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Product Carbon Footprint Analysis Report

Product: Samsung Galaxy S24 Ultra

Functional Unit: 1.0 unit

System Boundary: Lifetime (Cradle-to-Grave)

Geographic Scope: Final Production Country: China, Supply Chain Focus: Oceania plus Global Chain

Protocol Data (Accounting Standard): GHG Protocol

Disclaimer: This report is generated based on available secondary data, industry averages, and recognized standards. Specific primary data from the manufacturer was not accessible for this analysis, thus results are illustrative and intended for general guidance.

Product Carbon Footprint Analysis

Samsung Galaxy S24 Ultra

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Executive Summary

This report presents a high-detail Product Carbon Footprint (PCF) analysis for one unit of the Samsung Galaxy S24 Ultra, conducted in accordance with the GHG Protocol standards. The assessment covers the entire product lifecycle, from raw material extraction and processing through manufacturing, distribution, use, and end-of-life. Given the inherent complexity of global supply chains for consumer electronics, this analysis relies on a combination of publicly available product specifications, industry average data, and established emission factors. The primary objective is to identify significant greenhouse gas (GHG) emission hotspots across the product\'s value chain, categorized into Scope 1, 2, and 3 emissions as per the GHG Protocol, including considerations for the 2026 Land Sector and Removals (LSR) Standard. The findings underscore that the manufacturing phase remains the predominant contributor to the device\'s carbon footprint, a common trend observed across the electronics industry.

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1. Scope Definition

The foundation of this PCF analysis is meticulously defined to ensure consistency and relevance:

- **Functional Unit:** 1.0 unit of Samsung Galaxy S24 Ultra smartphone. This unit serves as the reference flow to which all inputs and outputs are related.
- **System Boundary:** A "cradle-to-grave" approach is adopted, encompassing the entire lifecycle of the product. This includes:
    - Raw material extraction and processing.
    - Component manufacturing and assembly.
    - Packaging production.
    - Transportation (raw materials, components, finished product).
    - Product use phase (charging, data transfer).
    - End-of-life treatment (disposal, recycling).
- **Geographic Scope:**
    - **Final Production Country:** China (as per user prompt). It is noted that public sources indicate primary assembly for the S24 series also occurs in Vietnam and India. For this report, manufacturing emission factors relating to electricity grids will primarily reflect China\'s energy mix to align with the specified parameter.
    - **Supply Chain Focus:** Oceania plus Global Chain. This implies that raw materials and components may originate globally, travel to China for assembly, and then be distributed to Oceania and other global markets.
- **Accounting Standard:** GHG Protocol Product 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). This analysis emphasizes comprehensive Scope 3 reporting, aiming for at least 95% coverage as per anticipated 2026 requirements.
- **Allocation:** System expansion is implicitly applied where recycled content is considered, crediting the

product with avoided virgin material production. Where co-product allocation is necessary (e.g., in raw material production), mass-based allocation is preferred due to data limitations for economic allocation for all sub-components.

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

This section details the primary materials and energy inputs throughout the Samsung Galaxy S24 Ultra\'s lifecycle. Data is collected from publicly available reports by Samsung and general industry data for high-end smartphones. Where specific weights for the S24 Ultra are unavailable, reasonable estimations based on typical smartphone compositions are applied.

2.1. Material Extraction & Processing

The Samsung Galaxy S24 Ultra incorporates a diverse array of materials, many of which involve energy-intensive extraction and refining processes. Samsung has made strides in integrating recycled content into the device.

Key Material Inputs (Estimated Composition & Recycled Content):

- **Metals:**
  - **Aluminum:** The internal chassis is largely composed of aluminum, with recycled aluminum sourced from manufacturing scrap. The Galaxy S24 Ultra includes 28% recycled aluminum in various components. (Estimated contribution: ~30-40% of device mass, considering frame, internal structure, camera modules).
  - **Titanium:** Grade 2 titanium is used for the side rails of the frame. The remainder of the frame utilizes 6061 aluminum, with plastic fusing the aluminum and titanium parts. (Estimated contribution: ~5-10% of device mass, primarily frame).

    - **Copper:** Found in wiring, connectors, circuit boards, and the wireless charging coil. (Estimated contribution: ~10-15% of device mass).
    - **Steel:** Minimum of 40% recycled steel is used in the speakers. (Estimated contribution: ~5% of device mass, including some internal components).
    - **Precious Metals (Gold, Silver, Palladium):** Used in circuitry and connectors due to high conductivity and corrosion resistance. Though small in quantity, their extraction is highly impactful. (Estimated contribution: <1% of device mass).

- **Plastics:** A variety of plastics are used in internal and external components. Samsung utilizes recycled plastics sourced from discarded fishing nets (ocean-bound plastic), water barrels, and PET bottles, as well as pre- or post-consumer recycled Polyamide (PA), Polycarbonate (PC), Polyethylene Terephthalate (PET), and Thermoplastic Polyurethane (TPU). The side and volume keys incorporate a minimum of 10% pre-consumer recycled TPU. (Estimated contribution: ~20-30% of device mass, including internal structures and various components).
- **Glass:** Corning® Gorilla® Armor for the front and rear, with an average of 25% recycled content in the front and back glass of the Galaxy S24 series. (Estimated contribution: ~15-20% of device mass, for display and back panel).
- **Silicon:** A crucial material for semiconductors and integrated circuits, forming the core of the processor and memory chips. (Estimated contribution: ~5-10% of device mass, largely for the Snapdragon 8 Gen 3 processor).
- **Rare Earth Elements (REEs) & Critical Minerals:**
    - **Cobalt:** The battery contains a minimum of 50% recycled cobalt. (Estimated contribution: <1% of device mass, primarily in the 5000 mAh battery).
    - **Neodymium:** 100% recycled rare earth elements (including Neodymium) are

    incorporated into the speakers. (Estimated contribution: <0.1% of device mass, for magnets).
    - Other REEs are critical for display, vibration motors, and other functionalities, with mining having significant environmental impacts.

Packaging: The packaging box is made using 100% recycled paper material.

2.2. Manufacturing & Assembly

The manufacturing process, including component fabrication and final assembly, is highly energy-intensive and constitutes the largest portion (80-85%) of a smartphone\'s lifecycle emissions.

- **Energy Inputs:** Electricity is the primary energy source for factory operations, including high-tech fabrication, assembly lines, climate control, and testing. For this analysis, we assume the final assembly occurs in China, thus using a Chinese national grid electricity mix for Scope 2 emissions associated with these activities.
- **Processes:** Includes chip manufacturing, printed circuit board (PCB) production, display fabrication, battery cell production, casing formation, and final device assembly.

2.3. Transportation & Distribution

The global supply chain involves extensive transportation of raw materials, components, and finished products.

- **Modes:** Predominantly ocean freight for bulk materials and finished goods (less carbon-intensive per tonne-km), with air freight used for time-sensitive or high-value components (more carbon-intensive). Road transport is used for last-mile delivery.
- **Routes:** Materials originate globally, travel to manufacturing hubs (assumed China for final assembly as per prompt), and then distributed to global markets, including Oceania.

2.4. Use Phase

The use phase primarily accounts for energy consumed during device charging and data transfer.

- **Charging:** An average smartphone consumes approximately 7.3 kWh per year for charging. Another source indicates annual consumption could be around 1.83 kWh to 7.3 kWh for different wattage chargers. Assuming a typical lifespan of 3 years for a smartphone, the total charging energy is significant.
- **Data Transfer:** Data transfer over the internet and network infrastructure (data centers, cell towers) also consumes substantial energy. Estimates suggest around 24 kWh per year for data transfer per mobile phone user.
- **Total Use Phase:** For a 3-year lifespan, the total energy consumption (charging + data) is estimated to be around 31.3 kWh/year * 3 years = 93.9 kWh per device, impacting Scope 3 emissions.

2.5. End-of-Life (EoL)

The EoL phase accounts for emissions from disposal (landfilling, incineration) and potential avoided emissions from recycling.

- **Disposal:** A significant portion of discarded phones (estimated 85%) end up in landfills or are incinerated, leading to loss of valuable materials and potential release of toxic substances and greenhouse gases.
- **Recycling:** Only a small percentage (around 15%) of phones are recycled. Recycling recovers valuable materials like gold, copper, cobalt, and rare earth elements, reducing the need for virgin material extraction and thus avoiding emissions.

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

Emissions are calculated by multiplying activity data (e.g., kg of material, kWh of electricity, tonne-km of transport) by relevant GHG Protocol-compliant emission factors (e.g., from Ecoinvent, DEFRA). Due to the proprietary nature of precise material breakdowns for the Samsung Galaxy S24 Ultra, and the unavailability of primary data, this calculation utilizes generalized material compositions for high-end smartphones and representative industry emission factors. These values provide a robust estimation aligned with best practices for secondary data analysis.

4.1. Emission Factors Utilized (Illustrative)

Emission factors (EFs) are drawn from recognized databases like Ecoinvent and DEFRA, reflecting global averages or specific regional conditions where applicable. Global Warming Potentials (GWP100) from IPCC AR5 are used for CO2e conversions.

Category	Material/ Activity	Representative Emission Factor (kg CO2e / unit)	Source (Type)
Materials (Primary)	Aluminum (Primary)	~15.0 kg CO2e / kg	Ecoinvent/ Industry Average
	Titanium (Primary, Grade 2)	~25.0 kg CO2e / kg	Ecoinvent/ Industry Average
	Plastics (Mixed, Virgin)	~2.5 - 3.5 kg CO2e / kg	Ecoinvent/ DEFRA
	Glass (Primary)	~0.8 kg CO2e / kg	Ecoinvent/ Industry Average
Materials (Recycled Content)	Aluminum (Recycled)	~0.5 - 1.0 kg CO2e / kg	Ecoinvent/ Industry Average

Category	Material/ Activity	Representative Emission Factor (kg CO2e / unit)	Source (Type)
		(avoided 90-95% virgin)	
	Cobalt (Recycled)	Significantly reduced from virgin (~15.0 kg CO2e/kg primary)	Ecoinvent/ Industry Average
	Rare Earth Elements (Recycled)	Significantly reduced from virgin (highly impactful mining)	Ecoinvent/ Industry Average
	Steel (Recycled)	~0.5 kg CO2e / kg (avoided ~70% virgin)	Ecoinvent/ Industry Average
Energy (Scope 2)	Electricity (China Grid Mix)	~0.6 - 0.8 kg CO2e / kWh	Ecoinvent/ IEA/DEFRA (China-specific)
	Electricity (Global Average)	~0.47 kg CO2e / kWh	Ecoinvent/ IEA
Transportation (Scope 3)	Ocean Freight (Container ship)	~0.016 kg CO2e / tonne-km	DEFRA
	Air Freight (Cargo plane)	~0.6 - 1.0 kg CO2e / tonne-km	DEFRA/ Industry Average
	Road Freight (HGV, average)	~0.06 - 0.15 kg CO2e / tonne-km	DEFRA
End-of-Life (Scope 3)	Landfilling (Mixed Waste, per kg)	~0.2 - 0.5 kg CO2e / kg	EPA/GHG Protocol

Category	Material/ Activity	Representative Emission Factor (kg CO2e / unit)	Source (Type)
	Recycling (Avoided Emissions)	Negative (credit for virgin material avoided)	Ecoinvent/ Industry Average

Note: Specific emission factors are indicative and subject to variation based on data source version, geographical context, and specific processes. For proprietary products like the Samsung Galaxy S24 Ultra, these figures represent best available estimates for similar components and processes.

4.2. Estimated Product Carbon Footprint (PCF) for Samsung Galaxy S24 Ultra (1.0 Unit)

Based on the defined scope, material and energy inputs, and representative emission factors, the estimated PCF for one unit of the Samsung Galaxy S24 Ultra over its lifetime is presented below. The breakdown aligns with GHG Protocol Scope 1, 2, and 3 categorization.

Lifecycle Stage	GHG Scope	Estimated CO2e (kg) per unit	Key Contributions & Assumptions
1. Material Extraction & Processing	Scope 3 (Upstream)	~45.0 - 65.0	Mining & refining of metals (Al, Ti, Cu, REEs, precious metals), silicon, plastics, glass. Recycled content significantly reduces virgin material impacts. EFs applied based on material type and virgin/ recycled proportions. This stage includes

Lifecycle Stage	GHG Scope	Estimated CO2e (kg) per unit	Key Contributions & Assumptions
			initial processing of raw materials before delivery to component manufacturers.
2. Component Manufacturing & Assembly	Scope 1 (Direct), Scope 2 (Energy), Scope 3 (Upstream)	~25.0 - 40.0	Energy-intensive processes for chips, PCBs, display, battery. Assumed final assembly in China (EF for China grid electricity). Direct emissions (Scope 1) from minor on-site fuel combustion are considered negligible for the product level PCF without primary data. Upstream emissions (Scope 3) from component suppliers are embedded here.
3. Packaging	Scope 3 (Upstream)	~0.5 - 1.0	Production of 100% recycled paper packaging. Emission factors for recycled paper are significantly lower than virgin paper.
		~3.0 - 6.0	Global movement of

Lifecycle Stage	GHG Scope	Estimated CO2e (kg) per unit	Key Contributions & Assumptions
4. Transportation & Distribution	Scope 3 (Upstream & Downstream)		raw materials, components (air/ ocean freight), and finished goods to markets including Oceania (ocean/ road freight). Distance and mode assumptions are generalized based on global supply chains.
5. Product Use Phase	Scope 2 (Charging), Scope 3 (Data Transfer)	~5.0 - 10.0	Electricity consumption for charging (estimated ~7.3 kWh/year over 3 years, global average grid mix). Energy for data transfer (estimated ~24 kWh/year over 3 years, associated with network infrastructure and data centers).
6. End-of-Life (EoL)	Scope 3 (Downstream)	~1.0 - 3.0 (Net)	Emissions from landfilling (for ~85% of devices), partially offset by avoided emissions from recycling (~15% of devices, recovering

Lifecycle Stage	GHG Scope	Estimated CO2e (kg) per unit	Key Contributions & Assumptions
			valuable materials). The net figure accounts for both burdens and credits.
Total Estimated PCF (Lifetime)		**~79.5 - 125.0 kg CO2e**	

The sum of emissions from material extraction, component manufacturing, and packaging (pre-use phase) is estimated to account for approximately 85-90% of the total lifetime emissions, consistent with industry trends for smartphones.

4.3. Scope 3 Compliance (2026 Requirements)

This analysis has aimed for comprehensive Scope 3 coverage, encompassing all relevant upstream and downstream categories. By including detailed breakdowns for material production, manufacturing, transport, use-phase energy (including network effects), and end-of-life, the report endeavors to achieve at least 95% coverage for Scope 3 reporting, aligning with the stringent 2026 requirements of the GHG Protocol. The primary areas contributing to Scope 3 are purchased goods and services (materials, components, packaging), fuel- and energy-related activities (not included in Scope 1 or 2), upstream and downstream transportation, use of sold products, and end-of-life treatment of sold products.

4.4. 2026 LSR Update: Land Sector and Removals (LSR) Standard

The Land Sector and Removals (LSR) Standard, to be applied from 2026, aims to provide comprehensive guidance for accounting and reporting GHG emissions and removals from land use, land-use change, and forestry (LULUCF) activities. For a product like the Samsung Galaxy S24 Ultra, direct land-use change emissions are typically negligible. However, the LSR Standard is relevant in the following contexts:

- **Bio-based Materials:** If any bio-based materials (e.g., certain bioplastics) were used, their cultivation and associated land-use impacts would be assessed. Currently, Samsung\'s recycled plastics are largely fossil-derived (PET, PC, PA, TPU).
- **Carbon Removals:** The use of 100% recycled paper for packaging and significant recycled content in materials (cobalt, rare earth elements, steel, aluminum, glass, plastics) contributes to avoided emissions from virgin material production, indirectly reducing pressure on land for primary resource extraction. These avoided emissions could be viewed as a form of "removal" from the perspective of reducing future emissions from land-intensive activities like mining and virgin material production, aligning with the spirit of the LSR in promoting circularity.
- **Raw Material Sourcing Impact:** While not direct land-use change by the product\'s life cycle, the standard acknowledges the broader impacts of sourcing. The mining of rare earth elements, cobalt, and other minerals, though often in established sites, can cause habitat destruction, soil erosion, and water contamination, which are indirect land impacts that the LSR standard encourages consideration of in a broader value chain context. The integration of recycled content directly mitigates these upstream land-related impacts.

For this PCF, the application of LSR is primarily qualitative, acknowledging the product\'s role in the circular economy by using recycled content and reducing reliance on virgin materials, thereby alleviating pressure on land resources that would otherwise be exploited for primary extraction.

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5. Review & Report

5.1. Hotspots Analysis

Consistent with industry trends, the manufacturing phase (including upstream material extraction and processing) accounts for the vast majority of the Samsung Galaxy S24 Ultra\'s carbon footprint, estimated to be approximately 85-90% of total lifetime emissions.

- **Materials:** The extraction and processing of metals (especially primary aluminum, titanium, copper, and rare earth elements) and silicon for semiconductors are major contributors due to their energy-intensive production. The use of recycled content by Samsung (e.g., 50% recycled cobalt, 100% recycled rare earth elements, 40% recycled steel, recycled aluminum, 25% recycled glass, recycled plastics) is a crucial mitigation factor.
- **Manufacturing Energy:** Electricity consumption during component fabrication and final assembly, particularly in regions relying heavily on fossil fuels for power generation (like China), is a significant hotspot.
- **Use Phase:** While individually smaller, the collective energy consumption for charging and data transfer over the device\'s lifespan contributes notably, especially considering the global user base and varied electricity mixes.
- **End-of-Life:** The low global recycling rate for smartphones (~15%) means that a large proportion of devices end up in landfills, representing a lost opportunity for material recovery and an ongoing emission source.

5.2. Reliability and Limitations

The reliability of this PCF analysis is influenced by several factors:

- **Secondary Data Reliance:** This report is based on publicly available data, industry averages, and generic emission factors. Actual primary data from Samsung (e.g., exact material composition by

weight, specific energy consumption per factory, precise transport logistics) would yield more accurate results.
- **Estimation and Assumptions:** Where specific data was unavailable (e.g., exact mass of each material), reasonable estimations based on typical smartphone compositions and expert judgment were applied. These assumptions introduce a degree of uncertainty.
- **Dynamic Supply Chains:** Global supply chains for electronics are complex and dynamic. Geographic scope for component sourcing and manufacturing can shift, impacting emission factors (e.g., changes in regional electricity grids).
- **Emission Factor Specificity:** While industry-standard emission factors (Ecoinvent, DEFRA) are used, their general nature may not perfectly capture the specific technologies or efficiencies of Samsung\'s suppliers.

Despite these limitations, this report provides a robust and transparent estimation of the Samsung Galaxy S24 Ultra\'s product carbon footprint, adhering to the principles of the GHG Protocol and highlighting key areas for environmental improvement.

Conclusion and Recommendations

The Samsung Galaxy S24 Ultra, like most high-end smartphones, carries a substantial carbon footprint predominantly driven by its manufacturing and the upstream extraction of its constituent materials. Samsung\'s efforts in incorporating recycled content for cobalt, rare earth elements, steel, aluminum, glass, and plastics are commendable steps towards circularity and reducing these impacts.

Recommendations for Further Reduction:

- **Increase Recycled Content:** Continue to expand the types and proportions of recycled materials,

especially for critical and energy-intensive components.
- **Renewable Energy in Manufacturing:** Encourage suppliers, particularly in high-impact regions, to transition to renewable energy sources for manufacturing operations (Scope 2 emissions reduction).
- **Extended Product Lifespan:** Promote device longevity through durable design, ease of repair, and software support to reduce replacement cycles and the overall per-year impact of device production.
- **Closed-Loop Recycling Systems:** Invest in and support advanced recycling technologies to improve recovery rates of valuable materials, especially rare earth elements and precious metals, from end-of-life devices.
- **Transparent Reporting:** Provide more granular, product-specific environmental data (e.g., material masses, factory energy mixes) in public reports to enable more precise PCF assessments.