



**NUPI INDUSTRIE ITALIANE S.p.A.**



## **ENVIRONMENTAL PRODUCT DECLARATION**

Product names:

**POLYETHYLENE PIPING SYSTEM FOR  
WATER, GAS AND INDUSTRIAL  
APPLICATIONS TYPE  
“POLIETILENETUBI” AND ELOFIT**

Site Plants:

**Castel Guelfo (BO)  
Busto Arsizio (VA)**

**in compliance with ISO 14025 and EN 15804**


Program Operator	EPDItaly
Publisher	EPDItaly

Declaration Number	2019PC1222
EPDItaly Registration Number	EPDITALY0089
ECO EPD Registration Number	00001092

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## General information

<b>EPD OWNER:</b>	Nupi Industrie Italiane S.p.A., Via Stefano Ferrario n. 8, Z.I. Sud-Ovest - 21052 Busto Arsizio (VA) Italia
<b>PLANT INVOLVED in the declaration:</b>	Castel Guelfo: Via dell'Artigianato n. 13 - 40023 Castel Guelfo di Bologna (BO) – Italy Busto Arsizio: Via Stefano Ferrario n. 8, Z.I. Sud-Ovest - 21052 Busto Arsizio (VA) Italy
<b>SCOPE OF APPLICATION:</b>	This Environmental Product Declaration (EPD) is valid for POLIETILENETUBI (NADIR, NADIR PLUS, NADIR GAS, NUPIGAS, NADIR PLUS GAS) and ELOFIT (electrofusione, spigot, fabricated, metal transition fittings) products. The production facilities are in Castel Guelfo (BO) and Busto Arsizio (VA). The type of declaration is related to an average product produced partly in Castel Guelfo (pipes) and partly in Busto Arsizio (fittings). The life cycle assessment is representative for the product introduced in the declaration for the given system boundaries.
<b>PROGRAM OPERATOR:</b>	EPDITALY, via Gaetano De Castillia 10, 20124 Milano, Italia.
<b>INDEPENDENT CHECK:</b>	This declaration has been developed referring to EPDItaly, following the General Program Instruction; further information and the document itself are available at: <a href="http://www.epditaly.it">www.epditaly.it</a> . EPD document valid within the following geographical area: Italy and other countries according to sales market conditions.  CEN standard EN 15804:2012+A1:2013 served as the core PCR (PCR ICMQ-001/15 rev 2.1). PCR review was conducted by Daniele Pace. Contact via <a href="mailto:info@epditaly.it">info@epditaly.it</a>  Independent verification of the declaration and data, according to EN ISO 14025:2010.  Third party verifier: ICMQ SpA, via De Castillia, 10 20124 Milano ( <a href="http://www.icmq.it">www.icmq.it</a> )  <input type="checkbox"/> EPD process certification (Internal) <input checked="" type="checkbox"/> EPD verification (External)  <b>Accredited by: Accredia</b>
<b>CPC CODE:</b>	3632 - Tubes, pipes and hoses, and fittings therefor, of plastics
<b>CORPORATE CONTACT:</b>	<a href="mailto:info@nupinet.com">info@nupinet.com</a>
<b>TECHNICAL SUPPORT:</b>	thinkstep Italia, via Bovini 41 Ravenna (IT) <a href="http://www.thinkstep.com">www.thinkstep.com</a>  thinkstep a sphere company



<b>COMPARABILITY:</b>	Environmental statements published within the same product category, but from different programs, may not be comparable. In particular, EPDs of construction products may not be comparable if they do not comply with EN 15804.
<b>ACCOUNTABILITY:</b>	Nupi Industrie Italiane S.p.A relieves EPDItaly from any non-compliance with environmental legislation. The holder of the declaration will be responsible for the information and supporting evidence; EPDItaly declines all responsibility for the manufacturer's information, data and results of the life cycle assessment.
<b>REFERENCE DOCUMENT:</b>	This declaration has been developed following the General Programme Instruction document of EPDItaly, available at <a href="http://www.epditaly.it">www.epditaly.it</a> .
<b>PRODUCT CATEGORY RULES (PCR):</b>	PCR ICMQ-001/15 rev 2.1 EN 15804:2012+A1:2013 is the framework reference for PCRs.

## Company



In October 2015, Nupi Industrie Italiane S.p.A. took over Nupigeco S.p.A.

The name change brings with it the experience of an “all-Italian” company that exports its products worldwide.

Nupigeco S.p.A. was founded on October 1st 2008 by the merger of two of our companies, NUPI S.p.A. and Geco System S.p.A. - both founded more than 45 years ago. Combining their many years of experience and constant growth, the two firms decided to create a new flexible and advanced company, ready to play its role to satisfy the demands of the market whilst being environmentally astute.

### MISSION

The primary goal of Nupi Industrie Italiane S.p.A. corporate strategy is not only the production of systems that meet performance requirements and comply with the use for which they are intended, but above all general customer satisfaction. Producing better and faster are goals that technology makes more and more compatible.

Nupi Industrie Italiane S.p.A. combines high productivity with high and consistent quality standards while preventing pollution and minimizing the environmental impacts of its operations, making the most efficient use of natural resources and energy. To reduce raw materials wastes, Nupi Industrie italiane S.p.A. re-introduces in its production cycle its own reprocessed material.







## Company Certifications

**Nupi Industrie Italiane S.p.A.** submits its management and production systems to external audits performed by third party certification bodies. The external audit consists of inspections carried out at given intervals.

Audit frequency depends on the procedure established by the specific standard and by each certification body. Nupi Industrie Italiane S.p.A. is certified in compliance with the standards for quality (EN ISO 9001), environment (EN ISO 14001) and Health and Safety of workers (OHSAS 18001).



UNI EN ISO 9001

UNI EN ISO 14001

BS OHSAS 18001



## Product Certifications

NUPI products are of high quality, complying with regulations and conforming to the most stringent standards and certifications schemes (according to EN ISO 12201, EN ISO 1555, EN ISO 4427, EN ISO 4437, EN ISO 15494, DIN 8074, DIN 8075, PAS 1075, ASTM D 2513, ASTM D 3035, ASTM F 1055, ASTM F 714, FM 1613, NSF 61, etc...) from around the world (the full updated list is available on the website: [www.nupiindustriaitaliane.com](http://www.nupiindustriaitaliane.com)).



## Goal and scope of EPD

The entire life cycle of the product is considered (Type of EPD: cradle to grave) and the modules described below are declared in this EPD:

Modules **A1-A3** include those processes that provide energy and material input for the system (A1), transport up to the factory gate of the plant (A2), manufacturing processes as well as waste processing and emissions to air (A3).

Module **A4** includes the transport from the production site to the customer or to the point of installation of the products.

Module **A5** considers all piping systems installation steps to build the construction site (like auxiliaries and mechanical energy consumption) including packaging waste processing (recycling, incineration, disposal). Credits from energy substitution are declared in module D. During this phase a pipe leftover of 2% has been considered.

Module **B1** considers the use of the installed product. During the use of plastic piping systems, a scenario of zero impact is considered.

Module **B2** includes the maintenance of the product. A scenario of zero impact is considered.

Modules **B3-B4-B5** are related to the repair, replacement and refurbishment of the products. If the products are properly installed no repair, replacement or refurbishment processes are necessary. A scenario of zero impact is then considered.

Modules **B6-B7** consider energy use and operational water to operate the piping system. No operational energy or water use are considered. A scenario of zero impact is then considered.

Module **C1** considers deconstruction, including dismantling or demolition of the product from the construction site (trench). The energy consumption related to shredding activities is considered.

Module **C2** considers transportation of the discarded piping system to a recycling or disposal process.

Module **C3** considers waste processing for products recycling and incineration.

Module **C4** includes all waste disposal processes, including pre-treatment and management of the disposal site.

Module **D** includes benefits from all net flows in the end-of-life stage that leave the product boundary system after having passed the end-of-waste stage. Benefits from packaging incineration (electricity and thermal energy) are declared within module D.

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

X = modules included in the study



The type of EPD is “cradle to grave” and it is an average EPD for the product “POLIETILENETUBI” AND ELOFIT produced in NUPI INDUSTRIE ITALIANE S.p.A. plants located in Castel Guelfo (BO) and Busto Arsizio (VA) and sold worldwide. All data refer to the 2018 production and sales.

According to the PCR ICMQ-001/15 rev. 2.1, this is a “cradle to grave” EPD. Modules included are A1, A2, A3, A4, A5, B, C and D. All manufacturing activities and packaging/auxiliary’s production are in module A3, while energy production and input materials are in A1. Transport to clients (A4) and installation (A5) are included together with end of life scenarios (benefits and loads included according to D module).

The declaration is 1d (average product from different products and from more than one plant of a specific manufacturer).

The production facilities are in Castel Guelfo - Bologna (IT) - and Busto Arsizio - Varese (IT). The market range is Worldwide.

**Geographical validity:** Worldwide

**Database:** GaBi Database SP38 (2019)

**Software:** EPD Process Creator, implemented through GaBi professional 9 and GaBi Envision 9.0 software. The identification code of the EPD process tool used is: NUPI EPD Process Tool – V.3 del 10/07/2019 developed by thinkstep Italy.

**EPD realized by means of a validated algorithm:**

In 2019 NUPI Industrie Italiane S.p.A. implemented and certified a Process for EPD generation by using an algorithm that has been validated and certified by ICMQ S.p.A., in agreement with EPDItaly’s requirements. The process is based on an automatic data collection from different manufacturing plants that have been integrated, verified and validated in compliance with internal procedures. The validated algorithm allows the automatic calculation of the indicators reported into the current EPD coming from an LCA model implemented into the EPD process tool.



## Product description

### 1.1. Detailed product description

Nupi Industrie Italiane S.p.A. produces Polyethylene (High density HDPE and Low density LDPE) pipes and fittings systems for the distribution of water, gas and industrial fluids under pressure.

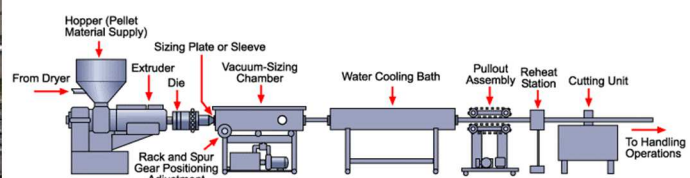
ELOFIT is a High Density Polyethylene - PE100 and PE100 RC system of electrofusion, spigot, fabricated, metal transition fittings and special components for the conveyance of fluids under pressure (gas, potable water, water for general purposes and chemicals).

“POLIETILENETUBI” pipes (*NADIR, NADIR PLUS, NADIR GAS, NUPIGAS, NADIR PLUS GAS*) are suitable for potable water, water for general purposes, gas and industrial applications. “POLIETILENETUBI” pipes are made of PE100, PE100 RC and PE80 grades, single and multi-layer.

They are manufactured using advanced technologies and according to the most stringent international standards.

### 1.2. Production processes description

#### PIPE EXTRUSION (Castel Guelfo)



**Figure 1 Pipes extrusion process**

Nupi Industrie Italiane S.p.A. manufactures both solid wall (monolayer) polyethylene pipes, in diameter sizes ranging from 16 mm to 1000 mm, and coextruded multilayer (from two to five layers) pipes.

The raw materials used to manufacture polyethylene pipes are supplied in pellets (provided in bulk transporter, octabins or bags), both as natural resin or finished compound. Resin is pneumatically conveyed from the bulk transporters to silos at the plant site. The resin is then transferred from the silos to the pipe extruder by a vacuum transfer system.

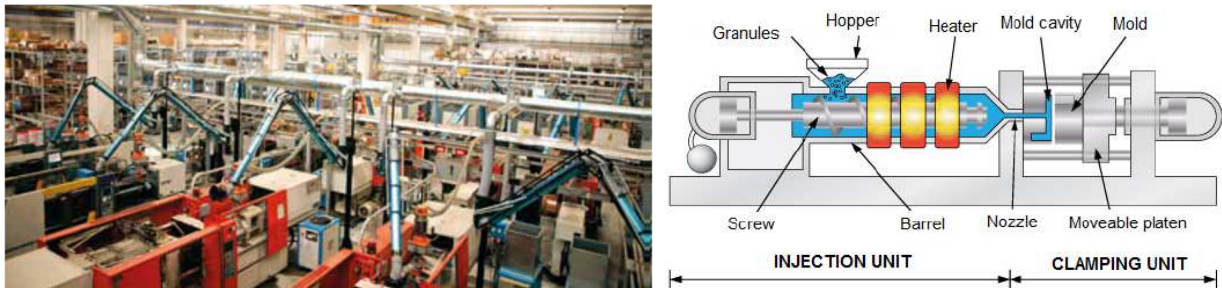
The pipe extrusion line consists of the extruder, die, cooling systems, puller, printer, saw and take-off equipment. The function of the extruder is to heat, melt, mix, and convey the material to the die, where it is shaped into a pipe. The extruder is used to heat the raw material and then force the resulting melted polymer through the pipe extrusion die. The pipe extrusion die supports and distributes the homogeneous polymer melt around a solid mandrel, which forms it into an annular shape for solid wall pipe.

The dimensions and tolerances of the pipe are determined and set during the sizing and cooling operation. The sizing operation holds the pipe in its proper dimensions during the cooling of the molten material. During vacuum sizing, the molten material is drawn through a sizing tube or rings while its surface is cooled enough to maintain proper dimensions and a circular form. The outside surface of the pipe is held against the sizing sleeve by vacuum. After the pipe exits the vacuum sizing tank, it is moved through a second vacuum tank or a series of spray or immersion cooling tanks.

The puller must provide the necessary force to pull the pipe through the entire cooling operation. Pipes are marked at specific intervals through ink jet or hot marking with tape machines.

Finished pipes can be coiled (depending to their sizes and physical/mechanical characteristics) or cut in customised straight lengths for handling and shipping convenience. Coiled pipes and straight lengths are then arranged with the proper packaging, ready for the storage, handling and transport phases.

## FITTINGS INJECTION MOULDING (Busto Arsizio)



**Figure 2 Fittings injection moulding process**

Equipment to mould fittings consists of a mould and an injection moulding press. The mould is a split metal block that is machined to form a part shaped cavity in the block. Hollows in the part are created by core pins shaped into the part cavity. The moulded part is created by filling the cavity in the mould block through a filling port, called a gate.

The injection moulding press has two parts; a press to open and close the mould block, and an injection extruder to inject material into the mould block cavity. The injection extruder is similar to a conventional extruder except that, in addition to rotating, the extruder screw also moves lengthwise in the barrel. Injection moulding is a cyclical process. The mould block is closed and the extruder barrel is moved into contact with the mould gate. The screw is rotated and then drawn back, filling the barrel ahead of the screw with material. Screw rotation is stopped, and the screw is rammed forward, injecting molten material into the mould cavity under high pressure. The part in the mould block is cooled by water circulating through the mould block. When the part has solidified, the extruder barrel and mould core pins are retracted, the mould is opened, and the part is ejected.

NUPI Industrie Italiane S.p.A. manufactures a wide range of electrofusion fittings that incorporate a metal wire for the welding process, socket fusion, spigot and transition fittings.

### 1.3. Technical data

For design purposes of polyethylene piping system under pressure, it is essential to know the internal pressure capability by defining the nominal pressure (PN) typical for water applications and the maximum allowable pressure (MOP) typical for gas and/or industrial applications.

The most important properties for the design of a PE pipe is the MRS (Minimum Required Strength) of the PE grade selected. For a PE100 grade, the MRS is 10 MPa and takes into account the creep properties and applies to operating temperatures up to 20°C. MOP (Maximum Operating Pressure) is related to the MRS of the material used; the pipe geometry is also essential (SDR; standard dimension ratio) as well as the service conditions.

For HDPE pipe, continuously operating in pressure at 20°C for 50 years with water, the design coefficient (C) is 1,25; for natural gas not ruled by national regulations and industrial applications, C is minimum 2.

$$PN = \frac{20 \times MRS}{C \times (SDR - 1)}$$

#### Relationship between MRS, PN, MOP (gas) and SDR (some SDR)

SDR	PN (C = 1,25)		MOP (gas), European (C = 2)	MOP (gas), Italy (C ≥ 3,25)	MOP (gas), European (C = 2)	MOP (gas), Italy (C ≥ 3,25)
	PE100	PE80	PE100	PE100	PE80	PE80
7.4	25	16	NA*	NA*	NA*	NA*
11	16	12.5	10	5	8	5
17	10	8	6.3	3.9	5	3
26	6	5	NA*	NA*	NA*	NA*

\*NA: not applicable. SDR 7.4 and 26 not included in EN 1555 for gas applications.

Some physical and mechanical characteristics of “POLIETILENETUBI” and ELOFIT system are summarized in the following tables:

#### Raw Material Physical Characteristics

Material property	Unit of measure	Requirements	Test method
Density	Kg/m <sup>3</sup>	>950	ISO 1183
Thermal Stability (T=200 °C)	min	>20	ISO 11357-6
MFI (190°C/5 kg) (PE80 and PE100)	g/10 min	0.2-1.4 (max. diff. +/- 20%)	ISO 1133
Volatile content	mg/kg	<350	ISO 760
Water content	mg/kg	<350	ISO 760
Carbon Black content	%	2-2.5	ISO 6964
Carbon black dispersion	-	Grade <=3 A1, A2, A3, B	ISO 18553

#### Mechanical Characteristics

Raw Material grade	Unit of measure	Requirements	Test parameters	Test method
PE100	h	>100	$\sigma=12.0$ MPa T=20 °C	EN ISO 1167
	h	>165	$\sigma =5.4$ MPa T=80 °C	EN ISO 1167
	h	>1000	$\sigma =5.0$ MPa T=80 °C	EN ISO 1167
PE80	h	>100	$\sigma =10.0$ MPa T=20 °C	EN ISO 1167
	h	>165	$\sigma =4.5$ MPa T=80 °C	EN ISO 1167
	h	>1000	$\sigma =4.0$ MPa T=80 °C	EN ISO 1167

Property	Unit of measure	Requirements	Test method
Elongation at Break	%	>350	EN ISO 6259
Tensile Strength at Yield	MPa	> 19 per PE80 > 21 per PE100	EN ISO 6259
MFI	g/10'	0.2<MFI<1.2 variation <20% after production	ISO 1133
Thermal Stability (OIT) @200°C	min	>20	ISO11357-6
Longitudinal Reversion @ 110°C	%	≤ 3	EN ISO 2505
Resistance to Rapid Crack Propagation	Bar	Pc≥ 1.5MOP	EN ISO 13477
Resistance to Slow Crack Propagation - pipe size DN 110	h	80°C, 500h	EN ISO 13479

#### 1.4. Base materials/ancillary materials

Material		Pipe (CG)	Fittings (BA)
Polyethylene compound (with carbon black and/or additives)	Base	100%	100%
TOTAL		100%	100%

#### 1.5. Description of piping system components

The environmental burdens are calculated in relation to the functional unit defined as 100 m buried polyethylene piping system for the conveyance of fluids under pressure with the following basic pipe system components: PE pipes, PE fittings, brass transition fittings, aluminium flanges (bolts and nuts not included) and NBR gaskets.

The reference pipe considered in the study is made of black or coloured polyethylene PE100 or PE80 and has a diameter of 110 mm that is the most common pipe used (as representative for the average pipe diameter from the exit of the supplying plant to the fluid meter of the building\users).

Standard dimension ratio considered is SDR 17 with wall thickness of 6,6 mm. The most typical method of joining is electrofusion.



Both flanged and threaded joining method has been included. The service lifetime of 100 years is considered according to relevant international publication on this item (Ulrich Schulte and Joachim Hessel, 2006).

NUPI Polyethylene piping system for the conveyance of fluids under pressure are conforming to the principal standards as EN ISO 12201, EN 805, EN ISO 4437 for water and EN ISO 1555, EN 12007-2, EN ISO 4427 for natural gas and EN ISO 15494 for industrial application. CEN TR 1046, EN 12007-1 and EN 1610, can be used as installation guidelines.

## 1.6. Products Distribution

Pipes and fittings are supplied to customers in customised dimensions (straight lengths or coils) with appropriate protection and packaging. The product packaging is made of cardboard boxes, wooden pallets and crates, stretch film and bags.



### Installation

Ancillary materials (bedding and backfilling material) and electricity are used during installation. No emissions are generated during installation and piping systems installations do not cause health or environmental hazards.

### Functional unit

The functional unit is defined as 100 m buried polyethylene piping system for the conveyance of fluids under pressure with the following basic pipe system components: PE pipes, PE fittings, brass transition fittings, aluminium flanges (bolts and nuts not included) and NBR gaskets.

The reference pipe considered in the study is made of black or coloured polyethylene PE100 or PE80 and has a diameter of 110 mm that is the most common pipe used (as representative for the average pipe diameter from the exit of the supplying plant to the fluid meter of the building\users).

Standard dimension ratio considered is SDR 17 with wall thickness of 6,6 mm. The most typical method of joining is electrofusion.

Both flanged and threaded joining method has been included. The service lifetime of 100 years is considered according to relevant international publication on this item (Ulrich Schulte and Joachim Hessel, 2006).

The installation method considered in the study was the open trench (U-shaped) method.

Name	Value	Unit
Reference flow	229,799	Kg/FU
Total pipes length	100	m
Pipes	218	Kg/FU
Plastic fittings	8,792	Kg/FU
Brass inserts	1,378	Kg/FU
Aluminium flanges	0,84	Kg/FU
NBR gaskets	0,058	Kg/FU
Cu-Ni alloys	0,73106	Kg/FU
Conversion factor to 1 kg	0,004351628	
Conversion factor to 1 m	0,01	

### Dangerous materials

The product does not contain any substances included in the "Candidate List of Substances of Very High Concern for Authorization" compliant with /REACH/ and with EC 1272/2008

The total mass involved is **229,799** kg of which 226,85 kg of total plastic, including 0,058 of NBR gaskets, 8,79 kg of plastic fittings and 2,94 kg of metal fittings/parts (aluminium, brass and Cu-Ni alloy).

### Condition of use:

Operational use (pumping energy) is not relevant for the EPD, since it falls outside the system boundaries of the LCA project. Maintenance is not needed for the "POLIETILENETUBI" AND ELOFIT pipe system (the cleaning process has not been included). According to /FprEN 16903/a general scenario of zero impact for buried polyethylene piping systems is considered.

### Reference service life

Polyethylene piping systems are regarded as having 100 years RSL independent of their material according to /FprEN 16903/ and (Ulrich Schulte and Joachim Hessel, 2006).

### End of life

After the demolition and deconstruction phase, polyethylene piping systems can be incinerated, sent to landfill or recycled.

## LCA results – Environmental impact per functional unit

The tables below show the results of the “POLIETILENETUBI” AND ELOFIT LCA (Life Cycle Assessment).

ENVIRONMENTAL IMPACTS																
Parameter	Unit	A1-3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
GWP	[kg CO2-eq.]	4,79E+02	2,08E+01	2,07E+02	0	0	0	0	0	0	0	1,14E-01	1,01E+00	1,77E+01	0,00E+00	-2,67E+01
ODP	[kg CFC11-eq.]	2,03E-10	4,49E-15	2,97E-12	0	0	0	0	0	0	0	3,20E-15	1,67E-16	6,33E-15	0,00E+00	-2,62E-12
AP	[kg SO2-eq.]	1,05E+00	1,82E-01	1,40E+00	0	0	0	0	0	0	0	3,24E-04	8,15E-04	6,21E-03	0,00E+00	-4,95E-02
EP	[kg (PO4) <sup>3-</sup> -eq.]	1,18E-01	2,10E-02	2,81E-01	0	0	0	0	0	0	0	3,04E-05	1,80E-04	1,08E-03	0,00E+00	-5,59E-03
POCP	[kg ethene-eq.]	1,63E-01	9,17E-03	1,20E-01	0	0	0	0	0	0	0	2,06E-05	2,12E-05	5,91E-04	0,00E+00	-6,96E-03
ADPE	[kg Sb-eq.]	3,86E-03	1,48E-06	1,76E-05	0	0	0	0	0	0	0	3,64E-08	7,80E-08	8,99E-07	0,00E+00	-1,69E-05
ADPF	[MJ]	1,61E+04	2,75E+02	2,84E+03	0	0	0	0	0	0	0	1,23E+00	1,37E+01	2,90E+01	0,00E+00	-6,71E+02
Caption	GWP = Global warming potential; ODP = Ozone depletion potential; AP = Acidification potential; EP = Eutrophication potential; POCP = Photochemical ozone creation potential; ADPE = Abiotic depletion potential for non fossil resources; ADPF = Abiotic depletion potential for fossil resources															

## LCA results – Environmental impact per functional unit - TRACI

TRACI Indicators																
Parameter	Unit	A1-3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Global Warming Air	[kg CO <sub>2</sub> -eq.]	4,79E+02	2,08E+01	2,07E+02	0	0	0	0	0	0	0	1,14E-01	1,01E+00	1,77E+01	0,00E+00	-2,67E+01
Ozone Depletion Air	[kg CFC11-eq.]	1,84E-10	-6,68E-14	2,19E-12	0	0	0	0	0	0	0	-1,72E-15	-3,14E-15	-1,75E-13	0,00E+00	5,57E-14
Acidification Air	[kg SO <sub>2</sub> -eq.]	1,11E+00	1,95E-01	1,75E+00	0	0	0	0	0	0	0	3,29E-04	9,05E-04	6,50E-03	0,00E+00	-5,22E-02
Eutrophication	[kg N - eq.]	7,54E-02	8,73E-03	1,17E-01	0	0	0	0	0	0	0	2,48E-05	1,64E-04	8,82E-04	0,00E+00	-3,53E-03
Smog Air	[kg O <sub>3</sub> -eq.]	1,80E+01	3,69E+00	5,01E+01	0	0	0	0	0	0	0	4,06E-03	1,42E-02	7,40E-02	0,00E+00	-8,85E-01

## LCA results – Resource use per functional unit

RESOURCE USE																	
Parameter	Unit	A1-3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	
PERE	[MJ]	1,34E+03	1,27E+01	1,77E+02	0	0	0	0	0	0	0	8,32E-01	7,99E-01	3,54E+00	0,00E+00	-7,55E+01	
PERM	[MJ]	8,17E+01	0	-2,06E+01	0	0	0	0	0	0	0	0	0	0	0	0	
PERT	[MJ]	1,42E+03	1,27E+01	1,57E+02	0	0	0	0	0	0	0	8,32E-01	7,99E-01	3,54E+00	0,00E+00	-7,55E+01	
PENRE	[MJ]	7,59E+03	2,77E+02	2,96E+03	0	0	0	0	0	0	0	2,07E+00	1,38E+01	2,59E+02	0,00E+00	-7,33E+02	
PENRM	[MJ]	8,99E+03	0	-1,01E+02	0	0	0	0	0	0	0	0	0	-2,24E+02	0	0	
PENRT	[MJ]	1,66E+04	2,77E+02	2,86E+03	0	0	0	0	0	0	0	2,07E+00	1,38E+01	3,44E+01	0,00E+00	-7,33E+02	
SM*	[kg]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,41E+00	
RSF	[MJ]	9,30E-11	0,00E+00	9,23E-23	0	0	0	0	0	0	0	0	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-1,17E-22
NRSF	[MJ]	1,09E-09	0,00E+00	1,08E-21	0	0	0	0	0	0	0	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-1,38E-21
FW	[m3]	3,00E+00	2,14E-02	3,15E-01	0	0	0	0	0	0	0	9,80E-04	1,35E-03	4,25E-02	0,00E+00	-1,25E-01	
Caption	PERE = Use of renewable primary energy excluding renewable primary energy resources 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 resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non renewable secondary fuels; FW = Use of net fresh water																

\* Reference to only foreground system.



## LCA results – Output flows and waste categories per functional unit

OUTPUT FLOWS AND WASTE CATEGORIES																
Parameter	Unit	A1-3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
HWD	[kg]	2,46E-05	1,17E-05	1,43E-04	0	0	0	0	0	0	0	9,88E-10	7,69E-07	1,72E-08	0,00E+00	-2,31E-07
NHWD	[kg]	1,21E+01	1,81E-02	9,67E+00	0	0	0	0	0	0	0	1,50E-03	1,12E-03	7,31E-01	0,00E+00	-2,67E-01
RWD	[kg]	1,94E-01	5,10E-04	7,23E-03	0	0	0	0	0	0	0	3,33E-04	1,87E-05	2,11E-03	0,00E+00	-2,47E-02
CRU*	[kg]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MFR*	[kg]	0	0	2,78E+00	0	0	0	0	0	0	0	0	0	4,24E+00	0	0
MER*	[kg]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EEE	[MJ]	0	0	1,89E+01	0	0	0	0	0	0	0	0	0	3,27E+01	0	0
EET	[MJ]	0	0	3,48E+01	0	0	0	0	0	0	0	0	0	5,82E+01	0	0
Caption	HWD = Hazardous waste disposed; NHWD = Non hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy															

\* Reference to only foreground system.

## Calculation rules

### Assumptions

Where possible, a conservative approach has been adopted, overestimating burdens to prove irrelevance. In other cases, alternatives data were selected based on scientific experience, in order to improve the accuracy of the model. Where it was not possible to know the exact materials composition in the supply chain (due to commercial or industrial confidential suppliers' reasons or due to missing datasets), these have been approximated with LCIs of similar materials, estimated by the combination of available dataset or reconstructed with literature data.

1. For brass recycling, the steel billet recycling process has been used as a conservative choice (melting temperature for recycling brass is higher than for steel).
2. Where potential benefits from energy recovery in A5 and C modules are considered, the grid mix of non-European countries has been considered as the European one.
3. For boilers (natural gas fed) an efficiency factor equal to 0,95 is considered.
4. Wastes coming from extraordinary maintenance activities have not been considered.
5. For mixed packaging wastes the production impact is taken into account but as it is mainly made of polyethylene, the polyethylene production is considered.
6. Auxiliaries used in installations are assumed to be sent to landfill at the end of life of the product.
7. The functional unit is defined as mass of pipes and fittings without packaging.
8. Some components produced by third party companies arrive at NUPI with their own packaging. This packaging is not accounted for in this study.

### Cut off rules

EN 15804 requires that where there are data discrepancies or insufficient input data for a unit process, the cut-off criteria shall be 1% of renewable and non-renewable primary energy usage and 1% of the total mass of this unit process. The total neglected flows from a product stage must be no more than 5% of product inputs by mass or 5% of primary energy contribution.

Only nylon strips for some fitting packaging and ozone emissions have been ignored as widely < 1% of the total mass.

### Data quality

The data quality can be considered as good. The LCA models have been checked and most relevant flows were considered. Technological, geographical and temporal representativeness is appropriate.

### Examination period

Primary data collected in the context of this study refer to 2018.

## Allocation – upstream data

In general, the allocation principles used in standard GaBi datasets are explained within GABI 9 2019 DOCUMENTATION.

For all refinery products, allocation by mass and net calorific value has been applied. The specific manufacturing route of every refinery product is modelled and so the impacts associated with the production of these products are calculated individually. Two allocation rules are applied:

1. the raw material (crude oil) consumption of the respective stages, which is necessary to produce a product or an intermediate product, is allocated by energy (mass of the product \* calorific value of the product);
2. the energy consumption (thermal energy, steam, electricity) of a process, e.g. atmospheric distillation, being required by a product or an intermediate product, are charged on the product according to the share of the throughput of the stage (mass allocation).

Materials and chemicals needed used in the manufacturing process are modelled using the allocation most suitable rule for the respective product. For further information on a specific product, see the documentation on [gabi-software.com](http://gabi-software.com).

In addition to the abovementioned allocation methods for refinery products and materials, inventories for electricity and thermal energy generation also include allocation by economic value for some by-products (e.g. gypsum, boiler ash and fly ash). In case of plants for the co-generation of heat and power, allocation by exergy is applied.

## Scenarios and additional technical information

- Module A1 refers to all raw materials impacts production with packaging included and all types of energy inputs
- Module A2 includes the raw materials (also auxiliary's and packaging) transport to the factory gate
- Module A3 comprises all production activities and waste treatment and process emissions (both to air and to water). Such activities refer to NUPI Industrie Italiane S.p.A. direct activities. Primary data have been used for (such as plastic extrusion for pipes production, plastic injection moulding for fittings production) and processes not directly carried out by NUPI Industrie Italiane S.p.A such as the other materials (aluminium, brass, NBR, Cu-Ni alloys) production, included in the study as requested in the functional unit. (secondary data have been used in this case).
- Module A4 takes into account the transport to the final customer/distributor. In 2018, "POLIETILENETUBI" AND ELOFIT piping system was sold to Europe (80%), to USA (11%) and to the rest of the world (9%). The distribution scenario is shown below:

Means of transport	GaBi transport dataset	Weighted Average distance [km]
<b>Truck</b>	Truck-trailer, Euro 6, up to 28t gross weight / 12,4t payload capacity	770
<b>Ship</b>	Average ship, 1500t payload capacity/ canal	1695

- For Module A5 the following parameters (TEPPFA reference) have been taken into account:

Parameter	Parameter unit expressed per functional unit	Source
<b>Backfilling sand</b>	8,70 m <sup>3</sup>	/Recalculated by using <a href="#">TEPPFA EPD,2017</a> /*
<b>Mechanical energy</b>	897 MJ (excavating, backfilling and vibrating)	/Recalculated by using <a href="#">TEPPFA EPD,2017</a> /*
<b>Soil transported away</b>	9,66 m <sup>3</sup>	/Recalculated by using <a href="#">TEPPFA EPD,2017</a> /*
<b>Leftover</b>	2%	/ <a href="#">TEPPFA EPD, 2017</a> /

\*: The value has been recalculated taking into account a no supported trench (U-shaped) with parallel sides of 0,51m width and 1,1m (0,9+dn) deep. A 50% of suitable native soil reuse has been considered and the other 50% has been considered to be transported away.

Moreover, following leftover end of life scenarios have been included:

	Landfill	Incineration	Mechanical recycling	Source
<b>Leftover</b>	80 %	15 %	5 %	<u>/TEPPFA EPD, 2017/</u>
<b>Distance to treatment</b>	to 50 km	150 km	600 km	<u>/TEPPFA EPD, 2017/</u>

- Module B (maintenance and operational use): Operational use and Maintenance are not relevant for the piping system. According to /FprEN 16903/ a general scenario of zero impact for buried polyethylene piping systems is considered for all B modules (B1-B2-B3-B4-B5-B6-B7).
- Module C1 (Deconstruction / demolition) has been included and deconstruction impacts have been considered.
- Module C2, C3 (recycling and incineration with energy recovery) and C4 (landfilling) consider the end of life scenarios of the product, considering all components of the piping system. The percentages to the given scenarios have been suggested by the /TEPPFA EPD, 2017/ and /FprEN 16903/ as shown below:

Material	EoL treatment – <u>/FprEN 16903/</u>	Distances to treatment [C2] <u>/TEPPFA EPD, 2017/</u>
<b>Piping systems</b>	95% left in ground 2,5% incineration 2,5% mechanical recycling	150 km to incineration 600 km to recycling

- Module D consists of loads and benefits beyond the system boundaries.





## Other additional environmental information

### **Emissions to indoor air:**

No direct emissions at the construction site. Nupi Industrie Italiane S.p.A confirms that the “POLIETILENETUBI” AND ELOFIT piping system does not contain any substances mentioned on the REACH-list.

### **Emissions to soil and water:**

No direct emissions at the construction site. Nupi Industrie Italiane S.p.A confirms that the “POLIETILENETUBI” AND ELOFIT piping system does not contain any substances mentioned on the REACH-list.

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