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

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LCA method overview	
Background database	Ecoinvent v3.10
Dataset type	Cut-off, unit processes
Declared unit	'Production of 1 kg of mechanically recycled MPO 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

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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 mixed polyolefin (rMPO) 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.

- rMPO is a downcycled polymer produced from a combination of polyethylene (PE) and polypropylene (PP) waste streams. While hard MPO fractions are often used for products like plastic lumber or profiles, soft MPO fractions are typically used in flexible applications like packaging films. The usage of mechanically recycled MPO may reduce the demand for primary plastics of the associated waste streams.

- Mechanical recycling of MPO plastic waste involves separating mixed PE and PP from other waste streams to blend the PE and PP waste into a downcycled polymer mix. The resulting fractions are classified as 'hard' (PP and HDPE) and 'soft' MPO (PP and LDPE).

- 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 rMPO production. Data was collected from 3 sites in 2022 in Italy and the Netherlands and represents the recycling of household and packaging waste streams streams of PE and PP that cannot be separated, and 5.58% 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 MPO plastic recyclate flakes. The product under investigation is 1 kg of recycled MPO flakes. The main production steps in mechanical recycling are included in the system boundaries of the EcoProfile are visualised in Figure 1.

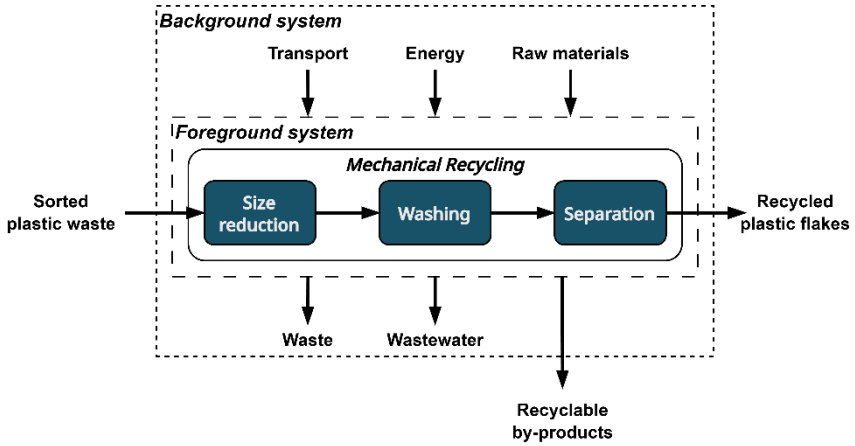

Figure 1: System description and boundaries. Following the PRE recycling scheme.

- The functional unit of the rMPO EcoProfile is '**Production of 1 kg of mechanically recycled MPO flakes, obtained from post-consumer household packaging waste, at gate, unpackaged'** where the reference flow of the rMPO EcoProfile provided is '**1 kg of rMPO 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 MPO flakes with a gate-to-gate boundary

Incoming Material	**Flow Quantities per 1 kg**
Mixed plastic waste including impurities[1]	1.64 kg
Material inputs	
calcium carbonate, precipitated	1.73E-05 kg
chemical, inorganic	4.34E-06 kg
Cleaning consumables, with water	9.19E-05 kg
diesel, low-sulfur	1.40E-04 kg
iron sulfate	4.24E-03 kg
magnesium sulfate	7.40E-04 kg
phosphoric acid, industrial grade, without water, in 85% solution state	1.58E-05 kg
polyacrylamide	2.43E-05 kg
polyaluminium chloride	1.00E-04 kg
polydimethylsiloxane	5.16E-05 kg
silicone product	4.13E-06 kg
sodium chloride, powder	2.34E-02 kg
sodium hydroxide, without water, in 50% solution state	1.53E-03 kg
urea	1.30E-05 kg
Service inputs	
machine operation, diesel, < 18.64 kW, low load factor	1.40E-04 h
Water consumption	
tap water	6.77E-03 kg
ground water	5.80E-04 m³
Energy	
electricity, high voltage	0.123 MJ
electricity, low voltage	0.646 MJ
heat, district or industrial, natural gas	0.142 MJ
Infrastructure	
waste preparation facility	2.00E-09 Item(s)
Transportation	
Transport, forklift, diesel-driven	1.90E-04 t*km
transport, freight train	6.85E-05 t*km
transport, freight, lorry 16-32 metric ton, EURO4	5.47E-02 t*km
transport, freight, lorry 3.5-7.5 metric ton, EURO4	2.44E-03 t*km
transport, freight, lorry 7.5-16 metric ton, EURO4	1.47E-06 t*km
transport, freight, lorry, unspecified	3.86E-02 t*km
transport, freight, sea, container ship	1.97E-03 t*km
Solid Waste	
hazardous waste, for incineration	3.76E-07 kg
municipal solid waste	0.131 kg
raw sludge	7.28E-02 kg
waste plastic, mixture	0.311 kg
waste polyethylene terephthalate	4.50E-04 kg
waste polyurethane	4.44E-02 kg
waste yarn and waste textile	2.21E-07 kg
Secondary material outputs	
Waste fraction - metal - recycling cut-off	4.75E-02 kg
Wastewater treatment	
wastewater, average	2.54E-07 m³
Water	4.98E-03 m³
Probability to litter plastic	
plastic litter	1.56E-03 kg

[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.

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

Energy carrier	**Total energy input for 1kg of rMPO flakes**
Uranium	0.83 MJ-Eq
Gas, natural	0.77 MJ-Eq
Oil, crude	0.48 MJ-Eq
Coal, hard	0.31 MJ-Eq
Coal, brown	0.23 MJ-Eq
Energy resources: non-renewable	2.63 MJ-Eq
Energy resources: renewable	0.48 MJ-Eq
Total	3.11 MJ-Eq

4 LCIA RESULTS

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

Impact Category	**Impact assessment[2]**	**Unit**
Acidification	9.24E-04 ± 1.27E-04	mol H+-Eq
Climate change	0.859 ± 0.076	kg CO2-Eq
Ecotoxicity: freshwater	3.09 ± 0.31	CTUe
Energy resources: non-renewable	2.49 ± 0.30	MJ, net calorific value
Eutrophication: freshwater	8.48E-05 ± 9.58E-06	kg P-Eq
Eutrophication: marine	9.95E-04 ± 8.60E-05	kg N-Eq
Eutrophication: terrestrial	2.72E-03 ± 3.52E-04	mol N-Eq
Human toxicity: carcinogenic	9.13E-10 ± 3.13E-10	CTUh
Human toxicity: non-carcinogenic	5.14E-09 ± 7.17E-10	CTUh
Ionising radiation: human health	4.74E-02 ± 4.81E-03	kBq U235-Eq
Land use	1.59 ± 1.37	dimensionless
Material resources: metals/minerals	2.01E-06 ± 6.71E-07	kg Sb-Eq
Ozone depletion	6.19E-08 ± 7.22E-09	kg CFC-11-Eq
Particulate matter formation	8.06E-09 ± 1.58E-09	disease incidence
Photochemical oxidant formation: human health	8.30E-04 ± 1.14E-04	kg NMVOC-Eq
Plastic litter	0.130 ± 0.013	kg
Water use	0.100 ± 0.009	m3 world Eq deprived

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