$ CARBONCALCPCF.COM ANALYTICS

Methyl Methacrylate (MMA)

CAS 80-62-6

Functional Unit: **1.0 kg liquid monomer** • Cradle-to-Grave Lifetime • Origin: **Germany (DE)**

✓ GHG Protocol Product Standard

2026 LSR Standard Verified

Scope 3 Completeness: 98.2%

TOTAL LIFETIME PCF

5.860 kg CO_2e / kg

100% Life Cycle Baseline

SCOPE 3 VALUE CHAIN

87.5% 5.127 kg CO_2e

Upstream (49.4%) + Downstream (38.1%)

LARGEST SINGLE HOTSPOT

1.866 kg CO_2e (31.8%)

EoL Incineration (Fossil C oxidation)

LOGISTICS EFFICIENCY

0.023 kg CO_2e / kg

-82% vs Road (900 km European Rail)

Life Cycle Stage Contribution (Cradle-to-Grave)

5 Stages Analyzed

Raw Precursors (ACH)	**2.894** kg (49.4%)
DE Synthesis (Facility)	**0.733** kg (12.5%)
Packaging & Rail Freight	**0.052** kg (0.9%)
Polymerization (Use)	**0.065** kg (1.1%)
EoL Incineration & Ash	**2.116** kg (36.1%)

GHG Protocol Scope Allocation



Scope 3 (Upstream)	**2.894 kg (49.4%)**
Scope 3 (Downstream)	**2.233 kg (38.1%)**
Scope 1 (Direct Fuel/Off-gas)	**0.421 kg (7.2%)**
Scope 2 (Grid & Steam)	**0.312 kg (5.3%)**

Material & Process Hotspot Profile

Mass vs Carbon Impact

Acetone Precursor (0.65 kg input) — **1.378 kg CO_2e** (23.5%)

Cumene peroxidation route; intensive fossil benzene & propylene origin.

End-of-Life Incineration (85% recovery) — **1.866 kg CO_2e** (31.8%)

Stoichiometric conversion of 0.599 kg contained fossil carbon ($C_5H_8O_2$).

Hydrogen Cyanide (0.31 kg input) — **0.787 kg CO_2e** (13.4%)

Andrussow high-temperature methane & ammonia ammoxidation.

H_2SO_4 Thermal Cleaving & Recovery — **0.448 kg CO_2e** (7.6%)

1.52 kg acid regeneration cycle; energy-dense contact cracking furnaces.

In-plant Heat & Power (DE Grid) — **0.733 kg CO_2e** (12.5%)

German natural gas reboilers (4.85 MJ) and national electric grid mix (0.72 kWh).

Sustainability Executive Highlights

1

Fossil Carbon Trap at End-of-Life

Over **31.8% of emissions (1.866 kg CO_2e)** occur post-consumer when PMMA resins are incinerated in municipal waste streams. MMA holds 0.599 kg pure fossil carbon per kilogram that completely oxidizes without chemical recycling.

2

Precursor Synthesis Dictates Scope 3

Petrochemical acetone and hydrogen cyanide make up **36.9% combined**. Monomer decarbonization cannot be achieved within factory fence-lines alone; supplier upstream intervention is mandatory.

3

Logistics Model Benchmark

Using electric rail for the 900 km European corridor limits distribution footprint to only **0.023 kg CO_2e/kg (0.4%)**. Substituting with standard road freight would have magnified logistics impact by +350% to 0.104 kg CO_2e.

Decarbonization Pathways (Action Plan)

Target: -3.72 kg CO_2e

1. Closed-Loop PMMA Chemical Pyrolysis

-1.87 kg CO_2e

Deploy buyback and molecular depolymerization for PMMA scrap. Thermal unzipping preserves the monomer backbone and diverts material from fossil thermal incineration.

2. Bio-Attributed Acetone & Bio-Methanol

-1.45 kg CO_2e

Shift to mass-balanced bio-glycerol acetone and bio-methane inputs. Fully compatible with ACH infrastructure while qualifying under 2026 LSR biogenic removal rules.

3. Reboiler Electrification & 100% PPA

-0.40 kg CO_2e

Transition distillation column reboilers to high-temperature industrial heat pumps and procure certified on-site wind/solar power at the German chemical hub.

LSR 2026 Audit: dLUC 0.00 | sLUC 0.00 | Removals 0.00

Calculated via IPCC AR6 GWP100 • Datasets: Ecoinvent v3.10 / PlasticsEurope

Audited by **Business Analytiq Advisory** • Released: November 2026