EcoProfile of recycled PVC pellets EU27+3, cradle-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 PVC 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

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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 polyvinylchloride (rPVC) 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.

- rPVC is a widespread material known for its high corrosion resistance, commonly used in packaging, cables and window frames. The usage of mechanically recycled PVC reduces the use of fossil fuels and energy compared to the production of primary PVC.

- Mechanical recycling of PVC plastic waste involves collection, sorting, shredding, sorting to remove non-plastics (via magnetic separation and eddy-current separation), density separation, grinding and extrusion to produce rPVC pellets.
- 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 rPVC production. Data was collected from 3 sites in 2022 in France, Germany and the Netherlands, represents the recycling of window frames originating from construction waste, and 6.22% 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 PVC plastic recyclate pellets. The product under investigation is 1 kg of recycled PVC pellets. The main production steps in mechanical recycling are included in the system boundaries of the EcoProfile are visualised in Figure 1.

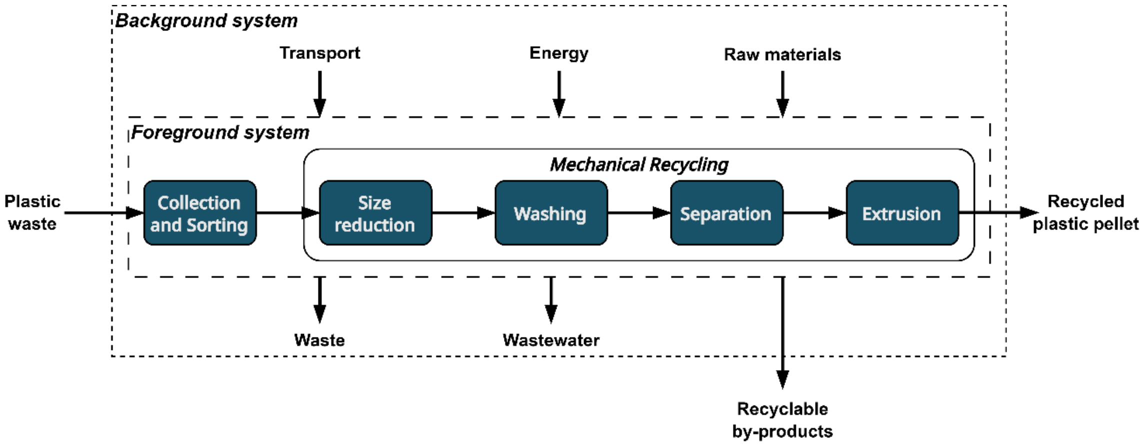

Figure 1: System description and boundaries. Following the PRE recycling scheme.

- The functional unit of the rPVC EcoProfile is '**Production of 1 kg of mechanically recycled PVC pellets, obtained from WEEE and household waste after collection and sorting, at gate, unpackaged, representing 6.22% of European production**' where the reference flow of the rPVC EcoProfile provided is '**1 kg of rPVC 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 PVC pellets with a cradle-to-gate boundary

Incoming Material	**Flow Quantities per 1 kg of rPVC**
Mixed plastic waste including impurities[1]	1.55 kg
Material inputs	
air filter, central unit, 600 m3/h	2.70E-04 Item(s)
Cleaning consumables, with water	2.09E-06 kg
Colour masterbatch	2.80E-04 kg
fleece, polyethylene	7.73E-09 kg
lubricating oil	3.13E-06 kg
magnesium sulfate	5.90E-04 kg
polyethylene, low density, granulate	2.58E-02 kg
polypropylene, granulate	1.60E-04 kg
steel, low-alloyed	6.24E-03 kg
Talcum powder	0.00E+00 kg
waste collection lorry, 21 metric ton	9.44E-08 Item(s)
Service inputs	
extrusion, plastic film	2.57E-02 kg
wire drawing, steel	6.24E-03 kg
Water consumption	
tap water	0.206 kg
Energy	
diesel, burned in building machine	0.184 MJ
electricity, low voltage	1.79 MJ
heat, central or small-scale, other than natural gas	3.42E-02 MJ
Infrastructure	
waste preparation facility	4.23E-09 Item(s)
Transportation	
municipal waste collection service by 21 metric ton lorry	7.73E-03 t*km
transport, freight, lorry 16-32 metric ton, EURO3	2.09E-02 t*km
transport, freight, lorry 16-32 metric ton, EURO4	1.31E-02 t*km
transport, freight, lorry 16-32 metric ton, EURO5	0.143 t*km
transport, freight, lorry 16-32 metric ton, EURO6	2.46E-02 t*km
transport, freight, lorry, unspecified	1.28E-02 t*km
Solid Waste	
municipal solid waste	0.404 kg
raw sludge	3.32E-02 kg
waste plastic, mixture	7.22E-03 kg
Secondary material outputs	
Waste fraction - metal - recycling cut-off	9.48E-06 kg
Wastewater treatment	
wastewater, average	1.30E-04 m^3
Probability to litter plastic	
plastic litter	1.26E-03 kg

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

Energy carrier	**Total energy input for 1kg of rABS pellets**
Oil, crude	2.40 MJ-Eq
Gas, natural	2.04 MJ-Eq
Uranium	1.98 MJ-Eq
Coal, hard	1.07 MJ-Eq
Coal, brown	0.57 MJ-Eq
Energy resources: non-renewable	8.08 MJ-Eq
Energy resources: renewable	1.22 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.

Total	9.30 MJ-Eq

4 LCIA RESULTS

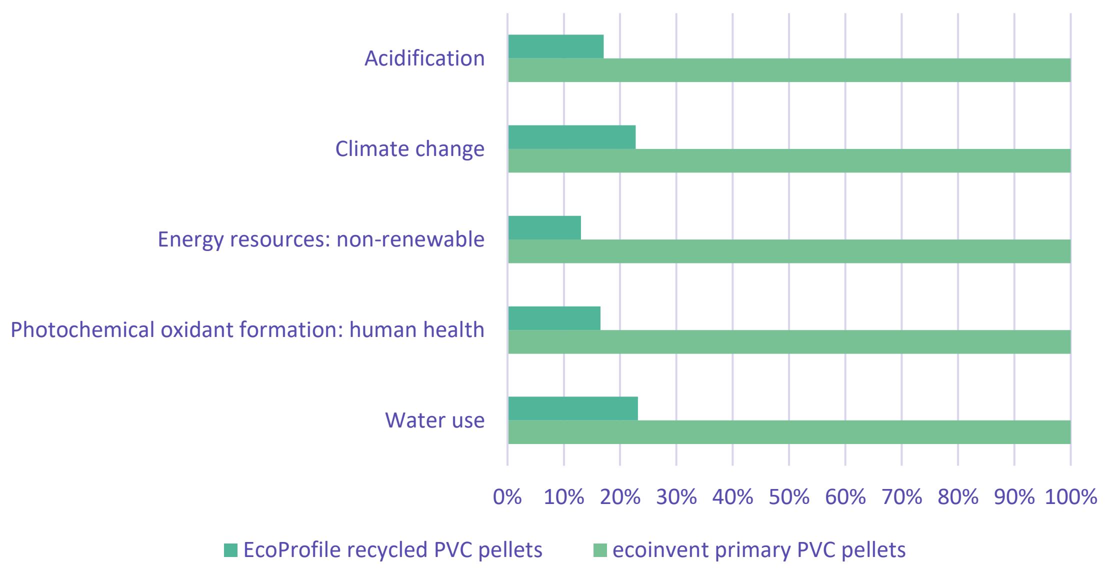

Figure 2: Comparison of primary[2] and secondary PVC pellet production impacts for selected impact categories.

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

Impact Category	**Impact assessment[3]**	**Unit**
Acidification	2.08E-03 ± 3.65E-04	mol H+-Eq
Climate change	0.674 ± 0.098	kg CO2-Eq
Ecotoxicity: freshwater	4.60 ± 0.79	CTUe
Energy resources: non-renewable	7.65 ± 2.13	MJ, net calorific value
Eutrophication: freshwater	2.20E-04 ± 2.88E-05	kg P-Eq
Eutrophication: marine	7.20E-04 ± 8.67E-05	kg N-Eq
Eutrophication: terrestrial	4.90E-03 ± 8.28E-04	mol N-Eq
Human toxicity: carcinogenic	3.33E-09 ± 1.39E-09	CTUh
Human toxicity: non-carcinogenic	8.09E-09 ± 1.14E-09	CTUh
Ionising radiation: human health	0.113 ± 0.013	kBq U235-Eq
Land use	3.70 ± 1.69	dimensionless
Material resources: metals/minerals	4.10E-06 ± 1.00E-06	kg Sb-Eq
Ozone depletion	7.54E-09 ± 2.35E-09	kg CFC-11-Eq
Particulate matter formation	2.70E-08 ± 4.60E-09	disease incidence
Photochemical oxidant formation: human health	1.88E-03 ± 4.60E-04	kg NMVOC-Eq
Plastic litter	2.34E-02 ± 2.37E-03	kg
Water use	0.189 ± 0.038	m3 world Eq deprived

[2] For this comparison, the ecoinvent v3.10 process "acrylonitrile-butadiene-styrene copolymer production | acrylonitrile-butadiene-styrene copolymer | Cutoff, U - RER" was used.
[3] The uncertainty value presented here has been calculated on the foreground data. Details are described in the methodology.