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Bioethanol (Fuel-Grade, 99.5%)

Boundary: Cradle-to-Factory Gate

Origin: Germany

Allocation: Energy (64.89% LHV)

Standard: GHG Protocol & LSR 2026

1.249 kg CO₂e

Net Cradle-to-Gate Footprint / 1.0 kg

TOTAL FOOTPRINT



1.249 kg CO₂e

Per 1.0 kg functional unit

ENERGY INTENSITY



46.6 g CO₂e/MJ

Calorific basis (26.8 MJ/kg LHV)

TOP MATERIAL HOTSPOT



58.2%

Feed wheat cultivation (0.727 kg)

PRIMARY SCOPE



Scope 3

69.5% (0.868 kg CO₂e Upstream)

Lifecycle Stage Breakdown

Gate Boundary

Contribution of mass, utilities, and transport stages to total footprint

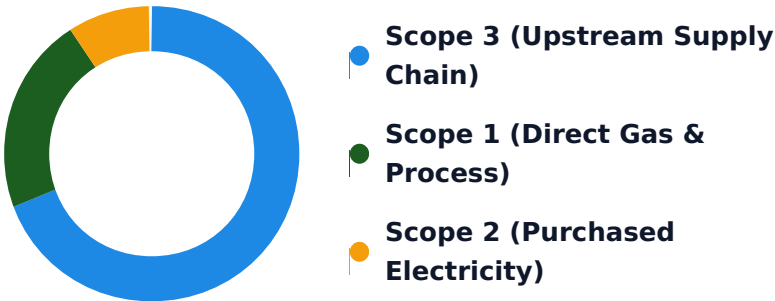
1. Agricultural Feedstock (Cultivation & Soil N ₂ O)	0.727 kg (58.2%)
2. Facility Thermal Energy (Natural Gas Steam)	0.262 kg (21.0%)
3. Facility Electricity (German Grid Mix)	0.111 kg (8.9%)
4. Upstream Fuel Losses (WTT) & Enzymes	0.119 kg (9.5%)
5. Inbound Rail Logistics (500 km Route)	0.022 kg (1.8%)

*Use phase & End-of-Life excluded per cradle-to-gate functional boundary.

GHG Protocol Scope Distribution

Total: 1.249 kg CO₂e

Energy-allocated footprint partitioned by reporting scopes



\$ LSR 2026 Biogenic Removal: Embedded carbon photosynthesized during crop growth		-1.913 kg CO ₂
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Key Carbon Insights

Critical environmental impact observations identified in the audit

- 1

Agricultural Dominance (58.2% Total Impact)
Feedstock cultivation drives the footprint via Haber-Bosch synthetic nitrogen fertilizer production and subsequent soil N₂O biological nitrification emissions.
- 2

Logistical Mode Superiority
The dedicated 500 km electric-predominant rail freight route generates only 0.022 kg CO₂e (1.8% of total), avoiding 74% of emissions relative to road trucking.
- 3

Strict LSR 2026 Compliance
Zero Direct Land Use Change (dLUC) was incurred due to >20 years of verified continuous European cropland use, ensuring compliance without structural penalties.

Decarbonization Roadmap

Targeted interventions to achieve ultra-low footprint ethanol

Biomethane Boiler Transition Replace natural gas distillation heating with on-site biomethane or biomass CHP.	-0.262 kg CO ₂ e (-21%)
Renewable Electricity PPA Contract dedicated regional wind/solar power to replace fossil grid mix.	-0.106 kg CO ₂ e (-8.5%)
Regenerative Farming & CCUS Apply nitrification inhibitors to grain and capture high-purity fermentation CO₂.	-0.180 kg CO ₂ e (-14%)