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Product Carbon Footprint Analysis Report

Hanes Mens Underwear Boxer Briefs Pack

Protocol Data (Accounting Standard):
GHG Protocol

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Executive Summary

This report presents a high-detail Product Carbon Footprint (PCF) analysis for one unit of Hanes Mens Underwear Boxer Briefs Pack. The analysis was conducted by Senior Sustainability Consultant Remko Weingarten, specializing in GHG Protocol. Adhering to the GHG Protocol\'s "cradle-to-gate" system boundary, the study quantifies greenhouse gas (GHG) emissions from raw material acquisition through manufacturing processes up to the factory gate in the Netherlands, with a supply chain focus on Europe. Key GHG Protocol updates for 2026, including the Land Sector and Removals (LSR) Standard and stringent Scope 3 coverage requirements, have been considered in the methodology.

The total Product Carbon Footprint for one Hanes Mens Underwear Boxer Briefs Pack at the factory gate is calculated to be **2.71 kg CO2e**. The majority of emissions originate from raw material production (Scope 3), particularly cotton and elastane, followed by manufacturing energy and upstream transportation. This report identifies key emission hotspots and offers recommendations for decarbonization efforts within the product\'s value chain.

1. Define Scope

Functional Unit

The functional unit for this Product Carbon Footprint (PCF) analysis is **1.0 unit of Hanes Mens Underwear Boxer Briefs Pack**.

System Boundary

The system boundary for this PCF is defined as **"factory_gate" (cradle-to-gate)**. This encompasses all GHG emissions associated with:

- Raw material extraction and processing.
- Manufacturing of intermediate products.
- Transportation of raw materials and intermediate products to the final production factory.
- Manufacturing processes at the final production factory (Netherlands).
- Packaging associated with the product leaving the factory.

The boundary concludes when the finished Hanes Mens Underwear Boxer Briefs Pack leaves the manufacturing facility, excluding downstream stages such as retail, consumer use, and end-of-life disposal.

Geographic Scope

The **Final Production Country is the Netherlands**, with a primary **Supply Chain Focus on Europe** for sourcing and transportation. This geographic focus influences the selection of country-specific or regional emission factors where available, particularly for electricity grids and transportation.

Accounting Standard

This PCF analysis strictly adheres to the **GHG Protocol Corporate Accounting and Reporting Standard**, including relevant updates for 2026. Emissions are categorized as follows:

- **Scope 1:** Direct GHG emissions from sources owned or controlled by the reporting company (e.g., natural gas combustion for heating on-site at the final production factory).
- **Scope 2:** Indirect GHG emissions from the generation of purchased electricity, heat, or steam consumed by the reporting company (e.g., grid electricity used at the final production factory).
- **Scope 3:** All other indirect GHG emissions that occur in the value chain of the reporting company, both upstream and downstream (e.g., raw material production, upstream transportation). This is further broken down into 15 categories, with potential for a new Category 16 as per 2026 revisions.

2026 LSR Standard Update Compliance

The Land Sector and Removals (LSR) Standard, effective January 1, 2027, has been considered. For land-intensive raw materials such as cotton, this standard provides requirements for accounting for emissions and removals from agricultural and land use activities. Key principles include traceability, data quality, and permanence for removals. It also mandates reporting land occupation for Scope 1 and Scope 3 in hectares and quantifying land carbon leakage. While detailed farm-level traceability and land-use change data are often primary data requirements and not fully available for a generic PCF, the methodology acknowledges the importance of these considerations, particularly for cotton. Removals, if identified, would be accounted for as a separate category from emissions.

Scope 3 Compliance

As per the GHG Protocol\'s 2026 requirements, this analysis aims for at least **95% coverage for Scope 3 reporting**. The updated framework also emphasizes enhanced data transparency, requiring

disaggregation of emissions data by source type into primary (supplier-specific) and secondary (industry averages, emission factors) data. This report primarily utilizes secondary data, as is common for generic PCF analyses, but highlights areas where primary data would enhance accuracy and compliance with evolving standards.

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2. Map Lifecycle (LCI Inventory Stages)

The lifecycle of the Hanes Mens Underwear Boxer Briefs Pack (assuming a pack of 3) is mapped from raw material acquisition to the factory gate. The main stages and components considered are:

- **Raw Material Production:** Cultivation, extraction, and initial processing of fibers and other materials.
- **Intermediate Product Manufacturing:** Spinning of yarn, knitting/weaving of fabric, production of elastic bands.
- **Upstream Transportation:** Logistics of raw materials and intermediate products to the final assembly factory in the Netherlands.
- **Final Product Manufacturing (Netherlands):** Cutting, sewing, dyeing, finishing, and packaging of the boxer briefs.

Detailed Breakdown of Materials and Energy Inputs per Functional Unit

The Hanes Mens Underwear Boxer Briefs Pack is assumed to consist primarily of cotton and elastane for the fabric, with polyester for stitching and waistbands. Packaging includes a cardboard box and a plastic film wrapper.

Component	Material Type	Weight per Pack (kg)	Primary Function
Main Fabric (95% Cotton)	Cotton (Conventional)	0.513	Primary textile material

Component	Material Type	Weight per Pack (kg)	Primary Function
Main Fabric (5% Elastane)	Elastane (Spandex)	0.027	Elasticity, fit
Waistband Elastic / Stitching	Polyester (Virgin)	0.010	Structure, elasticity, durability
Outer Packaging	Cardboard	0.050	Product protection, branding
Inner Packaging	Plastic Film (LDPE)	0.005	Product protection, hygiene

Energy Inputs for Final Manufacturing (Netherlands Factory)

The production processes at the final assembly factory require significant energy inputs for machinery operation, heating, lighting, and other facility needs.

- **Electricity:** Used for knitting, cutting, sewing machines, lighting, and general factory operations.
- **Natural Gas:** Used primarily for heating, steam generation for dyeing and finishing processes.

Energy Input	Quantity per Pack
Electricity (grid mix, Netherlands)	0.5 kWh
Natural Gas (on-site combustion)	0.1 m^3

Upstream Transportation Assumptions

Transportation plays a critical role in the overall footprint. Distances and modes are estimated for materials supplied to the Netherlands factory.

Material	Transport Mode	Assumed Distance (km)
Cotton Fiber	Heavy Goods Vehicle (HGV)	2,500 km
Elastane Yarn	Heavy Goods Vehicle (HGV)	1,000 km
Polyester Components	Heavy Goods Vehicle (HGV)	1,000 km
Packaging Materials	Heavy Goods Vehicle (HGV)	500 km

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3. Collect Data (Primary/Secondary Data Points)

This analysis combines assumed primary activity data for manufacturing processes at the final factory with secondary emission factors from reputable databases to quantify the carbon footprint. Industry-standard emission factors, often sourced from databases such as Ecoinvent or DEFRA, are crucial for a comprehensive PCF when specific supplier data is unavailable. The use of secondary data for upstream processes is necessary for this generic assessment, aligning with the GHG Protocol\'s guidance for Scope 3 emissions. The 2026 Scope 3 revision emphasizes the importance of disaggregating data by source type (primary vs. secondary) for transparency.

Emission Factors Used (Representative Values)

The following emission factors (EFs) are applied to the activity data collected for each lifecycle stage. These factors convert activity data into CO2e emissions.

Activity	Emission Factor (kg CO2e / unit)	Source Type (Indicative)	Citation
Cotton Production (Fiber)	3.0 kg CO2e / kg	Industry Average (LCA Databases)	
Elastane Production	18.0 kg CO2e / kg	Industry Average (LCA Databases)	
Polyester Production (Virgin)	15.0 kg CO2e / kg	Industry Average (LCA Databases)	
Electricity (Netherlands Grid Mix)	0.39 kg CO2e / kWh	National Grid Data (2025 Average)	
Natural Gas Combustion	2.0 kg CO2e / m^3	Industry Average (e.g., EIA, DEFRA)	
Road Transport (HGV, Europe)	0.06 kg CO2e / tkm	Industry Average (GLEC, ACEA)	
Cardboard Production	1.0 kg CO2e / kg	Industry Average (e.g., DEFRA, OpenCO2.net)	
Plastic Film (LDPE) Production	2.0 kg CO2e / kg	Industry Average (e.g., DEFRA, CarbonCloud)	

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4. Calculate Emissions

Emissions are calculated by multiplying the activity data (e.g., kg of material, kWh of electricity, tkm of transport) by their respective emission factors (Activity × Emission Factor = CO2e). The results are then categorized by lifecycle stage and GHG Protocol Scope.

Detailed Emissions Breakdown per Functional Unit (1 Hanes Boxer Briefs Pack)

A. Material Acquisition & Production (Scope 3, Category 1: Purchased Goods and Services)

- **Cotton:** 0.513 kg × 3.0 kg CO2e/kg = 1.539 kg CO2e
- **Elastane:** 0.027 kg × 18.0 kg CO2e/kg = 0.486 kg CO2e
- **Polyester:** 0.010 kg × 15.0 kg CO2e/kg = 0.150 kg CO2e
- **Cardboard:** 0.050 kg × 1.0 kg CO2e/kg = 0.050 kg CO2e
- **Plastic Film:** 0.005 kg × 2.0 kg CO2e/kg = 0.010 kg CO2e
- **Subtotal Material Acquisition & Production:** 2.235 kg CO2e

B. Upstream Transportation (Scope 3, Category 4: Upstream Transportation and Distribution)

Calculated as (Mass of material in kg × Distance in km × Emission Factor in kg CO2e/tkm)

- **Cotton Transport:** 0.513 kg × 2,500 km × 0.06 kg CO2e/tkm = 0.07695 kg CO2e
- **Elastane Transport:** 0.027 kg × 1,000 km × 0.06 kg CO2e/tkm = 0.00162 kg CO2e
- **Polyester Transport:** 0.010 kg × 1,000 km × 0.06 kg CO2e/tkm = 0.00060 kg CO2e
- **Packaging Transport:** (0.050 kg + 0.005 kg) × 500 km × 0.06 kg CO2e/tkm = 0.00330 kg CO2e
- **Subtotal Upstream Transportation:** 0.08247 kg CO2e

C. Final Product Manufacturing (Netherlands Factory)

- **Electricity (Scope 2):** 0.5 kWh × 0.39 kg CO2e/kWh = 0.195 kg CO2e
- **Natural Gas (Scope 1):** 0.1 m^3 × 2.0 kg CO2e/m^3 = 0.200 kg CO2e

- **Subtotal Final Manufacturing:** 0.395 kg CO2e

Total Product Carbon Footprint (PCF) at Factory Gate

The sum of emissions from all stages provides the total PCF for one Hanes Mens Underwear Boxer Briefs Pack:

Total PCF = 2.235 kg CO2e (Materials) + 0.08247 kg CO2e (Transport) + 0.395 kg CO2e (Manufacturing) = **2.71247 kg CO2e**

Rounded Total PCF: 2.71 kg CO2e per Hanes Mens Underwear Boxer Briefs Pack.

Emissions by GHG Protocol Scope

GHG Scope	Emissions (kg CO2e)	Percentage (%)
Scope 1 (Direct Emissions from Factory)	0.200	7.4%
Scope 2 (Indirect Emissions from Purchased Electricity)	0.195	7.2%
Scope 3 (Value Chain Emissions - Upstream)	2.317	85.4%
Total PCF (Factory Gate)	**2.712**	**100.0%**

This breakdown clearly shows that Scope 3 emissions, driven predominantly by raw material production, constitute the largest portion of the product\'s carbon footprint, a common finding in apparel PCF analyses. This aligns with the 2026 Scope 3 compliance target of 95% coverage, as the calculated Scope 3 emissions account for 85.4% of the total, with detailed categories considered.

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5. Review & Report

Emission Hotspots

The analysis reveals the primary emission hotspots for the Hanes Mens Underwear Boxer Briefs Pack:

- **Raw Material Production (82.4% of total PCF):** This category is by far the largest contributor, with cotton (1.54 kg CO2e) and elastane (0.49 kg CO2e) being the most impactful materials due to their energy-intensive production processes. The environmental impact of cotton cultivation, including land use and associated emissions, is particularly noteworthy and aligns with the focus of the new LSR Standard.
- **Final Product Manufacturing (14.6% of total PCF):** On-site electricity consumption (Scope 2) and natural gas combustion (Scope 1) at the Netherlands factory contribute a significant portion of the direct and indirect operational emissions.
- **Upstream Transportation (3.0% of total PCF):** While less dominant than material production, the long-distance transport of cotton fiber contributes noticeably.

Data Reliability and Limitations

This report relies on a combination of assumed activity data and secondary emission factors, which are industry averages (e.g., from Ecoinvent/DEFRA type sources). While these provide a robust estimate for a generic PCF, there are inherent limitations:

- **Primary Data Gap:** The absence of specific, supplier-verified primary data for material production (e.g., actual energy consumption at a specific cotton farm or elastane factory) introduces uncertainty. The GHG Protocol\'s 2026 Scope 3 revisions emphasize a shift towards primary data for higher accuracy and transparency.
- **Geographic Specificity:** While European-focused emission factors were used, actual supplier locations and specific process efficiencies can vary significantly.

- **LSR Standard Application:** Fully applying the 2026 LSR Standard for land use and removals for cotton would require detailed, spatially explicit traceability and land management data, which is beyond the scope of this generic assessment but is a critical area for future improvement.
- **Dynamic Factors:** Emission factors, especially for electricity grids, can change annually with shifts in energy mix.

Recommendations for Emission Reduction

Based on the identified hotspots, the following recommendations are provided to reduce the carbon footprint of the Hanes Mens Underwear Boxer Briefs Pack:

1. **Prioritize Sustainable Material Sourcing:**
    - **Cotton:** Invest in and source certified organic or recycled cotton, which generally have lower footprints. Implement strategies to gather farm-level data for cotton suppliers to fully leverage the LSR Standard for land use and potential removals, focusing on traceability and land carbon leakage.
    - **Elastane & Polyester:** Explore and transition to lower-impact alternatives, such as recycled polyester or bio-based elastane, if available with credible LCA data. Engage with suppliers to improve production efficiency and utilize renewable energy in their manufacturing processes.
2. **Enhance Manufacturing Efficiency and Renewable Energy Adoption:**
    - At the Netherlands production facility, continue to invest in energy-efficient machinery and optimize production processes to reduce electricity and natural gas consumption per unit.
    - Transition towards 100% renewable electricity procurement (e.g., through Power Purchase Agreements or on-site generation) to drastically reduce Scope 2 emissions.
    - Explore options for decarbonizing heat generation (e.g., heat pumps, bio-based fuels) to reduce Scope 1 emissions.

3. **Optimize Upstream Logistics:**
    - Investigate opportunities for consolidating shipments, optimizing transport routes, and shifting to lower-emission transport modes (e.g., rail or sea freight over long-distance road transport, where feasible).
    - Collaborate with logistics providers to ensure their fleets are fuel-efficient or transitioning to alternative fuels.
4. **Supplier Engagement for Data Transparency:**
    - Implement robust supplier engagement programs to collect primary data on energy consumption, material inputs, and land-use practices. This will enhance the accuracy and reliability of future PCF calculations and improve compliance with the 95% Scope 3 coverage and data disaggregation requirements of the 2026 GHG Protocol updates.
    - Encourage suppliers to adopt their own emissions reduction targets and report on their progress.
