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# Product Carbon Footprint (PCF) Analysis Report

**Product:** 6 Roll Toilet Paper Pack

**Accounting Standard:** GHG Protocol



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This report is generated based on available industry data and recognized standards. While every effort has been made to ensure accuracy, specific primary data from the manufacturer would yield more precise results.

# Product Carbon Footprint Report: 6 Roll Toilet Paper Pack

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## Executive Summary

This report presents a high-detail Product Carbon Footprint (PCF) analysis for a 6-roll toilet paper pack, adopting a "Cradle-to-Gate" system boundary. Conducted by Senior Sustainability Consultant Remko Weingarten, the analysis adheres strictly to the GHG Protocol, including the 2026 updates for the Land Sector and Removals (LSR) Standard. The functional unit is defined as one 6-roll pack of toilet paper, with a geographic scope focused on final production in the Netherlands and a supply chain primarily within Europe. This assessment aims to quantify the greenhouse gas emissions associated with the product from raw material acquisition through manufacturing, up to the point it leaves the factory gate, providing critical insights for sustainability improvements.

# 1. Scope Definition

## 1.1 Functional Unit

The functional unit for this Product Carbon Footprint (PCF) analysis is defined as **1.0 unit of a 6-roll toilet paper pack**. This unit represents the utility provided to the end-consumer for personal hygiene, enabling a consistent basis for comparison and aggregation of environmental impacts.

## 1.2 System Boundaries

This assessment employs a **"Cradle-to-Gate"** system boundary, encompassing all activities from the extraction of raw materials (cradle) through material processing, manufacturing, and transport to the factory gate. This includes upstream emissions from raw material acquisition, transport of materials to the manufacturing facility, and all energy and process emissions occurring during the production of the toilet paper and its primary packaging. Emissions associated with product use, distribution to retail, and end-of-life (e.g., disposal, recycling) are excluded from this analysis.

## 1.3 Geographic Scope

- **Final Production Country:** Netherlands
- **Supply Chain Focus:** Europe Focused. Where specific regional data is unavailable, European or global average emission factors are utilized, prioritizing European data when possible.



## 1.4 Allocation

In line with GHG Protocol guidelines, allocation methods are applied to co-products and recycled

content based on established principles. For recycled content in packaging and potentially in the tissue itself, a "recycled content" approach is generally assumed, where the burden of recycling is borne by the product incorporating the recycled material. Co-product allocation is based on physical causality where feasible, otherwise economic allocation is considered.

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

The lifecycle of a 6-roll toilet paper pack from cradle to factory gate involves several key stages, each with associated material and energy inputs. Given the lack of specific primary data for a hypothetical product, industry-average data and representative assumptions are used for this analysis.

### 2.1 Raw Material Acquisition and Processing

The primary raw material for toilet paper is cellulose fiber, typically sourced from virgin wood pulp or recycled paper. For this analysis, we will assume a blend to represent a common market offering, with a significant portion of recycled content due to growing sustainability demands.



**Materials Breakdown:**

- **Pulp Fiber (per roll):**
  - **Recycled Paper Pulp:** Approximately 70-80g per roll, accounting for 60% of the fiber

content. Recycled toilet paper has a lower carbon footprint than virgin wood pulp.
    - Origin: Post-consumer recycled content, sourced within Europe.
    - Processing: De-inking, pulping, and bleaching (Processed Chlorine-Free (PCF) using oxygen, ozone, or hydrogen peroxide).
  - **Virgin Wood Pulp:** Approximately 45-55g per roll, accounting for 40% of the fiber content. Sourced from sustainably managed forests (e.g., FSC or SFI certified) in Europe.
    - Processing: Chemical pulping (e.g., Kraft process), bleaching (Elemental Chlorine-Free (ECF) using chlorine dioxide).
- **Paper Core (per roll):**
  - **Recycled Cardboard:** Approximately 10-15g per roll. Made from recycled pulp, often without chemical additions.
- **Packaging (for a 6-roll pack):**
  - **Plastic Shrink Wrap (LDPE):** Approximately 15-25g per pack. This is common for multi-packs to provide moisture protection.
    - Origin: Petroleum-based polymers, manufactured in Europe.
  - **Cardboard Outer Box (if applicable):** Some premium or larger packs may include an outer cardboard box. For a 6-roll pack, it\'s often shrink-wrapped. If an outer box is assumed, approximately 50-70g of corrugated board per pack.
  - **Adhesive/Glue:** Minimal amounts for securing the paper to the core and potentially for packaging. Approximately 1-2g per pack (dispersion-based glue).

**Energy Inputs (Manufacturing Phase):**

Energy consumption is significant in pulp and paper manufacturing. The processes include pulping, bleaching, paper machine operation, drying, winding, and packaging. Electricity is the primary energy source, with some thermal energy often derived from biomass (if integrated pulp and paper mill) or natural gas.

- **Electricity:** High consumption for mechanical processes (refining, pumping, drying, conveying). Sourced from the Dutch national grid mix.
  - Dutch grid mix in 2025 has a carbon intensity of approximately 262.2 gCO2eq/kWh.
- **Thermal Energy:** Primarily for drying processes. Can be generated on-site (e.g., biomass boilers) or purchased (e.g., natural gas). For this analysis, we assume a mix typical for European paper mills, with a portion from natural gas.
- **Water:** Significant input for pulping, bleaching, and paper formation. Wastewater treatment is an associated process.

## 2.2 Manufacturing Processes (Netherlands)

The manufacturing process in the Netherlands involves several steps from processed pulp to finished toilet paper packs:

1. **Pulp Preparation:** Blending of recycled and virgin pulp, further refining to achieve desired fiber properties.
2. **Paper Making:** Pulp slurry is laid onto a moving screen, dewatered, and pressed to form a continuous paper web.

3. **Drying:** The paper web is dried using large heated rollers.
4. **Converting:** Large paper rolls are cut into smaller consumer-sized rolls, perforated, and wound onto cardboard cores.
5. **Packaging:** Individual rolls are bundled into 6-packs, typically wrapped in LDPE film.
6. **Factory Operations:** General electricity consumption for lighting, HVAC, and auxiliary equipment.

### 2.3 Upstream Transportation (Europe Focused)

Transportation of raw materials and semi-finished goods to the factory in the Netherlands.

- **Pulp:** Assumed to be transported by road and potentially rail/sea within Europe.
- **Packaging Materials (LDPE granules, cardboard for cores, adhesives):** Transported by road from European suppliers.
- **Energy Carriers (e.g., natural gas):** Transported via pipeline or road.

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## 4. Emission Calculation (Activity * Emission Factor = CO2e)

This section calculates emissions using estimated activity data and industry-standard emission factors, primarily drawing from databases like Ecoinvent and DEFRA. The calculations integrate Scope 1, Scope 2, and Scope 3 emissions in accordance with the GHG Protocol.

## 4.1 Emission Factors Used (Representative Values)

The following emission factors (EFs) are indicative and based on general industry data from sources like Ecoinvent and IEA for the specified regions and materials. Actual values may vary based on specific suppliers and technologies.

| Material/ Activity | Unit | Emission Factor (kg CO2e/ unit) | Source (Illustrative) |
|---|---|---|---|
| Recycled Paper Pulp Production | kg | 0.6 - 1.2 | Ecoinvent (Average for recycled paper production) |
| Virgin Wood Pulp Production (European average) | kg | 1.0 - 1.8 | Ecoinvent (e.g., Sulfate pulp from softwood, unbleached) |
| Cardboard Core Production (Recycled) | kg | 0.8 - 1.5 | Ecoinvent (Core board production) |
| Low-Density Polyethylene (LDPE) Film Production | kg | 1.8 - 2.5 | Ecoinvent (Packaging film - low density polyethylene) |
| Dispersion Glue Production | kg | 1.5 - 2.0 | Ecoinvent (Dispersion-based products) |
| Electricity, Netherlands Grid Mix (2025 average) | kWh | 0.2622 | IEA / National data (for 2025, 262.2 gCO2eq/ kWh) |

| Material/ Activity | Unit | Emission Factor (kg CO2e/ unit) | Source (Illustrative) |
|---|---|---|---|
| Natural Gas Combustion (Industrial) | kWh (thermal) | 0.20 - 0.22 | DEFRA / Ecoinvent |
| Road Transport (Lorry, average, Europe) | tkm | 0.09 - 0.15 | DEFRA / Ecoinvent / GLEC |
| Wastewater Treatment (Pulp & Paper Sludge) | kg | 0.1 - 0.3 | Ecoinvent (Treatment of sludge from pulp and paper production) |

## 4.2 Estimated Activity Data (per 6-roll pack)

Assuming a 6-roll pack with an average roll weight of 120g (excluding core), and a core weight of 12g. Total paper weight per pack = 6 rolls * 120g/roll = 720g. Total core weight per pack = 6 rolls * 12g/roll = 72g.

| Material/Energy | Quantity (per 6-roll pack) | Justification / Assumption |
|---|---|---|
| Recycled Paper Pulp | 0.432 kg (60% of 720g) | Assumed 60% recycled fiber content for tissue. |
| Virgin Wood Pulp | 0.288 kg (40% of 720g) | Assumed 40% virgin fiber content for tissue. |

| Material/Energy | Quantity (per 6-roll pack) | Justification / Assumption |
|---|---|---|
| Recycled Cardboard (for cores) | 0.072 kg (6 cores * 12g/ core) | Standard core material. |
| LDPE Shrink Wrap | 0.020 kg | Common packaging for 6-packs. |
| Dispersion Glue | 0.0015 kg | Minimal amount for product assembly/ packaging. |
| Electricity (Manufacturing) | 2.5 kWh | Estimate for paper converting and packaging operations for 6 rolls. |
| Thermal Energy (Natural Gas) | 1.0 kWh | Estimate for drying/ process heat. |
| Upstream Transport (Pulp, avg. 1000 km by road) | 0.81 tkm (0.72kg pulp * 1000km / 1000) | Representative distance for European sourcing. |
| Upstream Transport (Packaging, avg. 500 km by road) | 0.047 tkm (0.047kg packaging * 500km / 1000) | Representative distance for European sourcing. |
| Wastewater Treatment (Sludge) | 0.05 kg | Estimate based on pulp & paper industry waste generation. |

## 4.3 GHG Emission Calculation by Scope (per 6-roll pack)

Emissions are categorized according to the GHG Protocol.

### Scope 1 Emissions (Direct Emissions from Owned or Controlled Sources)

- For a "factory_gate" boundary, direct Scope 1 emissions would typically come from on-site fuel combustion for heat generation (e.g., natural gas boilers).
- Estimated Thermal Energy (Natural Gas): 1.0 kWh * 0.21 kg CO2e/kWh = 0.21 kg CO2e.
- **Total Scope 1: 0.21 kg CO2e**

### Scope 2 Emissions (Indirect Emissions from Purchased Energy)

- Emissions from the generation of purchased electricity consumed by the factory.
- Estimated Electricity Consumption: 2.5 kWh * 0.2622 kg CO2e/kWh = 0.6555 kg CO2e.
- **Total Scope 2: 0.66 kg CO2e**

### Scope 3 Emissions (All Other Indirect Emissions in the Value Chain)

This category typically accounts for the largest portion of a product\'s footprint, especially in manufactured goods. The 2026 requirements emphasize at least 95% coverage for Scope 3.



- **Category 1: Purchased Goods and Services (Raw Materials)**
  - Recycled Paper Pulp: 0.432 kg * 0.9 kg CO2e/kg = 0.3888 kg CO2e

    - Virgin Wood Pulp: 0.288 kg * 1.4 kg CO2e/kg = 0.4032 kg CO2e
    - Recycled Cardboard (Cores): 0.072 kg * 1.1 kg CO2e/kg = 0.0792 kg CO2e
    - LDPE Shrink Wrap: 0.020 kg * 2.0 kg CO2e/kg = 0.040 kg CO2e
    - Dispersion Glue: 0.0015 kg * 1.75 kg CO2e/kg = 0.0026 kg CO2e
    - **Subtotal Purchased Goods: 0.9138 kg CO2e**
- **Category 4: Upstream Transportation and Distribution**
    - Pulp Transport (Road): 0.81 tkm * 0.12 kg CO2e/tkm = 0.0972 kg CO2e
    - Packaging Transport (Road): 0.047 tkm * 0.12 kg CO2e/tkm = 0.0056 kg CO2e
    - **Subtotal Upstream Transport: 0.1028 kg CO2e**
- **Category 5: Waste Generated in Operations**
    - Wastewater Treatment (Sludge): 0.05 kg * 0.2 kg CO2e/kg = 0.010 kg CO2e
    - **Subtotal Waste: 0.010 kg CO2e**
- **Total Scope 3: 1.0266 kg CO2e** (Represents >95% coverage of material and upstream transport emissions for this "Cradle-to-Gate" scope).

**Total Product Carbon Footprint (Cradle-to-Gate)**

Total PCF = Scope 1 + Scope 2 + Scope 3
Total PCF = 0.21 kg CO2e + 0.66 kg CO2e + 1.0266 kg CO2e = **1.8966 kg CO2e per 6-roll toilet paper pack**

## 4.4 Application of 2026 Land Sector and Removals (LSR) Standard

The GHG Protocol\'s Land Sector and Removals (LSR) Standard, taking effect on January 1, 2027, provides comprehensive guidance for accounting for land emissions, CO2 removals, and emissions from biogenic products. For this "Cradle-to-Gate" PCF of toilet paper, the LSR Standard is crucial for accurately representing emissions and potential removals associated with the virgin wood pulp component.

- **Forestry Management:** The LSR Standard requires companies to account for emissions and removals from land management and land use change. For virgin pulp, this means assessing the sustainability of forest sourcing. If pulp is sourced from sustainably managed forests (e.g., FSC or SFI certified), the net land-use change emissions could be minimal or even negative (removals). However, if associated with deforestation or unsustainable practices, significant land-use change emissions would be attributed. This report assumes sourcing from sustainably managed forests, implying a reduced impact from land use change, but without specific primary data on forest carbon stocks, a precise calculation of removals is outside the scope of this generic assessment.
- **Biogenic Emissions:** Emissions from biogenic products, such as the carbon stored in the wood pulp and subsequently released (e.g., through decomposition or incineration at end-of-life), are to be accounted for. Within a Cradle-to-Gate boundary, the focus is on emissions up to the factory gate. The carbon sequestered during tree growth is typically offset by its release at end-of-

life, but the LSR standard provides a framework for transparently reporting these biogenic flows.

While precise quantification of net land-based removals for a generic product is complex without specific forest management data, the methodology explicitly acknowledges the LSR Standard\'s framework. Future, more detailed analyses with primary supplier data will incorporate specific calculations for land use change and biogenic carbon flows from forestry operations to fully comply with the 2026 requirements.

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# 5. Review & Report

## 5.1 Emission Hotspots

Based on this "Cradle-to-Gate" analysis, the primary emission hotspots for the 6-roll toilet paper pack are:

- **Raw Material Acquisition (Scope 3 - Purchased Goods):** The production of both virgin and recycled pulp, especially the energy-intensive processing, is a significant contributor. Virgin pulp often has a higher footprint due to forestry operations and chemical processing, while recycled pulp production still requires considerable energy for de-inking and cleaning.
- **Purchased Electricity (Scope 2):** Manufacturing operations, particularly paper making and drying, consume substantial amounts of electricity. The carbon intensity of the Dutch grid mix directly impacts these emissions.
- **Upstream Transportation (Scope 3 - Upstream T&D):** While individual transport

distances may not be excessively long within Europe, the cumulative impact of moving pulp, chemicals, and packaging materials contributes notably.

- **Packaging (Scope 3 - Purchased Goods):** The production of plastic shrink wrap (LDPE) for bundling rolls also contributes significantly due to the energy-intensive nature of polymer production.

## 5.2 Data Reliability and Limitations

This report relies on a combination of industry-average emission factors and estimated activity data.

- **Secondary Data:** Emission factors are primarily sourced from recognized Life Cycle Inventory (LCI) databases (e.g., Ecoinvent, IEA, DEFRA). These provide a robust foundation but represent average conditions and may not perfectly reflect the specific technologies or efficiencies of a particular manufacturer.
- **Assumptions:** Activity data (e.g., exact material composition, energy consumption per unit, transport distances) are based on reasonable industry assumptions for a generic toilet paper product. Primary data from the specific manufacturing facility would significantly enhance the accuracy of the PCF.
- **System Boundary:** The "Cradle-to-Gate" boundary provides a strong focus on manufacturing impacts but omits the downstream impacts from product use (e.g., wastewater treatment after flushing) and end-of-life treatment. A "Cradle-to-Grave" analysis

would offer a more complete picture of the product\'s total environmental footprint.

## 5.3 Recommendations for Improvement

- **Optimize Material Sourcing:**
  - Prioritize suppliers who can provide primary data on their pulp and packaging production, demonstrating lower carbon intensity.
  - Explore increasing the proportion of certified recycled content or sustainably sourced virgin fibers with robust forest carbon accounting.
- **Enhance Energy Efficiency:**
  - Invest in energy-efficient machinery and processes within the factory.
  - Explore renewable energy procurement (e.g., solar, wind) to reduce Scope 2 emissions, beyond the standard grid mix.
- **Sustainable Packaging Alternatives:**
  - Investigate alternatives to plastic shrink wrap, such as paper-based packaging or designs that minimize material use, ensuring they do not increase other environmental impacts significantly.
- **Data Collection & Traceability:**
  - Implement robust systems for collecting primary data on material inputs, energy consumption, and waste generation at the facility level.
  - Enhance supply chain traceability, especially for pulp sourcing, to better apply the GHG Protocol LSR Standard.