

Statement of Verification

BREG EN EPD No.: 000478

Issue 01

This is to verify that the
Environmental Product Declaration
provided by:
Aquatherm, GmbH

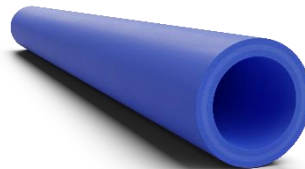


is in accordance with the requirements of:
EN 15804:2012+A2:2019
and
BRE Global Scheme Document SD207

This declaration is for:
1m of green/blue S / MF / MF-RP piping system

Company Address

Aquatherm, GmbH
Biggen 5,
57439 Attendorn,
Germany



Emma Baker
Operator

10 February 2023
Date of this Issue

10 February 2023
Date of First Issue

09 February 2028
Expiry Date



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Environmental Product Declaration

EPD Number: 000478

General Information

| EPD Programme Operator | Applicable Product Category Rules |
|---|---|
| BRE Global Watford, Herts WD25 9XX United Kingdom | BRE Environmental Profiles 2013 Product Category Rules for Type III environmental product declaration of construction products to EN 15804+A2 PN 514 Rev 3.0. |
| Commissioner of LCA study | LCA consultant/Tool |
| Aquatherm, GmbH Biggen 5, 57439 Attendorn, Germany | Sphera Solutions - GaBi Innovation Centre Warwick Technology Park Gallows Hill, Heathcote CV34 6UW |
| Declared Unit | Applicability/Coverage |
| 1m of green/blue S / MF / MF-RP piping system | Product Average. |
| EPD Type | Background database |
| Cradle to Gate, with A5 & Module C1-4 and D | GaBi Software System and Database for Life Cycle Engineering 1992-2022 © Sphera Solutions GmbH |
| Demonstration of Verification | |
| RIGID AND FLEXIBLE BUILDING PIPING SYSTEMS IN NORTH AMERICA (PCR-1002) ^a in combination with the general program rules of BRE. | |
| Independent verification of the declaration and data according to EN ISO 14025:2010 <input type="checkbox"/> Internal <input checked="" type="checkbox"/> External | |
| (Where appropriate ^b)Third party verifier: Nigel Jones | |
| a: Product category rules b: Optional for business-to-business communication; mandatory for business-to-consumer communication (see EN ISO 14025:2010, 9.4) | |
| Comparability | |
| Environmental product declarations from different programmes may not be comparable if not compliant with EN 15804:2012+A2:2019. Comparability is further dependent on the specific product category rules, system boundaries and allocations, and background data sources. See Clause 5.3 of EN 15804:2012+A2:2019 for further guidance | |

Information modules covered

| Product | | | Construction | | Use stage | | | | | | | End-of-life | | | | Benefits and loads beyond the system boundary |
|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------|-------------------------------------|--------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|---|
| | | | | | Related to the building fabric | | | | | Related to the building | | | | | | |
| A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
| Raw materials supply | Transport | Manufacturing | Transport to site | Construction – Installation | Use | Maintenance | Repair | Replacement | Refurbishment | Operational energy use | Operational water use | Deconstruction demolition | Transport | Waste processing | Disposal | Reuse, Recovery and/or Recycling potential |
| <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

Note: Ticks indicate the Information Modules declared.

Manufacturing sites

Attendorn
Biggen 5,
57439 Attendorn,
Germany

Radeberg
Wilhelm-Rönsch-Strasse 4,
01454 Radeberg,
Germany

Construction Product

The results of this EPD build on the results of **EPD 1: Aquatherm green/blue S / MF / MF-RP pipe** (average product: from cluster 1 & cluster 2). This report quantifies the results of three representative products, each with the addition of different additive materials to provide specific additional technical qualities for different commercial applications.

The results presented within the body of this EPD document refer to the **Aquatherm green/blue S / MF / MF-RP pipe (TI)**; this product was selected for the main report due to this specification having the most significant environmental impacts of all three product specifications quantified. The results from the other two variations can be found in Annex 1 & 2.

The three variations of the Aquatherm green/blue S/MF pipe are as follows:

| Representative product | Additional additive material | Results location |
|------------------------|------------------------------|------------------|
| EPD 4a | TI (pre-insulated) | Body of report |
| EPD 4b | OT (oxygen-tight) | Annex 1 |
| EPD 4c | UV (UV-resistant) | Annex 2 |

*S (single-layer), MF (multi-layer, fibre-reinforced), OT (oxygen-tight), UV (UV-resistant), TI (pre-insulated).

Product Description

Aquatherm blue / green pipe S / MF / MF-RP

Aquatherm blue pipe made of corrosion-resistant polypropylene (PP-R & PP-RCT) is a specialist for the transport of cooling and heating media in closed systems and is therefore particularly suitable for various industrial applications. The physical properties of the plastic are adapted to the special requirements of the heating and cooling sector. It is characterized by its high temperature and pressure resistance. Added to this are the exceptionally good welding properties and the fusion into a homogeneous and materially cohesive unit, so that a maximum of safety and service life is achieved. The system contains – in combination with the Aquatherm green pipe fittings – all components for the pipe installation of air conditioning and heating systems as well as for the plant engineering.

Aquatherm green pipe has revolutionized the plastic piping sector and has been shaping it for decades. The innovative all-rounder made of corrosion-resistant polypropylene (PP-R & PP-RCT) shows its advantages due to its excellent ecological properties, especially in the field of drinking water applications, because it is completely free of heavy metals and toxic chemicals. Aquatherm green pipe is also suitable for swimming pools, agriculture, shipbuilding or the transport of chemicals considering the chemical resistance. Thanks to the very good welding properties, a form-fit and material-fit and thus secure connection is created.

Product characteristics:

Blue pipe

- High environmental compatibility
- Free of heavy metals
- Extremely corrosion-resistant
- High stability
- Easy to process
- Air conditioning and heating systems

Green pipe

- Extremely corrosion resistant
- Suitable for drinking water
- High environmental compatibility
- Thermal/sound insulation properties
- High stability
- Simple processing
- Drinking water applications

Technical Information

| Property | Value, Unit |
|---|-----------------------|
| Density of the Piping system's material (PP-R / PP-RCT) | 0,9 g/cm ³ |
| Pipe colour/s | Blue / Green |
| Weight per meter | 1.568 kg/m |
| Pipe profile diameters | |

The results of EPD4c refer to a representative product of pipe diameter of 32mm and product weight 1.568 kg/m. Information on the full product range (0.111 kg/m – 68.044 kg/m & 20mm - 630mm) can be found in Annex 3.

This EPD declares an average product. The average product represents PP-pipes with the same pipe diameter and with the same amount of PP (approx. 90%). Due to the comparability of the material composition between the products the mean value of the green and blue pipes was used. Additional materials are also included for each EPD 4 a-c which are listed in each material input table.



Main Product Contents

| Material Input | % |
|------------------------|-------|
| Polyethylene Granulate | 49.8% |
| PUR foam insulation | 19.7% |

| Material Input | % |
|---|-------|
| Polypropylene-R Granulate / Polypropylene-RCT Granulate | 25.4% |
| Brass inserts for transition fittings | 4.2% |
| Reinforcement | 0.7% |
| Pigments | 0.2% |

Material: fusiolen® PP-R and fusiolen® PP-RCT (polypropylene random copolymer) properties are:

- Combination of carbon and hydrogen
- Polymerized from propene
- Thermoplastic polymer: meltable many a time / weldable
- Suitable for: extrusion process / injection moulding
- Fully recyclable and therefore a valuable raw material
- Contains colours, stabilisers, antioxidants
- Is: long lasting, free of heavy metals, heat stabilised

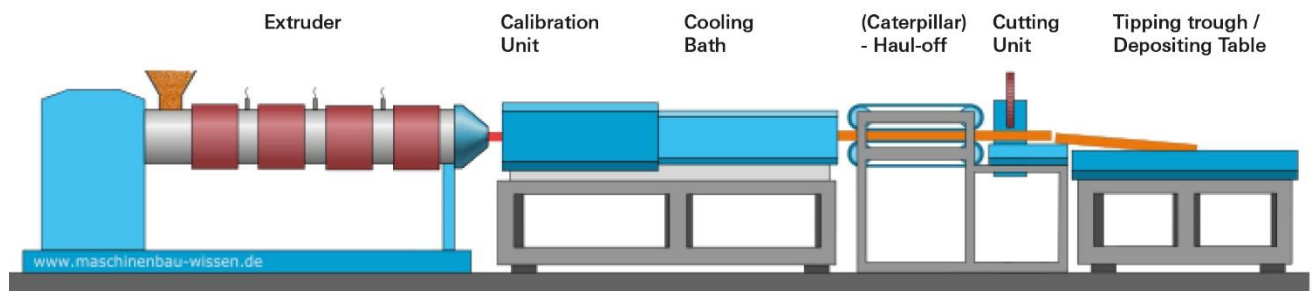
Manufacturing Process

Pipe production / Extrusion:

Plastic granulates are continuously melted and pressed through a shaping opening. The ejected semi-finished parts (pipe, profiles, plates, foils) are cooled down immediately after leaving the tool.

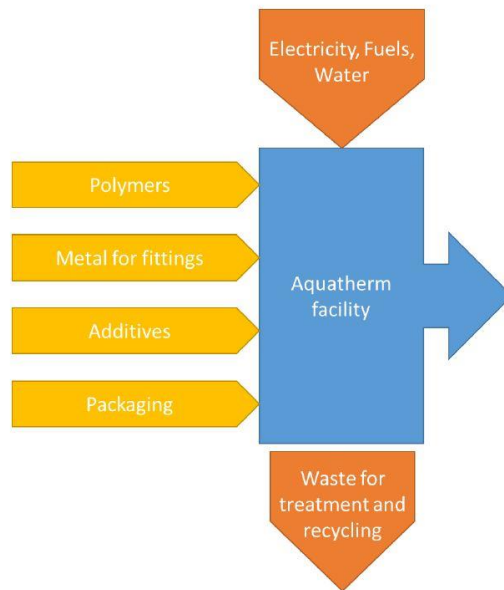
The single production steps are as following described:

1. Feeding the granulates to the extruder.
2. Melting of the material while moving it forward with the lead screw.
3. Extrude via jet.
4. Enforcing and cooling.
5. Cutting to the requested length.



Process flow diagram

The following diagram shows the input flows for the production of the pipes:



Construction Installation

Module A5 Installation has been partially included within the system boundaries of this study. The only impacts considered within module A5 is the end of life of packaging used to package Aquatherm products.

End of Life

Modules C1 – C4 have been included within the system boundaries of this study in accordance with EN 15804 +A2. The EoL scenarios considered within module C3 are 100% recycling of brass fittings and 100% incineration of the remaining piping system.

Life Cycle Assessment Calculation Rules

Declared unit description

The declared unit being evaluated, in accordance with the guiding PCR is: “1 meter of piping system.”

System boundary

The scope of this EPD is “cradle to gate + Module C and D with options (module A5).” It follows the module approach required by EN 15804+A2. Transport to the construction site and impacts from installation and use B1 – B7 were excluded from the study. However, processing of packaging is included in module A5. This EPD also includes modules C and D under the requirements of the revised EN 15804+ A2 standard.

Data sources, quality and allocation

Data for the manufacture of Aquatherm piping systems has been collected by the client. For the data collection a specifically prepared questionnaire by Sphera has been used. The collection of the foreground data refers to the year 2019 (annual average production). Plant-level data is allocated to the declared product based on yearly produced mass. The data acquisition was done by the client considering the following data sources: Measurements of technical machines/equipment and material consumption.

The EPD uses background data from the GaBi database, 2021, v2, and EPD data for the specific primary input material used. The quality of the data used for the EPD is quantified in terms of its temporal, geographical and technological representativeness in accordance with EN 15804:2012+A2:2019. The data quality of this EPD has been determined as being "good".

Background data incl. allocations are documented at <http://database-documentation.gabi-software.com/support/gabi/>). There is no allocation key within the GaBi model.

Cut-off criteria

In the assessment, all available data from the production process are considered, i.e. all raw materials used, utilized thermal energy, and electric power consumption using best available LCI datasets. For validity for this LCA, the cut-off criteria for material and energy flows are 1% of the consumption of renewable and non-renewable primary energy and 1% of the total mass input of the respective process unit. The sum of the excluded material flows does not exceed 5% of mass, energy or environmental relevance. Machinery, plants and infrastructure required in the manufacturing process were not considered. With acknowledgement of the above exclusions, this EPD complies with the PCR requirements related to the exclusion of inputs and outputs.

LCA Results

| Parameters describing environmental impacts | | | GWP-total | GWP-fossil | GWP-biogenic | GWP-luluc | ODP | AP | EP-freshwater |
|---|--------------------------------------|------|-----------------------|-----------------------|-----------------------|-----------------------|-------------|-----------------------|--|
| | | | kg CO ₂ eq | kg CO ₂ eq | kg CO ₂ eq | kg CO ₂ eq | kg CFC11 eq | mol H ⁺ eq | kg (PO ₄) ³⁻ eq |
| Product stage | Raw material supply | A1 | 4.29E+00 | 4.26E+00 | 2.70E-02 | 2.86E-03 | 6.22E-10 | 7.16E-03 | 9.41E-06 |
| | Transport | A2 | 3.19E-02 | 3.15E-02 | 9.29E-05 | 2.50E-04 | 6.14E-18 | 6.62E-05 | 9.11E-08 |
| | Manufacturing | A3 | 2.73E-02 | 3.39E-02 | -6.64E-03 | 5.33E-05 | 9.87E-16 | 7.40E-05 | 6.76E-06 |
| | Total (of product stage) | A1-3 | 4.35E+00 | 4.33E+00 | 2.05E-02 | 3.16E-03 | 6.22E-10 | 7.30E-03 | 1.63E-05 |
| Construction process stage | Construction | A5 | 2.16E-03 | 1.58E-04 | 2.01E-03 | 1.79E-07 | 2.22E-18 | 6.33E-07 | 6.98E-09 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 2.37E-02 | 2.34E-02 | 2.87E-04 | 5.94E-05 | 7.96E-16 | 3.35E-05 | 9.75E-08 |
| | Transport | C2 | 9.62E-03 | 9.52E-03 | 2.85E-05 | 7.78E-05 | 1.88E-18 | 1.01E-05 | 2.83E-08 |
| | Waste processing | C3 | 4.37E+00 | 4.37E+00 | 1.78E-04 | 2.77E-05 | 3.70E-16 | 7.74E-04 | 5.51E-08 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -3.02E+00 | -3.01E+00 | -3.23E-03 | -5.41E-04 | -3.80E-15 | -3.46E-03 | -3.32E-07 |

GWP-total = Global warming potential, total;
 GWP-fossil = Global warming potential, fossil;
 GWP-biogenic = Global warming potential, biogenic;
 GWP-luluc = Global warming potential, land use and land use change;

ODP = Depletion potential of the stratospheric ozone layer;
 AP = Acidification potential, accumulated exceedance; and
 EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment

LCA Results (continued)

| Parameters describing environmental impacts | | | EP-marine | EP-terrestrial | POCP | ADP-mineral&metals | ADP-fossil | WDP | PM |
|---|--------------------------------------|------|-----------|----------------|-------------|--------------------|-------------------------|----------------------------------|-------------------|
| | | | kg N eq | mol N eq | kg NMVOC eq | kg Sb eq | MJ, net calorific value | m ³ world eq deprived | disease incidence |
| Product stage | Raw material supply | A1 | 1.97E-03 | 2.08E-02 | 7.86E-03 | 3.23E-05 | 1.24E+02 | 1.73E-01 | 6.49E-08 |
| | Transport | A2 | 1.93E-05 | 2.21E-04 | 5.31E-05 | 2.74E-09 | 4.19E-01 | 2.85E-04 | 8.00E-10 |
| | Manufacturing | A3 | 5.17E-05 | 2.76E-04 | 7.25E-05 | 7.86E-09 | 6.97E-01 | 4.14E-01 | 2.93E-09 |
| | Total (of product stage) | A1-3 | 2.04E-03 | 2.13E-02 | 7.99E-03 | 3.23E-05 | 1.25E+02 | 5.87E-01 | 6.86E-08 |
| Construction process stage | Construction | A5 | 2.61E-07 | 2.22E-06 | 8.61E-07 | 3.00E-11 | 2.48E-03 | 1.06E-04 | 5.42E-12 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 1.07E-05 | 1.12E-04 | 2.66E-05 | 9.55E-09 | 2.95E-01 | 5.05E-04 | 2.66E-10 |
| | Transport | C2 | 3.22E-06 | 3.82E-05 | 8.77E-06 | 8.43E-10 | 1.27E-01 | 8.83E-05 | 6.95E-11 |
| | Waste processing | C3 | 2.74E-04 | 3.98E-03 | 7.35E-04 | 5.86E-09 | 6.68E-01 | 4.09E-01 | 3.38E-09 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -1.05E-03 | -1.14E-02 | -2.98E-03 | -2.87E-05 | -4.71E+01 | -3.49E-02 | -3.18E-08 |

EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment;
 EP-terrestrial = Eutrophication potential, accumulated exceedance;
 POCP = Formation potential of tropospheric ozone;
 ADP-mineral&metals = Abiotic depletion potential for non-fossil resources;

ADP-fossil = Depletion potential of the stratospheric ozone layer;
 WDP = Water (user) deprivation potential, deprivation-weighted water consumption; and
 PM = Particulate matter.

LCA Results (continued)

| Parameters describing environmental impacts | | | IRP | ETP-fw | HTP-c | HTP-nc | SQP |
|---|--------------------------------------|------|-------------------------|-----------|-----------|-----------|---------------|
| | | | kBq U ²³⁵ eq | CTUe | CTUh | CTUh | dimensionless |
| Product stage | Raw material supply | A1 | 1.41E-01 | 6.23E+01 | 2.08E-09 | 1.42E-07 | 6.41E+00 |
| | Transport | A2 | 1.10E-04 | 3.11E-01 | 6.27E-12 | 3.24E-10 | 1.40E-01 |
| | Manufacturing | A3 | 3.42E-03 | 1.31E+00 | 5.38E-11 | 5.27E-09 | 2.55E+00 |
| | Total (of product stage) | A1-3 | 1.45E-01 | 6.39E+01 | 2.14E-09 | 1.48E-07 | 9.10E+00 |
| Construction process stage | Construction | A5 | 3.56E-05 | 1.49E-03 | 6.07E-14 | 5.61E-12 | 5.62E-04 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 2.18E-03 | 1.12E-01 | 4.44E-12 | 1.77E-10 | 1.50E-01 |
| | Transport | C2 | 3.37E-05 | 9.40E-02 | 1.90E-12 | 9.86E-11 | 4.36E-02 |
| | Waste processing | C3 | 5.32E-03 | 2.76E-01 | 2.87E-11 | 9.52E-10 | 1.65E-01 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -1.85E-01 | -6.93E+00 | -3.03E-10 | -1.71E-08 | -6.79E-01 |

IRP = Potential human exposure efficiency relative to U235;
 ETP-fw = Potential comparative toxic unit for ecosystems;
 HTP-c = Potential comparative toxic unit for humans;

HTP-nc = Potential comparative toxic unit for humans; and
 SQP = Potential soil quality index.

LCA Results (continued)

| Parameters describing resource use, primary energy | | | PERE | PERM | PERT | PENRE | PENRM | PENRT |
|---|--------------------------------------|------|-----------|-----------|-----------|-----------|-----------|-----------|
| | | | MJ | MJ | MJ | MJ | MJ | MJ |
| Product stage | Raw material supply | A1 | 6.93E+00 | 0.00E+00 | 6.93E+00 | 6.22E+01 | 6.18E+01 | 1.24E+02 |
| | Transport | A2 | 2.35E-02 | 0.00E+00 | 2.35E-02 | 4.20E-01 | 0.00E+00 | 4.20E-01 |
| | Manufacturing | A3 | 5.74E-02 | 2.67E-01 | 3.24E-01 | 4.66E-01 | 2.31E-01 | 6.98E-01 |
| | Total (of product stage) | A1-3 | 7.01E+00 | 2.67E-01 | 7.28E+00 | 6.31E+01 | 6.20E+01 | 1.25E+02 |
| Construction process stage | Construction | A5 | 2.68E-01 | -2.67E-01 | 7.51E-04 | 2.34E-01 | -2.31E-01 | 2.48E-03 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 1.93E-01 | 0.00E+00 | 1.93E-01 | 2.95E-01 | 0.00E+00 | 2.95E-01 |
| | Transport | C2 | 7.29E-03 | 0.00E+00 | 7.29E-03 | 1.27E-01 | 0.00E+00 | 1.27E-01 |
| | Waste processing | C3 | 1.18E-01 | 0.00E+00 | 1.18E-01 | 6.25E+01 | -6.18E+01 | 6.68E-01 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -6.13E-01 | 0.00E+00 | -6.13E-01 | -4.72E+01 | 0.00E+00 | -4.72E+01 |

PERE = Use of renewable primary energy excluding renewable primary energy used as raw materials;
 PERM = Use of renewable primary energy resources used as raw materials;
 PERT = Total use of renewable primary energy resources;

PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials;
 PENRM = Use of non-renewable primary energy resources used as raw materials;
 PENRT = Total use of non-renewable primary energy resource

LCA Results (continued)

| Parameters describing resource use, secondary materials and fuels, use of water | | | | | | |
|---|--------------------------------------|------|----------|---------------------------|---------------------------|----------------|
| | | | SM | RSF | NRSF | FW |
| | | | kg | MJ net calorific value | MJ net calorific value | m ³ |
| Product stage | Raw material supply | A1 | 6.92E-02 | 0.00E+00 | 0.00E+00 | 1.73E-02 |
| | Transport | A2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.69E-05 |
| | Manufacturing | A3 | 5.09E-03 | 0.00E+00 | 0.00E+00 | 1.63E-04 |
| | Total (of product stage) | A1-3 | 7.43E-02 | 0.00E+00 | 0.00E+00 | 1.75E-02 |
| Construction process stage | Construction | A5 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.84E-06 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.06E-05 |
| | Transport | C2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.35E-06 |
| | Waste processing | C3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.58E-03 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | -4.34E-03 |

SM = Use of secondary material;
RSF = Use of renewable secondary fuels;

NRSF = Use of non-renewable secondary fuels;
FW = Net use of fresh water

LCA Results (continued)

| Other environmental information describing waste categories | | | | HWD | NHWD | RWD |
|---|--------------------------------------|------|--|-----------|-----------|-----------|
| | | | | kg | kg | kg |
| Product stage | Raw material supply | A1 | | 1.64E-08 | 7.52E-02 | 1.31E-03 |
| | Transport | A2 | | 2.16E-11 | 6.53E-05 | 7.55E-07 |
| | Manufacturing | A3 | | 1.47E-10 | 1.07E-02 | 2.56E-05 |
| | Total (of product stage) | A1-3 | | 1.66E-08 | 8.60E-02 | 1.34E-03 |
| Construction process stage | Construction | A5 | | 5.73E-13 | 6.36E-04 | 2.21E-07 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | |
| End of life | Deconstruction, demolition | C1 | | 1.07E-10 | 2.30E-04 | 2.36E-05 |
| | Transport | C2 | | 6.70E-12 | 2.00E-05 | 2.31E-07 |
| | Waste processing | C3 | | 1.25E-10 | 2.48E-02 | 3.44E-05 |
| | Disposal | C4 | | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | | -6.04E-09 | -3.00E-02 | -2.31E-03 |

HWD = Hazardous waste disposed;
 NHWD = Non-hazardous waste disposed;
 RWD = Radioactive waste disposed

LCA Results (continued)

| Other environmental information describing output flows – at end of life | | | | | | | | |
|---|--------------------------------------|------|----------|----------|----------|-----------------------|---------------------------|-----------------------------|
| | | | CRU | MFR | MER | EE | Biogenic carbon (product) | Biogenic carbon (packaging) |
| | | | kg | kg | kg | MJ per energy carrier | kg C | kg C |
| Product stage | Raw material supply | A1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | A2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Manufacturing | A3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.00E-02 |
| | Total (of product stage) | A1-3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.00E-02 |
| Construction process stage | Construction | A5 | 0.00E+00 | 4.75E-04 | 0.00E+00 | 9.57E-04 | 0.00E+00 | -1.00E-02 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Waste processing | C3 | 0.00E+00 | 6.63E-02 | 0.00E+00 | 9.05E+00 | 0.00E+00 | 0.00E+00 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

CRU = Components for reuse;
MFR = Materials for recycling

MER = Materials for energy recovery;
EE = Exported Energy

Scenarios and additional technical information

| Scenarios and additional technical information | | | |
|--|--|--------------|--|
| Scenario | Parameter | Units | Results |
| A4 – Transport to the building site | Transport to the construction site | | |
| | Fuel type / Vehicle type | Vehicle type | Truck-trailer, Euro 6, 34 - 40t gross weight / 27t payload. Diesel |
| | Distance: | km | 100 |
| | Capacity utilisation (incl. empty returns) | % | 61% |
| | Mass of transported piping system | kg | 1.568 |
| A5 – Installation in the building | Packaging EoL treatment | | |
| | PE Film to recycling | kg/m | 0.0005 |
| | Cardboard to landfill | kg/m | 0.0008 |
| C1 to C4 End of life, | Wood to incineration | kg/m | 0.0005 |
| | Piping system to incineration, recycling | | |
| | Polypropylene incineration | kg/m | 0.3980 |
| | Brass recycling | kg/m | 0.0663 |
| | Polypropylene incineration | kg/m | 0.7790 |
| | Glass flakes (reinforcement) incineration | kg/m | 0.0117 |
| Module D | Polyurethane incineration | kg/m | 0.3080 |
| | Credits for module A5. Credits for module C3 from energy substitution. | | |

Summary, comments and additional information

Interpretation

The Aquatherm green/blue S/MF pipe (TI) (representative product) has impacts dominated by module A1 which is the main contributor to impact indicators GWP, ODP, AP, EP freshwater, EP marine, EP terrestrial, POCP, ADPE and ADPF. Module A3 has the most significant relative contributions for WDP.

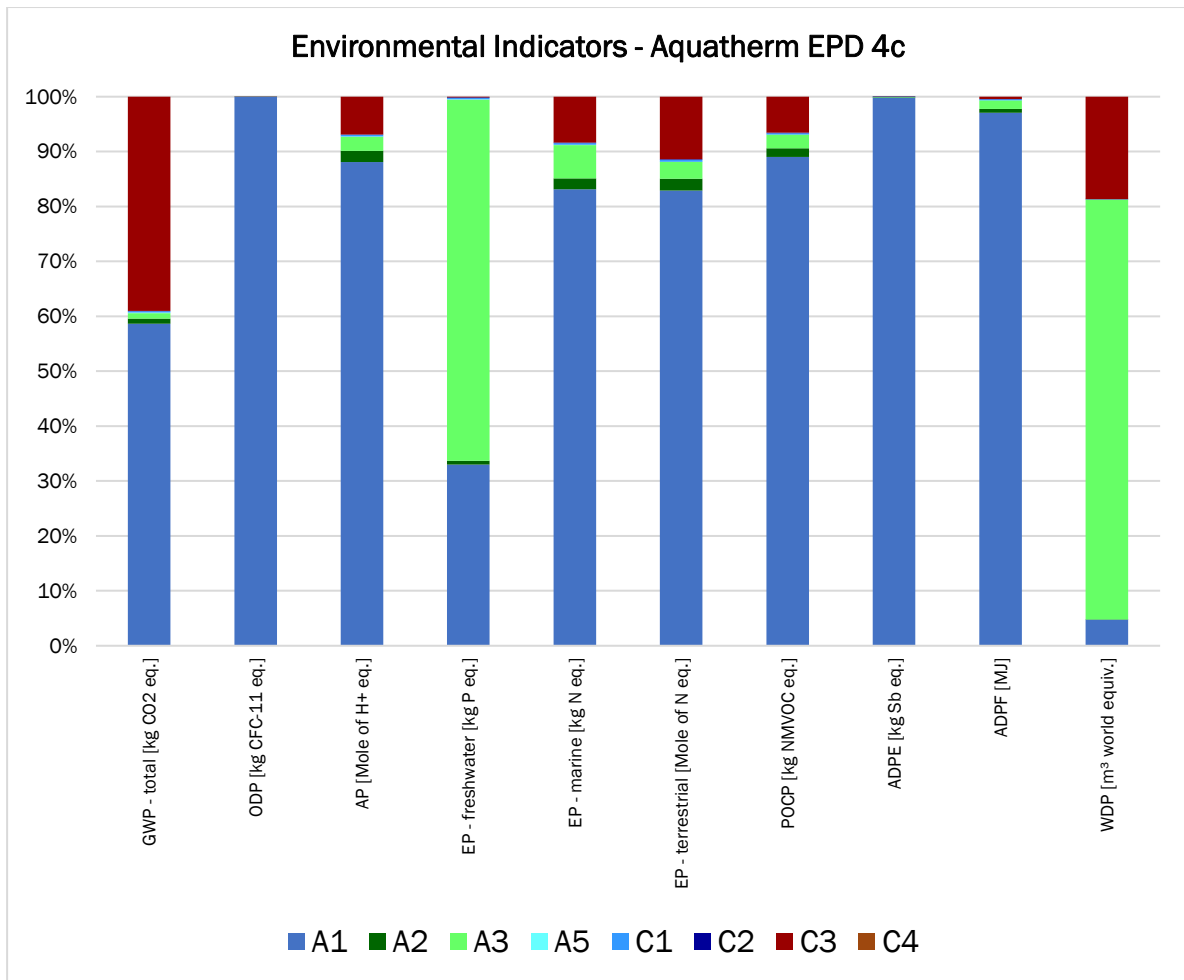


Figure 1: EPD 4c relative contribution of declared modules to EN 15804 +A2 environmental indicators, excluding module D.

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Annex 1

EPD 4a: Aquatherm green/blue S/MF pipe (OT) (Representative product: based on data from EPD 1, with the addition of additive material to provide specific technical qualities).

Technical Information

| Property | Value, Unit |
|--------------------------|-----------------------|
| Density of Piping system | 0,9 kg/m ³ |
| Pipe colour/s | Blue / Green |
| Weight per meter | 0.443kg |
| Pipe profile diameters | 32mm |

The results of EPD4a refer to a representative product of pipe diameter of 32mm and product weight 0.443 kg/m. Information on the full product range (0,111 kg/m - 68,044 kg/m & 20mm - 630mm) can be found in Annex 3.

Main Product Contents

| Material Input | % |
|---------------------------|-------|
| Polypropylene-R Granulate | 85.4% |
| Brass fittings | 4.2% |
| Reinforcement | 2.7% |
| Pigments | 0.7% |
| Oxygen barrier layer | 7.0% |

LCA Results

| Parameters describing environmental impacts | | | GWP-total | GWP-fossil | GWP-biogenic | GWP-luluc | ODP | AP | EP-freshwater |
|---|--------------------------------------|------|-----------------------|-----------------------|-----------------------|-----------------------|-------------|-----------------------|--|
| | | | kg CO ₂ eq | kg CO ₂ eq | kg CO ₂ eq | kg CO ₂ eq | kg CFC11 eq | mol H ⁺ eq | kg (PO ₄) ³⁻ eq |
| Product stage | Raw material supply | A1 | 1.16E+00 | 1.15E+00 | 8.09E-03 | 5.58E-04 | 5.90E-15 | 1.78E-03 | 2.38E-06 |
| | Transport | A2 | 2.76E-02 | 2.73E-02 | 7.62E-05 | 1.96E-04 | 5.08E-18 | 1.47E-04 | 7.20E-08 |
| | Manufacturing | A3 | 2.73E-02 | 3.39E-02 | -6.64E-03 | 5.33E-05 | 9.87E-16 | 7.40E-05 | 6.76E-06 |
| | Total (of product stage) | A1-3 | 1.21E+00 | 1.21E+00 | 1.53E-03 | 8.07E-04 | 6.89E-15 | 2.00E-03 | 9.21E-06 |
| Construction process stage | Construction | A5 | 3.47E-03 | 1.86E-04 | 3.28E-03 | 2.11E-07 | 2.57E-18 | 9.00E-07 | 7.03E-09 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 5.95E-03 | 5.86E-03 | 7.20E-05 | 1.49E-05 | 2.00E-16 | 8.40E-06 | 2.45E-08 |
| | Transport | C2 | 2.43E-03 | 2.40E-03 | 7.19E-06 | 1.96E-05 | 4.74E-19 | 2.55E-06 | 7.13E-09 |
| | Waste processing | C3 | 1.12E+00 | 1.12E+00 | 4.07E-05 | 7.54E-06 | 9.16E-17 | 1.16E-04 | 1.54E-08 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -7.92E-01 | -7.91E-01 | -8.52E-04 | -1.41E-04 | -1.00E-15 | -9.02E-04 | -8.72E-08 |

GWP-total = Global warming potential, total;
 GWP-fossil = Global warming potential, fossil;
 GWP-biogenic = Global warming potential, biogenic;
 GWP-luluc = Global warming potential, land use and land use change;

ODP = Depletion potential of the stratospheric ozone layer;
 AP = Acidification potential, accumulated exceedance; and
 EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment

LCA Results (continued)

| Parameters describing environmental impacts | | | EP-marine | EP-terrestrial | POCP | ADP-mineral&metals | ADP-fossil | WDP | PM |
|---|--------------------------------------|------|-----------|----------------|-------------|--------------------|-------------------------|----------------------------------|-------------------|
| | | | kg N eq | mol N eq | kg NMVOC eq | kg Sb eq | MJ, net calorific value | m ³ world eq deprived | disease incidence |
| Product stage | Raw material supply | A1 | 4.81E-04 | 4.97E-03 | 1.75E-03 | 1.02E-05 | 3.53E+01 | 1.74E-02 | 1.36E-08 |
| | Transport | A2 | 4.04E-05 | 4.50E-04 | 1.12E-04 | 2.23E-09 | 3.60E-01 | 2.28E-04 | 2.26E-09 |
| | Manufacturing | A3 | 5.17E-05 | 2.76E-04 | 7.25E-05 | 7.86E-09 | 6.97E-01 | 4.14E-01 | 2.93E-09 |
| | Total (of product stage) | A1-3 | 5.73E-04 | 5.70E-03 | 1.93E-03 | 1.02E-05 | 3.64E+01 | 4.32E-01 | 1.88E-08 |
| Construction process stage | Construction | A5 | 3.28E-07 | 3.36E-06 | 1.04E-06 | 3.51E-11 | 2.84E-03 | 2.47E-04 | 7.21E-12 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 2.69E-06 | 2.80E-05 | 6.67E-06 | 2.39E-09 | 7.40E-02 | 1.27E-04 | 6.68E-11 |
| | Transport | C2 | 8.12E-07 | 9.64E-06 | 2.21E-06 | 2.13E-10 | 3.20E-02 | 2.23E-05 | 1.75E-11 |
| | Waste processing | C3 | 2.53E-05 | 5.42E-04 | 7.46E-05 | 1.42E-09 | 1.65E-01 | 1.05E-01 | 7.31E-10 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -2.75E-04 | -3.00E-03 | -7.81E-04 | -7.21E-06 | -1.24E+01 | -8.88E-03 | -8.31E-09 |

EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment;
 EP-terrestrial = Eutrophication potential, accumulated exceedance;
 POCP = Formation potential of tropospheric ozone;
 ADP-mineral&metals = Abiotic depletion potential for non-fossil resources;

ADP-fossil = Depletion potential of the stratospheric ozone layer;
 WDP = Water (user) deprivation potential, deprivation-weighted water consumption; and
 PM = Particulate matter.

LCA Results (continued)

| Parameters describing environmental impacts | | | IRP | ETP-fw | HTP-c | HTP-nc | SQP |
|---|--------------------------------------|------|-------------------------|-----------|-----------|-----------|---------------|
| | | | kBq U ²³⁵ eq | CTUe | CTUh | CTUh | dimensionless |
| Product stage | Raw material supply | A1 | 4.20E-02 | 1.51E+01 | 4.03E-10 | 2.19E-08 | 1.23E+00 |
| | Transport | A2 | 9.15E-05 | 2.66E-01 | 5.34E-12 | 2.74E-10 | 1.10E-01 |
| | Manufacturing | A3 | 3.42E-03 | 1.31E+00 | 5.38E-11 | 5.27E-09 | 2.55E+00 |
| | Total (of product stage) | A1-3 | 4.55E-02 | 1.67E+01 | 4.62E-10 | 2.74E-08 | 3.89E+00 |
| Construction process stage | Construction | A5 | 3.66E-05 | 1.64E-03 | 7.32E-14 | 6.38E-12 | 6.72E-04 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 5.48E-04 | 2.80E-02 | 1.11E-12 | 4.44E-11 | 3.77E-02 |
| | Transport | C2 | 8.51E-06 | 2.37E-02 | 4.80E-13 | 2.49E-11 | 1.10E-02 |
| | Waste processing | C3 | 1.39E-03 | 7.17E-02 | 7.49E-12 | 2.49E-10 | 4.14E-02 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -4.85E-02 | -1.82E+00 | -7.96E-11 | -4.47E-09 | -1.75E-01 |

IRP = Potential human exposure efficiency relative to U235;
 ETP-fw = Potential comparative toxic unit for ecosystems;
 HTP-c = Potential comparative toxic unit for humans;

HTP-nc = Potential comparative toxic unit for humans; and
 SQP = Potential soil quality index.

LCA Results (continued)

| Parameters describing resource use, primary energy | | | PERE | PERM | PERT | PENRE | PENRM | PENRT |
|---|--------------------------------------|------|-----------|-----------|-----------|-----------|-----------|-----------|
| | | | MJ | MJ | MJ | MJ | MJ | MJ |
| Product stage | Raw material supply | A1 | 1.43E+00 | 0.00E+00 | 1.43E+00 | 1.70E+01 | 1.83E+01 | 3.53E+01 |
| | Transport | A2 | 1.85E-02 | 0.00E+00 | 1.85E-02 | 3.61E-01 | | 3.61E-01 |
| | Manufacturing | A3 | 5.74E-02 | 2.67E-01 | 3.24E-01 | 4.66E-01 | 2.31E-01 | 6.98E-01 |
| | Total (of product stage) | A1-3 | 1.51E+00 | 2.67E-01 | 1.77E+00 | 1.78E+01 | 1.85E+01 | 3.64E+01 |
| Construction process stage | Construction | A5 | 2.68E-01 | -2.67E-01 | 8.38E-04 | 2.34E-01 | -2.31E-01 | 2.84E-03 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 4.83E-02 | 0.00E+00 | 4.83E-02 | 7.40E-02 | 0.00E+00 | 7.40E-02 |
| | Transport | C2 | 1.84E-03 | 0.00E+00 | 1.84E-03 | 3.21E-02 | 0.00E+00 | 3.21E-02 |
| | Waste processing | C3 | 2.92E-02 | 0.00E+00 | 2.92E-02 | 1.84E+01 | -1.83E+01 | 1.66E-01 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -1.60E-01 | 0.00E+00 | -1.60E-01 | -1.24E+01 | 0.00E+00 | -1.24E+01 |

PERE = Use of renewable primary energy excluding renewable primary energy used as raw materials;
 PERM = Use of renewable primary energy resources used as raw materials;
 PERT = Total use of renewable primary energy resources;

PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials;
 PENRM = Use of non-renewable primary energy resources used as raw materials;
 PENRT = Total use of non-renewable primary energy resource

LCA Results (continued)

| Parameters describing resource use, secondary materials and fuels, use of water | | | | | | |
|---|--------------------------------------|------|----------|---------------------------|---------------------------|----------------|
| | | | SM | RSF | NRSF | FW |
| | | | kg | MJ net calorific value | MJ net calorific value | m ³ |
| Product stage | Raw material supply | A1 | 1.96E-02 | 0.00E+00 | 0.00E+00 | 5.68E-03 |
| | Transport | A2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.13E-05 |
| | Manufacturing | A3 | 5.09E-03 | 0.00E+00 | 0.00E+00 | 1.63E-04 |
| | Total (of product stage) | A1-3 | 2.47E-02 | 0.00E+00 | 0.00E+00 | 5.86E-03 |
| Construction process stage | Construction | A5 | | | | 6.18E-06 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.27E-05 |
| | Transport | C2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.11E-06 |
| | Waste processing | C3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.46E-03 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | -1.14E-03 |

SM = Use of secondary material;
RSF = Use of renewable secondary fuels;

NRSF = Use of non-renewable secondary fuels;
FW = Net use of fresh water

LCA Results (continued)

| Other environmental information describing waste categories | | | | | |
|---|--------------------------------------|------|-----------|-----------|-----------|
| | | | HWD | NHWD | RWD |
| | | | kg | kg | kg |
| Product stage | Raw material supply | A1 | 5.35E-09 | 2.04E-02 | 4.87E-04 |
| | Transport | A2 | 1.72E-11 | 5.44E-05 | 6.27E-07 |
| | Manufacturing | A3 | 1.47E-10 | 1.07E-02 | 2.56E-05 |
| | Total (of product stage) | A1-3 | 5.51E-09 | 3.12E-02 | 5.13E-04 |
| Construction process stage | Construction | A5 | 6.54E-13 | 6.55E-04 | 2.32E-07 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | |
| End of life | Deconstruction, demolition | C1 | 2.69E-11 | 5.77E-05 | 5.93E-06 |
| | Transport | C2 | 1.69E-12 | 5.03E-06 | 5.82E-08 |
| | Waste processing | C3 | 2.81E-11 | 1.05E-02 | 9.32E-06 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -1.59E-09 | -7.68E-03 | -6.05E-04 |

HWD = Hazardous waste disposed;
 NHWD = Non-hazardous waste disposed;
 RWD = Radioactive waste disposed

LCA Results (continued)

| | | | Other environmental information describing output flows – at end of life | | | | | |
|---|--------------------------------------|------|--|----------|----------|-----------------------|---------------------------|-----------------------------|
| | | | CRU | MFR | MER | EE | Biogenic carbon (product) | Biogenic carbon (packaging) |
| | | | kg | kg | kg | MJ per energy carrier | kg C | kg C |
| Product stage | Raw material supply | A1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | A2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Manufacturing | A3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.63E-03 |
| | Total (of product stage) | A1-3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.63E-03 |
| Construction process stage | Construction | A5 | 0.00E+00 | 4.75E-04 | 0.00E+00 | 2.48E-03 | 0.00E+00 | -6.63E-03 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Waste processing | C3 | 0.00E+00 | 1.88E-02 | 0.00E+00 | 2.37E+00 | 0.00E+00 | 0.00E+00 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

CRU = Components for reuse;
MFR = Materials for recycling

MER = Materials for energy recovery;
EE = Exported Energy

Scenarios and additional technical information

| Scenarios and additional technical information | | | |
|--|--|--------------|--|
| Scenario | Parameter | Units | Results |
| A4 – Transport to the building site | Transport to the construction site | | |
| | Fuel type / Vehicle type | Vehicle type | Truck-trailer, Euro 6, 34 - 40t gross weight / 27t payload. Diesel |
| | Distance: | km | 100 |
| | Capacity utilisation (incl. empty returns) | % | 61% |
| | Mass of transported piping system | kg | 0.4433 |
| A5 – Installation in the building | Packaging EoL treatment | | |
| | PE Film to recycling | kg/m | 0.0005 |
| | Cardboard to landfill | kg/m | 0.0008 |
| C1 to C4 End of life, | Wood to incineration | kg/m | 0.0005 |
| | Piping system to incineration, recycling | | |
| | Polypropylene incineration | kg/m | 0.3754 |
| | Brass recycling | kg/m | 0.0188 |
| | Glass flakes (reinforcement) incineration | kg/m | 0.0117 |
| Module D | Oxygen barrier layer incineration | kg/m | 0.0308 |
| | Credits for module A5. Credits for module C3 from energy substitution. | | |

Annex 2

EPD 4b: Aquatherm green/blue S/MF pipe (UV) (Representative product: based on data from EPD 1, with the addition of material for specific technical qualities)

Technical Information

| Property | Value, Unit |
|--------------------------|-----------------------|
| Density of Piping system | 0,9 kg/m ³ |
| Pipe colour/s | Blue / Green |
| Weight per meter | 0.502 kg/m |
| Pipe profile diameters | 32mm |

The results of EPD4b refer to a representative product of pipe diameter of 32mm and product weight 0.502 kg/m. Information on the full product range (0,111 kg/m - 68,044 kg/m & 20mm - 630mm) can be found in Annex 3.

Main Product Contents

| Material Input | % |
|---------------------------|-------|
| Polypropylene-R Granulate | 75.7% |
| PE granulate | 17.1% |
| Brass fittings | 4.2% |
| Reinforcement | 2.3% |
| Pigments | 0.6% |

LCA Results

| Parameters describing environmental impacts | | | GWP-total | GWP-fossil | GWP-biogenic | GWP-luluc | ODP | AP | EP-freshwater |
|---|--------------------------------------|------|-----------------------|-----------------------|-----------------------|-----------------------|-------------|-----------------------|--|
| | | | kg CO ₂ eq | kg CO ₂ eq | kg CO ₂ eq | kg CO ₂ eq | kg CFC11 eq | mol H ⁺ eq | kg (PO ₄) ³⁻ eq |
| Product stage | Raw material supply | A1 | 1.10E+00 | 1.10E+00 | 7.03E-03 | 5.48E-04 | 5.53E-15 | 1.87E-03 | 1.23E-06 |
| | Transport | A2 | 2.53E-02 | 2.50E-02 | 7.34E-05 | 1.97E-04 | 4.86E-18 | 5.93E-05 | 7.19E-08 |
| | Manufacturing | A3 | 2.73E-02 | 3.39E-02 | -6.64E-03 | 5.33E-05 | 9.87E-16 | 7.40E-05 | 6.76E-06 |
| | Total (of product stage) | A1-3 | 1.15E+00 | 1.16E+00 | 4.63E-04 | 7.98E-04 | 6.52E-15 | 2.00E-03 | 8.06E-06 |
| Construction process stage | Construction | A5 | 3.47E-03 | 1.86E-04 | 3.28E-03 | 2.11E-07 | 2.57E-18 | 9.00E-07 | 7.03E-09 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 5.95E-03 | 5.86E-03 | 7.20E-05 | 1.49E-05 | 2.00E-16 | 8.40E-06 | 2.45E-08 |
| | Transport | C2 | 2.43E-03 | 2.40E-03 | 7.19E-06 | 1.96E-05 | 4.74E-19 | 2.55E-06 | 7.13E-09 |
| | Waste processing | C3 | 1.14E+00 | 1.14E+00 | 4.05E-05 | 7.40E-06 | 9.13E-17 | 1.17E-04 | 1.50E-08 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -8.12E-01 | -8.11E-01 | -8.75E-04 | -1.43E-04 | -1.02E-15 | -9.22E-04 | -8.89E-08 |

GWP-total = Global warming potential, total;
 GWP-fossil = Global warming potential, fossil;
 GWP-biogenic = Global warming potential, biogenic;
 GWP-luluc = Global warming potential, land use and land use change;

ODP = Depletion potential of the stratospheric ozone layer;
 AP = Acidification potential, accumulated exceedance; and
 EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment

LCA Results (continued)

| Parameters describing environmental impacts | | | EP-marine | EP-terrestrial | POCP | ADP-mineral&metals | ADP-fossil | WDP | PM |
|---|--------------------------------------|------|-----------|----------------|-------------|--------------------|-------------------------|----------------------------------|-------------------|
| | | | kg N eq | mol N eq | kg NMVOC eq | kg Sb eq | MJ, net calorific value | m ³ world eq deprived | disease incidence |
| Product stage | Raw material supply | A1 | 4.75E-04 | 4.94E-03 | 1.72E-03 | 1.13E-05 | 3.63E+01 | 2.67E-02 | 1.50E-08 |
| | Transport | A2 | 1.71E-05 | 1.94E-04 | 4.71E-05 | 2.16E-09 | 3.32E-01 | 2.25E-04 | 7.52E-10 |
| | Manufacturing | A3 | 5.17E-05 | 2.76E-04 | 7.25E-05 | 7.86E-09 | 6.97E-01 | 4.14E-01 | 2.93E-09 |
| | Total (of product stage) | A1-3 | 5.44E-04 | 5.41E-03 | 1.84E-03 | 1.13E-05 | 3.73E+01 | 4.41E-01 | 1.87E-08 |
| Construction process stage | Construction | A5 | 3.28E-07 | 3.36E-06 | 1.04E-06 | 3.51E-11 | 2.84E-03 | 2.47E-04 | 7.21E-12 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 2.69E-06 | 2.80E-05 | 6.67E-06 | 2.39E-09 | 7.40E-02 | 1.27E-04 | 6.68E-11 |
| | Transport | C2 | 8.12E-07 | 9.64E-06 | 2.21E-06 | 2.13E-10 | 3.20E-02 | 2.23E-05 | 1.75E-11 |
| | Waste processing | C3 | 2.52E-05 | 5.48E-04 | 7.48E-05 | 1.41E-09 | 1.63E-01 | 1.07E-01 | 7.35E-10 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -2.82E-04 | -3.08E-03 | -8.01E-04 | -7.21E-06 | -1.27E+01 | -8.95E-03 | -8.50E-09 |

EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment;
 EP-terrestrial = Eutrophication potential, accumulated exceedance;
 POCP = Formation potential of tropospheric ozone;
 ADP-mineral&metals = Abiotic depletion potential for non-fossil resources;

ADP-fossil = Depletion potential of the stratospheric ozone layer;
 WDP = Water (user) deprivation potential, deprivation-weighted water consumption; and
 PM = Particulate matter.

LCA Results (continued)

| Parameters describing environmental impacts | | | IRP | ETP-fw | HTP-c | HTP-nc | SQP |
|---|--------------------------------------|------|-------------------------|-----------|-----------|-----------|---------------|
| | | | kBq U ²³⁵ eq | CTUe | CTUh | CTUh | dimensionless |
| Product stage | Raw material supply | A1 | 4.45E-02 | 1.69E+01 | 4.24E-10 | 2.20E-08 | 1.19E+00 |
| | Transport | A2 | 8.73E-05 | 2.46E-01 | 4.97E-12 | 2.57E-10 | 1.10E-01 |
| | Manufacturing | A3 | 3.42E-03 | 1.31E+00 | 5.38E-11 | 5.27E-09 | 2.55E+00 |
| | Total (of product stage) | A1-3 | 4.80E-02 | 1.85E+01 | 4.83E-10 | 2.75E-08 | 3.85E+00 |
| Construction process stage | Construction | A5 | 3.66E-05 | 1.64E-03 | 7.32E-14 | 6.38E-12 | 6.72E-04 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 5.48E-04 | 2.80E-02 | 1.11E-12 | 4.44E-11 | 3.77E-02 |
| | Transport | C2 | 8.51E-06 | 2.37E-02 | 4.80E-13 | 2.49E-11 | 1.10E-02 |
| | Waste processing | C3 | 1.38E-03 | 7.11E-02 | 7.60E-12 | 2.51E-10 | 4.13E-02 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -4.97E-02 | -1.86E+00 | -8.15E-11 | -4.58E-09 | -1.77E-01 |

IRP = Potential human exposure efficiency relative to U235;
 ETP-fw = Potential comparative toxic unit for ecosystems;
 HTP-c = Potential comparative toxic unit for humans;

HTP-nc = Potential comparative toxic unit for humans; and
 SQP = Potential soil quality index.

LCA Results (continued)

| | | | Parameters describing resource use, primary energy | | | | | |
|---|--------------------------------------|------|--|-----------|-----------|-----------|-----------|-----------|
| | | | PERE | PERM | PERT | PENRE | PENRM | PENRT |
| | | | MJ | MJ | MJ | MJ | MJ | MJ |
| Product stage | Raw material supply | A1 | 1.35E+00 | 0.00E+00 | 1.35E+00 | 1.50E+01 | 2.13E+01 | 3.63E+01 |
| | Transport | A2 | 1.85E-02 | 0.00E+00 | 1.85E-02 | 3.34E-01 | | 3.34E-01 |
| | Manufacturing | A3 | 5.74E-02 | 2.67E-01 | 3.24E-01 | 4.66E-01 | 2.31E-01 | 6.98E-01 |
| | Total (of product stage) | A1-3 | 1.43E+00 | 2.67E-01 | 1.69E+00 | 1.58E+01 | 2.15E+01 | 3.73E+01 |
| Construction process stage | Construction | A5 | 2.68E-01 | -2.67E-01 | 8.38E-04 | 2.34E-01 | -2.31E-01 | 2.84E-03 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 4.83E-02 | 0.00E+00 | 4.83E-02 | 7.40E-02 | 0.00E+00 | 7.40E-02 |
| | Transport | C2 | 1.84E-03 | 0.00E+00 | 1.84E-03 | 3.21E-02 | 0.00E+00 | 3.21E-02 |
| | Waste processing | C3 | 2.91E-02 | 0.00E+00 | 2.91E-02 | 2.15E+01 | -2.13E+01 | 1.63E-01 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -1.63E-01 | 0.00E+00 | -1.63E-01 | -1.27E+01 | 0.00E+00 | -1.27E+01 |

PERE = Use of renewable primary energy excluding renewable primary energy used as raw materials;
 PERM = Use of renewable primary energy resources used as raw materials;
 PERT = Total use of renewable primary energy resources;

PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials;
 PENRM = Use of non-renewable primary energy resources used as raw materials;
 PENRT = Total use of non-renewable primary energy resource

LCA Results (continued)

| Parameters describing resource use, secondary materials and fuels, use of water | | | | | | |
|---|--------------------------------------|------|----------|---------------------------|---------------------------|----------------|
| | | | SM | RSF | NRSF | FW |
| | | | kg | MJ net calorific value | MJ net calorific value | m ³ |
| Product stage | Raw material supply | A1 | 2.21E-02 | 0.00E+00 | 0.00E+00 | 4.12E-03 |
| | Transport | A2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.12E-05 |
| | Manufacturing | A3 | 5.09E-03 | 0.00E+00 | 0.00E+00 | 1.63E-04 |
| | Total (of product stage) | A1-3 | 2.72E-02 | 0.00E+00 | 0.00E+00 | 4.30E-03 |
| Construction process stage | Construction | A5 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.18E-06 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.27E-05 |
| | Transport | C2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.11E-06 |
| | Waste processing | C3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.50E-03 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | -1.16E-03 |

SM = Use of secondary material;
RSF = Use of renewable secondary fuels;

NRSF = Use of non-renewable secondary fuels;
FW = Net use of fresh water

LCA Results (continued)

| Other environmental information describing waste categories | | | | | |
|---|--------------------------------------|------|-----------|-----------|-----------|
| | | | HWD | NHWD | RWD |
| | | | kg | kg | kg |
| Product stage | Raw material supply | A1 | 4.88E-09 | 1.88E-02 | 4.92E-04 |
| | Transport | A2 | 1.71E-11 | 5.17E-05 | 5.97E-07 |
| | Manufacturing | A3 | 1.47E-10 | 1.07E-02 | 2.56E-05 |
| | Total (of product stage) | A1-3 | 5.04E-09 | 2.96E-02 | 5.18E-04 |
| Construction process stage | Construction | A5 | 6.54E-13 | 6.55E-04 | 2.32E-07 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | |
| End of life | Deconstruction, demolition | C1 | 2.69E-11 | 5.77E-05 | 5.93E-06 |
| | Transport | C2 | 1.69E-12 | 5.03E-06 | 5.82E-08 |
| | Waste processing | C3 | 2.78E-11 | 9.83E-03 | 9.19E-06 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | -1.63E-09 | -7.76E-03 | -6.21E-04 |

HWD = Hazardous waste disposed;
 NHWD = Non-hazardous waste disposed;
 RWD = Radioactive waste disposed

LCA Results (continued)

| | | | Other environmental information describing output flows – at end of life | | | | | |
|---|--------------------------------------|------|--|----------|----------|-----------------------|---------------------------|-----------------------------|
| | | | CRU | MFR | MER | EE | Biogenic carbon (product) | Biogenic carbon (packaging) |
| | | | kg | kg | kg | MJ per energy carrier | kg C | kg C |
| Product stage | Raw material supply | A1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | A2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Manufacturing | A3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.63E-03 |
| | Total (of product stage) | A1-3 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.63E-03 |
| Construction process stage | Construction | A5 | 0.00E+00 | 4.75E-04 | 0.00E+00 | 2.48E-03 | 0.00E+00 | -6.63E-03 |
| 100% incineration scenario for plastic pipe & 100% recycling scenario for brass fittings | | | | | | | | |
| End of life | Deconstruction, demolition | C1 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Transport | C2 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | Waste processing | C3 | 0.00E+00 | 2.13E-02 | 0.00E+00 | 2.44E+00 | 0.00E+00 | 0.00E+00 |
| | Disposal | C4 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Potential benefits and loads beyond the system boundaries | Reuse, recovery, recycling potential | D | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

CRU = Components for reuse;
MFR = Materials for recycling

MER = Materials for energy recovery;
EE = Exported Energy

Scenarios and additional technical information

| Scenarios and additional technical information | | | |
|--|--|--------------|--|
| Scenario | Parameter | Units | Results |
| A4 – Transport to the building site | Transport to the construction site | | |
| | Fuel type / Vehicle type | Vehicle type | Truck-trailer, Euro 6, 34 - 40t gross weight / 27t payload. Diesel |
| | Distance: | km | 100 |
| | Capacity utilisation (incl. empty returns) | % | 61% |
| | Mass of transported piping system | kg | 0.5016 |
| A5 – Installation in the building | Packaging EoL treatment | | |
| | PE Film to recycling | kg/m | 0.0005 |
| | Cardboard to landfill | kg/m | 0.0008 |
| C1 to C4 End of life, | Wood to incineration | kg/m | 0.0005 |
| | Piping system to incineration, recycling | | |
| | Polypropylene incineration | kg/m | 0.3754 |
| | Brass recycling | kg/m | 0.0213 |
| | Glass flakes (reinforcement) incineration | kg/m | 0.0117 |
| Module D | Polyethylene incineration | kg/m | 0.0855 |
| | Credits for module A5. Credits for module C3 from energy substitution. | | |