Life Cycle Assessment study of FITT Force Pro

External Report
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Report by:
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Summary

1. General aspects and goal of the study

1.1. Company information

FITT in an international leader and company specialising in the creation of complete fluid transfer systems made of thermoplastic materials for both the industrial and constructions sectors – civil engineering and infrastructure – as well as home, 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 its headquarters in Sandrigo (Vicenza), FITT exports to 87 countries, with a total staff of 950 and a total of 15 offices worldwide (6 in Italy and 9 in other countries). In 2020, FITT had a turnover of 236 million euro.

1.2. Product information

FITT Force Pro is the innovative lightweight and compact garden hose suitable for professional use. The hose is made of vulcanised thermoplastic elastomer material (TPV) and double knitted No Torsion System Plus (NTS Plus) polyester PET. The TPV, finished with HD-TECH technology, guarantees easy handling, flexibility, high abrasion and puncture resistance, while the NTS mesh prevents knots and kinks.
The hose is flattened at rest and takes on its classic round shape as the pressurised water passes through, returning to its flattened shape once the water flow has stopped. This characteristics makes it very easy to handle and extremely compact, also having positive consequences in terms of logistics, as it takes up less space in the warehouse, on the shelves and on the means of transport.
The aluminium fittings are easily detachable from the pipe, facilitating their replacement in case of breakage and thus increasing the product's service life. They also facilitate the correct disposal of the two materials at and-of-life.
The products analysed were produced from 2020 onwards at the Sandrigo (VI) plant.

1.3. Information and goal of the study

This external report, based on the contents of the technical report "Life Cycle Assessment Study of FITT Force Pro" dated 29/06/2022, has the main purpose of communicating externally the results obtained from the assessment and quantification of the environmental performance of the following products:

- Fitt Force Pro 3/4" 100FT;
- Fitt Force Pro 5/8" 50FT.

This study was commissioned by FITT S.p.A. (hereinafter FITT) to Spinlife – Spin-off of the University of Padua (hereinafter Spinlife).
This study was carried out in the period March 2022 – June 2022 and was conducted according to the principles and requirements of the following International Standards:

- ISO 14040:2006/Amd 1:2020 Environmental management – Life Cycle Assessment – Principles and framework Amendment 1 (ISO 2020);
- ISO 14044:2006/Amd 2:2020 Environmental management – Life Cycle Assessment – Requirements and guidelines Amendment 2 (ISO 2020).

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2. Scope of the study

2.1. Functional unit

The functional unit is the sales unit of the pipe, i.e., the whole pipe together with fittings and finale packaging. In Table 1 the key characteristics of the functional unit considered are summarised.

Table 1 Key aspects of the functional unit

Question	Answer
What?	Hose fittings used to conduct water for manual watering of vegetable gardens, terraces or other hobby purposes
What quantity?	A sales unit
How?	Under operating conditions in line with the product instruction manual

2.2. System boundaries

The system boundaries include the entire life cycle of the analysed product, according to a "*from cradle to grave*" application, with the exception of the use phase. It is emphasised that the construction, maintenance and decommissioning of infrastructures, understood as buildings and machinery, as well as the occupation of industrial land have not been considered, as their contribution to the environmental impact relative to the functional units is considered negligible.
The reference period considered is the entire year 2020.
The following flows/processes were considered in conducting the study;

- Upstream: production and transport process of the raw material used (including accessories if any and packaging of the finished product), production and disposal process of the packaging used for their transport, production process of electricity purchased from the grid, natural gas supply process;
- Core: production of electricity and cooling energy through the tri-generation plant, air emissions from the production process, management of the processing waste generated, production and disposal of auxiliary materials used in production, water withdrawal and discharge, consumption associated with internal handling and other auxiliary activities;
- Downstream: distribution of the finished product, disposal of the product and its packaging.

2.3. Assumptions and limitations

For the conduct of this study, reference was made to primary data where available. Where access to this type of data was not possible, datasets from the Ecoinvent v3.6 database (Frischknecht, 2005) were taken as reference.
The following were excluded in this study: the construction, maintenance and decommissioning of infrastructure, understood as machinery and buildings, and the occupation of industrial land (id this information was not already present within the dataset used).

The subject of this study refers to the product with PP yarn, produced in 2020 and distributed in 2021. In order to guarantee the robustness of the study, general plant data (plant energy profile, general consumption, waste generated, water consumption) for the whole of 2020 were taken as reference, as well as the specific energy and material consumption of the production line. It is also emphasised here that the information such as material composition and origin, accessories, packaging and distribution scenario is specific to FITT Force Pro.
For the definition of product characteristics, reference was made to the BOMs referring to the year 2020.
Tha packaging of incoming raw materials was modelled punctually for granules and accessories, while the packaging with which materials for packaging the finished product arrive at the plant was omitted. A proxy dataset was considered for modelling the dyes used in the granule production process. This assumption proved to be irrelevant, as demonstrated in the LCA study conducted on the Force pipe.
For the atmospheric emissions from pipe production and processing, reference was made to 2019 values, assuming that per kg of pipe, these emissions remain constant.
Plant energy consumption (electricity and methane gas consumption) was used to calculate the production-specific energy consumption of the FITT Force Pro in order to simplify data collection and modelling. Th change in approach was justified by calculating the value of energy consumption per kg of product. The specific consumption therefore changes from 0,494 kWh/kg in the FITT Force LCA study (EU version) to 0,514 kWh/kg in the current study, a difference of 4% between the two values.

2.4. Exclusion criteria

The criterion chosen for the initial inclusions of inputs and outputs is based on the definition of a 1% cut-off level, both in terms of mass, energy and environmental relevance. This means that a process has been neglected if it responsible for less than 1% of the total mass, primary energy and impact. However, all processes for which data available have been taken into account, even if they contribute less than 1%. Consequently, this threshold value was used in order to avoid collecting unknown data, but not to neglect data that were nevertheless available. This choice is confirmed by similar LCA studies reported in the literature (Humbert et al., 2009).
According to this criterion, input packaging of the packaging for the final product, whose finale weight is well below the 1% threshold, and glue used in labels were excluded.

3. Life cycle inventory analysis

3.1. Data collection process

The information-gathering phase 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 analysed.

The data collection form was verified and checked by means of mass balances and reporting any inconsistencies, which were clarified and resolved.
In choosing the data to be used for the LCA study, priority was given to primary data. In particular, the following primary data were used:

- The transport of input 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 type) and raw materials used (quantity and type). In the particular, process efficiencies (and the related waste generated) are deduced from the ratio between finished product and quantity of discarded pipe, data collected on a monthly basis by the company;
- The production process of the starting granules and yarn conducted by suppliers (material compositions, energy consumption);
- The pipe extrusion and knitting process at the Sandrigo plant (mass balance, energy consumption and emissions).

The following information was extracted from specific documents (given 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 accessories and packaging materials (accessory design documents and bill of materials).

Where no primary data or models were available for the calculation of such data, secondary data obtained through consultation of internationally recognised databases were used, with preference given to the most up-to-date ones where possible. The secondary data in particular concern:

- Vehicle combustion process: emissions, maintenance, road use, fuel consumption (data sets Ecoinvent version 3.6.);
- Electricity: production processes, distribution network (data sets Ecoinvent version 3.6.);
- Raw materials for pipe production and packaging;
- End-of-life of pipe and plant waste disposal scenarios.

3.2. Product BOMs and production processes

[information is omitted for confidentiality reasons]

3.7. Product disposal scenario

All products and fittings have been associated with a waste category in order to streamline modelling. The waste types considered are: mixed plastics, polypropylene (PP), paper, cardboard, plank and coil, wood and metal (aluminium).

Table 2 Recycling, landfill and incineration rates in the United States

Market	Recycling	Landfill	Incineration
Mixed plastic	8,7%	75,6%	15,8%
PP	8,7%	75,6%	15,8%
Aluminium	34,1%	54,4%	11,5%
Paper	68,2%	6,2%	25,6%
Cardboard	68,2%	6,2%	25,6%
Partition and coil	68,2%	6,2%	25,6%
Wood	67,2%	15,7%	17,1%

In accordance with the end-of-life allocation approach employed, no impact is associated with the fraction destined for recycling operations (apart from the transport of the waste, assumed to be 50km).

3.8. Data quality

The quality level of the study was calculated using the formula provided by the PEFCR Guidance (Europeans Commission 2018) which takes into account the weighted average of 4 quality parameters:

- Ter – Technological representativeness: the degree to which the data relate to the technology that is actually used in the process under consideration;
- Gr – Geographical representativeness: the degree to which data refer to the actual geographical location where processes take place;
- Tir – Temporal representativeness: the degree to which data refer to as current a time span as possible;
- P – Accuracy/Uncertainty: the degree to which data are statistically representative of the processes to which they relate. This is ensured by conducting the uncertainty analysis, which precisely assesses the influence of statistical variability of the data on the results of the study.

The DQR obtained for the two products ranged from 2,04 to 2,09, being "GOOD".

4. Assessment of impacts

The impact assessment phase involves using the results obtained in the previous inventory analysis phase to define the potential impacts that the system under investigation may have on the environment. In accordance with the 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 characterisation. It should be noted that, as required by the Reference Standards for conducting LCA studies, the results on the assessment of impacts are relative expressions and do not include considerations of threshold exceedances, safety margins or risks.
The results are presented according to the following life cycle phases:

- **Raw materials (pipe)**: includes all processes for the production of granules and yarn, as well as the packaging used for their input transport;
- **Fittings**: includes all impacts associated with the production of the final product's packaging;
- **Packaging**: includes the transport associated with the production of the final product's packaging;
- **Transport**: includes the transport activities of raw materials that occur throughout the life cycle and the distribution of the finished product;
- **Production**: associated with this category are all impacts due to the transformations that take place within the plant, such as energy consumption, waste management, emissions and plant consumption;
- **End of life**: this category includes the end of life of the product and its accessories and packaging.

4.1. Impact categories

The methodology chosen to assess the potential environmental impacts of the product subject of this study was created in such a way to include the impact categories classified as *"Core environmental impact indicators"* by the Standard EN 15804 (CEN, 2019). This choice was made in such a way as to ensure consistency between the different studies that the company has conducted and will conduct in the current year for its other products, some of which are aimed at obtaining EPDs. The impact categories analysed are those of the EN15804+A2 standard and are listed below:

- Depletion of abiotic resources-elements (kg Sb eq) and Depletion of abiotic resources-fossil fuels (MJ). These impact categories concern the protection of human welfare, human health and ecosystem health, and the extraction of minerals and fossil fuels;
- Acidification (mol H^+ eq.). 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 CFC11 eq.). This category concerns stratospheric ozone depletion, which can have harmful effects on human health, animal health, terrestrial and aquatic ecosystems, biochemical cycles and materials;
- Climate change (kg CO_2 eq.). Climate change can cause adverse effects on ecosystem health, human health and material well-being. Climate change is linked to greenhouse gas emissions into the air;
- Eutrophication aquatic freshwater (kgPO_4^{3-}eq.), Eutrophication aquatic marine (kg N eq.) and Eutrophication terrestrial (mol N eq.). 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 (kg NMVOC eq.). Photochemical ozone formation is the formation of reactive substances (mainly ozone) that are harmful health and ecosystems and can also damage crops. This problem is also referred to as "summer smog". Winter smog does not fall under this category;

- Water use (m^3 world eq. deprived). The indicator assesses the deprivation potential of the water resource, both for humans and ecosystems, based on the assumption that the less water remains available, the more likely it is that an additional user, be it a humane or an ecosystem, will be deprived of it (Boulay er al., 2016).

4.2. Assessment of the environmental impacts of FITT Force Pro 3/4" 100FT

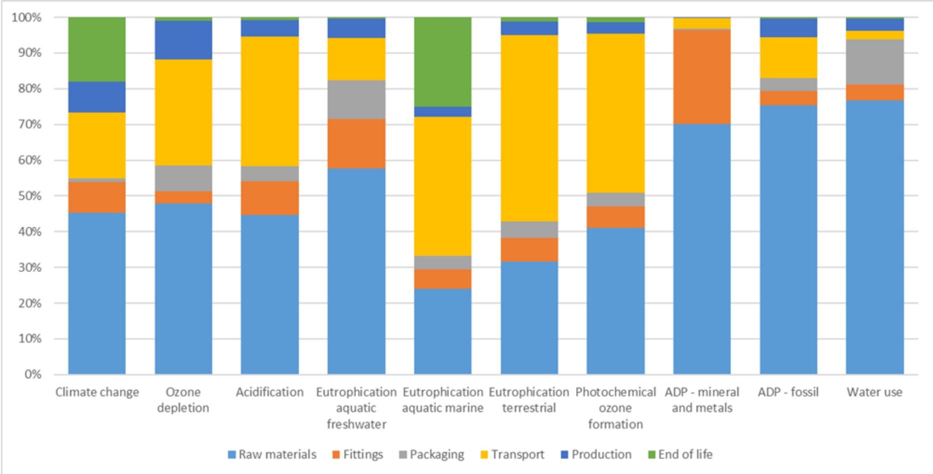

Figure 1 Graphical impact assessment results for FITT Force Pro 3/4" 100FT

Table 3 Life cycle impact assessment for FITT Force Pro 3/4" 100FT

Impact category	Unit	Total	Raw material	Fittings	Packaging	Transport	Production	End of life
Climate change	kg CO2 eq	1,45E+01	6,56E+00	1,27E+00	1,38E-01	2,66E+00	1,24E+00	2,62E+00
Ozone depletion	kg CFC11 eq	1,78E-06	8,51E-07	6,05E-08	1,29E-07	5,25E-07	1,92E-07	1,90E-08
Acidification	mol H+ eq	7,98E-02	3,56E-02	7,59E-03	3,32E-03	2,90E-02	3,66E-03	6,36E-04
Eutrophication aquatic freshwater	kg P eq	3,05E-03	1,76E-03	4,28E-04	3,31E-04	3,59E-04	1,63E-04	1,37E-05
Eutrophication aquatic marine	kg N eq	2,50E-02	6,00E-03	1,32E-03	9,75E-04	9,71E-03	6,99E-04	6,27E-03
Eutrophication terrestrial	mol N eq	2,04E-01	6,44E-02	1,35E-02	9,32E-03	1,06E-01	7,35E-03	2,62E-03
Photochemical ozone formation	kg NMVOC eq	6,45E-02	2,64E-02	3,92E-03	2,51E-03	2,87E-02	2,12E-03	8,42E-04
ADP - mineral and metals	kg Sb eq	1,56E-03	1,09E-03	4,08E-04	6,80E-06	4,81E-05	1,67E-06	6,47E-07
ADP - fossil	MJ	3,31E+02	2,50E+02	1,34E+01	1,18E+01	3,77E+01	1,78E+01	1,02E+00
Water use	m3 depriv.	6,39E+00	4,91E+00	2,75E-01	8,05E-01	1,63E-01	2,13E-01	2,36E-02

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4.3. Assessment of the environmental impacts of FITT Force Pro 5/8" 50FT

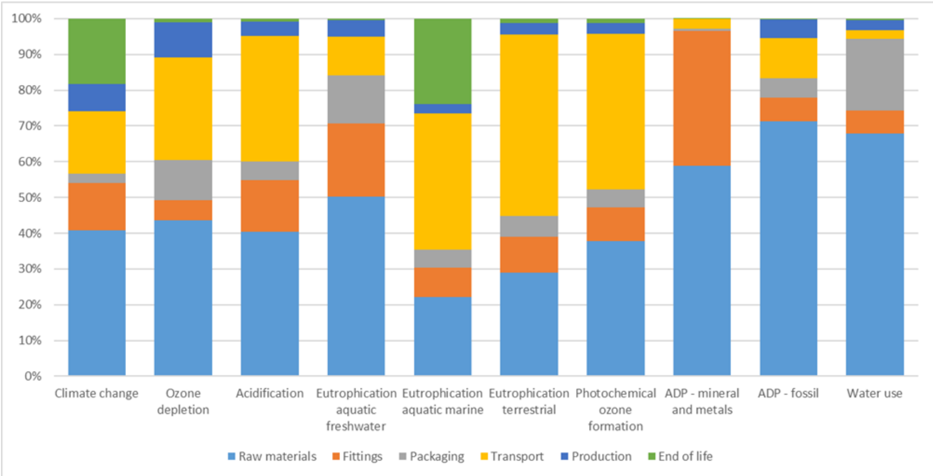

Figure 2 Graphical impact assessment results for FITT Force Pro 5/8" 50FT

Table 4 Life cycle impact assessment for FITT Force Pro 5/8" 50FT

Impact category	Unit	Total	Raw material	Fittings	Packaging	Transport	Production	End of life
Climate change	kg CO2 eq	8,11E+00	3,30E+00	1,07E+00	2,19E-01	1,41E+00	6,30E-01	1,48E+00
Ozone depletion	kg CFC11 eq	9,67E-07	4,22E-07	5,34E-08	1,10E-07	2,76E-07	9,61E-08	9,92E-09
Acidification	mol H+ eq	4,44E-02	1,79E-02	6,42E-03	2,38E-03	1,55E-02	1,83E-03	3,39E-04
Eutrophication aquatic freshwater	kg P eq	1,76E-03	8,82E-04	3,62E-04	2,34E-04	1,91E-04	8,15E-05	7,48E-06
Eutrophication aquatic marine	kg N eq	1,36E-02	3,02E-03	1,12E-03	6,79E-04	5,18E-03	3,52E-04	3,25E-03
Eutrophication terrestrial	mol N eq	1,12E-01	3,24E-02	1,14E-02	6,52E-03	5,68E-02	3,68E-03	1,38E-03
Photochemical ozone formation	kg NMVOC eq	3,52E-02	1,33E-02	3,34E-03	1,77E-03	1,53E-02	1,06E-03	4,52E-04
ADP - mineral and metals	kg Sb eq	9,13E-04	5,38E-04	3,45E-04	4,56E-06	2,50E-05	8,37E-07	3,44E-07
ADP - fossil	MJ	1,76E+02	1,25E+02	1,16E+01	9,39E+00	1,98E+01	8,89E+00	5,45E-01
Water use	m3 depriv.	3,70E+00	2,51E+00	2,40E-01	7,43E-01	8,63E-02	1,06E-01	1,28E-02

5. Life cycle interpretation

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

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

Importantly, the LCIA results are based on a relative approach and refer to potential environmental impacts. The study was conducted with a view to enabling the identification of preparations 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 stated that in relation to the objective of the study, the unit chosen proved to be appropriate for the system, studied, since it made it possible to identify the operations and specific activities with the greatest environmental impact for the product system studied. The criteria defined for the evaluation of data quality were consistently met. In light of these considerations, the different elements of the interpretation phase are analysed below.

5.1. Identification of relevant processes

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

Table 5 Analysis of relevant contributions ofr FITT Force Pro 3/4" 100FT

Contribution	Climate change	Ozone depletion	Acidification	Eutrophication aquatic freshwater	Eutrophication aquatic marine	Eutrophication terrestrial	Photochemical ozone formation	ADP - mineral and metals	ADP - fossil	Water use
Granule	37,2%	6,9%	0,5%	8,6%	0,8%	7,1%	8,6%	1,0%	11,3%	18,1%
Yarn	45,3%	1,9%	0,4%	3,3%	0,4%	13,2%	10,8%	7,3%	16,4%	1,1%
Dyes	37,5%	5,4%	0,4%	9,4%	1,5%	9,2%	4,6%	4,2%	27,1%	0,8%
Fittings	49,7%	5,7%	0,5%	13,8%	1,8%	2,4%	5,3%	10,8%	9,3%	0,4%
Packaging raw materials	19,9%	3,0%	0,2%	5,2%	1,0%	11,2%	2,8%	3,9%	27,6%	25,1%
Raw material transport	26,4%	3,9%	0,3%	6,5%	1,2%	15,1%	3,6%	4,6%	37,2%	1,3%
Production	34,5%	5,0%	0,5%	6,0%	1,1%	13,0%	3,3%	3,9%	31,4%	1,3%
Finished product packaging	69,3%	0,6%	0,0%	26,2%	0,1%	1,8%	0,1%	0,4%	1,3%	0,0%
Distribution	63,4%	10,3%	0,6%	3,9%	1,1%	4,7%	5,4%	3,6%	6,7%	0,3%
End of life	54,7%	19,6%	0,8%	4,1%	2,1%	0,7%	3,3%	12,6%	1,9%	0,4%

Table 6 Analysis of relevant contributions for FITT Force Pro 5/8" 50FT

Contribution	Climate change	Ozone depletion	Acidification	Eutrophication aquatic freshwater	Eutrophication aquatic marine	Eutrophication terrestrial	Photochemical ozone formation	ADP - mineral and metals	ADP - fossil	Water use
Granule	32,7%	7,0%	0,4%	13,1%	0,8%	6,4%	7,8%	2,7%	10,9%	18,2%
Yarn	41,0%	1,9%	0,3%	5,4%	0,5%	12,3%	9,9%	11,4%	16,2%	1,0%
Dyes	33,2%	5,5%	0,3%	14,2%	1,5%	8,7%	4,1%	5,4%	26,3%	0,8%
Fittings	42,6%	5,6%	0,4%	20,3%	1,9%	2,2%	4,6%	13,3%	8,7%	0,4%
Packaging raw materials	18,0%	3,1%	0,2%	8,1%	1,1%	10,7%	2,6%	5,0%	27,4%	23,9%
Raw material transport	23,6%	3,9%	0,3%	10,0%	1,3%	14,2%	3,3%	5,8%	36,4%	1,2%
Production	31,1%	5,2%	0,4%	9,3%	1,2%	12,4%	3,0%	5,0%	31,1%	1,3%
Finished product packaging	58,2%	0,6%	0,0%	37,7%	0,1%	1,5%	0,1%	0,5%	1,2%	0,0%
Distribution	58,9%	11,0%	0,5%	6,4%	1,2%	4,5%	5,1%	5,3%	6,8%	0,3%
End of life	46,5%	19,0%	0,6%	6,1%	2,1%	0,6%	2,9%	20,1%	1,8%	0,3%

5.2. Sensitivity analysis

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

1. Different finished product distribution scenario. In particular, the share of product distributed by truck is increased, as the available data do not refer to a specific location but to different areas of the US territory;
2. Energy consumption. The consumption of grid- supplied electricity and methane gas I decreased by 5% to create the same scenario as in the Force tube study;
3. % recycled Al. A decrease of 40% of recycled aluminium used in the different fittings and replaced by the corresponding weight of virgin aluminium is estimated.

The results obtained show that the assumptions made do not affect the goodness of the results obtained, with variations always less (in absolute terms) than 5%.

5.3. Uncertainty analysis

This analysis was conducted in order to identify the level of uncertainty related to the data used on the final result of the study, through the Monte Carlo method. The results obtained demonstrate a good reliability of the data used, with coefficients of variation (CVs) of less than 30% in all impact categories, with the exception of the Eutrophication aquatic freshwater (50,9% for FITT Force Pro 3/4" 100FT and 45,6% for FITT Force Pro 5/8" 50FT) and Water use (782% for FITT Force Pro 3/4" 100FT and 1212% for FITT Force Pro 5/8" 50FT, due to the high uncertainty of the applied method).

6. Conclusions

FITT decided to use the LCA (Life Cycle Assessment) methodology according to international standards ISO 14040 and ISO 14044 to assess the potential environmental impacts associated with two product codes of the FITT Force Pro family.

The aim of the study is to provide results that can support the company in identifying the main sources of impact, once a critical review by an independent third party has been carried out.

For the inventory analysis, company-specific data was collected referring to the Sandrigo plant involved in the production process. Where primary data were not available, the Ecoinvent v.3.6 database was used.

FITT Force Pro was produced from 2020 and its distributions started in 2021. All data refer to the entire year 2020, with the exception of the distribution (2021) and atmospheric emissions from the production process, which were held constant for the production of 1kg of pipe and therefore the 2019 valued used for FITT Force in the European version were maintained.

For the sake of simplification of data collection and modelling, the specific line consumption for pipe production was not mapped, but everything was derived from the overall consumption and production. This approach was deemed reliable as, in terms of energy consumption per kg of pipe, the percentage change is only 4% when compared to the specific values used in previous studies.

The results of the study show that for the products studied, the impacts stem mainly from the production processes of raw materials and the distribution process, and to a lesser extent from energy consumption for the production processes and the transport processes of raw materials and the finished product.

The sensitivity analyses carried out made it possible to verify that the assumptions made during the modelling phase have no significant effect on the final results. In particular, while there is a large reduction in terms of mass of recycled aluminium used for the production of fittings (-40%), maximum variations of -13% are observed in the ADP – Mineral and metals category. In any case, in order to improve the accuracy of the study, it would be desirable to question the suppliers of these raw materials in order to obtain data as accurate as possible.

The uncertainty analyses carried out made it possible to identify the categories for which the results are most uncertain (Eutrophication aquatic freshwater and Water Use) and which require greater caution in their use and interpretation. In particular, the Water Use category is greatly penalised by the evaluation of uncertainty through the Monte Carlo method (with CVs greater than 100%), since the water flows at the exit and entrance to a given process are considered as independent variables, thus not guaranteeing the water balance. These data, although characterised by their uncertainty, can be considered valid for the achievement of the targets set by the company.
It should be noted that the results of the study are of relative value, have validity in relation to the assumptions made and the choice of system, and are not intended for comparative purposes.

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