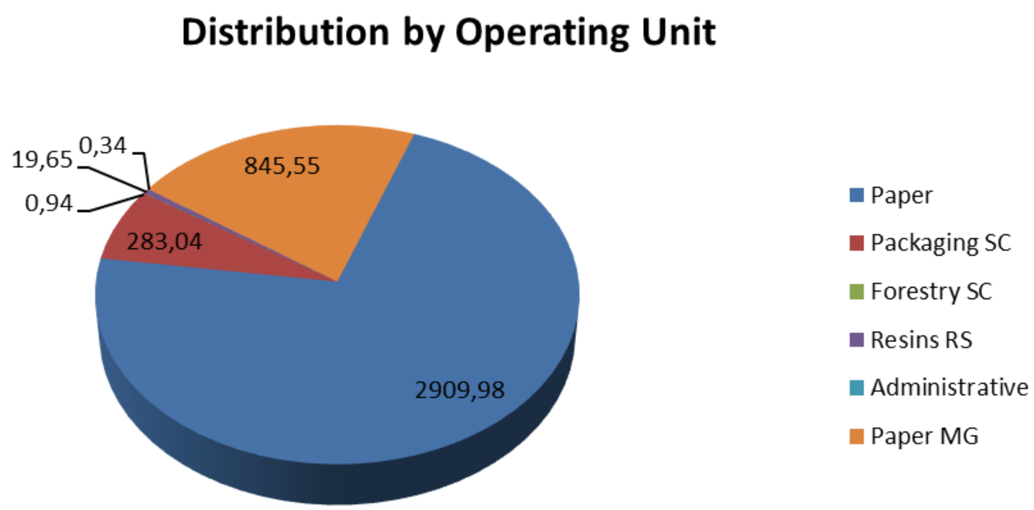

Figure 09 – Percentage of emission between units – tCO2e

Regarding the energy consumed by the company, we have some important observations, as the acquisition takes place under certain forms and obligations. Below are the considerations:

- Paper-SC and Packaging-SC Unit: energy purchased on Mercado Livre. The energy produced by PCH's and Thermoelectric by Biomass and Licor Preto are their own production. For calculation purposes, we only count the energy purchased;
- Packaging Unit-SP: energy purchased fully incentivized, as per federal standard. CPFL only distributes. When accounting for GHG, emissions were considered and compensated with the acquisition of a Renewable Energy Certificate for each MWh consumed by the unit.
- Resinas-RS and Florestal-RS Units: energy purchased from the Grid;
- Florestal-SC Unit: energy purchased from the Grid;
- ADM Office: energy purchased from the Grid;
- Paper Unit-MG: energy purchased fully incentivized, as perfederal standard. When accounting for GHG, emissions were considered;

NOTE 01: The energy purchased from the Grid is managed by the National System Operator (ONS). The Grid represents the following Energies: Hydraulic, Thermo – Conventional, Thermo – Nuclear and Thermo – Emergency. These are the consumer units that have a demand of less than 500 KW/h, and are called the captive market, and cannot purchase energy on the free market.

NOTE 02: Incentivized energy is energy purchased on the free market in which renewable sources are used, such as: PCH, Biomass and Wind. In this case, they are consumers who use demand between 500 KW/h and 3,000 KW/h.

NOTE 03: And for demands greater than 3,000 KW/h, energy can be purchased on the free market from any incentive or conventional source.

5.4.4 Scope 3 – Indirect Emissions from Other Sources

Over the years, we seek to improve the accounting of emissions related to Scope 03. This search reflects the company's commitment to monitoring all activities that may in some way impact the environment. Remembering that the reporting of emissions for Scope 03 is optional according to the standard.

In table 18, we have a comparison with all years, demonstrating the evolution in activity control:

Table 18– Comparative Summary Scope 03

Atividade	Substance	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1 - Transport of Inputs; Harvest; Forestry	Diesel	4439,00	5459,00	4793,00	5405,00	6462,00	7072,34	6905,66	8207,36	7889,82	9698,50	9281,53	9735,11	8516,52	7112,51	7430,23	8044,15	6104,80	6383,97
2 - Chainsaws; Brushcutters (Forestry SC)	Gasoline	209,00	194,00	144,00	134,00	139,00	139,00	99,97	58,17	15,84	23,70	30,15	13,17	11,59	24,62	14,67	17,02	6,96	3,64
3 - Chainsaws (Forestry SC)	Oil/Oil 2T	47,00	88,00	43,00	79,00	65,00	96,87	59,88	47,43	53,47	85,49	85,33	77,13	51,42	52,07	60,21	63,79	65,42	62,55
4 - Employee Transport (Paper and Packaging SC)	Diesel	*	*	582,00	491,00	827,00	640,49	607,82	562,75	609,65	633,65	635,23	583,90	467,36	656,70	671,71	655,37	827,18	1010,26
5 -Waste Transport (Paper and Packaging SC)	Diesel	*	*	242,00	248,00	231,00	237,91	225,36	223,12	228,72	231,40	229,99	231,72	227,26	184,89	149,59	161,03	169,98	197,16
- Transport of inputs; Harvest; Forestry; RS Agricultural Machinery	Diesel	*	*	142,00	61,00	115,00	1.132,25	999,79	1135,21	840,01	608,35	690,87	746,53	812,50	987,85	544,82	519,56	106,29	398,50
7 - Employee Transportation (Pack_SP)	Diesel	*	*	*	72,00	83,00	116,03	112,99	142,19	193,23	174,18	176,09	138,75	127,68	135,26	120,71	127,02	129,86	128,01
8 - Taxi Travel - ADM's/Paper	Gasoline	*	*	*	33,00	0,02	85,87	67,66	99,19	54,61	36,72	49,72	38,76	45,04	69,57	37,09	42,26	65,38	70,07
9 - Support transport + Chainsaw (Forestry RS)	Gasoline	*	*	*	42,00	155,00	123,23	71,96	38,19	30,23	16,00	17,18	19,76	9,16	12,77	29,72	14,18	4,13	0,00
10 - Chainsaws and Brushcutters (Forestry RS)	Oil/Oil 2T	*	*	*	43,00	69,00	19,19	26,33	20,54	0,79	0,10	0,73	5,21	10,89	0,00	0,00	0,00	2,26	4,45
11 - Support vehicle (Forestry RS)	Ethanol	*	*	*		959,00	0,04	*	*	*	*	*	*	*	*	*	*	*	*
12- Agricultural Machinery (Forestry RS)	Diesel	*	*	*	289,00	0,22	*	*	*	*	*	*	*	*	*	*	*	*	*
13- Road Transport/Van (Line Bus) - ADM's	Diesel	*	*	*	*	0,09	260,94	151,19	165,88	161,29	231,82	193,21	183,24	136,26	184,49	27,00	7,54	43,36	48,51
14 - Employee Transport - Air (National and International)	Kerosene	*	*	*	*	0,03	237,06	258,58	409,97	269,64	140,62	172,39	168,11	207,29	199,40	102,87	51,25	507,59	344,86
15 - Private Landfills	Waste-ton	*	*	*		138,00	52,79	27,75	362,64	144,99	196,10	148,45	162,86	132,52	501,60	235,58	278,32	254,81	233,68
16 - Employee transportation - Florestal RS	Diesel	*	*	*	30,00	72,00	200,30	253,18	147,94	184,02	300,23	413,43	678,27	188,15	42,70	682,00	717,80	729,03	270,16
17 - LPG oil Restaurant	LGP	*	*	*	*	*	*	*	44,02	52,06	50,34	57,79	62,29	45,50	60,95	46,80	43,84	53,19	46,54
18 - Employee Transportation - Pape MG	Diesel	*	*	*	*	*	*	*		202,63	194,50	189,10	21,04	24,10	23,44	24,45	32,07	34,95	40,18
19 - Waste Transport - Paper MG	Diesel	*	*	*	*	*	*	*	*	97,15	100,07	89,45	47,70	47,83	46,63	44,96	59,51	*	*
20 - Waste Transport - Vila Maria	Diesel	*	*	*	*	*	*	*	*	*	*	*	2,81	1,47	0,37	*	*	*	*
21- Waste Transport - Indaiatuba SP	Diesel	*	*	*	*	*	*	*	*	*	*	*	9,23	8,87	10,09	4,88	5,25	4,72	4,78
22- Chainsaws and Brushcutters- Indaiatuba SP	GasolinE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	2,02	1,03	0,75	1,30
23- Chainsaws and Brushcutters- Indaiatuba SP	Oil/Oil 2T	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0,13	0,12	0,06	0,09
24- Chainsaws and Brushcutters- Paper MG	Oil/Oil 2T	*	*	*	*	*	*	*	*	*	*	*	*	10,76	18,61	129,14	113,70	*	*
25 - Waste Transport - Resin	Diesel	*	*	*	*	*	*	*	*	*	*	*	*	*	0,01	0,00	0,00	31,54	22,73
26 - Brushcutters - Paper MG	Gasoline	*	*	*	*	*	*	*	*	*	*	*	*	*	0,73	0,37	0,67	0,97	0,49
Total		**4.695,00**	**5.741,00**	**5.946,00**	**6.927,00**	**9.315,35**	**10.414,31**	**9.868,13**	**11.664,61**	**11.028,16**	**12.721,77**	**12.460,64**	**12.925,58**	**11.082,18**	**10.325,28**	**10.358,96**	**10.955,48**	**9.143,23**	**9.271,94**

5.4.5 Emissions Indexes

As with removals, we have an emissions index per net production in each operational unit. Making a comparison with 2006, there was a reduction in emissions, strengthening our decarbonization plan. In table 19, we have the comparative indices between the base years and the current one, including the three scopes. And in table 20, only scopes 01 and 02.

Table 19– Comparative (Scope 1, 2 and 3) – tCO2e

INDUSTRIAL UNITS	Base Year: 2006			Base Year: 2013			2023		
	PRODUÇÃO LÍQUIDA	EMISSIONS	INDICATOR	NET PRODUCTION	Emissions	INDICATOR	NET PRODUCTION	EMISSIONS	INDICATOR
PAPER SC	172.201	64.127	0,37	203.688,04	13.262,82	0,07	243.450	25.574	0,11
PACKAGING SC	30.998	4.454	0,14	63.811,65	1.570,42	0,02	85.370	1.751	0,02
PACKAGING SP	47.859	4.725	0,10	73.243,72	5.798,40	0,08	77.037	4.667	0,06
RESIN RS	5.467	550	0,10	7.911,32	14.126,47	1,79	11.953	725	0,06
PAPER MG	-	-	-	42.910,15	15.231,41	0,35	54.822	15.418	0,28

Table 20– Comparative (Scope 1 and 2) – tCO2e

INDUSTRIAL UNITS	Base Year: 2006			Base Year: 2013			2023		
	PRODUÇÃO LÍQUIDA	EMISSIONS	INDICATOR	NET PRODUCTION	Emissions	INDICATOR	NET PRODUCTION	EMISSIONS	INDICATOR
PAPER SC	172.201	62.700	0,36	203.688,04	13.262,82	0,07	243.450	23.594	0,10
PACKAGING SC	30.998	4.438	0,14	63.811,65	1.561,00	0,02	85.370	1.739	0,02
PACKAGING SP	47.859	3.110	0,06	73.243,72	4.057,00	0,06	77.037	4.335	0,06
RESIN RS	5.467	84	0,02	7.911,32	14.119,00	1,78	11.953	300	0,03
PAPER MG	-	-	-	42.910,15	32.931,00	0,77	54.822	14.811	0,27

6. Emissions Liabilities

The anaerobic decomposition model of solid waste considers first order decay (FOD), that is, the microbiological activity of degradation of organic waste begins in the year the waste is disposed of and will continue to occur for the subsequent nine years. Therefore, not all CH4 emissions from the decomposition of organic waste generated in a given year will occur in the same year. Thus, at the Paper - SC unit, where emissions were recorded due to the disposal of solid waste in industrial landfills, there will be an emissions liability that must be considered in subsequent years. Table 21 and figure 10 below show the organization's accumulated emissions liabilities, since the base year:

Table 21– Emission liabilities due to accumulated solid waste – tCO2e

ISW Tons	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Accumulated
	1518	1074	1099	1452	1350	1457	322	474	427	420,99	440,99	442,94	372,08	388,94	412,85	274,84	237,57	153,04	
2006	1.517,92																		1518
2007	1.429,52	1.074,00																	2504
2008	1.346,27	1.011,46	1.098,57																3456
2009	1.267,87	952,55	1.034,59	1.451,88							Equation :	$\int_0^t \frac{d(DDOCm)}{DDOCm} = -k \int_0^t dt$							4707
2010	1.194,04	897,08	974,34	1.367,33	1.350,00														5783
2011	1.124,50	795,64	813,84	1.075,58	1.000,10	1.457,00						$DDCOm = DDCOm_0 * e^{-k*t}$							6267
2012	1.059,02	795,64	864,17	1.212,71	1.197,34	1.372,15	322,00												6823
2013	997,34	749,30	813,84	1.142,09	1.127,61	1.292,24	303,25	473,92											6900
2014	939,26	705,67	766,45	1.075,58	1.061,95	1.216,99	285,59	446,32	427,41										6925
2015	884,57	664,57	721,81	1.012,94	1.000,10	1.146,12	268,96	420,33	402,52	420,99									6943
2016		625,87	679,78	953,95	941,86	1.079,37	253,29	395,85	379,08	396,47	440,99								6147
2017			640,19	898,40	887,01	1.016,51	238,54	372,80	357,00	373,38	415,31	442,94							5642
2018				846,08	835,36	957,32	224,65	351,09	336,21	351,64	391,12	417,15	372,08						5083
2019					786,71	901,57	211,57	330,64	316,63	331,16	368,34	392,85	350,41	388,94					4379
2020						849,06	199,25	311,39	298,19	311,88	346,89	369,98	330,01	366,29	412,85				3796
2021							187,64	293,25	280,83	293,71	326,69	348,43	310,79	344,96	388,80	274,84			3050
2022								276,17	264,47	276,61	307,67	328,14	292,69	324,87	366,16	258,84	223,74		2696
2023									249,07	260,50	289,75	309,03	275,64	305,95	344,84	243,76	210,71	153,04	2279
2024										245,33	272,88	291,03	259,59	288,14	324,76	229,57	198,44	144,13	1911
2025											256,99	274,08	244,47	271,36	305,84	216,20	186,88	135,73	1569
2026												258,12	230,24	255,55	288,03	203,61	176,00	127,83	1236
2027													216,83	240,67	271,26	191,75	165,75	120,39	921
2028														226,66	255,46	180,58	156,09	113,38	663
2029															240,59	170,07	147,00	106,77	411
2030																160,16	138,44	100,55	160

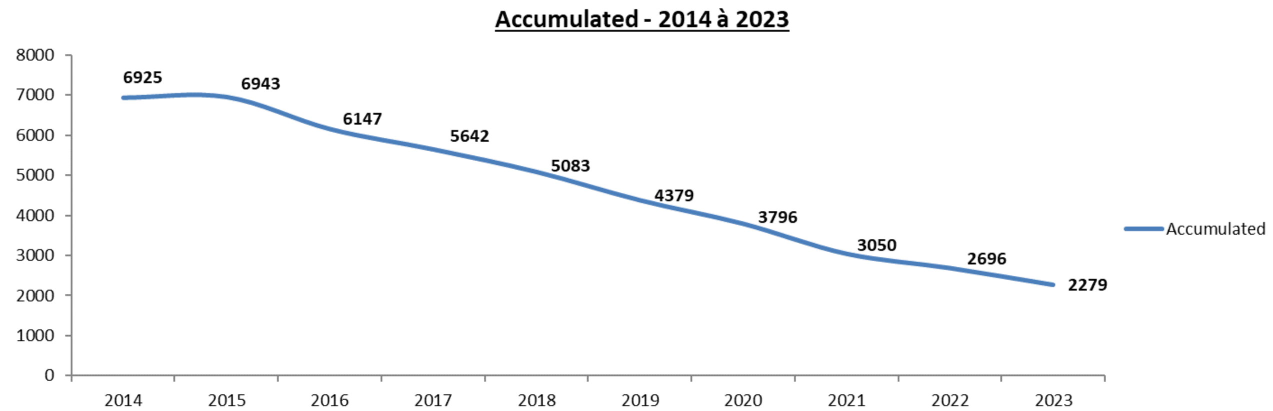

Figure 10 –Emission liabilities accumulated at the Paper Unit – SC

Figure 10 above shows a positive trend in reducing emissions due to the environmental liability of solid waste accumulated in the industrial landfill and the annual reduction in the amount of waste disposed of in the company's industrial landfill.

7. Final considerations

In 2023 the carbon balance of*Irani Papel e Embalagem SA*the equivalent of 37,892 tCO2e was positive at 41%, that is, forest removals have a potential for carbon absorption greater than the production units emit CO2e due to their operationalization, and for each net ton of product produced (Paper , Packaging and Resin), the company's forestry base sequestered the equivalent of 0.59 tCO2e.

Regarding emissions, the largest individual source of emissions is due to the natural gas boiler at the MG Paper Unit, followed by the consumption of biomass at the SC Paper Unit.

As a good environmental practice to make the Corporate GHG Inventory more complete and comprehensive, we constantly seek to review new sources of emissions through internal audits.

Regarding the operating units, we obtained the following indexes in the year:

- **SC Paper Unit:** there was an increase in emissions by 2% compared to 2022, driven mainly by the increase in consumption of BPF oil and energy, as a result of the start-up of the recovery boiler.
- **SC Packaging Unit**: reduction in emissions by 24%, influenced by the reduction in consumption of BPF oil.
- **RS Resins Unit:** 36% increase in emissions, mainly due to the diesel consumption of the third-party fleet.
- **Administrative:** there was a reduction in emissions by 28%, the main factor was the reduction in the number of air trips carried out in the year.
- **MG Paper Unit:** reduction in emissions by 9%, mainly caused by the general shutdown of the factory in April, reducing natural gas consumption.
- **Indaiatuba SP Unit:** there was a reduction in emissions by 6%, caused by the reduction in natural gas consumption, this factor is correlated with the reduction in production. Another factor that contributes to reducing the unit's emissions is the compensation of scope 02 emissions, with 7,501 I-RECs (renewable energy certificates) being acquired in

2023, which fit into the energy modality - Approach Based on Choice of Purchase and your emission factor is zero. If there were no compensation, the unit's scope 02 emission would be 291.02 tCO2e. The amount of IREC's represents the volume of energy, in MWh, consumed in the year by the industrial unit in Indaiatuba SP.

- **RS Forestry Unit:** there was a reduction in emissions by 58%, influenced by the reduction in fuel consumption of forestry machines.
- **SC Forestry Unit**: there was an 11% increase in emissions due to the consumption of third-party fuel from wood transport.
- Agricultural emissions in planted forests are not taken into account, as fertilization does not occur in the field, but only during the preparation of seedlings in the Forest Nursery.

In the following graphs we can see the evolution of emissions at the company's industrial units over the last three years:

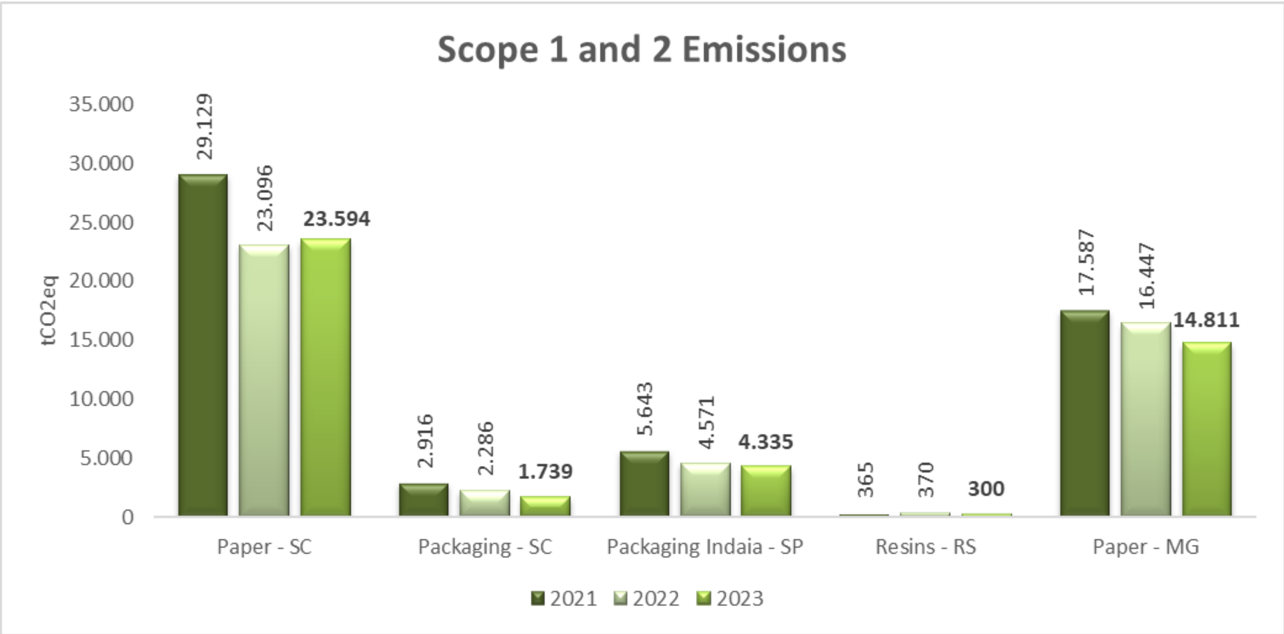

Figure 12– Industrial Units – Scope 1 and 2

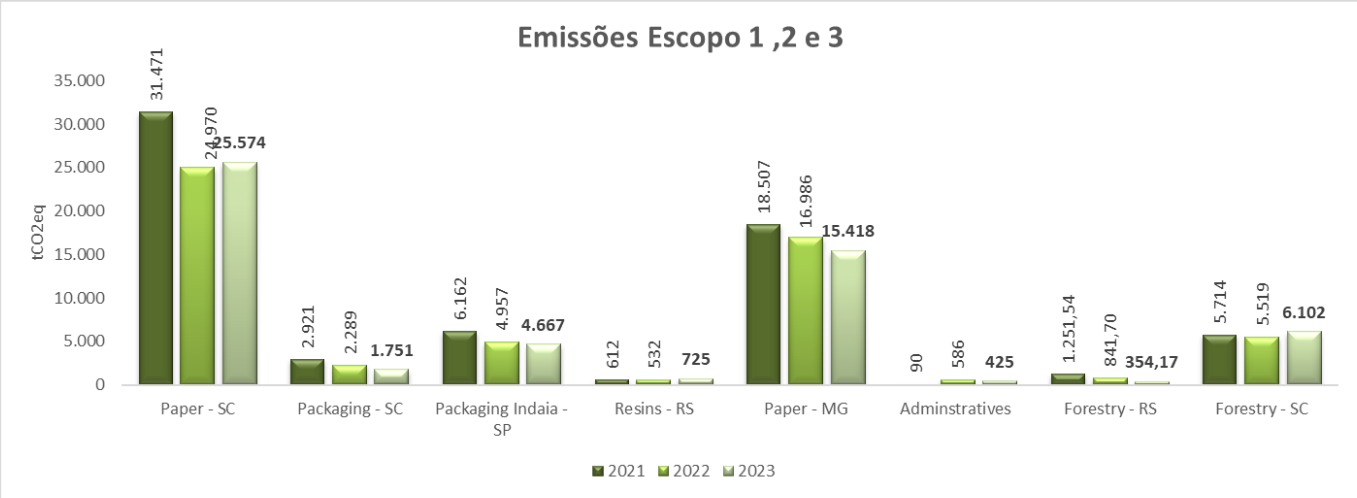

Figure 13– Industrial Units – Scope 1, 2 and 3

The organization is recommended to implement some of the actions considered to be best GHG management practices highlighted by the CERES Institute report presented in session 1 of this document. Table 22 below summarizes some of the actions mentioned in the report. Some of them are already implemented in the company.

This report was submitted to external certification, which generated an audit report and final validation, the certificate of conformity with the NBR ISO 14064:2007 standard. This report was submitted to external certification, which generated an audit report and final validation, the certificate of conformity with the NBR ISO 14064:2007 standard.

Table 22– Proposals and Implemented Actions

Strategy Area	Proposal:	Implemented Actions:
1. Board Control	1.1 Approve a responsibility plan that considers incentives for energy efficiency projects and expansion of the use of renewable fuels in the company, as well as outline a strategy for its implementation; 1.2 Establish a committee of senior managers who monitor the plan implementation strategy, reviewing the implementation strategy, as necessary;	1.1 Creation of the energy efficiency GAP. In 2010, Irani presented work at the energy efficiency symposium at ABTCP. Creation of HGE – Habitasul Sustainable Energy. 1.2 Monitoring by the Sustainability Report. In 2010, the company was a finalist for the PPI Award in the Category: Environmental Strategy of the Year.
2. Management Execution	2.1 Promote awareness among all employees, through training and lectures, regarding the impacts of climate change on society and the company's activities; 2.2 Create teams in each department to think about and suggest energy efficiency actions; 2.3 Link to the employee bonus system (profit sharing) some component related to the company's climate performance;	2.1 Activities developed in the environmental education project since 2007. 2.2 Energy Efficiency GAP, published the ABTCP guide for energy efficiency in 2011; 2.3 Included in the SUPERA Program, the ETE Flow indicator, Fiber Loss for ETE and energy efficiency, and water consumption in packaging, efficiency of the primary ETE system and final effluent quality. In 2012, this included the recovery of plastic from the MP5.
3. Public Disclosure	3.1 Engagement in a GHG balance disclosure program: Carbon Disclosure Project (www.cdproject.net), Brazilian GHG Protocol Program (www.ghgprotocol.org).	3.1 The results of the inventory have been published voluntarily in the Carbon Disclosure Project (CDP) since 2010; 3.1 The results of the inventory from 2009 to 2014 were disclosed in the GHG Protocol Brasil. In 2018, the results for 2017 will be disclosed. Disclosure also occurs through the Integrated Report.
4. Emission Quantifications	4.1 Update the company's GHG inventory monthly; 4.2 Submit the GHG inventory for independent verification by an entity accredited in the ISO 14.065 standard. 4.3 Characterize the waste that is sent to landfill to discount waste that does not generate greenhouse gasses; 4.4 Account for recurring emissions from air travel by employees and third parties who provide services to Irani.	4.1 Data is not updated every month, as some sources are updated annually; 4.2 We submitted the report for external audit and verification by BRTUV (2006 to 2011) and WayCarbon in accordance with ISO 14064 (2006), between 2012 and 2021 with the Totum Institute; 4.3 It was implemented from 2010 onwards, also including some service providers and continuous improvements. 4.4 BPF oil boiler deactivated at the MG Paper Unit in 2015, reducing the unit's emissions as a result of this source. 4.5 In 2017, fuel consumption resulting from the third-party transportation of waste at the Packaging Indaiatuba, Packaging Vila Maria and Resin Unit units was included. 4.6 In 2017, the Resina unit stopped carrying out anaerobic biological treatment of industrial effluent, for use as irrigation in the planting of pine trees in the forestry area of RS. 4.7 In 2021, the MG Paper Unit began operating a new effluent treatment plant with an anaerobic system, with the gas from the reactor being burned in a flare, thus increasing the unit's biogenic emissions. 4.8 The removal methodology was changed in 2021, with the moving average of removals over the last three years being considered from 2022 onwards 4.9 In 2022, we acquired Renewable Energy Certificates (I´REC) for the Packaging Indaiatuba SP unit. 4.10 In 2023 we developed our strategic decarbonization plan, which is in line with actions that will directly imply reductions in GHG emissions.
5. Strategic Planning and Execution	5.1 Incorporate climate management into Strategic Planning, establishing climate objectives and GHG emissions reduction targets; 5.2 Evaluate investment in increasing renewable energy generation capacity, or purchasing electricity on the free market, directly from electricity producers that use renewable sources (hydraulic, biomass or wind).	5.1 Irani's strategic map includes from the process perspective "optimizing the operational and environmental efficiency of plants", while from the people and culture perspective "promoting the circular economy in the value chain. These strategic objectives will promote greater efficiency in plants and reduce waste sent to landfills, prioritizing recycling and reducing GHG emissions due to their degradation in landfills. 5.2 According to strategic planning, electricity was purchased in December 2011 on the free market. In 2012, the purchase of energy began to be prioritized in an incentivized manner. 5.3 In 2017, the luminaires in the Packaging units were replaced with LED lamps, contributing to lower energy consumption. 5.4 The removal methodology was changed in 2021. This work was carried out in partnership with the Federal University of Paraná - UFPR.

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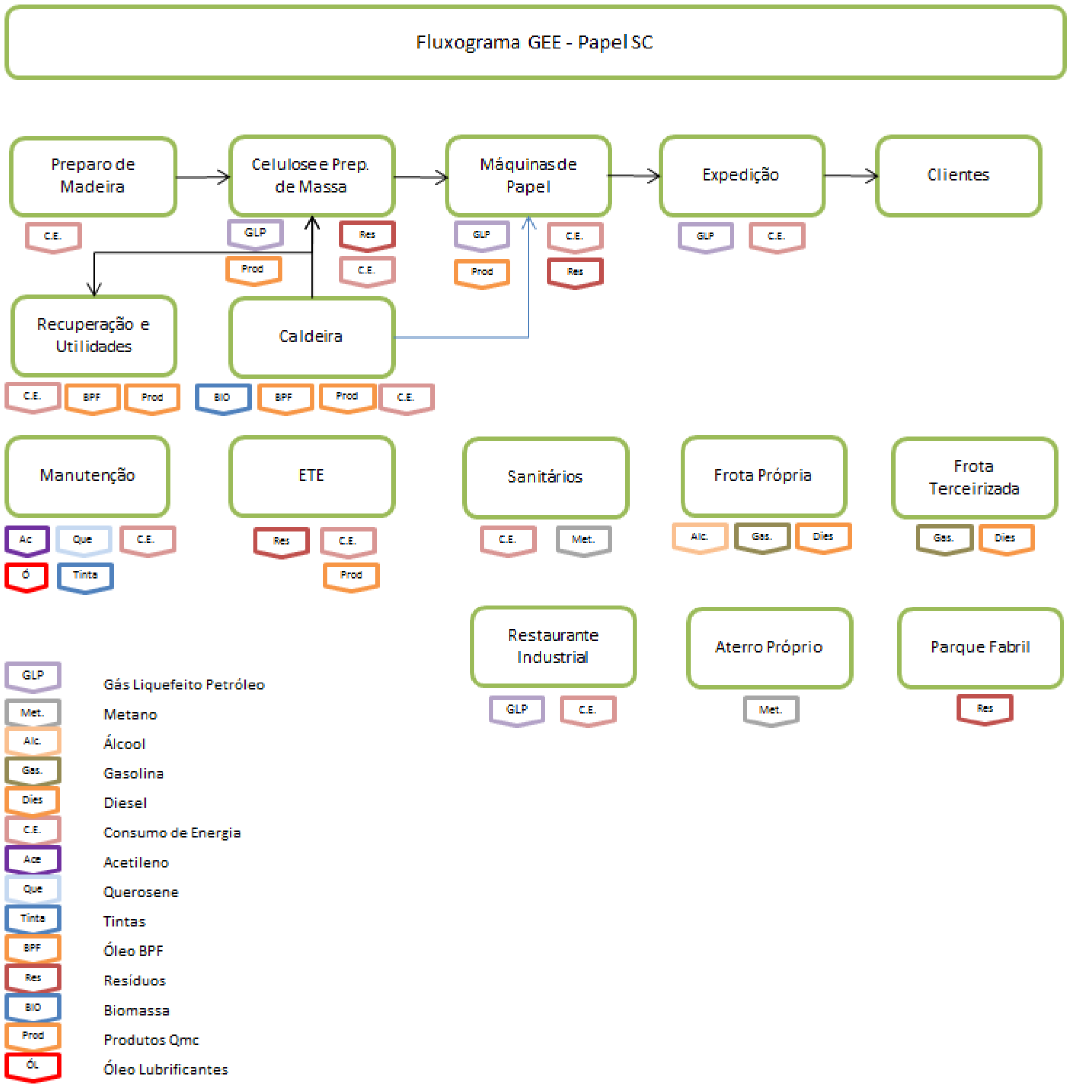
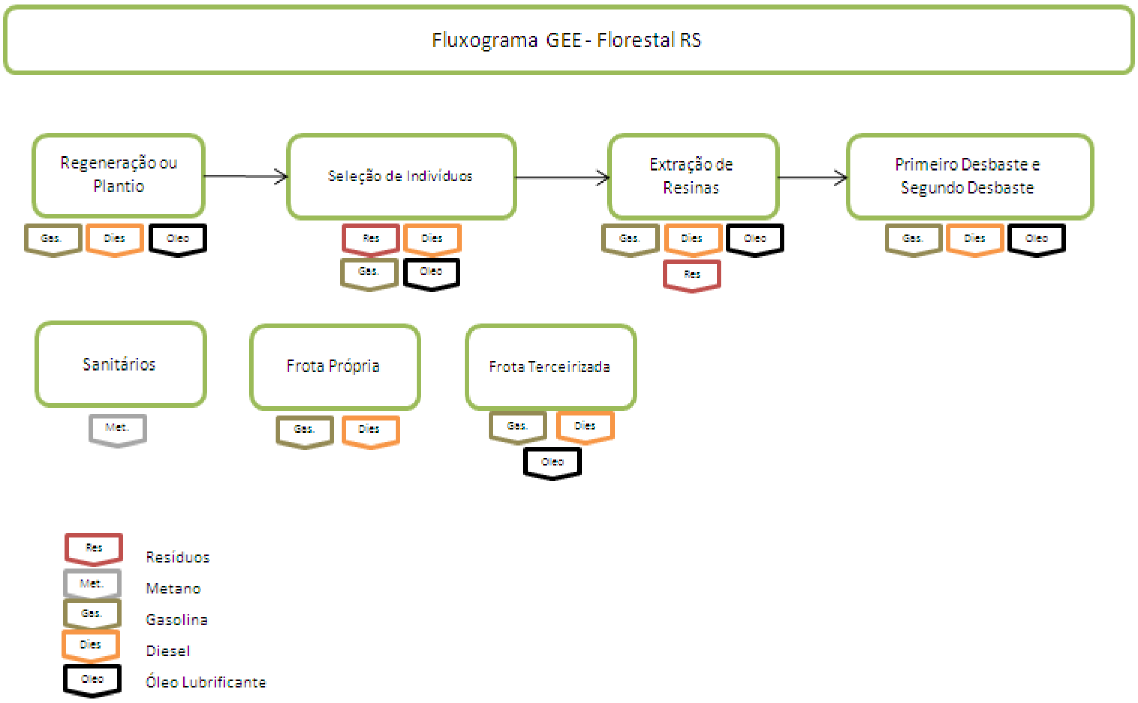
9. Process flowchart

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Oleo
Extração de Resinas
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Dies
Oleo
Res
Primeiro Desbaste e Segundo Desbaste
Gas.
Dies
Oleo
Sanitários
Met.
Frota Própria
Gas.
Dies
Frota Terceirizada
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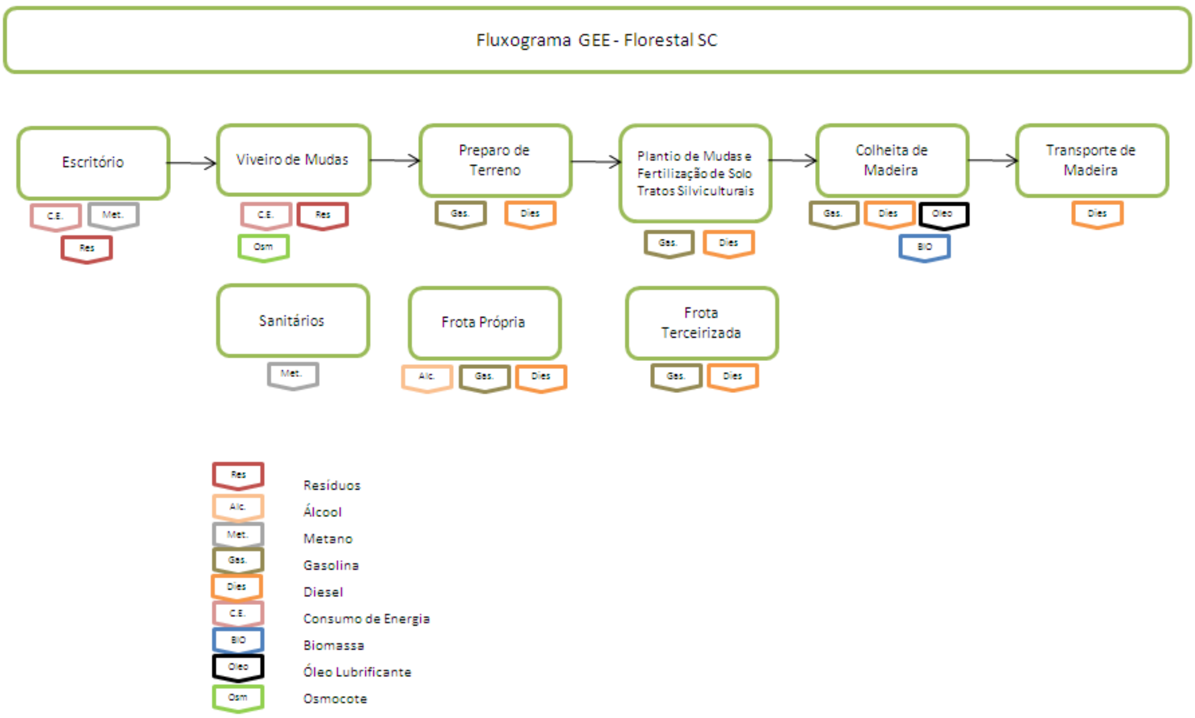
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Dies
Plantio de Mudas e Fertilização de Solo Tratos Silviculturais
Gas.
Dies
Colheita de Madeira
Gas.
Dies
Oleo
BIO
Transporte de Madeira
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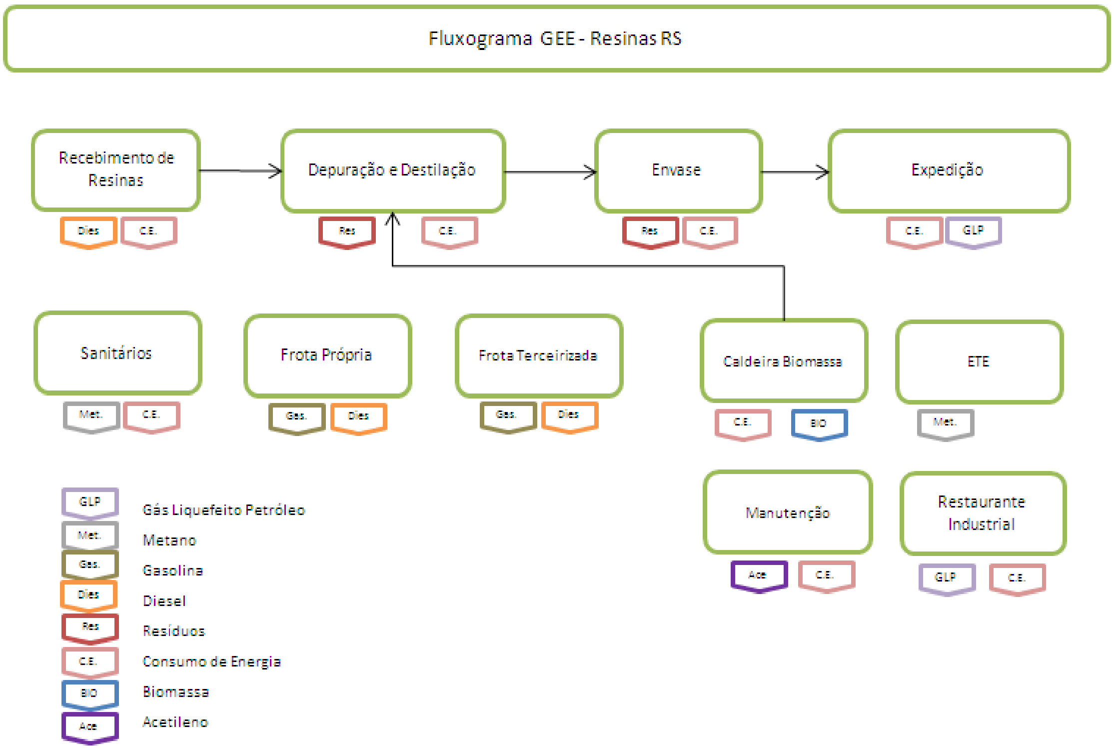
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C.E.
GLP Gás Liquefeito Petróleo
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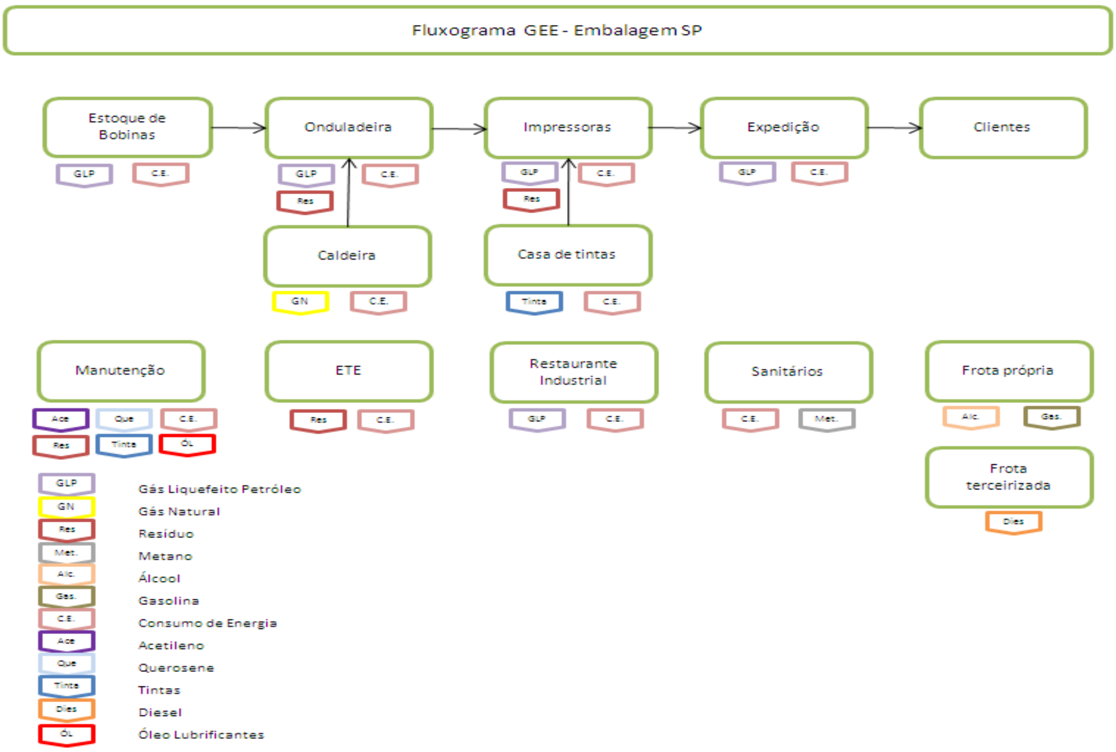
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Expedição
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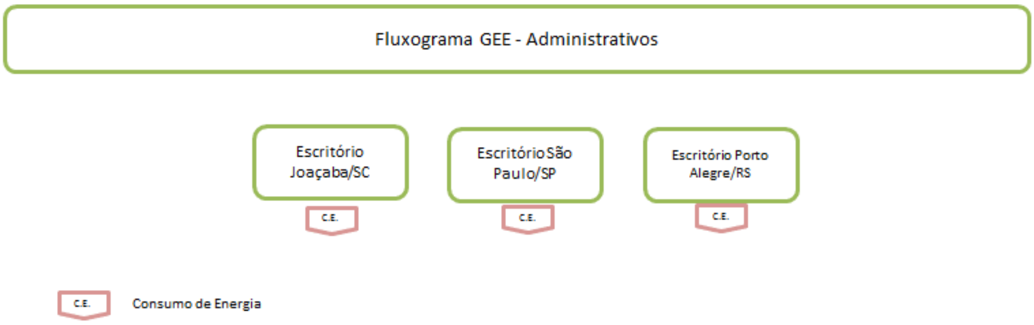
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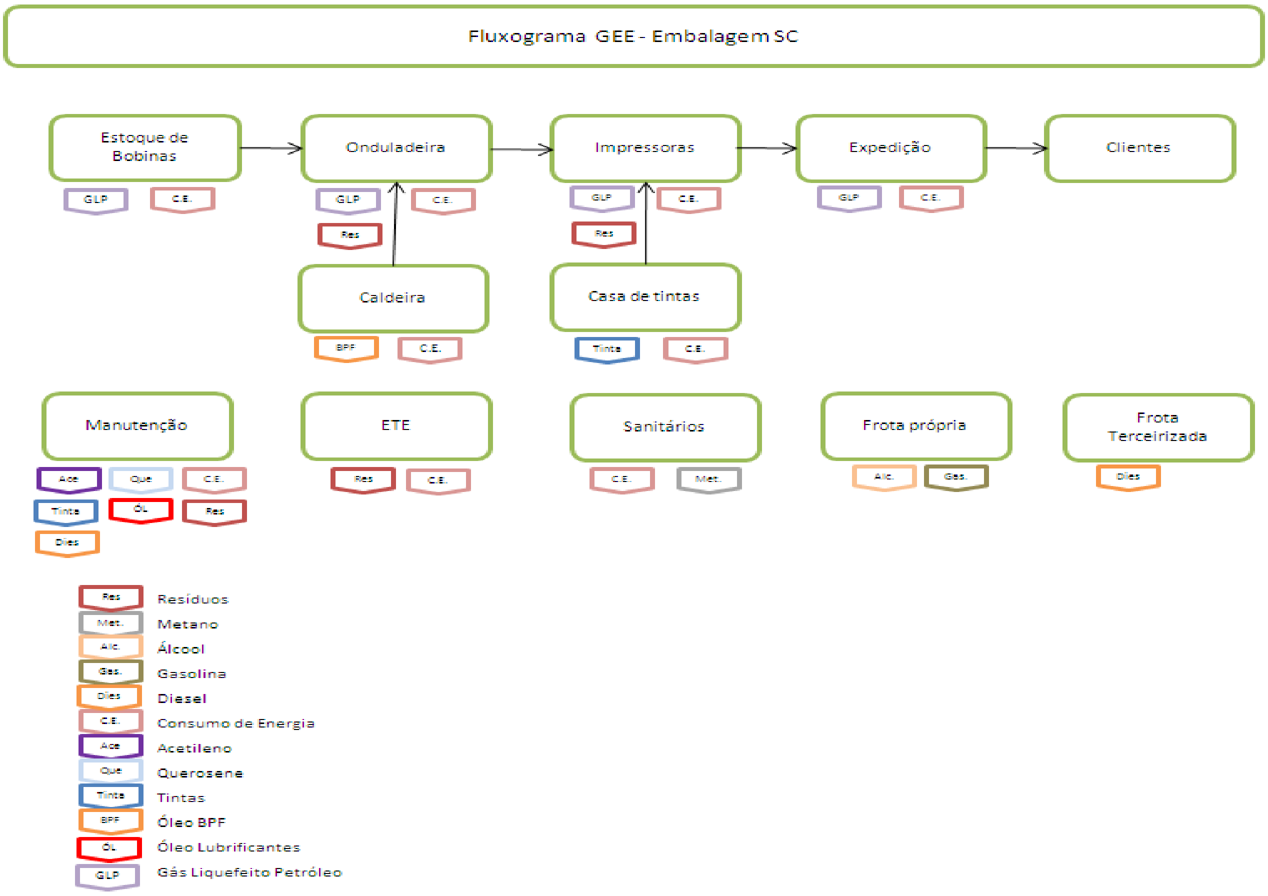
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