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Product Carbon Footprint Analysis Report

For the product: tqknyxznuv (Smart IoT Sensor)

Company Name: mnpwypoyli

Senior Sustainability Consultant: udyeypoqzo

Accounting Standard: GHG Protocol

Disclaimer: This report is generated based on available data and industry standards, providing an estimate of the Product Carbon Footprint. Actual emissions may vary based on specific operational details and real-time data not explicitly provided.

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Executive Summary

This report presents a high-detail Product Carbon Footprint (PCF) analysis for the "Smart IoT Sensor" (tqknyxznuv) manufactured by mnpwypoyli. Conducted by udyeypoqzo, Senior Sustainability Consultant, this analysis adheres strictly to the GHG Protocol and incorporates the 2026 Land Sector and Removals (LSR) Standard update, along with a commitment to at least 95% coverage for Scope 3 emissions. The total estimated Product Carbon Footprint for one functional unit of the Smart IoT Sensor is 26.55 kg CO_2e. Key emission hotspots identified include the production phase energy consumption and last-mile logistics, highlighting critical areas for potential decarbonization efforts.

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1. Introduction

In response to increasing demands for environmental accountability and transparency, mnpwypoyli has commissioned this Product Carbon Footprint (PCF) analysis for its "Smart IoT Sensor" (tqknyxznuv). This assessment is performed by udyeypoqzo, a Senior Sustainability Consultant specializing in GHG Protocol. The objective is to quantify the greenhouse gas (GHG) emissions associated with the product\'s entire lifecycle, providing crucial insights for sustainability strategy, supply chain optimization, and regulatory compliance. The analysis explicitly follows the GHG Protocol as the accounting standard.

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2. Methodology

The Product Carbon Footprint analysis follows a robust methodology, aligned with international best practices and the specific requirements of the GHG Protocol.

2.1. Five-Step Approach:

1. **Define Scope:** Establishment of the functional unit, system boundaries, geographic scope, and allocation rules.
2. **Map Lifecycle (LCI Inventory Stages):** Identification of all relevant processes and flows throughout the product\'s life cycle.
3. **Collect Data:** Gathering of primary and secondary data points for material inputs, energy consumption, transport, and waste.
4. **Calculate Emissions:** Quantification of GHG emissions by multiplying activity data with appropriate emission factors (Activity × Emission Factor = CO_2e).
5. **Review & Report:** Identification of emission hotspots, assessment of data reliability, and presentation of findings.

2.2. GHG Protocol Adherence:

Emissions are systematically categorized into the three scopes as defined by the GHG Protocol:

- **Scope 1:** Direct GHG emissions from sources owned or controlled by the company (e.g., fuel combustion in owned vehicles or facilities). In this analysis, Scope 1 direct emissions from the production process are considered negligible or integrated into overall energy intensity for simplicity, as per available data.

- **Scope 2:** Indirect GHG emissions from the generation of purchased electricity, steam, heating, or cooling consumed by the company.
- **Scope 3:** All other indirect emissions that occur in the value chain of the reporting company, both upstream and downstream. This analysis ensures at least 95% coverage for Scope 3 reporting, in line with 2026 requirements, for a comprehensive view of value chain impacts.

2.3. 2026 LSR Update:

The Land Sector and Removals (LSR) Standard for land use and carbon removals has been applied, acknowledging the growing importance of land-based emissions and removals in comprehensive GHG accounting. While specific land-use changes directly attributable to the product\'s bill of materials or processes were not detailed in the provided data, the framework for including such considerations in future analyses is integrated.

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3. Scope Definition

The precise definition of the study\'s scope is fundamental to ensure accuracy and comparability of the PCF results.

- **Functional Unit:** 1.0 unit of "Smart IoT Sensor" (tqknyxznuv). This represents the quantified performance of the product for which the PCF is calculated.
- **System Boundary:** factory gate. This "cradle-to-gate" boundary for initial assessment encompasses raw material acquisition, pre-processing, and manufacturing up to the point the product leaves the factory. However, for a holistic PCF, the analysis extends to "cradle-to-grave" covering

transport, use phase, and end-of-life, explicitly categorizing these as Scope 3 downstream emissions.

- **Geographic Scope:** Final Production Country: China, Supply Chain Focus: Europe Focused. This dual focus acknowledges manufacturing location while emphasizing the market and subsequent value chain impacts relevant to European distribution and use.
- **Accounting Standard:** GHG Protocol. This standard ensures a consistent and internationally recognized framework for GHG quantification and reporting.

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4. Lifecycle Inventory (LCI) & Data Collection

This section details the primary and secondary data collected and utilized for the PCF calculation, covering material inputs, energy consumption, and logistics.

4.1. Detailed Bill of Materials (BOM)

The following table presents the detailed Bill of Materials (BOM) for the Smart IoT Sensor, including specific emission factors and total carbon impact per material item. These specific values were used for high-accuracy material impact calculation instead of default estimates.

ID	Description	Category	Process	Qty	Unit	Emission Factor (kg CO2e/ unit or kg)	Total Carbon (kg CO2e)
P1	ABS Plastic Casing	Plastic	Injection Molding	0.15	kg	2.5	0.375

ID	Description	Category	Process	Qty	Unit	Emission Factor (kg CO2e/ unit or kg)	Total Carbon (kg CO2e)
P2	Lithium-ion Battery	Electronics	Battery Production	0.05	kg	15.0	0.750
P3	PCB with Components	Electronics	Assembly	0.03	kg	20.0	0.600
P4	Packaging (Cardboard)	Paper/ Wood	Pulping & Forming	0.02	kg	0.8	0.016
						Total Material Carbon Impact:	**1.741**

4.2. Energy Inputs for Production

- **Energy Intensity (kWh/unit):** 50 kWh/unit.
- **Renewable Energy Usage:** 60%. This indicates that 60% of the consumed electricity for production comes from renewable sources, reducing the grid electricity demand.

4.3. Logistics Data

- **Transport Mode (Main):** Road Freight (Heavy Goods Vehicle - HGV).
- **Transport Distance (Main):** 1500 km. This distance is considered for the primary distribution route from the production facility to the main distribution hub in Europe.
- **Last-Mile Delivery Channel:** Light Commercial Vehicle (LCV).
- **Assumed Last-Mile Distance:** 50 km per unit.

4.4. Use Phase Data

- **Product Lifespan:** 3 years. This is the estimated functional duration of the Smart IoT Sensor.
- **Energy Consumption in Use:** 5 kWh/year. This represents the average annual electricity consumption during the product\'s operational phase.

4.5. End-of-Life (EoL) Scenarios

- **Recyclability Percentage:** 70%. This indicates the proportion of the product\'s material that can be technically recycled at the end of its life.
- **Circular/Take-back Programs:** An established product refurbishment and recycling scheme is in place, demonstrating a commitment to circular economy principles.

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5. Emissions Calculation

Emissions were calculated using activity data combined with industry-standard emission factors (e.g., from Ecoinvent/DEFRA equivalents). The calculations are categorized by Scope and lifecycle stage.

5.1. Scope 3: Upstream Emissions

5.1.1. Materials Acquisition and Pre-processing

Based on the provided Detailed Bill of Materials (BOM), the total carbon impact from raw material extraction, processing, and component manufacturing is **1.741 kg CO2e** per unit of Smart IoT Sensor.

5.1.2. Upstream Transport and Distribution (Materials to Factory)

- Average material mass per unit: 0.25 kg.
- Assumed upstream inbound transport distance (within China): 500 km.
- Road freight (HGV) emission factor: 0.08 kg CO2e/tkm.
- Calculated emissions: (0.25 kg / 1000) * 500 km * 0.08 kg CO2e/tkm = **0.010 kg CO2e**.

5.2. Scope 2: Purchased Electricity (Production)

- Total energy intensity for production: 50 kWh/unit.
- Renewable energy usage: 60%.
- Non-renewable electricity consumption: 50 kWh/unit * (1 - 0.60) = 20 kWh/unit.
- Emission factor for China\'s electricity grid mix: 0.6 kg CO2e/kWh (national average for 2023).
- Calculated emissions: 20 kWh/unit * 0.6 kg CO2e/kWh = **12.000 kg CO2e**.

5.3. Scope 3: Downstream Emissions

5.3.1. Main Transport to Distribution (Factory to Europe Hub)

- Product mass for transport: 0.25 kg.
- Transport Distance: 1500 km.
- Transport Mode: Road Freight (HGV).
- Road freight (HGV) emission factor: 0.08 kg CO2e/tkm.
- Calculated emissions: (0.25 kg / 1000) * 1500 km * 0.08 kg CO2e/tkm = **0.030 kg CO2e**.

5.3.2. Last-Mile Delivery

- Last-Mile Delivery Channel: Light Commercial Vehicle (LCV).
- Assumed last-mile distance: 50 km per unit.
- LCV emission factor: 0.18 kg CO2e/km.
- Calculated emissions: 50 km * 0.18 kg CO2e/km = **9.000 kg CO2e**.

5.3.3. Use Phase

- Product Lifespan: 3 years.
- Energy Consumption in Use: 5 kWh/year.
- Total energy consumption over lifespan: 3 years * 5 kWh/year = 15 kWh.
- Emission factor for average European electricity grid mix (as per supply chain focus): 0.25 kg CO2e/kWh.
- Calculated emissions: 15 kWh * 0.25 kg CO2e/kWh = **3.750 kg CO2e**.

5.3.4. End-of-Life (EoL)

- Product total weight: 0.25 kg.
- Recyclability Percentage: 70%.
- Portion of product to landfill: 100% - 70% = 30%.
- Weight to landfill: 0.25 kg * 0.30 = 0.075 kg.
- Assumed landfill emission factor (mixed waste): 0.3 kg CO2e/kg.
- Calculated emissions from disposal: 0.075 kg * 0.3 kg CO2e/kg = **0.023 kg CO2e**.

- The presence of an "Established product refurbishment and recycling scheme" (lxujmufwow) signifies a positive impact by potentially avoiding raw material production emissions, though not quantified as a negative emission in this primary calculation.

5.4. Summary of Emissions by Scope and Lifecycle Stage

Lifecycle Stage	Scope	Emissions (kg CO_2e)
Materials Acquisition & Pre-processing	Scope 3 Upstream	1.741
Upstream Transport (Materials Inbound)	Scope 3 Upstream	0.010
Manufacturing (Purchased Electricity)	Scope 2	12.000
Main Transport (Factory to Europe Hub)	Scope 3 Downstream	0.030
Last-Mile Delivery	Scope 3 Downstream	9.000
Use Phase	Scope 3 Downstream	3.750
End-of-Life (Disposal)	Scope 3 Downstream	0.023
Total Product Carbon Footprint (PCF)		**26.554**

6. Review & Reporting

6.1. Hotspots and Reliability

The primary emission hotspots for the Smart IoT Sensor are identified as:

- **Manufacturing (Scope 2 Purchased Electricity):** Accounting for 12.000 kg CO2e (approx. 45% of total PCF). This highlights the significant impact of electricity sources, even with 60% renewable energy usage. Further investment in renewable energy or sourcing from lower-carbon grids would yield substantial reductions.
- **Last-Mile Delivery (Scope 3 Downstream):** Contributing 9.000 kg CO2e (approx. 34% of total PCF). The relatively high impact per unit suggests opportunities in optimizing delivery routes, shifting to electric vehicles, or exploring alternative delivery models.
- **Materials Acquisition (Scope 3 Upstream):** Responsible for 1.741 kg CO2e (approx. 7% of total PCF). While lower than energy and last-mile transport, this area can be addressed through material optimization, use of recycled content, or sourcing lower-impact materials.
- **Use Phase (Scope 3 Downstream):** 3.750 kg CO2e (approx. 14% of total PCF). Enhancing product energy efficiency during its operational life is crucial, especially for longer-lifespan products.

The reliability of this assessment is considered high for the material and energy inputs, as it leverages specific BOM data and provided energy customization. Emission factors are based on recognized industry databases (e.g., those referenced by Ecoinvent/DEFRA and regional grid mixes). Assumptions have been made for certain generic transport distances and last-mile delivery details where precise operational data was not available; refining these with primary data would further enhance accuracy.

6.2. Overall Product Carbon Footprint

The total Product Carbon Footprint for one unit of the "Smart IoT Sensor" (tqknyxznuv) by mnpwypoyli is calculated to be **26.55 kg CO2e**.

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7. Conclusion and Recommendations

This detailed PCF analysis provides mnpwypoyli with a comprehensive understanding of the environmental impact of its Smart IoT Sensor across its lifecycle. The identified hotspots offer clear pathways for targeted emission reduction strategies.

Recommendations for mnpwypoyli to reduce the PCF of the Smart IoT Sensor include:

- **Decarbonize Production Energy:** Explore options to increase the share of renewable energy beyond 60% for the production facility in China, potentially through on-site generation or purchasing renewable energy credits with strong additionality.
- **Optimize Last-Mile Logistics:** Investigate opportunities to reduce emissions from last-mile delivery, such as shifting to electric delivery vehicles, optimizing delivery routes for efficiency, or collaborating with logistics partners committed to decarbonization.
- **Material Innovations:** Research and adopt lower-carbon alternative materials or increase the use of recycled content for components like the ABS plastic casing.
- **Enhance Use Phase Efficiency:** Continue to innovate for increased energy efficiency during the product\'s

operational lifespan, thereby reducing the indirect emissions from electricity consumption by end-users.

- **Strengthen Circularity:** Leverage the "Established product refurbishment and recycling scheme" to maximize material recovery and minimize waste, potentially developing metrics for avoided emissions through these programs.

By focusing on these areas, mnpwypoyli can significantly reduce the environmental footprint of the Smart IoT Sensor, demonstrating leadership in sustainable product development and contributing to global climate goals.