# ENVIRONMENTAL PRODUCT DECLARATION

# NEEDLEFELT

FORBO FLOORING SYSTEMS
NEEDLEFELT FLOOR COVERING

Showtime Metropolis 06 - 939202

FLOORING SYSTEMS

Measured pedestrian-noise levels of between 19 and 22 dB mean reduced ambient noise, making needle felt ideal for use in places which require a tranquil atmosphere and a minimum of noise distraction, such as offices. The textile look and typical range of coloring will blend harmoniously and inadvertently into any interior-design scheme. Needle felt often provides a cost-efficient alternative to conventional broadloom carpeting in heavily-used areas that require a practical and durable floor covering.

Forbo was the first flooring manufacturer to publish a complete Life Cycle Assessment (LCA) report verified by CML in 2000.In addition Forbo is now to publish Environmental Product Declarations (EPD) for all products including full LCA reports. This EPD is using all recognized flooring Product Category Rules and is including additional information to show the impacts on human health and eco-toxicity. By offering the complete story we hope that our stakeholders will be able to use this document as a tool that will translate the environmental performance of Needlefelt into the true value and benefits to all our customers and stakeholders alike.

For more information visit;
www.forbo-flooring.com

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

This declaration is an environmental product declaration (EPD) in accordance with ISO 14025. EPDs rely on Life Cycle Assessment (LCA) to provide information on a number of environmental impacts of products over their life cycle. Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc. Accuracy of Results: EPDs regularly rely on estimations of impacts, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. Comparability: EPDs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. EPDs from different programs may not be comparable.

| | |
|---|---|
| PROGRAM OPERATOR | UL Environment<br>333 Pfingsten Road<br>Northbrook, IL 60611 |
| DECLARATION HOLDER | Forbo Flooring B.V.<br>Industrieweg 12<br>P.O. Box 13<br>NL-1560 AA Krommenie |
| DECLARATION NUMBER | 4788294459.118.1 |
| DECLARED PRODUCT | Needlefelt Floor Covering |
| REFERENCE PCR | EN 16810: Resilient, Textile and Laminate floor coverings – Environmental product declarations – Product category rules |
| DATE OF ISSUE | January 1, 2019 |
| PERIOD OF VALIDITY | 5 Years |
| CONTENTS OF THE DECLARATION | Product definition and information about building physics<br>Information about basic material and the material's origin<br>Description of the product's manufacture<br>Indication of product processing<br>Information about the in-use conditions<br>Life cycle assessment results<br>Testing results and verifications |

| | |
|---|---|
| The PCR review was conducted by: | PCR Review Panel |
| This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories<br>☐ INTERNAL ☒ EXTERNAL | Grant R. Martin, UL Environment |
| This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by: | Thomas P. Gloria, Industrial Ecology Consultants |

This EPD conforms with EN 15804

# Product Definition

## Product Classification and description

This declaration covers a broad range of designs and colors. Needle felt is a floor covering complying with all the requirements of EN 1470 : Textile floor coverings - Classification of needled floor coverings except for needled pile floor coverings.
The key raw materials include fibers (polyamide, polyester), water-based inks and latex.

Needle felt is produced by Forbo Flooring and is sold worldwide. This declaration refers to Needle felt covering a broad range of designs and colours :

Forte, Forte Graphic, Markant, Markant Graphic, Akzent, Showtime Experience, Showtime Nuance

Needle felt floor is build up in 2 layers :

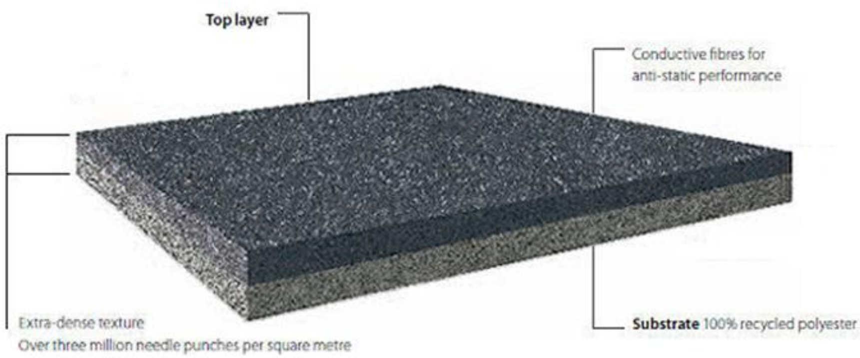



***Figure 1: Typical construction***

1. **Top layer :** This layer consists of polyamide and has an extra dense texture over 3 million needle punches per square meter. Conductive fibers guarantee anti-static performance.
2. **Underlayer** : This layer consists of 100% recycled polyester.

The total construction can be half bath or full impregnated.

This declaration refers to the declared/functional unit of 1 $m^2$ installed flooring product.

## Range of application

Needle felt is classified in accordance with EN 1470 to be installed in the following use areas defined in ISO 10874 :

| Area of application | | |
|---|---|---|
| **Domestic** | Class 23 | |
| **Commercial** | Class 32 | Class 33 |

## Product Standard

The products considered in this EPD have the following technical specifications:

- Meets or exceeds all technical requirements in EN 1470 : Textile floor coverings - Classification of needled floor coverings except for needled pile floor coverings.

CE

Needlefelt meets the requirements of EN 14041

| | | |
|---|---|---|
| EN 13501-1 | Reaction to fire | $B_{fl}$ – s1 |
| EN ISO 6356 | Body voltage | < 2 kV |
| EN ISO10456 | Thermal conductivity | 0,06 W/mK |

## Accreditation

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems
- SA 8000 Social Accountability International

ISO 9001 ISO 14001 OHSAS 18001 SA 8000

## Delivery Status

*Table 1: Specification of delivered product*

| Characteristics | Nominal Value | Unit |
|---|---|---|
| Product thickness | min : 3.8 / max : 6.5 | mm |
| Product Weight | min : 800 / max : 1500 | g/m² |
| Rolls Width<br>Length | 2.00<br>30 / 40 | Meter |

## Material Content

### Material Content of the Product

*Table 2: Composition of Needlefelt*

| Component | Material | Availability | Mass % | Origin of raw material |
|---|---|---|---|---|
| **Staple fiber** | Nylon 6<br>Polypropylene<br>PET | Limited<br>Limited<br>Limited | 39<br>2<br>44 | Europe<br>Europe<br>Europe |
| **Binder** | Carboxylated SBR latex | Limited | 11 | Europe |
| **Decorating** | Coloring agents, antifoam, additives, lubricant | Limited | 0.05 | Europe |
| **Substrate** | PE film | Limited | 4 | Europe |

### Production of Main Materials

**Nylon 6 :** Polyamide 6 is obtained by ring opening polymerization of caprolactam.
**PET :** Polyethylene Terephthalate is obtained by polycondensation of ethylene glycol and dimethyl terephthalate or terephthalic acid.
**Polypropylene :** Also known as polypropene, is a thermoplastic polymer used in a wide variety of applications. It is produced via chain-growth polymerization from the monomer propylene.
**PE film :** used as a substrate, provides better dimensional stability during processing.
**Carboxylated SBR latex :** made by polymerization of styrene and butadiene with several per cent of carboxylic acid.
**Lubricant :** Derivatives of ethers.
**Additives :** Various chemicals.

## Production of the Floor Covering

Needle felt is produced in several stages starting with the needle punching of the underlayer (consists of consolidating a sheet of fibers by making penetrations of special needles). The underlayer is needle punched with the same technology. These two layers are needle punched together. A next stage (depending on the product) is printing : the design is printed with environmentally friendly water-based inks.
Then the product is sent to the finishing line: a latex is deposited on the back of the product and goes between two cylinders which regulates penetration of the latex. Inspection is done and edges are cut (trimmings and rejected product are reused). Finally the floor covering is cut to length into rolls and is sent to warehouse department.

### Health, Safety and Environmental Aspects during Production

- ISO 14001 Environmental Management System
- SA 8000 Social Accountability standard
- OHSAS 18001 Health & Safety Management System

### Production Waste

Rejected material and the cuttings of the trimming stage are reused in the manufacturing process. Packaging materials are collected separately and externally recycled.

## Delivery and Installation of the Floor Covering

### Delivery

A worldwide distribution by truck and container ship is considered. On average every square meter of Needlefelt is transported as follows:

- Transport distance 40 t truck — 694 km
- Transport distance 7.5t truck (Fine distribution) — 257 km
- Capacity utilization trucks (including empty runs) — 85 %
- Transport distance Ocean ship — 0 km
- Capacity utilization Ocean ship — 48%

### Installation

Because of the specific techniques used during the installation of Needlefelt, approximately 4% of the material is cut off as installation waste. For installation of Needlefelt on the floor a scenario has been modeled assuming 0.25 $kg/m^2$ of flooring adhesive is applied to the sub-floor.

Waste during the installation process may be recycled as floor covering through the manufacturers’ facilities or thermally recycled in a waste incineration plant. Since the major part of Needlefelt is sold in Europe, the European electricity grid mix is used in the calculations for the energy recovery during incineration.

## Health, Safety and Environmental Aspects during Installation

Forbo flooring recommends to use (low) zero emission adhesives for installing Needlefelt floorcovering.

### Waste

Waste during the installation process may be recycled as floor covering through the manufacturers’ facilities or disposed of via land fill or thermally recycled in a waste incineration plant.

## Packaging

The packaging can be collected separately and should be used in a local recycling process.

# Use stage

The service lifetime of a floor covering for a certain application on a floor is too widespread to give one common number. For this EPD model the reference service lifetime (RSL) is set to one year. This means that all impacts for the use phase are based on the cleaning and maintenance model for one year. Depending on the area of use, the technical lifetime advised by the manufacturer and the estimated time on the floor by the customer, the service lifetime can be determined. The use phase impacts should be calculated with the foreseen service life to arrive at the total environmental impact.

## Cleaning and Maintenance

| Level of use | Cleaning Process | Cleaning Frequency | Consumption of energy and resources |
|---|---|---|---|
| Commercial/Residential | Vacuuming | Twice a week | Electricity |
| | Wet Cleaning | Once a week | Hot water<br>Neutral detergent |

For the calculations the following cleaning regime is considered:

- Dry cleaning with a 1.5 kW vacuum cleaner for 0.21 min/m², twice a week. This equates to 0.55 kWh/m²*year.
- Once a week wet cleaning with 0.062 l/m² water and 0.0008 kg/m² detergent. This result in the use of 3.224 l/m²*year water and 0.04 kg/m²*year detergent. The wet cleaning takes place without power machine usage. Waste water treatment of the arising waste water from cleaning is considered (Data sourced from Forbo GABI model).

The cleaning regime that is recommended in practice will be highly dependent on the use of the premises where the floor covering is installed. In high traffic areas more frequent cleaning will be needed compared to areas where there is low traffic. The use of an entrance mat of at least four Needlefelts will reduce the cleaning frequency.
The cleaning regime used in the calculations is suitable for high traffic areas.

## Prevention of Structural Damage

All newly laid floor covering should be covered and protected with a suitable non-staining protective covering if other building activities are still in progress. Castor wheels should be suitable for textile floor coverings.

## Health Aspects during Usage

Needlefelt is in compliance with:

- AgBB/ABG requirements
- French act Grenelle: A+
- GUT

## End of Life

The deconstruction of installed Needlefelt from the floor is done mechanically and the electrical energy needed for this is estimated to be 0.03 kWh/sqm. This amount of energy is included into the calculations.
For the End of Life stage 100% incineration is taken into account, the average distance to the incineration plant per lorry is set to 200 km.

## Life Cycle Assessment

A full Life Cycle Assessment has bee carried out according to ISO 14040 and ISO 14044.

The following Life Cycle Stages are assessed :

- A1-3 : Product Stage (Raw material acquisition, transportation to Manufacturing and Manufacturing)
- A4-5 : Construction stage (Transport Gate to User, Installation flooring)
- B2 : Use Stage (Maintenance of the floor)
- C1-4 : End of Life Stage (Deconstruction, transport, waste processing, disposal)
- D : Benefits and loads beyond the system boundary (Reuse, recovery, recycling potential)

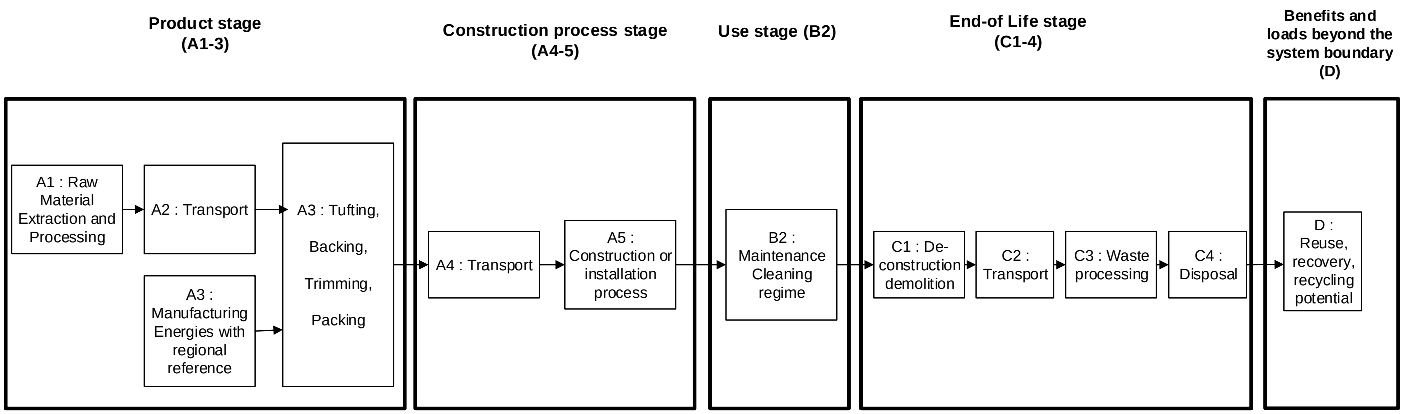



*Figure 2: Flow chart of the Life Cycle Assessment*

Comparisons of different floor coverings are only allowed, where EN 15804 consistent and/or preverified background data and EN 15804 consistent calculation methods and database versions are used and when the building context is taken into account, i.e. on the basis of the same use-classification (EN ISO 10874), same service life and comparable assumptions for the end of life.

### Description of the Declared Functional Unit

The functional unit is one square meter of installed product and the use stage is considered for one year of service life.

### Cut off Criteria

The cut-off criteria shall be 1% of renewable and non-renewable primary energy usage and 1% of the total mass of the unit process. The total neglected input flows per module shall be a maximum of 5% of energy usage and mass.

In practice, in this assessment, all data from the production data acquisition are considered, i.e. all raw materials used as per formulation, use of water, electricity and other fuels, the required packaging materials, and all direct production waste. Transport data on all considered inputs and output material are also considered.

## Allocations

In the present study some allocations have been made. Detailed explanations can be found in the chapters below.

## Co-product allocation

No co-product allocation occurs in the product system.

## Allocation of multi-input processes

The Production and End of Life stage include incineration plants. In these processes different products are treated together within a process. The allocation procedures followed in these cases are based on a physical classification of the mass flows or calorific values.

Credits from energy substitution are allocated to the production stage, because the gained energy from energy substitution is lower than the energy input in this stage. The same quality of energy is considered.

## Allocation procedure of reuse, recycling and recovery

The installation waste and end of life waste is fed into incineration processes. Incineration processes include cogeneration processes which give thermal and power energy as outputs. It is assumed that this recovered energy offsets that produced by the European average grid mix and thermal energy generation from natural gas.

## Description of the allocation processes in the LCA report

The description of allocation rules in of this LCA report meets the requirements of the PCR.

## LCA Data

As a general rule, specific data derived from specific production processes or average data derived from specific production processes have been used as the first choice as a basis for calculating an EPD.

For life cycle modeling of the considered products, the GaBi 6 Software System for Life Cycle Engineering, developed by Thinkstep has been used. All relevant LCA datasets are taken from the GaBi 6 software database. The datasets from the database GaBi are documented in the online documentation. To ensure comparability of results in the LCA, the basic data of GaBi database were used for energy, transportation and auxiliary materials.

## Data Quality

The requirements for data quality and LCA data correspond to the specifications of the PCR.

Foreground data are based on 1 year averaged data (year 2017). The reference ages of LCA datasets vary but are given in the table in the Appendix. The time period over which inputs to and outputs from the system is accounted for is 100 years from the year for which the data set is deemed representative. The technological LCA of the collected data reflects the physical reality of the declared product. The datasets are complete, conform to the system boundaries and the criteria for the exclusion of inputs and outputs and are geographical representative for the supply chain of Forbo flooring.

For life cycle modeling of the considered products the GaBi 6 Software System for Life Cycle Engineering, developed by Thinkstep, is used. All relevant LCA datasets are taken from the GaBi 6 software database. The last revision of the used data sets took place within the last 10 years.

## System Boundaries

Production Stage includes provision of all materials, products and energy, packaging processing and its transport, as well as waste processing up to the end-of waste state or disposal of final residues during the product stage.

Transport and Installation Stage includes provision of all materials, products and energy, as well as waste processing up to the end-of-waste state or disposal of final residues during the construction stage. These information modules also include all impacts and aspects related to any losses during this construction stage (i.e. production, transport, and waste processing and disposal of the lost products and materials). For the transportation a worldwide distribution is considered.

Use Stage includes provision and transport of all materials, products and related energy and water use, as well as waste processing up to the end-of-waste state or disposal of final residues during this part of the use stage. These information modules also include all impacts and aspects related to the losses during this part of the use stage (i.e. production, transport, and waste processing and disposal of the lost products and materials).

End of Life Stage includes provision and all transports, provision of all materials, products and related energy and water use. It also includes any declared benefits and loads from net flows leaving the product system that have not been allocated as co-products and that have passed the end-of-waste state in the form of reuse, recovery and/or recycling potentials.

## Power mix

The selection of LCA data for the electricity generation is in line with the PCR.

The products are manufactured in Reims, France. The GaBi 6 Hydropower dataset has therefore been used (reference year 2017). The energy supplier is providing Forbo with a certificate every year.

## $CO_2$-Certificates

No $CO_2$-certificates are considered in this study.

## Life Cycle Inventory Analysis

In table 3 the environmental impacts for one lifecycle are presented for Needlefelt. In table 4 the environmental impacts are presented for all the lifecycle stages.

Table 3: Results of the LCA – Environmental impacts one lifecycle (one year) – Needlefelt

| Impact Category : CML 2001 – Jan. 2016 | Needlefelt | Unit |
|---|---|---|
| Global Warming Potential (GWP 100 years) | 1,11E+01 | kg CO2-Equiv. |
| Ozone Layer Depletion Potential (ODP. steady state) | 5,61E-10 | kg R11-Equiv. |
| Acidification Potential (AP) | 2,02E-02 | kg SO2-Equiv. |
| Eutrophication Potential (EP) | 3,51E-03 | kg Phosphate-Equiv. |
| Photochem. Ozone Creation Potential (POCP) | 2,27E-03 | kg Ethene-Equiv. |
| Abiotic Depletion Potential Elements (ADPE) | 2,40E-06 | kg Sb-Equiv. |
| Abiotic Depletion Potential Fossil (ADPF) | 1,61E+02 | [MJ] |

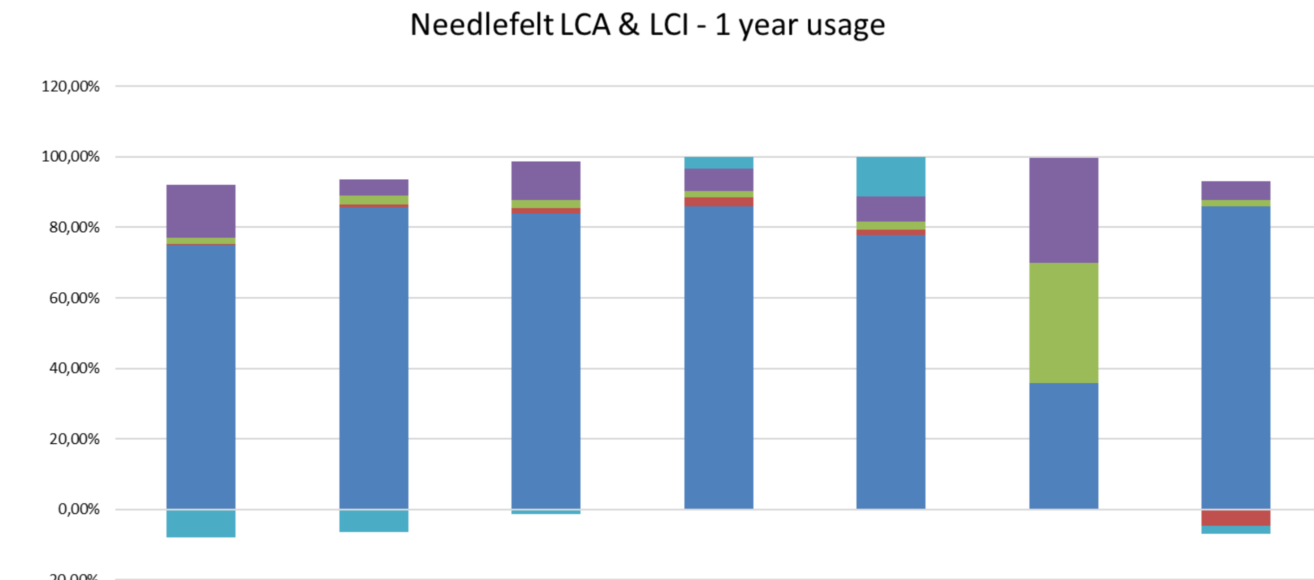
Table 4: Results of the LCA – Environmental impact for Needlefelt (one year)

| Impact Category : CML 2001 – Jan. 2016 | | Manufacturing | Installation | | Use (1yr) | End of Life | | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| Parameter | Unit | A1-3 | A4 | A5 | B2 | C1 | C2 | C3 | D |
| GWP | [kg $CO_2$-Eq.] | 8,62E+00 | 1,63E-01 | 2,48E-01 | 8,04E-01 | 2,57E-03 | 8,61E-03 | 2,15E+00 | -9,23E-01 |
| ODP | [kg CFC11-Eq.] | 2,03E-10 | 2,31E-15 | 1,92E-10 | 1,68E-10 | 1,14E-14 | 2,35E-16 | 4,95E-14 | -2,02E-12 |
| AP | [kg $SO_2$-Eq.] | 1,74E-02 | 3,13E-04 | 4,68E-04 | 2,27E-03 | 7,31E-06 | 2,09E-05 | 1,24E-03 | -1,56E-03 |
| EP | [kg $PO_4^{3-}$- Eq.] | 3,02E-03 | 8,10E-05 | 7,02E-05 | 2,16E-04 | 6,85E-07 | 5,30E-06 | 2,83E-04 | -1,68E-04 |
| POCP | [kg Ethen Eq.] | 2,26E-03 | -1,24E-04 | 4,52E-05 | 1,43E-04 | 4,57E-07 | -7,23E-06 | 7,37E-05 | -1,22E-04 |
| ADPE | [kg Sb Eq.] | 2,14E-06 | 6,95E-09 | 5,07E-08 | 4,26E-07 | 1,37E-09 | 7,06E-10 | 3,36E-08 | -2,62E-07 |
| ADPF | [MJ] | 1,58E+02 | 1,15E+00 | 4,74E+00 | 8,57E+00 | 2,74E-02 | 1,17E-01 | 7,23E-01 | -1,27E+01 |

GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources

The relative contribution of each process stage to each impact category for Needlefelt is shown in figure 3.

Figure 3: relative contribution of each process stage to each impact category for Needlefelt for a one year usage.




| | Abiotic Depletion (Elements) | Abiotic Depletion (Fossil) | Acidification Potential | Eutrophication Potential | Global Warming Potential | Ozone Layer Depletion Potential | Photochem. Ozone Creation Potential |
|---|---|---|---|---|---|---|---|
| End of Life | -7,94% | -6,42% | -1,41% | 3,45% | 11,18% | -0,35% | -2,10% |
| Use | 14,95% | 4,65% | 10,94% | 6,16% | 7,26% | 29,74% | 5,44% |
| Installation | 1,78% | 2,57% | 2,26% | 2,00% | 2,24% | 33,98% | 1,72% |
| Transport | 0,24% | 0,62% | 1,51% | 2,31% | 1,47% | 0,00% | -4,72% |
| Production | 75,09% | 85,73% | 83,88% | 86,08% | 77,85% | 35,93% | 86,02% |

## Interpretation

The interpretation of the results has been carried out considering the assumptions and limitations declared in the EPD, both methodology- and data-related for a one year usage.

In all of the impact categories the production stage has the main contribution to the overall impact. The raw material supply is the key contributor for all of these impact categories with a share of 94 – 100% of the total impact of the production stage mainly coming from PA 6 and PET fibers used for the production of Needlefelt.

Although Forbo declares in the EPD a worldwide distribution the transport by container ship is negligible, so the transport stage has a limited effect on most of the impacts. Only AP, EP and GWP have a minor impact for this life cycle stage.

For AP, EP, GWP, POCP, and ADPF the adhesive as main contributor for the flooring installation has a minor impact of 2 – 3% of the total environmental impact of Needlefelt. In this life cycle stage major impact of 34% is coming from ODP with the adhesive as the main contributor.

In the Use stage  a significant share is seen for ADPE, ADPF, AP, EP, GWP and POCP between 5 to 15% of the total impacts. This is almost completely caused by the electricity needed to vacuum the floor. The impact for ODP is quite large with 30% caused by the detergent used to clean the floor.
The cleaning regime used in the calculations is a worst-case scenario which will be in practice almost always be lower.

Energy recovery from incineration and the respective energy substitution at the end of life results in a credit for ADPE, ADPF, AP and POCP in the End of Life stage. For ODP the End of Life stage has a very small impact on the total. This is mainly due to the fact that the waste at the End of Life stage is considered as being incinerated.

For GWP and EP the End of Life stage has got a minor to significant influence of respectively 3.5 and 11% on the total impacts of these impact categories. Also for these three categories this is caused by the incineration of the waste at the End of Life stage.

## Resource use

In table 5 the parameters describing resource use are presented for all the lifecycle stages for a one year usage.

Table 5: Results of the LCA – Resource use for Needlefelt (one year)

| | | Manufacturing | Installation | | Use (1yr) | End of Life | | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Unit** | **A1-3** | **A4** | **A5** | **B2** | **C1** | **C2** | **C3** | **D** |
| PERE | [MJ] | 1,53E+01 | - | - | - | - | - | - | - |
| PERM | [MJ] | 0,00E+00 | - | - | - | - | - | - | - |
| PERT | [MJ] | 1,53E+01 | 6,38E-02 | 1,69E-01 | 5,47E+00 | 1,77E-02 | 6,47E-03 | 9,39E-02 | -3,13E+00 |
| PENRE | [MJ] | 1,33E+02 | - | - | - | - | - | - | - |
| PENRM | [MJ] | 3,78E+01 | - | - | - | - | - | - | - |
| PENRT | [MJ] | 1,71E+02 | 1,16E+00 | 4,85E+00 | 1,47E+01 | 4,70E-02 | 1,17E-01 | 8,12E-01 | -1,62E+01 |
| SM | [kg] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| RSF | [MJ] | 1,56E-09 | 6,25E-30 | 2,10E-21 | 2,68E-25 | 0,00E+00 | 6,34E-31 | 3,63E-23 | 0,00E+00 |
| NRSF | [MJ] | 1,83E-08 | 9,48E-29 | 2,46E-20 | 3,15E-24 | 6,98E-32 | 9,62E-30 | 4,26E-22 | -1,23E-29 |
| FW | [$m^3$] | 3,89E-01 | 1,18E-04 | 8,55E-04 | 7,47E-03 | 2,41E-05 | 1,19E-05 | 5,83E-03 | -4,27E-03 |

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

### Waste categories and output flows

In table 6 other environmental information describing different waste categories and output flows are presented for all the lifecycle stages.

Table 6: Results of the LCA – Output flows and Waste categories for Needlefelt (one year)

| | | Manufacturing | Transport | Installation | Use (1yr) | End of Life/credits | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Unit** | **A1-3** | **A4** | **A5** | **B2** | **C1** | **C2** | **C3** | **D** |
| HWD | [kg] | 6,18E-08 | 6,69E-08 | 1,46E-09 | 6,84E-09 | 2,20E-11 | 6,79E-09 | 6,62E-10 | -6,59E-09 |
| NHWD | [kg] | 1,40E-01 | 9,69E-05 | 1,68E-03 | 1,10E-02 | 3,31E-05 | 9,83E-06 | 1,70E-02 | -6,95E-03 |
| RWD | [kg] | 5,18E-03 | 1,58E-06 | 4,21E-05 | 2,41E-03 | 7,78E-06 | 1,61E-07 | 3,52E-05 | -1,38E-03 |
| CRU | [kg] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| MFR | [kg] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| MER | [kg] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| EE Power | [MJ] | 0,00E+00 | 0,00E+00 | 8,60E-02 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 3,85E+00 | 0,00E+00 |
| EE Thermal energy | [MJ] | 0,00E+00 | 0,00E+00 | 1,55E-01 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 6,93E+00 | 0,00E+00 |

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; EE = Exported energy per energy carrier

## Additional Environmental Information

To be fully transparant Forbo Flooring does not only want to declare the environmental impacts required in the PCR, but also the impacts on human health and eco-toxicity. Furthermore the outcome of the calculations according to the european Standard EN15804 are published in this section.

### Toxicity

For this calculations the USEtoxTM model is used as being the globally recommended preferred model for characterization modeling of human and eco-toxic impacts in LCIA by the United Nations Environment Programme SETAC Life Cycle Initiative.

According to the "ILCD Handbook: Recommendations for Life Cycle Impact Assessment in the European context" the recommended characterization models and associated characterization factors are classified according to their quality into three levels:

- Level I (recommended and satisfactory),
- level II (recommended but in need of some improvements)
- level III (recommended, but to be applied with caution).

A mixed classification sometimes is related to the application of the classified method to different types of substances. USEtoxTM is classified as Level II / III, unlike for example the CML impact categories which are classified as Level I.

Table 7: Results of the LCA – Environmental impacts one lifecycle (one year) – Needlefelt

| **Impact Category : USEtox** | **Needlefelt** | **Unit** |
|---|---|---|
| Eco toxicity | 2,58E-02 | PAF m3.day |
| Human toxicity, cancer | 3,78E-10 | Cases |
| Human toxicity, non-canc. | 4,93E-11 | Cases |

In the following table the impacts are subdivided into the lifecycle stages.

*Table 8: Results of the LCA – Environmental impact for Needlefelt (one year)*

| Impact Category : USEtox | Unit | Production | Transport | Installation | Use (1yr) | End of Life |
|---|---|---|---|---|---|---|
| Eco toxicity | PAF m3.day | 2,44E-02 | 2,71E-04 | 4,85E-04 | 1,36E-03 | -7,13E-04 |
| Human toxicity, cancer | cases | 3,90E-10 | 2,73E-13 | 8,62E-12 | 3,61E-11 | -5,68E-11 |
| Human toxicity, non-canc. | cases | 1,74E-11 | 1,31E-13 | 3,14E-11 | 1,89E-12 | -1,47E-12 |

### Interpretation

The interpretation of the results has been carried out considering the assumptions and limitations declared in the EPD, both methodology- and data-related for a one year usage.

For Eco Toxicity and Human Toxicity (Canc.) the production stage is the main contributor to the total overall impact. The raw material supply has a share of 99-100% of the production stage, mainly caused by the manufacturing of PA 6 and PET fibers.
For Human Toxicity (non canc.) the contribution to the production stage is 33% of the total and a share of 99% from producing PA 6 and PET fibers.

The transport stage is almost negligible for all Toxicity categories with a share of 0.06 to 1%, mainly caused by the use of diesel for the trucks.

The adhesive used for the installation of Needlefelt is the dominant contributor for all toxicity categories, where especially Human toxicity (non-canc.) is having a significant share of 60% over the total impacts of the life cycles.

The Use stage has a minor impact for all three impact categories. This is mainly due to the use of electricity for the cleaning of the floor. The cleaning regime used in the calculations is a worst-case scenario which will be in practice almost always be lower.

Energy recovery from incineration and the respective energy substitution at the end of life results in a credit for all three toxicity categories.

## References

| | |
|---|---|
| GaBi 6 2012 | THINKSTEP AG; GaBi 6: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2017. |
| GaBi 6 2012D | GaBi 6: Documentation of GaBi 6: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2017. http://documentation.gabi-software.com/ |
| UL Environment | UL Environment's Program Operator Rules |
| PE 2012<br>ILCD Handbook: General guide for Life Cycle Assessment - Detailed guidance | Description of Selected Impact Categories, THINKSTEP AG, 2012<br>European Commission-Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook- Recommendations for Life Cycle Impact Assessment in the European context. First edition November 2011. EUR 24571 EN. Luxemburg. Publications Office of the European Union; 2011 |
| **Standards and Laws** | |
| DIN EN ISO 14044 | Environmental management - Life cycle assessment - Requirements and guidelines (ISO 14044:2006); German and English version EN ISO 14044 |
| ISO 14025 2006 | DIN EN ISO 14025: Environmental labels and declarations — Type III environmental declarations — Principles and procedures |
| ISO 14040 2006 | Environmental management - Life cycle assessment - Principles and framework (ISO 14040); German and English version EN ISO 14040 |
| CEN/TR 15941 | Sustainability of construction works - Environmental product declarations - Methodology for selection and use of generic data; German version CEN/TR 15941 |
| EN 16810 | Resilient, textile and laminate floor coverings - Environmental product declarations - Product category rules |
| EN 15804 | EN 15804: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products |
| CPR | REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011 laying down harmonized conditions for the marketing of construction products and repealing Council Directive 89/106/EEC |
| EN-ISO 10874<br>EN 1470 | Resilient, textile and laminate floor coverings – Classification<br>Textile floor coverings - Classification of needled floor coverings except for needled pile floor coverings |

# Life Cycle Assessment

## Needlefelt

LCA study conducted by:
Forbo Flooring
Industrieweg 12
1566 JP Assendelft
The Netherlands

*December 2018*

Environment

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## Nomenclature

| Abbreviation | Explanation |
|---|---|
| ADPF | Abiotic Depletion Potential Fossil |
| ADPE | Abiotic Depletion Potential Elements |
| AP | Acidification Potential |
| BLBSB | Benefits and Loads Beyond the System Boundary |
| CRU | Components for re-use |
| EE | Exported energy per energy carrier |
| EP | Eutrophication Potential |
| EPD | Environmental Product Declaration |
| FCSS | Floor Covering Standard Symbol |
| FW | Use of net fresh water |
| GWP | Global Warming Potential |
| HWD | Hazardous waste disposed |
| LCA | Life Cycle Assessment |
| LCI | Life Cycle Inventory analysis |
| LCIA | Life Cycle Impact Assessment |
| MER | Materials for energy recovery |
| MFR | Materials for recycling |
| NRSF | Use of non-renewable secondary fuels |
| ODP | Ozone Layer Depletion Potential |
| PENRE | Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials |
| PENRM | Use of non-renewable primary energy resources used as raw materials |
| PENRT | Total use of non-renewable primary energy resources |
| PERE | Use of renewable primary energy excluding renewable primary energy resources used as raw materials |
| PERM | Use of renewable primary energy resources used as raw materials |
| PERT | Total use of renewable primary energy resources |
| PCR | Product Category Rules |
| POCP | Photochemical Ozone Creation Potential |
| RSF | Use of renewable secondary fuels |
| RSL | Reference Service Life |
| RWD | Radioactive waste disposed |
| SM | Use of secondary material |

## General

The present LCA study of the company Forbo Flooring, a manufacturer of resilient floor coverings, has been performed by Forbo Flooring and has been conducted according to the requirements of the European Standard EN15804 and EN16810 “Resilient, textile and laminate floor coverings – Environmental product declarations – Product category rules. The LCA report was sent to verification on 14/12/18.

## Scope

This document is the LCA report for the “Environmental Product Declaration” (EPD) of "Needlefelt".
The provision of an LCA report is required for each EPD of the EPD-program holder (UL Environment). This document shows how the calculation rules were applied and describes additional LCA information on the Life Cycle Assessment in accordance with the requirements of ISO 14040 series.

## Content, structure and accessibility of the LCA report

The LCA report provides a systematic and comprehensive summary of the project documentation supporting the verification of an EPD.
The report documents the information on which the Life Cycle Assessment is based, while also ensuring the additional information contained within the EPD complies with the requirements of ISO 14040 series.
The LCA report contains all of the data and information of importance for the details published in the EPD. Care is been given to all explanations as to how the data and information declared in the EPD arises from the Life Cycle Assessment.
The verification of the EPD is aligned towards the structure of the rule document based on ISO 14025, EN15804 and EN 16810.

## Goal of the study

The reason for performing this LCA study is to publish an EPD based on EN 16810, EN 15804 and ISO 14025.
This study contains the calculation and interpretation of the LCA results for Needlefelt complying with EN 1470 Textile floor coverings - Classification of needled floor coverings except for needled pile floor coverings.

Manufactured by
Forbo Sarlino S.A.S.
63, rue Gosset
B.P. 2717
FR-51055 Reims Cedex
France
The following life cycle stages were considered:

- Product stage
- Transport stage
- Installation stage
- Use stage
- End-of-life stage
- Benefits and loads beyond the product system boundary

The main purpose of EPD is for use in business-to-business communication. As all EPD are publicly available on the website of UL Environment and therefore are accessible to the end consumer they can also be used in business-to-consumer communication.
The intended use of the EPD is to communicate environmentally related information and LCA results to support the assessment of the sustainable use of resources and of the impact of construction works on the environment

## Scope of the study

**Declared / functional unit**

The declaration refers to the declared/functional unit of 1m² installed flooring product.

**Declaration of construction products classes**

The LCA report refers to a manufacturer declaration of type 1a): Declaration of a specific product from a manufacturer's plant.
Needlefelt Textiles are also known under the following brand names:

Forte, Forte Graphic, Markant, Markant Graphic, Akzent, Showtime Experience, Showtime Nuance

Needlefelt is produced at the following manufacturing site:
Forbo Sarlino S.A.S.
63, rue Gosset
B.P. 2717
FR-51055 Reims Cedex
France

## Product Definition

**Product Classification and description**

This declaration covers a broad range of designs and colors. Needle felt is a floor covering complying with all the requirements of EN 1470 : Textile floor coverings - Classification of needled floor coverings except for needled pile floor coverings.
The key raw materials include fibers (polyamide, polyester), water-based inks and latex.

Needle felt is produced by Forbo Flooring and is sold worldwide. This declaration refers to Needle felt covering a broad range of designs and colours :

Forte, Forte Graphic, Markant, Markant Graphic, Akzent, Showtime Experience, Showtime Nuance

Needle felt floor is build up in 2 layers :

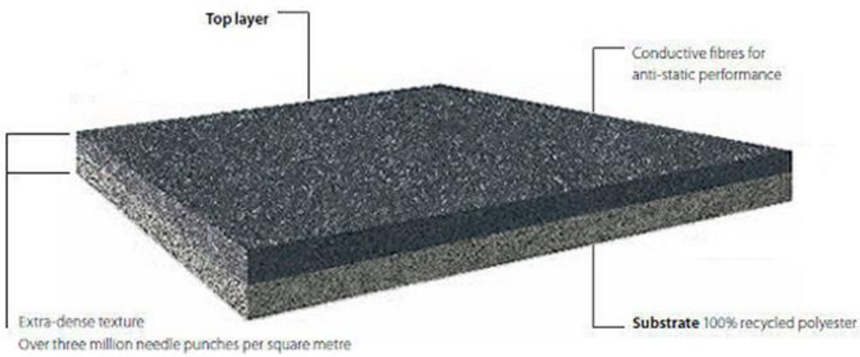



***Figure 1: Typical construction***

1. **Top layer :** This layer consists of polyamide and has an extra dense texture over 3 million needle punches per square meter. Conductive fibers guarantee anti-static performance.
2. **Underlayer** : This layer consists of 100% recycled polyester.

The total construction can be half bath or full impregnated.

This declaration refers to the declared/functional unit of 1 m$^2$ installed flooring product.

Needlefelt
Needlefelt Floor Covering

According to ISO 14025 and EN 15804

## Range of application

Needle felt is classified in accordance with EN 1470 to be installed in the following use areas defined in ISO 10874 :

| Area of application | | |
|---|---|---|
| **Domestic** | Class 23 | |
| **Commercial** | Class 32 | Class 33 |

## Product Standard

The products considered in this EPD have the following technical specifications:

- Meets or exceeds all technical requirements in EN 1470 : Textile floor coverings - Classification of needled floor coverings except for needled pile floor coverings.

CE

Needlefelt meets the requirements of EN 14041

| | | |
|---|---|---|
| EN 13501-1 | Reaction to fire | $B_{fl}$ – s1 |
| EN ISO 6356 | Body voltage | < 2 kV |
| EN ISO10456 | Thermal conductivity | 0,06 W/mK |

## Accreditation

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems
- SA 8000 Social Accountability International

## Delivery status

| Characteristics | Nominal Value | Unit |
|---|---|---|
| Characteristics | Nominal Value | Unit |
| Product thickness | min : 3.8 / max : 6.5 | mm |
| Product Weight | min : 800 / max : 1500 | $g/m^2$ |
| Rolls Width<br>Length | 2.00<br>30 / 40 | Meter |

FLOORING SYSTEMS

Needlefelt
Needlefelt Floor Covering

According to ISO 14025 and EN 15804

## Material Content

| Component | Material | Availability | Mass % | Origin of raw material |
|---|---|---|---|---|
| **Staple fiber** | Nylon 6<br>Polypropylene<br>PET | Limited<br>Limited<br>Limited | 39<br>2<br>44 | Europe<br>Europe<br>Europe |
| **Binder** | Carboxylated SBR latex | Limited | 11 | Europe |
| **Decorating** | Coloring agents, antifoam, additives, lubricant | Limited | 0.05 | Europe |
| **Substrate** | PE film | Limited | 4 | Europe |

## Production of Main Materials

**Nylon 6 :** Polyamide 6 is obtained by ring opening polymerization of caprolactam.
**PET :** Polyethylene Terephthalate is obtained by polycondensation of ethylene glycol and dimethyl terephthalate or terephthalic acid.
**Polypropylene :** Also known as polypropene, is a thermoplastic polymer used in a wide variety of applications. It is produced via chain-growth polymerization from the monomer propylene.
**PE film :** used as a substrate, provides better dimensional stability during processing.
**Carboxylated SBR latex :** made by polymerization of styrene and butadiene with several per cent of carboxylic acid.
**Lubricant :** Derivatives of ethers.
**Additives :** Various chemicals.

## Production of the Floor Covering

Needle felt is produced in several stages starting with the needle punching of the underlayer (consists of consolidating a sheet of fibers by making penetrations of special needles). The underlayer is needle punched with the same technology. These two layers are needle punched together. A next stage (depending on the product) is printing : the design is printed with environmentally friendly water-based inks.
Then the product is sent to the finishing line: a latex is deposited on the back of the product and goes between two cylinders which regulates penetration of the latex. Inspection is done and edges are cut (trimmings and rejected product are reused). Finally the floor covering is cut to length into rolls and is sent to warehouse department.

## Health, Safety and Environmental Aspects during Production

- ISO 14001 Environmental Management System
- SA 8000 Social Accountability standard
- OHSAS 18001 Health & Safety Management System

## Production Waste

Rejected material and the cuttings of the trimming stage are reused in the manufacturing process. Packaging materials are collected separately and externally recycled.

## Delivery and Installation of the Floor Covering

### Delivery

A worldwide distribution by truck and container ship is considered. On average every square meter of Needlefelt is transported as follows:

- Transport distance 40 t truck 694 km
- Transport distance 7.5t truck (Fine distribution) 257 km
- Capacity utilization trucks (including empty runs) 85 %
- Transport distance Ocean ship 0 km
- Capacity utilization Ocean ship 48%

### Installation

Because of the specific techniques used during the installation of Needlefelt, approximately 4% of the material is cut off as installation waste. For installation of Needlefelt on the floor a scenario has been modeled assuming 0.25 kg/m$^2$ of flooring adhesive is applied to the sub-floor.

Waste during the installation process may be recycled as floor covering through the manufacturers' facilities or thermally recycled in a waste incineration plant. Since the major part of Needlefelt is sold in Europe, the European electricity grid mix is used in the calculations for the energy recovery during incineration.

## Health, Safety and Environmental Aspects during Installation

Forbo flooring recommends to use (low) zero emission adhesives for installing Needlefelt floorcovering.

### Waste

Waste during the installation process may be recycled as floor covering through the manufacturers' facilities or disposed of via land fill or thermally recycled in a waste incineration plant.

### Packaging

Cardboard tubes and packaging paper can be collected separately and should be used in a local recycling process. In the calculation model 100% incineration is taken into account for which there is a credit received.

## Use stage

The service lifetime of a floor covering for a certain application on a floor is too widespread to give one common number. For this EPD model the reference service lifetime (RSL) is set to one year. This means that all impacts for the use phase are based on the cleaning and maintenance model for one year. Depending on the area of use, the technical lifetime advised by the manufacturer and the estimated time on the floor by the customer, the service lifetime can be determined. The use phase impacts should be calculated with the foreseen service life to arrive at the total environmental impact.

### Cleaning and Maintenance

| Level of use | Cleaning Process | Cleaning Frequency | Consumption of energy and resources |
|---|---|---|---|
| Commercial/Residential/Industrial | Vacuuming | Twice a week | Electricity |
| | Damp mopping | Once a week | Hot water<br>Neutral detergent |

For the calculations the following cleaning regime is considered:

- Dry cleaning with a 1.5 kW vacuum cleaner for 0.21 min/m², twice a week. This equates to 0.55 kWh/m²*year.
- Once a week wet cleaning with 0.062 l/m² water and 0.0008 kg/m² detergent. This result in the use of 3.224 l/m²*year water and 0.04 kg/m²*year detergent. The wet cleaning takes place without power machine usage. Waste water treatment of the arising waste water from cleaning is considered.

The cleaning regime that is recommended in practice will be highly dependent on the use of the premises where the floor covering is installed. In high traffic areas more frequent cleaning will be needed compared to areas where there is low traffic. The use of an entrance mat of at least four Needlefelts will reduce the cleaning frequency.
The cleaning regime used in the calculations is suitable for high traffic areas and is a worst-case scenario.

### Prevention of Structural Damage

All newly laid floor covering should be covered and protected with a suitable non-staining protective covering if other building activities are still in progress. Use protective feet on chairs and tables to reduce scratching. Castor wheels should be suitable for resilient floor coverings

### Health Aspects during Usage

Needlefelt is complying with:

- AgBB requirements
- French act Grenelle: A+
- GUT

## End of Life

The deconstruction of installed Needlefelt from the floor is done mechanically and the electrical energy needed for this is estimated to be 0.03 kWh/sqm. This amount of energy is included into the calculations.
For the End of Life stage 100% incineration is taken into account, the average distance to the incineration plant or landfill facility per lorry is set to 200 km.

## Life Cycle Assessment

A full Life Cycle Assessment has bee carried out according to ISO 14040 and ISO 14044.

The following Life Cycle Stages are assessed :

- A1-3 : Product Stage (Raw material acquisition, transportation to Manufacturing and Manufacturing)
- A4-5 : Construction stage (Transport Gate to User, Installation flooring)
- B2 : Use Stage (Maintenance of the floor)
- C1-4 : End of Life Stage (Deconstruction, transport, waste processing, disposal)
- D : Benefits and loads beyond the system boundary (Reuse, recovery, recycling potential)

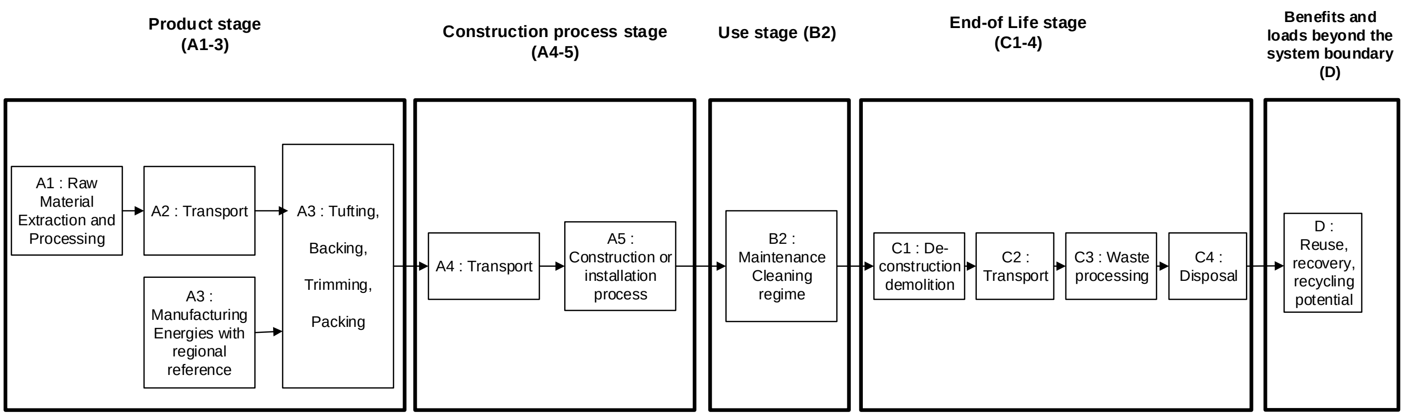



**Figure 2 : Flow chart of the Life Cycle Assessment**

Comparisons of different floor coverings are only allowed, where EN 15804 consistent and/or preverified background data and EN 15804 consistent calculation methods and database versions are used and when the building context is taken into account, i.e. on the basis of the same use-classification (EN ISO 10874), same service life and comparable assumptions for the end of life.

### Description of the declared Functional Unit

The functional unit is one square meter of installed product and the use stage is considered for one year of service life.

### Cut off Criteria

The cut-off criteria shall be 1% of renewable and non-renewable primary energy usage and 1% of the total mass of the unit process. The total neglected input flows per module shall be a maximum of 5% of energy usage and mass.

In practice, in this assessment, all data from the production data acquisition are considered, i.e. all raw materials used as per formulation, use of water, electricity and other fuels, the required packaging materials, and all direct production waste. Transport data on all considered inputs and output material are also considered.

### LCA Data

As a general rule, specific data derived from specific production processes or average data derived from specific production processes have been used as the first choice as a basis for calculating an EPD.

For life cycle modeling of the considered products, the GaBi 6 Software System for Life Cycle Engineering, developed by THINKSTEP, has been used. All relevant LCA datasets are taken from the GaBi 6 software database. The datasets from the database GaBi are documented in the online documentation. To ensure comparability of results in the LCA, the basic data of GaBi database were used for energy, transportation and auxiliary materials.

## Data Quality

The requirements for data quality and LCA data correspond to the specifications of the PCR.

Foreground data are based on 1 year averaged data (year 2017). The reference ages of LCA datasets vary but are given in the table in the Appendix. The time period over which inputs to and outputs from the system is accounted for is 100 years from the year for which the data set is deemed representative. The technological LCA of the collected data reflects the physical reality of the declared product. The datasets are complete, conform to the system boundaries and the criteria for the exclusion of inputs and outputs and are geographical representative for the supply chain of Forbo flooring.

For life cycle modeling of the considered products the GaBi 6 Software System for Life Cycle Engineering, developed by THINKSTEP, is used. All relevant LCA datasets are taken from the GaBi 6 software database. The last revision of the used data sets took place within the last 10 years.

*Table 1: LCA datasets used in the LCA model*

| Data set | Region | Reference year |
|---|---|---|
| Polypropylene fibers | Europe | 2018 |
| PET fibers | Europe | 2018 |
| Polyamide 6 fibers | Germany | 2010 |
| SBR Latex | Germany | 2012 |
| Inorganic pigment | Germany | 2010 |
| Polyester backing | Germany | 2018 |
| Proprietary mixtures & lubricants | Global | 2012 |
| Water (desalinated; deionized) | Germany | 2017 |
| Detergent (ammonia based) | Germany | 2007 |
| Tap water | Germany | 2017 |
| Adhesive for resilient flooring | Germany | 2012 |
| Waste incineration of Textiles | Europe | 2017 |
| Electricity from Hydro power | France | 2018 |
| Power grid mix | Europe | 2018 |
| Thermal energy from natural gas | France | 2018 |
| Thermal energy from natural gas | Europe | 2018 |
| Trucks | Global | 2018 |
| Municipal waste water treatment (Sludge incineration). | Europe | 2018 |
| Container ship | Global | 2018 |
| Diesel mix at refinery | Europe | 2018 |
| Heavy fuel oil at refinery (1.0wt.% S) | Europe | 2018 |
| Polyethylene film | Germany | 2018 |
| Cardboard | Europe | 2018 |
| Packing paper | Europe | 2018 |

The documentation of the LCA data sets can be taken from the GaBi documentation.

## System Boundaries

Production Stage includes provision of all materials, products and energy, packaging processing and its transport, as well as waste processing up to the end-of waste state or disposal of final residues during the product stage.

Transport and Installation Stage includes provision of all materials, products and energy, as well as waste processing up to the end-of-waste state or disposal of final residues during the construction stage. These information modules also include all impacts and aspects related to any losses during this construction stage (i.e. production, transport, and waste processing and disposal of the lost products and materials). For the transportation a worldwide distribution is considered.

Use Stage includes provision and transport of all materials, products and related energy and water use, as well as waste processing up to the end-of-waste state or disposal of final residues during this part of the use stage. These information modules also include all impacts and aspects related to the losses during this part of the use stage (i.e. production, transport, and waste processing and disposal of the lost products and materials).

End of Life Stage includes provision and all transports, provision of all materials, products and related energy and water use. It also includes any declared benefits and loads from net flows leaving the product system that have not been allocated as co-products and that have passed the end-of-waste state in the form of reuse, recovery and/or recycling potentials.

## Power mix

The selection of LCA data for the electricity generation is in line with the PCR.

The products are manufactured in Reims, France. The GaBi 6 Hydro power datasets has therefore been used (reference year 2017). The energy supplier is providing Forbo with a certificate every year.

## $CO_2$-Certificates

No $CO_2$-certificates are considered in this study.

## Allocations

In the present study some allocations have been made. Detailed explanations can be found in the chapters below.

### *Co-product allocation*

No co-product allocation occurs in the product system.

### *Allocation of multi-Input processes*

The Production and End of Life stage include incineration plants. In these processes different products are treated together within a process. The allocation procedures followed in these cases are based on a physical classification of the mass flows or calorific values.

Credits from energy substitution are allocated to the production stage, because the gained energy from energy substitution is lower than the energy input in this stage. The same quality of energy is considered.

### *Allocation procedure of reuse, recycling and recovery*

The installation waste and end of life waste can be fed into incineration processes. Incineration processes include cogeneration processes which give thermal and power energy as outputs. It is assumed that this recovered energy offsets that produced by the European average grid mix and thermal energy generation from natural gas.

### *Description of the allocation processes in the LCA report*

The description of allocation rules in of this LCA report meets the requirements of the PCR.

## Description of the unit processes in the LCA report

The modeling of the unit processes reported for the LCA are documented in a transparent way, respecting the confidentiality of the data present in the LCA report.

In the following tables the type and amount of the different input and output flows are listed for 1m² produced flooring; installed flooring includes the material loss during installation (4%):

*Table 2: Composition of Needlefelt*

| Process data | Unit | Needlefelt |
|---|---|---|
| Nylon 6 | kg/m2 | 0.48 |
| Polypropylene | kg/m2 | 0.03 |
| PET | kg/m2 | 0.54 |
| Carboxylated SBR latex | kg/m2 | 0.14 |
| Coloring agents, antifoam, additives, lubricant | kg/m2 | 0.001 |
| PE film | kg/m2 | 0.05 |

*Table 3: Production related inputs/outputs*

| Process data | Unit | Needlefelt |
|---|---|---|
| **INPUTS** | | |
| Needlefelt | kg | 1.63 |
| Electricity | MJ | 0.99 |
| Thermal energy from natural gas | MJ | 1.92 |
| **OUTPUTS** | | |
| Needlefelt | kg | 1.24 |
| Waste | kg | 0.39 |

*Table 4: Packaging requirements (per m² manufactured product)*

| Process data | Unit | Needlefelt |
|---|---|---|
| Polyethylene | kg | 0.0022 |
| Cardboard | kg | 0.0023 |
| Packing paper | kg | 0.016 |

*Table 5: Transport distances*

| Process data | Unit | Road | Truck size | Ship |
|---|---|---|---|---|
| Nylon 6 | km | 941 | 14 - 20t gross weight / 11,4t payload capacity | - |
| Polypropylene | km | 941 | | - |
| PET | km | 252 | | - |
| Carboxylated SBR latex | km | 1467 | | - |
| Coloring agents, antifoam, additives, lubricant | km | 272 | | - |
| PE film | km | 582 | | - |
| Polyethylene | km | 289 | | - |
| Cardboard | km | 215 | | |
| Packaging paper | km | 2740 | | |
| Transport to construction site :<br>-Transport distance 40 t truck | km | 951<br>694 | 34 - 40 t gross weight / 27t payload capacity<br>7,5 t - 12t gross | - |

| Process data | Unit | Road | Truck size | Ship |
|---|---|---|---|---|
| -Transport distance 7.5t truck (Fine distribution) | | 257 | weight / 5t payload capacity | |
| Waste transport to incineration | km | 200 | 7,5 t - 12t gross weight / 5t payload capacity | - |

*Table 6: Inputs/outputs from Installation*

| Process data | Unit | Needlefelt |
|---|---|---|
| **INPUTS** | | |
| Needlefelt | kg | 1.29 |
| Adhesive (30% water content)<br>- Water<br>- Acrylate co-polymer<br>- Styrene Butadiene co-polymer<br>- Limestone flour<br>- Sand | kg | 0.25 |
| **OUTPUTS** | | |
| Installed Needlefelt | kg | 1.24 |
| Installation Waste | kg | 0.05 |

*Table 7: Inputs from use stage (per $m^2$.year of installed product)*

| Process data | Unit | Needlefelt |
|---|---|---|
| Detergent | kg/year | 0.04 |
| Electricity | kWh/year | 0.55 |
| Water | kg/year | 3.224 |

*Table 8: Disposal*

| Process data | Unit | Needlefelt |
|---|---|---|
| Post-consumer Needlefelt to incineration | % | 100 |

## Life Cycle Inventory Analysis

In table 9 the environmental impacts for one lifecycle are presented for Needlefelt. In the table 10 the environmental impacts are presented for all the lifecycle stages.

Table 9: Results of the LCA – Environmental impacts one lifecycle (one year) – Needlefelt

| Impact Category : CML 2001 – April 2015 | Needlefelt | Unit |
|---|---|---|
| Global Warming Potential (GWP 100 years) | 1,11E+01 | kg CO2-Equiv. |
| Ozone Layer Depletion Potential (ODP. steady state) | 5,61E-10 | kg R11-Equiv. |
| Acidification Potential (AP) | 2,02E-02 | kg SO2-Equiv. |
| Eutrophication Potential (EP) | 3,51E-03 | kg Phosphate-Equiv. |
| Photochem. Ozone Creation Potential (POCP) | 2,27E-03 | kg Ethene-Equiv. |
| Abiotic Depletion Potential Elements (ADPE) | 2,40E-06 | kg Sb-Equiv. |
| Abiotic Depletion Potential Fossil (ADPF) | 1,61E+02 | [MJ] |

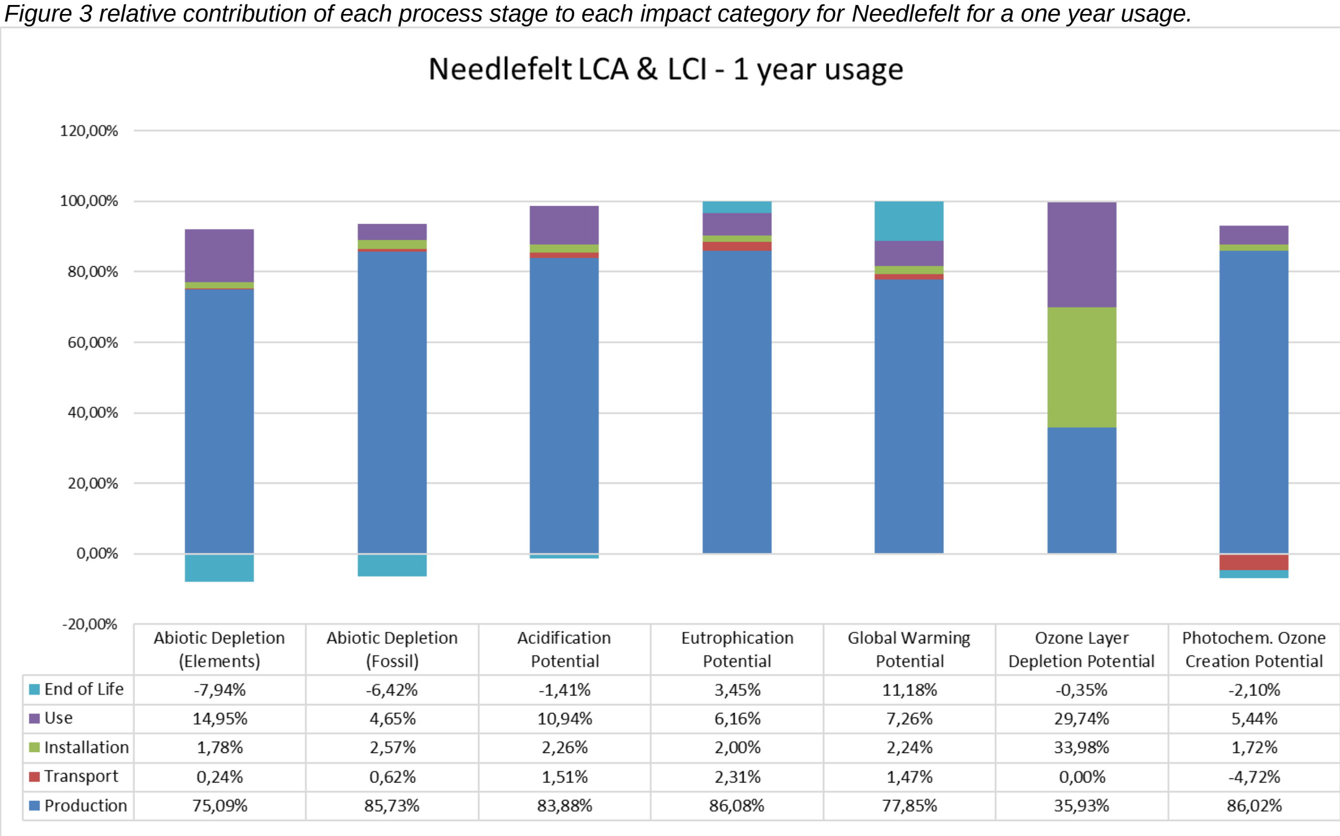
*Table 10: Results of the LCA – Environmental impact for Needlefelt (one year)*

| Impact Category : CML 2001 – April 2015 | | Manufacturing | Installation | | Use (1yr) | End of Life | | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Unit** | **A1-3** | **A4** | **A5** | **B2** | **C1** | **C2** | **C3** | **D** |
| GWP | [kg $CO_2$-Eq.] | 8,62E+00 | 1,63E-01 | 2,48E-01 | 8,04E-01 | 2,57E-03 | 8,61E-03 | 2,15E+00 | -9,23E-01 |
| ODP | [kg CFC11-Eq.] | 2,03E-10 | 2,31E-15 | 1,92E-10 | 1,68E-10 | 1,14E-14 | 2,35E-16 | 4,95E-14 | -2,02E-12 |
| AP | [kg $SO_2$-Eq.] | 1,74E-02 | 3,13E-04 | 4,68E-04 | 2,27E-03 | 7,31E-06 | 2,09E-05 | 1,24E-03 | -1,56E-03 |
| EP | [kg $PO_4^{3-}$- Eq.] | 3,02E-03 | 8,10E-05 | 7,02E-05 | 2,16E-04 | 6,85E-07 | 5,30E-06 | 2,83E-04 | -1,68E-04 |
| POCP | [kg Ethen Eq.] | 2,26E-03 | -1,24E-04 | 4,52E-05 | 1,43E-04 | 4,57E-07 | -7,23E-06 | 7,37E-05 | -1,22E-04 |
| ADPE | [kg Sb Eq.] | 2,14E-06 | 6,95E-09 | 5,07E-08 | 4,26E-07 | 1,37E-09 | 7,06E-10 | 3,36E-08 | -2,62E-07 |
| ADPF | [MJ] | 1,58E+02 | 1,15E+00 | 4,74E+00 | 8,57E+00 | 2,74E-02 | 1,17E-01 | 7,23E-01 | -1,27E+01 |

GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources

The relative contribution of each process stage to each impact category for Needlefelt is shown in figure 3.

*Figure 3 relative contribution of each process stage to each impact category for Needlefelt for a one year usage.*




## Interpretation

The interpretation of the results has been carried out considering the assumptions and limitations declared in the EPD, both methodology- and data-related for a <u>one year usage</u>.

In all of the impact categories the production stage has the main contribution to the overall impact. The raw material supply is the key contributor for all of these impact categories with a share of 94 – 100% of the total impact of the production stage mainly coming from PA 6 and PET fibers used for the production of Needlefelt.

Although Forbo declares in the EPD a worldwide distribution the transport by container ship is negligible, so the transport stage has a limited effect on most of the impacts. Only AP, EP and GWP have a minor impact for this life cycle stage.

For AP, EP, GWP, POCP, and ADPF the adhesive as main contributor for the flooring installation has a minor impact of 2 – 3% of the total environmental impact of Needlefelt. In this life cycle stage major impact of 34% is coming from ODP with the adhesive as the main contributor.

In the Use stage a significant share is seen for ADPE, ADPF, AP, EP, GWP and POCP between 5 to 15% of the total impacts. This is almost completely caused by the electricity needed to vacuum the floor. The impact for ODP is quite large with 30% caused by the detergent used to clean the floor.
The cleaning regime used in the calculations is a worst-case scenario which will be in practice almost always be lower.

Energy recovery from incineration and the respective energy substitution at the end of life results in a credit for ADPE, ADPF, AP and POCP in the End of Life stage. For ODP the End of Life stage has a very small impact on the total. This is mainly due to the fact that the waste at the End of Life stage is considered as being incinerated.

For GWP and EP the End of Life stage has got a minor to significant influence of respectively 3.5 and 11% on the total impacts of these impact categories. Also for these three categories this is caused by the incineration of the waste at the End of Life stage.

## Resource use

In table 11 the parameters describing resource use are presented for all the life cycle stages for a one year usage.

Table 11 : Results of the LCA – Resource use for Needlefelt (one year)

| | | Manufacturing | Installation | | Use (1yr) | End of Life | | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Unit** | **A1-3** | **A4** | **A5** | **B2** | **C1** | **C2** | **C3** | **D** |
| PERE | [MJ] | 1,53E+01 | - | - | - | - | - | - | - |
| PERM | [MJ] | 0,00E+00 | - | - | - | - | - | - | - |
| PERT | [MJ] | 1,53E+01 | 6,38E-02 | 1,69E-01 | 5,47E+00 | 1,77E-02 | 6,47E-03 | 9,39E-02 | -3,13E+00 |
| PENRE | [MJ] | 1,33E+02 | - | - | - | - | - | - | - |
| PENRM | [MJ] | 3,78E+01 | - | - | - | - | - | - | - |
| PENRT | [MJ] | 1,71E+02 | 1,16E+00 | 4,85E+00 | 1,47E+01 | 4,70E-02 | 1,17E-01 | 8,12E-01 | -1,62E+01 |
| SM | [kg] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| RSF | [MJ] | 1,56E-09 | 6,25E-30 | 2,10E-21 | 2,68E-25 | 0,00E+00 | 6,34E-31 | 3,63E-23 | 0,00E+00 |
| NRSF | [MJ] | 1,83E-08 | 9,48E-29 | 2,46E-20 | 3,15E-24 | 6,98E-32 | 9,62E-30 | 4,26E-22 | -1,23E-29 |
| FW | [m$^3$] | 3,89E-01 | 1,18E-04 | 8,55E-04 | 7,47E-03 | 2,41E-05 | 1,19E-05 | 5,83E-03 | -4,27E-03 |

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

## Waste categories and output flows

In table 12 other environmental information describing different waste categories and output flows are presented for all the life cycle stages.

Table 12: Results of the LCA – Output flows and Waste categories for Needlefelt (one year)

| | | Manufacturing | Transport | Installation | Use (1yr) | End of Life/credits | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Unit** | **A1-3** | **A4** | **A5** | **B2** | **C1** | **C2** | **C3** | **D** |
| HWD | [kg] | 6,18E-08 | 6,69E-08 | 1,46E-09 | 6,84E-09 | 2,20E-11 | 6,79E-09 | 6,62E-10 | -6,59E-09 |
| NHWD | [kg] | 1,40E-01 | 9,69E-05 | 1,68E-03 | 1,10E-02 | 3,31E-05 | 9,83E-06 | 1,70E-02 | -6,95E-03 |
| RWD | [kg] | 5,18E-03 | 1,58E-06 | 4,21E-05 | 2,41E-03 | 7,78E-06 | 1,61E-07 | 3,52E-05 | -1,38E-03 |
| CRU | [kg] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| MFR | [kg] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| MER | [kg] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| EE Power | [MJ] | 0,00E+00 | 0,00E+00 | 8,60E-02 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 3,85E+00 | 0,00E+00 |
| EE Thermal energy | [MJ] | 0,00E+00 | 0,00E+00 | 1,55E-01 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 6,93E+00 | 0,00E+00 |
| 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; EE = Exported energy per energy carrier | | | | | | | | | |

## Additional Environmental Information

To be fully transparant Forbo Flooring does not only want to declare the environmental impacts required in the PCR, but also the impacts on human health and eco-toxicity. Furthermore the outcome of the calculations according to the european Standard EN15804 are published in this section.

### Toxicity

For this calculations the USEtoxTM model is used as being the globally recommended preferred model for characterization modeling of human and eco-toxic impacts in LCIA by the United Nations Environment Programme SETAC Life Cycle Initiative.

According to the "ILCD Handbook: Recommendations for Life Cycle Impact Assessment in the European context" the recommended characterization models and associated characterization factors are classified according to their quality into three levels:

- Level I (recommended and satisfactory),
- level II (recommended but in need of some improvements)
- level III (recommended, but to be applied with caution).

A mixed classification sometimes is related to the application of the classified method to different types of substances. USEtoxTM is classified as Level II / III, unlike for example the CML impact categories which are classified as Level I.

Table 13: Results of the LCA – Environmental impacts one lifecycle (one year) – Needlefelt

| Impact Category : USEtox | Needlefelt | Unit |
|---|---|---|
| Eco toxicity | 2,58E-02 | PAF m3.day |
| Human toxicity, cancer | 3,78E-10 | Cases |
| Human toxicity, non-canc. | 4,93E-11 | Cases |

In the following table the impacts are subdivided into the lifecycle stages.

Table 14: Results of the LCA – Environmental impact for Needlefelt (one year)

| Impact Category : USEtox | Unit | Production | Transport | Installation | Use (1yr) | End of Life |
|---|---|---|---|---|---|---|
| Eco toxicity | PAF m3.day | 2,44E-02 | 2,71E-04 | 4,85E-04 | 1,36E-03 | -7,13E-04 |
| Human toxicity, cancer | cases | 3,90E-10 | 2,73E-13 | 8,62E-12 | 3,61E-11 | -5,68E-11 |
| Human toxicity, non-canc. | cases | 1,74E-11 | 1,31E-13 | 3,14E-11 | 1,89E-12 | -1,47E-12 |

## Interpretation

The interpretation of the results has been carried out considering the assumptions and limitations declared in the EPD, both methodology- and data-related for a one year usage.

For Eco Toxicity and Human Toxicity (Canc.) the production stage is the main contributor to the total overall impact. The raw material supply has a share of 99-100% of the production stage, mainly caused by the manufacturing of PA 6 and PET fibers.
For Human Toxicity (non canc.) the contribution to the production stage is 33% of the total and a share of 99% from producing PA 6 and PET fibers.

The transport stage is almost negligible for all Toxicity categories with a share of 0.06 to 1%, mainly caused by the use of diesel for the trucks.

The adhesive used for the installation of Needlefelt is the dominant contributor for all toxicity categories, where especially Human toxicity (non-canc.) is having a significant share of 60% over the total impacts of the life cycles.

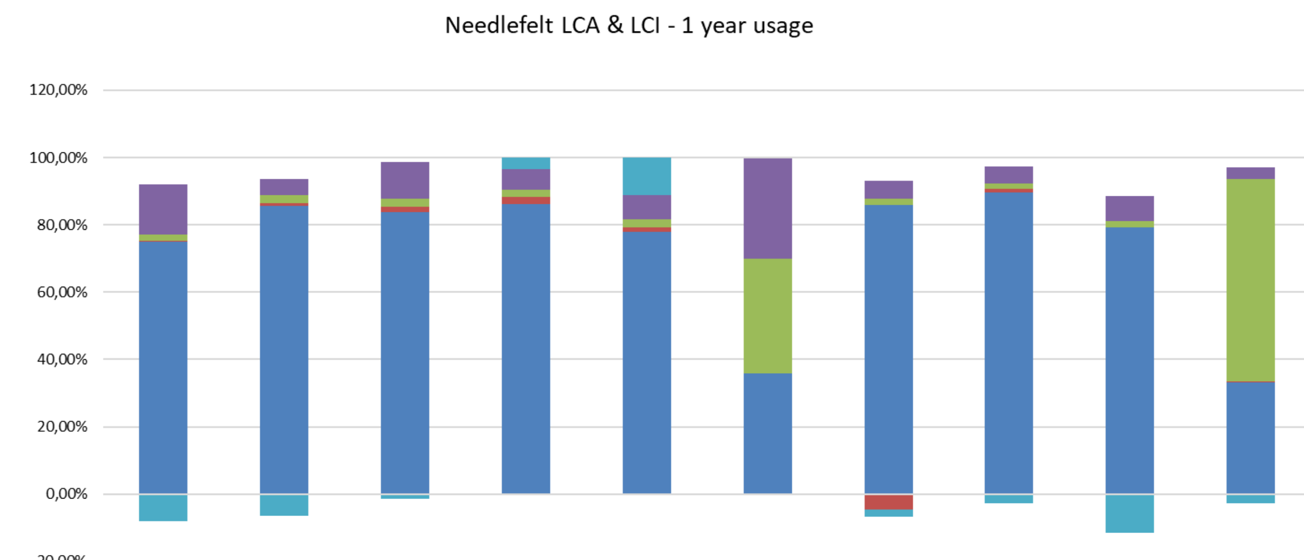
The Use stage has a minor impact for all three impact categories. This is mainly due to the use of electricity for the cleaning of the floor. The cleaning regime used in the calculations is a worst-case scenario which will be in practice almost always be lower.

Energy recovery from incineration and the respective energy substitution at the end of life results in a credit for all three toxicity categories.

## Interpretation main modules and flows

The interpretation of the main modules and flows contributing to the total impact in each category is presented in following figure and table.

*Figure 4: relative contribution of each process stage to each impact category for Needlefelt for a one year usage.*




| | Abiotic Depletion (Elements) | Abiotic Depletion (Fossil) | Acidification Potential | Eutrophication Potential | Global Warming Potential | Ozone Layer Depletion Potential | Photochem. Ozone Creation Potential | Ecotoxicity | Human toxicity, cancer | Human toxicity, non-canc. |
|---|---|---|---|---|---|---|---|---|---|---|
| End of Life | -7,94% | -6,42% | -1,41% | 3,45% | 11,18% | -0,35% | -2,10% | -2,62% | -11,55% | -2,82% |
| Use | 14,95% | 4,65% | 10,94% | 6,16% | 7,26% | 29,74% | 5,44% | 4,99% | 7,34% | 3,62% |
| Installation | 1,78% | 2,57% | 2,26% | 2,00% | 2,24% | 33,98% | 1,72% | 1,78% | 1,75% | 60,03% |
| Transport | 0,24% | 0,62% | 1,51% | 2,31% | 1,47% | 0,00% | -4,72% | 1,00% | 0,06% | 0,25% |
| Production | 75,09% | 85,73% | 83,88% | 86,08% | 77,85% | 35,93% | 86,02% | 89,62% | 79,30% | 33,28% |

*Table 15: Main modules and flows contributing to the total impact in each impact category for Needlefelt for a one year usage*

| Impact Category | Stage | Module | | Main contributor | Main contributing flows |
|---|---|---|---|---|---|
| GWP | Production | Raw Material Extraction | 8.37 kg $CO_2$-equiv. | PET (2.59 kg $CO_2$-eq.)<br>PA 6 (5.8 kg $CO_2$-eq.) | Production : Inorganic emissions to air, Carbon dioxide |
| | | Transport of Raw materials | 0.01 kg $CO_2$-equiv. | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 0.24 kg $CO_2$-equiv. | 76% Waste treatment<br>24% Thermal energy | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Inorganic emissions to air, Carbon dioxide |
| | Installation | Installation | | 81% Adhesive<br>19% Disposal of PVC installation waste | |
| | Use | Use | | 99% Electricity | Use : Inorganic emissions to air, Carbon |

| Impact Category | Stage | Module | | Main contributor | Main contributing flows |
|---|---|---|---|---|---|
| | | | | 18% Detergent | dioxide |
| | EOL | EOL | | Incineration of post-consumer Needlefelt. Energy substitution from incineration | EOL : Inorganic emissions to air, Carbon dioxide |
| ODP | Production | Raw Material Extraction | 100% | 96% Latex | Production : Halogenated organic emissions to air, R114 (Dichlorotetrafluorethane) |
| | | Transport of Raw materials | < 0.05% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | < 0.05% | 94% Packaging | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Halogenated organic emissions to air, R114 (Dichlorotetrafluorethane) |
| | Installation | Installation | | 100% Adhesive | |
| | Use | Use | | 98% Detergent | Use : Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane), R12 (Dichlorodifluoromethane) |
| | EOL | EOL | | Incineration of post-consumer Needlefelt. Energy substitution from incineration | EOL: Halogenated organic emissions to air, R22 (chlorodifluoromethane) |
| AP | Production | Raw Material Extraction | 99% | 19% Latex<br>24% PET<br>56% PA 6 | Production : Inorganic emissions to air, $NO_x$ and Sulphur dioxide |
| | | Transport of Raw materials | <0.5% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 1% | 52% Packaging<br>36% Thermal energy | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Inorganic emissions to air, $NO_x$ and Sulphur dioxide |
| | Installation | Installation | | 94% Adhesive | |
| | Use | Use | | 99% Electricity | Use : Inorganic emissions to air, $NO_x$ and Sulphur dioxide |
| | EOL | EOL | | Incineration of post-consumer Needlefelt. Energy substitution from incineration | EOL : Inorganic emissions to air, Hydrogen chloride, $NO_x$ and Sulphur dioxide |
| EP | Production | Raw Material Extraction | 94% | 13% Latex<br>17% PET<br>70% PA 6 | Production : Inorganic emissions to air, Ammonia, $NO_x$<br>Production : Inorganic emissions to fresh water, Nitrate, Nitrogen, Ammonium/Ammonia |
| | | Transport of Raw materials | < 0.5% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 6% | 85% Waste treatment | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Inorganic emissions to air, $NO_x$ |
| | Installation | Installation | | 91% Adhesive | |
| | Use | Use | | 98% Electricity | Use : Inorganic emissions to air, $NO_x$ |
| | EOL | EOL | | Incineration of post-consumer Needlefelt. Energy substitution from incineration | EOL : Inorganic emissions to air, $NO_x$ and Ammonia |
| POCP | Production | Raw Material Extraction | 99% | 34% PET<br>57% PA 6 | Production : Inorganic emissions to air, Carbon monoxide, $NO_x$ , Sulphur dioxide<br>Production : Halogenated organic emissions to air, NMVOC (Unspecified), Propane, Methane, Ethane |
| | | Transport of Raw materials | < 0.5% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 1% | 91% Waste treatment | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Inorganic emissions to air, Carbon monoxide, $NO_x$, Sulphur dioxide<br>Transport & Installation : Halogenated organic emissions to air, NMVOC (Unspecified), |
| | Installation | Installation | | 97% Adhesive | |
| | Use | Use | | 99% electricity | Use : Inorganic emissions to air, Sulphur |

| Impact Category | Stage | Module | | Main contributor | Main contributing flows |
|---|---|---|---|---|---|
| | | | | | dioxide, Nitrogen dioxide |
| | EOL | EOL | | Incineration of post-consumer Needlefelt. Energy substitution from incineration | EOL : Inorganic emissions to air, Carbon monoxide, $NO_x$, Sulphur dioxide |
| ADPe | Production | Raw Material Extraction | 99% | 63% PA 6<br>31% PET | Production : Nonrenewable resources, Sodium chloride (rock salt)<br>Production : Nonrenewable elements, Copper, Lead, Silver |
| | | Transport of Raw materials | < 0,05% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 1% | 28% Electricity<br>50% Packaging | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Nonrenewable resources, Sodium chloride (rock salt)<br>Transport & Installation : Nonrenewable elements, Lead, Silver, Copper |
| | Installation | Installation | | 99% Adhesive | |
| | Use | Use | | 99% Electricity | Use : Nonrenewable elements, Copper, Lead, Silver |
| | EOL | EOL | | Incineration of post-consumer Needlefelt. Energy substitution from incineration | EOL : Nonrenewable elements, Copper, Lead, Silver |
| ADPf | Production | Raw Material Extraction | 100% | 36% PET<br>61% PA 6 | Production : Crude oil resource, Crude oil (in MJ)<br>Production : Natural gas (resource), Natural gas (in MJ) |
| | | Transport of Raw materials | < 0.1% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | < 0.5% | 80% Thermal energy | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Crude oil (resource)<br>Transport & Installation : Natural gas (resource), |
| | Installation | Installation | | 100% Adhesive | |
| | Use | Use | | 99% electricity | Use : Hard coal (resource), Natural gas (resource), Hard coal (resource) |
| | EOL | EOL | | Incineration of post-consumer Needlefelt. Energy substitution from incineration | EOL : Hard coal (resource), Natural gas (resource), Lignite (resource), Crude oil (resource) |
| Eco toxicity | Production | Raw Material Extraction | 100% | 34% PET<br>64% PA 6 | Production : Hydrocarbons to fresh water, Phenol (hydroxy benzene), Anthracene,<br>Production : Pesticides to fresh water, Alachlor |
| | | Transport of Raw materials | < 0.2% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | < 0.5% | 70% Paper packaging | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & installation : Hydrocarbons to fresh water, Phenol (hydroxy benzene), Anthracene, Benzene, Methanol<br>Transport & installation : Pesticides to fresh water, Alachlor |
| | Installation | Installation | | 99% Adhesive | |
| | Use | Use | | 100% Electricity | Use : Hydrocarbons to fresh water, Phenol (hydroxy benzene), Anthracene,<br>Use : Pesticides to fresh water, Alachlor |
| | EOL | EOL | | Incineration of post-consumer Needlefelt. Energy substitution from incineration | EOL : Hydrocarbons to fresh water, Phenol (hydroxy benzene), Methanol<br>EOL : Pesticides to fresh water, Alachlor |
| Human toxicity, cancer | Production | Raw Material Extraction | 99% | 63% PA 6<br>36% PET | Production : Organic emissions to air (Group VOC), Formaldehyde (Methanal) |
| | | Transport of Raw materials | < 0.05% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 1% | 78% Thermal energy | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Organic emissions to air (Group VOC), Formaldehyde (Methanal) |
| | Installation | Installation | | 99% adhesive | |

| Impact Category | Stage | Module | | Main contributor | Main contributing flows |
|---|---|---|---|---|---|
| | Use | Use | | 100% Electricity | Use : Organic emissions to air (Group VOC), Formaldehyde (Methanal) |
| | EOL | EOL | | Incineration of post-consumer Needlefelt. Energy substitution from incineration | EOL : Organic emissions to air (Group VOC), Formaldehyde (Methanal) |
| Human toxicity, non canc. | Production | Raw Material Extraction | 99% | 69% PA 6<br>29% PET | Production : Organic emissions to air (Group VOC), Formaldehyde (Methanal), Hexane, Xylene<br>Production : Halogenated organic emissions to fresh water, Methanol, Phenol |
| | | Transport of Raw materials | < 0.1% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 1% | 95% Waste treatment | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Organic emissions to air (Group VOC), Methyl Methacrylate (MMA) |
| | Installation | Installation | | 100% adhesive | |
| | Use | Use | | 99% electricity | Use : Organic emissions to air (Group VOC), Formaldehyde (Methanal), Xylene (dimethyl benzene) |
| | EOL | EOL | | Incineration of post-consumer Needlefelt. Energy substitution from incineration | EOL : Organic emissions to air (Group VOC), Formaldehyde (Methanal), Xylene |

## Description of Selected Impact Categories

### Abiotic Depletion Potential

The abiotic depletion potential covers all natural resources such as metal containing ores, crude oil and mineral raw materials. Abiotic resources include all raw materials from non-living resources that are non-renewable. This impact category describes the reduction of the global amount of non-renewable raw materials. Non-renewable means a time frame of at least 500 years. This impact category covers an evaluation of the availability of natural elements in general, as well as the availability of fossil energy carriers.

ADP (elements) describes the quantity of non-energetic resources directly withdrawn from the geosphere. It reflects the scarcity of the materials in the geosphere and is expressed in Antimony equivalents. The characterization factors are published by the CML, Oers 2010.

Are fossil energy carriers included in the impact category, it is ADP (fossil). Fossil fuels are used similarly to the primary energy consumption; the unit is therefore also MJ. In contrast to the primary fossil energy ADP fossil does not contain uranium, because this does not count as a fossil fuel.

Primary energy consumption

Primary energy demand is often difficult to determine due to the various types of energy source. Primary energy demand is the quantity of energy directly withdrawn from the hydrosphere, atmosphere or geosphere or energy source without any anthropogenic change. For fossil fuels and uranium, this would be the amount of resource withdrawn expressed in its energy equivalent (i.e. the energy content of the raw material). For renewable resources, the energy-characterized amount of biomass consumed would be described. For hydropower, it would be based on the amount of energy that is gained from the change in the potential energy of water (i.e. from the height difference). As aggregated values, the following primary energies are designated:

The total **"Primary energy consumption non-renewable"**, given in MJ, essentially characterizes the gain from the energy sources natural gas, crude oil, lignite, coal and uranium. Natural gas and crude oil will both be used for energy production and as material constituents e.g. in plastics. Coal will primarily be used for energy production. Uranium will only be used for electricity production in nuclear power stations.

The total **"Primary energy consumption renewable"**, given in MJ, is generally accounted separately and comprises hydropower, wind power, solar energy and biomass. It is important that the end energy (e.g. 1 kWh of electricity) and the primary energy used are not miscalculated with each other; otherwise the efficiency for production or supply of the end energy will not be accounted for. The energy content of the manufactured products will be considered as feedstock energy content. It will be characterized by the net calorific value of the product. It represents the still usable energy content.

Waste categories

There are various different qualities of waste. For example, waste can be classed according to German and European waste directives. The modeling principles have changed with the last GaBi4 database update in October 2006. Now all LCA data sets (electricity generation, raw material etc.) already contain the treatment of the waste with very low waste output at the end of the stage. So the amount of waste is predominantly caused by foreground processes during the production phase. This is important for the interpretation of waste amounts.

From a balancing point of view, it makes sense to divide waste into three categories. The categories overburden/tailings, industrial waste for municipal disposal and hazardous waste will be used.

**Overburden / tailings** in kg: This category consists of the layer which must be removed in order to access raw material extraction, ash and other raw material extraction conditional materials for disposal. Also included in this category are tailings such as inert rock, slag, red mud etc.

**Industrial waste for municipal disposal** in kg: This term contains the aggregated values of industrial waste for municipal waste according to 3. AbfVwV TA SiedlABf.

**Hazardous waste** in kg: This category includes materials that will be treated in a hazardous waste incinerator or hazardous waste landfill, such as painting sludge's, galvanic sludge's, filter dusts or other solid or liquid hazardous waste and radioactive waste from the operation of nuclear power plants and fuel rod production.

Global Warming Potential (GWP)

The mechanism of the greenhouse effect can be observed on a small scale, as the name suggests, in a greenhouse. These effects are also occurring on a global scale. The occurring short-wave radiation from the sun comes into contact with the earth's surface and is partly absorbed (leading to direct warming) and partly reflected as infrared radiation. The reflected part is absorbed by so-called greenhouse gases in the troposphere and is re-radiated in all directions, including back to earth. This results in a warming effect on the earth's surface.

In addition to the natural mechanism, the greenhouse effect is enhanced by human activities. Greenhouse gases that are considered to be caused, or increased, anthropogenically are, for example, carbon dioxide, methane and CFCs. *Figure A1* shows the main processes of the anthropogenic greenhouse effect. An analysis of the greenhouse effect should consider the possible long term global effects.

The global warming potential is calculated in carbon dioxide equivalents ($CO_2$-Eq.). This means that the greenhouse potential of an emission is given in relation to $CO_2$. Since the residence time of the gases in the atmosphere is incorporated into the calculation, a time range for the assessment must also be specified. A period of 100 years is customary.

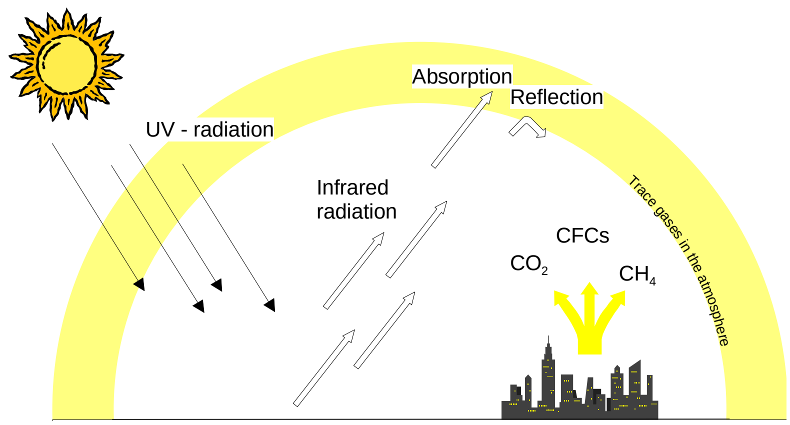



*Figure A1: Greenhouse effect (KREISSIG 1999)*

## Acidification Potential (AP)

The acidification of soils and waters predominantly occurs through the transformation of air pollutants into acids. This leads to a decrease in the pH-value of rainwater and fog from 5.6 to 4 and below. Sulphur dioxide and nitrogen oxide and their respective acids ($H_2SO_4$ and $HNO_3$) produce relevant contributions. This damages ecosystems, whereby forest dieback is the most well-known impact.

Acidification has direct and indirect damaging effects (such as nutrients being elutriated from soils or an increased solubility of metals into soils). But even buildings and building materials can be damaged. Examples include metals and natural stones which are corroded or disintegrated at an increased rate.

When analyzing acidification, it should be considered that although it is a global problem, the regional effects of acidification can vary. *Figure A2* displays the primary impact pathways of acidification.

The acidification potential is given in sulphur dioxide equivalents (SO2-Eq.). The acidification potential is described as the ability of certain substances to build and release H+ - ions. Certain emissions can also be considered to have an acidification potential, if the given S-, N- and halogen atoms are set in proportion to the molecular mass of the emission. The reference substance is sulphur dioxide.

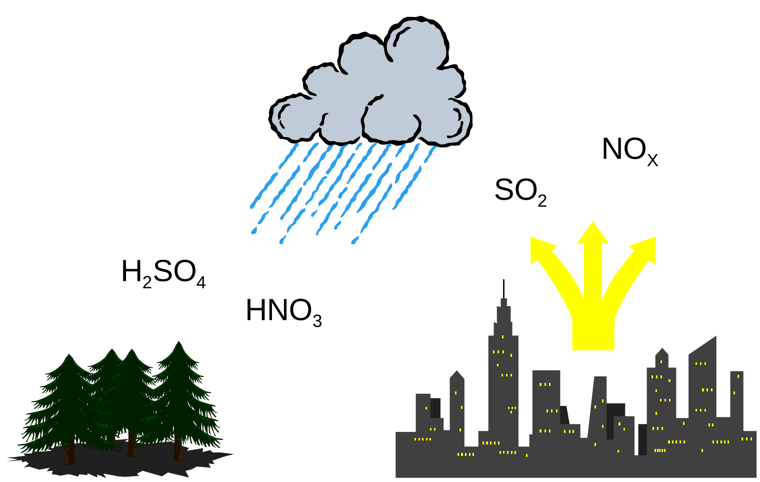



*Figure A2: Acidification Potential (KREISSIG 1999)*

## Eutrophication Potential (EP)

Eutrophication is the enrichment of nutrients in a certain place. Eutrophication can be aquatic or terrestrial. Air pollutants, waste water and fertilization in agriculture all contribute to eutrophication.

The result in water is an accelerated algae growth, which in turn, prevents sunlight from reaching the lower depths. This leads to a decrease in photosynthesis and less oxygen production. In addition, oxygen is needed for the decomposition of dead algae. Both effects cause a decreased oxygen concentration in the water, which can eventually lead to fish dying and to anaerobic decomposition (decomposition without the presence of oxygen). Hydrogen sulphide and methane are thereby produced. This can lead, among others, to the destruction of the eco-system.

On eutrophicated soils, an increased susceptibility of plants to diseases and pests is often observed, as is a degradation of plant stability. If the nutrification level exceeds the amounts of nitrogen necessary for a maximum harvest, it can lead to an enrichment of nitrate. This can cause, by means of leaching, increased nitrate content in groundwater. Nitrate also ends up in drinking water.

Nitrate at low levels is harmless from a toxicological point of view. However, nitrite, a reaction product of nitrate, is toxic to humans. The causes of eutrophication are displayed in Figure A3. The eutrophication potential is calculated in phosphate equivalents (PO4-Eq). As with acidification potential, it's important to remember that the effects of eutrophication potential differ regionally.

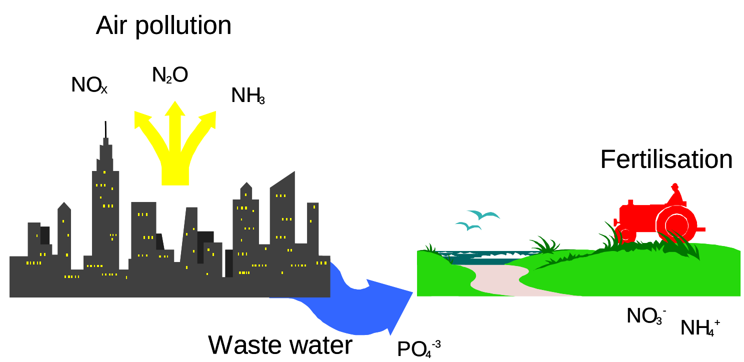



*Figure A3: Eutrophication Potential (Kreissig 1999)*

## Photochemical Ozone Creation Potential (POCP)

Despite playing a protective role in the stratosphere, at ground-level ozone is classified as a damaging trace gas. Photochemical ozone production in the troposphere, also known as summer smog, is suspected to damage vegetation and material. High concentrations of ozone are toxic to humans.

Radiation from the sun and the presence of nitrogen oxides and hydrocarbons incur complex chemical reactions, producing aggressive reaction products, one of which is ozone. Nitrogen oxides alone do not cause high ozone concentration levels. Hydrocarbon emissions occur from incomplete combustion, in conjunction with petrol (storage, turnover, refueling etc.) or from solvents. High concentrations of ozone arise when the temperature is high, humidity is low, when air is relatively static and when there are high concentrations of hydrocarbons. Today it is assumed that the existence of NO and CO reduces the accumulated ozone to $NO_2$, $CO_2$ and $O_2$. This means, that high concentrations of ozone do not often occur near hydrocarbon emission sources. Higher ozone concentrations more commonly arise in areas of clean air, such as forests, where there is less NO and CO (*Figure A4*).

In Life Cycle Assessments, photochemical ozone creation potential (POCP) is referred to in ethylene-equivalents ($C_2H_4$-Äq.). When analyzing, it’s important to remember that the actual ozone concentration is strongly influenced by the weather and by the characteristics of the local conditions.

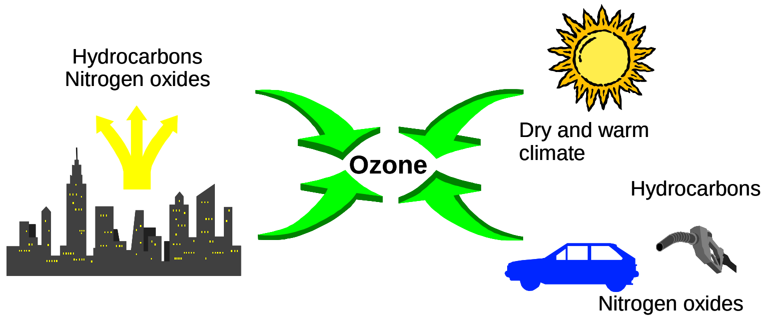



*Figure A4: Photochemical Ozone Creation Potential*

## Ozone Depletion Potential (ODP)

Ozone is created in the stratosphere by the disassociation of oxygen atoms that are exposed to short-wave UV-light. This leads to the formation of the so-called ozone layer in the stratosphere (15 - 50 km high). About 10 % of this ozone reaches the troposphere through mixing processes. In spite of its minimal concentration, the ozone layer is essential for life on earth. Ozone absorbs the short-wave UV-radiation and releases it in longer wavelengths. As a result, only a small part of the UV-radiation reaches the earth.

Anthropogenic emissions deplete ozone. This is well-known from reports on the hole in the ozone layer. The hole is currently confined to the region above Antarctica, however another ozone depletion can be identified, albeit not to the same extent, over the mid-latitudes (e.g. Europe). The substances which have a depleting effect on the ozone can essentially be divided into two groups; the fluorine-chlorine-hydrocarbons (CFCs) and the nitrogen oxides (NOX). *Figure A5* depicts the procedure of ozone depletion.

One effect of ozone depletion is the warming of the earth's surface. The sensitivity of humans, animals and plants to UV-B and UV-A radiation is of particular importance. Possible effects are changes in growth or a decrease in harvest crops (disruption of photosynthesis), indications of tumors (skin cancer and eye diseases) and decrease of sea plankton, which would strongly affect the food chain. In calculating the ozone depletion potential, the anthropogenically released halogenated hydrocarbons, which can destroy many ozone molecules, are recorded first. The so-called Ozone Depletion Potential (ODP) results from the calculation of the potential of different ozone relevant substances.

This is done by calculating, first of all, a scenario for a fixed quantity of emissions of a CFC reference (CFC 11). This results in an equilibrium state of total ozone reduction. The same scenario is considered for each substance under study whereby CFC 11 is replaced by the quantity of the substance. This leads to the ozone depletion potential for each respective substance, which is given in CFC 11 equivalents. An evaluation of the ozone depletion potential should take the long term, global and partly irreversible effects into consideration.

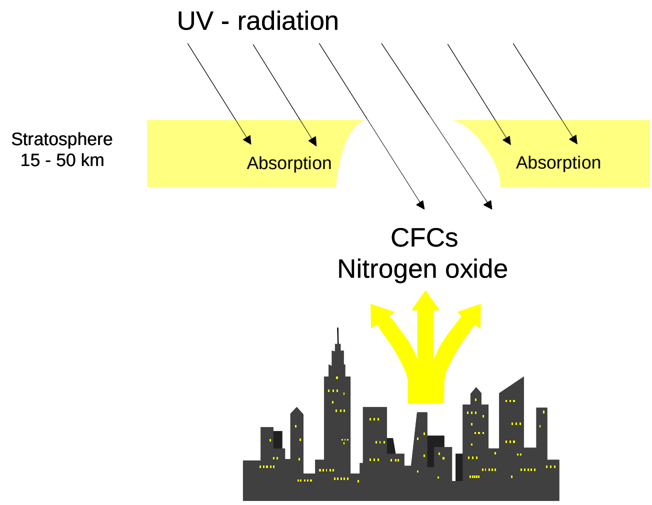



*Figure A5: Ozone Depletion Potential (KREISSIG 1999)*

## References

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|---|---|
| GaBi 6 2012 | THINKSTEP AG; GaBi 6: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2017. |
| GaBi 6 2012D | GaBi 6: Documentation of GaBi 6: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2017. http://documentation.gabi-software.com/ |
| UL Environment | UL Environment's Program Operator Rules |
| PE 2012<br>ILCD Handbook: General guide for Life Cycle Assessment - Detailed guidance | Description of Selected Impact Categories, THINKSTEP AG, 2012<br>European Commission-Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook- Recommendations for Life Cycle Impact Assessment in the European context. First edition November 2011. EUR 24571 EN. Luxemburg. Publications Office of the European Union; 2011 |
| **Standards and laws** | |
| DIN EN ISO 14044 | Environmental management - Life cycle assessment - Requirements and guidelines (ISO 14044:2006); German and English version EN ISO 14044 |
| ISO 14025 2006 | DIN EN ISO 14025: Environmental labels and declarations — Type III environmental declarations — Principles and procedures |
| ISO 14040 2006 | Environmental management - Life cycle assessment - Principles and framework (ISO 14040); German and English version EN ISO 14040 |
| CEN/TR 15941 | Sustainability of construction works - Environmental product declarations - Methodology for selection and use of generic data; German version CEN/TR 15941 |
| EN 16810 | Resilient, textile and laminate floor coverings - Environmental product declarations - Product category rules |
| EN 15804 | EN 15804: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products |
| CPR | REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011 laying down harmonized conditions for the marketing of construction products and repealing Council Directive 89/106/EEC |
| EN-ISO 10874<br>EN 1307 | Resilient, textile and laminate floor coverings – Classification<br>Textile floor coverings - Specification |