



EcoProfile of recycled MPO pellets EU27+3, cradle-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 pellets'
ISO conformity	ISO 14040 and 14044 structure, internal review
LCIA method	Environmental Footprint 3.1
Software	openLCA 2.4
System boundary	Cradle-to-gate



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) pellets 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 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 'cradle-to-gate' fashion for collection, sorting of waste, and production of MPO plastic recycle pellets. The product under investigation is 1 kg of recycled MPO pellets. The main production steps in mechanical recycling are included in the system boundaries of the EcoProfile are visualised in Figure 1.

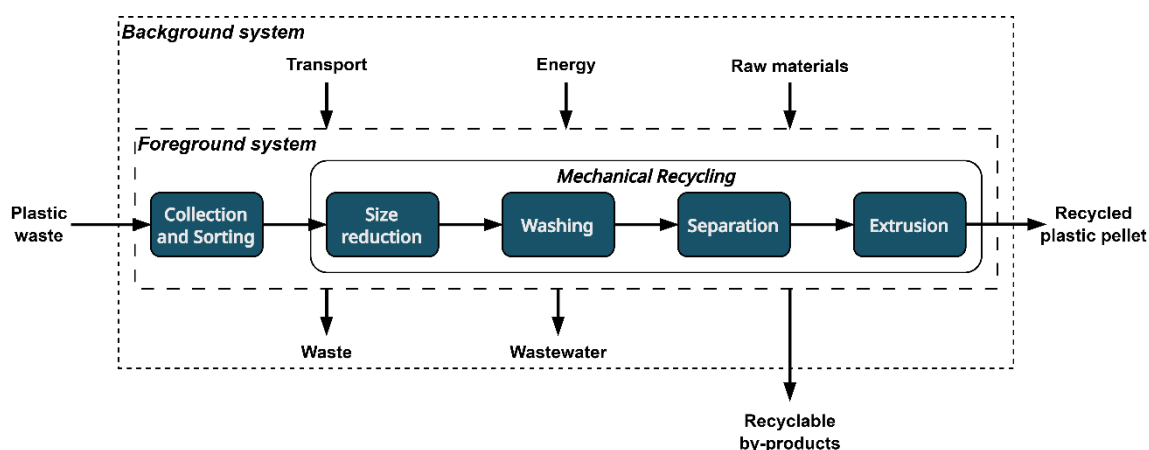


Figure 1: System description and boundaries. Following the PRE recycling scheme.

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

Incoming Material	Flow Quantities per 1 kg of rMPO
Mixed plastic waste including impurities ¹	1.94 kg
Material inputs	
calcium carbonate, precipitated	1.73E-05 kg
chemical, inorganic	4.34E-06 kg
Cleaning consumables, with water	9.19E-05 kg
containerboard, linerboard	6.20E-04 kg
diesel, low-sulfur	1.40E-04 kg
fleece, polyethylene	9.71E-09 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
polyethylene, high density, granulate	5.50E-04 kg
polyethylene, low density, granulate	3.24E-02 kg
polypropylene, granulate	8.20E-04 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
steel, low-alloyed	7.92E-03 kg
tin plated chromium steel sheet, 2 mm	6.78E-05 m ²
urea	1.30E-05 kg
waste collection lorry, 21 metric ton	3.29E-8 Item(s)
Service inputs	
drawing of pipe, steel	6.03E-05 kg
extrusion, plastic film	3.29E-02 kg
injection moulding	5.50E-04 kg
machine operation, diesel, < 18.64 kW, low load factor	1.40E-04 h
wire drawing, steel	7.86E-03 kg
Water consumption	
tap water	0.193 kg
ground water	5.80E-04 m ³
Energy	
diesel, burned in building machine	0.125 MJ
electricity, high voltage	0.123 MJ
electricity, low voltage	1.97 MJ
electricity, medium voltage	9.00E-03 MJ
heat, central or small-scale, other than natural gas	4.23E-02 MJ
heat, district or industrial, natural gas	0.142 MJ
Infrastructure	
waste preparation facility	4.81E-09 Item(s)
Transportation	
municipal waste collection service by 21 metric ton lorry	2.70E-03 t*km
Transport, forklift, diesel-driven	1.90E-04 t*km
transport, freight train	6.85E-05 t*km
transport, freight, lorry 16-32 metric ton, EURO3	2.62E-02 t*km
transport, freight, lorry 16-32 metric ton, EURO4	7.11E-02 t*km

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.

transport, freight, lorry 16-32 metric ton, EURO5	0.179 t*km
transport, freight, lorry 16-32 metric ton, EURO6	3.09E-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
transport, passenger car	134.7 m
Solid Waste	
hazardous waste, for incineration	3.76E-07 kg
municipal solid waste	0.447 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	2.70E-07 m ³
Water	4.98E-03 m ³
Probability to litter plastic	
plastic litter	1.59E-03 kg

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

Energy carrier	Total energy input for 1kg of rMPO pellets
Oil, crude	3.59 MJ-Eq
Gas, natural	2.88 MJ-Eq
Uranium	2.40 MJ-Eq
Coal, hard	1.48 MJ-Eq
Coal, brown	0.70 MJ-Eq
Energy resources: non-renewable	11.08 MJ-Eq
Energy resources: renewable	1.50 MJ-Eq
Total	12.58 MJ-Eq

4 LCIA RESULTS

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

Impact Category	Impact assessment²	Unit
<i>Acidification</i>	2.91E-03 ± 4.94E-04	mol H ⁺ -Eq
<i>Climate change</i>	1.46 ± 0.16	kg CO ₂ -Eq
<i>Ecotoxicity: freshwater</i>	7.49 ± 1.10	CTU _e
<i>Energy resources: non-renewable</i>	10.5 ± 2.8	MJ, net calorific value
<i>Eutrophication: freshwater</i>	2.80E-04 ± 3.54E-05	kg P-Eq
<i>Eutrophication: marine</i>	1.63E-03 ± 1.56E-04	kg N-Eq
<i>Eutrophication: terrestrial</i>	7.38E-03 ± 1.25E-03	mol N-Eq
<i>Human toxicity: carcinogenic</i>	4.84E-09 ± 1.88E-09	CTU _h
<i>Human toxicity: non-carcinogenic</i>	1.23E-08 ± 1.53E-09	CTU _h
<i>Ionising radiation: human health</i>	0.138 ± 0.015	kBq U235-Eq
<i>Land use</i>	4.94 ± 1.96	dimensionless
<i>Material resources: metals/minerals</i>	6.05E-06 ± 1.29E-06	kg Sb-Eq
<i>Ozone depletion</i>	7.01E-08 ± 7.93E-09	kg CFC-11-Eq
<i>Particulate matter formation</i>	3.49E-08 ± 6.85E-09	disease incidence
<i>Photochemical oxidant formation: human health</i>	2.78E-03 ± 6.33E-04	kg NMVOC-Eq
<i>Plastic litter</i>	0.146 ± 0.014	kg
<i>Water use</i>	0.278 ± 0.048	m ³ world Eq deprived

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