Certified translation from German into English

EPD –

ENVIRONMENTAL PRODUCT DECLARATION as per ISO 14025 and EN 15804+A1

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VRS®-T Ductile Iron Pipe Systems

Tiroler Rohre GmbH

Contents of the EPD

1 General information

Product name TRM VRS®-T ductile iron pipe system	**Declared product / declared unit** 1 m ductile iron pipe of the VRS®-T system (restrained locking system) with Portland composite cement lining and zinc coating with PUR Longlife coating with the nominal dimensions:
Declaration number BAU-EPD-2020-1-TRM-ECOINVENT-VRS-T-Rohrsystem	
Declaration data ☒ Specific data ☐ Average data	
Declaration based on: Name of the PCR: Construction products made of ductile iron PCR code: 2.16.8, version: 1.4 from 07.06.2019 (PCR tested and approved by the independent expert committee) The owner of the declaration is liable for the underlying information and evidence; Bau EPD GmbH is not liable with respect to manufacturer information, life cycle assessment data and evidence.	**Number of data sets in this EPD document: 10** **Range of validity** The EPD applies to the VRS®-T ductile iron pipe system with the above-mentioned lining and duplex outer coating from the Hall in Tyrol plant of Tiroler Rohre GmbH.
Type of declaration as per OENORM EN 15804 From cradle to grave	**Database, software, version** Database ecoinvent 3.5, system model “cut-off by classification” Software SimaPro 9.0.0.35
Author of the life cycle assessment DI Dr. Florian Gschösser floGeco Hinteranger 61d 6161 Natters Austria	**The European standard EN 15804:2014+A1 serves as the core PCR.** **Independent verification of the declaration according to EN ISO 14025:2010** ☐ internally ☒ externally **Verifier 1:** DI Therese Daxner, M.Sc., Daxner & Merl GmbH **Verifier 2:** DI Roman Smutny, University of Natural Resources and Life Sciences, Vienna
Owner of the declaration Tiroler Rohre GmbH Innsbruckerstrasse 51 6060 Hall in Tyrol Austria	**Publisher and programme operator** Bau EPD GmbH Seidengasse 13/3 1070 Vienna Austria

Nominal diameter [mm]	Longitudinally related mass [kg/m]
80	16.3
100	20.0
125	25.6
150	31.5
200	40.9
250	53.8
300	67.9
400	104.0
500	142.4
600	181.9

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Information: EPDs from similar product groups from different programmes might not be comparable.

2 Product

2.1 General product description

The declared products are ductile iron pipes of the VRS®-T system (restrained locking system) from Tiroler Rohre GmbH (TRM) with cement mortar lining (CML) and zinc coating with PUR Longlife coating.

The TRM pipe system VRS®-T is a ductile centrifugally cast pipe with a spigot end with a welded bead and a joint/socket, which are joined together to form any length of pipe. The VRS®-T joint, consisting of a VRS®-T socket, VRS®-T gasket ring, spigot end with a welded bead and locking elements, is a highly resilient, flexible and restrained locking system. It is quick and easy to install and can be bent up to 5°. No welding and no weld-seam testing is necessary. The joint can be dismantled at any time.

The ductile iron pipes are manufactured in lengths of 5 m with nominal diameters from DN 80 to DN 600 and different wall thicknesses. The nominal dimensions of the declared cast iron pipes and the corresponding wall thickness classes, (normative) minimum wall thicknesses and masses per metre of pipe are shown in Table 1.

Table 1: VRS®-T cast iron pipes – nominal dimensions, wall thickness class, minimum wall thicknesses, masses per metre

DN	Wall thickness class (K class)	Minimum wall thickness [mm]	Mass per m of pipe [kg/m]
80	K 10	4.7	16.3
100	K 10	4.7	20.0
125	K 10	4.8	25.6
150	K 9	4.7	31.5
200	K 9	4.8	40.9
250	K 9	5.2	53.8
300	K 9	5.6	67.9
400	K 9	6.4	104.0
500	K 9	7.2	142.4
600	K 9	8.0	181.9

2.2 Application

The VRS®-T ductile iron pipe system with Portland composite cement lining is mainly used for drinking water supply and for fire extinguishing pipes, snow-making systems and turbine pipes.

The ductile iron pipe can be installed or fitted in various ways (examples):

- Conventional installation (trench)
- Trenchless installation
- Bridge pipes
- Interim pipes
- Floating

The usual installation method is conventional laying with the excavation of a trench, the creation of a bedding for the pipe and backfilling with suitable material.

2.3 Product-related standards, regulations and guidelines

Table 2: Product-related regulations

Regulation	Title
OENORM EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
OENORM B 2599-1	Ductile iron pipes and fittings — Part 1: Use for water pipelines
OENORM B 2597	Ductile cast iron pipes and fittings for water, sewage and gas pipelines - Restrained push-in-joints - Requirements and tests
OENORM B 2555	Coating of cast iron pipes - Thermal zinc spraying
OENORM B 2560	Ductile iron pipes - Finishing coating of polyurethane, epoxy or acrylic materials - Requirements and test methods
OENORM B 2562	Ductile cast iron pipes - Factory made lining with cement mortar - Requirements and test methods
OENORM EN 681-1	Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

2.4 Technical data

Evidence of the mechanical material properties shall be provided by the test method according to OENORM EN 545:2011, sections 6.3 and 6.4.

Table 3: Material parameters for ductile cast iron pipes of the VRS®-T system

Name	Value	Unit
Iron density	7050	kg/m^3
Minimum tensile strength	≥ 420	MPa
Proportional limit, 0.2% yield strength ($R_{p0.2}$)	≥ 300	MPa
Minimum elongation at fracture	≥ 10	%
Maximum Brinell hardness	≤ 230	HB
Pipe length	5000	mm
Mean coefficient of linear thermal expansion	$10*10^{-6}$	m/m*K
Thermal conductivity	0.42	W/cm*K

Table 4: VRS®-T pipes – Nominal dimension-dependent technical data

DN	Wall thickness class K class	Minimum wall thickness [mm]	Mass per metre of pipe [kg/m]	Allowable operating pressure PFA [bar]	Permissible tensile force [kN]
80	K 10	4.7	16.3	100	115
100	K 10	4.7	20.0	75	150
125	K 10	4.8	25.6	63	225
150	K 9	4.7	31.5	63	240
200	K 9	4.8	40.9	40	350
250	K 9	5.2	53.8	40	375
300	K 9	5.6	67.9	40	380
400	K 9	6.4	104.0	30	650
500	K 9	7.2	142.4	25	860
600	K 9	8.0	181.9	32	1525

2.5 Basic/auxiliary materials

Table 5: VRS®-T pipes – basic materials in mass %

DN	Casting	Zinc	Cement stone	PUR
80	81.6%	0.9%	16.7%	0.8%
100	81.4%	0.7%	17.0%	0.8%
125	81.9%	0.7%	16.6%	0.8%
150	82.4%	0.6%	16.2%	0.8%
200	81.8%	0.6%	16.8%	0.8%
250	82.8%	0.5%	15.9%	0.7%
300	83.7%	0.5%	15.2%	0.7%
400	82.6%	0.4%	16.4%	0.6%
500	84.1%	0.4%	14.9%	0.5%
600	85.1%	0.4%	14.0%	0.5%

Table 6: Basic materials – casting in mass %

Ingredients:	Mass %
Iron 1)	approx. 94%
Carbon 2)	approx. 3.5%
Silicon 3)	approx. 2%
Ferric by-elements 4)	approx. 0.5%

1) Scrap iron

2) Foundry coke carbon. The coke in the cupola furnace serves as an energy supplier for the scrap melting on the one hand and the setting of the desired carbon content on the other

3) Silicon is added in the form of SiC briquettes and/or ferro-silicon

4) Ferric by-elements are found in the steel scrap in different minor quantities (<<1%)

2.6 Production

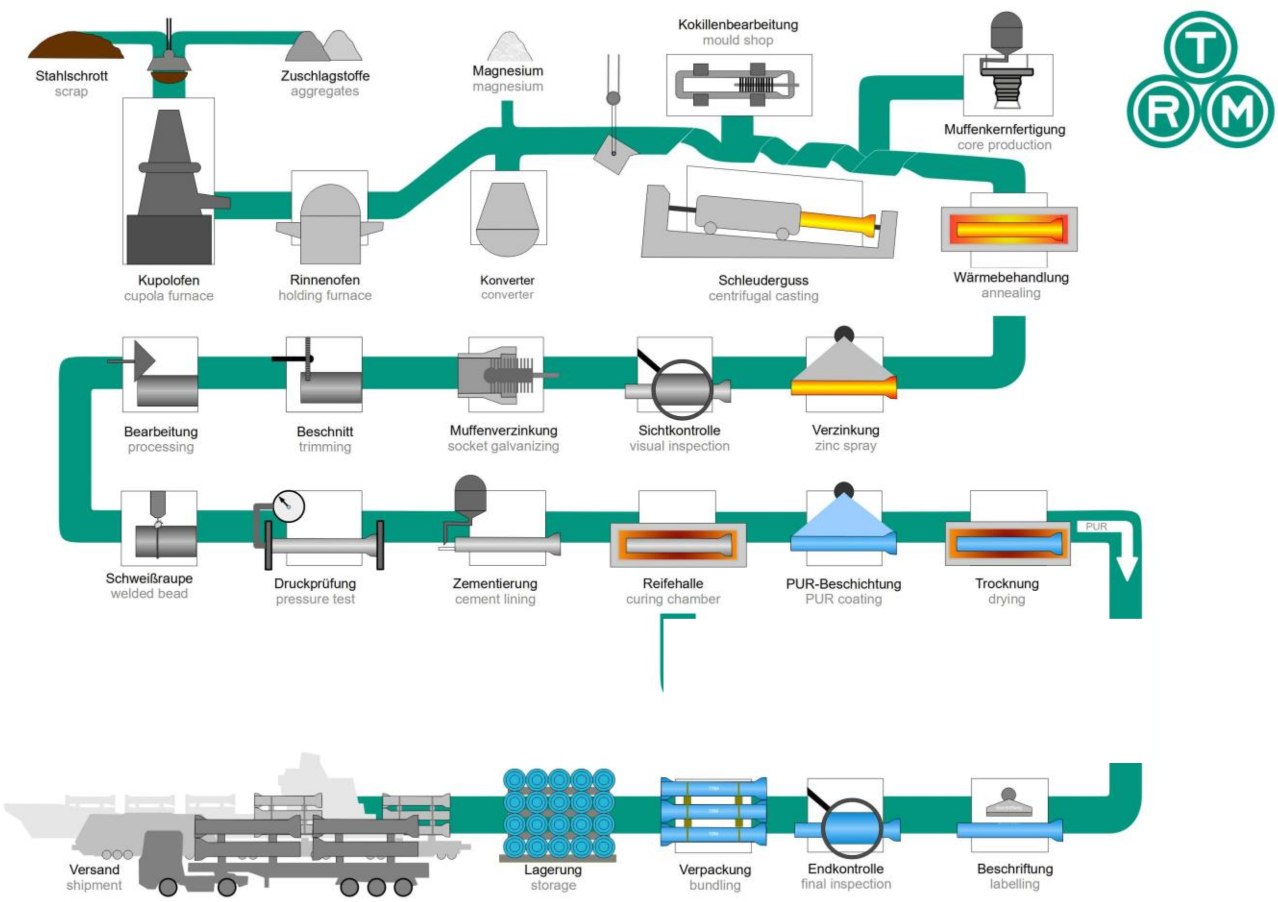


Figure 1: Flow chart of production process

For casting production, steel scrap and recycled material are smelted in the cupola furnace with the help of coke as a reaction and reduction agent. Silicon carbide is added as an alloying element. Added aggregates enhance slagging. The chemical composition of the smelted basic iron is then constantly monitored through spectral analysis. The smelted basic iron is kept warm in the holding furnace, a storage medium, and then treated with magnesium in the Georg Fischer converter, in order to reach the appropriate ductility. The liquid iron is then cast in a centrifuge machine with the De Lavaud procedure. In order to produce a specific pipe diameter, this machine is equipped with the corresponding mould (metal form that the liquid iron is poured into). The socket core made of quartz sand seals the inlet of the machine and forms the pipe socket. The glowing pipe is pulled out of the cast unit and placed in a furnace with the help of an automatic transport system. Here it undergoes annealing in order to achieve the desired mechanical properties.

The pipe is then galvanised using the electric arc spraying process and then cooled. The pipe is visually inspected in the pipeline. The spigot end and socket are machined if necessary. In the area of the welded bead, the zinc and annealing skin (tinder) are ground off and finally the welded bead is applied.

During the pressure test, each pipe is hydrostatically pressurised with a certain internal pressure and checked for leaks. The pipe is then lined with cement mortar using the centrifugal rotation process. The weld seam is galvanised, and the pipes are visually inspected again. The cement stone hardens in the curing chamber. Finally, a solvent-free two-component polyurethane top coat is applied. All pipes are labelled according to the specifications, bundled and brought to the warehouse.

2.7 Packaging

The TRM pipes are sealed with covers and bundled with the help of squared lumber (as a stacking aid) and PET tapes. All packaging materials can be used for thermal recycling.

2.8 Delivery condition

The ductile cast iron pipes are bundled with the help of squared lumber and PET binding tapes for transport and storage.

2.9 Transport

Within Europe, the cast iron pipes are transported via truck to their destination and by ship for overseas destinations.

2.10 Processing/installation

The installation of pressure pipes made of ductile cast iron must comply with OENORM EN 805 (Water supply - Requirements for systems and components outside buildings) and OENORM B 2538 (Additional specifications concerning OENORM EN 805). When constructing the pipe trench, sufficient working space must be provided for the installation of the pipeline, depending on the trench depth and the outer diameter of the pipe. The Ordinance on Protection of Construction Workers (Bauarbeiterschutzverordnung) and other provisions as well as relevant standards and regulations must be complied with accordingly.

As this is a push-in joint, no additional work such as welding is required. The pipe trench must be constructed and excavated in such a way that all pipe sections are at frost-free depths. The trench must be excavated deep enough so that the final cover height is at least 1.50 m. In the case of ductile iron pipes, the existing soil is generally suitable for bedding the pipeline. This means there is no need for a lower bedding layer or the bottom of the trench becomes the lower bedding.

The pipeline must be embedded and the pipe trench refilled in such a way that the pipeline is securely fixed in its intended position and that damage to the pipeline is prevented and settlement can only occur to the permissible extent. Suitable material that does not damage the pipe components and the coating must be used for embedding the pipeline. The backfill material should be installed in layers and sufficiently compacted.

2.11 Use stage

If installed and designed professionally and if the phase of utilisation is not disturbed, no modification of the material composition of construction products made of ductile cast iron occur.

2.12 Reference service life (RSL)

Table 7: Reference service life (RSL)

Name	Value	Unit
Ductile cast iron pipes	50	Years

In practice, it has been shown that a service life of 100 years, based on the DVGW damage statistics (German Technical and Scientific Association for Gas and Water – https://www.dvgw.de/themen/sicherheit/gas-und-wasserstatistik/), is achieved. OENORM EN 805 specifies a “design life” of 50 years under item 5.2.

2.13 Re-use and recycling

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. These pipes can then be recycled accordingly.

2.14 Disposal

The pipes are disposed of in very rare cases. The EAK waste code number for iron and steel from construction and demolition is 170405.

2.15 Further information

For further information about the TRM pipe system and its possible applications, see the website http://trm.at/rohr.

3 LCA: Calculation rules

3.1 Declared unit/functional unit

The functional unit is 1 metre [m] of pipe. For conversion into kg, Table 8 can be used.

Table 8: Conversion factor to mass

Nominal diameter [mm]	Longitudinally related mass [kg/m]	Multiplication factor
80	16.3	0.0613
100	20.0	0.0500
125	25.6	0.0391
150	31.5	0.0317
200	40.9	0.0244
250	53.8	0.0186
300	67.9	0.0143
400	104.0	0.00962
500	142.4	0.00702
600	181.9	0.00550

3.2 System boundary

The entire product life cycle is declared. This is an EPD "From cradle to grave".

Table 9: Declared life cycle stages

PRODUCT STAGE			CONSTRUCTION STAGE		USE STAGE							END-OF-LIFE STAGE				BENEFITS AND LOADS
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Production	Transport	Construction/installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Demolition	Transport	Waste processing	Disposal	Reuse, recovery, recycling potential
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

x = included in life cycle assessment; MND = module not declared

3.2.1 A1-A3 Product stage:

The cast iron pipes (semi-finished parts) are almost exclusively made of the secondary material steel scrap. The system limit for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant. The product stage includes the production steps in the plant along with the energy supply (including the upstream chains), the production of raw materials, auxiliary materials and packaging (including transport to the plant), the infrastructure and the disposal of the waste occurring during production. Module A1-A3 also includes the manufacture of the locks and gaskets required for assembling the pipe.

3.2.2 A4-A5 Construction stage:

The cast iron pipe can be installed in various ways. This EPD considers the standard case for installation, i.e. the conventional laying of the pipe:

- Excavation of trench
- Bedding of the pipe
- Backfilling with suitable material

The covers, squared lumber and binding tapes needed for transport are thermally recycled.

3.2.3 B1-B7 Use stage:

Generally construction products made of ductile cast iron show no impact on the LCA.

3.2.4 C1-C4 End-of-life stage:

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario.

The removed pipes are sent for a recycling process, being considered until the end-of-waste state according to EN 15804 in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system.

As a recycling scenario, due to the robustness of the pipe systems, it is assumed that 97% of the removed pipes are suitable for the recycling process and 3% have to be sent to landfill due to breakage, etc.

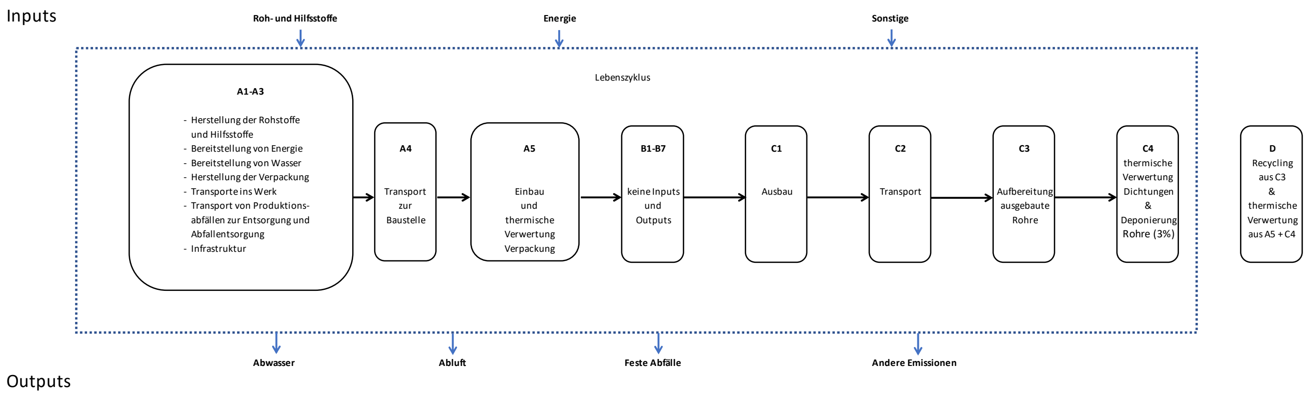
3.2.5 D Benefits and loads:

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

3.2.6 D* Additional potential for recycling:

Due to the multi-recycling potential of the products, they could again replace primary raw materials in the next product system. For this reason, this EPD also includes a Module D* with this recycling potential. This Module D* is explicitly and clearly indicated in the results tables as **non-compliant with EN 15804**.

3.3 Process flow chart during service life



Inputs	Inputs
Roh- und Hilfsstoffe	Raw and auxiliary materials
Energie	Energy
Sonstige	Others
Herstellung der Rohstoffe…	Production of raw and auxiliary materials
Bereitstellung von Energie	Supply of energy
Bereitstellung von Wasser	Supply of water
Herstellung der Verpackung	Production of packaging
Transporte ins Werk	Transport to the plant
Transport von Produktionsabfällen…	Transport of waste for disposal and dumping
Infrastruktur	Infrastructure
Transport zur Baustelle	Transport to building site
Einbau und thermische…	Installation and thermal utilisation Packaging
Keine Inputs…	No inputs and outputs
Ausbau	Removal
Transport	Transport
Aufbereitung ausgebaute Rohre	Processing of removed pipes
Thermische Verwertung…	Thermal utilisation of gaskets & disposal of pipes (3%)
Recycling aus…	Recycling from C3 & thermal utilisation from A5 + C4
Outputs	Outputs
Abwasser	Waste water
Abluft	Exhaust air
Feste Abfälle	Solid waste
Andere Emissionen	Other emissions

Figure 2: Service life flow chart

3.4 Estimations and assumptions

The SiC pellets used in casting production consist of various silicon components, Portland cement and water. In ecoinvent 3.5 there is only one data set for silicon carbide, which is typical of wafer production and has a very high SiC purity compared to the SiC component mixture used in casting production and therefore also energy intensity (information from the manufacturer of the pellets). According to the manufacturer of the SiC pellets, the energy required to produce the SiC components or silicon carbide is reflected in the respective prices per tonne, which additionally allows an adjustment of the SiC purity (correction factor) of the data set available in ecoinvent based on an economic comparison (i.e. in the style of an economic allocation).

Cast steel is a special steel with no data set. As the cast is below 1 kg per t of casting, the ecoinvent data set for chrome steel was used.

For magnesium, which mainly comes from China, the data set "GLO: market for magnesium" was used.

Since the infrastructure only makes a very small contribution to environmental impact, the machines were only shown with the main components steel and casting.

For the use stage, it was assumed that no material and energy flows of relevance for the LCA occur.

All transport distances, with the exception of magnesium, were collected by the customer and taken into account in the LCA. For magnesium, the average transports over the data set "GLO: market for magnesium" are taken into account.

3.5 Cut-off criteria

The producer calculated and submitted the amount of all applied materials, energy needed, the packaging material, the arising waste material and the way of disposal and the necessary infrastructure (buildings and machinery for the production). The measurement values for emissions according to the casting regulations were specified.

Auxiliary materials whose material flow is less than 1% were ignored as insignificant. In-company transports were insignificant on account of the short transport distances. It can be assumed that the total of insignificant processes is less than 5% of the impact categories.

During the production of the ductile pipes, slag (from cupola furnace) and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the "General rules for the life cycle assessment and the requirements for the background report – PCR Part A". The system limit for these two recyclable materials is set when they are collected from the plant by the future user.

The materials resulting from the production of semi-finished parts – foundry debris, fly-ash, filter cake from cupola furnace dust extraction and converter slag – are taken to a recycling plant for processing and the system limit is set when the substances arrive at this plant because no detailed information is available on the further treatment processes and because the influence on the results of the impact categories is classified as negligible.

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence.

3.6 Background data

As the background database, ecoinvent 3.5 with the system model cut-off by classification was applied. The software used was the program SimaPro 9.0.0.35 from Pré.

3.7 Data quality

The data meets the following quality requirements:

- The data is up to date (annual average over the production year 2017 or 2015 for the semi-finished part production – TRM pile EPD).
- The criteria of Bau EPD GmbH for data collection, generic data and the cut-off of material and energy flows were observed.
- All essential data such as energy and raw material consumption, transport distances, means of transportation and packaging within the system limits was provided by the producer.
- The data is plausible, i.e. the deviations from comparable results (literature, similar products) are low.
- The data is representative of the cast iron pipes of the VRS®-T system with Portland composite cement lining and zinc coating with PUR Longlife coating with the nominal dimensions from Table 4 manufactured in the Hall in Tyrol plant in the 2017 production year. As nothing has changed in production in the meantime, the 2015 survey data for the TRM pile EPD (BAU EPD-TRM-2017-1-Ecoinvent) was reused for the production of the pure cast iron pipe (semi-finished part).

3.8 Reporting period

The data used for the further processing of the pure cast iron pipe corresponds to the annual average of the production year 2017. As nothing has changed in production in the meantime, the 2015 survey data for the TRM pile EPD (BAU EPD-TRM-2017-1-Ecoinvent) was reused for the production of the pure cast iron pipe (semi-finished part).

3.9 Allocation

The system limit for the steel scrap is set when the processed steel scrap leaves the recycling plants, because the end of the waste properties of the steel scrap is reached here. This system is blamed for the transportation of the scrap to the TRM plant.

In the liquid iron sector, an allocation by mass was carried out between the pipes considered in this EPD and the products not considered, based on receipt of goods. The same applies to waste.

During the production of the ductile pipes, slag and coke dust are produced as by-products. Part of the waste heat is sold as district heating. However, these by-products contribute less than 1% to the operational income and can therefore be ignored according to the “General rules for the life cycle assessment and the requirements for the background report – PCR Part A”.

For the annealing, the energy used was allocated according to the dwell times in the furnace.

Due to the recycling of the removed pipes, there is a corresponding output of secondary raw materials in C3. The output flows are compared with the scrap share in the production of the cast iron pipes in accordance with the net flow rule according to EN 15804 and the net output flow is determined.

Due to the multi-recycling potential of the products, they could again replace primary raw materials in the next product system. For this reason, this EPD also includes a Module D* with this recycling potential. This Module D* is explicitly and clearly indicated in the results tables as **non-compliant with EN 15804**.

3.10 Comparability

The calculated results can be classified as plausible because deviations from similar study results (e.g. TRM piles) are small.

4 LCA: Scenarios and further technical information

4.1 A1-A3 Product stage

According to OENORM EN 15804, no technical scenario details are required for A1-A3 as the producer is responsible for the accounting of these modules, and this must not be changed by the user of the LCA.

Data collection for the product stage was carried out according to ISO 14044 Section 4.3.2. In accordance with the target definition, all relevant input and output flows that occur in connection with the product under consideration were identified and quantified in the life cycle inventory analysis.

4.2 A4-A5 Construction stage

4.2.1 Description of the scenario "Transport to the building site (A4)"

Within Europe, the pipes are transported via truck to their destination and by ship for overseas destinations. The client provided the information on the transports as shown in Table 10.

Table 10: Average transport distances

Country name	Allocation	Average transport routes by truck [km]	Average transport routes by ship [km]
Austria	67.40%	217	
Italy	18.23%	227	
Switzerland	1.67%	294	
Germany	0.69%	69	
South Eastern Europe	3.07%	828	
Eastern Europe	4.79%	1,258	
Rest of the world	4.16%	1,720	2,841
Total	**100%**		

The data sets "Transport, freight, lorry 16-32 metric ton, EURO6 {RER} transport, freight, lorry 16-32 metric ton, EURO6 (3.5)" and "Transport, freight, sea, transoceanic ship {GLO} processing (3.5)" were used to model the individual transport processes.

Table 11: Description of the scenario "Transport to the building site (A4)"

Parameters to describe the transport to the building site (A4)	Value	Unit
Average transport distance	see Table 10	km
Vehicle type according to Commission Directive 2007/37/EC (European Emission Standard)	Euro 6 or transoceanic freight ship	-
Average fuel consumption, fuel type: Diesel or heavy oil	29.8 or 15,000	l/100 km
Average transport mass	5.79 or 50,000	t
Average capacity utilisation (including empty returns)	100 or 65	%
Average gross density of transported products	see Table 3	t/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

4.2.2 Description of the scenario "Installation of the product in the building (A5)"

Conventional laying was chosen as the installation method for the EPD, i.e. excavating a trench, bedding the pipe and backfilling with suitable material. A hydraulic excavator with an engine power of 80 kW, a scoop capacity of 0.87 m³ and a weight of 17 t was used for the excavation and backfilling of the pipe trench (including bedding) up to DN300, and a hydraulic excavator with 150 kW, 2.2 m³ scoop capacity and a weight of 35 t was used for the nominal diameters D400, DN 500 and DN 600.

Most of the excavation material is temporarily stored and reused for backfilling. However, a certain proportion of the excavation material (varying for the specific nominal diameters depending on the proportion of bedding) must be disposed of at a landfill 20 km away. The additional backfill material required for this is transported from a gravel pit 20 km away.

The spacer ring (PP), protective caps (PE), stacked wood and binding tape (PET) are thermally recycled in a waste incinerator 100 km away.

Table 12: Description of the scenario "Installation (A5)"

Parameters to describe the installation (A5)	Value	Unit
Auxiliary materials for the installation	Backfill material 113 to 893	kg/m
Aids for the installation	Hydraulic excavator	-
Water consumption	0	m³/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: diesel	8 to 15.1	MJ/t
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	Stacked wood 0.0886 to 0.206 PP 0.008 to 0.06 PE 0.012 to 0.353 PET 0.0009 to 0.00461	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

4.3 B1-B7 Use stage

In the use stage, no material and energy flows relevant for the life cycle assessment take place for the VRS®-T pipe systems. This means that the inputs and outputs are zero.

4.4 C1-C4 End-of-life stage

4.4.1 Description of the scenario "Demolition (C1)"

In inner-city areas, the main area of application for the pipe systems, the installed pipes are currently almost entirely removed. For this reason, a 100% removal rate is used as a scenario. The removed pipes are sent for a recycling process, being considered until the end-of-waste state in the current product system. The system limit is set when the processed steel scrap leaves the recycling plants. From this point on, the pipe is part of a new product system. As a recycling scenario it is assumed that 97% of the pipes are suitable for the recycling process and 3% have to be sent to landfill.

The pipes are removed with the same excavator that was used to install them. The excavation volume for the removal corresponds to that of the installation. The existing excavation material is reinstalled, but must be supplemented with additional backfill material (different for the specific DN). The distance to the gravel pit is estimated at 20 km.

Table 13: Description of the scenario “Demolition (C1)”

Parameters to describe the demolition (C1)	Value	Unit
Auxiliary materials for the demolition	Backfill material 16.7 to 700	kg/m
Aids for the demolition	Hydraulic excavator	-
Water consumption	0	m^3/m
Other resource use	0	kg/m
Electricity consumption	0	kWh/m
Other energy carrier: diesel	8 to 15.1	MJ/t
Material loss on the construction site before waste treatment, caused by the installation of the product	0	kg/m
Output materials due to waste treatment on the construction site, e.g. collection for recycling, for energy recovery or for disposal	0	kg/m
Direct emissions to ambient air (e.g. dust, VOC), soil and water	-	kg/m

4.4.2 Description of the scenario “Transport processes (C2)”

The transport distance to the nearest recycling company (97% of the pipes) as well as to the nearest inert material landfill (3% of the pipes) or waste incineration plant (gaskets) was assumed to be 100 km.

The data set “Transport, freight, lorry 16-32 metric ton, EURO6 {RER} transport, freight, lorry 16-32 metric ton, EURO6 (3.5)” was used to model the individual transport processes in C2.

Table 14: Description of the scenario “Transport for disposal (C2)”

Parameters to describe the transport for disposal (C2)	Value	Unit
Average transport distance	100	km
Vehicle type according to Commission Directive 2007/37/EC (European Emission Standard)	Euro 6	-
Average fuel consumption, fuel type: Diesel or heavy oil	29.8	l/100 km
Average transport mass	5.79	t
Average capacity utilisation (including empty returns)	100	%
Average gross density of transported products	see Table 3	t/m
Volume capacity utilisation factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaged products)	<1	-

4.4.3 Description of the scenario “Waste processing (C3)”

In C3, the recycling of the pipes (97%), i.e. the processing of the removed pipes in a recycling plant into a secondary raw material that can be used in cast iron and steel production, is taken into account. For this purpose, it is assumed that the pipe (including CML, etc.) is sent as a whole to the recycling plant, where any materials that cannot be used for cast iron and steel production are separated out. The treatment of these separated out materials is excluded due to the expected minor influence. A new product system begins with the transport of the processed scrap from the recycling plant to the production plant.

4.4.1 Description of the scenario “Disposal (C4)”

In C4, the disposal of 3% of the pipe mass in an inert material landfill and the disposal of the EPDM sealing material in a waste incinerator are considered. A 100% recycling rate is applied for the removed locks, which are made of pure cast material.

Table 15: Disposal processes (C3 and C4) per m of pipe

DN	Mass per metre of pipe	Total pipe mass for recycling (97%)	Total pipe mass for disposal (3%)	Lock mass for recycling (100%)	Total mass (pipe and lock) for recycling	Gasket mass for waste incineration
[mm]	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*	*[kg/m]*
80	16.30	15.811	0.489	0.078	15.889	0.0374
100	20.00	19.400	0.600	0.092	19.492	0.0426
125	25.60	24.832	0.768	0.126	24.958	0.0520
150	31.50	30.555	0.945	0.152	30.707	0.0704
200	40.90	39.673	1.227	0.272	39.945	0.1080
250	53.80	52.186	1.614	0.300	52.486	0.1160
300	67.90	65.863	2.037	0.540	66.403	0.1620
400	104.00	100.880	3.120	0.880	101.760	0.1860
500	142.40	138.128	4.272	1.100	139.228	0.2860
600	181.90	176.443	5.457	1.840	178.283	0.4600

Table 16: Description of the scenario "Disposal of the product (C1 to C4)"

Parameters for end-of-life stage (C1-C4)	Value	Unit
Collection process, separate	see Table 15	kg collected separately
Recycling	see Table 15	kg recycling
Disposal, inert material landfill	see Table 15	kg product or material for final deposition

4.5 D Reuse, recovery, recycling potential

4.5.1 Description of the scenario "Benefits and loads (D)"

Due to the recycling of the removed pipes (97%), there is a corresponding output of secondary raw materials in C3. Due to the net flow rule according to EN 15804 and the high proportion of scrap in the production of cast iron pipes (988 kg per tonne of cast semi-finished part), there is a slightly negative net output flow here. In accordance with the decision of Bau-EPD GmbH, the result of Module D is shown as zero.

Table 17: Description of the scenario "Reuse, recovery, recycling potential (Module D)"

Parameters for the module (D)	Value	Unit
Materials for reuse or recycling from A4-A5	-	%
Energy recovery or secondary fuels from A4-A5	0.118 to 0.347	kg/m
Materials for reuse or recycling from B2-B5	-	%
Energy recovery or secondary fuels from B2-B5	-	kg/m
Materials for reuse or recycling from C1-C4	97	%
Energy recovery or secondary fuels from C1-C4	see Table 15	kg/m

4.5.2 Description of the scenario "Additional potential for recycling (D*)"

Due to the multi-recycling potential of the pipes, they could again replace primary raw materials in the next product system. For this reason, this EPD also includes a Module D* with this recycling potential. This Module D* is explicitly and clearly indicated in the results tables as non-compliant with EN 15804. The calculation of the benefit is based on the assumption that 100% of the recycled cast iron replaces pig iron from primary production, using a representative global average for the pig iron production process.

5 LCA: Results

5.1 TRM pipe system VRS®-T, DN 80, 16.3 kg/m

Table 18: Results of the life cycle assessment – environmental impact per metre [m] of VRS®-T DN 80

Results compliant with EN 15804												Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
GWP	kg CO2 eq	18.275	0.971	3.324	0	0.982	0.272	0.339	0.121	-0.052	-0.026	0	-21.645
ODP	kg CFC-11 eq	1.24E-06	1.80E-07	5.64E-07	0	1.56E-07	5.06E-08	4.10E-08	1.18E-09	-3.06E-09	-1.54E-09	0	-1.16E-06
AP	kg SO2 eq	5.21E-02	4.78E-03	2.26E-02	0	8.44E-03	1.24E-03	3.49E-03	3.86E-05	-1.47E-04	-7.37E-05	0	-9.11E-02
EP	kg PO_4^{3-} eq	2.76E-02	9.23E-04	5.48E-03	0	1.76E-03	2.51E-04	1.62E-03	1.35E-05	-5.42E-05	-2.73E-05	0	-3.36E-02
POCP	kg C2H4 eq	4.51E-03	1.71E-04	8.63E-04	0	2.18E-04	4.48E-05	1.27E-04	1.31E-06	-7.47E-06	-3.75E-06	0	-1.65E-02
ADPE	kg Sb eq	1.25E-03	2.87E-06	1.35E-05	0	2.02E-06	8.23E-07	7.32E-06	5.38E-09	-1.03E-08	-5.16E-09	0	-6.25E-06
ADPF	MJ, H_u	209.332	15.706	56.699	0	14.494	4.416	4.336	0.101	-0.781	-0.392	0	-238.637
Legend		GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of soil and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 19: Results of the life cycle assessment – resource use per metre [m] of VRS®-T DN 80

Results compliant with EN 15804												Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
PERE	MJ H_u	20.517	0.162	1.537	0	0.270	0.044	0.814	0.001	-0.033	-0.017	0	-4.255
PERM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PERT	MJ H_u	20.517	0.162	1.537	0	0.270	0.044	0.814	0.001	-0.033	-0.017	0	-4.255
PENRE	MJ H_u	210.385	15.036	55.586	0	14.067	4.225	4.804	0.098	-0.811	-0.407	0	-216.977
PENRM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PENRT	MJ H_u	210.385	15.036	55.586	0	14.067	4.225	4.804	0.098	-0.811	-0.407	0	-216.977
SM	kg	13.218	0	0	0	0	0	0	0	0	0	0	-12.980
RSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	INA[5)]	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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 fresh water											

5) INA – Indicator Not Assessed: Ecoinvent data sets do not allow complete determination of the water flows.

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 20: Results of the life cycle assessment – output flows and waste categories per metre [m] of VRS®-T DN 80

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
HWD	kg	7.93E-04	9.47E-06	5.28E-05	0	1.05E-05	2.66E-06	1.08E-05	1.52E-07	-9.33E-07	-4.68E-07	0	-2.33E-03
NHWD	kg	1.686	0.693	113.752	0	0.090	0.199	0.116	0.492	-0.002	-0.001	0	-0.960
RWD	kg	8.16E-04	2.02E-04	6.53E-04	0	1.78E-04	5.69E-05	5.62E-05	1.16E-06	-1.96E-06	-9.90E-07	0	-5.61E-04
CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0
MFR	kg	0	0	0	0	0	0	12.980	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	0	0	0.115	0	0	0	0	0.058	0	0	0	0
EET	MJ	0	0	1.016	0	0	0	0	0.508	0	0	0	0
Legend		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 electric energy; EET = Exported thermal energy											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

5.2 TRM pipe system VRS®-T, DN 100, 20.0 kg/m

Table 21: Results of the life cycle assessment – environmental impact per metre [m] of VRS®-T DN 100

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
GWP	kg CO2 eq	21.600	1.190	3.790	0	1.094	0.334	0.416	0.138	-0.068	-0.030	0	-26.488
ODP	kg CFC-11 eq	1.46E-06	2.20E-07	6.38E-07	0	1.68E-07	6.20E-08	5.02E-08	1.42E-09	-3.96E-09	-1.75E-09	0	-1.42E-06
AP	kg SO2 eq	6.14E-02	5.86E-03	2.53E-02	0	9.10E-03	1.52E-03	4.28E-03	4.60E-05	-1.90E-04	-8.40E-05	0	-1.11E-01
EP	kg PO_4^{3-} eq	3.28E-02	1.13E-03	6.20E-03	0	1.97E-03	3.08E-04	1.99E-03	1.58E-05	-7.02E-05	-3.11E-05	0	-4.12E-02
POCP	kg C2H4 eq	5.40E-03	2.10E-04	9.84E-04	0	2.48E-04	5.49E-05	1.56E-04	1.58E-06	-9.67E-06	-4.27E-06	0	-2.02E-02
ADPE	kg Sb eq	1.22E-03	3.52E-06	1.57E-05	0	2.78E-06	1.01E-06	8.97E-06	6.38E-09	-1.33E-08	-5.87E-09	0	-7.65E-06
ADPF	MJ, H_u	246.519	19.247	64.434	0	15.956	5.411	5.319	0.123	-1.011	-0.446	0	-292.027
Legend		GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of soil and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 22: Results of the life cycle assessment – resource use per metre [m] of VRS®-T DN 100

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C4**	**D from C3**	**D* from C3**
PERE	MJ H_u	24.520	0.199	1.783	0	0.353	0.054	0.999	0.002	-0.043	-0.019	0	-5.206
PERM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PERT	MJ H_u	24.520	0.199	1.783	0	0.353	0.054	0.999	0.002	-0.043	-0.019	0	-5.206
PENRE	MJ H_u	247.964	18.426	63.212	0	15.555	5.178	5.893	0.118	-1.050	-0.463	0	-265.521
PENRM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PENRT	MJ H_u	247.964	18.426	63.212	0	15.555	5.178	5.893	0.118	-1.050	-0.463	0	-265.521
SM	kg	16.176	0	0	0	0	0	0	0	0	0	0	-15.884
RSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	INA[6)]	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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 fresh water											

6) INA – Indicator Not Assessed: Ecoinvent data sets do not allow complete determination of the water flows.

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 23: Results of the life cycle assessment – output flows and waste categories per metre [m] of VRS®-T DN 100

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C4**	**D from C3**	**D* from C3**
HWD	kg	8.21E-04	1.16E-05	6.08E-05	0	1.27E-05	3.27E-06	1.33E-05	1.78E-07	-1.21E-06	-5.33E-07	0	-2.85E-03
NHWD	kg	2.019	0.850	132.876	0	0.123	0.244	0.142	0.604	-0.002	-0.001	0	-1.175
RWD	kg	1.00E-03	2.48E-04	7.39E-04	0	1.92E-04	6.98E-05	6.90E-05	1.41E-06	-2.54E-06	-1.13E-06	0	-6.87E-04
CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0
MFR	kg	0	0	0	0	0	0	15.884	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	0	0	0.149	0	0	0	0	0.066	0	0	0	0
EET	MJ	0	0	1.315	0	0	0	0	0.579	0	0	0	0
Legend		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 electric energy; EET = Exported thermal energy											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

5.3 TRM pipe system VRS®-T, DN 125, 25.6 kg/m

Table 24: Results of the life cycle assessment – environmental impact per metre [m] of VRS®-T DN 125

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
GWP	kg CO2 eq	26.884	1.523	4.324	0	1.264	0.428	0.533	0.168	-0.074	-0.036	0	-34.751
ODP	kg CFC-11 eq	1.75E-06	2.82E-07	7.27E-07	0	1.85E-07	7.95E-08	6.43E-08	1.80E-09	-4.33E-09	-2.13E-09	0	-1.87E-06
AP	kg SO2 eq	7.71E-02	7.49E-03	2.85E-02	0	1.01E-02	1.94E-03	5.48E-03	5.78E-05	-2.08E-04	-1.02E-04	0	-1.46E-01
EP	kg PO_4^{3-} eq	4.17E-02	1.45E-03	7.05E-03	0	2.27E-03	3.94E-04	2.55E-03	1.96E-05	-7.67E-05	-3.77E-05	0	-5.40E-02
POCP	kg C2H4 eq	6.84E-03	2.68E-04	1.13E-03	0	2.95E-04	7.03E-05	2.00E-04	2.00E-06	-1.06E-05	-5.20E-06	0	-2.65E-02
ADPE	kg Sb eq	1.55E-03	4.50E-06	1.83E-05	0	3.96E-06	1.29E-06	1.15E-05	8.00E-09	-1.45E-08	-7.14E-09	0	-1.00E-05
ADPF	MJ, H_u	299.011	24.626	73.705	0	18.175	6.931	6.811	0.156	-1.104	-0.543	0	-383.125
Legend		GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of soil and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 25: Results of the life cycle assessment – resource use per metre [m] of VRS®-T DN 125

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
PERE	MJ H_u	30.479	0.254	2.078	0	0.484	0.070	1.279	0.002	-0.047	-0.023	0	-6.831
PERM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PERT	MJ H_u	30.479	0.254	2.078	0	0.484	0.070	1.279	0.002	-0.047	-0.023	0	-6.831
PENRE	MJ H_u	300.328	23.576	72.355	0	17.820	6.632	7.546	0.150	-1.146	-0.564	0	-348.350
PENRM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PENRT	MJ H_u	300.328	23.576	72,355	0	17.820	6.632	7.546	0.150	-1.146	-0.564	0	-348.350
SM	kg	20.839	0	0	0	0	0	0	0	0	0	0	-20.463
RSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	INA[7)]	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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 fresh water											

7) INA – Indicator Not Assessed: Ecoinvent data sets do not allow complete determination of the water flows.

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 26: Results of the life cycle assessment – output flows and waste categories per metre [m] of VRS®-T DN 125

Results compliant with EN 15804												Results non-compliant with EN 15804
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C4**	**D from C3**	**D* from C3**
HWD	kg	1.03E-03	1.48E-05	7.03E-05	0	1.60E-05	4.18E-06	1.70E-05	2.21E-07	-1.32E-06	-6.49E-07	0	-3.74E-03
NHWD	kg	2.557	1.087	156.023	0	0.175	0.312	0.181	0.773	-0.003	-0.001	0	-1.542
RWD	kg	1.22E-03	3.17E-04	8.42E-04	0	2.13E-04	8.94E-05	8.84E-05	1.80E-06	-2.78E-06	-1.37E-06	0	-9.01E-04
CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0
MFR	kg	0	0	0	0	0	0	20.463	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	0	0	0.163	0	0	0	0	0.080	0	0	0	0
EET	MJ	0	0	1.435	0	0	0	0	0.707	0	0	0	0
Legend		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 electric energy; EET = Exported thermal energy											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

5.4 TRM pipe system VRS®-T, DN 150, 31.5 kg/m

Table 27: Results of the life cycle assessment – environmental impact per metre [m] of VRS®-T DN 150

Results compliant with EN 15804												Results non-compliant with EN 15804
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C4**	**D from C3**	**D* from C3**
GWP	kg CO2 eq	33.320	1.872	4.812	0	1.467	0.526	0.655	0.227	-0.088	-0.049	0	-43.015
ODP	kg CFC-11 eq	2.20E-06	3.47E-07	8.05E-07	0	2.04E-07	9.78E-08	7.92E-08	2.26E-09	-5.15E-09	-2.88E-09	0	-2.31E-06
AP	kg SO2 eq	9.38E-02	9.21E-03	3.13E-02	0	1.12E-02	2.39E-03	6.75E-03	7.38E-05	-2.47E-04	-1.38E-04	0	-1.81E-01
EP	kg PO_4^{3-} eq	5.08E-02	1.78E-03	7.80E-03	0	2.64E-03	4.85E-04	3.14E-03	2.57E-05	-9.13E-05	-5.09E-05	0	-6.69E-02
POCP	kg C2H4 eq	8.37E-03	3.30E-04	1.26E-03	0	3.50E-04	8.66E-05	2.46E-04	2.52E-06	-1.26E-05	-7.02E-06	0	-3.28E-02
ADPE	kg Sb eq	1.72E-03	5.54E-06	2.07E-05	0	5.39E-06	1.59E-06	1.41E-05	1.03E-08	-1.73E-08	-9.65E-09	0	-1.24E-05
ADPF	MJ, H_u	373.964	30.277	81.877	0	20.811	8.533	8.380	0.195	-1.314	-0.735	0	-474.241
Legend		GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of soil and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 28: Results of the life cycle assessment – resource use per metre [m] of VRS®-T DN 150

Results compliant with EN 15804												Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
PERE	MJ H_u	36.800	0.313	2.337	0	0.640	0.086	1.573	0.003	-0.056	-0.031	0	-8.455
PERM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PERT	MJ H_u	36.800	0.313	2.337	0	0.640	0.086	1.573	0.003	-0.056	-0.031	0	-8.455
PENRE	MJ H_u	375.772	28.986	80.411	0	20.512	8.165	9.284	0.188	-1.364	-0.763	0	-431.196
PENRM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PENRT	MJ H_u	375.772	28.986	80.411	0	20.512	8.165	9.284	0.188	-1.364	-0.763	0	-431.196
SM	kg	25.795	0	0	0	0	0	0	0	0	0	0	-25,329
RSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	INA[8)]	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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 fresh water											

8) INA – Indicator Not Assessed: Ecoinvent data sets do not allow complete determination of the water flows.

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 29: Results of the life cycle assessment – output flows and waste categories per metre [m] of VRS®-T DN 150

Results compliant with EN 15804												Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
HWD	kg	1.19E-03	1.83E-05	7.87E-05	0	1.99E-05	5.15E-06	2.10E-05	2.89E-07	-1.57E-06	-8.78E-07	0	-4.63E-03
NHWD	kg	3.125	1.337	176.155	0	0.238	0.384	0.223	0.951	-0.003	-0.002	0	-1.908
RWD	kg	1.51E-03	3.90E-04	9.34E-04	0	2.37E-04	1.10E-04	1.09E-04	2.24E-06	-3.31E-06	-1.84E-06	0	-1.12E-03
CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0
MFR	kg	0	0	0	0	0	0	25.329	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	0	0	0.194	0	0	0	0	0.108	0	0	0	0
EET	MJ	0	0	1.707	0	0	0	0	0.957	0	0	0	0
Legend		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 electric energy; EET = Exported thermal energy											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

5.5 TRM pipe system VRS®-T, DN 200, 40.9 kg/m

Table 30: Results of the life cycle assessment – environmental impact per metre [m] of VRS®-T DN 200

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
GWP	kg CO2 eq	43.431	2.440	5.942	0	2.005	0.688	0.853	0.347	-0.125	-0.075	0	-55.637
ODP	kg CFC-11 eq	2.89E-06	4.52E-07	9.85E-07	0	2.60E-07	1.28E-07	1.03E-07	3.04E-09	-7.34E-09	-4.42E-09	0	-2.99E-06
AP	kg SO2 eq	1.22E-01	1.20E-02	3.80E-02	0	1.44E-02	3.12E-03	8.78E-03	1.03E-04	-3.52E-04	-2.12E-04	0	-2.34E-01
EP	kg PO_4^{3-} eq	6.59E-02	2.32E-03	9.55E-03	0	3.62E-03	6.34E-04	4.08E-03	3.75E-05	-1.30E-04	-7.82E-05	0	-8.65E-02
POCP	kg C2H4 eq	1.09E-02	4.30E-04	1.55E-03	0	4.94E-04	1.13E-04	3.20E-04	3.43E-06	-1.79E-05	-1.08E-05	0	-4.24E-02
ADPE	kg Sb eq	2.19E-03	7.22E-06	2.59E-05	0	8.95E-06	2.08E-06	1.84E-05	1.44E-08	-2.46E-08	-1.48E-08	0	-1.61E-05
ADPF	MJ, H_u	490.864	39.467	100.649	0	27.883	11.151	10.901	0.261	-1.873	-1.128	0	-613.397
Legend		GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of soil and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 31: Results of the life cycle assessment – resource use per metre [m] of VRS®-T DN 200

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
PERE	MJ H_u	47.865	0.408	2.920	0	1.034	0.112	2.047	0.004	-0.079	-0.048	0	-10.936
PERM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PERT	MJ H_u	47.865	0.408	2.920	0	1.034	0.112	2.047	0.004	-0.079	-0.048	0	-10.936
PENRE	MJ H_u	493.692	37.784	98.904	0	27.702	10.670	12.077	0.252	-1.944	-1.171	0	-557.721
PENRM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PENRT	MJ H_u	493.692	37.784	98.904	0	27.702	10.670	12.077	0.252	-1.944	-1.171	0	-557.721
SM	kg	33.364	0	0	0	0	0	0	0	0	0	0	-32.764
RSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	INA9)	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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 fresh water											

9) INA – Indicator Not Assessed: Ecoinvent data sets do not allow complete determination of the water flows.

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 32: Results of the life cycle assessment – output flows and waste categories per metre [m] of VRS®-T DN 200

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
HWD	kg	1.53E-03	2.38E-05	9.78E-05	0	3.00E-05	6.73E-06	2.73E-05	4.19E-07	-2.24E-06	-1.35E-06	0	-5.99E-03
NHWD	kg	4.135	1.742	221.447	0	0.395	0.502	0.290	1.237	-0.004	-0.003	0	-2.468
RWD	kg	1.98E-03	5.09E-04	1.14E-03	0	3.06E-04	1.44E-04	1.41E-04	2.96E-06	-4.71E-06	-2.83E-06	0	-1.44E-03
CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0
MFR	kg	0	0	0	0	0	0	32.764	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	0	0	0.276	0	0	0	0	0.166	0	0	0	0
EET	MJ	0	0	2.436	0	0	0	0	1.468	0	0	0	0
Legend		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 electric energy; EET = Exported thermal energy											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

5.6 TRM pipe system VRS®-T, DN 250, 53.8 kg/m

Table 33: Results of the life cycle assessment – environmental impact per metre [m] of VRS®-T DN 250

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
GWP	kg CO2 eq	56.168	3.209	7.427	0	2.720	0.900	1.120	0.375	-0.177	-0.081	0	-73.887
ODP	kg CFC-11 eq	3.68E-06	5.94E-07	1.22E-06	0	3.36E-07	1.67E-07	1.35E-07	3.83E-09	-1.04E-08	-4.76E-09	0	-3.97E-06
AP	kg SO2 eq	1.57E-01	1.58E-02	4.69E-02	0	1.88E-02	4.09E-03	1.15E-02	1.24E-04	-4.97E-04	-2.28E-04	0	-3.11E-01
EP	kg PO_4^{3-} eq	8.57E-02	3.05E-03	1.19E-02	0	4.92E-03	8.30E-04	5.36E-03	4.28E-05	-1.84E-04	-8.43E-05	0	-1.15E-01
POCP	kg C2H4 eq	1.42E-02	5.65E-04	1.93E-03	0	6.83E-04	1.48E-04	4.20E-04	4.27E-06	-2.53E-05	-1.16E-05	0	-5.63E-02
ADPE	kg Sb eq	2.53E-03	9.49E-06	3.27E-05	0	1.35E-05	2.72E-06	2.42E-05	1.73E-08	-3.48E-08	-1.60E-08	0	-2.13E-05
ADPF	MJ, H_u	626.708	51.902	125.427	0	37.338	14.596	14.324	0.330	-2.646	-1.213	0	-814,603
Legend		GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of soil and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 34: Results of the life cycle assessment – resource use per metre [m] of VRS®-T DN 250

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C4**	**D from C3**	**D* from C3**
PERE	MJ H_u	62.929	0.536	3.677	0	1.538	0.147	2.689	0.005	-0.112	-0.051	0	-14.523
PERM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PERT	MJ H_u	62.929	0.536	3.677	0	1.538	0.147	2.689	0.005	-0.112	-0.051	0	-14.523
PENRE	MJ H_u	629.734	49.688	123.298	0	37.285	13.966	15.869	0.319	-2.746	-1.259	0	-740.664
PENRM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PENRT	MJ H_u	629.734	49.688	123.298	0	37.285	13.966	15.869	0.319	-2.746	-1.259	0	-740.664
SM	kg	44.308	0	0	0	0	0	0	0	0	0	0	-43.510
RSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	INA[10]	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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 fresh water											

10) INA – Indicator Not Assessed: Ecoinvent data sets do not allow complete determination of the water flows.

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 35: Results of the life cycle assessment – output flows and waste categories per metre [m] of VRS®-T DN 250

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C4**	**D from C3**	**D* from C3**
HWD	kg	1.84E-03	3.13E-05	1.23E-04	0	4.30E-05	8.81E-06	3.58E-05	4.82E-07	-3.16E-06	-1.45E-06	0	-7.96E-03
NHWD	kg	5.355	2.291	279.829	0	0.595	0.657	0.382	1.624	-0.006	-0.003	0	-3.278
RWD	kg	2.55E-03	6.69E-04	1.42E-03	0	3.98E-04	1.88E-04	1.86E-04	3.81E-06	-6.66E-06	-3.06E-06	0	-1.92E-03
CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0
MFR	kg	0	0	0	0	0	0	43.510	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	0	0	0.390	0	0	0	0	0.179	0	0	0	0
EET	MJ	0	0	3.440	0	0	0	0	1.577	0	0	0	0
Legend		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 electric energy; EET = Exported thermal energy											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

5.7 TRM pipe system VRS®-T, DN 300, 67.9 kg/m

Table 36: Results of the life cycle assessment – environmental impact per metre [m] of VRS®-T DN 300

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
GWP	kg CO2 eq	70.696	4.062	8.971	0	3.553	1.133	1.417	0.522	-0.219	-0.113	0	-92.829
ODP	kg CFC-11 eq	4.60E-06	7.52E-07	1.47E-06	0	4.22E-07	2.11E-07	1.71E-07	4.94E-09	-1.28E-08	-6.64E-09	0	-4.99E-06
AP	kg SO2 eq	1.98E-01	2.00E-02	5.61E-02	0	2.37E-02	5.14E-03	1.46E-02	1.64E-04	-6.14E-04	-3.18E-04	0	-3.91E-01
EP	kg PO_4^{3-} eq	1.09E-01	3.86E-03	1.43E-02	0	6.43E-03	1.04E-03	6.78E-03	5.79E-05	-2.27E-04	-1.18E-04	0	-1.44E-01
POCP	kg C2H4 eq	1.80E-02	7.15E-04	2.34E-03	0	9.06E-04	1.86E-04	5.32E-04	5.53E-06	-3.13E-05	-1.62E-05	0	-7.07E-02
ADPE	kg Sb eq	3.02E-03	1.20E-05	3.98E-05	0	1.90E-05	3.42E-06	3.06E-05	2.28E-08	-4.30E-08	-2.23E-08	0	-2.68E-05
ADPF	MJ, H_u	784.688	65.690	151.201	0	48.300	18.371	18.122	0.425	-3.272	-1.694	0	-1023.438
Legend		GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of soil and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 37: Results of the life cycle assessment – resource use per metre [m] of VRS®-T DN 300

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
PERE	MJ H_u	79.081	0.678	4.471	0	2.143	0.185	3.402	0.006	-0.138	-0.072	0	-18.247
PERM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PERT	MJ H_u	79.081	0.678	4.471	0	2.143	0.185	3.402	0.006	-0.138	-0.072	0	-18.247
PENRE	MJ H_u	788.243	62.889	148.682	0	48.422	17.578	20.076	0.410	-3.396	-1.759	0	-930.544
PENRM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PENRT	MJ H_u	788.243	62.889	148.682	0	48.422	17.578	20.076	0.410	-3.396	-1.759	0	-930.544
SM	kg	56.684	0	0	0	0	0	0	0	0	0	0	-55.667
RSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	INA[11)]	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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 fresh water											

11) INA – Indicator Not Assessed: Ecoinvent data sets do not allow complete determination of the water flows.

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 38: Results of the life cycle assessment – output flows and waste categories per metre [m] of VRS®-T DN 300

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C4**	**D from C3**	**D* from C3**
HWD	kg	2.25E-03	3.96E-05	1.49E-04	0	5.86E-05	1.11E-05	0	4.53E-05	6.50E-07	-3.91E-06	0	1.83E-04
NHWD	kg	6.773	2.900	341.227	0	0.836	0.827	0	0.483	2.052	-0.007	0	0.075
RWD	kg	3.23E-03	8.47E-04	1.71E-03	0	5.04E-04	2.37E-04	0	2.35E-04	4.86E-06	-8.23E-06	0	4.40E-05
CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0
MFR	kg	0	0	0	0	0	0	55.667	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	0	0	0.482	0	0	0	0	0.250	0	0	0	0
EET	MJ	0	0	4.256	0	0	0	0	2.202	0	0	0	0
Legend		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 electric energy; EET = Exported thermal energy											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

5.8 TRM pipe system VRS®-T, DN 400, 104.0 kg/m

Table 39: Results of the life cycle assessment – environmental impact per metre [m] of VRS®-T DN 400

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	**Unit**	**A1 - A3**	**A4**	**A5**	**B1 - B7**	**C1**	**C2**	**C3**	**C4**	**D from A5**	**D from C4**	**D from C3**	**D* from C3**
GWP	kg CO2 eq	106.963	6.201	14.098	0	5.411	1.732	2.172	0.604	-0.210	-0.130	0	-140.422
ODP	kg CFC-11 eq	7.02E-06	1.15E-06	2.32E-06	0	5.98E-07	3.22E-07	2.62E-07	7.16E-09	-1.23E-08	-7.63E-09	0	-7.55E-06
AP	kg SO2 eq	2.92E-01	3.05E-02	8.64E-02	0	3.41E-02	7.86E-03	2.24E-02	2.24E-04	-5.89E-04	-3.66E-04	0	-5.91E-01
EP	kg PO_4^{3-} eq	1.61E-01	5.90E-03	2.23E-02	0	9.81E-03	1.60E-03	1.04E-02	7.31E-05	-2.18E-04	-1.35E-04	0	-2.18E-01
POCP	kg C2H4 eq	2.67E-02	1.09E-03	3.73E-03	0	1.42E-03	2.85E-04	8.15E-04	7.88E-06	-3.00E-05	-1.86E-05	0	-1.07E-01
ADPE	kg Sb eq	3.66E-03	1.83E-05	6.56E-05	0	3.25E-05	5.23E-06	4.69E-05	3.08E-08	-4.12E-08	-2.56E-08	0	-4.05E-05
ADPF	MJ, H_u	1187.909	100.289	240.058	0	72.286	28.071	27.771	0.620	-3.137	-1.946	0	-1548.146
Legend		GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of soil and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 40: Results of the life cycle assessment – resource use per metre [m] of VRS®-T DN 400

Results compliant with EN 15804												Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
PERE	MJ H_u	109.722	1.036	7.322	0	3.625	0.283	5.214	0.008	-0.132	-0.082	0	-27.602
PERM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PERT	MJ H_u	109.722	1.036	7.322	0	3.625	0.283	5.214	0.008	-0.132	-0.082	0	-27.602
PENRE	MJ H_u	1193.221	96.012	236.327	0	72.989	26.860	30.766	0.598	-3.256	-2.020	0	-1407.626
PENRM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PENRT	MJ H_u	1193.221	96.012	236.327	0	72.989	26.860	30.766	0.598	-3.256	-2.020	0	-1407.626
SM	kg	85.743	0	0	0	0	0	0	0	0	0	0	-84.207
RSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	INA[12)]	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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 fresh water											

12) INA – Indicator Not Assessed: Ecoinvent data sets do not allow complete determination of the water flows.

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 41: Results of the life cycle assessment – output flows and waste categories per metre [m] of VRS®-T DN 400

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
HWD	kg	3.00E-03	6.05E-05	2.41E-04	0	9.55E-05	1.69E-05	6.95E-05	8.31E-07	-3.75E-06	-2.33E-06	0	-1.51E-02
NHWD	kg	10.204	4.427	564.666	0	1.432	1.264	0.740	3.137	-0.007	-0.004	0	-6.229
RWD	kg	4.85E-03	1.29E-03	2.70E-03	0	7.25E-04	3.62E-04	3.60E-04	7.25E-06	-7.89E-06	-4.90E-06	0	-3.64E-03
CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0
MFR	kg	0	0	0	0	0	0	84.207	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	0	0	0.462	0	0	0	0	0.287	0	0	0	0
EET	MJ	0	0	4.080	0	0	0	0	2.529	0	0	0	0
Legend		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 electric energy; EET = Exported thermal energy											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

5.9 TRM pipe system VRS®-T, DN 500, 142.4 kg/m

Table 42: Results of the life cycle assessment – environmental impact per metre [m] of VRS®-T DN 500

Results compliant with EN 15804												Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
GWP	kg CO2 eq	143.965	8.491	17.983	0	7.934	2.372	2.971	0.926	-0.257	-0.200	0	-195.551
ODP	kg CFC-11 eq	9.27E-06	1.57E-06	2.96E-06	0	8.50E-07	4.41E-07	3.59E-07	1.00E-08	-1.51E-08	-1.17E-08	0	-1.05E-05
AP	kg SO2 eq	3.96E-01	4.18E-02	1.10E-01	0	4.87E-02	1.08E-02	3.06E-02	3.20E-04	-7.23E-04	-5.62E-04	0	-8.23E-01
EP	kg PO_4^{3-} eq	2.20E-01	8.07E-03	2.85E-02	0	1.44E-02	2.19E-03	1.42E-02	1.08E-04	-2.67E-04	-2.08E-04	0	-3.04E-01
POCP	kg C2H4 eq	3.65E-02	1.50E-03	4.77E-03	0	2.10E-03	3.90E-04	1.11E-03	1.11E-05	-3.69E-05	-2.86E-05	0	-1.49E-01
ADPE	kg Sb eq	4.60E-03	2.51E-05	8.43E-05	0	4.98E-05	7.17E-06	6.41E-05	4.43E-08	-5.06E-08	-3.93E-08	0	-5.65E-05
ADPF	MJ, H_u	1582.257	137.320	307.012	0	105.216	38.444	37.996	0.865	-3.852	-2.991	0	-2155.936
Legend		GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of soil and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 43: Results of the life cycle assessment – resource use per metre [m] of VRS®-T DN 500

Results compliant with EN 15804												Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
PERE	MJ H_u	150.649	1.418	9.408	0	5.532	0.387	7.134	0.012	-0.163	-0.126	0	-38.438
PERM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PERT	MJ H_u	150.649	1.418	9.408	0	5.532	0.387	7.134	0.012	-0.163	-0.126	0	-38.438
PENRE	MJ H_u	1588.807	131.464	302.293	0	106.556	36.786	42.094	0.835	-3.998	-3.104	0	-1960.249
PENRM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PENRT	MJ H_u	1588.807	131.464	302.293	0	106.556	36.786	42.094	0.835	-3.998	-3.104	0	-1960.249
SM	kg	119.408	0	0	0	0	0	0	0	0	0	0	-117.266
RSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	INA[13)]	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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 fresh water											

13) INA – Indicator Not Assessed: Ecoinvent data sets do not allow complete determination of the water flows.

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 44: Results of the life cycle assessment – output flows and waste categories per metre [m] of VRS®-T DN 500

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
HWD	kg	3.87E-03	8.28E-05	3.09E-04	0	1.44E-04	2.32E-05	9.51E-05	1.22E-06	-4.60E-06	-3.57E-06	0	-2.11E-02
NHWD	kg	13.821	6.062	726.714	0	2.195	1.732	1.012	4.298	-0.009	-0.007	0	-8.674
RWD	kg	6.57E-03	1.77E-03	3.45E-03	0	1.04E-03	4.96E-04	4.93E-04	1.00E-05	-9.70E-06	-7.53E-06	0	-5.07E-03
CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0
MFR	kg	0	0	0	0	0	0	117.266	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	0	0	0.568	0	0	0	0	0.441	0	0	0	0
EET	MJ	0	0	5.008	0	0	0	0	3.888	0	0	0	0
Legend		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 electric energy; EET = Exported thermal energy											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

5.10 TRM pipe system VRS®-T, DN 600, 181.98 kg/m

Table 45: Results of the life cycle assessment – environmental impact per metre [m] of VRS®-T DN 600

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
GWP	kg CO2 eq	188.948	10.814	22.460	0	10.967	2.911	3.805	1.481	-0.436	-0.321	0	-253.461
ODP	kg CFC-11 eq	1.24E-05	2.00E-06	3.64E-06	0	1.15E-06	5.41E-07	4.60E-07	1.34E-08	-2.56E-08	-1.89E-08	0	-1.36E-05
AP	kg SO2 eq	5.16E-01	5.32E-02	1.35E-01	0	6.62E-02	1.32E-02	3.92E-02	4.50E-04	-1.22E-03	-9.03E-04	0	-1.07E+00
EP	kg PO_4^{3-} eq	2.86E-01	1.03E-02	3.51E-02	0	1.99E-02	2.68E-03	1.82E-02	1.62E-04	-4.53E-04	-3.34E-04	0	-3.94E-01
POCP	kg C2H4 eq	4.76E-02	1.90E-03	5.88E-03	0	2.92E-03	4.79E-04	1.43E-03	1.51E-05	-6.24E-05	-4.60E-05	0	-1.93E-01
ADPE	kg Sb eq	5.34E-03	3.20E-05	1.04E-04	0	7.08E-05	8.79E-06	8.21E-05	6.28E-08	-8.57E-08	-6.32E-08	0	-7.32E-05
ADPF	MJ, H_u	2103.418	174.897	378.171	0	144.757	47.178	48.654	1.150	-6.521	-4.810	0	-2794.392
Legend		GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of soil and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources											

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 46: Results of the life cycle assessment – resource use per metre [m] of VRS®-T DN 600

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
PERE	MJ H_u	195.941	1.806	11.625	0	7.843	0.475	9.135	0.017	-0.275	-0.203	0	-49.821
PERM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PERT	MJ H_u	195.941	1.806	11.625	0	7.843	0.475	9.135	0.017	-0.275	-0.203	0	-49.821
PENRE	MJ H_u	2112.545	167.439	372.403	0	146.889	45.143	53.902	1.112	-6.768	-4.992	0	-2540.754
PENRM	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
PENRT	MJ H_u	2112.545	167.439	372.403	0	146.889	45.143	53.902	1.112	-6.768	-4.992	0	-2540.754
SM	kg	154.757	0	0	0	0	0	0	0	0	0	0	-151.993
RSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
NRSF	MJ H_u	0	0	0	0	0	0	0	0	0	0	0	0
FW	m^3	INA[14)]	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA
Legend		PERE = Renewable primary energy as energy carrier; PERM = Renewable primary energy resources as material utilisation; PERT = Total use of renewable primary energy resources; PENRE = Non-renewable primary energy as energy carrier; PENRM = Non-renewable primary energy as material utilisation; 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 fresh water											

14) INA – Indicator Not Assessed: Ecoinvent data sets do not allow complete determination of the water flows.

D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

Table 47: Results of the life cycle assessment – output flows and waste categories per metre [m] of VRS®-T DN 600

Results compliant with EN 15804													Results non-compliant with EN 15804
Parameter	Unit	A1 - A3	A4	A5	B1 - B7	C1	C2	C3	C4	D from A5	D from C4	D from C3	D* from C3
HWD	kg	4.80E-03	1.05E-04	3.82E-04	0	2.02E-04	2.85E-05	1.22E-04	1.81E-06	-7.79E-06	-5.75E-06	0	-2.73E-02
NHWD	kg	17.800	7.721	898.833	0	3.120	2.125	1.296	5.499	-0.015	-0.011	0	-11.243
RWD	kg	8.60E-03	2.25E-03	4.25E-03	0	1.41E-03	6.08E-04	6.31E-04	1.31E-05	-1.64E-05	-1.21E-05	0	-6.57E-03
CRU	kg	0	0	0	0	0	0	0	0	0	0	0	0
MFR	kg	0	0	0	0	0	0	151.993	0	0	0	0	0
MER	kg	0	0	0	0	0	0	0	0	0	0	0	0
EEE	MJ	0	0	0.961	0	0	0	0	0.709	0	0	0	0
EET	MJ	0	0	8.479	0	0	0	0	6.254	0	0	0	0
Legend		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 electric energy; EET = Exported thermal energy											

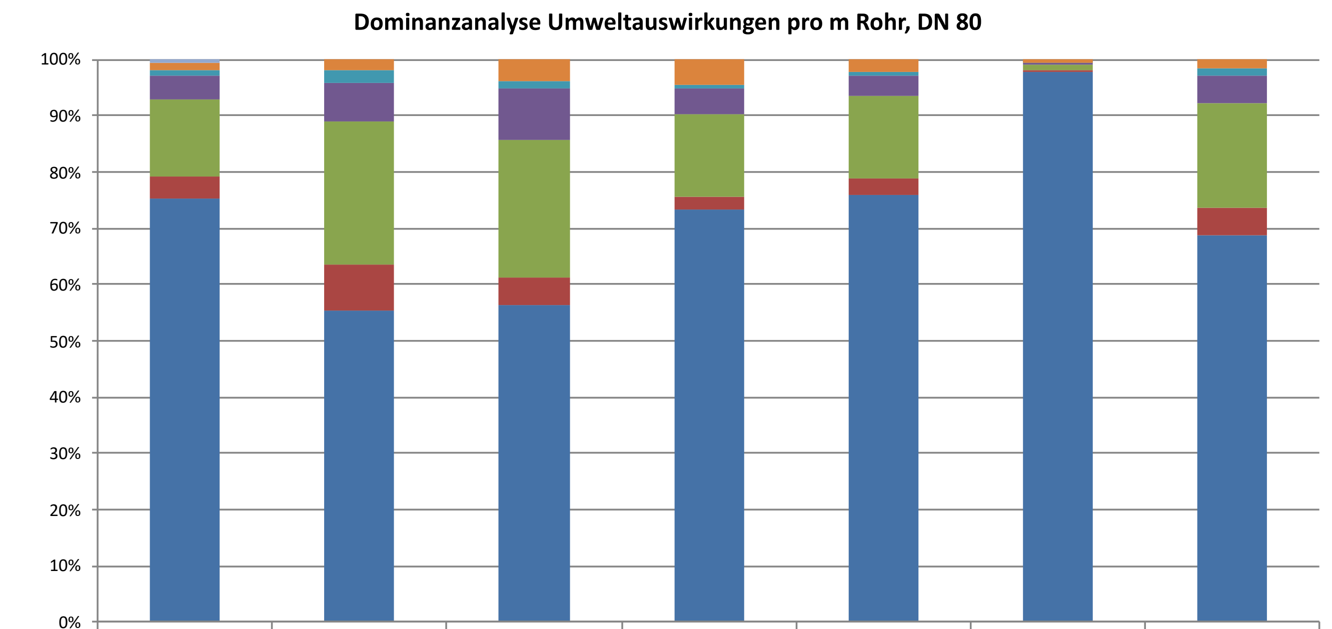
D* from C3 shows the recycling potential without taking into account the net flow rule according to OENORM EN 15804

6 LCA: Interpretation

It should be noted that the impact assessment results are only relative statements that do not include any statements about "end-points" of the impact categories, exceeding of thresholds or risks.

Since the definitions of raw materials (those substances that remain in the product) and auxiliary materials (those substances that do not remain in the product) are not easily applicable in the given case, as a certain small percentage of the energy carrier coke remains in the product, as for example also of the input materials ferrosilicon or silicon carbide, there is no splitting of A1-A3.

Figure 3 to Figure 12 show the percentage share of the modules A1-A3 production, A4 transport to the building site, A5 installation, C1 removal, C2 transport and C4 waste treatment in the examined environmental impacts for the respective nominal diameter. The production of pipes is the main contributor for all impact categories and the influence increases with increasing pipe diameter. The second and third largest influences are the installation and removal of the pipes, whose contributions to the environmental impacts decrease with increasing pipe diameter, with the exception of the abiotic depletion potential for non-fossil resources. Transport makes a significant contribution only to the ozone depletion potential and the abiotic depletion potential for non-fossil resources.



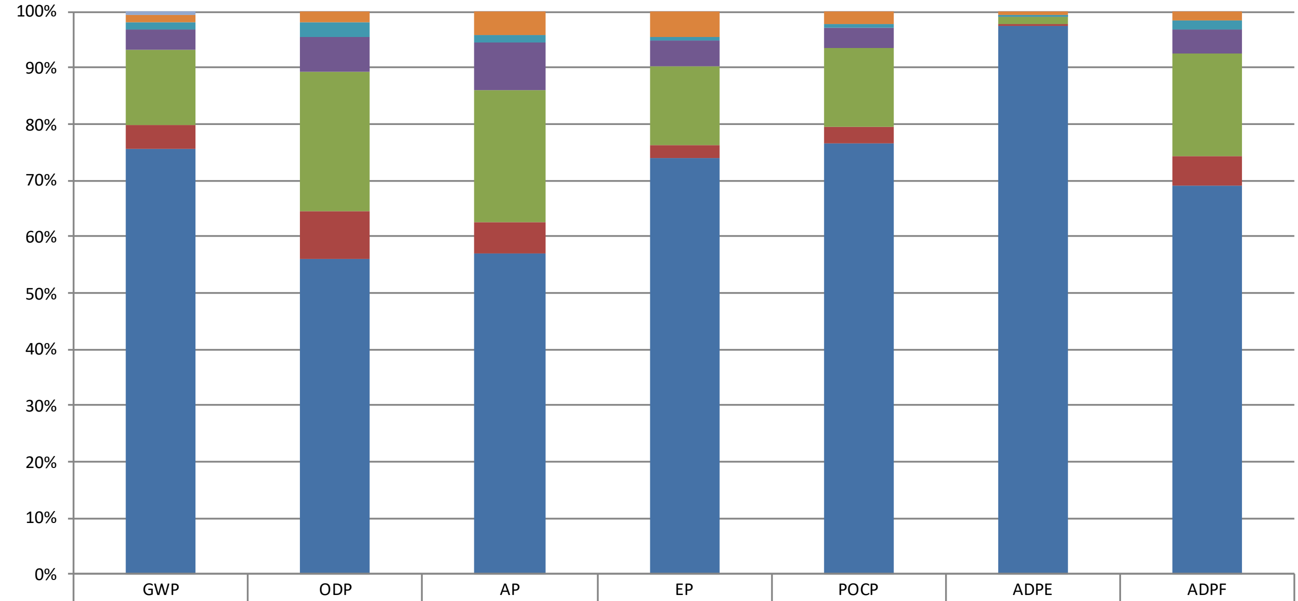
	GWP	ODP	AP	EP	POCP	ADPE	ADPF
C4	0,50%	0,05%	0,04%	0,04%	0,02%	0,00%	0,03%
C3	1,40%	1,83%	3,77%	4,30%	2,14%	0,58%	1,42%
C2	1,12%	2,27%	1,33%	0,67%	0,75%	0,06%	1,45%
C1	4,04%	7,01%	9,11%	4,67%	3,68%	0,16%	4,75%
A5	13,69%	25,27%	24,38%	14,55%	14,53%	1,06%	18,58%
A4	4,00%	8,05%	5,15%	2,45%	2,88%	0,23%	5,15%
A1-A3	75,25%	55,52%	56,22%	73,32%	75,99%	97,92%	68,61%

Figure 3: Dominance analysis – environmental impact of DN80

Dominanzanalyse Umweltauswirkungen…	Dominance analysis – environmental impact per m of pipe, DN 80

Translator's note: For practical reasons, the decimal comma as used in the German-speaking world has not been replaced by the decimal point in this chart and in subsequent charts below.

Dominanzanalyse Umweltauswirkungen pro m Rohr, DN 100

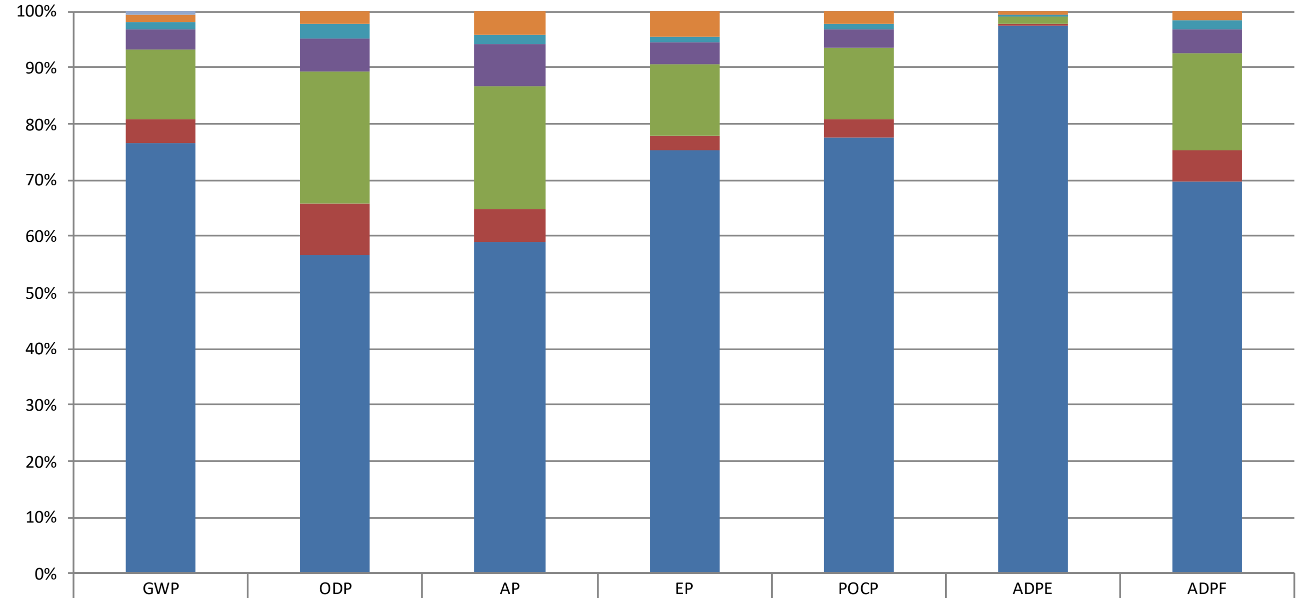


	GWP	ODP	AP	EP	POCP	ADPE	ADPF
C4	0,48%	0,05%	0,04%	0,04%	0,02%	0,00%	0,03%
C3	1,46%	1,93%	3,98%	4,48%	2,21%	0,71%	1,49%
C2	1,17%	2,39%	1,41%	0,69%	0,78%	0,08%	1,52%
C1	3,83%	6,45%	8,46%	4,42%	3,52%	0,22%	4,47%
A5	13,27%	24,55%	23,51%	13,95%	13,95%	1,25%	18,05%
A4	4,17%	8,48%	5,45%	2,55%	2,97%	0,28%	5,39%
A1-A3	75,63%	56,14%	57,15%	73,87%	76,55%	97,46%	69,05%

Figure 4: Dominance analysis – environmental impact of DN100

Dominanzanalyse…	Dominance analysis – environmental impact per m of pipe, DN 100

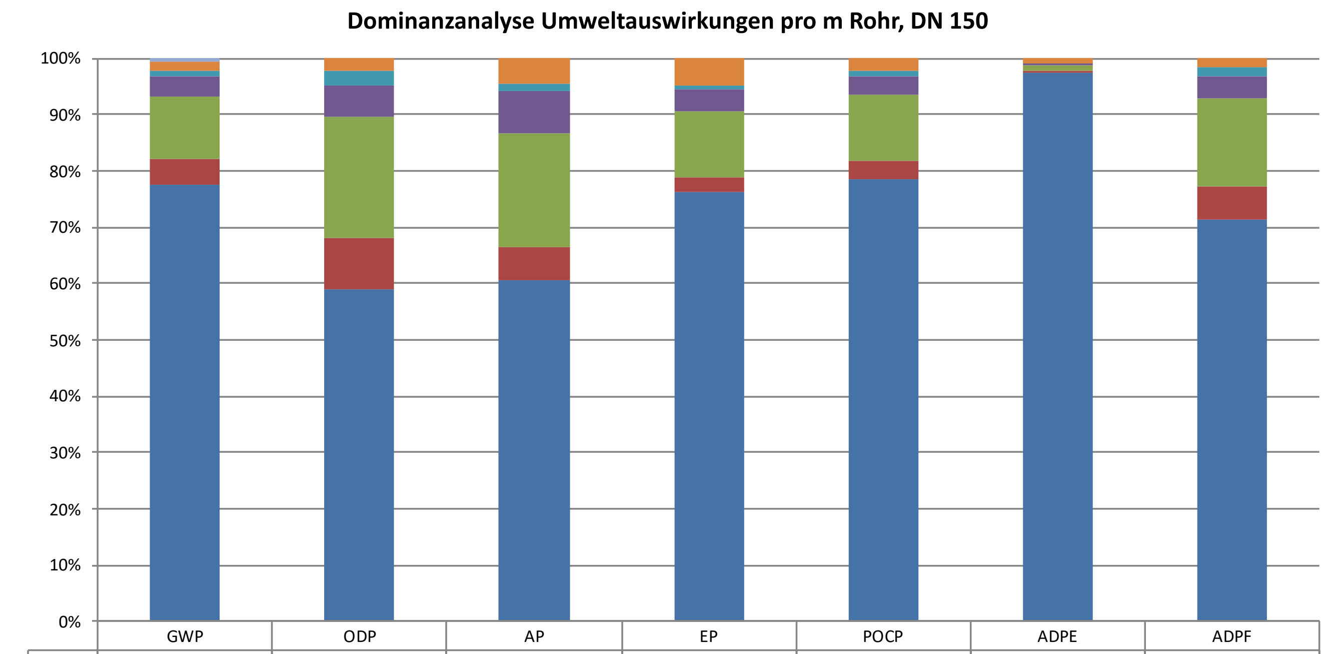
Dominanzanalyse Umweltauswirkungen pro m Rohr, DN 125



	GWP	ODP	AP	EP	POCP	ADPE	ADPF
C4	0,48%	0,06%	0,04%	0,04%	0,02%	0,00%	0,04%
C3	1,52%	2,08%	4,20%	4,60%	2,27%	0,72%	1,59%
C2	1,22%	2,57%	1,49%	0,71%	0,80%	0,08%	1,61%
C1	3,60%	5,97%	7,71%	4,10%	3,35%	0,25%	4,23%
A5	12,31%	23,51%	21,80%	12,72%	12,84%	1,15%	17,16%
A4	4,34%	9,13%	5,73%	2,61%	3,05%	0,28%	5,73%
A1-A3	76,54%	56,68%	59,03%	75,23%	77,67%	97,51%	69,63%

Figure 5: Dominance analysis – environmental impact of DN125

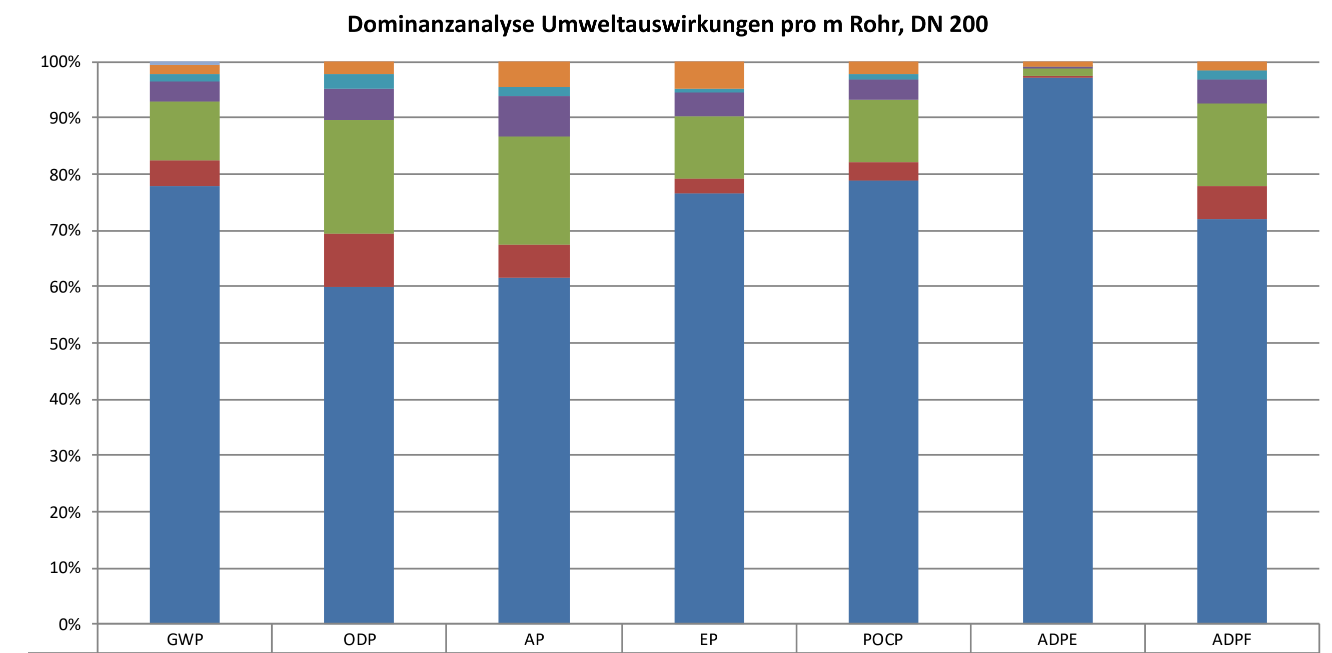
Dominanzanalyse…	Dominance analysis – environmental impact per m of pipe, DN 125



	GWP	ODP	AP	EP	POCP	ADPE	ADPF
C4	0,53%	0,06%	0,05%	0,04%	0,02%	0,00%	0,04%
C3	1,53%	2,12%	4,36%	4,71%	2,31%	0,80%	1,60%
C2	1,23%	2,62%	1,54%	0,73%	0,81%	0,09%	1,63%
C1	3,42%	5,47%	7,25%	3,97%	3,29%	0,31%	3,97%
A5	11,22%	21,52%	20,23%	11,71%	11,81%	1,17%	15,62%
A4	4,37%	9,27%	5,95%	2,67%	3,10%	0,31%	5,78%
A1-A3	77,70%	58,95%	60,62%	76,18%	78,65%	97,31%	71,36%

Figure 6: Dominance analysis – environmental impact of DN150

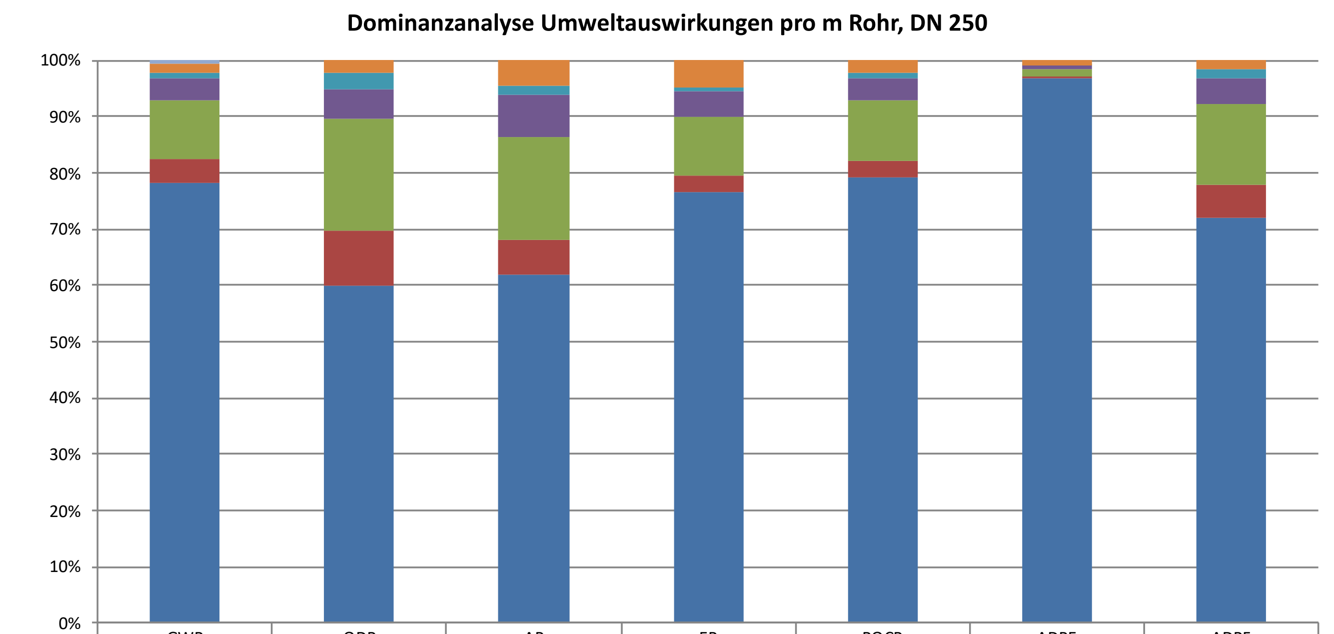
Dominanzanalyse…	Dominance analysis – environmental impact per m of pipe, DN 150



	GWP	ODP	AP	EP	POCP	ADPE	ADPF
C4	0,62%	0,06%	0,05%	0,04%	0,02%	0,00%	0,04%
C3	1,53%	2,14%	4,41%	4,74%	2,32%	0,81%	1,60%
C2	1,24%	2,65%	1,57%	0,74%	0,82%	0,09%	1,64%
C1	3,60%	5,39%	7,25%	4,21%	3,58%	0,40%	4,09%
A5	10,67%	20,44%	19,10%	11,09%	11,24%	1,15%	14,78%
A4	4,38%	9,38%	6,04%	2,69%	3,12%	0,32%	5,79%
A1-A3	77,96%	59,92%	61,57%	76,50%	78,89%	97,23%	72,06%

Figure 7: Dominance analysis – environmental impact of DN200

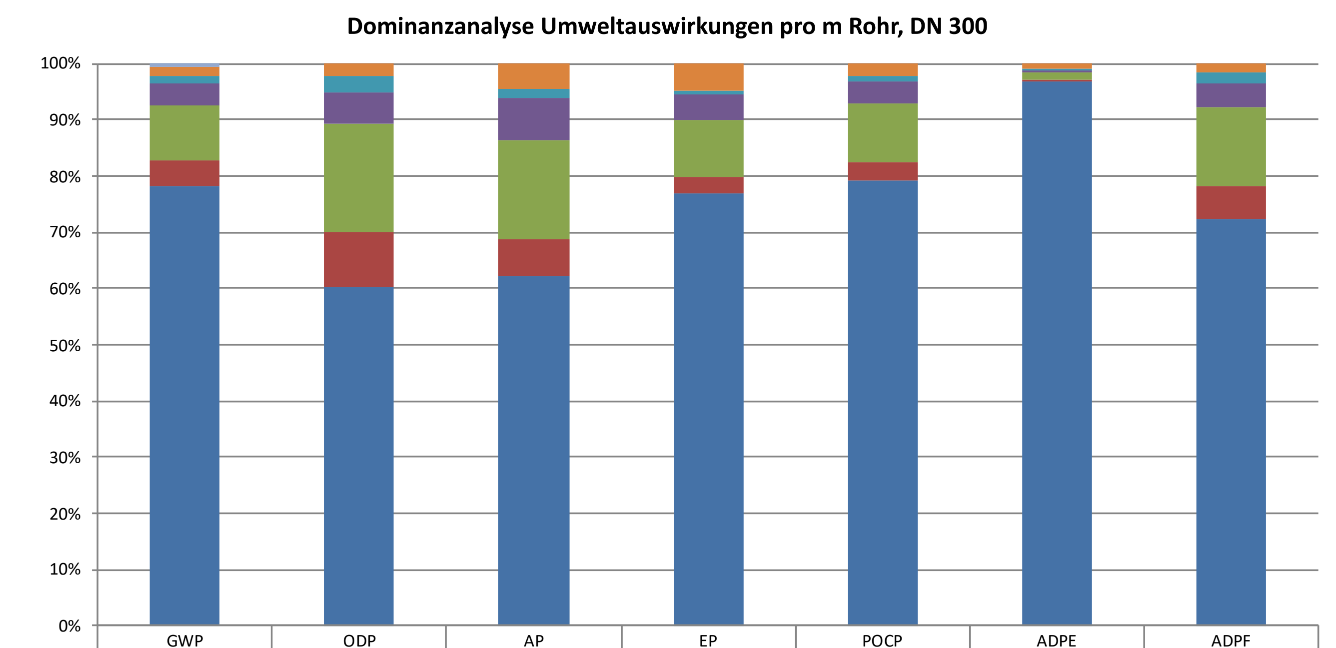
Dominanzanalyse	Dominance analysis – environmental impact per m of pipe, DN 200



	GWP	ODP	AP	EP	POCP	ADPE	ADPF
C4	0,52%	0,06%	0,05%	0,04%	0,02%	0,00%	0,04%
C3	1,56%	2,20%	4,53%	4,79%	2,34%	0,93%	1,65%
C2	1,25%	2,73%	1,61%	0,74%	0,83%	0,10%	1,68%
C1	3,78%	5,47%	7,38%	4,40%	3,81%	0,52%	4,29%
A5	10,33%	19,93%	18,42%	10,61%	10,78%	1,25%	14,41%
A4	4,46%	9,68%	6,20%	2,73%	3,15%	0,36%	5,96%
A1-A3	78,10%	59,93%	61,82%	76,68%	79,06%	96,84%	71,98%

Figure 8: Dominance analysis – environmental impact of DN250

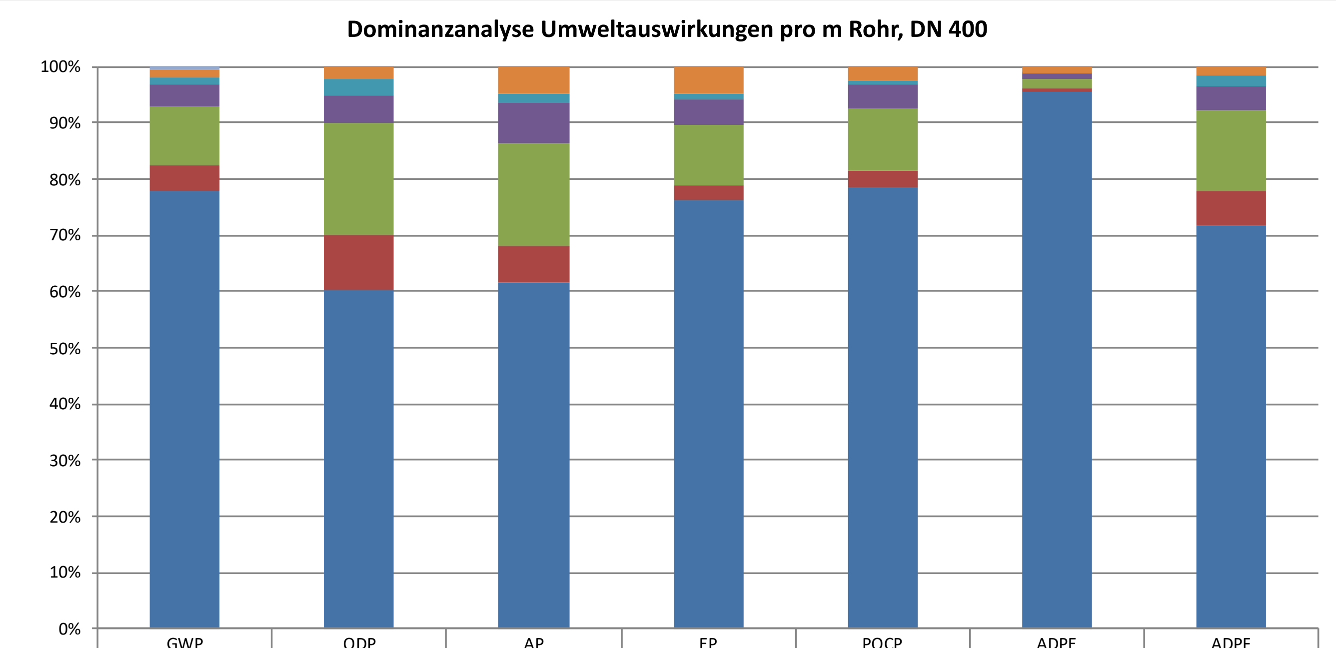
Dominanzanalyse	Dominance analysis – environmental impact per m of pipe, DN 250



	GWP	ODP	AP	EP	POCP	ADPE	ADPF
C4	0,58%	0,06%	0,05%	0,04%	0,02%	0,00%	0,04%
C3	1,57%	2,24%	4,59%	4,81%	2,35%	0,98%	1,67%
C2	1,25%	2,76%	1,62%	0,74%	0,82%	0,11%	1,69%
C1	3,93%	5,53%	7,47%	4,56%	4,00%	0,61%	4,44%
A5	9,93%	19,29%	17,64%	10,11%	10,31%	1,27%	13,91%
A4	4,50%	9,86%	6,29%	2,74%	3,16%	0,38%	6,04%
A1-A3	78,24%	60,25%	62,35%	76,99%	79,34%	96,65%	72,20%

Figure 9: Dominance analysis – environmental impact of DN300

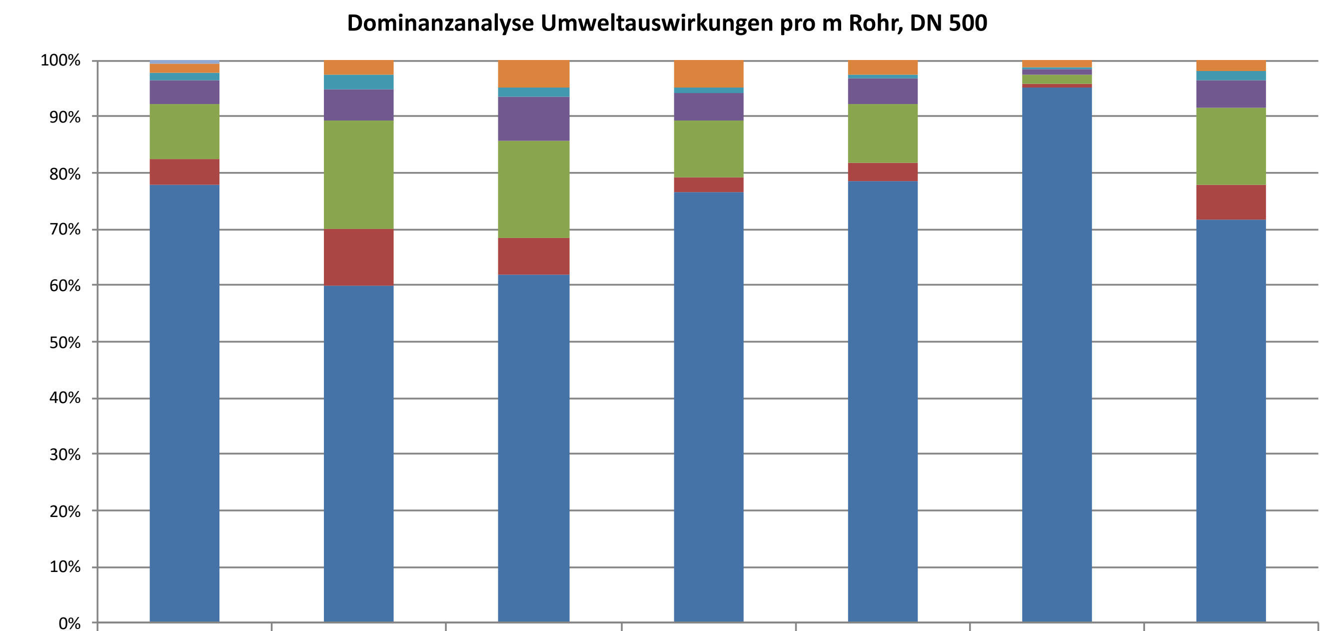
Dominanzanalyse…	Dominance analysis – environmental impact per m of pipe, DN 300



	GWP	ODP	AP	EP	POCP	ADPE	ADPF
C4	0,44%	0,06%	0,05%	0,03%	0,02%	0,00%	0,04%
C3	1,58%	2,25%	4,72%	4,93%	2,39%	1,22%	1,68%
C2	1,26%	2,76%	1,66%	0,76%	0,84%	0,14%	1,69%
C1	3,94%	5,12%	7,19%	4,66%	4,16%	0,85%	4,36%
A5	10,28%	19,85%	18,25%	10,59%	10,95%	1,71%	14,49%
A4	4,52%	9,84%	6,44%	2,80%	3,21%	0,48%	6,05%
A1-A3	77,97%	60,13%	61,69%	76,22%	78,43%	95,60%	71,69%

Figure 10: Dominance analysis – environmental impact of DN400

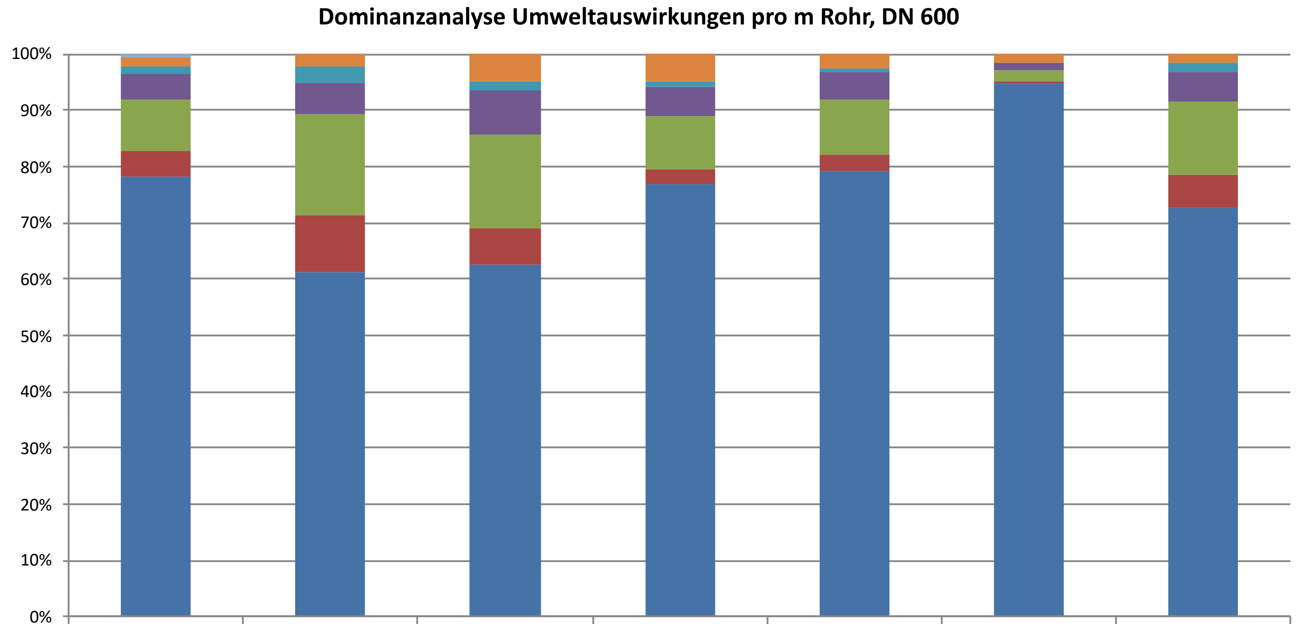
Dominanzanalyse…	Dominance analysis – environmental impact per m of pipe, DN 400



	GWP	ODP	AP	EP	POCP	ADPE	ADPF
C4	0,50%	0,06%	0,05%	0,04%	0,02%	0,00%	0,04%
C3	1,61%	2,32%	4,79%	4,95%	2,40%	1,33%	1,72%
C2	1,28%	2,85%	1,69%	0,76%	0,84%	0,15%	1,74%
C1	4,30%	5,49%	7,63%	5,02%	4,52%	1,03%	4,76%
A5	9,74%	19,14%	17,24%	9,92%	10,28%	1,74%	13,90%
A4	4,60%	10,17%	6,55%	2,81%	3,22%	0,52%	6,22%
A1-A3	77,97%	59,96%	62,05%	76,50%	78,70%	95,23%	71,62%

Figure 11: Dominance analysis – environmental impact of DN500

Dominanzanalyse…	Dominance analysis – environmental impact per m of pipe, DN 500

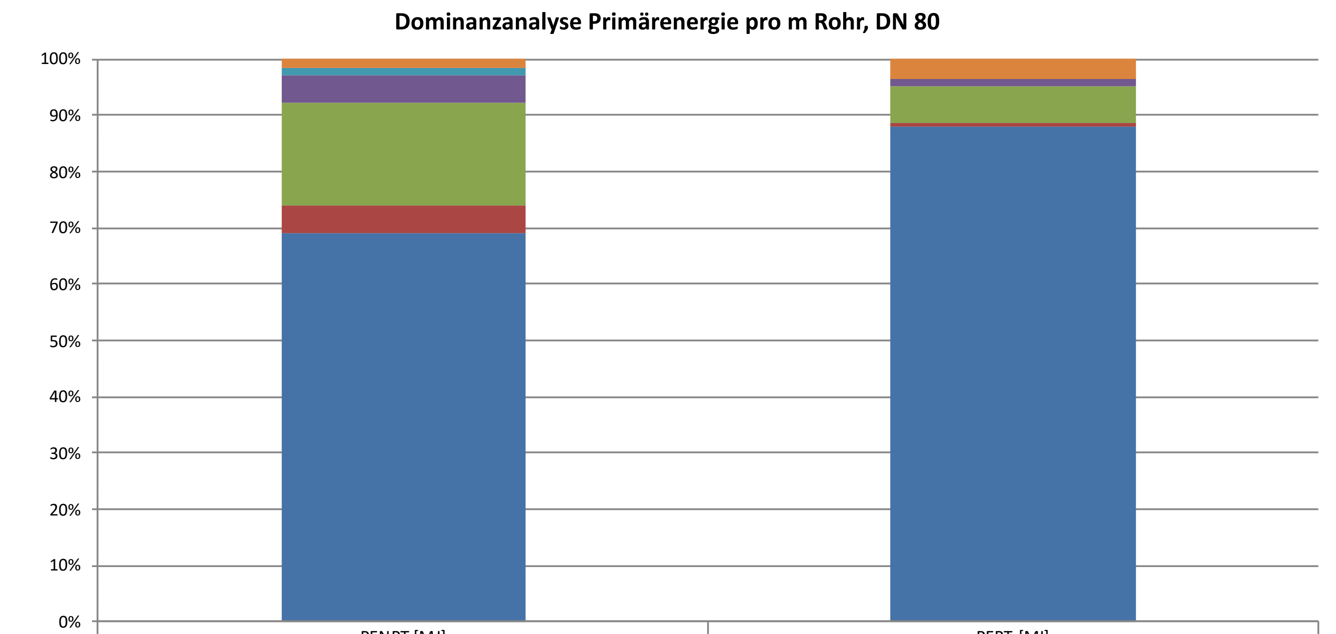


	GWP	ODP	AP	EP	POCP	ADPE	ADPF
C4	0,61%	0,07%	0,05%	0,04%	0,03%	0,00%	0,04%
C3	1,58%	2,28%	4,75%	4,89%	2,37%	1,45%	1,68%
C2	1,21%	2,68%	1,60%	0,72%	0,79%	0,16%	1,63%
C1	4,54%	5,70%	8,03%	5,35%	4,84%	1,25%	4,99%
A5	9,30%	18,06%	16,40%	9,43%	9,75%	1,85%	13,05%
A4	4,48%	9,93%	6,46%	2,76%	3,16%	0,57%	6,03%
A1-A3	78,28%	61,28%	62,69%	76,80%	79,05%	94,72%	72,58%

Figure 12: Dominance analysis – environmental impact of DN600

Dominanzanalyse…	Dominance analysis – environmental impact per m of pipe, DN 600

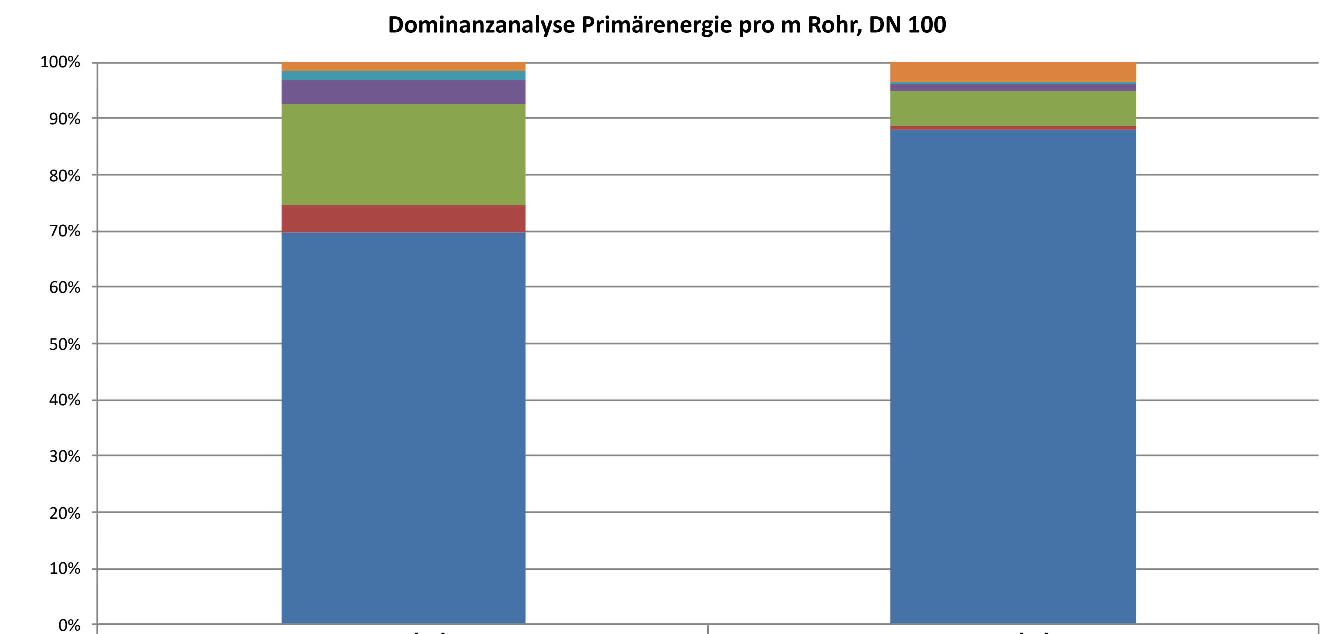
Figure 13 to Figure 22 show the percentage share of the modules A1-A3 production, A4 transport to the building site, A5 installation, C1 removal, C2 transport and C4 waste treatment in the primary energy requirement (PENRT & PERT) for the respective nominal diameter. The production of the pipes requires the most energy, and the influence of production increases as the pipe diameter increases. The second biggest influence is the installation of the pipes. The relative proportion of energy required for installation decreases as the diameter increases.



	PENRT [MJ]	PERT [MJ]
C4	0,03%	0,01%
C3	1,58%	3,49%
C2	1,39%	0,19%
C1	4,62%	1,15%
A5	18,27%	6,59%
A4	4,94%	0,69%
A1-A3	69,16%	87,88%

Figure 13: Dominance analysis – primary energy of DN80

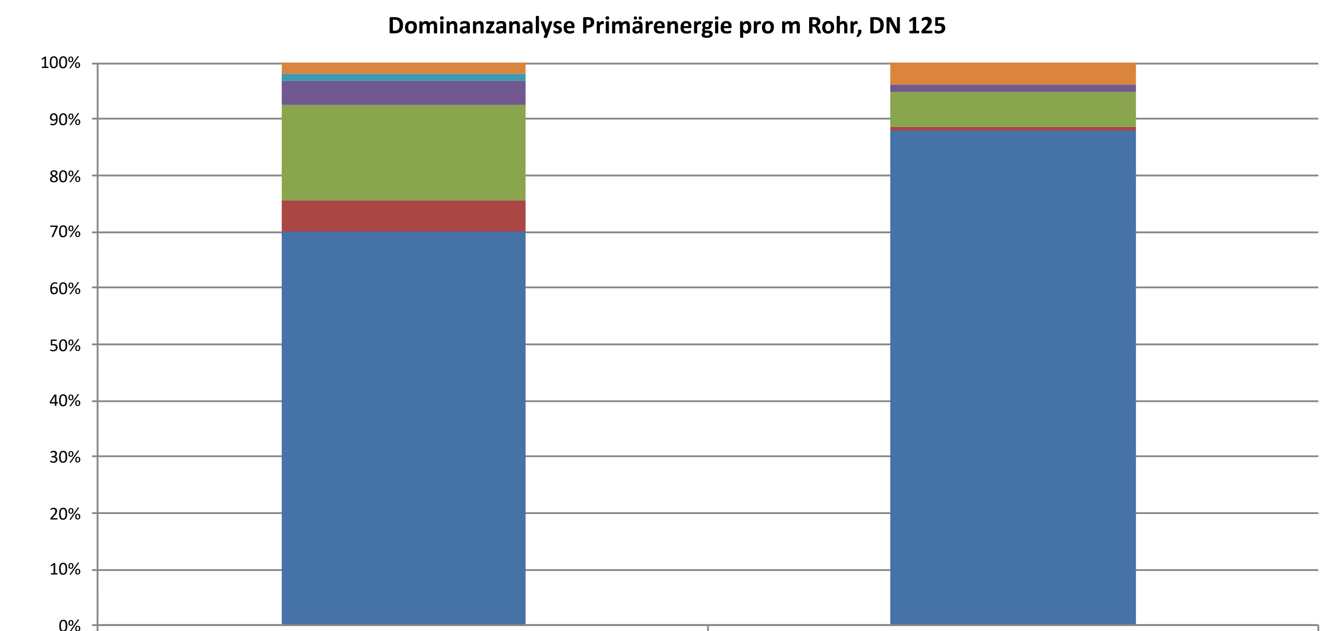
Dominanzanalyse…	Dominance analysis – primary energy per m of pipe, DN 80



	PENRT [MJ]	PERT [MJ]
C4	0,03%	0,01%
C3	1,65%	3,58%
C2	1,45%	0,20%
C1	4,37%	1,26%
A5	17,74%	6,39%
A4	5,17%	0,71%
A1-A3	69,59%	87,86%

Figure 14: Dominance analysis – primary energy of DN100

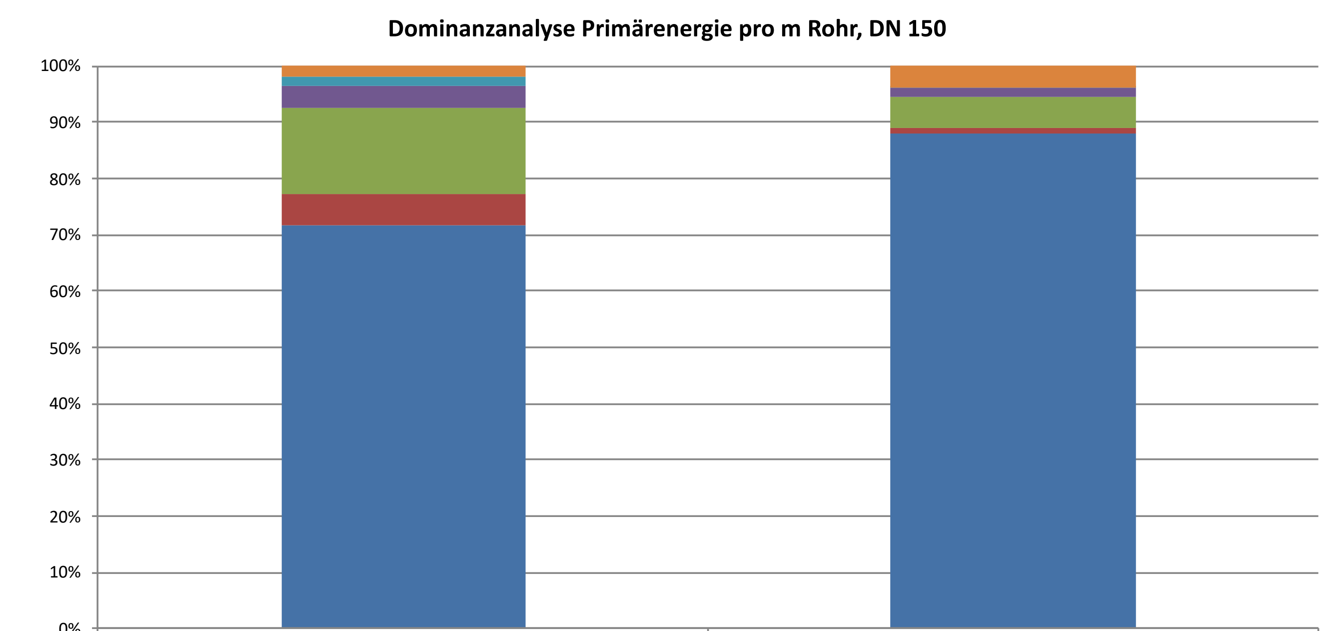
Dominanzanalyse…	Dominance analysis – primary energy per m of pipe, DN 100



	PENRT [MJ]	PERT [MJ]
C4	0,04%	0,01%
C3	1,76%	3,69%
C2	1,55%	0,20%
C1	4,16%	1,40%
A5	16,89%	6,00%
A4	5,50%	0,73%
A1-A3	70,10%	87,97%

Figure 15: Dominance analysis – primary energy of DN125

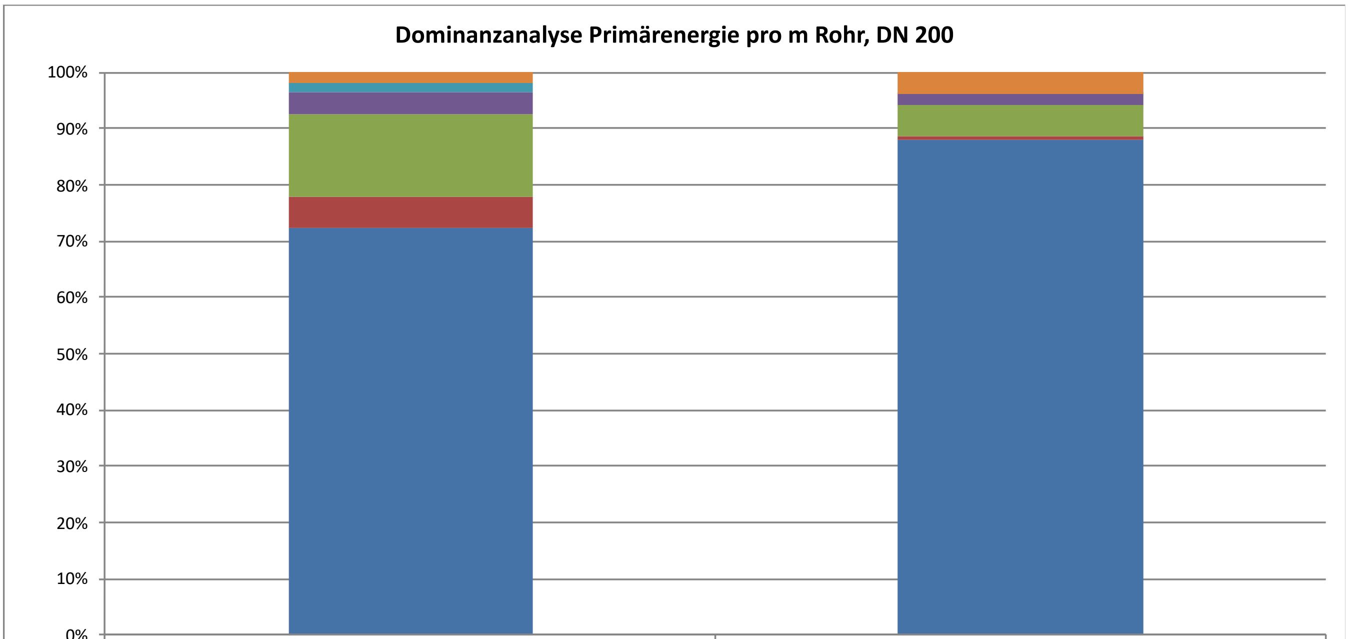
Dominanzanalyse…	Dominance analysis – primary energy per m of pipe, DN 125



	PENRT [MJ]	PERT [MJ]
C4	0,04%	0,01%
C3	1,77%	3,77%
C2	1,56%	0,21%
C1	3,92%	1,53%
A5	15,37%	5,60%
A4	5,54%	0,75%
A1-A3	71,81%	88,14%

Figure 16: Dominance analysis – primary energy of DN150

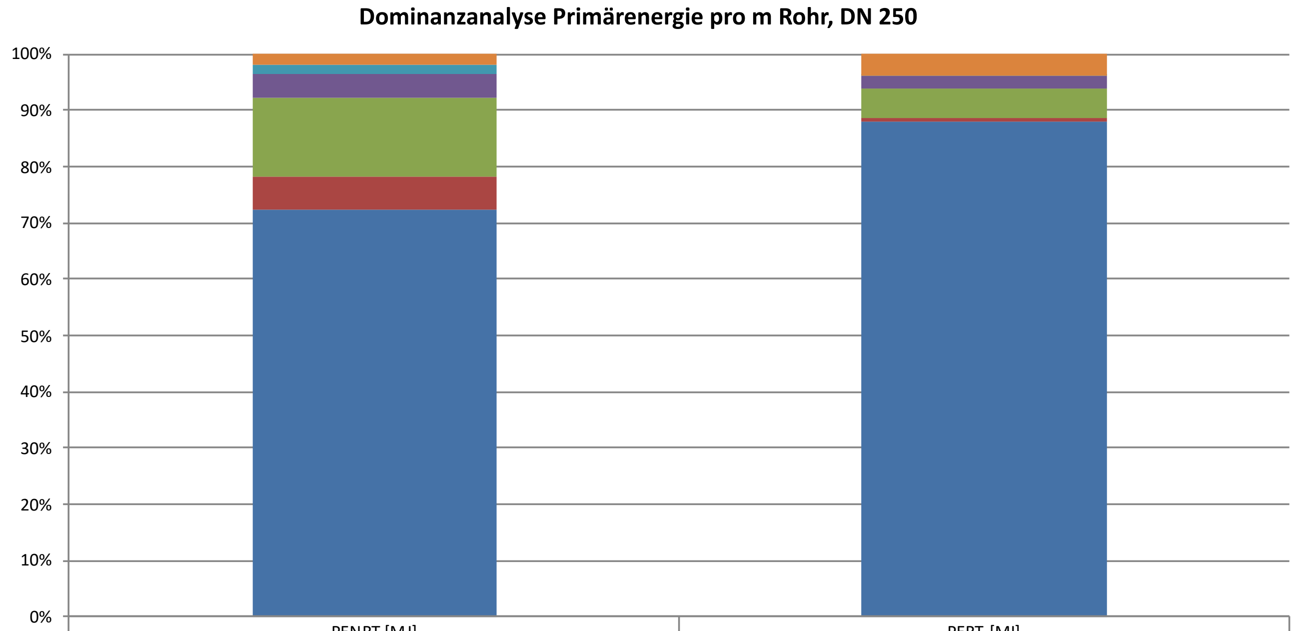
Dominanzanalyse…	Dominance analysis – primary energy per m of pipe, DN 150



	PENRT [MJ]	PERT [MJ]
C4	0,04%	0,01%
C3	1,77%	3,76%
C2	1,57%	0,21%
C1	4,07%	1,90%
A5	14,52%	5,37%
A4	5,55%	0,75%
A1-A3	72,49%	88,00%

Figure 17: Dominance analysis – primary energy of DN200

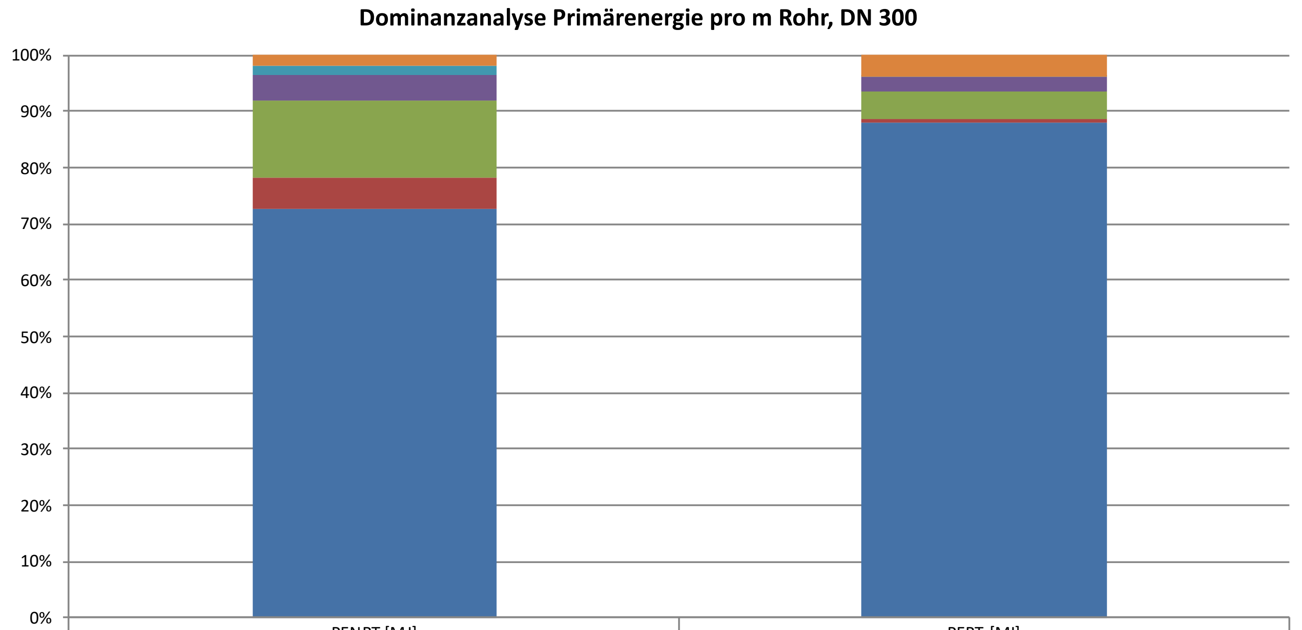
Dominanzanalyse…	Dominance analysis – primary energy per m of pipe, DN 200



	PENRT [MJ]	PERT [MJ]
C4	0,04%	0,01%
C3	1,82%	3,76%
C2	1,60%	0,21%
C1	4,28%	2,15%
A5	14,17%	5,14%
A4	5,71%	0,75%
A1-A3	72,37%	87,99%

Figure 18: Dominance analysis – primary energy of DN250

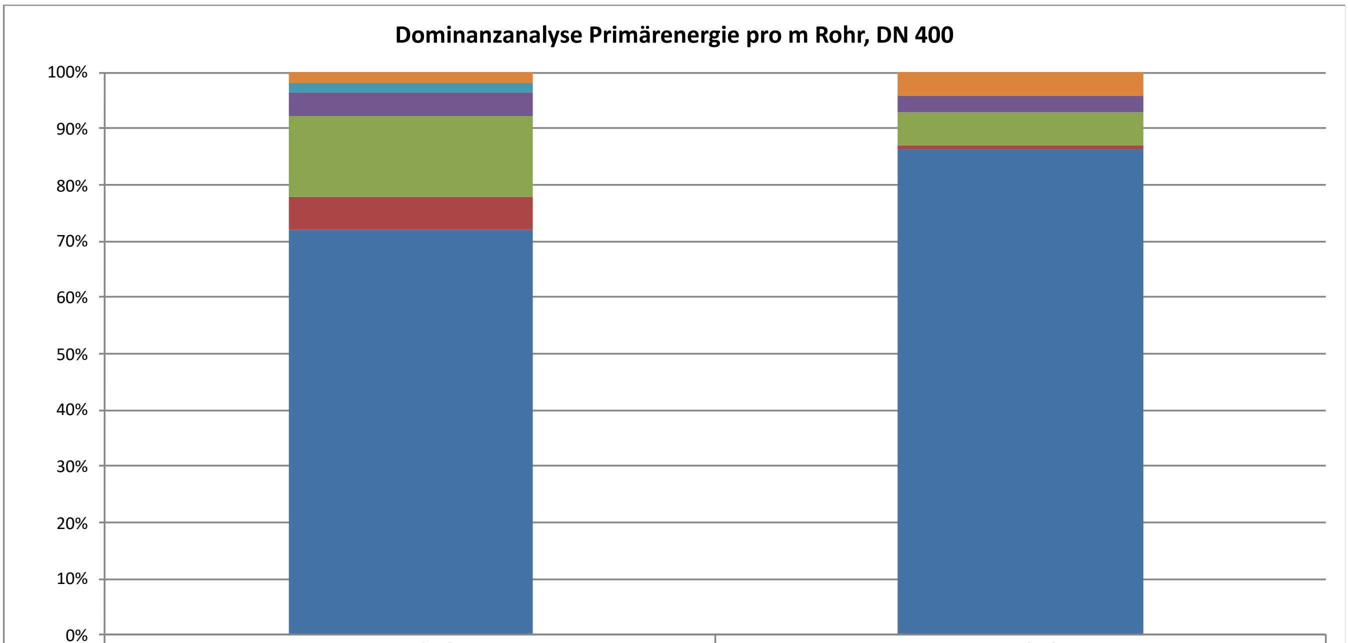
Dominanzanalyse…	Dominance analysis – primary energy per m of pipe, DN 250



	PENRT [MJ]	PERT [MJ]
C4	0,04%	0,01%
C3	1,85%	3,78%
C2	1,62%	0,21%
C1	4,46%	2,38%
A5	13,69%	4,97%
A4	5,79%	0,75%
A1-A3	72,56%	87,90%

Figure 19: Dominance analysis – primary energy of DN300

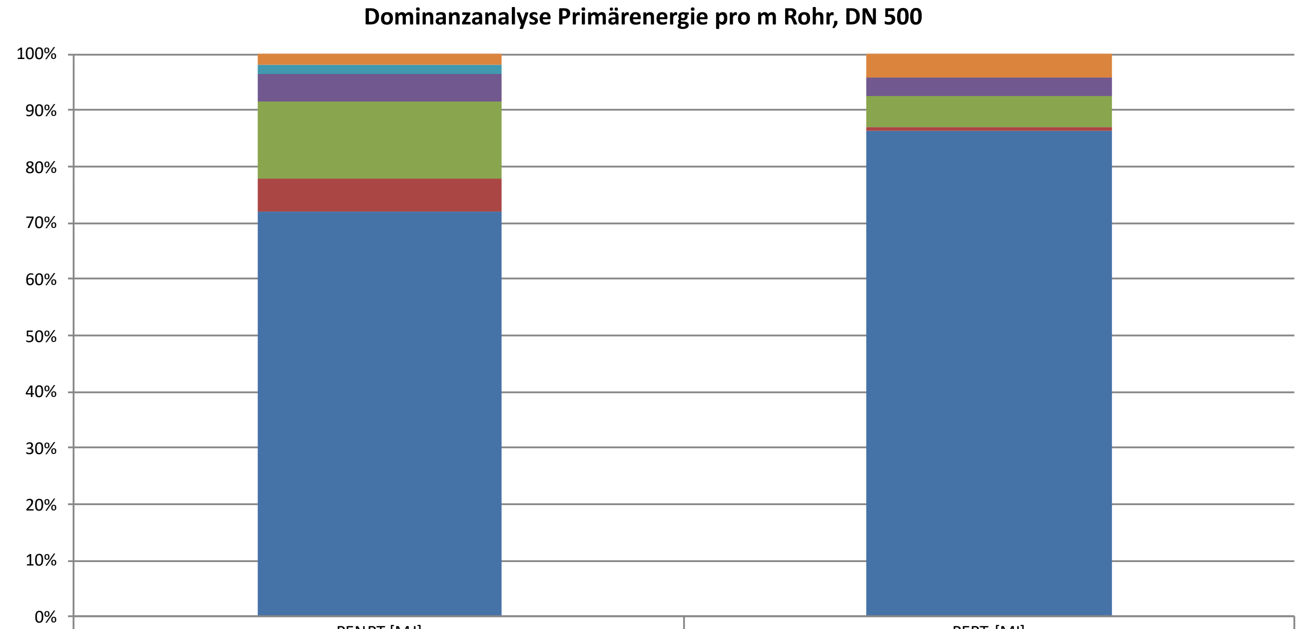
Dominanzanalyse…	Dominance analysis – primary energy per m of pipe, DN 300



	PENRT [MJ]	PERT [MJ]
C4	0,04%	0,01%
C3	1,86%	4,10%
C2	1,62%	0,22%
C1	4,41%	2,85%
A5	14,26%	5,76%
A4	5,80%	0,81%
A1-A3	72,02%	86,25%

Figure 20: Dominance analysis – primary energy of DN400

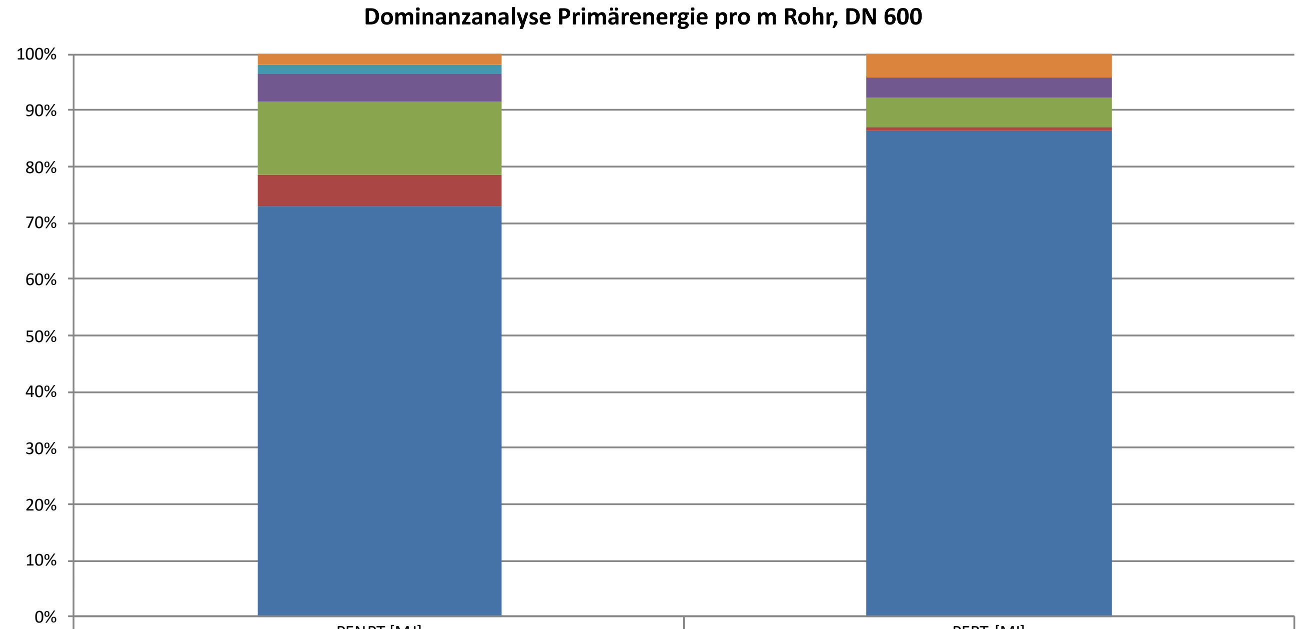
Dominanzanalyse…	Dominance analysis – primary energy per m of pipe, DN 400



	PENRT [MJ]	PERT [MJ]
C4	0,04%	0,01%
C3	1,91%	4,09%
C2	1,67%	0,22%
C1	4,82%	3,17%
A5	13,69%	5,39%
A4	5,95%	0,81%
A1-A3	71,93%	86,31%

Figure 21: Dominance analysis – primary energy of DN500

Dominanzanalyse…	Dominance analysis – primary energy per m of pipe, DN 500

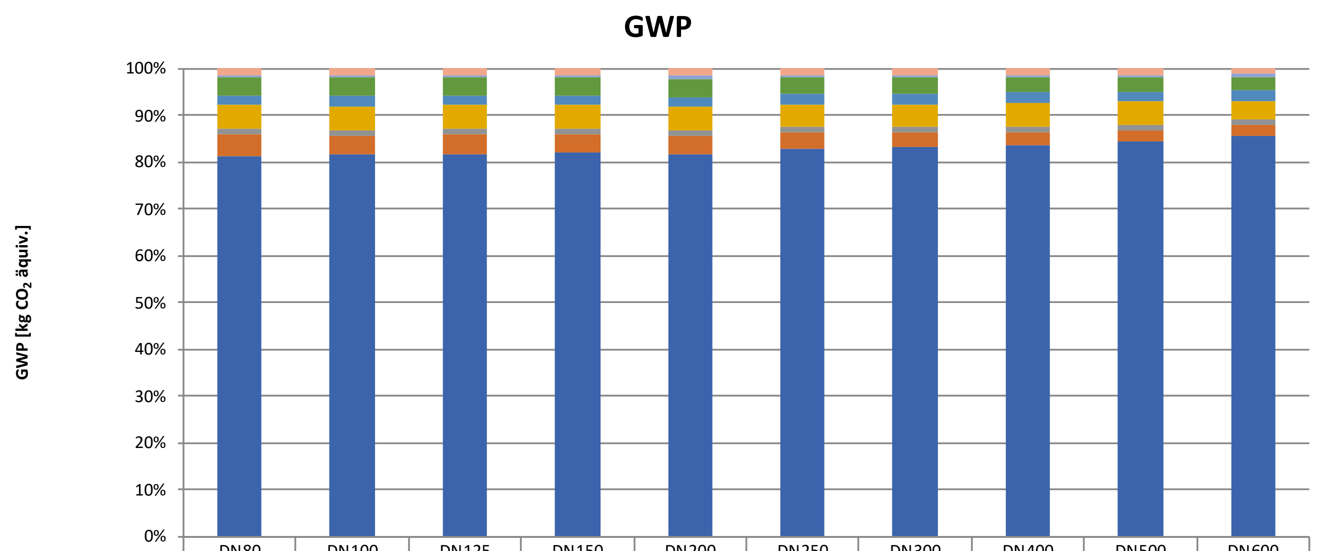


	PENRT [MJ]	PERT [MJ]
C4	0,04%	0,01%
C3	1,86%	4,03%
C2	1,56%	0,21%
C1	5,07%	3,46%
A5	12,84%	5,12%
A4	5,77%	0,80%
A1-A3	72,86%	86,38%

Figure 22: Dominance analysis – primary energy of DN600

Dominanzanalyse…	Dominance analysis – primary energy per m of pipe, DN 600

As production has the greatest influence on the environmental impact and primary energy requirement, this is analysed in detail in Figure 23 to Figure 31.

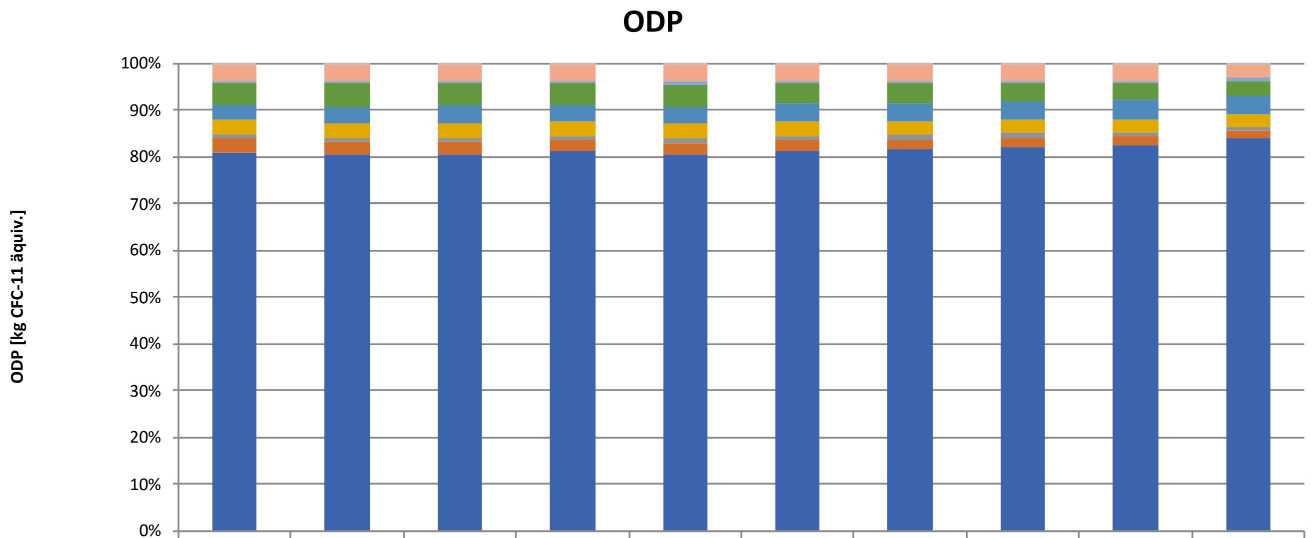


	DN80	DN100	DN125	DN150	DN200	DN250	DN300	DN400	DN500	DN600
Infrastruktur	0,09%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,10%	0,11%	0,10%
Produktionsabfälle	0,04%	0,04%	0,04%	0,04%	0,04%	0,04%	0,04%	0,04%	0,04%	0,04%
Transporte	1,32%	1,35%	1,33%	1,31%	1,35%	1,27%	1,22%	1,30%	1,21%	1,05%
Zusätzliches	0,44%	0,50%	0,49%	0,48%	0,76%	0,65%	0,68%	0,64%	0,76%	0,84%
PUR-Beschichtung	3,93%	4,02%	3,83%	3,79%	3,80%	3,56%	3,44%	3,03%	2,86%	2,69%
Reifehalle	2,00%	2,08%	2,13%	2,12%	2,12%	2,15%	2,16%	2,19%	2,23%	2,17%
Zementierung	4,95%	5,18%	5,10%	5,06%	5,19%	4,94%	4,80%	5,19%	4,86%	4,19%
Bearbeitung	1,16%	1,12%	1,09%	1,06%	1,23%	1,16%	1,13%	1,13%	1,07%	1,05%
Verzinkung	4,97%	4,19%	4,29%	3,87%	3,80%	3,44%	3,29%	2,74%	2,60%	2,33%
Prod. Halbteil	81,11%	81,42%	81,58%	82,17%	81,63%	82,70%	83,14%	83,65%	84,28%	85,53%

Figure 23: Dominance analysis – production of GWP

GWP	GWP
GWP [kg…	GWP [kg CO_2 equiv.]
Infrastruktur	Infrastructure
Produktionsabfälle	Production waste
Transporte	Transport
Zusätzliches	Additional
PUR-Beschichtung	PUR coating
Reifehalle	Curing chamber
Zementierung	Cement lining
Bearbeitung	Processing
Verzinkung	Zinc spray
Prod. Halbteil	Semi-finished part prod.

Around 80% to 85% of the global warming potential is attributable to the production of the semi-finished part. The zinc spray, cement lining and PUR coating provide similar proportions of approx. 2% to 5%.

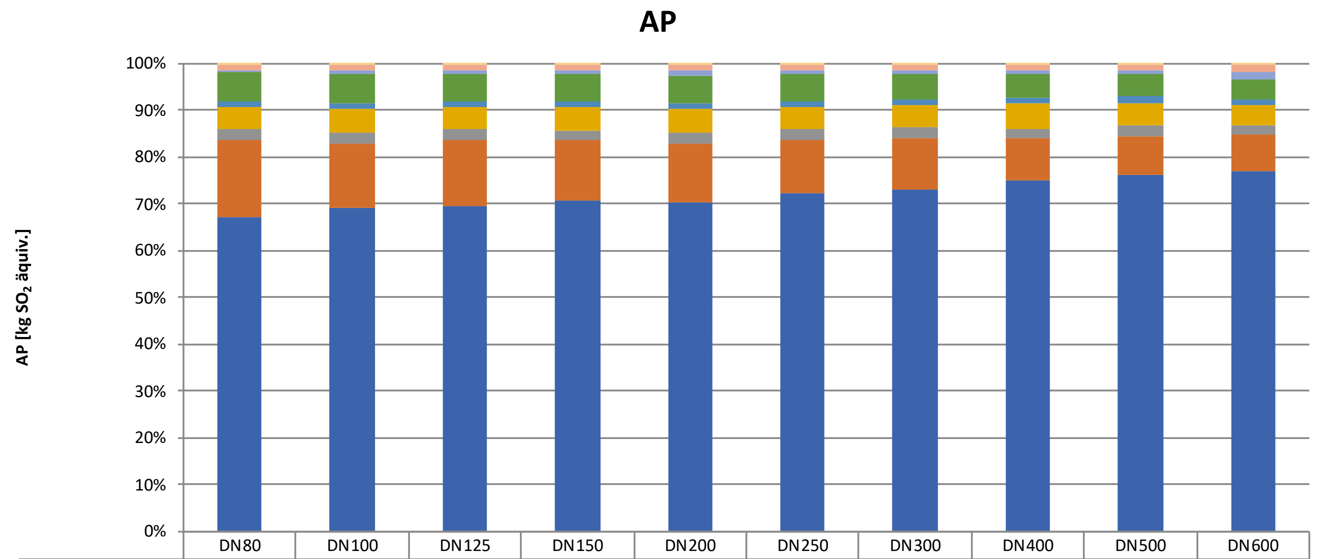


	DN80	DN100	DN125	DN150	DN200	DN250	DN300	DN400	DN500	DN600
Infrastruktur	0,09%	0,10%	0,10%	0,10%	0,10%	0,10%	0,11%	0,11%	0,11%	0,11%
Produktionsabfälle	0,11%	0,11%	0,12%	0,11%	0,12%	0,12%	0,12%	0,12%	0,12%	0,11%
Transporte	3,63%	3,79%	3,81%	3,70%	3,80%	3,62%	3,54%	3,71%	3,53%	3,03%
Zusätzliches	0,40%	0,44%	0,44%	0,41%	0,61%	0,54%	0,56%	0,46%	0,56%	0,62%
PUR-Beschichtung	4,59%	4,78%	4,67%	4,55%	4,56%	4,31%	4,20%	3,64%	3,51%	3,25%
Reifehalle	3,49%	3,70%	3,88%	3,80%	3,79%	3,89%	3,95%	3,95%	4,10%	3,96%
Zementierung	2,78%	2,96%	2,99%	2,93%	2,98%	2,89%	2,85%	3,02%	2,91%	2,50%
Bearbeitung	0,98%	0,98%	0,98%	0,94%	1,08%	1,05%	1,03%	1,03%	1,00%	0,97%
Verzinkung	2,93%	2,56%	2,68%	2,40%	2,36%	2,18%	2,12%	1,78%	1,74%	1,57%
Prod. Halbteil	81,00%	80,58%	80,32%	81,05%	80,60%	81,30%	81,53%	82,18%	82,41%	83,88%

Figure 24: Dominance analysis – production of ODP

ODP	ODP
ODP [kg…	ODP [kg CFC-11 equiv.]
Infrastruktur	Infrastructure
Produktionsabfälle	Production waste
Transporte	Transport
Zusätzliches	Additional
PUR-Beschichtung	PUR coating
Reifehalle	Curing chamber
Zementierung	Cement lining
Bearbeitung	Processing
Verzinkung	Zinc spray
Prod. Halbteil	Semi-finished part prod.

The production of the semi-finished part also has an influence of approx. 82% to 85% on the ODP.

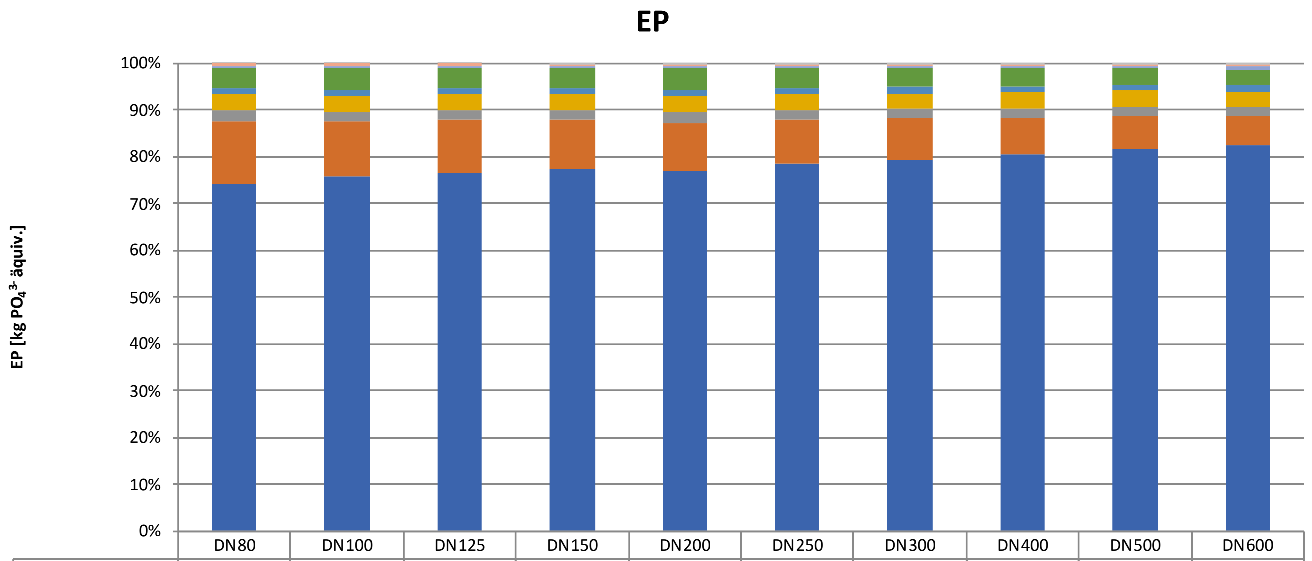


	DN80	DN100	DN125	DN150	DN200	DN250	DN300	DN400	DN500	DN600
Infrastruktur	0,24%	0,25%	0,25%	0,25%	0,25%	0,26%	0,26%	0,27%	0,27%	0,27%
Produktionsabfälle	0,03%	0,06%	0,06%	0,07%	0,07%	0,07%	0,06%	0,07%	0,07%	0,06%
Transporte	1,12%	1,16%	1,12%	1,13%	1,16%	1,10%	1,06%	1,16%	1,07%	1,75%
Zusätzliches	0,69%	0,76%	0,74%	0,73%	1,11%	0,97%	1,01%	0,92%	1,09%	1,23%
PUR-Beschichtung	6,10%	6,29%	5,93%	5,97%	5,99%	5,65%	5,45%	4,94%	4,64%	4,40%
Reifehalle	1,11%	1,16%	1,18%	1,19%	1,19%	1,22%	1,22%	1,27%	1,28%	1,26%
Zementierung	4,83%	5,10%	4,97%	5,03%	5,14%	4,95%	4,82%	5,32%	4,98%	4,37%
Bearbeitung	2,40%	2,31%	2,22%	2,17%	2,49%	2,34%	2,29%	2,28%	2,13%	2,09%
Verzinkung	16,36%	13,77%	13,91%	12,71%	12,47%	11,26%	10,73%	9,00%	8,43%	7,57%
Prod. Halbteil	67,12%	69,13%	69,63%	70,75%	70,13%	72,19%	73,10%	74,78%	76,03%	76,99%

Figure 25: Dominance analysis – production of AP

AP	AP
AP [kg…	AP [kg SO_2 equiv.]
Infrastruktur	Infrastructure
Produktionsabfälle	Production waste
Transporte	Transport
Zusätzliches	Additional
PUR-Beschichtung	PUR coating
Reifehalle	Curing chamber
Zementierung	Cement lining
Bearbeitung	Processing
Verzinkung	Zinc spray
Prod. Halbteil	Semi-finished part prod.

The production of the semi-finished part has a slightly smaller influence of approx. 75% to 84% on the acidification potential. The influence of the zinc spray increases to 7% to 15% here.

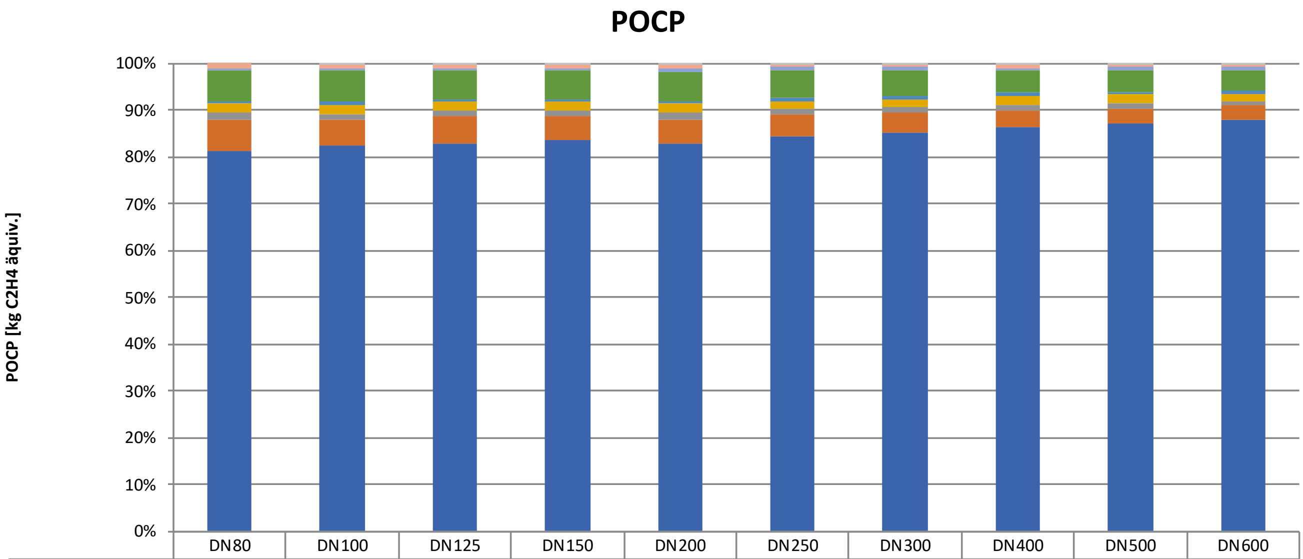


	DN80	DN100	DN125	DN150	DN200	DN250	DN300	DN400	DN500	DN600
Infrastruktur	0,13%	0,14%	0,14%	0,14%	0,14%	0,14%	0,14%	0,15%	0,15%	0,15%
Produktionsabfälle	0,01%	0,02%	0,02%	0,02%	0,02%	0,02%	0,02%	0,02%	0,02%	0,02%
Transporte	0,47%	0,48%	0,46%	0,46%	0,48%	0,44%	0,43%	0,46%	0,43%	0,64%
Zusätzliches	0,37%	0,40%	0,39%	0,38%	0,57%	0,49%	0,50%	0,45%	0,52%	0,58%
PUR-Beschichtung	4,66%	4,77%	4,50%	4,53%	4,56%	4,30%	4,15%	3,83%	3,61%	3,45%
Reifehalle	1,15%	1,20%	1,20%	1,21%	1,22%	1,23%	1,23%	1,27%	1,27%	1,25%
Zementierung	3,36%	3,50%	3,42%	3,45%	3,52%	3,41%	3,33%	3,60%	3,42%	3,11%
Bearbeitung	2,21%	2,14%	2,06%	2,03%	2,26%	2,14%	2,09%	2,09%	1,97%	1,94%
Verzinkung	13,60%	11,46%	11,47%	10,55%	10,40%	9,37%	8,91%	7,60%	7,09%	6,45%
Prod. Halbteil	74,03%	75,90%	76,34%	77,21%	76,81%	78,45%	79,19%	80,52%	81,51%	82,41%

Figure 26: Dominance analysis – production of EP

EP	EP
EP [kg…	EP [kg PO_4^{3-} equiv.]
Infrastruktur	Infrastructure
Produktionsabfälle	Production waste
Transporte	Transport
Zusätzliches	Additional
PUR-Beschichtung	PUR coating
Reifehalle	Curing chamber
Zementierung	Cement lining
Bearbeitung	Processing
Verzinkung	Zinc spray
Prod. Halbteil	Semi-finished part prod.

The main contributor to the eutrophication potential is also semi-finished part production, followed by the zinc spray.

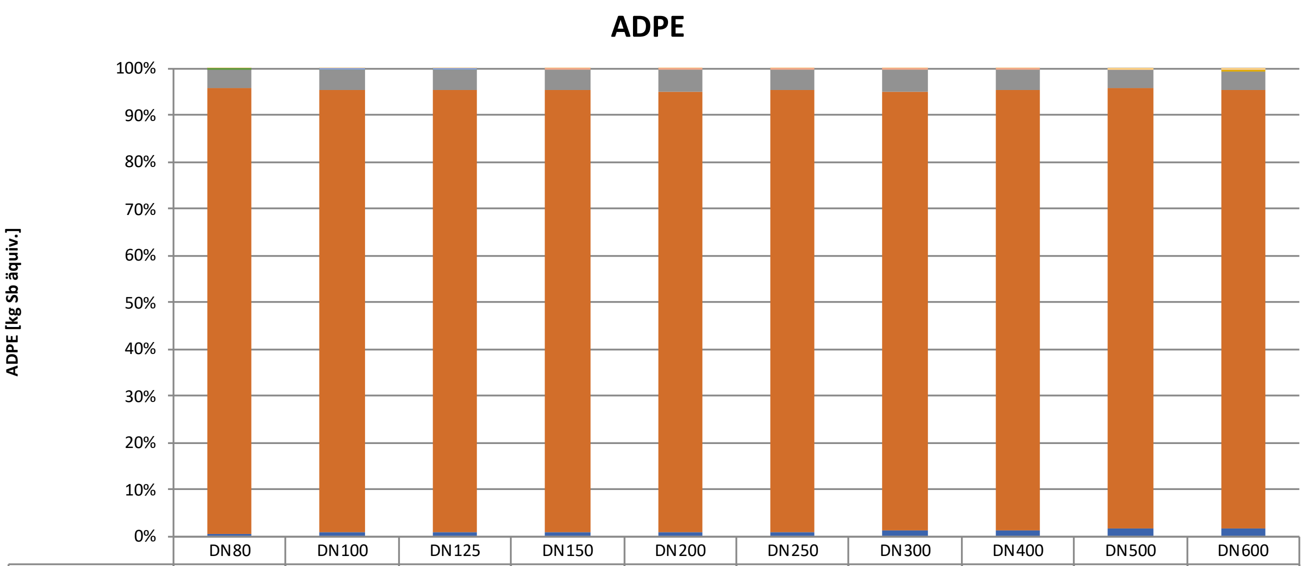


	DN80	DN100	DN125	DN150	DN200	DN250	DN300	DN400	DN500	DN600
Infrastruktur	0,14%	0,14%	0,14%	0,14%	0,14%	0,14%	0,14%	0,15%	0,15%	0,14%
Produktionsabfälle	0,02%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,02%
Transporte	0,81%	0,82%	0,79%	0,79%	0,82%	0,76%	0,73%	0,79%	0,73%	0,68%
Zusätzliches	0,59%	0,62%	0,58%	0,55%	0,80%	0,70%	0,70%	0,57%	0,67%	0,75%
PUR-Beschichtung	6,57%	6,64%	6,20%	6,21%	6,25%	5,76%	5,51%	4,89%	4,51%	4,24%
Reifehalle	0,62%	0,64%	0,65%	0,65%	0,65%	0,66%	0,66%	0,68%	0,68%	0,67%
Zementierung	1,87%	1,94%	1,88%	1,89%	1,94%	1,83%	1,77%	1,95%	1,80%	1,57%
Bearbeitung	1,31%	1,23%	1,17%	1,14%	1,35%	1,25%	1,21%	1,22%	1,12%	1,10%
Verzinkung	6,96%	5,73%	5,76%	5,22%	5,13%	4,56%	4,31%	3,57%	3,30%	2,95%
Prod. Halbteil	81,10%	82,22%	82,81%	83,39%	82,89%	84,31%	84,94%	86,16%	87,03%	87,87%

Figure 27: Dominance analysis – production of POCP

POCP	POCP
POCP [kg…	POCP [kg C2H4 equiv.]
Infrastruktur	Infrastructure
Produktionsabfälle	Production waste
Transporte	Transport
Zusätzliches	Additional
PUR-Beschichtung	PUR coating
Reifehalle	Curing chamber
Zementierung	Cement lining
Bearbeitung	Processing
Verzinkung	Zinc spray
Prod. Halbteil	Semi-finished part prod.

POCP also shows similar trends to before, with semi-finished part production as the main contributor, followed by the zinc spray.

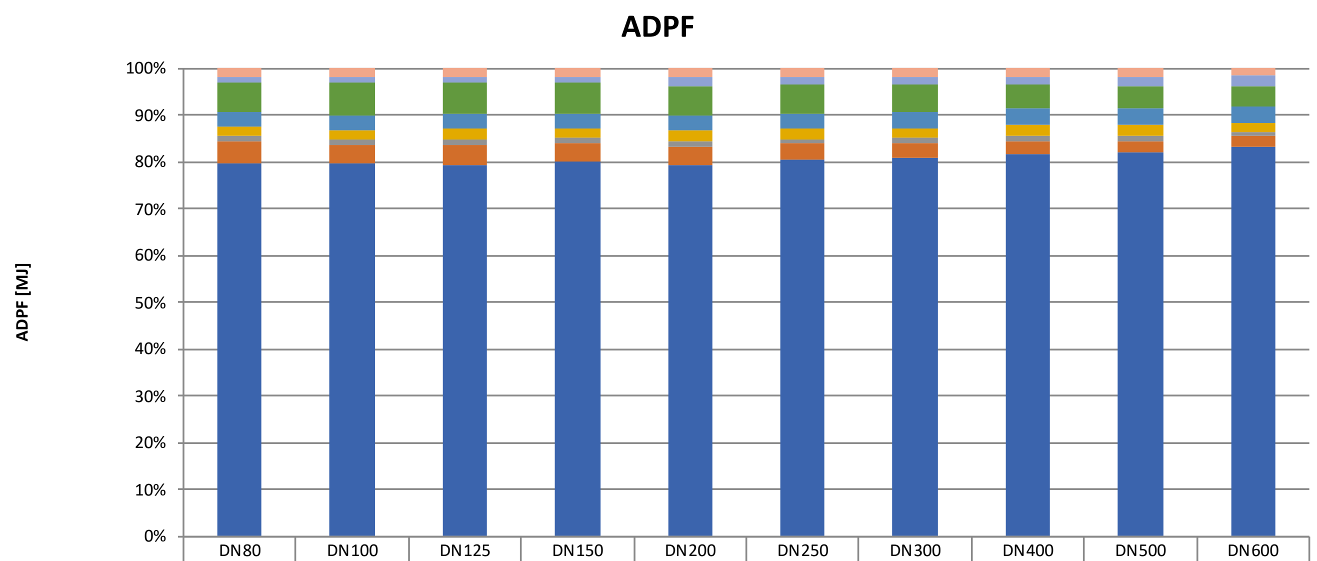


	DN80	DN100	DN125	DN150	DN200	DN250	DN300	DN400	DN500	DN600
Infrastruktur	0,07%	0,09%	0,09%	0,10%	0,10%	0,11%	0,12%	0,15%	0,17%	0,18%
Produktionsabfälle	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Transporte	0,06%	0,07%	0,07%	0,08%	0,08%	0,09%	0,09%	0,11%	0,11%	0,11%
Zusätzliches	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%
PUR-Beschichtung	0,10%	0,13%	0,12%	0,13%	0,13%	0,14%	0,14%	0,15%	0,15%	0,16%
Reifehalle	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%	0,02%	0,02%
Zementierung	0,04%	0,05%	0,05%	0,05%	0,05%	0,06%	0,06%	0,08%	0,08%	0,08%
Bearbeitung	4,12%	4,48%	4,15%	4,12%	4,51%	4,25%	4,47%	4,11%	3,81%	3,97%
Verzinkung	94,96%	94,39%	94,72%	94,63%	94,22%	94,32%	94,01%	94,02%	94,16%	93,78%
Prod. Halbteil	0,63%	0,78%	0,78%	0,87%	0,88%	1,01%	1,08%	1,34%	1,48%	1,68%

Figure 28: Dominance analysis – production of ADPE

ADPE	ADPE
ADPE [kg…	ADPE [kg Sb equiv.]
Infrastruktur	Infrastructure
Produktionsabfälle	Production waste
Transporte	Transport
Zusätzliches	Additional
PUR-Beschichtung	PUR coating
Reifehalle	Curing chamber
Zementierung	Cement lining
Bearbeitung	Processing
Verzinkung	Zinc spray
Prod. Halbteil	Semi-finished part prod.

Over 90% of the abiotic resource depletion potential for elements is attributable to the zinc spray.

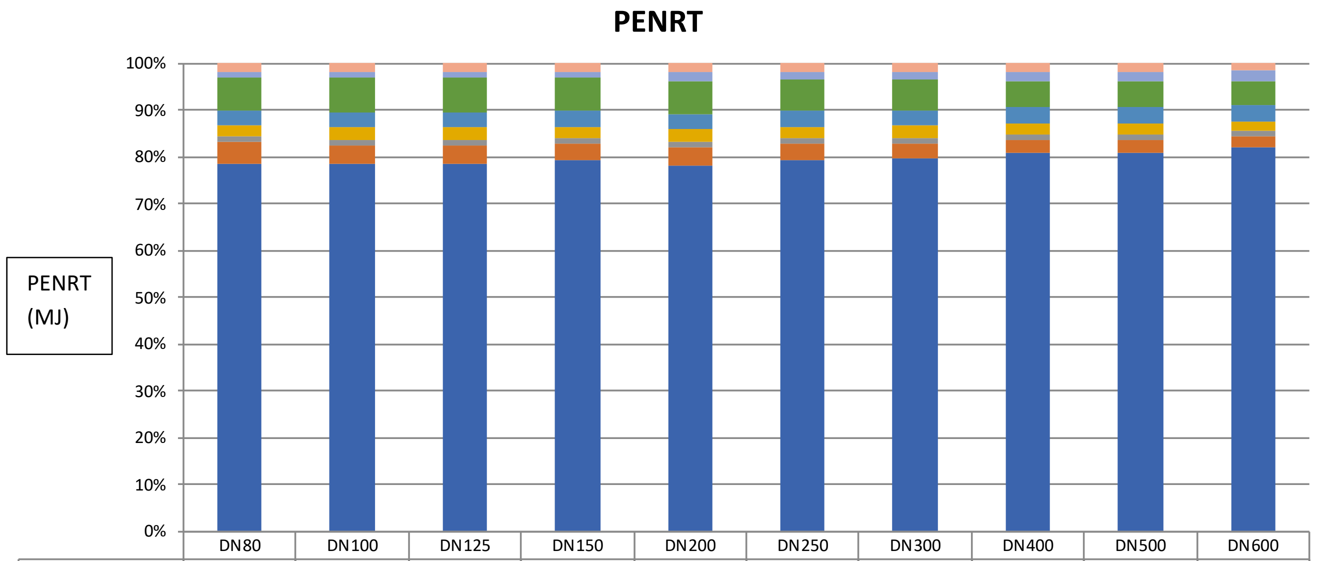


	DN80	DN100	DN125	DN150	DN200	DN250	DN300	DN400	DN500	DN600
Infrastruktur	0,09%	0,09%	0,10%	0,09%	0,09%	0,10%	0,10%	0,10%	0,10%	0,10%
Produktionsabfälle	0,05%	0,06%	0,06%	0,06%	0,06%	0,06%	0,06%	0,06%	0,06%	0,06%
Transporte	1,87%	1,94%	1,94%	1,89%	1,94%	1,85%	1,80%	1,90%	1,80%	1,54%
Zusätzliches	0,97%	1,13%	1,15%	1,13%	1,80%	1,53%	1,62%	1,60%	1,91%	2,11%
PUR-Beschichtung	6,56%	6,79%	6,57%	6,44%	6,42%	6,07%	5,88%	5,13%	4,87%	4,53%
Reifehalle	2,94%	3,10%	3,23%	3,18%	3,16%	3,24%	3,28%	3,31%	3,41%	3,29%
Zementierung	2,16%	2,29%	2,30%	2,27%	2,30%	2,24%	2,20%	2,35%	2,25%	1,95%
Bearbeitung	1,13%	1,10%	1,09%	1,05%	1,21%	1,16%	1,14%	1,13%	1,09%	1,05%
Verzinkung	4,72%	4,04%	4,20%	3,76%	3,67%	3,36%	3,23%	2,68%	2,57%	2,29%
Prod. Halbteil	79,52%	79,46%	79,36%	80,13%	79,34%	80,41%	80,69%	81,74%	81,94%	83,09%

Figure 29: Dominance analysis – production of ADPF

ADPF	ADPF
ADPF [MJ]	ADPF [MJ]
Infrastruktur	Infrastructure
Produktionsabfälle	Production waste
Transporte	Transport
Zusätzliches	Additional
PUR-Beschichtung	PUR coating
Reifehalle	Curing chamber
Zementierung	Cement lining
Bearbeitung	Processing
Verzinkung	Zinc spray
Prod. Halbteil	Semi-finished part prod.

Around 80% to 84% of the abiotic resource depletion potential for fossil fuels is attributable to the production of the semi-finished part.

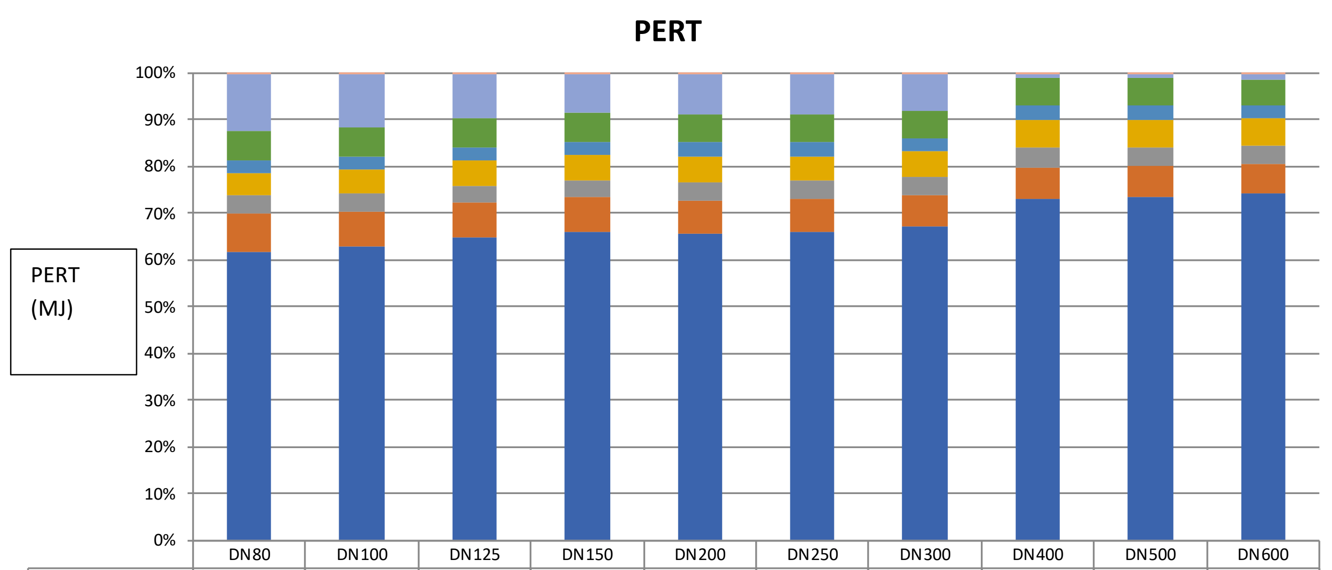


	DN80	DN100	DN125	DN150	DN200	DN250	DN300	DN400	DN500	DN600
Infrastruktur	0,09%	0,09%	0,10%	0,09%	0,09%	0,10%	0,10%	0,10%	0,10%	0,10%
Produktionsabfälle	0,05%	0,06%	0,06%	0,06%	0,06%	0,06%	0,06%	0,06%	0,06%	0,05%
Transporte	1,78%	1,85%	1,85%	1,80%	1,85%	1,76%	1,71%	1,81%	1,71%	1,47%
Zusätzliches	1,05%	1,22%	1,25%	1,22%	1,97%	1,67%	1,77%	1,76%	2,11%	2,33%
PUR-Beschichtung	7,14%	7,40%	7,17%	7,02%	7,00%	6,62%	6,42%	5,62%	5,34%	4,96%
Reifehalle	3,05%	3,22%	3,36%	3,31%	3,28%	3,37%	3,42%	3,44%	3,55%	3,43%
Zementierung	2,38%	2,52%	2,54%	2,50%	2,53%	2,47%	2,43%	2,59%	2,49%	2,17%
Bearbeitung	1,21%	1,19%	1,19%	1,15%	1,31%	1,26%	1,24%	1,24%	1,19%	1,16%
Verzinkung	4,65%	4,00%	4,17%	3,74%	3,65%	3,36%	3,25%	2,72%	2,62%	2,34%
Prod. Halbteil	78,60%	78,45%	78,32%	79,11%	78,26%	79,34%	79,61%	80,67%	80,83%	82,00%

Figure 30: Dominance analysis – production of PENRT

PENRT	PENRT
PENRT [MJ]	PENRT [MJ]
Infrastruktur	Infrastructure
Produktionsabfälle	Production waste
Transporte	Transport
Zusätzliches	Additional
PUR-Beschichtung	PUR coating
Reifehalle	Curing chamber
Zementierung	Cement lining
Bearbeitung	Processing
Verzinkung	Zinc spray
Prod. Halbteil	Semi-finished part prod.

Approximately 78% to 83% of the energy requirement for non-renewable energy is attributable to the production of the semi-finished part.



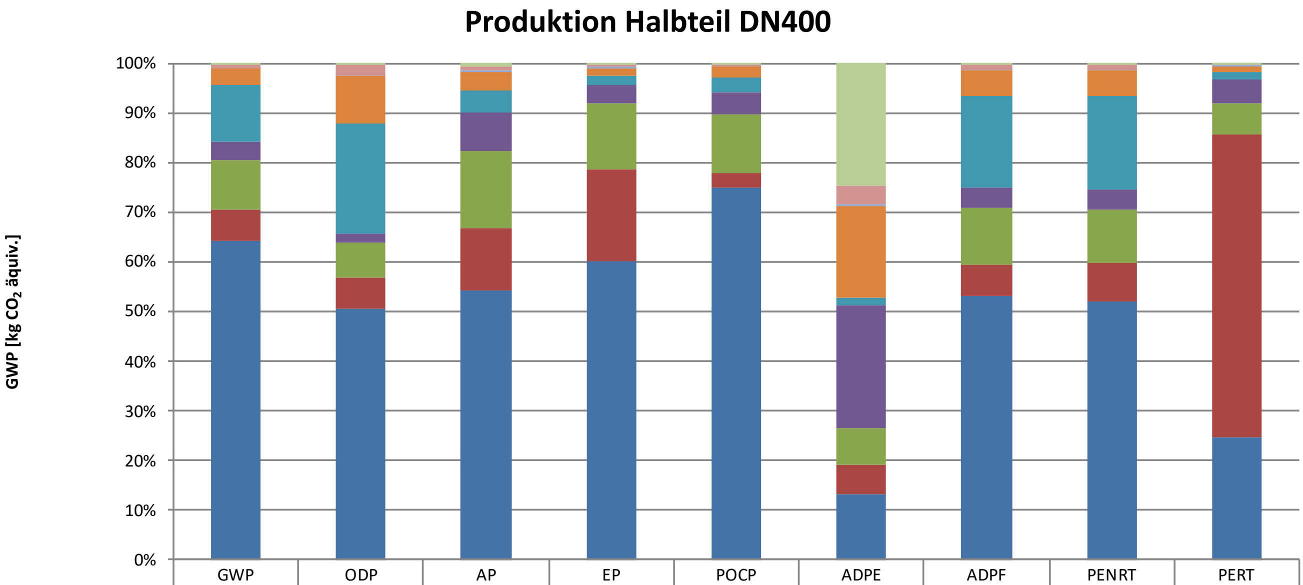
	DN80	DN100	DN125	DN150	DN200	DN250	DN300	DN400	DN500	DN600
Infrastruktur	0,06%	0,07%	0,07%	0,07%	0,07%	0,07%	0,07%	0,08%	0,08%	0,08%
Produktionsabfälle	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%	0,01%
Transporte	0,19%	0,20%	0,19%	0,19%	0,20%	0,19%	0,18%	0,21%	0,19%	0,16%
Zusätzliches	12,41%	11,59%	9,70%	8,41%	8,56%	8,87%	8,02%	0,83%	0,98%	1,11%
PUR-Beschichtung	6,09%	6,22%	6,10%	6,20%	6,22%	5,92%	5,82%	5,96%	5,71%	5,52%
Reifehalle	2,62%	2,70%	2,76%	2,82%	2,82%	2,82%	2,84%	3,13%	3,13%	3,08%
Zementierung	5,05%	5,22%	5,28%	5,38%	5,43%	5,31%	5,29%	5,96%	5,80%	5,51%
Bearbeitung	3,72%	3,69%	3,68%	3,71%	4,07%	3,91%	3,87%	4,28%	4,10%	4,05%
Verzinkung	8,22%	7,45%	7,63%	7,36%	7,29%	6,84%	6,71%	6,71%	6,48%	6,16%
Prod. Halbteil	61,63%	62,87%	64,60%	65,85%	65,34%	66,06%	67,20%	72,84%	73,52%	74,32%

Figure 31: Dominance analysis – production of PERT

PERT	PERT
PERT [MJ]	PERT [MJ]
Infrastruktur	Infrastructure
Produktionsabfälle	Production waste
Transporte	Transport
Zusätzliches	Additional
PUR-Beschichtung	PUR coating
Reifehalle	Curing chamber
Zementierung	Cement lining
Bearbeitung	Processing
Verzinkung	Zinc spray
Prod. Halbteil	Semi-finished part prod.

Around 65% to 77% of the renewable primary energy requirement is attributable to the production of the semi-finished part.

Due to the dominance of semi-finished part production in the results for total production, this is analysed in detail for the nominal diameter DN400 as an example.



	GWP	ODP	AP	EP	POCP	ADPE	ADPF	PENRT	PERT
Infrastruktur	0,31%	0,31%	0,84%	0,45%	0,40%	24,59%	0,30%	0,31%	0,29%
Produktionsabfälle	0,72%	2,09%	0,72%	0,27%	0,43%	3,95%	1,08%	1,04%	0,13%
Wasserbedarf	0,07%	0,12%	0,17%	0,18%	0,05%	0,08%	0,08%	0,13%	0,25%
Transporte	3,46%	9,70%	3,94%	1,70%	2,18%	18,47%	5,09%	5,02%	1,17%
Wärmebhandlung	11,15%	22,04%	4,20%	1,66%	2,83%	1,65%	18,45%	18,86%	1,49%
Gießerei	3,78%	1,94%	7,74%	3,90%	4,26%	24,68%	4,24%	4,02%	4,66%
Konverter	10,19%	6,98%	15,60%	13,11%	12,07%	7,31%	11,50%	10,76%	6,25%
Rinnenofen	6,03%	6,42%	12,45%	18,71%	2,94%	6,15%	6,08%	7,90%	61,11%
Kupolofen	64,29%	50,41%	54,34%	60,02%	74,85%	13,11%	53,19%	51,96%	24,64%

Figure 32: Dominance analysis – production of semi-finished part DN400

Produktion Halbteil DN400	Production of semi-finished part DN400
GWP [kg…	GWP [kg CO_2 equiv.]
Infrastruktur	Infrastructure
Produktionsabfälle	Production waste
Wasserbedarf	Water demand
Transporte	Transport
Wärmebehandlung	Annealing
Giesserei	Casting
Konverter	Converter
Rinnenofen	Holding furnace
Kupolofen	Cupola furnace

Figure 32 shows dominance of the cupola furnace process for almost all indicators. The exceptions here are ADPE (strong influence of the infrastructure and the casting) and PERT (strong influence of the holding furnace).

7 References

OENORM EN ISO 14025: 2010 07 01 Environmental labels and declarations – Type III environmental declarations – Principles and procedures

OENORM EN ISO 14040: 2009 11 01 Environmental management – Life cycle assessment – Principles and framework

OENORM EN ISO 14044: 2006 10 01 Environmental management – Life cycle assessment – Requirements and guidelines

OENORM EN 15804: 2014 04 15 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

General rules for the life cycle assessment and the requirements for the background report – PCR Part A, 16th edition, April 2018, Bau EPD GmbH

Requirements for an EPD for cast iron construction products – PCR Part B, version: 1.4 from 07.06.2019, Bau EPD GmbH

8 Lists and glossary

8.1 List of figures

8.2 List of tables

8.3 Abbreviations

EPD	Environmental product declaration
PCR	Product category rules
LCA	Life cycle assessment
LCI	Life cycle inventory analysis
LCIA	Life cycle impact assessment
RSL	Reference service life
ESL	Estimated service life
EPBD	Energy Performance of Buildings Directive
GWP	Global warming potential
ODP	Depletion potential of the stratospheric ozone layer
AP	Acidification potential of soil and water
EP	Eutrophication potential
POCP	Formation potential of tropospheric ozone
ADP	Abiotic depletion potential

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