Life Cycle Analysis of a 9V Battery (UK Context, Including Packaging)

Functional Unit

One 9V alkaline battery (PP3 size, ~550 mAh, ~5 Wh delivered capacity), with packaging included.

System Boundary

Cradle-to-grave: raw material extraction → production → packaging → distribution → use → end-of-life.

Raw Material Extraction (Battery Core)

Materials: zinc (5–6 g), manganese dioxide (13 g), steel casing (7–8 g), potassium hydroxide (3–4 g), plastics, brass/copper contacts. Impacts: mining zinc and manganese dioxide dominates energy demand and CO2 emissions. Steel casing adds significant CO2. Carbon footprint: ~0.12–0.15 kg CO2-eq. [EPBA, 2011]

Manufacturing & Assembly

Processes: electrode preparation, electrolyte filling, sealing, packaging preparation. Energy demand: ~0.2–0.3 MJ per battery. Impacts: UK grid mix (~0.2 kg CO2/kWh) → ~0.03–0.05 kg CO2-eq. [BEIS, 2024]

Packaging

Materials: blister pack (PET/PP plastic + cardboard insert) ~3–5 g. Impacts: Production ~0.01–0.015 kg CO2-eq; Manufacturing & printing: +0.001–0.002 kg CO2; End-of-life: ~70% cardboard recycled, ~40% plastics recycled → ~0.002–0.003 kg CO2 avoided. Net impact: ~0.01–0.015 kg CO2-eq per battery. [EPBA, 2011; WRAP UK]

Distribution & Transport

Supply chain: overseas mining → cell manufacturing (often Asia/EU) → UK distribution. Impacts: ~0.01–0.02 kg CO2-eq per battery.

Use Phase

Capacity: ~5 Wh delivered. Impacts: negligible direct emissions (stored chemical energy). Key factors: whether battery is fully discharged before disposal; device efficiency.

End-of-Life (Battery Core)

UK average: ~45% batteries collected/recycled, ~55% landfilled/incinerated. Impacts: Recycling credits (steel, zinc): –0.02 kg CO2. Landfill/incineration: +0.01–0.02 kg CO2. Net impact: ~0.01–0.02 kg CO2 per battery. [Environment Agency, 2023]

Summary (Disposable 9V Alkaline with Packaging)

Lifecycle Stage	CO2 per Battery (kg)
Raw materials (battery)	0.12–0.15
Manufacturing	0.03–0.05
Packaging (net)	0.01–0.015
Transport & distribution	0.01–0.02
End-of-life (battery)	0.01–0.02
Total	0.19–0.25

Comparison with Rechargeable 9V Batteries

NiMH 9V: ~1.0–1.2 kg CO2 over ~500 cycles (~0.0016 kg/Wh). Li-ion 9V: ~2.0–2.5 kg CO2 over ~1000 cycles (~0.0007 kg/Wh). Both are far lower per Wh than disposable alkaline (0.04 kg/Wh).

Everyday Carbon Equivalents

Benchmark	0.19 kg CO2	0.25 kg CO2
Car distance (avg UK car, 132 g/km)	1.4 km	1.9 km
UK grid electricity	0.92 kWh	1.21 kWh
Smartphone charges (~10 Wh each)	~92 charges	~121 charges
1 L kettle boils (~0.1 kWh each)	~9 boils	~12 boils

Notes & Caveats

• Car comparison: Based on average UK car emissions (132 g CO2/km). Newer cars are more efficient; SUVs emit more.
• Electricity comparison: Uses UK generation-based factor (~0.207 kg CO2/kWh). Lifecycle factors would adjust results.
• Smartphone charging: Assumes ~10 Wh per charge. Larger phones (12–15 Wh) reduce equivalent charges.
• Kettle boils: Assumes ~0.1 kWh for 1 L boil in an electric kettle.
• These equivalents are illustrative, to help visualise emissions in everyday terms.

References

BEIS (2024) ‘UK Government greenhouse gas conversion factors for company reporting’, Department for Business, Energy & Industrial Strategy, London.

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WRAP (2022) ‘UK Packaging Recycling Data’, Waste & Resources Action Programme, Banbury.

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GSMArena (2023) ‘Average smartphone battery capacity’, GSMArena.com, accessed 2023.