DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Life Cycle Assessment study of FITT B-ACTIVE® FLEX

Summary Report

Revision n. 2 of 13/01/2022

Summary

1. General aspects and objective of the study

Company information

FITT is an international leader and specialist in the creation of complete fluid transfer systems composed of thermoplastic materials, for both the industrial and construction sectors – civil engineering and infrastructure – as well as for the house, garden and hobby markets.

Founded in 1969, for 50 years FITT has been developing technologically advanced solutions that offer stability, safety, extremely high-performance levels and ease of use. From the headquarters in Sandrigo (Vicenza), FITT exports to 87 countries, having a total staff of 950 employees, 9 production sites (5 in Italy and 4 in other countries), 13 logistic sites all over the world and 5 subsidiaries. In 2020 FITT had a turnover of 233 million euros.

In 2019, FITT embarked on a journey to assess the environmental performance of its products through Life Cycle Assessment (LCA), obtaining EPDs in early 2020 for the FITT Bluforce and FITT Bluforce RJ products and in 2021 for the FITT Sewer and FITT Sewer EVO products; and conducting LCA studies intended for public disclosure for some gardening sector products (belonging to the FITT Force, FITT Ikon and FITT NTS families).

Product information

FITT B-Active Flex is a flexible spiral hose suitable for underground pressure systems of swimming pools and whirlpool baths. Plasticised PVC hose composed of an internal protective anti-chlorine film (Chlorine Defence System patent), a rigid PVC spiral reinforcing against crushing (D-Shape patent) and a special film covering the rigid spiral (Spiral Protection Barrier technology) which increases the hose's resistance to mechanical stress and cracking. Moreover, the hose is externally calibrated for a perfect bonding with the glue and compression fittings

FITT B-Active Flex complies with European Directive Reg. (EU) 10/2011 for simulants A and with EN ISO 3994:2014 proven by the international certification TUV SUD available on the product website (https://bactive.fitt.com/).
FITT B-Active Flex undergoes internal and external laboratory tests in collaboration with the University of Padua – DTG Laboratory. Tests certified by TUV (test report n. MEC16173.00), which validate at scientific level the mechanical resistance and chlorine resistance properties of the hose. Properties that guarantee durability over time. In fact, together with the flexibility and the special bending radius, the chlorine resistance is one of the most performing characteristics of the spiral hose for inground pools.
FITT offers a 10-year warranty and a specific 10-year insurance coverage for all damages that may be caused to third parties, including any costs of excavation, disassembly, assembly of the flexible PVC pipe and backfilling.

Information and objective of the study

This summary report based on the contents of the technical report "Life Cycle Assessment Study of FITT B-Acitve ® Flex", has as its main purpose the external communication of the results obtained from the assessment and quantification of the environmental performance of the following products:

- FITT B-Active 50mm, 25m;
- FITT B-Active 50mm, 50m;
- FITT B-Acitve 63mm, 25m;
- FITT B-Active 63mm, 50m.

The baseline study was conducted by the Centro Studi Qualità e Ambiente (CESQA) of the Department fo Industrial Engineering at the University of Padua between May 2021 and December 2021 and was subjected to a critical review process by SGS Italia S.p.A.

The following standards were referred to in conducting the study and this paper:

- ISO 14040:2006/Amd 1:2020 Environmental management – Life cycle assessment – Principles and framework – Amendment 1;
- ISO 14044:2006/Amd 2:2020 Environmental management – Life cycle assessment – Requirments and guidelines – Amendement 2.

2. Scope of the study

Declared unit

The declared unit corresponds to a unit of product. Below, in Table 1, the weights per metre (kg/m) of the different configurations of FITT B-Active are shown.

Table 1 Weights per metre of different diameters and lenghts of FITT B-Active

Diameter [mm]	Lenght [m]	Weight [kg/m]
50	25	0.75
50	50	0.75
63	25	0.96
63	50	0.96

System boundaries

The boundaries of the system include the entire life cycle of analysed product according to a "from cradle to grave" application, with the exception of the use phase- It should be noted that the construction, maintenance and decommissioning of infrastructures, i.e., buildings and machinery, as well as the occupation of industrial land have not been considered, since their contribution to the environmental impact of the functional unit is deemed negligible.

The reference period of this study is the entire year 2020 (January – December). This period covers the characteristics of the products analysed, as well as all production data (air emissions, water withdrawals and discharges, etc.) with the exception of:

- Specific energy consumption of the production line which is only available for the period January – October;
- FITT B-Active waste production, which dates from May to October, as the previous ones were considered unreliable.

Moreover, in order to define energy consumption per kg of product, reference was made to energy monitoring data available for the line most involved in the production of FITT B-Active (82% of total production). It should be noted that the two production lines are similar from a technological point of view, but the second line does not have precise energy data. The energy data are therefore to be considered representative of the entire production, considering also that the contribution of electrical energy on the overall impact profile of the product, this limitation is considered acceptable for the purpose of achieving the objective of the study.

Translated with www.DeepL.com/Translator (free version)
The diagram (Figure 1) describes the system boundaries of the FITT B-Active.

The following flows/processes were considered in conducting the study:

- Raw materials: production processes (e.g., material consumption and energy consumption) of purchased granules and raw materials for generating the granule produced by FITT, as well as all their packaging;
- Packaging: production processes of finished product packaging;
- Transport: transport processes for raw materials and packaging entering the plant;
- Production: energy and water consumption at the production plant, atmospheric emissions, disposal of PVC and other waste generated at the plant (including raw material packaging);
- End of life: disposal processes of the finished product and its packaging.

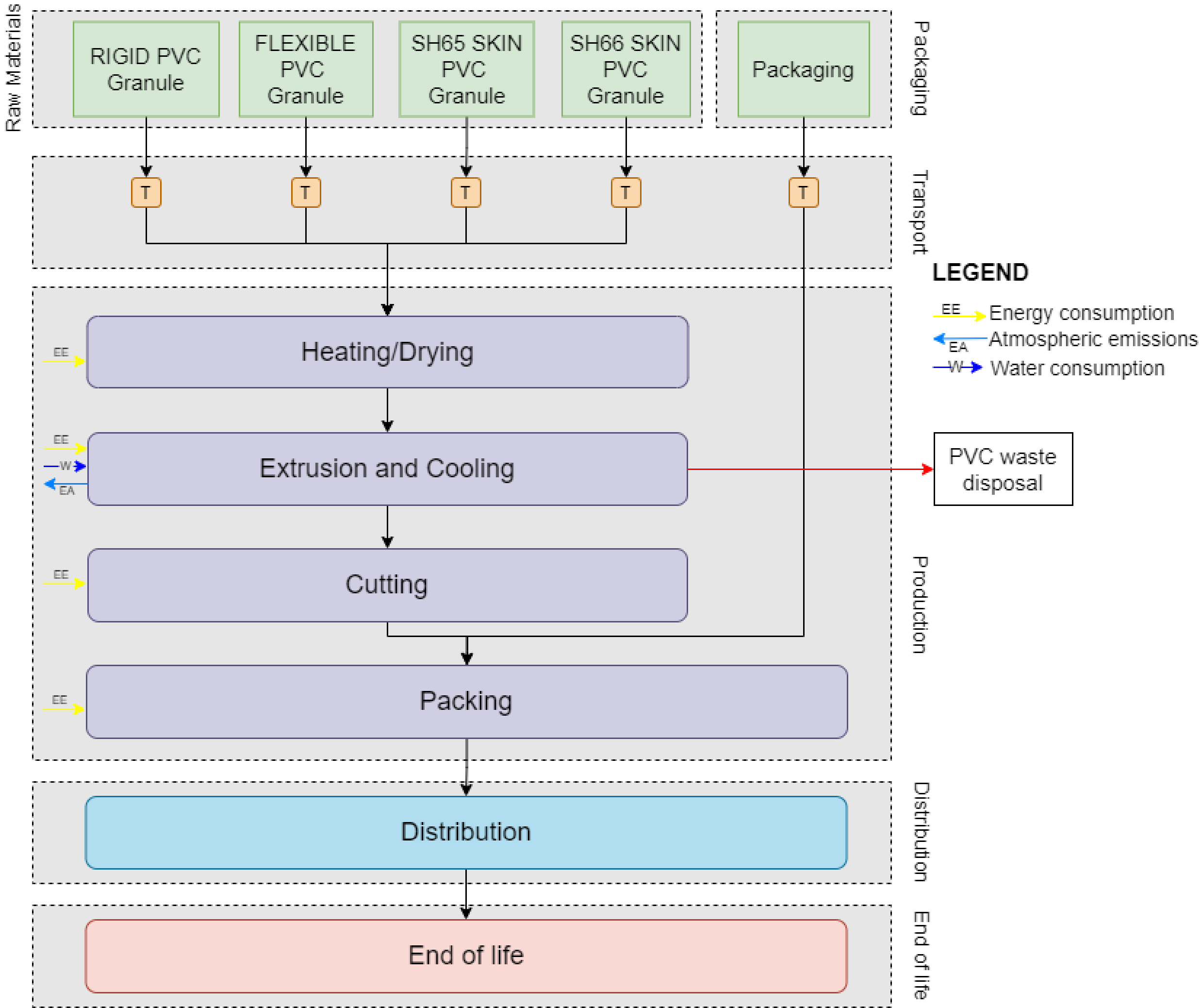

Figure 1 Diagram of the FITT B-Active production process

Exclusion criteria

The criterion chosen for the initial inclusion of input and output elements on the definition of a 1% cut-off level, both in terms of mass and/or energy. This means that a process has been neglected if it is responsible for less than 1% of the total primary mass and/or energy. However, all processes for which data were available were taken into account, even if the key contributed less than 1%. Consequently, this threshold value has been used to avoid collecting inknown dtaa, but not to neglet data that are available anyway. This choice is confirmed by similar LCA studies reported in the literature (Humbert et al., 2009).

Recruitment and limitations

For the conduction of this study reference was made to primary data, where available. Where access to this type of data was not possible, datasets from Ecoinvent v3.6 database were taken as reference.
The following were excluded from this study: the construction, maintenance and decommissioning of infrastructure, understood as machinery and buildings, and the occupation of industrial land (if this information was not already present in the dataset used).

For the definition of the characteristics of the products, reference was made to the bills of materials referring to the year 2020.

The packaging of the incoming raw materials has been modelled punctually for granules and accessories, while the packaging with which the materials for the packaging of the finished product arrive at the plant has been omitted

General consumption has been modelled on the basis of data for the year 2020.

Three of the four types of granules used for FITT B-Active products are produced by an external supplier. The formulation of these granules has been indicated by FITT, while it is assumed that the production process is similar to the production process of granule produced in the FITT plant in Lugo.

3. Life Cycle Inventory Analysis

Data collection process

Data collection pphase was conducted by preparing a sheet that collected input and output data, in terms of mass and energy consumption and emissions in the various environmental compartments for the products analyzed.
The data collection form was verified and checked by means of mass balances and reporting any inconsistencies which were clarified and resolved.

Primary data were preferred in the data sheet to be used for the LCA study. In particular, the following primary data were used:

- The transport of incoming materials for the production of the analysed products, as well as auxiliary materials such as accessories and packaging;
- Waste produced during the manufacture of the products analysed (quantity and tyoe) and raw materials used (quantity and type). In particular, the efficiency of the process (and the relative waste generated) are deduced from the ratio between the finished product and the quantity of pipe discarded, data collected on a monthly basis by the company;
- The production process of the granule produced at FITT's Lugo plant (material composition, energy consumption and emissions into the atmosphere);
- The pipe extrusion process at the San Pietro in Gù plant.

The following information has been extrapolated from specific documents (shown below in brackets) and relates to the products analysed:

- Chemical composition of the raw materials used (bills of materials, technical and safety data sheets, data from suppliers);
- Weights and composition of packaging materials (bill of materials).

Where primary data or models for calculating such data were not available, secondary data obtained through consultation of internationally recognised database were used, favouring where possible the use of the most up-to-date ones. The secondary data in particular concern:

- Vehicle combustion processes: emissions, maintenance, road network use, fuel consumption (Ecoinvent dataset v3.6);
- Electricity: production processes, distribution networks (Ecoinvent dataset v3.6);
- The production of some materials used (Ecoinvent dataset v3.6).

Product BOMs

[information is omitted for confidentiality reasons]

Allocation principles and procedures

The needs to allocate flows into an out of a product system between the system itself and other external systems car arise in two case (Nicholson et al., 2009; Toniolo, 2017):

- In the case of simultaneous products, i.e. in the case of co-product allocation;
- In the case of subsequent products, i.e. in the case of materials that enter a recycling process (end of life allocation/allocation procedure of reuse, recycling, recovery).

In general, almost all industrial processes produce more than one product or recycle waste (Frischknecht et al., 2005; Frischknecht et al., 2007; Frischknecht, 2010).
In the present LCA study, end-of-life allocation was applied for waste produced during the recycling process, i.e. the requirments of EN 15804 were applied during the material production process.
The calculation model was developed using cut-off Ecoinvent datasets for all selected items.

Within this study, the *“co-product allocation”* procedure was adopted for:

- Allocate impacts associated with plant consumption such as: electricity consumption for offices, electricity consumption for compressors, water withdrawal and discharge, electricity consumption of pumps for water withdrawal and movement, general plant waste and consumption of auxiliary materials. The allocation was therefore carried out according to a physical principle (mass), considering the total produced at the San Pietro in Gù plant (7.326.175 kg).

Data quality assessment

The data quality level of the study was calculated by adopting the formula provided in the PEFCR guidance (European Commission 2018) which takes into account the weighted average of 4 quality parameters:

- Ter – Technological representativeness: the degree to which data refer to the technology that is actually used in the process under consideration;
- Gr – Geographical representativeness: the degree to which the data relate to a time span as feasible;
- Tir – Temporal representativeness: the degree to which the data relate to a time period that is as feasible as possible;

The calculation was applied to the average product, considering the average of contributions in the various impact categories. Once the most relevant processes had been identified, they were re-proportioned on a 100% basis to obtain the actual weights to be applied to the score (on a scale from 1 to 5) attributed to each of the 3 parameters.

The scores from 1 to 5 correspond to the quality levels identified by EN 15804 in Annex E (Table E.2), in order: Very good, Good, Fair, Poor, Very poor.
The following table shows the weights obtained and the score attributed to the quality parameters in order to be able to proceed with the semi-quantitative evaluation of the quality level of the study. The value obtained is 1.75 ("Very good").

4. Life cycle impact assessment

The impact assessment phase involves using the results obtained on the previous inventory analysis phase to define the potential impacts that the investigated system may have on the environment. In accordance with ISO 14040 and ISO 14044 Standards, in this study the assessment phase is limited to the mandatory elements, i.e. the definition of impact categories, classification and characterization. It should be noted that, as required by the Reference Standards for conducting LCA studies, the results of the impact assessment are relative expressions and do not include considerations on exceedances of thresholds, safety margins or risks.

The results are presented broken down according to the following life cycle stages:

- **Raw materials (pipe composition)**: includes all production processes of the granules and the substances used in them;
- **Raw materials (packaging)**: includes all packaging that is used to transport incoming raw matyerials and distribute the finished product;
- **Transport**: includes transport activities of raw materials that occur throughout the life cycle and distribution of the finished product;
- **Production processes**: this category includes all the impacts due to the transformations that take place inside the plant, such as energy consumption, management of waste products, emissions and plant consumption;
- **End of life**: this category covers the end of life of the product and its accessories and packaging, including transport operations.

Impact categories

The methodology chosen to assess the potential environmental impacts of the product subject of this study was created in such a way as to include the impact categories classified as *"Core environmental impact indicators"* by the Standard EN 15804 (CEN, 2019) (with the exception of the impact subcategories Climate Change – fossil, Climate Change – biogenic and Climate Change – land use transformation). This choice was made in order to ensure consistency between the various studies that the company has conduscted and will conduct in the current year fot other of its products, some of which are aimed at obtaining EPDs. The impact categories analysed, the respective indicators and characterisazion models are those envisaged by the EN15804+A2 standard and are listed below:

- Depletion of abiotic resources – elements (kg SB equiv.) and Depletion of abiotic resources – fossil fuels (MJ). These impact categories cover the protection of human welfare, human health and ecosystems health, and the extraction of minerals and fossil fuels.
- Acidification (mol H^+ equiv.). This impact category covers acidifying substances that cause a wide range of impacts on soil, groundwater, surface water, organisms, ecosystems and materials (buildings).

- Ozone depletion (kg CFC 11 equiv.). This category covers stratospheric ozone depletion, which can have adverse effects in human health, animal health, terrestrial and aquatic ecosystems, biochemical cycles and materials.
- Climate change (kg CO_2 equiv.). Climate change can cause adverse effects on ecosystem health, human health and material wll-being. Climate change is linked to greenhouse gas emissions into the air.
- Eutrophication aquatics freshwater (kg PO_4^{3-}equiv.), Eutrophication aquatic marine (kg N equiv.) and Eutrophication terrestrial (mol N equiv.). Eutrophication includes all impacts due to excessive levels of macronutrients in the environment caused by nutrient emissions to air, water and soil.
- Photochemical ozone formation (kn NMVOC equiv.). Photochemical ozone formation is the formation of reactive substances (mainly ozone) that are harmful to human health and ecosystems and can also damage crops. This problem is also referred to as “summer smog”. Wuinter smog does not fall under this category.
- Water use (m^3 world eq. deprived.). This indicator assesses the potential for deprivation of the water resource, both for humans and ecosystems, based on the assumption that the less water that remains available, the more likely it is that an additional user, be it a human or an ecosystem, will be deprived (boulay et al., 2016).

Results for FITT B-Active 50mm, 25m

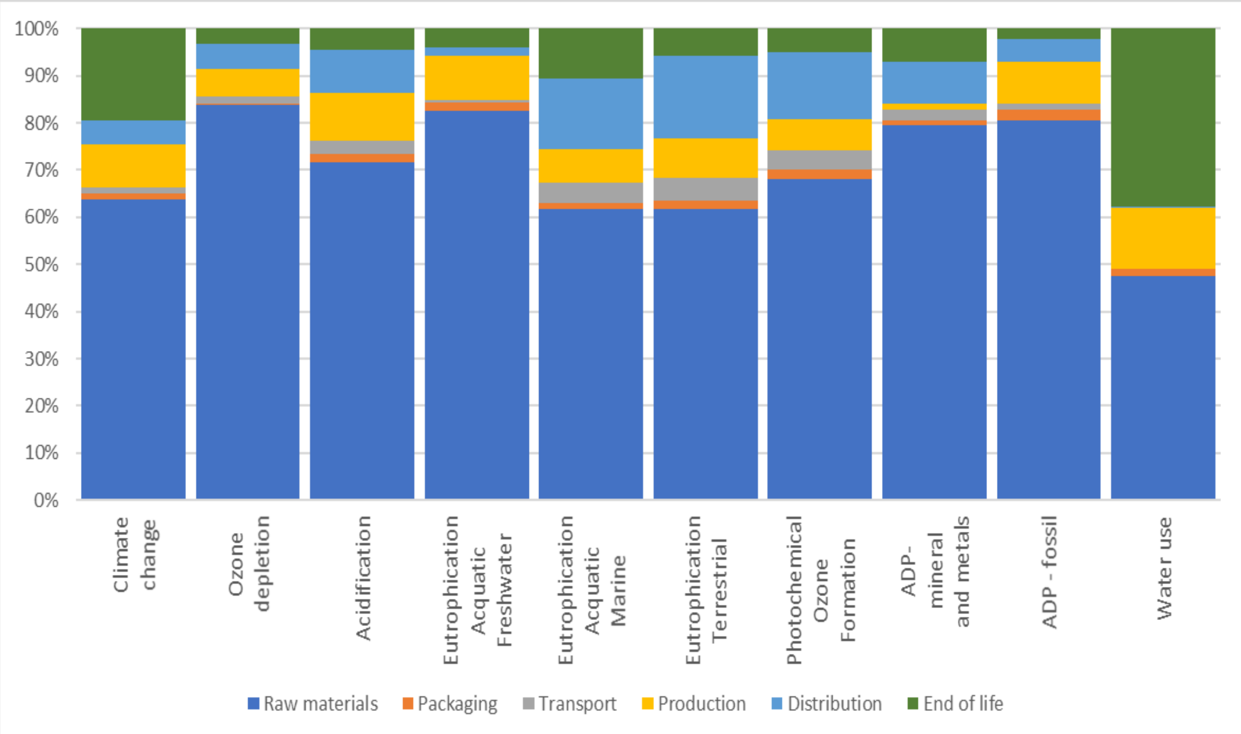

Figure 2 Graphical results for B-Active 50mm, 25m

Table 2 Assessment of impacts by life cycle stage for FITT B-Active 50mm, 25m

Impact category	Unit	Raw material	Packaging	Transport	Production	Distribution	End of life	Total
Climate change	kg CO2 eq	5,95E+1	1,08E+0	1,16E+0	8,47E+0	4,52E+0	1,80E+1	9,27E+1
Ozone depletion	kg CFC11 eq	1,64E-5	4,47E-8	2,64E-7	1,18E-6	1,04E-6	6,17E-7	1,95E-5
Acidification	mol H+ eq	2,42E-1	5,62E-3	9,25E-3	3,48E-2	3,09E-2	1,48E-2	3,37E-1
Eutrophication Acquatic Freshwater	kg P eq	1,57E-2	3,53E-4	8,32E-5	1,79E-3	3,31E-4	7,72E-4	1,90E-2
Eutrophication Acquatic Marine	kg N eq	4,94E-2	1,15E-3	3,36E-3	5,75E-3	1,20E-2	8,48E-3	8,02E-2
Eutrophication Terrestrial	mol N eq	4,63E-1	1,18E-2	3,69E-2	6,29E-2	1,32E-1	4,27E-2	7,49E-1
Photochemical Ozone Formation	kg NMVOC eq	1,74E-1	5,07E-3	1,01E-2	1,73E-2	3,62E-2	1,26E-2	2,55E-1
ADP- mineral and metals	kg Sb eq	1,07E-3	1,23E-5	3,04E-5	1,70E-5	1,22E-4	9,25E-5	1,34E-3
ADP - fossil	MJ	1,14E+3	3,27E+1	1,75E+1	1,28E+2	6,87E+1	3,09E+1	1,42E+3
Water use	m3 depriv.	2,96E+1	8,92E-1	4,74E-2	8,05E+0	1,90E-1	2,35E+1	6,23E+1

Results fot FITT B-Active 50mm, 50m

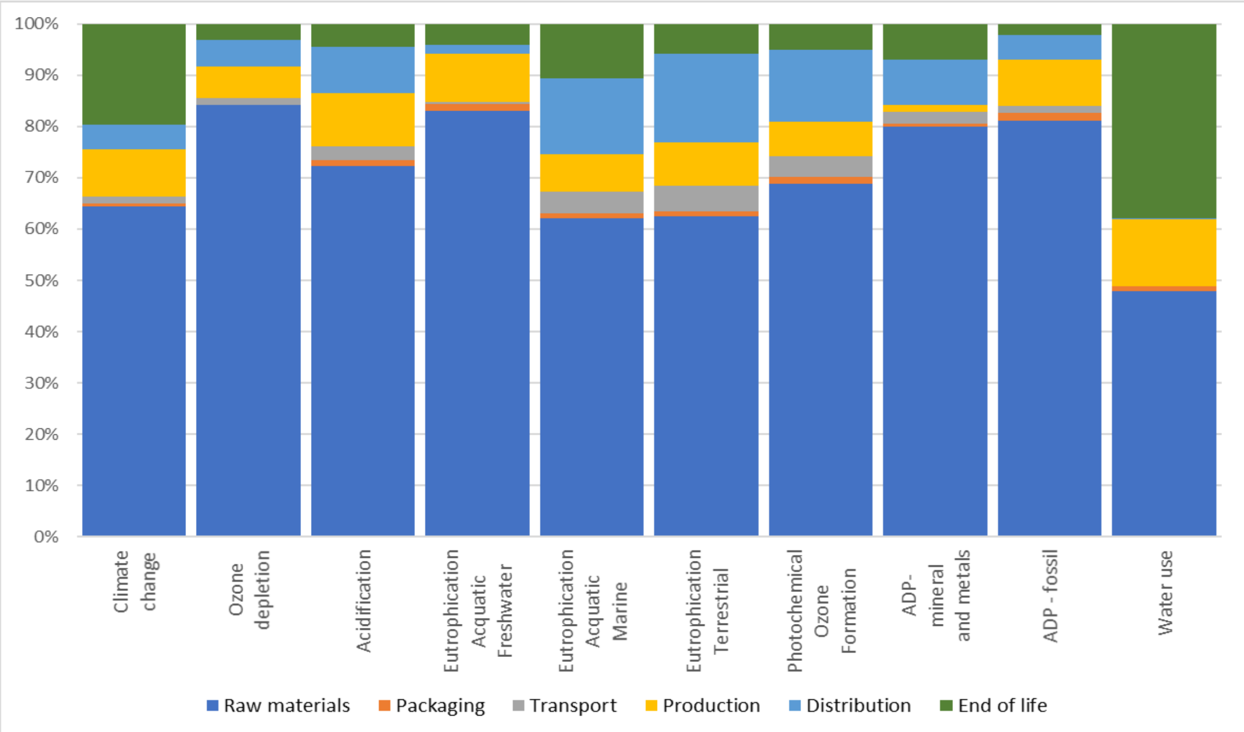

Figure 3 Graphical results of FITT B-Active 50mm, 50m

Table 3 Assessment of impacts by life cycle stage for FITT B-Active 50mm, 50m

Impact category	Unit	Raw material	Packaging	Transport	Production	Distribution	End of life	Total
Climate change	kg CO2 eq	1,19E+02	1,39E+00	2,32E+00	1,69E+01	8,84E+00	3,57E+01	1,84E+02
Ozone depletion	kg CFC11 eq	3,28E-05	5,87E-08	5,28E-07	2,35E-06	2,03E-06	1,23E-06	3,90E-05
Acidification	mol H+ eq	4,83E-01	7,37E-03	1,85E-02	6,96E-02	6,04E-02	2,96E-02	6,68E-01
Eutrophication Acquatic Freshwater	kg P eq	3,14E-02	4,63E-04	1,66E-04	3,57E-03	6,48E-04	1,54E-03	3,78E-02
Eutrophication Acquatic Marine	kg N eq	9,88E-02	1,50E-03	6,72E-03	1,15E-02	2,35E-02	1,69E-02	1,59E-01
Eutrophication Terrestrial	mol N eq	9,26E-01	1,55E-02	7,37E-02	1,26E-01	2,58E-01	8,53E-02	1,48E+00
Photochemical Ozone Formation	kg NMVOC eq	3,48E-01	6,68E-03	2,01E-02	3,45E-02	7,08E-02	2,52E-02	5,06E-01
ADP- mineral and metals	kg Sb eq	2,13E-03	1,61E-05	6,07E-05	3,41E-05	2,39E-04	1,85E-04	2,67E-03
ADP - fossil	MJ	2,29E+03	4,30E+01	3,50E+01	2,57E+02	1,34E+02	6,17E+01	2,82E+03
Water use	m3 depriv.	5,92E+01	1,17E+00	9,49E-02	1,61E+01	3,71E-01	4,69E+01	1,24E+02

Results for FITT B-Active 63mm, 25m

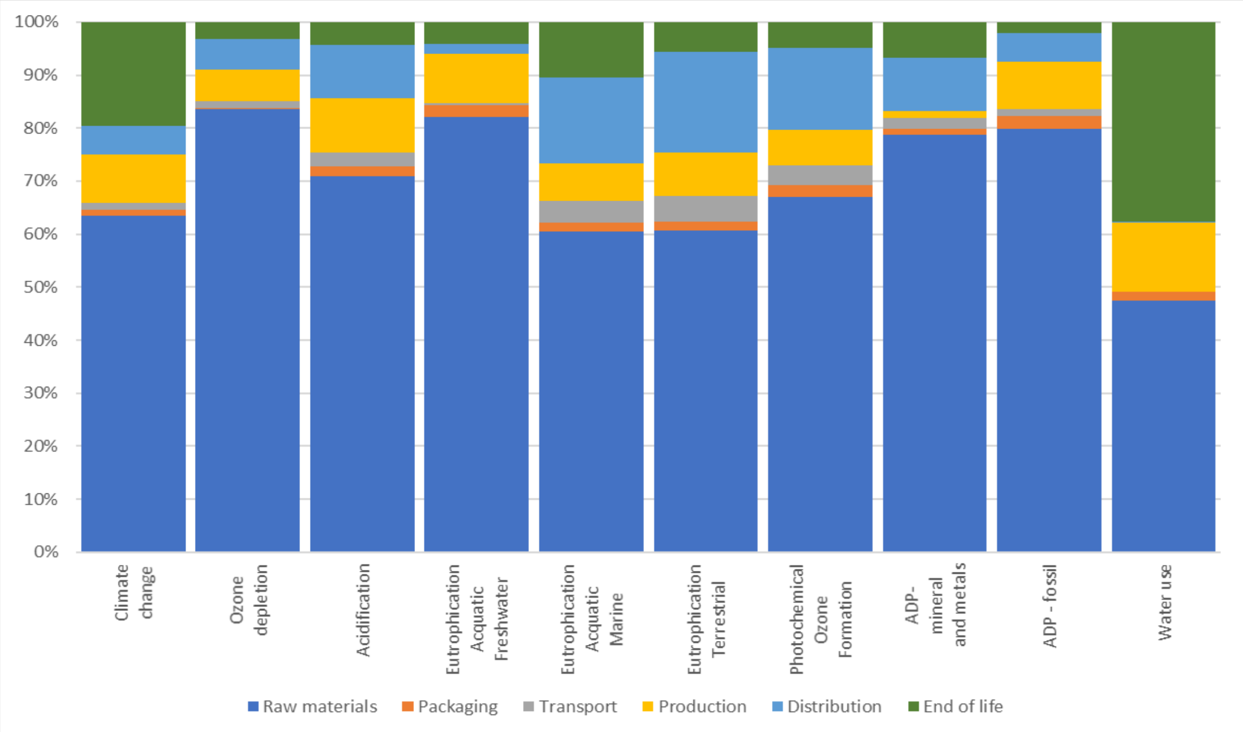

Figure 4 Graphical results of FITT B-Active 63mm, 25m

Table 4 Assessment of impacts by life cycle stage for FITT B-Active 63mm, 25m

Impact category	Unit	Raw material	Packaging	Transport	Production	Distribution	End of life	Total
Climate change	kg CO2 eq	7,58E+1	1,32E+0	1,47E+0	1,08E+1	6,36E+0	2,31E+1	1,19E+2
Ozone depletion	kg CFC11 eq	2,11E-5	6,62E-8	3,34E-7	1,51E-6	1,46E-6	7,90E-7	2,53E-5
Acidification	mol H+ eq	3,08E-1	8,09E-3	1,17E-2	4,45E-2	4,35E-2	1,90E-2	4,35E-1
Eutrophication Acquatic Freshwater	kg P eq	2,01E-2	5,05E-4	1,05E-4	2,29E-3	4,67E-4	9,89E-4	2,44E-2
Eutrophication Acquatic Marine	kg N eq	6,30E-2	1,66E-3	4,25E-3	7,36E-3	1,69E-2	1,09E-2	1,04E-1
Eutrophication Terrestrial	mol N eq	5,91E-1	1,72E-2	4,66E-2	8,05E-2	1,85E-1	5,48E-2	9,76E-1
Photochemical Ozone Formation	kg NMVOC eq	2,22E-1	7,39E-3	1,27E-2	2,21E-2	5,10E-2	1,62E-2	3,31E-1
ADP- mineral and metals	kg Sb eq	1,37E-3	1,78E-5	3,84E-5	2,18E-5	1,72E-4	1,18E-4	1,73E-3
ADP - fossil	MJ	1,46E+3	4,68E+1	2,21E+1	1,64E+2	9,68E+1	3,96E+1	1,83E+3
Water use	m3 depriv.	3,79E+1	1,27E+0	6,00E-2	1,03E+1	2,67E-1	3,00E+1	7,99E+1

Results for FITT B-Active 63mm, 50m

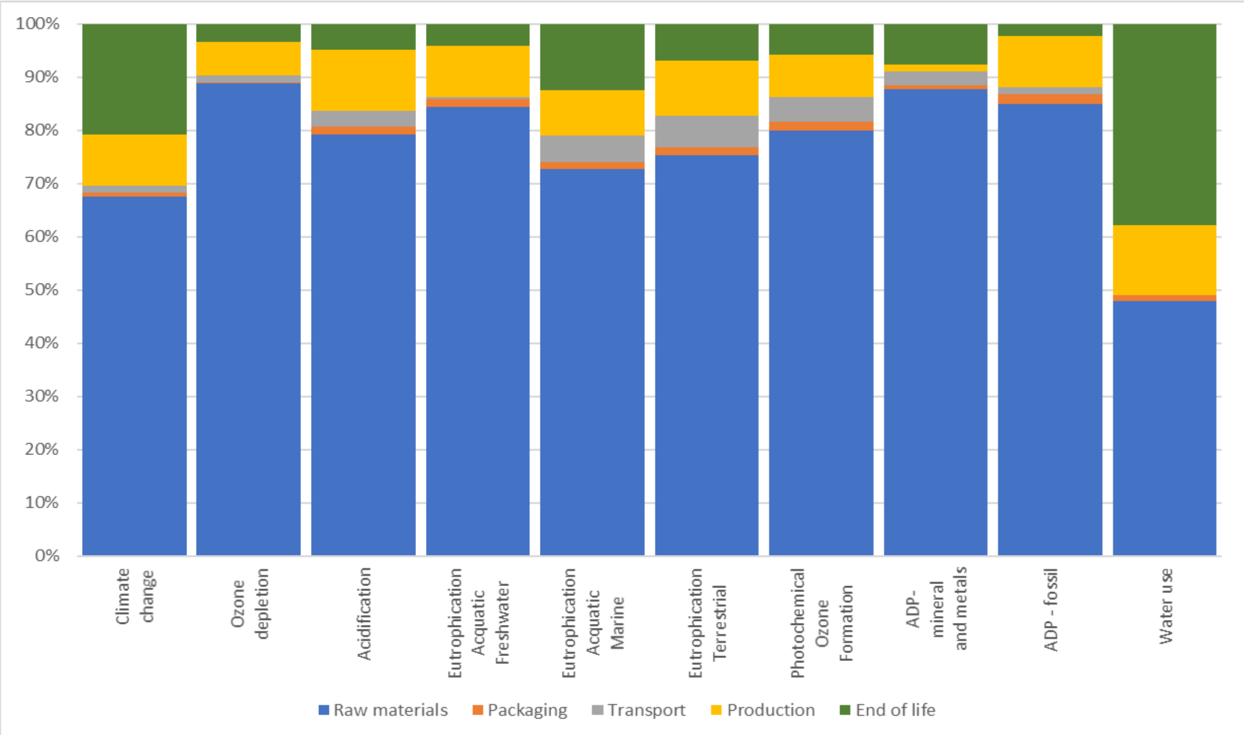

Figure 5 Graphical results of FITT B-Active 63mm, 50m

Table 5 Life Cycle Assessment for FITT B-Active 63mm, 50m

Impact category	Unit	Raw material	Packaging	Transport	Production	Distribution	End of life	Total
Climate change	kg CO2 eq	1,52E+2	1,63E+0	2,93E+0	2,17E+1	1,23E+1	4,59E+1	2,36E+2
Ozone depletion	kg CFC11 eq	4,22E-5	8,97E-8	6,68E-7	3,01E-6	2,83E-6	1,58E-6	5,04E-5
Acidification	mol H+ eq	6,17E-1	1,08E-2	2,34E-2	8,91E-2	8,44E-2	3,79E-2	8,62E-1
Eutrophication Acquatic Freshwater	kg P eq	4,01E-2	6,74E-4	2,10E-4	4,58E-3	9,06E-4	1,98E-3	4,85E-2
Eutrophication Acquatic Marine	kg N eq	1,26E-1	2,23E-3	8,50E-3	1,47E-2	3,29E-2	2,17E-2	2,06E-1
Eutrophication Terrestrial	mol N eq	1,18E+0	2,31E-2	9,32E-2	1,61E-1	3,60E-1	1,09E-1	1,93E+0
Photochemical Ozone Formation	kg NMVOC eq	4,44E-1	9,94E-3	2,54E-2	4,42E-2	9,89E-2	3,23E-2	6,54E-1
ADP- mineral and metals	kg Sb eq	2,73E-3	2,38E-5	7,68E-5	4,36E-5	3,34E-4	2,37E-4	3,45E-3
ADP - fossil	MJ	2,92E+3	6,24E+1	4,42E+1	3,29E+2	1,88E+2	7,91E+1	3,62E+3
Water use	m3 depriv.	7,59E+1	1,68E+0	1,20E-1	2,06E+1	5,19E-1	6,01E+1	1,59E+2

Results referred to 1m of average finished product

Table 6 Results of the assessment of impacts expressed to 1m of finished product

Impact category	Unit	B-Active 50mm, 25m [1m]	B-Active 50mm, 50m [1m]	B-Active 63mm, 25m [1m]	B-Active 63mm, 50m [1m]
Climate change	kg CO2 eq	3,71E+00	3,69E+00	4,75E+00	4,72E+00
Ozone depletion	kg CFC11 eq	7,81E-07	7,80E-07	1,01E-06	1,01E-06
Acidification	mol H+ eq	1,35E-02	1,34E-02	1,74E-02	1,72E-02
Eutrophication aquatic freshwater	kg P eq	7,61E-04	7,56E-04	9,77E-04	9,70E-04
Eutrophication aquatic marine	kg N eq	3,21E-03	3,18E-03	4,16E-03	4,12E-03
Eutrophication terrestrial	mol N eq	3,00E-02	2,97E-02	3,90E-02	3,86E-02
Photochemical ozone formation	kg NMVOC eq	1,02E-02	1,01E-02	1,32E-02	1,31E-02
ADP – mineral and metals	kg Sb eq	5,37E-05	5,34E-05	6,94E-05	6,89E-05
ADP – fossil	MJ	5,69E+01	5,64E+01	7,32E+01	7,25E+01
Water Use	m3 depriv.	2,49E+00	2,48E+00	3,20E+00	3,18E+00

5. Life cycle interpretation

In relation to what is defined in the reference standards (ISO 2006a,b) the life cycle interpretation phase consists of the analysis of the results of the inventory (LCI) and impact assessment (LCIA) phases, including several elements:

- Identification of significant factors;
- Evaluation;
- Conclusions, limitations, recommendations.

It is important to note that the LCIA results are based on a relative approach and refer to potential environmental impacts.
The study was conducted with a view to identifying the operations and specific activities with the greatest environmental impact for the product system studied.

As required by the reference standards (ISO, 2006a,b) it must be specified that in relation to the objective of the study, the unit chosen proved to be appropriate for the system studied, since it allowed the identification of the operations and specific activities with the greatest environmental impact for the product system studied. The criteria defined for data quality assessment were consistently met. In the light of these considerations, the different elements of the interpretation phase are analysed below.

In order to simplify the analysis in the following paragraphs, an average product was considered constructed as the arithmetic of the impacts of the four analysed product codes referring to 1m.

Analysis of contributions

In order to facilitate interpretation of the results obtained, a detailed analysis of potential environmental impacts is provided below, in order to identify the most relevant processes/materials.

Table 7 Analysis of relevant contributions for FITT B-Active average

Impact category	Climate change	Ozone depletion	Acidification	Eutrophication Acquatic Freshwater	Eutrophication Acquatic Marine	Eutrophication terrestrial	Photochemical Ozone Formation	ADP - mineral and metals	ADP - fossil	Water use
PVC Granule Rigid	19,5%	39,4%	24,4%	30,1%	20,0%	21,4%	20,6%	29,7%	26,1%	22,6%
PVC Granule SH66 Flexible	27,5%	34,0%	32,8%	38,3%	28,2%	27,5%	35,0%	36,8%	42,2%	25,6%
PVC Granule SH65 Skin	11,0%	7,0%	9,1%	9,4%	9,1%	8,0%	7,8%	8,6%	7,6%	5,8%
PVC Granule SH66 Skin	6,1%	3,4%	5,0%	4,8%	3,8%	4,3%	4,2%	4,3%	4,1%	3,0%
Input packaging	0,2%	0,0%	0,3%	0,2%	0,2%	0,3%	0,4%	0,1%	0,5%	0,2%
Outlet packaging	0,9%	0,2%	1,5%	1,6%	1,3%	1,4%	1,8%	0,8%	2,0%	1,3%
Raw material transport	1,2%	1,3%	2,7%	0,4%	4,1%	4,8%	3,9%	2,2%	1,2%	0,1%
Electricity	8,9%	6,0%	10,2%	9,2%	6,9%	8,3%	6,7%	1,2%	9,0%	3,4%
Other production consumption	0,2%	0,0%	0,0%	0,1%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
Distribution	5,1%	5,5%	9,5%	1,8%	15,6%	18,2%	14,8%	9,5%	5,0%	0,3%
Waste transport	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
End of life	19,4%	3,1%	4,4%	4,1%	10,5%	5,7%	4,9%	6,9%	2,2%	37,7%

Sensitivity analysis

In order to consolidate the results and conclusions of the LCA study, three sensitivity analyses were carried out:

1. Evaluation of the effect of lower synthesis efficiency of TOTM plasticiser production. In particular, in the scenario analysed, all inputs necessary for the production fo the substance are increased by 5%.

Table 8 Results of sensitivity analysis 1

Impact category	Units	Base case	Sensitivity 1	% change
Climate change	kg CO2 eq	4,22E+00	4,24E+00	0,58%
Ozone depletion	kg CFC11 eq	8,95E-07	8,96E-07	0,11%
Acidification	mol H+ eq	1,54E-02	1,55E-02	0,66%
Eutrophication Acquatic Freshwater	kg P eq	8,66E-04	8,72E-04	0,69%

Impact category	Units	Base case	Sensitivity 1	% change
Eutrophication Acquatic Marine	kg N eq	3,67E-03	3,68E-03	0,47%
Eutrophication Terrestrial	mol N eq	3,43E-02	3,45E-02	0,53%
Photochemical Ozone Formation	kg NMVOC eq	1,17E-02	1,18E-02	0,93%
ADP- mineral and metals	kg Sb eq	6,13E-05	6,17E-05	0,64%
ADP - fossil	MJ	6,48E+01	6,55E+01	1,07%
Water use	m3 depriv.	2,84E+00	2,85E+00	0,46%

The results shown in Table 8 show that all percentage changes form the base case are less than 2%, thus making the assumptions made for the construction of the TOTM dataset acceptable.

2. Choice of alternative dataset for modelling Polymic 400F plasticiser. In the alternative case, the use of the dataset without the modifications is evaluated;

Table 9 Results of sensitivity analysis 2

Impact category	Units	Base case	Sensitivity 1	% change
Climate change	kg CO2 eq	4,22E+00	3,96E+00	-6,21%
Ozone depletion	kg CFC11 eq	8,95E-07	9,09E-07	1,54%
Acidification	mol H+ eq	1,54E-02	1,51E-02	-1,58%
Eutrophication Acquatic Freshwater	kg P eq	8,66E-04	8,62E-04	-0,38%
Eutrophication Acquatic Marine	kg N eq	3,67E-03	3,65E-03	-0,54%
Eutrophication Terrestrial	mol N eq	3,43E-02	3,37E-02	-1,74%
Photochemical Ozone Formation	kg NMVOC eq	1,17E-02	1,16E-02	-0,32%
ADP- mineral and metals	kg Sb eq	6,13E-05	6,11E-05	-0,44%
ADP - fossil	MJ	6,48E+01	6,51E+01	0,58%
Water use	m3 depriv.	2,84E+00	2,90E+00	2,19%

The results shown in Table 9 show that all percentage variations from the base case are less than 10%, thus making the choice of dataset fro the characterisation of Polymix 400F acceptable.

Scenario analysis

An alternative scenario analysis was conducted in which the recycling option for end-of-life pipe is also considered. The adopted recyclability rate is equal to the values found in Table 10 under PE.

Table 10 Results of sensitivity analysis 3

Impact category	Units	Base case	Sensitivity 1	% change
Climate change	kg CO2 eq	4,22E+00	3,87E+00	-8,27%
Ozone depletion	kg CFC11 eq	8,95E-07	8,83E-07	-1,36%
Acidification	mol H+ eq	1,54E-02	1,51E-02	-1,90%
Eutrophication Acquatic Freshwater	kg P eq	8,66E-04	8,51E-04	-1,75%
Eutrophication Acquatic Marine	kg N eq	3,67E-03	3,50E-03	-4,63%
Eutrophication Terrestrial	mol N eq	3,43E-02	3,35E-02	-2,46%
Photochemical Ozone Formation	kg NMVOC eq	1,17E-02	1,14E-02	-2,14%
ADP- mineral and metals	kg Sb eq	6,13E-05	5,95E-05	-2,97%
ADP - fossil	MJ	6,48E+01	6,42E+01	-0,94%
Water use	m3 depriv.	2,84E+00	2,37E+00	-16,25%

The results of sensitivity analysis 3, shown in Table 19, demonstrate that by making the pipe recyclable, the benefit in terms of environmental impacts is appreciable, in particular for the Water Use category with a value of -16.25% compared to the base case (on the other hand, it should be noted that this impact category and the associated method are characterized by a high intrinsic uncertainty, as will be discussed in the following paragraphs).

Uncertainty analysis

This analysis was conducted in order to identify the level of uncertainty related to the data used on the final results of the study. This analysis was conducted using the Monte Carlo method. The results obtained show a good reliability of the data used, with Coefficients of Variation (CVs) lower than 17% in all impact categories, with exception of Eutrophication aquatic freshwater (42%), ADP – minerals and metals (34%) and Water Use (due to high uncertainty that characterises the applied method).

6. Conclusions

Fitt has decided to use the LCA (Life Cycle Assessment) methodology according to the international standards ISO 14040 and ISO 14044 to evaluate the potential environmental impacts associated with four configurations of FITT B-Active hose.
The objective of the study is to provide results that can support the company in identifying the main sources of impact, as well as support the external communication of the results themselves, once the critical review by and independent third party has been carried out.
For the inventory analysis, company – specific data were collected referring to the two plants (San Pietro in Gù and Lugo) involved in the production process. Where primary data were not available, the Ecoinvent v3.6 database was used.
The data collected for the characterization of the pipes under examination date back to the period January – December 2020, except for the determination of the B-Active production waste, which dates back to the period May – December 2020, as the previous ones were considered unreliable. The general factory data and product characteristics, defined on the basis of the BOMs, also date back to 2020.
The results of the study show that, for the products studied, the impacts derive mainly from the production processes of raw materials, and to a lesser extent from energy consumption for the production processes and the transport processes of raw materials and of the finished product.
The sensitivity analysis carried out have allowed to verify that the assumptions adopted during the modelling phase do not have significant repercussions on the final results.
The uncertainty analysis carried out with the Monte Carlo method has allowed to identify the categories for which the results are more uncertain (ADP – mineral and metals, Eutrophication aquatic freshwater and Water Use) and that require greater caution in the use and interpretation phase. In particular, the Water Use impact category is highly penalized by the evaluation of uncertainty through the Monte Carlo method (with CVs greater than 100%), as the water flows in and out of a given process are considered as independent variables, thus not guaranteeing the water balance. These data, although characterized by their uncertainty and using them with caution for any communications, can be considered valid for the achievement of the objectives set by the company.
It should be noted that the results of the study assume a relative value, have validity in relation to the assumptions made and the choice of systems and are not intended for comparative purposes.
In order to read this study, it is necessary to pay attention to the two main limitations, both inherent in the raw materials. The composition of the granules, in fact, derives from a level of knowledge of the compound equal to about 90% of the total, which, although reliable, is less precise than the primary data. In addition, not knowing the production data of these granules, the same data from the production of granules produced by FITT at the Lugo plant were used.
It is recommended to the recipients of this report that, when analyzing the results presented, consideration be given to the limitations arising from the assumptions required due to the lack of primary data (e.g. relating to externally produced granule primary data) and/or inherent limitations typical of the Life Cycle Assessment methodology and the impact assessment methods used (refer for example to the results of the uncertainty analysis shown above).

Index of Figures

Index of Tables

Bibliography

European Commission. “Model for Life Cycle Assessment (LCA) of buildings.” 2018.

European Commission. *Product Environmental Footprint Category Rules Guidance 6.3.* European Commission, 2018.

Giacomello, Luca, and Paolo Trombetti. *Valutazione dei costi socio/ambientali delle tecniche di scavo.* Telecom Italia, 2015.

Hajibabaei, Mohsen, Sara Nazif, and Fatemeh Tavanaei Sereshgi. “Life cycle assessment of pipes and piping process in drinkong water distribution networks to reduce environmental impact.” *Sustainable Cities and Society*, 2018.

ISO. “ISO 14040:2006/Amd 1:2020 Environmental management - Life cycle assessment - Principles and frameword.” 2020.

ISO. “ISO 14044:2006/Amd 2:2020 Environmental management - Life cycle assessment - Requirements and guidelines.” 2020.