ENVIRONMENTAL PRODUCT DECLARATION

In accordance with ISO 14025:2016 and PCR 2010:16 version 3.01 for:

1 kg of average Hydropol polymer pellets

from Aquapak Polymers

Programme	The International EPD® System www.environdec.com
Programme Operator	EPD International AB
EPD Registration Number	S-P-02097
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An EPD should provide current information and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com

PROGRAMME INFORMATION

PROGRAMME OPERATOR

The International EPD System
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The EPD owner, Aquapak Polymers, has the sole ownership, liability, and responsibility for the EPD.

DECLARATION HOLDER

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PROGRAMME DETAILS

PCR 2010:16 version 3.01 was used as the basic PCR.	
Product category rules (PCR):	PCR 2010:16 Plastic in Primary Forms, version 3.01, UN CPC code 347: Plastic in Primary Forms.
PCR review was conducted by:	Technical Committee of the International EPD® System. Chair: Paola Borla. President: Massimo Marino. Email: info@environdec.com
Independent third-party verification of the declaration and data, according to ISO 14025:2006: ☐ EPD process certification (internal)	☒ EPD verification (external)
Third party verifier: Jane Anderson, ConstructionLCA Ltd	
Jane Anderson	
Accredited or approved by: The International EPD®System Technical Committee, supported by the Secretariat	
Procedure for follow-up of data during EPD validity involves third party verifier: ☐ Yes ☒ No	

GENERAL INFORMATION

COMPANY INFORMATION

Aquapak Polymers are a manufacturing company who specialise in producing water soluble, marine-safe, non-toxic materials that can be used in a variety of packaging products. Aquapak are the study commissioner and EPD owner. They operate one production site where all Hydropol polymer pellets were manufactured and this site is operated under a quality management system accredited to ISO 9001:2015.

This cradle-to-gate with options environmental product declaration is for 1 kg of Hydropol polymer pellets produced from the locations fully owned and operated by Aquapak Polymers in the United Kingdom, as follows:

Hollymoor Point, Hollymoor
Way, Rubery, Birmingham
B31 5HE, United Kingdom

Further information regarding Aquapak
Polymers be accessed from
www.aquapakpolymers.com.

PRODUCT INFORMATION

This EPD provides information concerning Hydropol polymer pellets. Hydropol is a speciality polymer resin based on polyvinyl alcohol (PVOH), which is non-toxic, biodegradable and soluble in water. A number of different formulations of Hydropol are available, depending on the requirements of the customer. The intended application of Hydropol is for further processing into a variety of plastic products, including single-layer plastic film, extrusion coatings, laminations to paper or board and injection mouldings. The expected service lifetimes of Hydropol or products derived from it are unknown.

Hydropol is classified under the following UN CPC group and class/subclass: “347: plastic in primary forms” and “3474/34740: Polyacetals, other polyethers and epoxide resins, in primary forms; polycarbonates, alkyd resins, polyallyl esters and other polyesters, in primary forms”. Hydropol’s IUPAC name, EN ISO 1043-1:2011 code and CAS number are polyvinyl alcohol, PVOH and 9002-89-5, respectively. Hydropol is not classified according to the GHS scheme.

A key feature of Hydropol is inherent biodegradability and solubility in water. The base polymer of Hydropol, PVOH, is composed of a long carbon chain with hydroxyl (–OH) functional groups that largely determine the degree of hydrolysis, and therefore solubility of the polymer in water. Through careful control of the hydrolysis levels during manufacturing, Aquapak produce a range of Hydropol polymers with different functionalities for use and end-of-life. These Hydropol formations can biodegrade or dissolve in controlled and uncontrolled end-of-life treatment methods such as composting or anaerobic digestion and littering in ocean or soil. Aside from biodegradability and solubility in water, other important properties of Hydropol include high tensile strength, puncture resistance, resistance to oils, electrostatic dissipation and UV-resistance.

TECHNICAL SPECIFICATIONS OF PRODUCT

The properties of Hydropol formulations depend on the specific composition, however, the basic characteristics of an average Hydropol formulation are described in the table below.

Technical specification	Test method	Value and unit
Density	ISO 1183-2:2004	Bulk Density 745 kg/m3 Solid Density 1210 kg/m3
Melt flow rate	ISO 1133-1:2011I ISO 1133-2:2011	(230°C and 10 kg) 4.3g / 10mins
Mechanical properties: Tensile	ISO 527-1-2: 2012	Not applicable as product supplied in pellet form
Melting temperature (or glass transition temperature for amorphous polymers)	ISO 11357-1:2016ISO 11357-2:2013ISO 11357-5:2013	TG = 46 °C
Deflection temperature under load	ISO 75f:2004	Not applicable as product supplied in pellet form
Mechanical properties: impact	ISO 179: 2010	Not applicable as product supplied in pellet form
Vicat softening temperature	ISO 306:2013	TG = 46 °C
Thermal conductivity	ISO 22007-1:2009	Not applicable as product supplied in pellet form
Volume resistivity	IEC 62631-3-1:2016	Not applicable as product supplied in pellet form
Flame behaviour	UL 94 (rev.2006)	Not applicable as product supplied in pellet form

CONTENT DECLARATION

Polyvinyl alcohol is the base polymer for all Hydropol formulations and makes up the bulk (>69%) of the mass of the polymer. There are a number of variants of PVOH that are used to manufacture Hydropol, which are selected to control the hydrolysis levels and therefore the properties of the formulation. The composition of the average product modelled in this project was obtained from the total raw material usages supplied to the Aquapak Birmingham site for Hydropol manufacture over the period of data collection. The product under investigation can therefore be viewed as an average Hydropol formulation. The composition of this average formulation (representing 100% of the product content) is provided in the table below. Note that generic names based on function have been provided for additives as specific names for these chemicals are considered confidential.

Material	CAS number	Typical mass (g per kg)
Modified branched polyol containing at least 3 hydroxyl groups	Confidential	110
Sodium salt of aromatic organic acid	Confidential	3.26
Calcium carbonate	471-34-1	4.66
2,2-bis(hydroxymethyl) 1,3-propanediol	Confidential	142
PVOH	9002-89-5	740

The average Hydropol formulation contains no post-industrial or post-consumer recycled material, contains 0% bio-based material and does not contain any substances hazardous to health or the environment (in particular carcinogenic, mutagenic, toxic to reproduction, allergic, PBT5 or vPvB6 substances). No substances that are listed in the “Candidate List of Substances of very high concern for authorisation” are contained in the average Hydropol formulation.

Hydropol is delivered to Aquapak’s customers packaged in either octabins or half-octabins, which contain 1,000 kg or 500 kg of pellets, respectively. Octabins and half-octabins are made of cardboard, with a removable polyethylene lining and are placed on wooden pallets for shipping. Aquapak do not specify recycled content requirements of cardboard or polyethylene with their packaging suppliers and therefore average recycled content for the UK was used in this LCA.

LCA INFORMATION

GOAL OF STUDY

The goal of this study was to generate an environmental profile of Hydropol polymer pellets to better understand the associated lifecycle environmental impacts and to allow a Type III EPD to be generated and made public via the International EPD® System. The following product system was investigated:

- An average formulation of Hydropol polymer pellets produced at Aquapak's production facility in Birmingham, United Kingdom.

DECLARED UNIT

The PCR followed for the EPD (2010:16 version 3.01) prescribes the use of a declared unit rather than a functional unit as all functional and qualitative aspects are not possible to capture in the same unit, due to the variety of possible uses of plastic in its primary form. The declared unit provides a reference to which material flows of the product system are normalised and serves as a basis of comparison and is therefore an important factor. The declared unit for this study follows PCR 2010:16 version 3.01 and was defined as:

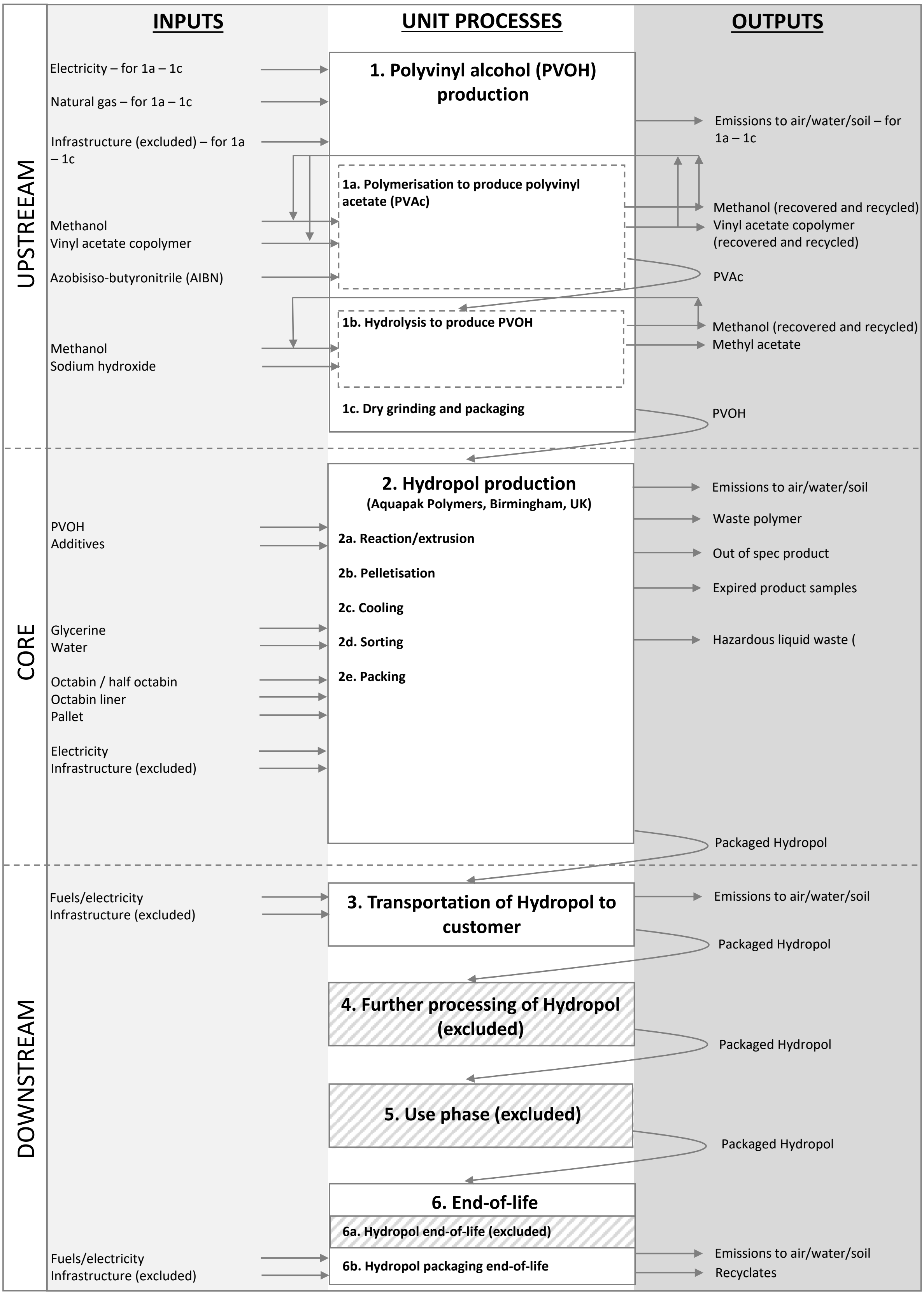
"1 kg of an average formulation of Hydropol polymer in the form of granules, including its primary packaging (the mass of the packaging is not included in this 1 kg)"

In this study, the declared unit also severed as a reference flow and their definitions are identical. Note that the 1 kg of Hydropol was defined at the point where the product arrives at the customer gate and any losses before this point were taken into account.

Following PCR 2010:16 version 3.01, reference service life is not applicable for this product category.

SYSTEM BOUNDARY

The system boundary of a product system determines the unit processes to be included in the LCA study and which data as inputs and/or outputs to/from the system can be omitted. In this LCA study and resulting EPD, the system boundary was defined as **cradle-to-gate with options**, which comprised extraction of raw materials, monomer production, polymer production, compounding, packaging production and packing, transportation to customer and end-of-life of packaging used to package pellets. Downstream processing, use and end-of-life of the Hydropol polymer were excluded from the system boundary, as is permitted by PCR 2010:16 version 3.01, due to the variety of options for further processing and applications that Hydropol polymers have. A system diagram for this product system is provided below.


INPUTS
UNIT PROCESSES
OUTPUTS
UPSTREEAM
CORE
DOWNSTREAM
Electricity – for 1a – 1c
Natural gas – for 1a – 1c
Infrastructure (excluded) – for 1a – 1c
Methanol
Vinyl acetate copolymer
Azobisiso-butyronitrile (AIBN)
Methanol
Sodium hydroxide
1. Polyvinyl alcohol (PVOH) production
1a. Polymerisation to produce polyvinyl acetate (PVAc)
1b. Hydrolysis to produce PVOH
1c. Dry grinding and packaging
Emissions to air/water/soil – for 1a – 1c
Methanol (recovered and recycled)
Vinyl acetate copolymer (recovered and recycled)
PVAc
Methanol (recovered and recycled)
Methyl acetate
PVOH
PVOH
Additives
Glycerine
Water
Octabin / half octabin
Octabin liner
Pallet
Electricity
Infrastructure (excluded)
2. Hydropol production
(Aquapak Polymers, Birmingham, UK)
2a. Reaction/extrusion
2b. Pelletisation
2c. Cooling
2d. Sorting
2e. Packing
Emissions to air/water/soil
Waste polymer
Out of spec product
Expired product samples
Hazardous liquid waste (
Packaged Hydropol
Fuels/electricity
Infrastructure (excluded)
3. Transportation of Hydropol to customer
Emissions to air/water/soil
Packaged Hydropol
4. Further processing of Hydropol (excluded)
Packaged Hydropol
5. Use phase (excluded)
Packaged Hydropol
6. End-of-life
6a. Hydropol end-of-life (excluded)
6b. Hydropol packaging end-of-life
Fuels/electricity
Infrastructure (excluded)
Emissions to air/water/soil
Recyclates

EXCLUSIONS

The follow exclusions from the scope of the study were made:

- Human and animal energy inputs to processes;
- Production and disposal of infrastructure (machines, transport vehicles, roads, etc.) and their maintenance;
- Transport of employees to and from their normal place of work and business travel;
- Environmental impacts associated with support functions (e.g. R&D, marketing, finance, management etc.).
- Packaging of incoming raw materials and ancillary materials (immaterial [calculated to be <1% of lifecycle impact for carbon footprint, which is a good proxy for many other impact categories]);
- Disposal of air filters used to collect glycerine mist condensate at Aquapak's Birmingham site (likely immaterial, filters not changed since start of operation or during period of data collection);
- Further processing of Hydropol (as is permitted by PCR 2010:16 version 3.01, due to the variety of options for further processing that Hydropol polymers have);
- Use phase (as is permitted by PCR 2010:16 version 3.01, due to the variety of options for application that Hydropol polymers have); and
- End-of-life of Hydropol (as is permitted by PCR 2010:16 version 3.01, due to the variety of options for application that Hydropol polymers have).

ASSUMPTIONS

During this LCA a number of assumptions were made, which are documented below for transparency:

- As Aquapak do not specify recycled content requirements with their packaging suppliers, recycled content of Hydropol packaging materials was assumed to be the average recycled content for these materials in the UK;
- Of the glycerine or water added as ancillary materials during Hydropol production, it was assumed all glycerine leaves the site as liquid waste;
- The majority of water added as an ancillary material during Hydropol production leaves the site as liquid waste, however, some is evaporated, and this amount was assumed based on the difference between liquid waste output and glycerine input (accounting for differences in density);
- It was assumed that no glycerine or water added as ancillary materials during Hydropol production forms part of the final formulation;
- Transportation of Hydropol factory waste to materials recovery facility was assumed to be 50 km;
- The mass of pallets for transportation of Hydropol polymer pellets was assumed to be 25 kg[1];
- Pallets used to transport Hydropol polymer pellets were assumed to be reused by customers;
- The main market for Hydropol polymer pellets is Malaysia and waste treatment was specific to this country: 21% recycling and 79%[2] landfill for both cardboard and plastic Hydropol packaging materials; and
- Transportation of Hydropol packaging waste to materials recovery facility was assumed to be 50 km.

DATA SOURCES AND QUALITY

Quantitative and qualitative data were collected for all processes within the system boundary and these data were used to compile the LCI. Specific data were sought as a preference, however, they could not be collected for

[1] Assumption based on https://www.epal-pallets.org/eu-en/load-carriers/epal-euro-pallet

[2] Assumption based on https://unstats.un.org/unsd/envstats/country_files

upstream and downstream lifecycle stages. Specific data for all core processes were collected from Aquapak from their site in Birmingham using data collection sheets via an iterative process and represent a time period of six months from 2019.06.01 to 2019.12.01. Data for an entire reference year could not be used because during the early part of 2019 Hydropol production was being scaled-up, and therefore was not representative of current commercial Hydropol manufacturing. Selected generic data were collected for the majority of upstream and downstream lifecycle stages from the LCI database ecoinvent v3.4 (cut-off) and literature sources (e.g. PVOH production from Guo [2012]). In some cases, for minor processes, proxy data had to be used where better data could not be sourced.

The LCA software SimaPro (version 8.5) was used to build a model for the product systems under investigation using specific and generic inventory data. In addition, SimaPro was used to apply characterisation models and factors from the impact assessment methods to generate results.

The table below provides details on the parameters for describing environmental impacts that were considered in this study, including the life cycle impact assessment (LCIA) method used. Characterisation models and factors from these LCIA methods were used unaltered and as provided in this LCA. In addition, environmental information describing resource use, waste and other output flows were also derived from LCI data and are presented in this EPD alongside parameters for describing environmental impacts.

Impact category	Explanation	Parameter and unit	LCIA method
Global warming [presented separately as a) fossil, b) biogenic, c) land use and land transformation, d) total]	Global warming is a long-term rise in the average temperature. Climate change is a change in global or regional climate patterns, a change apparent from the mid- to late-20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced using fossil fuels. a) "Fossil" refers to greenhouse gas emissions associated with carbon derived from a fossil source (e.g. crude oil) b) "Biogenic" refers to greenhouse gas emissions associated with carbon derived from a biogenic source (e.g. wood) c) "Land use and land transformation" refers to greenhouse gas emissions associated with a (positive or negative) change in carbon stock during to the occupation of transformation of land (e.g. transformation from forest to arable land) d) "Total" is the sum of a-c	Global warming potential (GWP), kg CO_2 equiv., 100 years	CML-IA baseline v4.1 / EU25
Acidification	Acidification potential refers to processes that can increase the hydrogen ion concentration ([H+]) in aquatic and soil systems, such as atmospheric deposition of sulphur, nitrogen and phosphorous compounds. Any change from the natural pH can have	Acidification potential (AP), kg SO_2 equiv.	CML-IA baseline v4.1 / EU25

Impact category	Explanation	Parameter and unit	LCIA method
	detrimental effects on plant and aquatic life.		
Eutrophication	Eutrophication is an excessive richness of nutrients in a lake or other body of water, which causes a dense growth of plant life and results in oxygen depletion. This nutrient pollution is typically generated in aquatic environments from phosphorous or nitrogen compounds through discharges from sewage treatment works or pulp and paper mills and storm water run-off of fertilisers or manure.	Eutrophication potential (EP), kg $(PO_4)^{3-}$equiv.	CML-IA baseline v4.1 / EU25
Formation of tropospheric ozone	Ozone formation (or photochemical oxidant formation, or smog) is a product of reactions that take place between NOx and volatile organic compounds (VOCs) in the presence of UV radiation. Low-level O_3 is a key photochemical oxidant of concern as it is toxic to humans. Ozone formation is a measure of the adverse effects from the formation of low-level ozone and other photo-oxidants. Models are used to calculate photochemical oxidation, and they are based on the mass of each released substance and the photochemical ozone creation potential (POCP) of the substance. This is a measure of how likely it is that the substance will contribute towards smog formation and are calculated from the change in ozone concentration in a set volume of air with the introduction of the emission of a substance relative to the change in emission of ethylene.	Formation potential of tropospheric ozone (POCP), kg NMVOC equiv.	ReCiPe 2008
Depletion of abiotic resources – elements	This impact category indicator is related to the extraction of virgin abiotic material e.g. extraction of aggregates, metal ores, minerals, earth etc. The extraction of such substances can mean that the natural carrying capacity of the earth is exceeded and make them unavailable for use by future generations. The category addresses the scarcity of the element.	Abiotic depletion potential for non-fossil resources (ADP-elements), kg Sb equiv.	CML-IA baseline v4.1 / EU25

Impact category	Explanation	Parameter and unit	LCIA method
Depletion of abiotic resources – Fossil fuels	This impact category indicator is related to the use of fossil fuels. Fossil fuels provide a valuable source of energy and feedstock for materials such as plastics. Although there are alternatives, these are only able to replace a small proportion of our current use. Fossil fuels are a finite resource and their continued consumption will make them unavailable for use by future generations.	Abiotic depletion potential for fossil resources (ADP-fossil fuels), MJ, net calorific value	CML-IA baseline v4.1 / EU25
Water scarcity	The impact category indicator is related to the extraction of water resources that are not returned subsequently to the same catchment area.	Water scarcity potential (WSP), m^3 equiv.	Boulay et al. 2017

ALLOCATION

For cases where there is more than one product in the system being studied, PCR 2010:16 version 3.01 prescribes the following procedure for the allocation of material and energy flows and environmental emissions.

- In the first instance, allocation should be avoided, by process sub-division.
- Where these methods are not applicable, the ISO 14040/44 requires that allocation reflects the physical relationships of the different products or functions. Allocation based on physical relationships such as mass or energy is a practical interpretation of this and is an approach often used in LCA.
- For some processes, allocation based on mass is not considered appropriate and, in these cases, economic allocation is used.

In this study, allocation procedures for multi-product processes followed the ISO approach above. In terms of generic data, the main database used, ecoinvent v3.4 (cut-off), defaults to an economic allocation for most processes. However, in some cases a mass-based allocation is used, where there is a direct physical relationship. The allocation approach of specific ecoinvent modules is documented on their website and method reports (see www.ecoinvent.org).

In this study a “cut-off” method (aka recycled content or 100:0 approach) was applied to all cases of end-of-life allocation, including in the case of generic data, where the ecoinvent v3.4 with a cut-off by classification end-of-life allocation method was used. In this approach, environmental burdens and benefits of recycled / reused materials are given to the product system consuming them, rather than the system providing them and are quantified based on recycling content of the material under investigation. This is a common approach in LCA for materials where there is a loss in inherent properties during recycling, the supply of recycled material exceeds demand and recycled content of the product is independent of whether it is recycled downstream. It is in compliance with the ISO standards on LCA and is prescribed in PCR 2010:16 version 3.01.

CUT-OFF CRITERIA

In the process of building an LCI it is typical to exclude items considered to have a negligible contribution to results. In order to do this in a consistent and robust manner there must be confidence that the exclusion is fair and reasonable. To this end, cut-off criteria were defined in this study, which allow items to be neglected if they meet the criteria. In accordance with PCR 2010:16 version 3.01, exclusions could be made if they were expected to be within the below criteria:

- Environmental significance: if a flow is anticipated to be less than 1% of the declared environmental impact categories it may be excluded.

COMPARABILITY

Note that EPDs within the same product category but from different programmes may not be comparable. In addition, EPDs of plastic products may not be comparable if they do not comply with PCR 2010:16 version 3.01, even if they comply with earlier versions of PCR 2010:16.

ENVIRONMENTAL PERFORMANCE

The environmental performance of the assessed product is declared and reported using the parameters as specified in PCR 2010:16 version 3.01. These LCIA results and other environmental results are presented in the table below per declared unit to three significant figures, and broken down into upstream, core and downstream lifecycle stages.

Parameter	Unit	Upstream	Core	Downstream	Total
Parameters describing environmental impacts					
Global warming potential (GWP) – fossil	kg CO_2 equiv.	8.12	3.34	0.100	11.6
Global warming potential (GWP) - biogenic	kg CO_2 equiv.	8.60E-03	1.20E-03	1.50E-02	2.48E-02
Global warming potential (GWP) – land use and land transformation	kg CO_2 equiv.	0.243	1.93E-04	2.78E-06	0.244
Global warming potential (GWP) - total	kg CO_2 equiv.	8.37	3.34	0.115	11.8
Acidification potential (AP)	kg SO_2 equiv.	3.21E-02	8.12E-03	2.19E-03	4.24E-02
Eutrophication potential (EP)	kg $(PO_4)_3$- equiv.	5.46E-03	1.51E-03	2.00E-04	7.17E-03
Formation potential of tropospheric ozone (POCP)	kg NMVOC equiv.	3.02E-02	4.45E-03	1.61E-03	3.62E-02
Abiotic depletion potential – elements (ADPE)	kg Sb equiv.	2.76E-06	2.47E-08	2.12E-10	2.79E-06
Abiotic depletion potential – fossil (ADPF)	MJ, net calorific	222	21.7	1.45	245
Water scarcity potential (WSP)	m^3 equiv.	7.23	0.158	5.50E-03	7.40
Parameters describing use of resources					
Use of renewable primary energy resources – use as energy carrier	MJ, net calorific value	12.5	3.05	0	15.5
Use of renewable primary energy resources – use as raw materials	MJ, net calorific value	0.215	0	0	0.215
Use of renewable primary energy resources – total	MJ, net calorific value	12.7	3.05	0	15.8
Use of non-renewable primary energy resources – use as energy carrier	MJ, net calorific value	212	25.3	1.54	239
Use of non-renewable primary energy resources – use as raw materials	MJ, net calorific value	40.4	0	0	40.4

Parameter	Unit	Upstream	Core	Downstream	Total
Use of non-renewable primary energy resources – total	MJ, net calorific value	253	25.3	1.54	280
Use of secondary material	kg	0	0	0	0
Use of renewable secondary fuels	MJ, net calorific value	0	0	0	0
Use of non-renewable secondary fuels	MJ, net calorific value	0	0	0	0
Net use of fresh water	m^3	0.188	3.80E-03	1.47E-04	0.192
Agricultural land use for renewable materials production	m^2	1.00	0.362	9.17E-05	1.36
Parameters describing waste production					
Hazardous waste disposed	kg	6.35E-04	9.46E-05	1.07E-05	7.40E-04
Non-hazardous waste disposed	kg	0.171	7.20E-02	8.08E-05	0.243
Radioactive waste disposed	kg	4.80E-04	8.24E-05	1.04E-05	5.73E-04
Parameters describing outputs flows					
Components for reuse	kg	0	0	0	0
Material for recycling	kg	0	0	0	0
Materials for energy recovery	kg	0	0	0	0
Export energy, electricity	MJ	0	0	0	0
Export energy, thermal	MJ	0	0	0	0

Note that the LCIA results are relative expressions and do not predict impacts on category end-points, the exceeding of thresholds, safety margins or risks.

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