EcoProfile of recycled HDPE flakes EU27+3, gate-to-gate, post-consumer

Jonas Hoffmann, Max Bringmann, Andreas Ciroth
GreenDelta GmbH
May 2025

LCA method overview	
Background database	Ecoinvent v3.10
Dataset type	Cut-off, unit processes
Declared unit	'Production of 1 kg of mechanically recycled HDPE flakes'
ISO conformity	ISO 14040 and 14044 structure, internal review
LCIA method	Environmental Footprint 3.1
Software	openLCA 2.4
System boundary	Gate-to-gate

Funded by the European Union's Horizon Europe Programme under Grant Agreement No. 101057067

1 BACKGROUND INFORMATION

- The primary purpose of this document is to present an average life cycle inventory (LCI) and impact assessment (LCIA) for mechanically recycled high-density polyethylene (rHDPE) flakes as result of the Horizon Project PRIMUS. The project seeks to provide a comprehensive understanding of and data for the environmental impacts associated with mechanically recycled plastics.

- rHDPE is a widespread material known for its rigidity, commonly used in containers, pipes, and household products. The usage of mechanically recycled HDPE reduces the use of fossil fuels and energy compared to the production of primary HDPE.

- Mechanical recycling of HDPE plastic waste involves cleaning to remove residues, shredding, density separation and reprocessing into rHDPE flakes.

- The documentation of the method followed in the herein presented EcoProfile follows the main principles of the ISO 14040-14044 standards and was internally reviewed by PlasticRecyclersEurope and experts from the VTT Technical Research Centre of Finland. It is intended for LCA practitioners and sustainability researchers and stakeholders in the field of plastic recyclates.

- Details for the methodology used for this EcoProfile can be found in the accompanying methodology publication. Datasets can be downloaded from openLCA Nexus in JSON-LD and ILCD formats.

2 MODEL DESCRIPTION

- This EcoProfile represents an average of European industry for mechanical rHDPE production. Data was collected from 9 sites in 2022 in Belgium, France, Germany, Italy, the Netherlands and Switzerland, represents the recycling of post-industrial and post-consumer packaging, agricultural and construction wastes, and 2.86% of the European installed mechanical recycling capacity of those waste streams. The European coverage has been calculated per waste-stream, as displayed in Table 2 of the accompanying methodology document.

- The herein generated EcoProfile embodies a life cycle inventory in a 'gate-to-gate' fashion for the production of HDPE plastic recyclate flakes. The product under investigation is 1 kg of recycled HDPE flakes. The main production steps in mechanical recycling are included in the system boundaries of the EcoProfile are visualised in Figure 1.

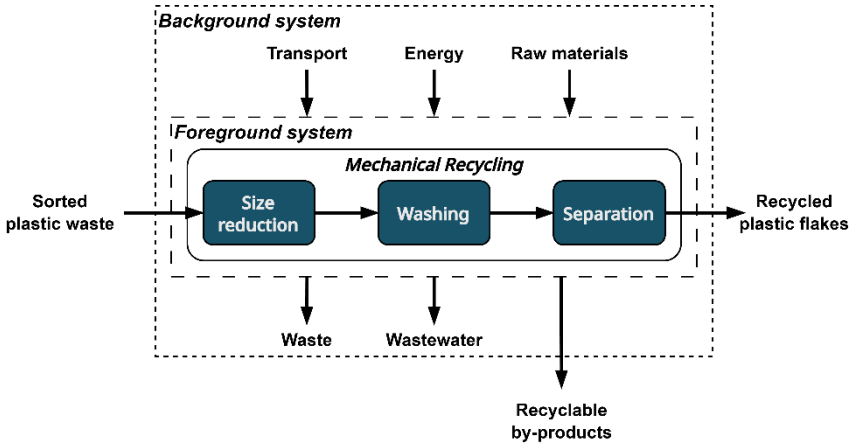

Figure 1: System description and boundaries. Following the PRE recycling scheme.

- The functional unit of the rHDPE EcoProfile is '**Production of 1 kg of mechanically recycled HDPE flakes, obtained from post-industrial and post-consumer packaging, agricultural and construction wastes, at gate, unpackaged, representing 2.86% of European production**' where the reference flow of the rHDPE EcoProfile provided is '**1 kg of rHDPE flakes, unpacked**'.

- Generally, a complete LCI was aimed for, though some neglectable amounts of secondary outputs had to be cut-off. For multi-output processes, physical allocation was used, as described in our methodology.

- The collected primary data was combined with secondary data (for transport, energy, chemicals, and water) from the ecoinvent 3.10 cut-off LCA database. The life cycle inventory and impacts were calculated using the CED and EF 3.1 method.

3 LCI RESULTS

Table 1. Summary of material and energy in- and outputs of an exemplary secondary material production process for recycled HDPE flakes with a gate-to-gate boundary

Incoming Material	**Flow Quantities per 1 kg**
Mixed plastic waste including impurities[1]	1.39 kg
Material inputs	
air filter, central unit, 600 m3/h	2.16E-05 kg
calcium carbonate, precipitated	1.75E-03 kg
chemical, organic	1.62E-03 kg
Cleaning consumables, with water	1.20E-04 kg
Colour masterbatch	8.20E-04 kg
hydrochloric acid, without water, in 30% solution state	2.62E-05 kg
iron(III) chloride, without water, in 40% solution state	4.50E-04 kg
lubricating oil	4.80E-06 kg
magnesium sulfate	5.30E-04 kg
polyacrylamide	6.26E-06 kg
polyaluminium chloride	7.28E-06 kg
polydimethylsiloxane	1.50E-04 kg
sodium hydroxide, without water, in 50% solution state	4.10E-04 kg
Talcum powder	1.06E-03 kg
Water consumption	
tap water	1.11 kg
water, completely softened	2.99E-05 kg
Energy	
diesel, burned in building machine	2.69E-02 MJ
electricity, low voltage	2.06 MJ
heat, district or industrial, natural gas	0.334 MJ
Infrastructure	
waste preparation facility	2.00E-09 Item(s)
Transportation	
Transport, forklift, propane-driven	2.10E-04 t*km
transport, freight train	1.39E-05 t*km
transport, freight, lorry, unspecified	3.60E-02 t*km
Solid Waste	
municipal solid waste	0.127 kg
raw sludge	0.208 kg
waste plastic, mixture	2.76E-02 kg
waste polyethylene terephthalate	3.50E-04 kg
Secondary material outputs	
Waste fraction - diverse - recycling cut-off	4.07E-03 kg
Waste fraction - metal - recycling cut-off	5.60E-04 kg
Wastewater treatment	
wastewater, average	7.70E-04 m³
Water	2.40E-04 m³
Probability to litter plastic	
plastic litter	1.32E-03 kg

Table 2. Primary energy demand by carrier using CED method for an exemplary secondary material production process for recycled HDPE flakes with a gate-to-gate boundary

Energy carrier	**Total energy input for 1kg of rHDPE flakes**
Uranium	2.14 MJ-Eq
Gas, natural	1.67 MJ-Eq
Coal, hard	0.62 MJ-Eq
Coal, brown	0.59 MJ-Eq
Oil, crude	0.43 MJ-Eq
Energy resources: non-renewable	5.47 MJ-Eq
Energy resources: renewable	1.23 MJ-Eq
Total	6.70 MJ-Eq

[1] This value expresses an aggregation of all polymer waste streams contributing to the EcoProfile inputs. Please find the disaggregated input values per-waste stream in the disaggregated datasets.

4 LCIA RESULTS

Table 3. Life cycle impacts of the gate-to-gate rHDPE model related to 1 kg of flakes

Impact Category	**Impact assessment[2]**	**Unit**
Acidification	1.41E-03 ± 1.53E-04	mol H+-Eq
Climate change	0.619 ± 0.045	kg CO2-Eq
Ecotoxicity: freshwater	2.51 ± 0.21	CTUe
Energy resources: non-renewable	5.22 ± 0.54	MJ, net calorific value
Eutrophication: freshwater	1.92E-04 ± 2.14E-05	kg P-Eq
Eutrophication: marine	3.87E-04 ± 2.90E-05	kg N-Eq
Eutrophication: terrestrial	2.64E-03 ± 2.48E-04	mol N-Eq
Human toxicity: carcinogenic	1.02E-09 ± 2.33E-10	CTUh
Human toxicity: non-carcinogenic	5.70E-09 ± 6.37E-10	CTUh
Ionising radiation: human health	0.122 ± 0.014	kBq U235-Eq
Land use	2.05 ± 1.06	dimensionless
Material resources: metals/minerals	3.11E-06 ± 5.87E-07	kg Sb-Eq
Ozone depletion	1.77E-07 ± 1.44E-08	kg CFC-11-Eq
Particulate matter formation	9.28E-09 ± 9.14E-10	disease incidence
Photochemical oxidant formation: human health	8.71E-04 ± 7.66E-05	kg NMVOC-Eq
Plastic litter	1.82E-02 ± 2.25E-03	kg
Water use	0.151 ± 0.015	m3 world Eq deprived

[2] The uncertainty value presented here has been calculated on the foreground data. Details are described in the methodology.