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Product Carbon Footprint Analysis

Leesbril (Reading Glasses)

Accounting Standard: GHG Protocol

Prepared by a Senior Sustainability Consultant specializing in GHG Protocol

Product Carbon Footprint Report: Leesbril

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Executive Summary

This report presents a high-detail Product Carbon Footprint (PCF) analysis for one unit of \'leesbril\' (reading glasses), conducted in accordance with the GHG Protocol. The analysis covers emissions from raw material acquisition, manufacturing in India, and sea transport to Europe, with a system boundary of "cradle-to-factory-gate" extended to include the specified outbound logistics. The total estimated carbon footprint for one leesbril unit is approximately 0.304 kg CO2e, with material production (Scope 3) and manufacturing energy (Scope 2) identified as the primary emission hotspots.

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1. Define Scope

1.1 Functional Unit

- The functional unit for this analysis is **1.0 unit of \'leesbril\' (reading glasses)**, capable of providing vision correction.

1.2 System Boundary

- The primary system boundary for the PCF is **\'factory_gate\' (cradle-to-gate)**, encompassing all upstream processes from raw material extraction and

processing through the manufacturing and packaging of the leesbril unit at the production facility.

- For a comprehensive supply chain analysis, the scope is extended to include **downstream transportation (from factory gate to Europe)**, as per the provided parameters. End-of-life phases, retail, and consumer use are outside this defined boundary.

1.3 Geographic Scope

- **Final Production Country:** India. This influences the grid electricity emission factors for manufacturing processes.
- **Supply Chain Focus:** Europe Focused. While production is in India, the subsequent transport to Europe for distribution is included. Upstream material supply chain impacts are considered globally where specific regional data is unavailable, defaulting to general industry averages.

1.4 Allocation

- All environmental impacts and emissions are allocated entirely to the functional unit (1.0 unit of leesbril). Co-product allocation is not applicable for this single-product analysis.

1.5 Accounting Standard

- This Product Carbon Footprint analysis strictly adheres to the **GHG Protocol (Corporate Value Chain (Scope 3) Standard)**, categorizing emissions into Scope 1 (direct), Scope 2 (purchased energy), and Scope 3 (value chain) for transparent reporting.

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2. Map Lifecycle (LCI Inventory Stages)

The lifecycle of the leesbril, within the defined system boundary, comprises the following stages:

2.1 Material Acquisition & Pre-processing

This stage includes the extraction of raw materials and their transformation into forms usable for manufacturing the leesbril components. Key materials identified for reading glasses typically include:

- **Plastics:** Primarily for frames and lenses (e.g., polycarbonate, CR-39, TR90). These involve the extraction of fossil fuels (e.g., crude oil, natural gas) and energy-intensive chemical polymerization processes.
- **Metals:** For small components like hinges and screws (e.g., stainless steel). This involves mining, smelting, refining, and alloying of various metals.
- **Packaging Materials:** Typically cardboard for primary product boxing and potentially thin plastic film for protection. This involves forestry, pulping, paper-making, or plastic resin production.

2.2 Manufacturing (in India)

This stage covers all processes at the factory in India to convert pre-processed materials into a finished leesbril unit, ready for shipment.

- **Component Fabrication:**
    - Injection molding of plastic frames.
    - Molding and cutting of plastic lenses.
- **Assembly:** Joining frames, inserting lenses, attaching hinges and screws.
- **Finishing & Quality Control:** Polishing, cleaning, testing.
- **Primary Packaging:** Placing the finished leesbril into its individual cardboard box and protective sleeve.

- **Energy Consumption:** Electricity for machinery (injection molding machines, assembly line equipment), lighting, and facility HVAC.

2.3 Downstream Transportation (India to Europe)

As per the parameters, this stage includes the transportation of the finished and packaged leesbril units from the factory gate in India to a distribution point in Europe.

- **Transport Mode:** Sea freight.
- **Transport Distance:** 3,000 km.

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3. Collect Data (Primary/Secondary Data Points)

Given the nature of this high-detail analysis without access to proprietary primary data, industry-average secondary data from reputable sources has been utilized. This ensures a robust and representative assessment.

3.1 Material Inputs (per 1 Leesbril)

Based on typical reading glasses construction and weights:

Material Category	Specific Material (Assumed)	Estimated Weight per Unit (kg)
Plastic (Frame)	Polycarbonate	0.025
Plastic (Lenses)	Polycarbonate	0.015
Metal (Hinges/Screws)	Stainless Steel	0.002
Packaging (Box)	Cardboard (virgin)	0.015
		0.057

Material Category	Specific Material (Assumed)	Estimated Weight per Unit (kg)
Total Product & Primary Packaging Weight		

Note: Assumed material composition for a typical pair of reading glasses. Polycarbonate is a common choice for its durability and clarity.

3.2 Energy Inputs (per 1 Leesbril during Manufacturing in India)

- **Plastic Injection Molding Energy:** The energy consumption for plastic injection molding is estimated to be 2.0 kWh per kilogram of plastic produced.
- **Total Plastic Weight for Molding:** 0.025 kg (frame) + 0.015 kg (lenses) = 0.040 kg.
- **Calculated Electricity Consumption:** 0.040 kg * 2.0 kWh/kg = 0.08 kWh.
- **Electricity Source:** Indian national grid.

3.3 Transport Data (for 1 Leesbril from India to Europe)

- **Transport Mode:** Sea freight.
- **Transport Distance:** 3,000 km.
- **Weight for Transport:** 0.057 kg (total product and primary packaging weight).

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4. Calculate Emissions (Activity * Emission Factor = CO2e)

Emissions are calculated by multiplying the activity data (e.g., kg of material, kWh of electricity, tonne-km of transport) by their respective industry-standard emission factors. All results are expressed in kilograms of carbon dioxide equivalent (kg CO2e).

4.1 Emission Factors Used

Category	Specific Item	Emission Factor (kg CO2e)	Unit	Source/Reference
Materials	Polycarbonate (virgin)	5.4	per kg	Carbonfact, Low Global Warming Potential Polycarbonate
Materials	Stainless Steel	6.15	per kg	CarbonCloud
Materials	Cardboard (virgin)	1.0	per kg	DEFRA, Carbonfact, OpenCO2.net (average)
Energy	Electricity (India Grid Average)	0.727	per kWh	Government of India - Central Electricity Authority, Climatiq
Transport	Sea Freight (Container Ship Average)	0.016	per tonne-km	UK BEIS/Defra, Climatiq, IPOINT Blog

Note: Emission factors are illustrative and based on publicly available averages. Regional and specific supplier data would enhance accuracy.

4.2 Emission Calculation by Scope

Scope 1 Emissions (Direct Emissions)

For the production of leesbril in India, Scope 1 emissions are assumed to be negligible within the factory gate boundary for product-specific processes. Any direct emissions from fuel combustion on-site for general factory operations are not directly allocated to individual product units in this model, assuming electricity covers primary manufacturing energy needs.

- **Total Scope 1 Emissions:** 0.000 kg CO2e

Scope 2 Emissions (Purchased Electricity)

These emissions arise from the electricity purchased for the manufacturing processes of the leesbril in India.

- **Activity:** 0.08 kWh (electricity for molding 0.040 kg plastic)
- **Emission Factor:** 0.727 kg CO2e/kWh (India Grid Average)
- **Calculation:** 0.08 kWh * 0.727 kg CO2e/kWh = 0.05816 kg CO2e
- **Total Scope 2 Emissions:** 0.05816 kg CO2e

Scope 3 Emissions (Value Chain Emissions)

Scope 3 emissions cover all other indirect emissions, including upstream material production and downstream transportation.

- **Category 1: Purchased Goods and Services (Materials)**
    - **Polycarbonate (Frame & Lenses):**
        - Activity: 0.040 kg
        - Emission Factor: 5.4 kg CO2e/kg
        - Calculation: 0.040 kg * 5.4 kg CO2e/kg = 0.216 kg CO2e
    - **Stainless Steel (Hinges/Screws):**
        - Activity: 0.002 kg
        - Emission Factor: 6.15 kg CO2e/kg
        - Calculation: 0.002 kg * 6.15 kg CO2e/kg = 0.0123 kg CO2e
    - **Cardboard (Packaging):**
        - Activity: 0.015 kg
        - Emission Factor: 1.0 kg CO2e/kg
        - Calculation: 0.015 kg * 1.0 kg CO2e/kg = 0.015 kg CO2e
- **Category 4: Upstream Transportation and Distribution**

  Emissions from the transport of raw materials to the manufacturing factory in India are typically embedded within the "cradle-to-gate" emission factors of the purchased goods

and services (materials). Therefore, no separate calculation is performed here to avoid double-counting.

- **Category 9: Downstream Transportation and Distribution (Sea Freight India to Europe)**
    - Activity: 0.057 kg (product weight) = 0.000057 tonnes
    - Distance: 3,000 km
    - Emission Factor: 0.016 kg CO2e/tonne-km
    - Calculation: 0.000057 tonnes * 3,000 km * 0.016 kg CO2e/tonne-km = 0.002736 kg CO2e
- **Total Scope 3 Emissions:** 0.216 + 0.0123 + 0.015 + 0.002736 = 0.246036 kg CO2e

4.3 Total Product Carbon Footprint (PCF) Summary

GHG Scope	Description	Emissions (kg CO2e per functional unit)
Scope 1	Direct Emissions from Owned/ Controlled Sources	0.00000
Scope 2	Purchased Electricity (Manufacturing in India)	0.05816
Scope 3	Category 1: Purchased Goods and Services (Materials)	0.24330
Scope 3	Category 9: Downstream Transportation and Distribution (Sea Freight)	0.00274
TOTAL PRODUCT CARBON FOOTPRINT (PCF)		**0.30420**

Note: Values rounded to five decimal places for final total, individual components may show more precision.

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5. Review & Report

5.1 Hotspots Identification

The analysis reveals the following key emission hotspots for the leesbril (reading glasses):

- **Material Production (Scope 3, Category 1):** This is the most significant hotspot, primarily driven by the production of plastic (polycarbonate) for frames and lenses. Polycarbonate has a relatively high emission factor per kilogram. The upstream impacts of stainless steel production also contribute, albeit to a lesser extent due to smaller quantities used.
- **Manufacturing Energy (Scope 2):** Electricity consumption during the injection molding and assembly processes in India contributes substantially, reflecting the carbon intensity of the Indian electricity grid.
- **Downstream Transportation (Scope 3, Category 9):** While sea freight is generally the most carbon-efficient mode for long distances, the 3,000 km journey from India to Europe still represents a notable contribution to the overall PCF.

5.2 Reliability and Limitations

The reliability of this PCF analysis is contingent on several factors:

- **Secondary Data Reliance:** The analysis relies on industry-average emission factors and estimated material/energy inputs. Actual emissions could vary if primary, supplier-specific data were available.
- **Geographic Specificity:** While India\'s electricity grid factor is specific, global average emission factors are used for some materials, which may not perfectly reflect the specific supply chain for every component.
- **System Boundary:** The \'factory_gate\' boundary, even with extended transport, excludes consumer use and end-of-life, which could add further emissions (e.g., waste treatment,

recycling impacts) if a \'cradle-to-grave\' assessment were performed.

5.3 GHG Protocol Adherence & 2026 LSR Update

- This report strictly adheres to the GHG Protocol\'s classification of emissions into Scope 1, Scope 2, and Scope 3, ensuring a comprehensive view of direct and indirect impacts.
- **2026 LSR Update (Land Sector and Removals Standard):** For a product like leesbril, primarily composed of plastics and metals, direct land use change or carbon removals at the factory site are not significant. The land sector impacts associated with the extraction and processing of raw materials (e.g., fossil fuels for plastics, mining for metals) are typically embedded within the upstream emission factors of these materials (Scope 3, Category 1). Therefore, no specific LSR calculations are performed beyond what is inherently covered in the material emission factors. If bio-based materials with significant land-use change impacts were used, a more detailed LSR assessment would be necessary.
- **Scope 3 Compliance:** By covering all major material inputs (plastics, metals, packaging) and key transportation links (sea freight), alongside manufacturing energy, this analysis achieves significant coverage of Scope 3 emissions, aiming for at least 95% of relevant value chain emissions as per anticipated 2026 requirements.

5.4 Recommendations for Reduction

To reduce the carbon footprint of the leesbril, the following areas should be prioritized:

- **Material Optimization:**
    - Explore the use of recycled plastics (e.g., recycled polycarbonate) for frames and lenses, which can significantly reduce the material\'s carbon footprint.

    - Investigate alternative, lower-impact materials or design for material efficiency (e.g., thinner frames, lighter lenses).
    - Source packaging made from higher recycled content cardboard.
- **Manufacturing Efficiency:**
    - Implement energy efficiency measures at the manufacturing facility in India to reduce electricity consumption per unit.
    - Explore sourcing renewable energy for manufacturing operations to reduce Scope 2 emissions (e.g., on-site solar, purchase of Renewable Energy Certificates).
- **Logistics Optimization:**
    - While sea freight is efficient, optimizing container loading (maximizing fill rates) can further reduce emissions per unit.
    - Consider sourcing components from closer regions if feasible and economically viable, to reduce upstream transport emissions.