



Ecofinance
NEGÓCIOS

CARBON FOOTPRINT
MADEM WOODEN REELS

BASE YEAR 2024



INSTITUTIONAL



OBJECTIVE AND SCOPE



RESULTS



RECOMMENDATIONS

MADEM

Madem is a Brazilian company with global reach, specialized in the manufacturing of wooden reels for the wire and electric cable industry. Founded in Garibaldi, in the state of Rio Grande do Sul, it has expanded its manufacturing operations to six countries: Brazil, Spain, Bahrain, Mexico, Colombia, and the United States. Today, it serves more than 150 clients across over 40 markets.

Environmental commitment is one of the company's core pillars. All raw materials used are renewable and sourced from controlled origins, supported by international certifications such as ISO 9001 and ISO 14001, FSC, and PEFC. MADEM also invests in technological innovation and operational efficiency, ensuring competitive, high-performance products.

In addition to sustainability, the company values human development and social responsibility, fostering a strong organizational culture focused on continuous growth. With more than 75 years of history, it continues to expand its global presence and strengthen its position as a worldwide reference in its segment.



STUDY OBJECTIVE

The objective of this Life Cycle Assessment (LCA) study is to calculate the contribution of MADEM's wooden reels to global warming, expressed in carbon dioxide equivalent (CO_2e), following the recommendations of ABNT NBR ISO 14.067:2023.

The study is conducted in accordance with the Product Category Rules (PCR) 2019:13, version 1.1.3 (Packaging).

The wooden reels covered by this study are manufactured by MADEM at the following facilities: MADEM Rio Negro/PR (Brazil), MADEM Moorecraft in Denton, TX (USA), MADEM Moorecraft in Tarboro, NC (USA), EuroMadem in Barcelona (Spain), and MADEM Gulf in Askar (Bahrain). In addition, reels produced in Rio Negro are transported to Cali, Valle del Cauca (Colombia), Barcarena/PA (Brazil), and Sorocaba/SP (Brazil) for assembly and distribution. The Sorocaba facility is also a reel recycling plant.

SCOPE OF THE STUDY

Declared Unit

1 m³ (one cubic meter) of wooden reel produced.

Temporal representativeness

The collected data refer to **2024**.

Cut-off criteria

All data related to input and output flows of the product system that contribute to at least **99% of the declared environmental impacts were included**, excluding inputs that are explicitly outside the scope of the analysis, according to the applied PCR. **All available data were used**, except for those excluded by the PCR.

Objective **Scope**

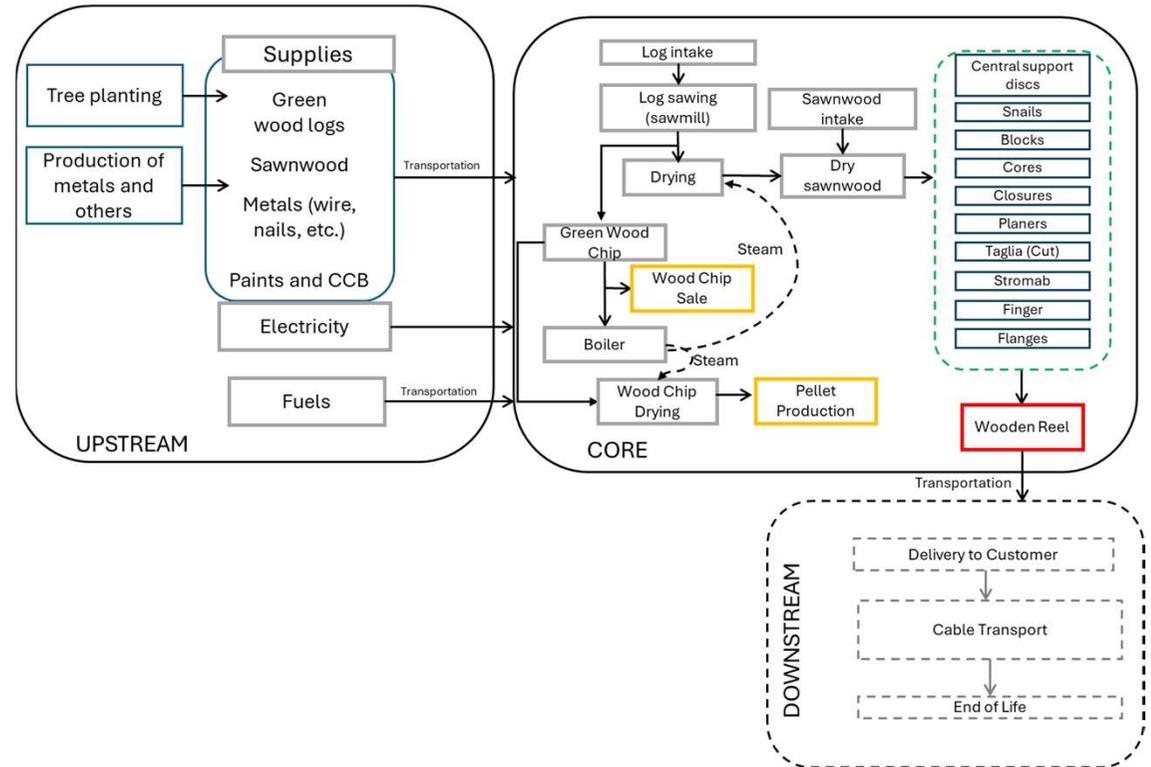
SCOPE OF THE STUDY

System boundaries

Emissions were accounted for across the following stages:

- **Upstream** = "Raw material supply"
- **Core** = "Transport" and "reel manufacturing"

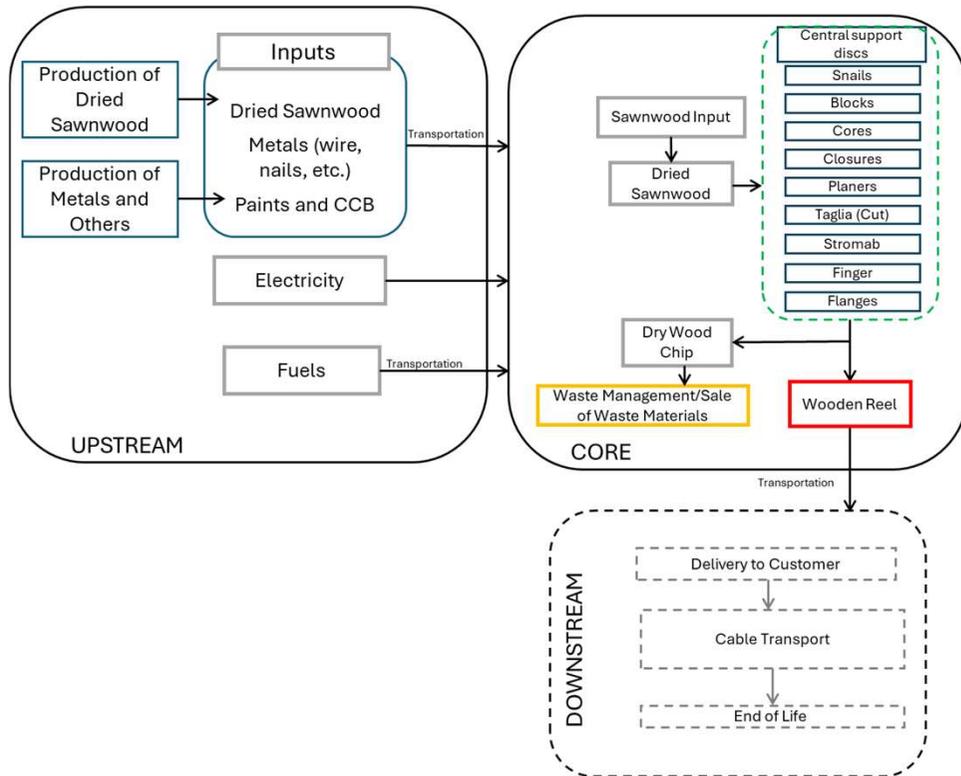
Process flow diagram for MADEM Rio Negro



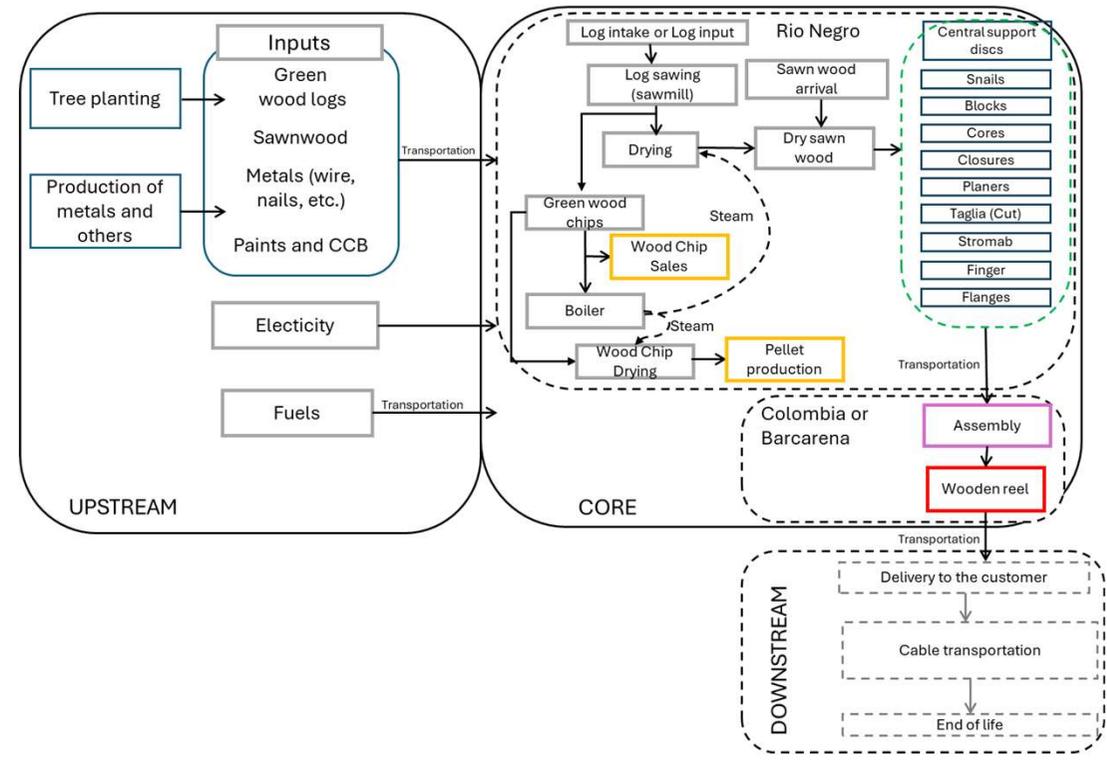
Objective **Scope**

SCOPE OF THE STUDY

Process flow diagram for MADEM Moorecraft - Denton, MADEM Moorecraft - Tarboro, and EuroMadem

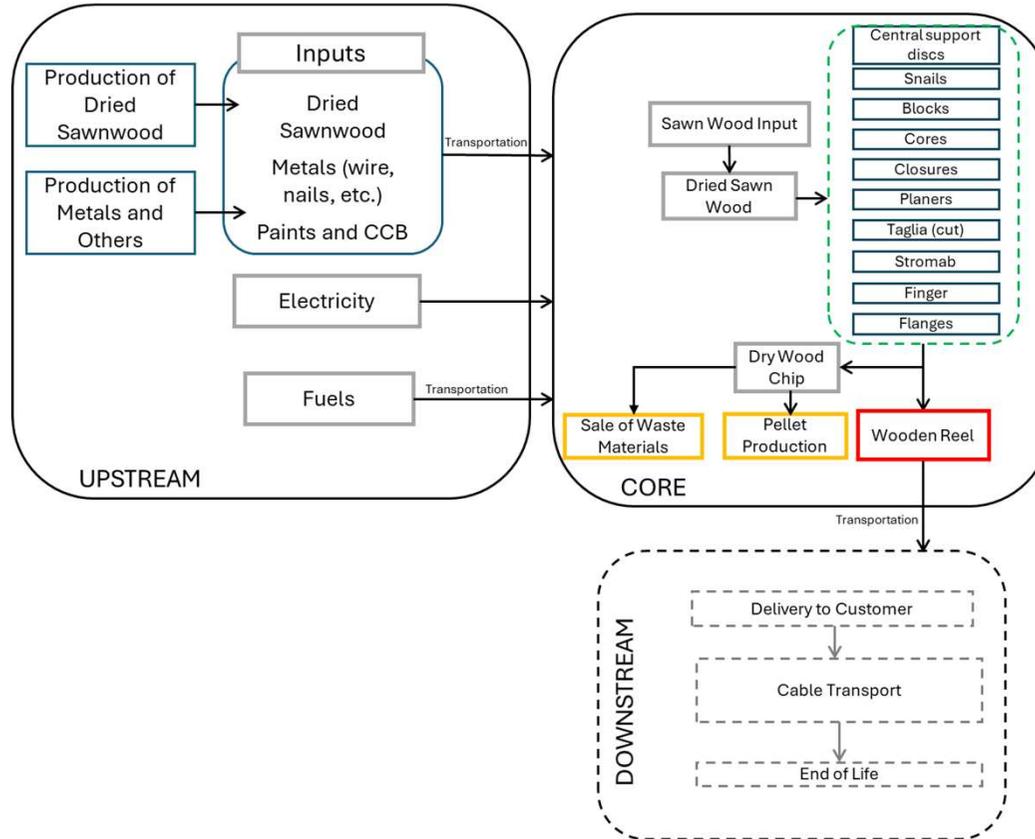


Process flow diagram for Madem Colômbia e Madem Barcarena



SCOPE OF THE STUDY

Process flow diagram for MADEM Gulf



SCOPE OF THE STUDY

Assumptions and allocation procedure

For the MADEM Florestal Rio Negro (PR) and MADEM Florestal Mostardas (RS) units, an LCA was developed for the produced wood logs, which were subsequently incorporated into the product system of the MADEM Rio Negro industrial unit.

For the other wood logs received by MADEM Rio Negro, it was assumed that those supplied from Paraná and Santa Catarina have a carbon footprint similar to that of MADEM Florestal Rio Negro. For logs supplied by suppliers from Rio Grande do Sul, a carbon footprint similar to that of MADEM Florestal Mostardas was assumed.

The economic allocation procedure was used for some sources (acquisition and use of acetylene, gasoline, LPG, diesel oil, and waste generation) at the Rio Negro industrial unit, which produces not only wooden reels but also green wood chips and wood pellets.

Emissions calculation

For the estimation of GHG emissions resulting from **energy inputs, material resources, and waste**, life cycle impact values provided by Ecoinvent v. 3.11 were used.

Emissions from the **transport of inputs, by road and maritime routes**, were calculated based on the load and the distance traveled in kilometers and/or nautical miles, using life cycle impact values provided **by Ecoinvent v. 3.11**.

For **emissions from fuel combustion**, emission factors from the Brazilian GHG Protocol Program (FGV) were used.

The **OpenLCA software v.2.5** was used to perform the calculations for this LCA.

LIFE CYCLE IMPACT ASSESSMENT

The environmental performance of the declared unit of 1 cubic meter of wooden reel, reported for **Total GWP (excl. biogenic CO₂)** and **Total GWP (incl. biogenic CO₂)**, considering the **IPCC 2021** – Global Warming Potential (**GWP 100**) method, is presented in the following tables, by business unit.

LIFE CYCLE IMPACT ASSESSMENT

Madem Rio Negro

The carbon footprint of 1 m³ of wooden reel produced in Rio Negro, considering Total GWP (excl. biogenic CO₂), is 105,16 kg CO₂e. Road transport is the main source of emissions, accounting for 23,5% of the total impact, which highlights the relevance of travel distances and fossil fuels in logistics. **Electricity consumption (18,5%) and the use of metals (16,7%)** also stand out.

In the Total GWP (incl. biogenic CO₂) category, strongly negative values associated with wood production are observed. The production of wood logs, mainly at MADEM's forestry units, incorporates the carbon sequestration of biomass.

	Climate change - IPCC 2021		Climate change - IPCC 2021 (incl. CO ₂ biogenic CO ₂)	
	Total GWP (excl. biogenic CO ₂)		GWP Total (incl. CO ₂ biogenic)	
	Total [kg CO ₂ -Eq]		Total [kg CO ₂ -Eq]	
TOTAL	105,16	100%	-729,96	100%
Road transport	24,75	23,5%	25,17	-3,4%
Electricity	19,43	18,5%	18,19	-2,5%
Metals (e.g., nails, screws, washers)	17,56	16,7%	17,90	-2,5%
Sawnwood	7,17	6,8%	-80,87	11,1%
Wires	6,90	6,6%	6,81	-0,9%
Paints	4,48	4,3%	4,11	-0,6%
Wood Log (Rio Negro Florestal)	2,95	2,8%	-1420	194,5%
Iron	1,75	1,7%	1,75	-0,2%
Chromated copper borate (CCB)	1,55	1,5%	1,56	-0,2%
Liquefied Petroleum Gas (LPG)	0,85	0,8%	0,85	-0,1%
Sheets	0,76	0,7%	0,76	-0,1%
Diesel oil	0,53	0,5%	0,53	-0,1%
Wood logs (Mostardas Florestal)	0,15	0,1%	-91,77	12,6%
Waste	0,18	0,2%	0,23	0,0%
Gasoline	0,05	0,0%	0,05	0,0%
Pipes	0,02	0,0%	-0,01	0,0%
Acetylene	0,01	0,0%	0,01	0,0%
Maritime transport	0,0001	0,0%	0,0001	0,0%
Direct emissions	16,09	15,3%	784,82	-107,5%

LIFE CYCLE IMPACT ASSESSMENT

EuroMadem

At the EuroMadem unit, the Total GWP (excluding biogenic CO₂) reaches 226,37 kg CO₂e, a value higher than that observed at Madem Rio Negro, mainly due to road transportation and the purchased sawnwood.

Land logistics accounts for 45,9% of the total climate impact. The t.km value (ton-kilometer) in Spain is 153,7% higher than the value in Rio Negro, which explains the higher level of emissions.

The production and supply of sawnwood represent 24.8%.

	Climate change - IPCC 2021		Climate change - IPCC 2021 (incl. CO ₂ biogenic CO ₂)	
	Total GWP (excl. biogenic CO ₂)		GWP Total (incl. CO ₂ biogenic)	
	Total [kg CO ₂ -Eq]		Total [kg CO ₂ -Eq]	
TOTAL	226,37	100%	-561,17	100%
Road transport	104,00	45,9%	104,09	-18,5%
Wood Log	56,09	24,8%	-739,00	131,7%
Paints	18,00	8,0%	16,55	-2,9%
Metals (e.g., nails, screws, washers)	16,77	7,4%	17,09	-3,0%
Electricity	8,86	3,9%	8,92	-1,6%
Wires	6,90	3,0%	6,81	-1,2%
Waste	4,77	2,1%	13	-2,4%
Maritime Transport	2,62	1,2%	2,62	-0,5%
Liquefied Petroleum Gas (LPG)	1,55	0,7%	1,56	-0,3%
Diesel Oil	0,87	0,4%	0,87	-0,2%
Direct emissions	5,95	2,6%	5,95	-1,1%

LIFE CYCLE IMPACT ASSESSMENT (LCIA)

Madem Gulf

The wooden reel produced in Bahrain has a Total GWP (excluding biogenic CO₂) of 196,01 kg CO₂e. This result is mainly due to maritime transport, which accounts for 37,2% of the total GWP. Another determining factor in the emissions profile is the use of sawnwood, which represents 34,2% of the total climate impact when carbon sequestration is not considered. Together, sawnwood and maritime transport account for more than 71,4% of total emissions.

Electricity also shows a significant contribution, representing 11,3% of the impact.

	Climate change - IPCC 2021		Climate change - IPCC 2021 (incl. CO2 biogenic CO2)	
	Total GWP (excl. biogenic CO2)		GWP Total (incl. CO2 biogenic)	
	Total [kg CO2-Eq]		Total [kg CO2-Eq]	
TOTAL	196,01	100%	-625,05	100%
Wood log	67,05	34,2%	-755,15	120,8%
Maritime transport	72,97	37,2%	72,96	-11,7%
Waste	4,76	2,4%	5,92	-0,9%
Electricity	22,07	11,3%	22,07	-3,5%
Metals (e.g., nails, screws, washers)	20,97	10,7%	21,20	-3,4%
Diesel oil	7,38	3,8%	7,13	-1,1%
Road transport	0,82	0,4%	1	-0,1%
Direct emissions	0,00	0,0%	0,00	0,0%

LIFE CYCLE IMPACT ASSESSMENT (LCIA)

Madem Moorecraft – Denton

The Total GWP (excluding biogenic CO₂) of the wooden reel reaches 255,14 kg CO₂e. This result is influenced by road transportation, which accounts for 49,7%. This is the highest impact among Madem’s units.

Sawnwood represents the second-largest contribution, accounting for 23,5% of the total. Electricity consumption accounts for 12,8% of emissions, and the metals used in the production process contribute 8,3%.

	Climate change - IPCC 2021		Climate change - IPCC 2021 (incl. CO2 biogenic CO2)	
	Total GWP (excl. biogenic CO2)		GWP Total (incl. CO2 biogenic)	
	Total [kg CO2-Eq]		Total [kg CO2-Eq]	
TOTAL	255,14	100%	-479,66	100%
Road transport	126,68	49,7%	126,78	-26,4%
Wood Log	59,97	23,5%	-675,64	140,9%
Electricity	32,60	12,8%	32,63	-6,8%
Metals (e.g., nails, screws, washers)	21,23	8,3%	21,42	-4,5%
Maritime transport	2,81	1,1%	2,81	-0,6%
Liquefied Petroleum Gas (LPG)	2,05	0,8%	2,05	-0,4%
Wastes	2,21	0,9%	3	-0,6%
Paints	0,77	0,3%	0,71	-0,1%
Plastic drum	0,74	0,3%	0,69	-0,1%
Chiller CNC	0,00	0,0%	0,00	0,0%
Direct emissions	6,08	2,4%	6,08	-1,3%

LIFE CYCLE IMPACT ASSESSMENT (LCIA)

Madem Moorecraft – Tarboro

The Madem Moorecraft – Tarboro unit has a Total GWP (excluding biogenic CO₂) of 157,94 kg CO₂e, a value lower than that observed in Denton. The main reasons for the difference in emissions between Denton and Tarboro are the shorter distances traveled for the delivery of sawnwood and the lower electricity consumption at the Tarboro unit.

Sawnwood is the primary source of emissions, accounting for 37,8% of the total GWP. Road transport is the second largest contributor, representing 32,3%.

	Climate change - IPCC 2021		Climate change - IPCC 2021 (incl. CO2 biogenic CO2)	
	Total GWP (excl. biogenic CO2)		GWP Total (incl. CO2 biogenic)	
	Total [kg CO2-Eq]		Total [kg CO2-Eq]	
TOTAL	157,94	100%	-575,31	100%
Wood Log	59,78	37,8%	-673,65	117,1%
Road transport	51,09	32,3%	51,13	-8,9%
Electricity	18,81	11,9%	18,86	-3,3%
Metals (e.g., nails, screws, washers)	22,47	14,2%	22,68	-3,9%
Maritime transport	3,58	2,3%	3,58	-0,6%
Wastes	1,08	0,7%	1,38	-0,2%
Fiber drum	0,21	0,1%	0	0,0%
Liquefied Petroleum Gas (LPG)	0,19	0,1%	0,19	0,0%
Diesel Oil	0,04	0,0%	0,04	0,0%
Chiller CNC	0,00	0,0%	0,00	0,0%
Direct emissions	0,69	0,4%	0,69	-0,1%

LIFE CYCLE IMPACT ASSESSMENT

Madem Colombia

The product manufactured in Cali, Colombia, has a Total GWP (excluding biogenic CO₂) of 175,90 kg CO₂e. To the life cycle emissions up to the gate of Rio Negro Industry, which account for 59,8% of the total GWP, are added the maritime transport emissions (24,7% of the total) and road transport emissions (14,1% of the total) of the wooden reel to the Madem Colombia facility. At the Colombia facility, electricity consumption accounts for 0,9% of the reel's emissions at the site, followed by gasoline (0,3%) and liquefied petroleum gas (0,2%).

	Climate change - IPCC 2021		Climate change - IPCC 2021 (incl. CO ₂ biogenic CO ₂)	
	Total GWP (excl. biogenic CO ₂)		GWP Total (incl. CO ₂ biogenic)	
	Total [kg CO ₂ -Eq]		Total [kg CO ₂ -Eq]	
TOTAL	175,90	100%	-656,92	100%
Wooden Reel (Rio Negro Industry)	105,20	59,8%	-729,92	111,1%
Maritime transport	43,41	24,7%	43,41	-6,6%
Road transport	24,87	14,1%	24,89	-3,8%
Electricity	1,52	0,9%	1,52	-0,2%
Gas	0,56	0,3%	0,51	-0,1%
Liquefied Petroleum Gas (LPG)	0,31	0,2%	0,31	0,0%
Waste	0,02	0,0%	2	-0,4%
Direct emissions	0,00	0,0%	0,00	0,0%

LIFE CYCLE IMPACT ASSESSMENT (LCIA)

Madem Barcarena

In Barcarena, the Total GWP (excluding biogenic CO₂) is 226,10 kg CO₂e. The wooden reel, up to the gate of the Rio Negro factory, accounts for 46,5% of the impact. Road transport from Rio Negro to Barcarena represents 47,7% of the total GWP, followed by maritime transport, which accounts for 5,6%. The energy consumption of liquefied petroleum gas (LPG), electricity, and gasoline at the Barcarena facility together represents less than 0,2% of the emissions.

	Climate change - IPCC 2021		Climate change - IPCC 2021 (incl. CO ₂ biogenic CO ₂)	
	Total GWP (excl. biogenic CO ₂)		GWP Total (incl. CO ₂ biogenic)	
	Total [kg CO ₂ -Eq]		Total [kg CO ₂ -Eq]	
TOTAL	226,10	100%	-608,95	100%
Road Transport	107,80	47,7%	107,88	-17,7%
Carretel de Madeira (Rio Negro Industry)	105,20	46,5%	-729,92	119,9%
Maritime Transport	12,55	5,6%	12,55	-2,1%
Liquefied Petroleum Gas (LPG)	0,38	0,2%	0,38	-0,1%
Electricity	0,10	0,0%	0,10	0,0%
Gasoline	0,06	0,0%	0,06	0,0%
Direct Emissions	0,00	0,0%	0	0,0%

LIFE CYCLE IMPACT ASSESSMENT (LCIA)

There are significant differences in the Total GWP (excluding biogenic CO₂) among the facilities, with values ranging from 105,16 kg CO₂e at Madem Rio Negro, the lowest observed impact, to 255,14 kg CO₂e at Madem Moorecraft – Denton, the highest among the evaluated facilities. The scenarios for Madem Moorecraft – Tarboro and Madem Colombia show intermediate and relatively similar impacts, while EuroMadem, Madem Gulf, and Barcarena stand out for their higher values.

The main factors determining climate performance are transport logistics and the supply of wood logs and sawnwood, followed by electricity consumption and the use of metals. Facilities with closer supply chains and greater production integration, such as Madem Rio Negro, tend to have lower impacts.

Based on the Total GWP (including biogenic CO₂), the wooden reel with the greatest carbon removal is at Madem Rio Negro, with a result of -729,96 kg CO₂e, followed by the Colombia facility with -656,92 kg CO₂e. The facility with the lowest removal is Denton (-479,66 kg CO₂e), mainly due to the impact of input transport on the total GWP.

UNCERTAINTY ANALYSIS

The uncertainty analysis was carried out using the Data Quality Matrix (Pedigree Matrix), a tool used in LCAs to assess and describe the uncertainty and reliability of inventory data. Based on this information, a Monte Carlo Simulation was performed.

The mean represents the average impact value obtained across the iterations, while the absolute standard deviation shows how much the result can vary in absolute terms. The coefficient of variation measures the relative uncertainty as a percentage, and the 5% and 95% percentiles indicate the minimum and maximum values the impact can reach, respectively.

Unity	Mean (kgCO ₂ e)	Absolute Standard Deviation (kgCO ₂ e)	Coefficient of Variation (%)	Percentile 5% (kgCO ₂ e)	Percentile 95% (kgCO ₂ e)
Madem Rio Negro	105,6	10,3	9,75	91,5	124,2
EuroMadem	224,0	41,2	18,4	168,0	299,3
Madem Gulf	193,0	31,7	16,4	148,8	251,8
Madem Moorecraft – Denton	252,1	48,0	19,0	187,4	340,5
Madem Moorecraft – Tarboro	156,9	24,4	15,6	123,5	201,0
Madem Colombia	181,3	22,19	12,2	149,9	220,9
Madem Barcarena	260,7	42,7	16,4	201,6	338,0

STUDY ON WOODEN REEL RECYCLING (MADEM SOROCABA FACILITY)

This study aims to identify the maximum transport distance of the used wooden reel for which recycling is the most advantageous option, considering that beyond this limit, disposal of the wooden reel would be more favourable.

Two alternative life cycles were compared:

- The full life cycle of the wooden reel produced by the Madem Rio Negro industrial facility (excluding the delivery to the customer), with disposal of the wooden reel at the end of its use;
- Destination of the used wooden reel for recycling (up to the factory gate).

As a premise, for the end-of-life of the wooden reel, the same assumptions used in the Ecoinvent v.11 inventory for “market for waste wood, untreated” (Brazil – BR) were applied, which defines the proportions for wood waste disposal as follows: sanitary landfill, wet infiltration class (500 mm) (88,1%), open dump (8,4%), open burning (2,9%), and municipal incineration (0,6%).

The sawnwood used to recycle the used wooden reel is transported from Madem Rio Negro to Madem Sorocaba and corresponds, on average, to 0,4% of the reel’s volume.

STUDY ON WOODEN REEL RECYCLING (MADEM SOROCABA FACILITY)

The results of the break-even analysis study are presented below, establishing 2,562 km as the maximum distance that a recycled wooden reel can travel for recycling to remain the most advantageous option compared to wooden reel disposal.



RECOMMENDATIONS

- For road and maritime transport, it is recommended to optimize logistics routes, reduce distances between suppliers and production facilities, gradually replace higher-emission transport modes, and use renewable fuels.
- For energy consumption, it is recommended to replace fossil energy sources (such as LPG, gasoline, and diesel) with renewable sources, obtain certifications, and increase the procurement of renewable electricity.
- Regarding metals, it is desirable to seek suppliers that conduct life cycle assessments of their own products, as this would make it possible to obtain the carbon footprint of the materials from primary data.