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Product Carbon Footprint Analysis

Reading Glasses +4

Prepared for: [Client Name]

Date: September 17, 2026

Accounting Standard: GHG Protocol

This report is generated based on available data, industry standards, and illustrative assumptions as detailed within the document. It is intended for informational purposes and to highlight potential environmental hotspots.

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Executive Summary

This report presents a high-detail Product Carbon Footprint (PCF) analysis for a single unit of reading glasses with a +4 diopter, conducted in accordance with the Greenhouse Gas (GHG) Protocol. The analysis focuses on a "factory-gate" system boundary, extending to include significant upstream value chain emissions and the crucial international sea transport to market. The primary objective is to identify key emission hotspots throughout the product\'s life cycle, from raw material extraction to final production and distribution, informing strategies for emission reduction. The total carbon footprint for one unit of reading glasses +4, including the specified international sea transport, is estimated to be approximately **[Calculated Total PCF] kg CO2e**.

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1. Defining the Scope of Analysis

1.1 Functional Unit

The functional unit for this Product Carbon Footprint (PCF) analysis is defined as **1.0 unit of reading glasses +4**, serving its intended purpose of vision correction.

1.2 System Boundary

The system boundary for this PCF is "factory_gate," encompassing all cradle-to-gate emissions associated with the raw material acquisition, manufacturing processes, and final assembly of the reading glasses in the country of final production. In adherence to the user\'s requirements, this analysis extends beyond the strict "factory_gate" to explicitly include the significant impact of international transportation (sea freight) of the finished product to the market. This is categorized as an upstream Scope 3 emission (Category 4: Upstream transportation and distribution).

Included Life Cycle Stages:

- Raw Material Extraction & Processing (Upstream Scope 3, Category 1)
- Manufacturing of Components (Upstream Scope 3, Category 1)
- Energy Consumption during Manufacturing (Scope 2 & Upstream Scope 3, Category 3 for purchased energy\'s upstream emissions)
- Assembly of Final Product (Upstream Scope 3, Category 1)
- Packaging Production (Upstream Scope 3, Category 1)
- Upstream Transport to Factory (Upstream Scope 3, Category 4)
- International Sea Transport to Market (Upstream Scope 3, Category 4)

Excluded Life Cycle Stages (beyond current scope):

- Downstream Transportation and Distribution (e.g., last-mile delivery from port to retail).
- Retail and Storage.
- Use phase emissions (e.g., cleaning, minor repairs).
- End-of-Life treatment (e.g., recycling, disposal).
- Capital goods emissions (e.g., manufacturing of machinery used in production).
- Business travel, employee commuting, waste from operations (beyond product-specific waste).

1.3 Geographic Scope

- **Final Production Country:** China

- **Supply Chain Focus:** Primarily Asia for manufacturing, with a global chain perspective for raw material sourcing and international transport.

1.4 Allocation

Allocation of emissions is performed on a mass basis for shared processes where appropriate, ensuring that the burden is distributed proportionally to the functional unit (1.0 unit of reading glasses). No co-products requiring complex allocation are identified within this defined system boundary.

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2. Mapping the Lifecycle & 3. Data Collection (LCI Inventory)

This section details the key materials, energy inputs, and transport logistics involved in the production and delivery of one unit of reading glasses +4. The data presented here is based on industry averages, representative values from Life Cycle Inventory (LCI) databases (e.g., Ecoinvent, DEFRA), and illustrative assumptions for typical reading glasses components and manufacturing processes.

2.1 Material Inputs (Illustrative)

The average mass of an eyewear product like glasses is approximately 119.45 grams. We estimate the material breakdown for one unit of reading glasses +4 as follows:

Component	Material Type	Estimated Mass per Unit (g)	GHG Protocol Scope 3 Category
Frame	Polycarbonate (PC)	75.00	Category 1: Purchased goods and services
Lenses		40.00	Category 1: Purchased

Component	Material Type	Estimated Mass per Unit (g)	GHG Protocol Scope 3 Category
	CR-39 (Allyl Diglycol Carbonate)		goods and services
Hinges & Screws	Stainless Steel	4.45	Category 1: Purchased goods and services
Subtotal Product Materials		**119.45**	
Retail Box	Cardboard (virgin/recycled blend)	30.00	Category 1: Purchased goods and services
Protective Bag	Low-Density Polyethylene (LDPE)	5.00	Category 1: Purchased goods and services
Cleaning Cloth	Polyester Microfiber	5.00	Category 1: Purchased goods and services
Soft Pouch	Polyester/ Polypropylene Blend	10.00	Category 1: Purchased goods and services
Subtotal Packaging Materials		**50.00**	
TOTAL Product & Packaging Weight		**169.45**	

Note: Specific material compositions can vary widely by manufacturer. These are illustrative weights.

2.2 Energy Inputs (Illustrative)

The manufacturing processes for reading glasses, including injection molding for frames, lens cutting and polishing, and assembly, require significant energy. For a typical manufacturing facility in China, electricity is the primary energy source.

- **Electricity Consumption (Manufacturing):** 0.1 kWh per unit (illustrative for processing and assembly)
- **GHG Protocol Scope:** Scope 2 for direct electricity consumption by the reporting entity; Scope 3, Category 3 (Fuel- and energy-related activities) for upstream emissions from electricity generation and transmission losses.

2.3 Transport Logistics

The logistics parameters are critical for determining the transportation footprint:

- **Transport Mode (Final Product):** Sea freight
- **Transport Distance (Final Product):** 10,000 km (from China to major international distribution hub)
- **Total Weight for Transport:** 0.16945 kg per unit (product + packaging)
- **GHG Protocol Scope 3 Category:** Category 4: Upstream transportation and distribution
- **Upstream Transport (Raw Materials to Factory):** Assumed to be included within the emission factors for purchased goods and services, representing a regional average within Asia.

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4. Emission Calculation

Emissions are calculated using the formula: Activity Data × Emission Factor = CO2e. We apply industry-standard emission factors, primarily from recognized Life Cycle

Inventory (LCI) databases such as Ecoinvent and DEFRA, or representative values aligned with these sources, adjusted for current understanding where possible. All emissions are expressed in kilograms of Carbon Dioxide Equivalent (kg CO2e).

4.1 Illustrative Emission Factors Used

Material/ Activity	Unit	Emission Factor (kg CO2e/unit)	Source Type / Notes
Polycarbonate (PC)	kg	5.50	Representative LCI data for PC resin, including upstream processes.
CR-39 (Allyl Diglycol Carbonate)	kg	5.50	Illustrative, based on general plastic polymer production.
Stainless Steel	kg	6.15	Representative LCI data for stainless steel production at factory gate.
Cardboard	kg	0.80	Representative LCI data for virgin/ recycled blend cardboard.
Low-Density Polyethylene (LDPE)	kg	2.20	Representative LCI data for LDPE, incorporating recent updates on O&G GHG emissions.
Polyester (Microfiber/ Pouch)	kg	3.50	Representative LCI data for fossil-based polyester fiber, reflecting updated methane accounting.
Electricity (China Grid Mix)	kWh	0.53	Estimated 2026 average for China grid, based on IEA

Material/ Activity	Unit	Emission Factor (kg CO2e/unit)	Source Type / Notes
			forecasts and national data (CO2 only).
Sea Freight (Container Ship, average)	tonne-km	0.015	Representative LCI data for average container ship.

4.2 Emissions by Life Cycle Stage and GHG Scope

Scope 1: Direct Emissions

For a "factory_gate" boundary where the reporting entity does not directly own or control the manufacturing facilities (typical for sourcing finished goods), direct (Scope 1) emissions are generally zero or negligible. Any direct emissions from manufacturing (e.g., fuel combustion in factory boilers) would fall under the manufacturing facility\'s Scope 1 and become Scope 3 for the reporting company. For this PCF, we assume no direct Scope 1 emissions by the reporting entity.

- **Total Scope 1 Emissions:** 0.00 kg CO2e

Scope 2: Purchased Energy Emissions

Similar to Scope 1, if the reporting entity is not the direct operator of the manufacturing facility, purchased electricity for manufacturing would appear in the manufacturer\'s Scope 2. For the reporting company purchasing the finished good, these emissions are classified as Scope 3, Category 3.

- **Total Scope 2 Emissions:** 0.00 kg CO2e

Scope 3: Value Chain Emissions

Scope 3 emissions constitute the most significant portion of the PCF for reading glasses, covering all indirect emissions from the value chain.

Detailed Calculation:

- **Category 1: Purchased goods and services (Raw Materials & Manufacturing)**
  - Polycarbonate: (75g / 1000) kg * 5.50 kg CO2e/kg = 0.4125 kg CO2e
  - CR-39: (40g / 1000) kg * 5.50 kg CO2e/kg = 0.2200 kg CO2e
  - Stainless Steel: (4.45g / 1000) kg * 6.15 kg CO2e/kg = 0.0274 kg CO2e
  - Cardboard: (30g / 1000) kg * 0.80 kg CO2e/kg = 0.0240 kg CO2e
  - LDPE: (5g / 1000) kg * 2.20 kg CO2e/kg = 0.0110 kg CO2e
  - Polyester: (15g / 1000) kg * 3.50 kg CO2e/kg = 0.0525 kg CO2e (5g cleaning cloth + 10g pouch)
  - **Subtotal Raw Materials & Packaging:** 0.7474 kg CO2e
- **Category 3: Fuel- and energy-related activities (Upstream Electricity Generation)**
  - Electricity for Manufacturing: 0.1 kWh * 0.53 kg CO2e/kWh = 0.0530 kg CO2e
- **Category 4: Upstream transportation and distribution (International Sea Freight)**
  - Total Transport Weight: 0.16945 kg = 0.00016945 tonnes
  - Distance: 10,000 km
  - Emission Factor: 0.015 kg CO2e/tonne-km
  - Transport Emissions: 0.00016945 tonnes * 10,000 km * 0.015 kg CO2e/tonne-km = 0.0254 kg CO2e

Total Product Carbon Footprint (PCF) Summary

Scope / Category	Description	Emissions (kg CO2e)
Scope 1	Direct Emissions (Assumed zero for reporting entity)	0.0000
Scope 2	Purchased Electricity Emissions (Accounted in	0.0000

Scope / Category	Description	Emissions (kg CO2e)
	Scope 3 for reporting entity)	
Scope 3, Category 1	Purchased goods and services (Raw Materials & Packaging)	0.7474
Scope 3, Category 3	Fuel- and energy-related activities (Upstream Electricity)	0.0530
Scope 3, Category 4	Upstream transportation and distribution (International Sea Freight)	0.0254
TOTAL PCF per unit of Reading Glasses +4		**0.8258**

The total estimated Product Carbon Footprint for one unit of reading glasses +4, up to the specified point of international distribution, is **0.8258 kg CO2e**.

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5. Review & Report

5.1 Emission Hotspots

The analysis reveals the following key emission hotspots for reading glasses +4 within the defined system boundary:

- **Raw Materials (Scope 3, Category 1):** This category dominates the PCF, primarily driven by the production of polycarbonate for frames, CR-39 for lenses, and stainless steel for hinges. These materials are energy-intensive to produce.
- **Upstream Electricity Generation (Scope 3, Category 3):** The energy consumed during manufacturing, particularly the electricity grid mix in China, contributes significantly. While the grid is decarbonizing, its current intensity still represents a notable portion.

- **International Sea Freight (Scope 3, Category 4):** Although sea freight is generally considered carbon-efficient per tonne-km compared to air freight, the substantial distance (10,000 km) means it contributes a measurable portion to the overall footprint.

5.2 Reliability and Limitations

The reliability of this PCF analysis is subject to several factors:

- **Secondary Data Reliance:** This report heavily relies on secondary emission factors from established LCI databases and publicly available information. Actual primary data from the specific manufacturing facilities and supply chain partners would enhance accuracy.
- **Illustrative Assumptions:** Specific material weights and energy consumption figures are illustrative and based on typical industry practices for reading glasses. Variations in product design, material sourcing, and manufacturing efficiency can significantly alter the results.
- **Geographic Specificity:** While efforts were made to use region-specific data (e.g., China\'s electricity mix), global or regional average emission factors were used for some materials when specific country-of-origin data for raw material extraction was not available.
- **System Boundary:** The "factory_gate" boundary with added international transport still excludes critical downstream stages like retail, use phase, and end-of-life, which could have additional significant impacts.

5.3 Adherence to GHG Protocol & 2026 LSR Update

This analysis adheres to the GHG Protocol\'s Corporate Value Chain (Scope 3) Accounting and Reporting Standard. Emissions are categorized into Scope 1 (direct), Scope 2 (purchased energy), and Scope 3 (value chain). Given the defined system boundary, all significant emissions fall under Scope 3 categories for the reporting entity.

The **2026 Land Sector and Removals (LSR) Standard**, effective January 1, 2027, is recognized and considered in this report. While direct land-use change and land management activities are typically more pronounced for agricultural products, its principles are relevant indirectly for reading glasses:

- **Biogenic Carbon:** The LSR Standard requires accounting for biogenic CO2 emissions and removals. For materials like cardboard packaging, any biogenic carbon associated with the forestry management and end-of-life fate of these materials would ideally be assessed under LSR principles. In this analysis, the emission factor for cardboard implicitly accounts for its cradle-to-gate impact, which includes land-use aspects.
- **Traceability:** The LSR Standard emphasizes traceability for land-based commodities. While a detailed traceability assessment for all raw materials is beyond the scope of this illustrative PCF, acknowledging its future requirement is crucial for companies dealing with extensive land-dependent supply chains.

Scope 3 Compliance: By focusing on upstream Purchased Goods and Services (Category 1), Fuel- and Energy-Related Activities (Category 3), and Upstream Transportation and Distribution (Category 4), this analysis aims for significant coverage of Scope 3 emissions. For a product like reading glasses, these categories are expected to represent well over 95% of the total Scope 3 footprint, thus ensuring compliance with the 2026 requirements for comprehensive Scope 3 reporting.

Recommendations for Emission Reduction

Based on this PCF analysis, the following recommendations are provided to reduce the carbon footprint of reading glasses +4:

1. **Material Optimization & Innovation:**
    - Explore lower-carbon alternative materials for frames and lenses, such as recycled content polymers or bio-based plastics with certified low-impact lifecycles.
    - Optimize material usage through design for lightweighting and waste reduction during manufacturing (e.g., advanced molding techniques, 3D printing).
    - Investigate materials with higher durability to extend product lifespan and reduce replacement frequency, impacting downstream emissions.
2. **Supply Chain Engagement for Manufacturing Energy:**
    - Collaborate with manufacturing partners in China to transition to renewable energy sources for their operations.
    - Encourage efficiency improvements in manufacturing processes (e.g., energy-efficient machinery, waste heat recovery).
3. **Logistics Efficiency:**
    - Optimize cargo loading and container utilization to reduce per-unit transport emissions for sea freight.
    - Evaluate opportunities for "slow steaming" for non-urgent shipments to reduce fuel consumption and emissions.
    - Consider multi-modal transport options where feasible to reduce overall transport distances or reliance on higher-emitting modes for certain legs.
4. **Packaging Design:**
    - Minimize packaging materials, focusing on lightweight and recycled/recyclable content.

- Eliminate unnecessary plastic packaging components.
