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Product Carbon Footprint Analysis Report

for **qehuhvkvs**

Protocol Data (Accounting Standard):
GHG Protocol

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This report is generated based on available data and industry standards. While every effort has been made to ensure accuracy, the results are indicative and subject to the quality and completeness of input parameters and emission factors.

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Generated Date: June 2, 2026

1. Executive Summary

This report presents a detailed Product Carbon Footprint (PCF) analysis for the product **qehuhvkvfs**, manufactured by **pmvhrvxpiq**. The analysis adheres strictly to the GHG Protocol accounting standard, incorporating the latest 2026 Land Sector and Removals (LSR) Standard updates and aiming for at least 95% Scope 3 coverage. Conducted by **wqhlhxsidm**, Senior Sustainability Consultant, this study evaluates greenhouse gas (GHG) emissions across the product's lifecycle from raw material acquisition to end-of-life, providing insights into emission hotspots and opportunities for reduction.

2. Methodology and Scope Definition

2.1. Functional Unit

- The functional unit for this PCF analysis is defined as **1.0 unit** of the product **qehuhvkvfs**. This unit represents the quantified performance of the product for which the environmental impacts are calculated.

2.2. System Boundary

- The primary system boundary for the Product Carbon Footprint is set as **"factory_gate"**. This encompasses all emissions from raw material extraction, processing, and transportation (upstream Scope 3) up to the point the finished product leaves the manufacturing facility.

- For a comprehensive assessment and to meet enhanced reporting requirements, the analysis has been expanded to include downstream Scope 3 emissions covering distribution, the product's use phase, and end-of-life scenarios.

2.3. Geographic Scope

- **Final Production Country:** China
- **Supply Chain Focus:** Europe Focused (primarily for downstream distribution and use phase assumptions, indicating primary market location).

2.4. Accounting Standard

- This Product Carbon Footprint analysis strictly follows the **GHG Protocol** standards. Emissions are categorized into Scope 1 (direct emissions), Scope 2 (indirect emissions from purchased energy), and Scope 3 (all other indirect emissions across the value chain).
- The analysis also applies the principles of the **2026 Land Sector and Removals (LSR) Standard**, particularly for land use impacts associated with raw material sourcing where applicable. The LSR Standard is effective January 1, 2027, and provides accounting requirements and guidance for land emissions and CO₂ removals.

2.5. Allocation

- Where shared processes or infrastructure are identified, emissions have been allocated to the functional unit (1.0 unit of qehuhvkvfs) using appropriate physical allocation methods (e.g., mass-based) or economic allocation, ensuring consistency and accuracy in attributing environmental burdens.
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3. Lifecycle Inventory (LCI) & Data Collection

3.1. Detailed Bill of Materials (BOM) Analysis

The following table details the materials, their quantities, and associated carbon emissions based on the provided Bill of Materials (BOM). The 'Total Carbon' values provided in the BOM are directly used for material impact calculations, representing the cradle-to-gate emissions for each component.

ID	Description	Category	Process	Quantity	Unit	Emission Factor (kgCO2e/unit or kg)	Total Carbon (kgCO2e)
1	Aluminum Casing	Metal	Casting	0.5	kg	12.0	6.0
2	Circuit Board	Electronics	Assembly	0.1	kg	25.0	2.5
3	Lithium-ion Battery	Chemical	Manufacturing	0.2	kg	18.0	3.6
4	Plastic Enclosure	Polymer	Injection Molding	0.3	kg	3.0	0.9
5	Packaging Cardboard	Paper	Processing	0.05	kg	1.5	0.075

3.2. Energy Inputs (Production Phase)

- **Energy Intensity (kWh/unit):** 10 kWh/unit
- **Renewable Energy Usage:** 70 %
- The production process in China utilizes electricity, with a significant portion sourced from renewable energy. The remaining non-renewable electricity consumption is accounted for using an average emission factor for the Chinese national grid.

3.3. Logistics Data

- **Primary Transport Mode (Outbound):** Road Freight (HGV > 28t)
- **Transport Distance:** 1200 km
- **Last-Mile Delivery Channel:** Parcel Service (LCV)
- Logistics emissions are calculated based on the specified modes and distances, accounting for both long-haul distribution from the factory and the final delivery to the end-user.

3.4. Use Phase Data

- **Product Lifespan:** 3 years
- **Energy Consumption in Use:** 5 kWh/year
- The use phase emissions are calculated based on the product's expected lifespan and its annual energy consumption, using an average European grid mix emission factor, reflecting the "Europe Focused" supply chain.

3.5. End-of-Life (EoL) Scenarios

- **Recyclability Percentage:** 75 %
- **Circular/Take-back Programs:** Implemented (return & refurbishment)
- EoL scenarios model the impacts of disposal for non-recycled components and account for potential avoided emissions through recycling and specific circular economy initiatives like take-back programs.

4. Emissions Calculation and GHG Protocol Categorization

This section details the calculated emissions across the lifecycle of **gehu hvk vfs**, categorized according to the GHG Protocol into Scope 1, Scope 2, and Scope 3.

Assumptions for Calculation:

- **Product Weight (derived from BOM for transport):** 1.15 kg (sum of quantities from provided BOM).
- **Chinese Grid Emission Factor (Electricity):** 0.6 kgCO₂e/kWh (approximate average, IEA reported 0.6093 kgCO₂/kWh in 2021).
- **European Grid Emission Factor (Electricity, Use Phase):** 0.24 kgCO₂e/kWh (approximate average, EU average was 0.242 kgCO₂/kWh in 2023).
- **Road Freight (HGV > 28t) Emission Factor:** 0.00008 kgCO₂e/kg-km (equivalent to 0.08 kgCO₂e/tonne-km, within common ranges).
- **Parcel Service (LCV) Last-Mile Emission Factor:** 0.15 kgCO₂e/kg (simplified average for parcel delivery).
- **End-of-Life (Landfill/Incineration):** 1.0 kgCO₂e/kg for non-recycled waste (average for mixed materials).
- **Recycling Avoided Emissions (Credit):** -1.5 kgCO₂e/kg for recycled material (average avoided emissions for recycling across typical materials like steel and plastics).

4.1. Scope 1 Emissions (Direct Emissions)

Direct emissions from sources owned or controlled by **pmvhrvxpiq** at the manufacturing facility (e.g., direct combustion for heating, owned vehicle fleet) are not explicitly provided within the given parameters. Therefore, Scope 1 emissions for the product's PCF are assumed to be negligible or covered within upstream Scope 3 material production if the 'Process' field in the BOM implicitly includes such direct emissions. For a more precise assessment, direct fuel consumption data at the factory would be required.

- **Total Scope 1 Emissions:** 0.00 kgCO₂e (Assumed negligible based on provided data.)

4.2. Scope 2 Emissions (Purchased Energy)

These emissions arise from the generation of purchased electricity for the manufacturing process of **qehuhvkvs** in China.

- Energy Intensity: 10 kWh/unit
- Renewable Energy Usage: 70 %
- Non-renewable energy consumption = $10 \text{ kWh/unit} * (1 - 70/100) = 3 \text{ kWh/unit}$
- Emissions = Non-renewable energy consumption * Chinese Grid Emission Factor
- Emissions = $3 \text{ kWh/unit} * 0.6 \text{ kgCO}_2\text{e/kWh} = 1.80 \text{ kgCO}_2\text{e}$
- **Total Scope 2 Emissions:** 1.80 kgCO₂e

4.3. Scope 3 Emissions (Value Chain Emissions)

Scope 3 emissions constitute the largest portion of a product's carbon footprint and cover all indirect emissions both upstream and downstream in the value chain. This analysis aims for at least 95% coverage as per 2026 GHG Protocol requirements.

4.3.1. Upstream Emissions (Category 1: Purchased Goods and Services & Category 4: Upstream Transportation and Distribution)

- **Materials (from BOM):** The sum of 'Total Carbon' from the detailed Bill of Materials.
- Total Carbon from BOM: 6.0 (Aluminum Casing) + 2.5 (Circuit Board) + 3.6 (Lithium-ion Battery) + 0.9 (Plastic Enclosure) + 0.075 (Packaging Cardboard) = 13.075 kgCO₂e
- **Total Upstream Material Emissions:** 13.075 kgCO₂e

4.3.2. Downstream Emissions (Category 9: Downstream Transportation and Distribution, Category 11: Use of Sold Products, Category 12: End-of-Life Treatment of Sold Products)

- **Outbound Transport (to market):**

- Mode: Road Freight (HGV > 28t)
- Distance: 1200 km
- Assumed Product Weight: 1.15 kg
- Emissions = $0.00008 \text{ kgCO}_2\text{e/kg-km} \times 1.15 \text{ kg} \times 1200 \text{ km} = 0.1104 \text{ kgCO}_2\text{e}$

- **Last-Mile Delivery:**

- Channel: Parcel Service (LCV)
- Assumed Product Weight: 1.15 kg
- Emissions = $0.15 \text{ kgCO}_2\text{e/kg} \times 1.15 \text{ kg} = 0.1725 \text{ kgCO}_2\text{e}$

- **Use Phase:**

- Product Lifespan: 3 years
- Energy Consumption in Use: 5 kWh/year
- Total Use Phase Energy = $5 \text{ kWh/year} \times 3 \text{ years} = 15 \text{ kWh}$
- Emissions = $15 \text{ kWh} \times 0.24 \text{ kgCO}_2\text{e/kWh (European Grid EF)} = 3.60 \text{ kgCO}_2\text{e}$

- **End-of-Life (EoL):**

- Recyclability Percentage: 75 %
- Product Weight: 1.15 kg
- Non-recycled portion = $1.15 \text{ kg} \times (1 - 0.75) = 0.2875 \text{ kg}$
- Recycled portion = $1.15 \text{ kg} \times 0.75 = 0.8625 \text{ kg}$
- Emissions from disposal (non-recycled) = $0.2875 \text{ kg} \times 1.0 \text{ kgCO}_2\text{e/kg} = 0.2875 \text{ kgCO}_2\text{e}$
- Credits from recycling (avoided emissions) = $0.8625 \text{ kg} \times (-1.5 \text{ kgCO}_2\text{e/kg}) = -1.29375 \text{ kgCO}_2\text{e}$
- Circular/Take-back Programs: Implemented (return & refurbishment). This further reduces the need for new material production, indirectly reducing emissions, but is

not directly quantified in the EoL calculation without specific data on avoided production.

- Net EoL Emissions = $0.2875 \text{ kgCO}_2\text{e} - 1.29375 \text{ kgCO}_2\text{e} = -1.00625 \text{ kgCO}_2\text{e}$ (a net credit due to high recyclability and assumed avoided emissions).
- **Total Downstream Emissions:** $0.1104 + 0.1725 + 3.60 - 1.00625 = 2.87665 \text{ kgCO}_2\text{e}$

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

The 2026 GHG Protocol Land Sector and Removals (LSR) Standard provides guidance on accounting for GHG emissions and removals from land use, land-use change, and forestry. For the product **qehuhvkvfs**, direct land-use change emissions or removals are not explicitly identified in the provided BOM or production data. However, the standard's principles have been considered, particularly for materials with potential forest or agricultural origins (e.g., Packaging Cardboard). Where relevant, emission factors used for such materials (e.g., pulp and paper) are assumed to implicitly include associated land-use change impacts as per industry best practices and available LCA databases. A more detailed assessment would require specific data on the origin and management practices of bio-based materials.

4.5. Summary of Emissions by Scope

GHG Scope	Category	Total Emissions (kgCO ₂ e)	Percentage of Total (%)
Scope 1	Direct Emissions	0.00	0.00%
Scope 2	Purchased Energy (Production)	1.80	10.09%
Scope 3	Upstream (Materials)	13.075	73.28%
	Downstream (Transport, Use, EoL)	2.87665	16.12%
	Total Scope 3	15.95165	89.40%

GHG Scope	Category	Total Emissions (kgCO2e)	Percentage of Total (%)
	TOTAL PRODUCT CARBON FOOTPRINT (PCF)	17.75165	100.00%

Note: The percentage breakdown is based on the sum of Scope 1, Scope 2, and the calculated Scope 3 components. Negative EoL emissions are factored into the total. The total Scope 3 coverage is approximately 89.4%, which, while substantial, indicates some minor categories might be outside the defined boundary for explicit calculation within this report, or assumed negligible for product-level PCF. Future efforts will aim to identify and quantify any remaining minor categories to further approach the >95% target.

5. Review and Reporting

5.1. Total Product Carbon Footprint

The calculated Product Carbon Footprint for **1.0 unit** of **qehuhvkvfs** is **17.75 kgCO2e**.

5.2. Hotspot Identification

The primary emission hotspots for **qehuhvkvfs** are:

- **Upstream Materials (Scope 3):** Constituting approximately 73.28% of the total footprint, the manufacturing of raw materials and components, particularly the Aluminum Casing, Circuit Board, and Lithium-ion Battery, represents the most significant area for emission reduction.
- **Use Phase (Scope 3):** Energy consumption during the product's 3-year lifespan contributes approximately 16.12% of the total, making energy efficiency in design crucial.
- **Purchased Energy (Production - Scope 2):** While partially offset by 70% renewable energy usage, the remaining non-renewable electricity for production contributes around 10.09% of the total footprint.

5.3. Reliability and Limitations

The reliability of this PCF analysis is highly dependent on the accuracy and completeness of the input data. Key factors influencing reliability include:

- The '\Total Carbon\' values provided in the Detailed Bill of Materials (gvfxrtkd) are assumed to be accurate and representative of the cradle-to-gate impacts of those components.
- Emission factors for generic transport modes, grid electricity mixes, and End-of-Life processes are based on industry averages (e.g., IEA, EU averages) and may vary based on specific supplier data or highly localized electricity grids.
- The "factory_gate" system boundary for the core PCF was expanded to include downstream impacts. While comprehensive, specific data on consumer behavior in the use phase or precise EoL infrastructure can refine these estimates.
- The application of the 2026 LSR Standard is qualitative due to a lack of specific land-use change data for material origins; however, its principles were acknowledged.
- The calculated Scope 3 coverage is approximately 89.4%. While this is a significant portion of the value chain, continuous efforts are needed to identify and quantify any remaining minor categories to meet or exceed the proposed 95% target of the GHG Protocol Scope 3 revisions.

5.4. Recommendations for Emission Reduction

- **Material Optimization:** Focus on sourcing lower-carbon alternative materials, optimizing material usage to reduce quantity, or exploring closed-loop material cycles with suppliers. Engage with suppliers to obtain primary data on their production emissions.
- **Renewable Energy Expansion:** Increase the percentage of renewable energy used in manufacturing beyond the current 70%. This directly reduces Scope 2 emissions.

- **Product Design for Energy Efficiency:** Implement design improvements to reduce the 5 kWh/year energy consumption during the 3 years lifespan of the product.
 - **Enhance Circularity:** Leverage and expand the existing 'Implemented (return & refurbishment)' circular/take-back programs to maximize refurbishment, remanufacturing, and high-value recycling, thereby generating further avoided emissions.
 - **Logistics Optimization:** Investigate more efficient transport modes, optimize routes, and consider localizing production or sourcing where feasible to reduce 1200 km transport distances.
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