EcoProfile of recycled HIPS flakes GB, gate-to-gate, post-consumer

Jonas Hoffmann, Max Bringmann, Andreas Ciroth
GreenDelta GmbH
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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 HIPS 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 high-impact polystyrene (rHIPS) 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.

- rHIPS is a material known for its thermal and electrical insulation properties, commonly used in small home appliances and medical devices. The usage of mechanically recycled HIPS reduces the use of fossil fuels and energy compared to the production of primary HIPS.

- Mechanical recycling of WEEE plastics waste involves collection, sorting, shredding, sorting to remove non-plastics (via magnetic separation and eddy-current separation) and grinding to produce 1 kg of rHIPS flakes. Density separation can be used to remove material with brominated flame retardants.

- 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 rHIPS production, adapted to a regional process located in Great Britain through the method described in the accompanying methodology document. Data was collected from 3 sites in 2022 in France, the Netherlands and the United Kingdom, represents the recycling of a mix of household wastes and ELV-WEEE wastes, and 29.6% 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 HIPS plastic recyclate flakes. The product under investigation is 1 kg of recycled HIPS flakes. The main production steps in mechanical recycling are included in the system boundaries of the EcoProfile are visualised in Figure 1.

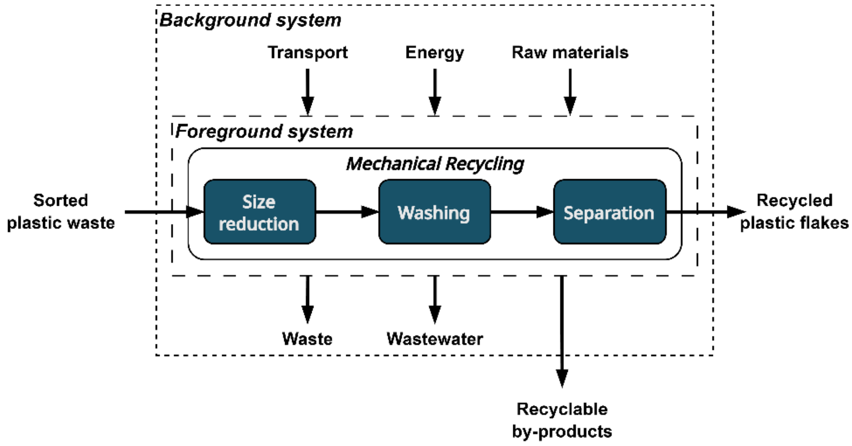

Figure 1: System description and boundaries. Following the PRE recycling scheme.

- The functional unit of the rHIPS EcoProfile is '**Production of 1 kg of mechanically recycled HIPS flakes, obtained from WEEE waste, at gate, unpackaged, representing British production**' where the reference flow of the rHIPS EcoProfile provided is '**1 kg of rHIPS 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 HIPS 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	1.07E-03 kg
chemical, organic	4.10E-04 kg
polyaluminium chloride	9.67E-05 kg
sodium chloride, powder	2.90E-02 kg
sodium hydroxide, without water, in 50% solution state	9.11E-05 kg
Talcum powder	6.50E-04 kg
Water consumption	
tap water	2.72E-02 kg
Energy	
electricity, low voltage	0.705 MJ
Infrastructure	
waste preparation facility	2.00E-09 Item(s)
Transportation	
transport, freight, lorry, unspecified	4.03E-02 t*km
Solid Waste	
municipal solid waste	0.232 kg
raw sludge	4.61E-02 kg
waste plastic, mixture	0.270 kg
waste polyurethane	4.14E-02 kg
Secondary material outputs	
Waste fraction - metal - recycling cut-off	4.43E-02 kg
Wastewater treatment	
wastewater, average	2.63E-05 m^3
Probability to litter plastic	
plastic litter	1.60E-03 kg

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

Energy carrier	**Total energy input for 1kg of rHIPS flakes**
Gas, natural	0.89 MJ-Eq
Uranium	0.67 MJ-Eq
Oil, crude	0.34 MJ-Eq
Coal, hard	0.18 MJ-Eq
Energy resources: non-renewable	2.11 MJ-Eq
Energy resources: renewable	0.50 MJ-Eq
Total	2.61 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 rHIPS model related to 1 kg of flakes

Impact Category	**Impact assessment[2]**	**Unit**
Acidification	6.19E-04 ± 8.69E-05	mol H+-Eq
Climate change	0.742 ± 0.061	kg CO2-Eq
Ecotoxicity: freshwater	3.13 ± 0.27	CTUe
Energy resources: non-renewable	1.99 ± 0.19	MJ, net calorific value
Eutrophication: freshwater	3.29E-05 ± 5.31E-06	kg P-Eq
Eutrophication: marine	8.55E-04 ± 6.42E-05	kg N-Eq
Eutrophication: terrestrial	2.19E-03 ± 2.02E-04	mol N-Eq
Human toxicity: carcinogenic	7.26E-10 ± 2.56E-10	CTUh
Human toxicity: non-carcinogenic	4.85E-09 ± 6.02E-10	CTUh
Ionising radiation: human health	5.03E-02 ± 5.76E-03	kBq U235-Eq
Land use	2.05 ± 1.20	dimensionless
Material resources: metals/minerals	2.09E-06 ± 5.91E-07	kg Sb-Eq
Ozone depletion	3.43E-09 ± 3.33E-10	kg CFC-11-Eq
Particulate matter formation	5.97E-09 ± 8.06E-10	disease incidence
Photochemical oxidant formation: human health	6.24E-04 ± 5.19E-05	kg NMVOC-Eq
Plastic litter	0.124 ± 0.012	kg
Water use	6.68E-02 ± 5.47E-03	m3 world Eq deprived

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