ENVIRONMENTAL PRODUCT DECLARATION
acc. to *ISO 14025* and *EN 15804+A2*

Declaration owner	CONEL GmbH
Publisher	Institut Bauen und Umwelt e.V. (IBU)
Programme holder	Institut Bauen und Umwelt e.V. (IBU)
Declaration number	EPD-CNL-20240599-IBA2-DE
Date of issue	22/10/2024
Valid until	21/10/2029

DRAIN
CONEL GmbH

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Institut Bauen und Umwelt e.V.

ECO PLATFORM EPD VERIFIED



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1. General information

CONEL GmbH

Programme holder

IBU – Institut Bauen und Umwelt e.V.
Hegelplatz 1
D-10117 Berlin
Germany

Declaration number

EPD-CNL-20240599-IBA2-DE

This declaration is based on the following product category rules:

Unpressurised plastic drain pipe systems, 23/04/2024 (PCR tested and approved by the Independent Expert Panel (SVR – unabhängiger Sachverständigenrat))

Date of issue

22/10/2024

Valid until

21/10/2029

Dipl.-Ing. Hans Peters
(Chair of the Institut Bauen und Umwelt e.V.)

Florian Pronold
(Managing director of the Institut Bauen und Umwelt e.V.)

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Owner of declaration

CONEL GmbH
Margot - Kalinke - Straße 9
D-80939 Munich
Germany

Declared product / Declared unit

The declared pipe system is a pipe system made of PP filled with mineral material. The declared unit is "1 kg pipe system". The subject of the assessment was the average variant of the declared product system.

Scope:

CONEL GmbH is the declaration owner. The compound for the fittings and pipes is manufactured in the Velen plant, pipes are extruded in Triptis, and the fittings are manufactured in the Viechtach plant.
The declaration owner is liable for the underlying data and supporting documents; the IBU shall not be held liable under any circumstances with regard to the manufacturer's information, eco-balance data, and supporting documents.

This EPD was drawn up in accordance with the provisions of EN 15804+A2. The Standard will simply be referred to as EN 15804 from here on.

Verification

The European Standard EN 15804 serves as the core PCR
Independent verification of the declaration and information as per ISO 14025:2011

☐ internal ☒ external

Matthias Klingler,
(Independent verifier)

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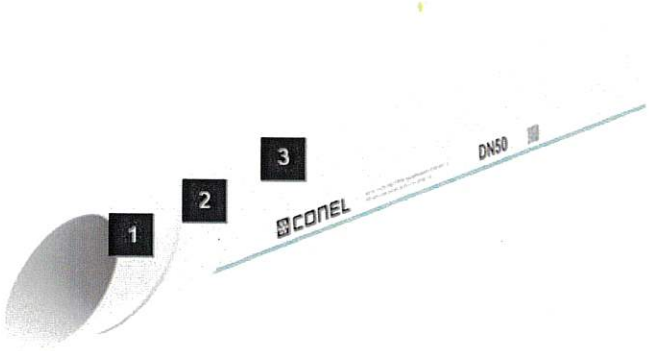
2. Product

2.1 Product description/Product definition

This study covers the manufacturing of the complete pipe system consisting of pipes and fittings with fitted sealing ring, in the different dimensions of the product range. The declared pipe system is a three-layer pipe system made of PP or PP filled with mineral material. DRAIN is a sound-absorbing building sewage pipe system and meets the requirements of *EN 1451-1*. Pipe dimensions from DN 32 to DN 100 acc. to *EN 1451-1* allow for smooth transitions to conventional (not sound-absorbing) PP pipe systems acc. to *EN 1451-1* and to sewer pipe systems acc. to *EN 1401-1*.



DRAIN has a three-layered pipe wall structure. The multi-layer design helps increase pipe stiffness. Number 1 is an abrasive-resistant PP inner layer with very good sliding characteristics. Number 2 consists of a high-stiffness intermediate layer made from mineral-reinforced PP, while number 3 forms an impact-resistant, shock-proof PP outer layer. The product is not subject to EU harmonisation legislation: Use of the product is covered by the applicable national provisions at the site of use and the technical regulations based on these provisions.

2.2 Application

The pipe system is applied in drainage installations for buildings and properties acc. to the *EN 12056 series* in the construction of residential buildings (single and multiple dwelling units, housing complexes), large-scale projects such as hotels, office buildings, hospitals and schools, as well as interior rainwater lines.

2.3 Technical data

The constructional data of the products assessed in this study are summarised in the following tables, based on the product data sheet and information directly from the manufacturer.

Structural data

Designation	Value	Unit
Material	PP-MD mineral-reinforced	-
Filler type (if applicable)	Mineral filler	-
Filler content/Ash residue of material (EN ISO 3451-1)*	40 - 60	%
Density of the PP material	895 - 900	kg/m³
Mean density of the material acc. to EN ISO 1183-1 or -2 of the pipes	1.0 - 1.3	kg/m³
Mean density of the fittings	1.0 - 1.25	kg/m³
Inner dimensions	27.6 - 151.5	mm
Exterior dimensions	32.0 - 160.5	mm
Wall thickness varies subject to dimensions acc. to EN 1451-1	1.9 - 2.8	mm
Short-term E module	2100	N/mm²
Linear expansion coefficient	0.09	mm/m x K
Chemical resistance	1 - 13	pH

This product is not subject to any EU harmonisation legislation: product performance values in relation to its characteristics under the relevant technical regulation (no EC label)

2.4 Delivery condition

The system DRAIN is available in all dimensions from DN 32 to DN 100. The pipes are offered in 500, 1000, 2000, and 3000 mm length.

- Pipes up to 500 mm and fittings in carton
- Pipes from 1000 mm in pipe bundles on crates

2.5 Base/Accessory materials

The pipes and fittings are factory-fitted with a sealing ring. The statistical composition of the pipe system based on annual sales volumes in mass percent in relation to the declared unit is given below:

Designation	DRAIN	Unit
Pipe	63.0	%
Fitting	34.4	%
Sealing ring	2.6	%

The plastic compound filled with mineral material for pipe and fitting production of the DRAIN system incorporates the following base and accessory materials:

- Polypropylene compound incl. pigment and stabilisers 40 - 60%
- Mineral material 60 - 40%

1. The product contains **no** substances according to the ECHA list of candidate substance of very high concern (SVCHC) for authorisation (dated 14/06/2023) above 0.1 mass %.
2. The product contains **no** additional, category 1A or 1B, CMR substances not included in the *candidate list*, above 0.1 mass % in at least one partial product.
3. The present construction product has **no** added biocidal products or it was not treated with biocidal products (meaning the product is not a treated article in the meaning of the Biocidal Products Regulation (EU) No. 528/2012).

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2.6 Manufacturing

This study covers the manufacture of the complete pipe systems consisting of the pipes, different variants of fittings and the sealing rings fitted between elements.
The pipe compound and the pipes of the assessed pipe systems are produced in the factory in Velen (compounds) and in Triptis (pipes), Germany.
In the compounding process, raw and accessory materials are added to the polypropylene raw material. The pipes themselves are extruded. The pipes are packed on a reusable wooden pallet, separated using wooden spacer blocks, and foil-wrapped.
The various fittings are made with the extrusion method in Viechtach, Germany. Sealing rings are used to establish an air and watertight connection between pipes and fittings.
The sealing rings are largely machine-fitted to the extruded fittings. Fitting may also be manual, depending on size.

2.7 Environment and health during manufacture

The statutory provisions on exhaust air, wastewater, waste and noise emission management are complied with, or better. Staff health is not at risk during production. The REHAU plants use certified management system for the environment acc. to ISO 14001 and for energy acc. to ISO 50001.

2.8 Product processing/Installation

Installation of lines in installation shafts DRAIN sewer pipes and fittings can be installed in installation shafts without the need for additional solid-borne sound absorption.

- Design wall and ceiling lead-throughs with commercially available, moisture-protected structure-borne sound absorption to provide for acoustic decoupling of the pipelines.
- Avoid acoustic bridged between pipe and shaft wall.

Laying of pipelines inside masonry
The design of wall recesses and slits is covered by *EN 1996*.

- Design wall recesses so that the pipeline can be installed tension-free.
- Avoid acoustic bridged between masonry and pipe.

Laying of pipelines inside concrete
When embedding in concrete, it is recommended that the pipelines are acoustically decoupled from the structure using commercially available, moisture-protected structure-borne sound absorption with an absorption thickness of > 4 mm.

Laying above suspended ceilings
Due to the specific installation, laying above suspended ceilings requires additional measures to ensure a high level of sound absorption. Appropriate sound absorption solutions are described in the DRAIN product data sheet.

Ceiling lead-throughs
Ceiling lead-throughs must be designed to be moisture-resistant and sound-absorbing. It must be ensured that the temperature-driven linear extension of the pipe is not restricted.

2.9 Packaging

DRAIN fittings are delivered in a carton on a EURO reusable pallet to the site of use.
The pipes are wrapped in stretch film and packaged with flat film in a timber frame crate. Disposal of the product packaging was accounted for in module A5. While the production of the reusable packaging was not accounted for, its transport was subjected to a life cycle assessment. Single-use product packaging was subjected to thermal waste treatment.

2.10 Condition in use

The polymers are stabilised and highly resistant to ageing.

2.11 Environment and health during use

There are no indications of an effect relation between the pipe system in use and the environment and health.

2.12 Reference service life

No reference service life is declared. Acc. to the European product standard of CEN/TC 155, the pipes are generally designed for a service life of 50 years.

2.13 Exceptional influences

Fire
Fire class B2 acc. to *DIN 4102-1* and building material class D-s2 d0 acc. to *EN 13501-1*.

Water
No environmental impact is to be expected in case of unforeseen exposure to water.

Mechanical destruction
No environmental impact is to be expected in case of unforeseen mechanical destruction.

2.14 End-of-life phase

For deconstruction, the pipe system can be subjected to material or thermal utilisation.

2.15 Disposal

Depending on the local situation, the product can be sent to landfill instead of material or thermal utilisation. Waste key acc. to the European Waste Code (EWC): 20 01 39 Plastics

2.16 Additional information

Additional information on DRAIN can be found on the website www.conel.de.

3. LCA: calculation rules

3.1 Declared unit

The declared unit is "1 kg pipe system", encompassing the components smooth pipe, fitting, and sealing ring. 2.5 shows the mass fractions of the single components.

An average variant of the DRAIN pipe system was assessed for the LCA. This is based on the quantities sold in the reference year 2022 and thus covers all dimensions and length. The mass relation varies subject to the pipe's dimensions.

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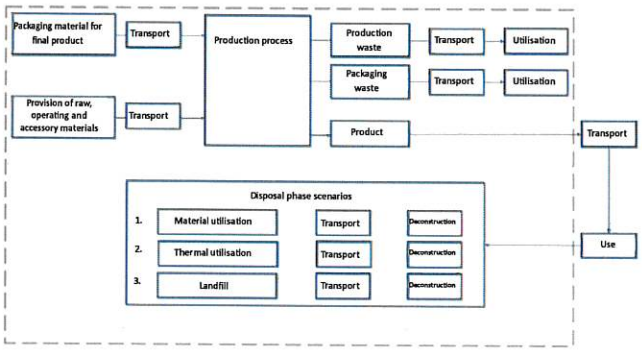
Declared unit

Designation	Value	Unit
Declared unit	1	kg
Polypropylene bulk density	900	kg/m³
Mass relation DN 32	0.179	kg/rm
Mass relation DN 40	0.227	kg/rm
Mass relation DN 50	0.288	kg/rm
Mass relation DN 70	0.459	kg/rm
Mass relation DN 90	0.649	kg/rm
Mass relation DN 100	1.012	kg/rm

3.2 System boundary

The respective life cycle is modular acc. to *DIN EN 15804*. The life cycle assessments cover the life product life cycle from the cradle to the factory gate, i.e., A1-A3 with modules C1-C4 and module D.



The life cycle segments or process modules of the pipe system are detailed below:

A1 – A3 Manufacturing phase

This module encompasses the following processes:

- Production of the base, auxiliary and operating materials incl. transport to respective factory
- Production of the sealing ring at supplier's plant incl. transport to respective factory
- Production of the packaging materials for final product and energy supply for production
- Production of the packaging materials for the raw materials incl. transport to utilisation with subsequent utilisation
- Transport of the reusable packaging of the raw materials
- Internal reprocessing of production waste and feedback into production

C1 – C4 Disposal

Three 100% disposal scenarios are assumed:

End-of-Life (EoL) scenario 1 (landfilling):
100% deconstruction of the pipe system incl. transport to disposal site. Disposal takes place at a local landfill (modules C4/1 and D/3 in the evaluation).

EoL scenario 2 (recycling):
100% reconstruction of the pipe system incl. transport to site of utilisation with material utilisation (modules C3/2 and D/2 in the evaluation).

EoL scenario 3 (energy recovery from waste):
100% reconstruction of the pipe system incl. transport to site of utilisation with energy recovery (modules C3/1 and D/1 in the evaluation).

D Reuse, recovery and/or recycling potentials

Reuse, recovery and/or recycling potentials exist in the disposal scenarios because the pipe system is subjected to energetic and/or material utilisation from which energy and/or secondary materials are recovered for use outside the system boundaries.

3.3 Estimates and assumptions

The primary data regarding the composition of the pipe system and the data regarding energy utilisation, transport routes and packaging of products and raw materials are supplied by the manufacturer. Possible data gaps were filled with statistic average and empirical values.

Energy requirements for production at the three factories in Velen, Viechtach, and Triptis were calculated with green electricity. The German residual mix was applied for the production of the seals while the German electricity mix was used for the production of precursor products.

3.4 Cut-off rules

All relevant inputs and outputs were included in the life-cycle assessment in this EPD. Due to their negligible relevance, individual processes and/or materials for which no data was available were left out. Each of the disregarded processes contribute less than 1% mass and energy and, in the aggregate, less than 5% in view of the declared unit.

3.5 Background data

The life-cycle assessment is entirely based on the background data retrieved from the *Database Managed LCA Content* by Sphera (version 2023.2, previously GaBi Database). Modelling was done using the *Software LCA for Experts* by Sphera (version 10.7, previously GaBi).

3.6 Data quality

The specific foreground data for the production of DRAIN was supplied by the manufacturer. Geographic and technical representativeness is considered to be very good. Temporal representativeness is rated as good to very good. Taken together, far more than 80% of the specific data were rated as good to very good.

Background data taken from the *Database Managed LCA Content* has a good or very good representativeness (geographic, technical, and temporal) in at least 80% of all core indicators.

3.7 Period under consideration

The specific data for DRAIN production was gathered over the production year 2022.

3.8 Geographic representative status

Land or region where the declared product is manufactured, used (if applicable), and treated at the end of its life cycle: global

3.9 Allocation

No co-products are generated in the production of DRAIN. The circulating material used comes from the same process (closed loop), so that no co-product allocation is needed in the foreground processes. Co-products are generated in the energy recovery and raw material production upstream chain so that allocations exist in the background data sets. The same applies for downstream processes like combustion processes during waste treatment.

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3.10 Comparability

Comparing or assessing EPD data is generally only possible if all datasets to be compared were generated as prescribed in *EN 15804* and the building context and/or product-specific performance characteristics are accounted for.

Background database: *Managed LCA Content* by Sphera

4. LCA: scenarios and additional technical information

Characteristic product properties biogenic carbon
The biogenic carbon content quantifies the amount of biogenic carbon in a construction product the moment it exits the factory gate. The mass of the biogenic carbon bound in the pipe system accounts for less than 5% of the product weight. According to the background data set, the wooden product packaging consists of approx. 43% of biogenic carbon while the carton product packaging consists of 47.7% per kg of carton and the fitting stabilisers 76.5% per kg of fatty acid.

Data used to describe the biogenic carbon content at the factory gate

Designation	Value	Unit
Biogenic carbon in product	0.001	kg C
Biogenic carbon contained in packaging	0.036	kg C

Note: 1 kg of biogenic carbon is equivalent to 44/12 kg CO_2.

Installation A5
The single-use product packaging is subjected to thermal utilisation in module A5, the transport distance to the utilisation site is assumed to be 50 km *[EURIMA,2019]*. The table refers to the declared unit.

Designation	Value	Unit
Film	0.0031	kg
Wood	0.080	kg
Carton/cardboard	0.084	kg
Reusable packaging (wooden pallet)	0.165	kg

Disposal C1-C4
No manufacturer-specific information is available for end-of-life disposal. Since these are simple construction products which are not segregated into individual components for waste treatment, three different 100% EoL scenarios are compared: [*IBU PCR-Teil A*, p. 20]: 100% landfilling of the excavated pipe system (EoL scenario 1, C4), 100% material utilisation (EoL scenario 2, C3/2), and 100% energetic utilisation (EoL scenario 3, C3/1). For deconstruction, the installed pipe is dug out with an excavator. Diesel consumption and the excavated material were considered.

Designation	Value	Unit
Pipe system	1	kg
Diesel fuel for deconstruction (C1)	1.72E-04	kg
Diesel fuel for transport(C2)	1.05E-03	kg

Module C2 includes transport to waste treatment or landfill. Transport by 32-tonne truck over a transport distance of 50 km is assumed, corresponding to EURIMA recommendations [*EURIMA, 2019*].

Disposal scenario 1 (landfilling):
100% of the pipe system is sent to landfill (C4). There are no additional advantages or disadvantages outside of the system boundaries (module D).

Disposal scenario 2 (recycling):
100% of the pipe system is materially recycled, washed, dried, shredded and ground using water and electric power. This process leaves 5% rejects which are then subjected to thermal utilisation. There are advantages or burdens outside the system boundaries due to the potential use of the ground material instead of new plastic products. A conservative substitution factor S = 0.5 is applied to account for the fact that the ground material cannot fully substitute for new material. Additional advantages are created by utilisation of the energy recovered via incineration of rejects.

Disposal scenario 3 (energetic utilisation):
100% of the pipe system is subjected to energetic utilisation (combustion). There are advantages or disadvantages outside the system boundaries due to the potential use of the recovered energy.

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5. LCA: results

In the next paragraph, the results of the life-cycle assessment and effect evaluation for the DRAIN pipe system are detailed. The tables differentiate between the described EoL scenarios:

EoL scenario 1 (100% landfilling) comprises modules C1, C2, C3, C4, and D.
EoL scenario 2 (100% material utilisation) comprises modules C1, C2, C3/1, C4/1, and D/1.
EoL scenario 3 (100% energetic utilisation) comprises modules C1, C2, C3/2, C4/2, and D/2.

SPECIFICATION OF SYSTEM BOUNDARIES (X = INCLUDED IN LIFE-CYCLE ASSESSMENT, MND = MODULE OR INDICATOR NOT DECLARED; MNR = MODULE NOT RELEVANT)

Production stage			Building construction stage		Use stage							Disposal stage				Credits and debits outside the system boundaries
Raw material supply	Transport	Manufacture	Transport from manufacturer to site of utilisation	Installation	Use/Application	Maintenance	Repair	Replacement	Renewal	Energy consumption for operation of	Water consumption for operation of	Dismantling/ Demolition	Transport	Waste treatment	Removal	Reuse, recovery or recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	MND	X	MND	MND	MNR	MNR	MNR	MND	MND	X	X	X	X	X

LIFE-CYCLE ASSESSMENT RESULTS – ENVIRONMENTAL EFFECTS acc. to EN 15804+A2: 1 kg pipe system

Indicator	Unit	A1-A3	A5	C1	C2	C3	C3/1	C3/2	C4	C4/1	C4/2	D	D/1	D/2
GWP-total	kg CO_2-eq.	1.58E+00	2.74E-01	6.4E-04	3.87E-03	0	2.13E-01	2.16E+00	2.69E-02	0	0	0	-7.12E-01	-1.1E+00
GWP-fossil	kg CO_2-eq.	1.67E+00	1.54E-02	6.46E-04	3.77E-03	0	2.1E-01	2.16E+00	2.48E-02	0	0	0	-7.08E-01	-1.09E+00
GWP-biogenic	kg CO_2-eq.	-8.88E-02	2.59E-01	0	2.16E-05	0	2.49E-03	2.05E-03	1.99E-03	0	0	0	-3.48E-03	-3.92E-03
GWP-luluc	kg CO_2-eq.	3.28E-03	1.56E-05	1.18E-05	7.25E-05	0	1.22E-05	7.5E-05	1.02E-04	0	0	0	-1.55E-04	-8.09E-05
ODP	kg CFC11-eq.	2.92E-11	3.99E-14	1.94E-16	1.19E-15	0	1.22E-12	2.88E-13	7.92E-14	0	0	0	-2.68E-12	-8.12E-12
AP	mol H^+-eq.	3.1E-03	6.13E-05	3.14E-06	4.53E-06	0	1.19E-04	2.64E-04	1.54E-04	0	0	0	-1.03E-03	-2.37E-03
EP-freshwater	kg P-eq.	8.62E-06	1.17E-08	1.68E-09	1.03E-08	0	2.36E-07	1.38E-07	1.15E-05	0	0	0	-9.82E-07	-1.62E-06
EP-marine	kg N-eq.	8.69E-04	2.01E-05	1.48E-06	1.63E-06	0	2.93E-05	6.91E-05	3.45E-05	0	0	0	-3.08E-04	-8.5E-04
EP-terrestrial	mol N-eq.	9.21E-03	2.87E-04	1.65E-05	1.94E-05	0	3.45E-04	1.26E-03	3.8E-04	0	0	0	-3.28E-03	-9.24E-03
POCP	kg NMVOC-eq.	3.13E-03	5.31E-05	4.21E-06	4.55E-06	0	7.83E-05	1.98E-04	1.09E-04	0	0	0	-1.27E-03	-2.46E-03
ADPE	kg Sb-eq.	5.44E-07	4.86E-10	1.05E-10	6.42E-10	0	1.01E-08	3.08E-09	1.64E-09	0	0	0	-5.89E-08	-8.41E-08
ADPF	MJ	5E+01	7.9E-02	8.09E-03	4.95E-02	0	1.14E+00	4.49E-01	4.02E-01	0	0	0	-2.34E+01	-1.7E+01
WDP	m^3 world-eq. deprived	7.32E-03	3.05E-02	4.41E-06	2.7E-05	0	3.03E-02	2.34E-01	3.14E-03	0	0	0	-4.11E-02	-9.87E-02

GWP = global warming potential; ODP = stratospheric ozone layer depletion potential; AP = soil and water acidification potential; EP = eutrophication potential; POCP = tropospheric ozone formation potential; ADPE = abiotic resource depletion potential – non-fossil resources (ADP – substances); ADPF = abiotic resource depletion potential – fossil fuels (ADP – fossil energy carriers); WDP = water deprivation potential (user)

LIFE-CYCLE ASSESSMENT RESULTS – RESOURCE UTILISATION INDICATORS acc. to EN 15804+A2: 1 kg pipe system

Indicator	Unit	A1-A3	A5	C1	C2	C3	C3/1	C3/2	C4	C4/1	C4/2	D	D/1	D/2
PERE	MJ	1.53E+01	2.79E+00	8.95E-04	5.48E-03	0	8.15E-01	1.78E-01	6.22E-02	0	0	0	-1.49E+00	-5.43E+00
PERM	MJ	2.78E+00	-2.76E+00	0	0	0	-1.78E-02	-1.78E-02	0	0	0	0	0	0
PERT	MJ	1.81E+01	2.24E-02	8.95E-04	5.48E-03	0	7.97E-01	1.6E-01	6.22E-02	0	0	0	-1.49E+00	-5.43E+00
PENRE	MJ	5.01E+01	2.11E-01	8.09E-03	4.95E-02	0	3.29E+00	2.98E+01	4.02E-01	0	0	0	-2.34E+01	-1.7E+01
PENRM	MJ	2.64E+01	-1.32E-01	0	0	0	-2.63E+01	-2.63E+01	0	0	0	0	0	0
PENRT	MJ	7.65E+01	7.9E-02	8.09E-03	4.95E-02	0	-2.3E+01	3.5E+00	4.02E-01	0	0	0	-2.34E+01	-1.7E+01
SM	kg	0	0	0	0	0	0	0	0	0	0	0	9.5E-01	0
RSF	MJ	0	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ	0	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	5.11E-03	7.17E-04	8.36E-07	5.12E-06	0	1.95E-03	5.5E-03	9.41E-05	0	0	0	-2.68E-03	-4.17E-03

PERE = renewable primary energy as energy carrier; PERM = renewable energy for material utilisation; PERT = total renewable primary energy; PENRE = non-renewable primary energy as energy carrier; PENRM = non-renewable primary energy for material utilisation; PENRT = total non-renewable primary energy; SM = use of secondary materials; RSF = renewable secondary fuels; NRSF = non-renewable secondary fuels; FW = net utilisation of sweet water resources

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RESULTS OF THE LIFE CYCLE ASSESSMENT – WASTE CATEGORIES AND OUTPUT FLOWS acc. to EN 15804+A2: 1 kg pipe system

Indicator	Unit	A1-A3	A5	C1	C2	C3	C3/1	C3/2	C4	C4/1	C4/2	D	D/1	D/2
HWD	kg	3.53E-08	4.77E-11	3.94E-13	2.41E-12	0	1.62E-09	3.44E-10	9.95E-11	0	0	0	-3.5E-09	-1.1E-08
NHWD	kg	2.16E-02	4.77E-03	1.37E-06	8.37E-06	0	1.86E-03	5.26E-02	9.97E-01	0	0	0	-5.88E-03	-8.15E-03
RWD	kg	3.57E-04	2.91E-06	1.29E-08	7.88E-08	0	1.79E-04	2.17E-05	5.43E-06	0	0	0	-2.1E-04	-1.2E-03
CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0	0
MFR	kg	8.48E-04	0	0	0	0	1E+00	0	0	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	1.21E-02	3.76E-01	0	0	0	3.34E-01	4.56E+00	0	0	0	0	0	0
EET	MJ	2.8E-02	7.74E-01	0	0	0	5.94E-01	8.11E+00	0	0	0	0	0	0

HWD = hazardous waste sent to landfill; NHWD = disposed, non-hazardous waste; RWD = disposed radioactive waste; CRU = components for reuse; MFR = materials for recycling; MER = materials for energy recovery; EEE = exported energy – electric; EET = exported energy – thermal

RESULTS OF THE LIFE CYCLE ASSESSMENT – additional effect categories acc. to EN 15804+A2-optional: 1 kg pipe system

Indicator	Unit	A1-A3	A5	C1	C2	C3	C3/1	C3/2	C4	C4/1	C4/2	D	D/1	D/2
PM	Cases of illness	3.62E-08	3.36E-10	3.74E-11	4.34E-11	0	9.58E-10	3.28E-09	1.67E-09	0	0	0	-8.89E-09	-1.55E-08
IR	kBq U235-eq.	4.56E-02	4.07E-04	1.36E-06	8.32E-06	0	2.95E-02	3.07E-03	7.3E-04	0	0	0	-3.04E-02	-1.97E-01
ETP-fw	CTUe	2.91E+01	3.61E-02	6.28E-03	3.84E-02	0	3.37E-01	2.02E-01	7.71E-01	0	0	0	-1.21E+01	-9.24E+00
HTP-c	CTUh	8.45E-10	2.1E-12	1.25E-13	7.66E-13	0	1.93E-11	1.75E-11	1.17E-11	0	0	0	-2.87E-10	-3.04E-10
HTP-nc	CTUh	2.38E-08	3.87E-11	5.28E-12	3.23E-11	0	2.94E-10	2.23E-10	2.61E-10	0	0	0	-1.06E-08	-5.94E-09
SQP	SQP	5.14E+01	2.88E-02	5.38E-03	3.29E-02	0	4.81E-01	1.82E-01	7.54E-02	0	0	0	-9.8E-01	-3.18E+00

PM = potential occurrence of disease caused by particulate emissions; IR = potential effect through human exposure to U235; ETP-fw = potential toxicity reference unit for ecosystems; HTP-c = potential toxicity reference unit for humans (carcinogenic effect); HTP-nc = potential toxicity reference unit for humans (non-carcinogenic effect); SQP = potential soil quality index

The characterisation factors acc. to *EK-JRC* were used. Long-term emissions at a time-scale of > 100 years are not included in the impact assessment. As of the date of the life cycle assessment, the list of characterisation factors for *EN 15804,* released in February 2023, were used, based on the EF Reference Package 3.1 (file EN 15804 XLS) [*EFJRC, 2023*].

Qualifier 1 – applies to indicator 'potential effect through human exposure to U235: This effect category mainly covers the potential impact of low-dosage ionising radiation on human health in the nuclear fuel cycle. It does not account for effects caused by possible nuclear accidents and occupational exposure nor for the disposal of radioactive waste in subterranean installations. This indicator also does not cover the potential ionising radiation emitted by the ground, radon, and certain construction materials.

Qualifier 2 – applies to the indicators: "abiotic resource depletion potential – non-fossil resources", "abiotic resource depletion potential – fossil fuels", "water deprivation potential (user)", "potential toxicity reference unit for ecosystems", "potential toxicity reference unit for humans – carcinogenic effect", "potential toxicity reference unit for humans – non-carcinogenic effect", and "potential soil quality index": Diligence must be applied when using the results of the environmental impact indicator because they are fraught with high uncertainties or experience with the indicator is limited.

6. LCA: Interpretation

Summary

For a general interpretation, the life cycle assessment results for the EoL scenario 100% combustion are considered (modules C3/2, C4/2, D/2). The values in the figures which enable a relative comparison are scaled for identical height of the bars. Effect categories with the value zero have no bars.

Values below 10% points are not shown in the diagrams. Most of the environmental effect and life cycle assessment indicators are dominated by the manufacturing phase (module A1-A3).

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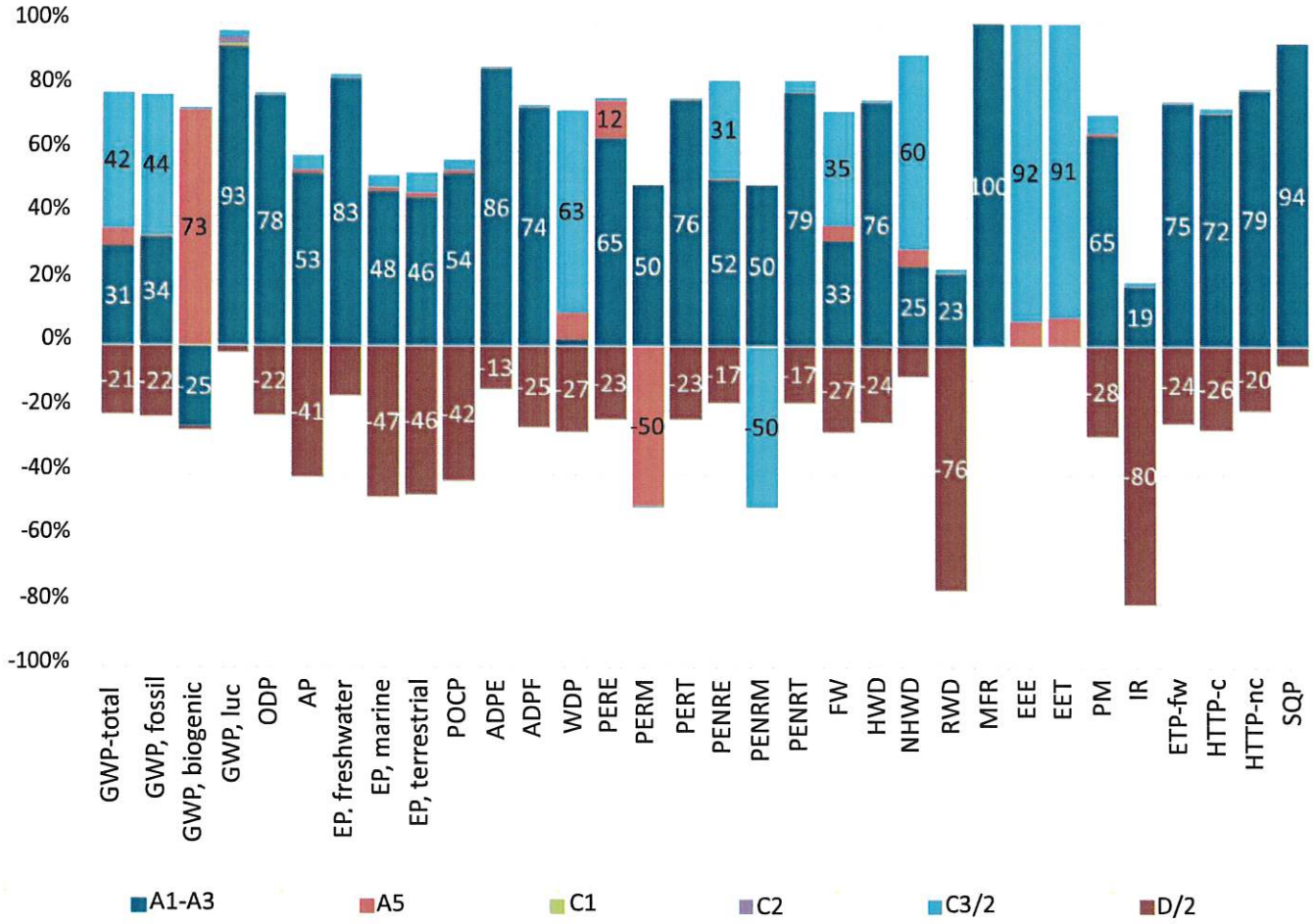

Except in GWP_{total}, GWP_{fossil}, and WDP, module A1-A3 contributes at least 50% across all core indicators. In GWP_{total}, the manufacturing phase contributes 31% of effects, followed by disposal in C3/2 with 42%, and module D/2 with -21%. As regards core indicators, WDP is an exception, with the manufacturing phase, with less than 10%, contributes the least to the effects in the core indicators. With 63%, C3/2 contributes the most to WDP. In comparison, effects from modules C1 deconstruction and C2 transport to disposal site are negligible for all indicators.

Resource consumption is dominated by the manufacturing phase with an average of 78%. Regarding output flows and waste categories, module C3/2 has a substantial impact (24% on average). In particular, the amount of electric and thermal energy exported (EEE, EET) is generated through thermal utilisation of the product waste at the end of the pipe systems' service life.

Manufacturing phase

The results reflected here refer to the product system DRAIN. Individual hotspots during manufacture are discussed below.

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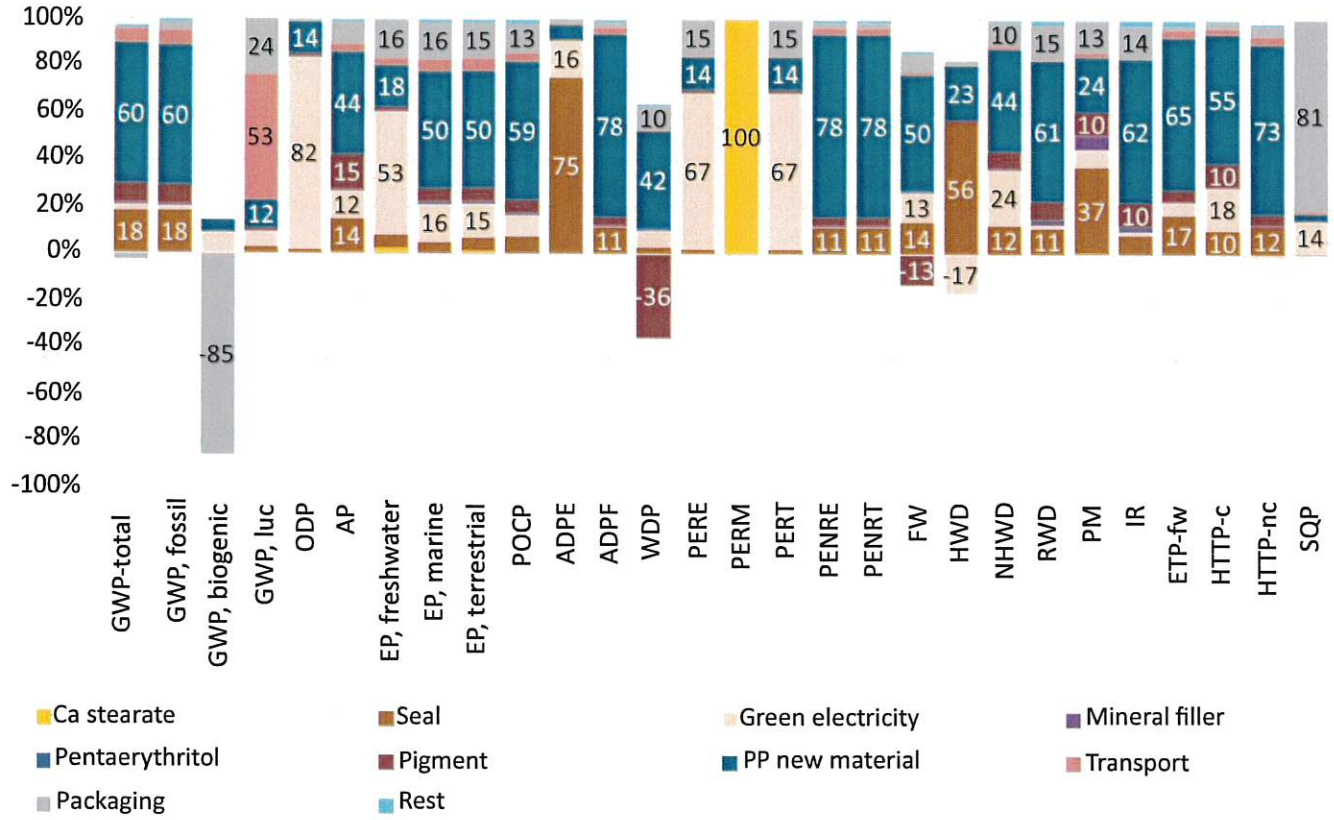

Polypropylene:
Supply of the raw material polypropylene contributes, per core indicator, between 78% in ADPEF and 5% in $GWP_{biogenic}$. As to GWP_{total}, the polymer contributes 60% to the effects in module A1-A3.As regards resource consumption, the largest share is in PENRE (use of non-renewable primary energy) with 33%. On average, the PP contributes 31% (between 3% and78%) to the effects of module A1-A3.

Mineral filler:
Supply of the raw material mineral filler contributes, per core indicator, between 0.1% in WDP and 0.6% in the indicators EP_{marine} and $EP_{terrestrial}$. As to GWP_{total}, the raw material contributes 0.4% to the effects in module A1-A3.As regards resource consumption, the largest share is in PERE (use of non-renewable primary energy) with 0.3%. On average, the filler used contributes 0.4% (between 0.1% and 5.7%) to the effects of module A1-A3.

Sealing ring:
The raw materials used for the sealing ring and its manufacture contribute 10% on average to the effects of the manufacturing phase. The precursor product accounts for a particularly large portion in categories ADPE (75%) and HWD (56%). With respect to the overall effects, the raw material EPDM caoutchouc contributes less than 1% on average to the effects in the effect categories.

Green electricity:
Energy supply from green power contributes 12% on average to the effects of the indicators of the manufacturing phase A1-A3. In the core indicators, the minimum of 0.5% is in ADPEF and the maximum of 82% is in ozone layer depletion (ODP). In GWP_{total}, it contributes 3% to the effects of the manufacturing phase.

GWP of the product system DRAIN according to disposal scenario

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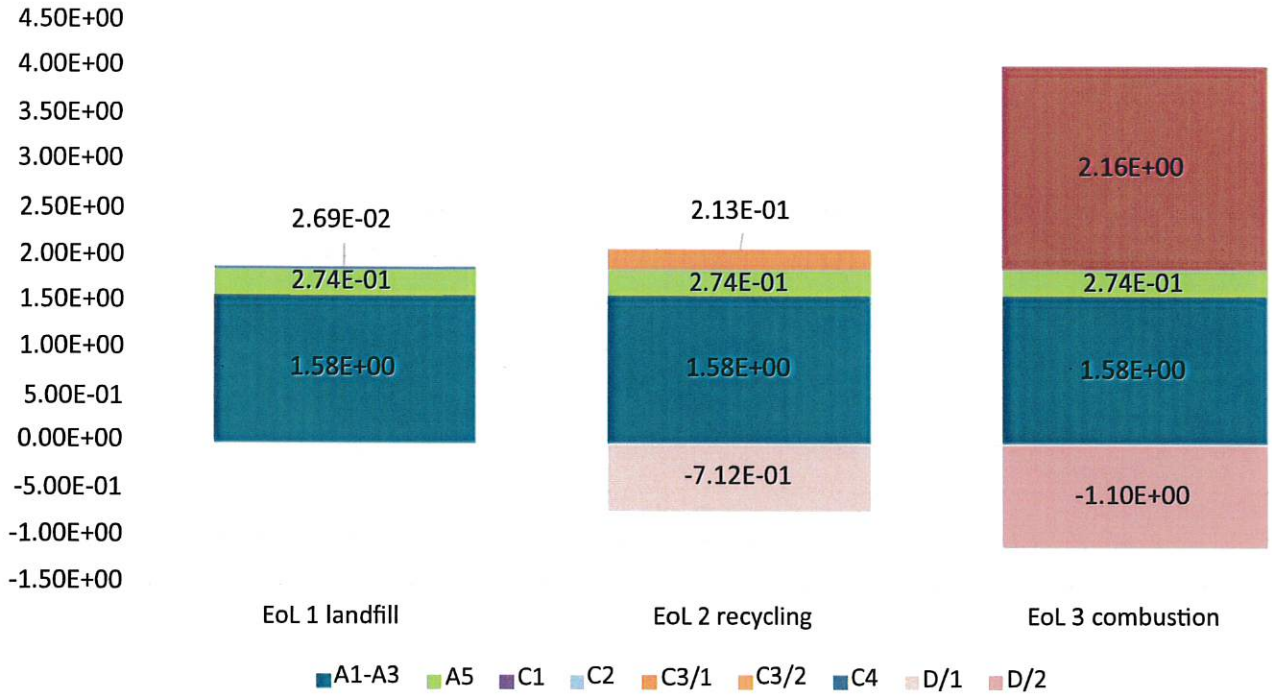

In all EoL scenarios, effects within the system boundaries can be compensated by utilisation and recycling potentials outside the system boundaries (module D) to different degrees. As reflected in the figure, EoL scenario 3 (combustion) produces advantages from the combustion of the plastic material, as well as disadvantages from the combustion of the inert material. The effect indicator GWP_{total} will be addressed in detail below. Module C3/2 (combustion at EoL) has a global warming potential of 2.16E+00 kg CO_2 eq. In the recycling scenario, secondary materials are generated in addition to the recovered energy from combustion of the recycling waste. The recycling process and combustion of the resulting process waste entail a GWP value of 2.11E-01 kg CO_2 eq.

The EoL scenario 1 landfill (C4) involves neither advantages nor disadvantages regarding end-of-life use. The global warming potential is lowest with landfilling at 2.48E-02 kg CO_2 eq., compared to the other disposal scenarios. It should be noted, however, that the other effect categories (which are not reflected in the diagram), such as landfill-driven freshwater eutrophication (with 1.15E-05 kg CO_2 eq.), is highest. In module D/2, there are advantages for the end-of-life use by combustion of the plastic component, as well as disadvantages entailed by the energy requirements for combustion of the inert material. However, when set off against one another, advantages arise which are included in module D. Module D/2 (EoL combustion) has a global warming potential of -1.10E+00 kg CO_2 eq. The global warming potential under module D/1 (EoL recycling) is -7.12E-01 kg CO_2 eq.

7. References

The pipe system DRAIN meets the requirements of *EN 1451-1*.
References are available on request.

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Software
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I, Dr. Sascha MALAK, translator for the English language, authorized by the President of Hamm Higher Regional Court (reg. no. 3162 E-17.5722), hereby certify the above to be a correct and complete translation of an original from German into English.

Dortmund, 19 March 2025