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Product Carbon Footprint Analysis Report

Product: Powerbank 100W

Accounting Standard: GHG Protocol

Company Name: carboncalc.online

Regulatory Framework: CSRD (Corporate Sustainability Reporting Directive)

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This report is generated based on available data and industry standards, employing representative emission factors and illustrative assumptions where primary data was not accessible. It serves as a high-level analysis.

Generated Date: April 13, 2026

Executive Summary

This report presents a high-detail Product Carbon Footprint (PCF) analysis for a 100W power bank, conducted by remko weingarten, Senior Sustainability Consultant at carboncalc.online. The analysis adheres strictly to the GHG Protocol accounting standard and considers the implications of the CSRD regulatory framework. The primary objective is to quantify the greenhouse gas (GHG) emissions associated with the power bank’s lifecycle up to the factory gate, identifying key emission hotspots and providing insights for potential reduction strategies. Our findings highlight that the majority of emissions are attributed to the upstream production of materials, particularly the lithium-ion battery and electronic components, along with their associated transportation.

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1. Define Scope

The initial step in any robust PCF analysis is to clearly define the boundaries and parameters of the study. This section outlines these critical aspects for the 100W power bank.

- **Functional Unit:** The functional unit for this analysis is 1.0 unit of a 100W power bank. This unit is defined as a portable device capable of delivering 100 Watts of power, typically featuring a capacity in the range of 20,000-30,000 mAh, designed to charge electronic devices such as laptops, tablets, and smartphones.

- **System Boundary:** The chosen system boundary is "factory gate". This includes all upstream activities from raw material extraction, component manufacturing, sub-assembly, and final assembly, up to the point where the finished power bank leaves the final production facility in the Netherlands. Emissions beyond this point, such as product distribution, use-phase, and end-of-life, are outside this defined PCF boundary but are acknowledged as important for broader corporate reporting under CSRD.
- **Geographic Scope:** The final production country for the power bank is the Netherlands. However, the supply chain focus is Asia plus the Global Chain, reflecting the globalized nature of electronics manufacturing, where most raw materials and components originate from Asian countries.
- **Allocation:** Where co-production occurs or shared processes are involved, emissions are allocated based on mass, economic value, or other relevant physical relationships, following GHG Protocol guidance. For this analysis, direct allocation methods are primarily applied to attribute emissions specifically to the 100W power bank.
- **Accounting Standard:** This analysis strictly adheres to the GHG Protocol\'s Product Life Cycle Accounting and Reporting Standard. Emissions are categorized into Scope 1 (direct emissions), Scope 2 (indirect emissions from purchased energy), and Scope 3 (all other indirect emissions in the value chain).
- **Regulatory Framework:** The report considers the requirements of the Corporate Sustainability Reporting Directive (CSRD), a European Union directive mandating comprehensive sustainability reporting.

- **Company and Consultant:** This report is prepared for carboncalc.online by remko weingarten, Senior Sustainability Consultant.

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2. Map Lifecycle (LCI Inventory Stages)

A 100W power bank comprises a complex array of materials and energy inputs across its lifecycle stages. For this "factory gate" analysis, the key stages considered for inventory data collection include:

- **Raw Material Extraction & Processing:** Mining and initial processing of metals (lithium, cobalt, nickel for batteries; aluminum for casing; copper for wiring; tin for solder), extraction of crude oil for plastics (ABS, PC), and silica for silicon-based semiconductors.
- **Component Manufacturing:** This is a critical stage with significant environmental impact.
    - **Battery Cells:** Production of lithium-ion or lithium-polymer cells, involving the manufacturing of cathodes (e.g., lithium cobalt oxide, lithium manganese oxide, lithium nickel manganese cobalt oxide, or lithium iron phosphate), anodes (graphite), electrolytes (lithium salts in organic solvents), and separators. Production processes for Li-ion battery cells are energy-intensive.
    - **Casing:** Manufacturing of the outer shell, typically from aluminum alloy or engineering

plastics like ABS (Acrylonitrile Butadiene Styrene) and PC (Polycarbonate). High-power fast-charging power banks often utilize aluminum alloy for superior heat dissipation and durability.

- **Printed Circuit Boards (PCBs) & Integrated Circuits (ICs)/Chips:** Production of PCBs involves fiberglass, epoxy resin, and copper traces. Semiconductor manufacturing (silicon wafers, microchips) is highly energy, water, and chemical intensive.
- **Cables & Connectors:** Production of copper wiring, insulation materials (PVC, TPE), and various plastic and metal components for USB ports and internal wiring.

- **Assembly:**
  - **Sub-assembly:** Combining battery cells into packs, soldering components onto PCBs, and preparing casing parts.
  - **Final Assembly:** Integration of the battery pack, PCB, and other components into the casing, followed by sealing, quality control, and testing. This process occurs in an assembly plant, often located in Asia, with final touches or packaging potentially in the Netherlands.
- **Packaging:** Production of retail packaging materials, including cardboard, plastic trays, manuals, and protective films.

Key Material Inputs (Illustrative for a 400g power bank):

- Lithium-ion Battery Cells (Li-NMC/LFP): ~250g
- Aluminum Alloy Casing: ~70g (assuming a metal casing for a 100W product)

- Printed Circuit Board (PCB) & Integrated Circuits (Silicon, Copper, Plastics): ~50g
- Copper Wiring & Connectors: ~20g
- Packaging (Cardboard, Plastic): ~10g

Key Energy Inputs:

- Electricity for material processing (e.g., aluminum smelting, plastic extrusion, silicon wafer fabrication).
- Electricity for component manufacturing (e.g., battery cell production, PCB assembly).
- Electricity for assembly, testing, and packaging processes in manufacturing facilities (primarily in Asia, with some final stages potentially in the Netherlands).
- Fuel for transportation of raw materials and components from source countries to assembly plants, and from assembly plants to the final production country (Netherlands).

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3. Collect Data (Primary/Secondary Data Points)

Accurate data collection is fundamental for a reliable PCF. For this analysis of a 100W power bank, a combination of data sources is employed:

- **Primary Data:** In a real-world scenario, primary data would be collected directly from the manufacturing facilities (e.g., electricity consumption for assembly lines, waste generation, specific material inputs from bills of materials). For this illustrative report, we

assume such data would be sought but are relying on secondary data for the quantitative assessment.

- **Secondary Data:** Due to the nature of a high-level analysis and the vast and complex global supply chain for electronics, industry-standard secondary data sources are extensively utilized. These include:
    - **Emission Factor Databases:** Predominantly Ecoinvent (versions 3.8, 3.9, 3.10, 3.11) and DEFRA (UK Government GHG Conversion Factors for Company Reporting) provide global and region-specific emission factors for materials, energy, and transport. These databases encompass a wide array of processes from raw material extraction to manufacturing, providing CO2e values per unit of mass, energy, or distance.
    - **Industry Averages:** For highly complex or proprietary components where specific data is unavailable, industry average data for similar electronic products or components are applied.
    - **Assumptions:** Given the lack of specific primary data for a generic "100W power bank," certain assumptions are made regarding material composition (as detailed in Section 2), manufacturing locations, transport distances, and energy mix for production. These assumptions are based on typical industry practices for electronics manufactured in Asia and shipped to Europe.

The selection of emission factors aims for representativeness for the global supply chain and the specific regional contexts (Asia for manufacturing, Netherlands for final production steps). Where multiple factors exist, a conservative approach is adopted.

4. Calculate Emissions (Activity * Emission Factor = CO2e)

Emissions are calculated by multiplying the activity data (e.g., kg of material, kWh of electricity, tonne-km of transport) by the relevant emission factor (kg CO2e per unit of activity). These are then categorized according to the GHG Protocol.

GHG Protocol Scopes:

- **Scope 1 Emissions (Direct Emissions):** These are GHG emissions from sources directly owned or controlled by carboncalc.online\'s final production facility in the Netherlands. For a "factory gate" PCF focused on power bank assembly, direct emissions from on-site fuel combustion (e.g., for heating, company vehicles) are generally considered negligible compared to upstream value chain emissions. Thus, for this PCF, Scope 1 emissions are assumed to be minimal and not separately quantified in this product-specific analysis but would be captured in a wider corporate inventory.
- **Scope 2 Emissions (Energy Indirect):** These are GHG emissions from the generation of purchased electricity consumed by carboncalc.online\'s final production facility in the Netherlands, as well as by upstream component manufacturing facilities (e.g., assembly plants in Asia).
    - Electricity used for assembly, testing, and final packaging in manufacturing facilities (Asia and Netherlands).

- **Scope 3 Emissions (Value Chain Indirect):** These are all other indirect emissions, occurring both upstream and downstream in the value chain. For a "factory gate" PCF of a power bank, Scope 3 emissions represent the vast majority of the total footprint. This includes:
    - **Category 1: Purchased Goods and Services:** Emissions from the extraction, production, and transportation of all raw materials and components (e.g., lithium-ion batteries, aluminum casing, plastics, silicon chips, copper wiring, PCBs) purchased by carboncalc.online or its suppliers.
    - **Category 4: Upstream Transportation and Distribution:** Emissions from the transportation of raw materials and and components from suppliers to the manufacturing facilities (e.g., sea freight from Asia to the Netherlands, road transport within regions).
    - **Other Upstream Categories:** Other relevant upstream categories (e.g., waste generated in operations, business travel) would be considered in a full corporate Scope 3 inventory but are typically embedded within the emission factors of purchased goods and services for a streamlined PCF.

  The "factory gate" boundary explicitly excludes downstream categories such as Category 9 (Downstream Transportation and Distribution), Category 10 (Processing of Sold Products), Category 11 (Use of Sold Products), and Category 12 (End-of-Life Treatment of Sold Products) from this specific product\'s carbon footprint. However, these are crucial for carboncalc.online\'s full corporate CSRD reporting.

2026 Land Sector and Removals (LSR) Standard Update:

The GHG Protocol\'s 2026 LSR Standard is designed to provide comprehensive guidance for accounting for GHG emissions and removals from land use and land-use change activities. While a power bank itself does not directly involve land-use changes in its operational phase, the LSR Standard\'s principles are applied implicitly through the selection of emission factors for raw materials. For instance, the production of metals, plastics, and specific battery components can have embedded land-use impacts associated with mining, agriculture (for some plastic feedstocks), or energy production. We acknowledge the importance of the LSR Standard for accurate accounting of biogenic carbon and land-related emissions/removals, and its considerations are integrated into the upstream material emission factors sourced from comprehensive LCA databases like Ecoinvent.

Scope 3 Compliance (95% Coverage):

In line with the 2026 requirements, carboncalc.online aims for at least 95% coverage for Scope 3 reporting. For this "factory gate" PCF, this is achieved by ensuring that all significant material inputs and transportation activities within the upstream value chain are quantified. Major components like batteries, casings, and electronics, along with their associated manufacturing energy and transport, represent the dominant emission sources, thus providing comprehensive coverage of the product\'s footprint up to the factory gate.

Illustrative Product Carbon Footprint Calculation (Powerbank 100W)

Note: All values below are illustrative and based on representative industry averages and emission factors from Ecoinvent/DEFRA for a typical 400g 100W Powerbank. Actual emissions may vary significantly based on specific supplier data, manufacturing processes, and exact material compositions.

Lifecycle Stage & GHG Scope	Activity Data Item	Quantity	Unit	Emission Factor (EF)	EF Unit	Total CO2e (kg)	Source of EF
Scope 2: Purchased Electricity (Manufacturing)							
Component Manufacturing (Asia)	Electricity for battery & electronics assembly	0.5	kWh	0.8	kg CO2e/kWh	0.40	Illustrative (Asia grid mix)
Final Assembly & Test (Netherlands)	Electricity for final assembly &	0.1	kWh	0.4	kg CO2e/kWh	0.04	Netherlands grid mix

Lifecycle Stage & GHG Scope	Activity Data Item	Quantity	Unit	Emission Factor (EF)	EF Unit	Total CO2e (kg)	Source of EF
	testing						
Scope 3, Category 1: Purchased Goods & Services (Materials)							
Raw Material Production	Li-ion Battery Cells (mass)	0.250	kg	70.0	kg CO2e/kg	17.50	Ecoinvent (Li-ion battery cell production, RoW/China)
Raw Material Production	Aluminum Alloy Casing (mass)	0.070	kg	17.5	kg CO2e/kg	1.23	Ecoinvent (Aluminium, primary - ingot)
Raw Material Production	PCB & Electronics (Silicon, other	0.050	kg	15.0	kg CO2e/kg	0.75	Ecoinvent (Silicon - electronics grade,

Lifecycle Stage & GHG Scope	Activity Data Item	Quantity	Unit	Emission Factor (EF)	EF Unit	Total CO2e (kg)	Source of EF
	plastics)						Polycarbonate)
Raw Material Production	Copper Wiring & Connectors (mass)	0.020	kg	5.0	kg CO2e/kg	0.10	Ecoinvent (Copper, processed)
Raw Material Production	Packaging (Cardboard, Plastic)	0.010	kg	1.0	kg CO2e/kg	0.01	Illustrative (Cardboard)
Scope 3, Category 4: Upstream Transportation & Distribution							
Transport: Asia to Netherlands (Sea)	Total Material Weight	0.400	kg	20000	km	0.019	kg CO2e/tonne-km
	(0.4kg *					0.152	

Lifecycle Stage & GHG Scope	Activity Data Item	Quantity	Unit	Emission Factor (EF)	EF Unit	Total CO2e (kg)	Source of EF
	20000km * 0.019 kg/tkm / 1000 kg/t)						
Transport: Local (Road, Asia & NL)	Total Material Weight	0.400	kg	500	km	0.062	kg CO2e / tonne-km
	(0.4kg * 500km * 0.062 kg/tkm / 1000 kg/t)					0.012	
Total Product Carbon Footprint (Factory Gate)						**19.19 kg CO2e**	

Summary of Emissions by Scope:

- **Scope 1:** ~0.00 kg CO2e (assumed negligible for product PCF at factory gate)
- **Scope 2:** 0.44 kg CO2e (Electricity for manufacturing processes)
- **Scope 3:** 18.60 kg CO2e (Materials + Upstream Transport)
- **Total PCF:** 19.19 kg CO2e per 100W Powerbank (factory gate)

This calculation reveals that the most significant portion of the PCF for the 100W power bank lies within Scope 3, particularly the emissions associated with the production of raw materials, with the lithium-ion battery being the dominant contributor.

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5. Review & Report (Hotspots and Reliability)

Emission Hotspots:

The detailed calculation highlights the following key emission hotspots for the 100W power bank:

- **Lithium-ion Battery Production:** As anticipated for electronic devices, the manufacturing of the battery

cells (including raw material extraction and processing) is by far the largest contributor to the overall carbon footprint, accounting for approximately 91% of the total PCF in this analysis. This is due to the energy-intensive processes and complex supply chain of critical minerals.

- **Aluminum Casing:** The production of aluminum, especially primary aluminum, is energy-intensive and constitutes the second-largest material hotspot, representing about 6% of the total PCF.
- **Electronics (PCB & Silicon):** The manufacturing of printed circuit boards and silicon chips also contributes significantly, though less than batteries, due to complex fabrication processes and specialized materials.
- **Manufacturing Electricity:** While smaller than material impacts, the electricity consumed during assembly and testing, particularly in regions with higher carbon intensity grids (e.g., in parts of Asia), is a notable contributor (around 2% of total PCF).
- **Upstream Transportation:** The global supply chain, involving long-distance sea and road freight, also contributes to the footprint, though it is a smaller portion compared to material production.

Data Reliability and Assumptions:

The reliability of this PCF analysis is contingent upon the quality of the underlying data and assumptions made:

- **Secondary Data Reliance:** This report heavily relies on secondary data from established databases like Ecoinvent and DEFRA. While these sources are widely recognized and peer-reviewed, they represent

average data and may not perfectly reflect the specific production processes or supply chain configurations of an individual supplier.

- **Illustrative Quantities:** Material weights, energy consumption, and transport distances are illustrative estimates for a generic 100W power bank. Actual values would require specific primary data from the product\'s bill of materials, manufacturing processes, and logistics records.
- **Geographic Specificity:** Efforts were made to use geographically relevant emission factors (e.g., electricity grids for Asia vs. Netherlands, sea freight for intercontinental transport). However, the "Rest-of-World" or broader regional Ecoinvent datasets are used where specific country data is unavailable.
- **System Boundary Limitations:** The "factory gate" boundary, while clear, excludes significant lifecycle stages like product use (Category 11) and end-of-life (Category 12). For a full understanding of environmental impact, these stages would need to be assessed in a comprehensive cradle-to-grave LCA. For a power bank, the use phase (charging/discharging) and end-of-life battery recycling can be substantial.

To enhance reliability, future analyses should prioritize collecting primary data from direct suppliers and manufacturing sites.

Regulatory Context: Corporate Sustainability Reporting Directive (CSRD)

The Corporate Sustainability Reporting Directive (CSRD) is a landmark piece of legislation by the European Union, significantly expanding the scope and detail of sustainability reporting for companies. As of its implementation, it mandates comprehensive disclosures on environmental, social, and governance (ESG) matters.

- **Scope and Reach:** The CSRD is projected to affect approximately 50,000 companies within the EU, including large companies already subject to the Non-Financial Reporting Directive (NFRD), large non-listed companies, and listed SMEs. Crucially, it also extends its reach to non-EU companies that generate a net turnover of more than €150 million in the EU and have at least one large or listed EU subsidiary or branch. This broad scope means many businesses with significant operations or presence in the EU, regardless of their headquarters location, will need to comply.
- **Double Materiality:** A cornerstone of the CSRD is the principle of "double materiality." This requires companies to report on two dimensions of materiality.
    - **Impact Materiality (Inside-Out Perspective):** This assesses the business\'s actual and potential significant impacts on people and the environment (e.g., GHG emissions from manufacturing, water pollution, human rights impacts in the supply chain). This is an "inside-out" view, focusing

on how the company\'s operations and value chain affect the world.

- **Financial Materiality (Outside-In Perspective):** This assesses how sustainability-related developments and events create financial risks and opportunities for the company (e.g., physical risks from climate change impacting operations, transition risks from new climate policies, opportunities from sustainable products). This is an "outside-in" view, focusing on how the external environment impacts the company\'s financial performance and value creation.

A topic is considered material if it is material from either an impact perspective, a financial perspective, or both. This dual perspective ensures a holistic view of sustainability performance and its relevance to both internal and external stakeholders. Companies must disclose information that is material from either or both perspectives.

- **Integration with GHG Protocol:** Companies reporting under CSRD will need to align their GHG accounting with standards like the GHG Protocol, providing detailed emissions data across all three scopes, particularly robust Scope 3 reporting, to meet the directive\'s stringent requirements. The high-detail PCF performed here is a foundational element for such comprehensive corporate reporting.