



EcoProfile of recycled LDPE 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 LDPE 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 low-density polyethylene (rLDPE) 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.
- rLDPE is a ubiquitous material known for its flexibility and low melting point, predominantly used in packaging films. The usage of mechanically recycled LDPE reduces the use of fossil fuels and energy compared to the production of primary LDPE.
- Mechanical recycling of LDPE plastic waste involves cleaning to remove residues, shredding, density separation and reprocessing into rLDPE pellets. The primary challenge with LDPE films is removing contaminants, a process typically managed through washing and air classification techniques. Post-processing, LDPE may be suitable for less demanding applications due to quality degradation, e.g. garbage bags or construction panelling. The overall recycling efficiency of LDPE within the EU was calculated as 59%, see the methodology description for further details.
- 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 rLDPE production. Data was collected from 3 sites in 2022 in France, and the Netherlands, represents the recycling of post-consumer household packaging waste, commonly found alongside HDPE and PP waste streams, 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 LDPE plastic recycle pellets. The product under investigation is 1 kg of recycled LDPE pellets. The main production steps in mechanical recycling are included in the system boundaries of the EcoProfile are visualised in Figure 1.

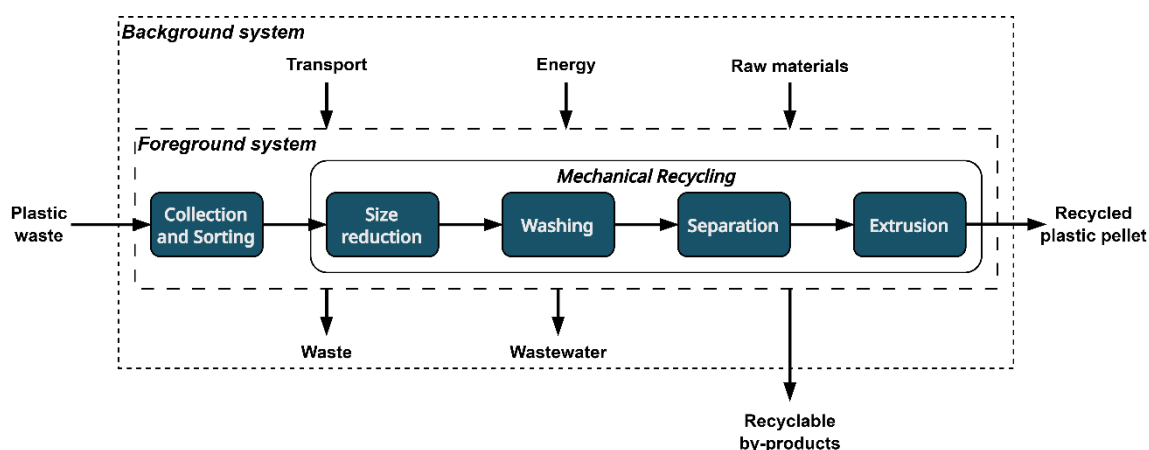


Figure 1: System description and boundaries. Following the PRE recycling scheme.

- The functional unit of the rLDPE EcoProfile is **'Production of 1 kg of mechanically recycled LDPE pellets, obtained from post-consumer household packaging waste after collection and sorting, at gate, unpackaged, representing 5.58% of European production'** where the reference flow of the rLDPE EcoProfile provided is **'1 kg of rLDPE 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 LDPE pellets with a cradle-to-gate boundary

Incoming Material	Flow Quantities per 1 kg of rLDPE
Mixed plastic waste including impurities ¹	2.94 kg
Material inputs	
air filter, central unit, 600 m3/h	1.10E-04 Item(s)
chemical, organic	4.75E-06 kg
Colour masterbatch	5.90E-04 kg
containerboard, linerboard	1.20E-04 kg
fleece, polyethylene	1.47E-08 kg
lubricating oil	2.47E-05 kg
polyethylene, high density, granulate	1.10E-04 kg
polyethylene, low density, granulate	4.91E-02 kg
polypropylene, granulate	4.30E-04 kg
sodium hydroxide, without water, in 50% solution state	3.08E-02 kg
steel, low-alloyed	1.50E-02 kg
tin plated chromium steel sheet, 2 mm	1.37E-05 m ²
waste collection lorry, 21 metric ton	1.62E-07 Item(s)
Service inputs	
drawing of pipe, steel	1.22E-05 kg
extrusion, plastic film	4.89E-02 kg
injection moulding	1.10E-04 kg
wire drawing, steel	1.50E-02 kg
Water consumption	
tap water	41.9 kg
Energy	
diesel, burned in building machine	0.353 MJ
electricity, low voltage	10.1 MJ
heat, central or small-scale, other than natural gas	8.80E-02 MJ
Infrastructure	
waste preparation facility	7.35E-09 Item(s)
Transportation	
municipal waste collection service by 21 metric ton lorry	1.33E-02 t*km
Transport, forklift, propane-driven	4.20E-04 t*km
transport, freight, lorry 16-32 metric ton, EURO3	3.97E-02 t*km
transport, freight, lorry 16-32 metric ton, EURO4	2.48E-02 t*km
transport, freight, lorry 16-32 metric ton, EURO5	0.271 t*km
transport, freight, lorry 16-32 metric ton, EURO6	4.67E-02 t*km
transport, freight, lorry, unspecified	4.69E-02 t*km
transport, passenger car	27.3 m
Solid Waste	
municipal solid waste	1.82898 kg
raw sludge	0.00858 kg
waste plastic, mixture	4.09E-02 kg
Secondary material outputs	
Waste fraction - diverse - recycling cut-off	3.53E-02 kg
Waste fraction - metal - recycling cut-off	2.50E-03 kg
Waste fraction - MPO lumps	3.13E-02 kg
Wastewater treatment	
wastewater, average	1.20E-04 m ³
Probability to litter plastic	
plastic litter	1.70E-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 LDPE pellets with a cradle-to-gate boundary

Energy carrier	Total energy input for 1kg of rLDPE pellets
Uranium	10.86 MJ-Eq
Gas, natural	7.98 MJ-Eq
Oil, crude	5.61 MJ-Eq
Coal, hard	3.97 MJ-Eq
Coal, brown	3.05 MJ-Eq
Energy resources: non-renewable	31.57 MJ-Eq
Energy resources: renewable	6.33 MJ-Eq
Total	37.90 MJ-Eq

4 LCIA RESULTS

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

Impact Category	Impact assessment²	Unit
Acidification	8.10E-03 ± 9.95E-04	mol H ⁺ -Eq
Climate change	2.59 ± 0.26	kg CO ₂ -Eq
Ecotoxicity: freshwater	17.7 ± 2.0	CTUe
Energy resources: non-renewable	30.1 ± 5.0	MJ, net calorific value
Eutrophication: freshwater	1.08E-03 ± 1.14E-04	kg P-Eq
Eutrophication: marine	2.76E-03 ± 2.79E-04	kg N-Eq
Eutrophication: terrestrial	1.63E-02 ± 2.38E-03	mol N-Eq
Human toxicity: carcinogenic	9.97E-09 ± 3.12E-09	CTUh
Human toxicity: non-carcinogenic	3.41E-08 ± 3.27E-09	CTUh
Ionising radiation: human health	0.619 ± 0.072	kBq U235-Eq
Land use	10.7 ± 3.3	dimensionless
Material resources: metals/minerals	1.71E-05 ± 2.39E-06	kg Sb-Eq
Ozone depletion	2.80E-08 ± 5.19E-09	kg CFC-11-Eq
Particulate matter formation	8.48E-08 ± 1.29E-08	disease incidence
Photochemical oxidant formation: human health	6.01E-03 ± 1.08E-03	kg NMVOC-Eq
Plastic litter	0.101 ± 0.010	kg
Water use	0.804 ± 0.101	m ³ world Eq deprived

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

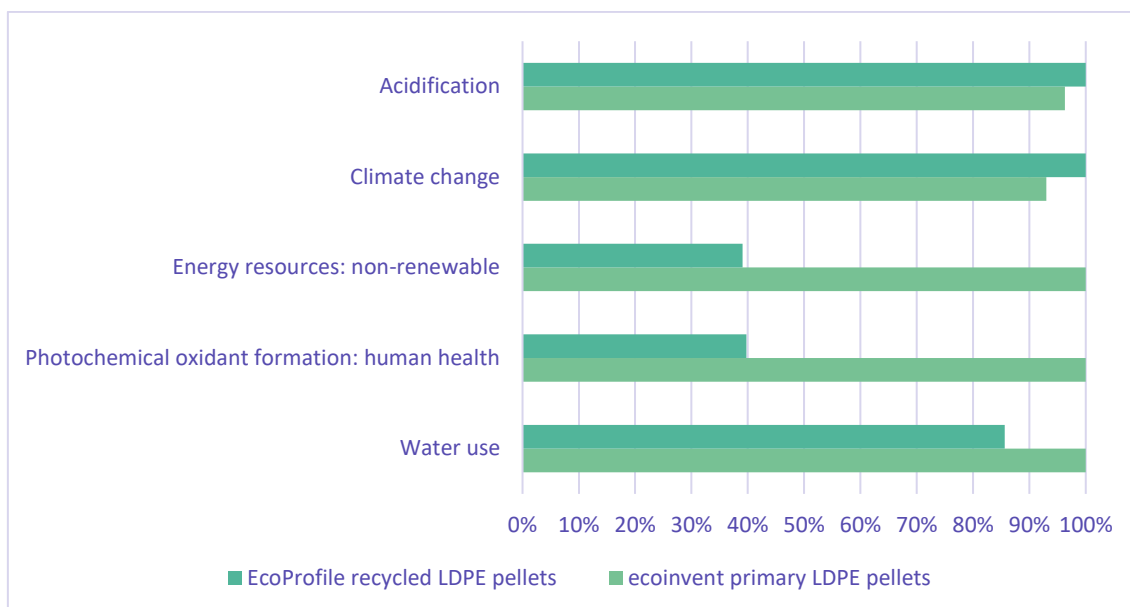


Figure 2: Comparison of primary³ and secondary LDPE pellet production impacts for selected impact categories.

³ For this comparison, the ecoinvent v3.10 process “acrylonitrile-butadiene-styrene copolymer production | acrylonitrile-butadiene-styrene copolymer | Cutoff, U - RER” was used.