

ENVIRONMENTAL PRODUCT DECLARATION

TESSERA STRUKTUR 1

FORBO FLOORING SYSTEMS
TEXTILE FLOOR COVERING

Tessera Struktur 1 – 3714 Grön



FLOORING SYSTEMS

Today's modern office environments with open office systems are designed for flexibility to accommodate frequent layout changes. A modular floor can be quickly adapted to new requirements thereby reducing the cost of reorganization. Where carpet tiles are installed, telephone, electrical and other under floor systems remain easily accessible for these changes to be made. Tessera offers attractive and hardwearing tufted carpet tiles in various pile constructions and textures, designed to deliver specific aesthetic and performance benefits. 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 ecotoxicity. 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 Tessera Carpet tiles into the true value and benefits to all our customers and stakeholders alike. For more information visit; www.forbo-flooring.com



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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 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 333 Pfingsten Road Northbrook, IL 60611 | |
| DECLARATION HOLDER | Forbo Flooring B.V. Industrieweg 12 P.O. Box 13 NL-1560 AA Krommenie | |
| DECLARATION NUMBER | 4789471078.143.1 | |
| DECLARED PRODUCT | Tessera Struktur 1 Textile Floor Covering | |
| REFERENCE PCR | EN 16810 : Resilient, Textile and Laminate floor coverings – Environmental product declarations – Product category rules | |
| DATE OF ISSUE | July 1, 2020 | |
| PERIOD OF VALIDITY | 5 Years | |
| CONTENT OF THE DECLARATION | Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results 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 <input type="checkbox"/> INTERNAL <input checked="" type="checkbox"/> EXTERNAL |  María José Monteagudo Arrebola | |
| |  Thomas P. Gloria, Industrial Ecology Consultants | |
| This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by: | | |

This EPD conforms with EN 15804

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Product Definition

Product Classification and description

This declaration covers Tessera Struktur 1 carpet tiles. Tessera Struktur 1 carpet tiles are a textile floor covering complying with all the requirements of the EN1307 Class 33 specification. The raw materials used in the construction of Tessera products are chosen for their low volatile organic compound levels combined with their high level of recycled content. All Tessera Struktur 1 carpet tiles are manufactured using renewable electricity and biogas.

The recycled content of the product is 65%

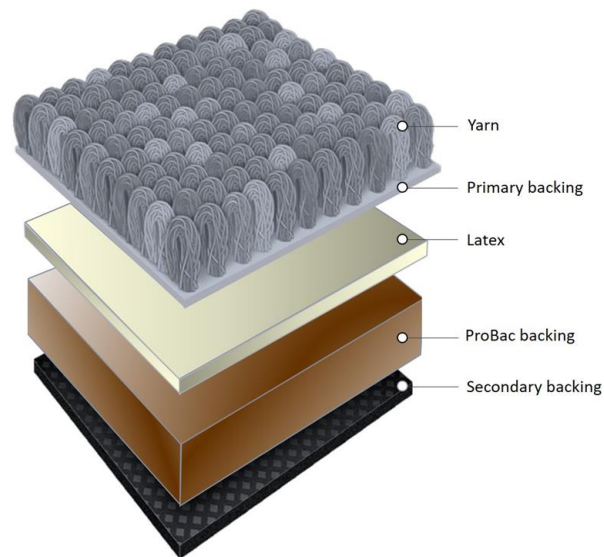
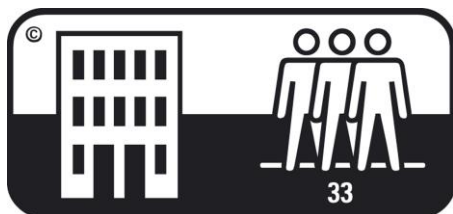


Figure 1: Illustration of Tessera Carpet tile

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

Range of application

Tessera Struktur 1 Carpet Tiles are classified in accordance with EN1307 to be installed in the following use areas defined in EN-ISO 10874:



Environment



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Product Standard

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

- Meets or exceeds all technical requirements EN1307 Class 33

Struktur 1 carpet tiles meet the requirements of EN 14041

| | | | |
|--|--------------------|------------|-----------------------------|
| | Product code | EN 14041 | 1170100-DoP-306 |
| | Reaction to fire | EN 13501-1 | C _f l-s1, G, NCS |
| | Slip resistance | EN 13893 | μ ≥ 0.30 |
| | Body voltage | ISO 3656 | < 2 kV |
| | Thermal resistance | EN 12667 | 0.055 m ² .K/W |

Accreditation

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health & Safety Management System
- SA8000 Social Accountability System

Delivery status

Table 1: Specification of delivered product

| Characteristics | Nominal Value | Unit |
|-------------------|---------------|------------------|
| Product thickness | 5.1 ± 10% | mm |
| Product Weight | 3765 | g/m ² |
| Tile size | 50 x 50 | cm |



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Material Content

Material Content of the Product

Table 2: Composition of Tessera Struktur 1

| Component | Material | Availability | Amount [%] | Origin |
|-------------------|-------------------|-------------------------|------------|----------------|
| Yarn | Nylon 6 | Limited | 9 | Belgium |
| Primary backing | Polyester | Limited | 3 | Thailand |
| Pre-coat | Synthetic latex | Limited | 4 | United Kingdom |
| | Calcium carbonate | Postindustrial recycled | 14 | United Kingdom |
| Backing | Bitumen | Limited | 16 | Global |
| | Calcium Sulphate | Postindustrial recycled | 51 | United Kingdom |
| Secondary backing | Polyester | Limited | 3 | Germany |

Production of Main Materials

Yarn: Nylon 6 is synthesized by ring-opening polymerization of caprolactam. During polymerization, the amide bond within each caprolactam molecule is broken, with the active groups on each side re-forming two new bonds as the monomer becomes part of the polymer backbone

Polyester: Polyester is a category of polymers that contain the ester functional group in their main chain. As a specific material, it most commonly refers to a type called polyethylene terephthalate (PET).

Latex: Styrene Butadiene latex is a polymer emulsion composed of two hydrocarbon monomers, styrene and butadiene.

Calcium carbonate: The Calcium carbonate used is coming from a postindustrial recycling process

Bitumen: Bitumen is an oil based substance. It is a semi-solid hydrocarbon product produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process.

Calcium Sulphate: The Calcium Sulphate (Gypsum) used is coming from a postindustrial recycling process.

Production of the Floor Covering

Struktur 1 is a microtuft loop pile carpet tile. Yarn is precisely inserted into the primary backing to create a decorative top-cloth. The residual yarn is re-used. This cloth is then pre-coated with latex compound to provide tuft anchorage and dimensional stability. The edges are trimmed at this point and the edge trim is repurposed. The cloth is then backed with a bitumen mix and a polyester scrim. It is then die / ultrasonically cut into 50cm x 50cm tiles. The ultrasonic cutting process reduces waste by 8% compared to the traditional pressing method. Cutting waste is recycled.

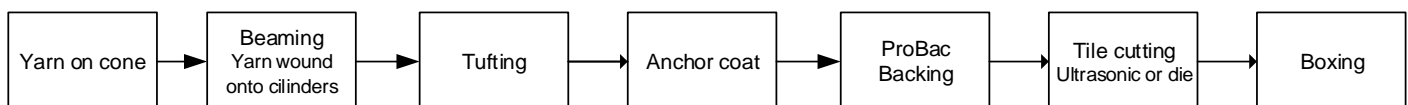


Figure 2: Production process of Tessera Struktur 1



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Health, Safety and Environmental Aspects during Production

- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems

Production Waste

All product rejected at final inspection stage is recycled externally. In coming packaging materials are collected, separated and recycled.

Delivery and Installation of the Floor Covering

Delivery

A worldwide distribution by truck and container ship is utilized. On average every square meter of Tessera Struktur 1 is transported as follows:

- | | |
|--|--------|
| ○ Transport distance 40 t truck | 290 km |
| ○ Transport distance 7.5 t truck | 84km |
| ○ Capacity utilization trucks (including empty runs) | 84 % |
| ○ Transport distance Ocean ship | 920 km |
| ○ Capacity utilization Ocean ship | 48% |

Although a worldwide distribution is taken into account, the average distance by Ocean ship is negligible.

Installation

During the installation of Tessera Struktur 1, an average of 3% of the material becomes installation waste. For the installation of Tessera Struktur 1 tiles 0.10 kg/m² of tackifier adhesive is required. Waste during the installation process can be thermally recycled in a waste incineration plant. The majority of Tessera Struktur 1 tile is sold in UK / 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 the use of (low) zero emission adhesives for installing Tessera Struktur 1.

Waste

Waste during the installation process can be thermally recycled in a waste incineration plant. Since the major part of Tessera Struktur 1 is sold in Europe the European electricity grid mix is used in the calculations for the energy recovery during incineration.

Packaging

Cardboard tile boxes, wooden pallets and PE-film can be collected separately and should be used in a local recycling



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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 | Daily | Electricity |
| | Spot/spill clean | As spill occurs | Spotting agent |
| | Dry fusion clean | Four times each year | Hot water |
| | Hot water extraction | | 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 every day. This equates to 1.92 kWh/m²*year.
- Four times a year wet cleaning with 0.062 l/m² water and 0.0008 kg/m² detergent. This result in the use of 0.248 l/m²*year water and 0.0032 kg/m²*year detergent. The wet cleaning takes place without power machine usage. The waste water treatment of the arising waste water from cleaning is considered (Data source 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 steps 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.

Health Aspects during Usage

Tessera Struktur 1 complies with:

- o AgBB requirements
- o CHPS section 01350



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End of Life

The deconstruction of installed Tessera Struktur 1 from the floor is a manual process. For the end of life stage no landfilling is taken into account, since the vast majority of the countries in which Tessera Struktur 1 is sold have a non landfill policy. Because of the high calorific value of Tessera Struktur 1 the incineration is very profitable as a waste to energy conversion.

Life Cycle Assessment

A full Life Cycle Assessment has been 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)

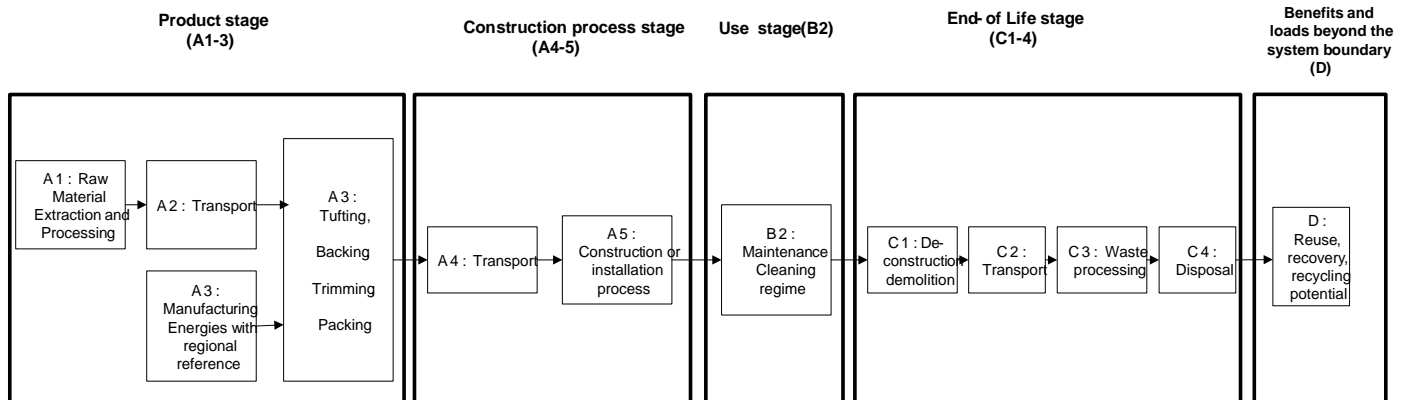


Figure 3: Flow chart of the Life Cycle Assessment

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



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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 9 Software System for Life Cycle Engineering, developed by Sphera has been used. All relevant LCA datasets are taken from the GaBi 9 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 2019). The reference ages of LCA datasets vary but are

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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 9 Software System for Life Cycle Engineering, developed by Sphera, is used. All relevant LCA datasets are taken from the GaBi 9 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 Bamber Bridge, the United Kingdom. The GaBi 9 Hydropower, Biomass and Wind power dataset have therefore been used (reference year 2020). The energy supplier is providing Forbo with a certificate every year.

CO₂-Certificates

No CO₂-certificates are considered in this study.

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Life Cycle Inventory Analysis

In table 3 the environmental impacts for one lifecycle are presented for Tessera Struktur 1. 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) – Tessera Struktur 1

| Impact Category : CML 2001 – Jan. 2016 | Tessera Struktur 1 | Unit |
|---|--------------------|----------------------------|
| Global Warming Potential (GWP 100 years) | 1,40E+01 | kg CO ₂ -Equiv. |
| Ozone Layer Depletion Potential (ODP, steady state) | 1,92E-07 | kg R11-Equiv. |
| Acidification Potential (AP) | 2,50E-02 | kg SO ₂ -Equiv. |
| Eutrophication Potential (EP) | 3,71E-03 | kg Phosphate-Equiv. |
| Photochem. Ozone Creation Potential (POCP) | 1,95E-03 | kg Ethene-Equiv. |
| Abiotic Depletion Potential Elements (ADPE) | 4,36E-06 | kg Sb-Equiv. |
| Abiotic Depletion Potential Fossil (ADPF) | 1,48E+02 | [MJ] |

Table 4: Results of the LCA – Environmental impact for Tessera Struktur 1 (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.] | 7,06E+00 | 2,50E-01 | 3,77E-01 | 7,63E-01 | 0,00E+00 | 2,59E-02 | 6,46E+00 | -9,78E-01 | |
| ODP | [kg CFC11-Eq.] | 1,92E-07 | 2,34E-17 | 2,27E-10 | 1,65E-10 | 0,00E+00 | 4,23E-18 | 1,44E-15 | -1,40E-14 | |
| AP | [kg SO ₂ -Eq.] | 1,84E-02 | 1,87E-03 | 5,96E-04 | 1,60E-03 | 0,00E+00 | 6,16E-05 | 3,70E-03 | -1,24E-03 | |
| EP | [kg PO ₄ ³⁻ - Eq.] | 2,47E-03 | 2,56E-04 | 9,38E-05 | 1,79E-04 | 0,00E+00 | 1,51E-05 | 8,48E-04 | -1,55E-04 | |
| POCP | [kg Ethen Eq.] | 1,77E-03 | -7,46E-05 | 5,63E-05 | 1,14E-04 | 0,00E+00 | -2,17E-05 | 2,21E-04 | -1,13E-04 | |
| ADPE | [kg Sb Eq.] | 4,13E-06 | 1,00E-08 | 5,42E-08 | 2,56E-07 | 0,00E+00 | 2,14E-09 | 9,58E-08 | -1,84E-07 | |
| ADPF | [MJ] | 1,43E+02 | 2,02E+00 | 5,69E+00 | 8,48E+00 | 0,00E+00 | 3,51E-01 | 2,24E+00 | -1,38E+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



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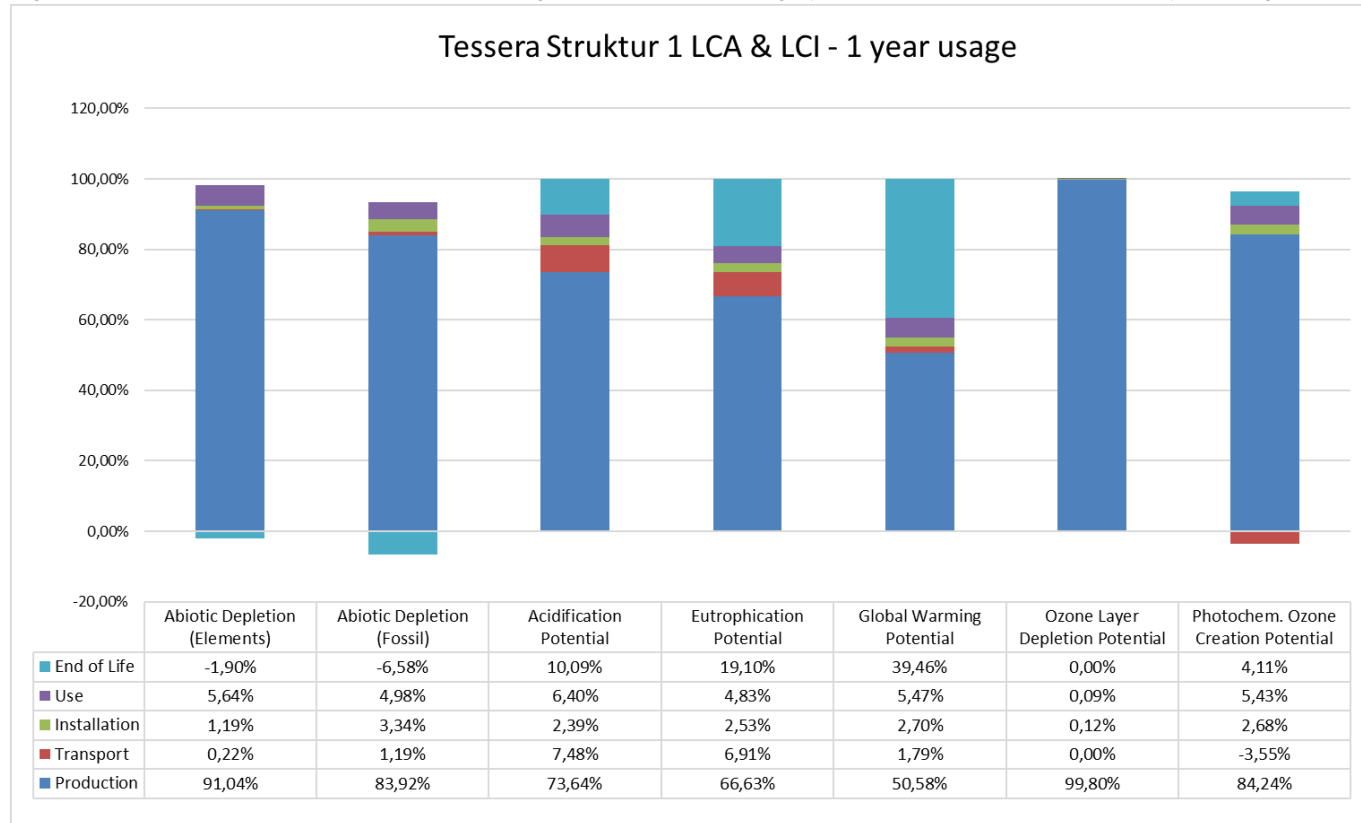


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The relative contribution of each process stage to each impact category for Tessera Struktur 1 is shown in figure 4.

Figure 4: relative contribution of each process stage to each impact category for Tessera Struktur 1 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 one year usage.

In all of the impact categories the production stage has the main contribution to the overall impact. The raw material supply, in particular PA 6, polyester and latex are the key contributors for all of these impact categories with a total share of 71 – 99% of the total impact of the production stage.

Forbo declares in the EPD a worldwide distribution which has a limited effect on most of the impact categories. Only for AP and EP there is a significant share of ± 7% of the total caused by the ships and trucks used to transport the product.

For AP, EP, GWP, POCP, and ADPF the adhesive as main contributor for the flooring installation has a minor impact of 2 – 3.5% of the total environmental impact of Tessera Struktur 1.



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In the Use stage the electricity needed to vacuum the floor is causing an impact of 5 – 6.5% for ADPE, ADPF, AP, EP, GWP and POCP. 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 small credit for ADPF and ADPE in the End of Life stage. For EP and GWP the End of Life stage has a significant impact on the total of respectively 19 and 40%. This is mainly due to the fact that the waste at the End of Life stage is considered as being incinerated.

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 Tessera Struktur 1 (one year)

| Parameter | Unit | Manufacturing | Installation | | Use (1yr) | End of Life | | | Credits |
|-----------|-------------------|---------------|--------------|----------|-----------|-------------|----------|----------|-----------|
| | | A1-3 | A4 | A5 | B2 | C1 | C2 | C3 | D |
| PERE | [MJ] | 2,61E+01 | - | - | - | - | - | - | - |
| PERM | [MJ] | 0,00E+00 | - | - | - | - | - | - | - |
| PERT | [MJ] | 2,61E+01 | 8,25E-02 | 2,28E-01 | 6,02E+00 | 0,00E+00 | 1,98E-02 | 3,31E-01 | -3,72E+00 |
| PENRE | [MJ] | 1,45E+02 | - | - | - | - | - | - | - |
| PENRM | [MJ] | 9,80E+00 | - | - | - | - | - | - | - |
| PENRT | [MJ] | 1,55E+02 | 2,02E+00 | 5,80E+00 | 1,37E+01 | 0,00E+00 | 3,52E-01 | 2,47E+00 | -1,70E+01 |
| SM | [kg] | 1,94E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| RSF | [MJ] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| NRSF | [MJ] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| FW | [m ³] | 3,76E-01 | 9,68E-05 | 1,25E-03 | 6,97E-03 | 0,00E+00 | 2,29E-05 | 1,75E-02 | -4,30E-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 Tessera Struktur 1 (one year)

| Parameter | Unit | Manufacturing | Transport | Installation | Use (1yr) | End of Life/credits | | | |
|-------------------|------|---------------|-----------|--------------|-----------|---------------------|----------|----------|-----------|
| | | A1-3 | A4 | A5 | B2 | C1 | C2 | C3 | D |
| HWD | [kg] | 3,81E-08 | 6,68E-08 | 1,95E-09 | 5,63E-09 | 0,00E+00 | 1,64E-08 | 1,92E-09 | -6,77E-09 |
| NHWD | [kg] | 3,34E-02 | 2,80E-04 | 3,59E-03 | 9,91E-03 | 0,00E+00 | 5,39E-05 | 8,36E-02 | -7,86E-03 |
| RWD | [kg] | 2,88E-03 | 2,43E-06 | 4,39E-05 | 2,06E-03 | 0,00E+00 | 4,36E-07 | 9,18E-05 | -1,27E-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 | 2,55E-01 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 1,15E+01 | 0,00E+00 |
| EE Thermal energy | [MJ] | 0,00E+00 | 0,00E+00 | 4,59E-01 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 2,08E+01 | 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



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According to ISO 14025 and EN 15804

Additional Environmental Information

To be fully transparent 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 calculation the USEtox™ 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. USEtox™ 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) – Tessera Struktur 1

| Impact Category : USEtox | Tessera Struktur 1 | Unit |
|---------------------------|--------------------|------------|
| Eco toxicity | 3,48E-02 | PAF m3.day |
| Human toxicity, cancer | 8,16E-10 | Cases |
| Human toxicity, non-canc. | 5,88E-11 | Cases |

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

Table 8: Results of the LCA – Environmental impact for Tessera Struktur 1 (one year)

| Impact Category : USEtox | Unit | Production | Transport | Installation | Use (1yr) | End of Life |
|---------------------------|------------|------------|-----------|--------------|-----------|-------------|
| Eco toxicity | PAF m3.day | 3,29E-02 | 4,74E-04 | 6,26E-04 | 1,31E-03 | -5,02E-04 |
| Human toxicity, cancer | cases | 7,95E-10 | 5,34E-13 | 1,23E-11 | 1,01E-10 | -9,23E-11 |
| Human toxicity, non-canc. | cases | 2,07E-11 | 1,77E-13 | 3,73E-11 | 1,87E-12 | -1,18E-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 Ecotoxicity and Human toxicity (cancer) the production stage is the main contributor to the total overall impact. The major impact for Ecotoxicity is coming from the manufacturing stage where the biogas used to produce Tessera is having a share of 98%. The raw material supply has a share of 73% of the production stage for Human toxicity (cancer), mainly caused by the manufacturing of polyamide 6. Human toxicity (non-canc) has a significant impact of



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34%, mainly influenced by the production of Polyamide 6.

The transport stage is negligible for Human toxicity (cancer and non-canc.). For Ecotoxicity a small impact of 1,32% is seen, mainly caused by the use of diesel for the trucks.

The adhesive used for the installation of Tessera Struktur 1 is the dominant contributor for all toxicity categories, where Ecotoxicity and Human toxicity (cancer) are having a small contribution to the total impacts of the life cycles. The contribution for Human toxicity (non-canc.) is very high with a share of 61%.

The Use stage has a minor impact for all the toxicity impacts and 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 small credit for all three of the toxicity impact categories.



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References

| | |
|---|---|
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| PE 2012 ILCD Handbook: General guide for Life Cycle Assessment - Detailed guidance | Description of Selected Impact Categories, Sphera AG, 2012 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 EN 1307 | Resilient, textile and laminate floor coverings – Classification Textile floor coverings – Classification |



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Textile Floor covering

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Life Cycle Assessment

Tessera Struktur 1



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

July 2020

Environment



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FLOORING SYSTEMS

Tessera Struktur 1
Textile Floor covering

According to ISO 14025 and EN 15804

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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 |



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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 13/07/20.

Scope

This document is the LCA report for the "Environmental Product Declaration" (EPD) of "Tessera Struktur 1". 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 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 Tessera Struktur 1 complying with EN 1307 Textile floor coverings – Classification.

Manufactured by
Forbo Flooring UK Ltd.
Unit 92, Seedlee Road
Walton Summit
Preston, Lancashire
PR5 8AE
United Kingdom

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



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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.

Tessera Struktur 1 is produced at the following manufacturing site:

Forbo Flooring UK Ltd.
Unit 92, Seedlee Road
Walton Summit
Preston, Lancashire
PR5 8AE
United Kingdom



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Product Definition

Product Classification and description

This declaration covers Tessera Struktur 1 carpet tiles. Tessera Struktur 1 carpet tiles are a textile floor covering complying with all the requirements of the EN1307 Class 33 specification. The raw materials used in the construction of Tessera products are chosen for their low volatile organic compound levels combined with their high level of recycled content. All Tessera Struktur 1 carpet tiles are manufactured using renewable electricity and biogas.

The recycled content of the product is 65%

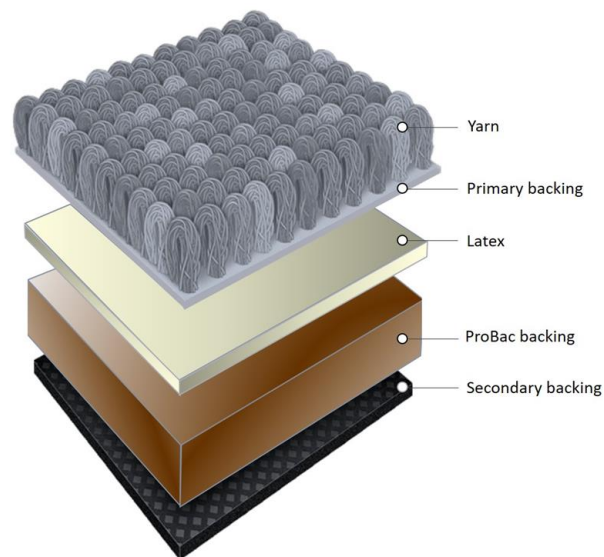
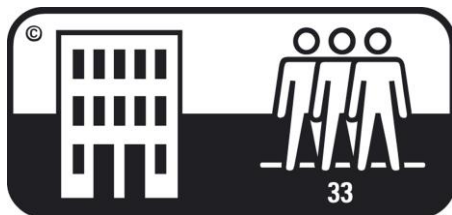


Figure 1: Illustration of Tessera Struktur 1

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

Range of application

Tessera Struktur 1 is classified in accordance with EN1307 to be installed in the following use areas defined in EN-ISO 10874:



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Product Standard

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

- Meets or exceeds all technical requirements EN1307 Class 33

Struktur 1 carpet tiles meet the requirements of EN 14041

| | Product code | EN 14041 | 1170100-DoP-306 |
|---|--------------------|------------|-----------------------------|
|   | Reaction to fire | EN 13501-1 | C _f l-s1, G, NCS |
|  | Slip resistance | EN 13893 | $\mu \geq 0.30$ |
|  | Body voltage | ISO 3656 | < 2 kV |
|  | Thermal resistance | EN 12667 | 0.055 m ² .K/W |

Accreditation

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health & Safety Management System
- SA8000 Social Accountability System

Delivery status

Table 1: Specification of delivered product

| Characteristics | Nominal Value | Unit |
|-------------------|---------------|------------------|
| Product thickness | 5.1 ± 10% | mm |
| Product Weight | 3765 | g/m ² |
| Tile size | 50 x 50 | cm |



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Tessera Struktur 1
Textile Floor covering

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Material Content

Material Content of the Product

Table 2: Composition of Tessera Struktur 1

| Component | Material | Availability | Amount [%] | Origin |
|-------------------|-------------------|-------------------------|------------|----------------|
| Yarn | Nylon 6 | Limited | 9 | Italy |
| Primary backing | Polyester | Limited | 3 | Thailand |
| Pre-coat | Synthetic latex | Limited | 4 | United Kingdom |
| | Calcium carbonate | Postindustrial recycled | 14 | United Kingdom |
| Backing | Bitumen | Limited | 16 | Global |
| | Calcium Sulphate | Postindustrial recycled | 51 | United Kingdom |
| Secondary backing | Polyester | Limited | 3 | Germany |

Production of Main Materials

Yarn: Nylon 6 is synthesized by ring-opening polymerization of caprolactam. During polymerization, the amide bond within each caprolactam molecule is broken, with the active groups on each side re-forming two new bonds as the monomer becomes part of the polymer backbone

Polyester: Polyester is a category of polymers that contain the ester functional group in their main chain. As a specific material, it most commonly refers to a type called polyethylene terephthalate (PET).

Latex: Styrene Butadiene latex is a polymer emulsion composed of two hydrocarbon monomers, styrene and butadiene.

Calcium carbonate: The Calcium carbonate used is coming from a postindustrial recycling process

Bitumen: Bitumen is an oil based substance. It is a semi-solid hydrocarbon product produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process.

Calcium Sulphate: The Calcium Sulphate (Gypsum) used is coming from a postindustrial recycling process.

Production of the Floor Covering

Struktur 1 is a microtuft loop pile carpet tile. Yarn is precisely inserted into the primary backing to create a decorative top-cloth. The residual yarn is re-used. This cloth is then pre-coated with latex compound to provide tuft anchorage and dimensional stability. The edges are trimmed at this point and the edge trim is repurposed. The cloth is then backed with a bitumen mix and a polyester scrim. It is then die / ultrasonically cut into 50cm x 50cm tiles. The ultrasonic cutting process reduces waste by 8% compared to the traditional pressing method. Cutting waste is recycled.

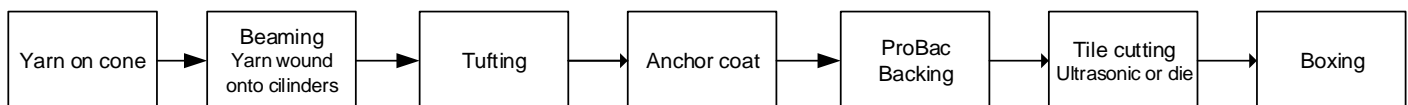


Figure 2: Production process of Tessera Struktur 1



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Textile Floor covering

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Health, Safety and Environmental Aspects during Production

- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems

Production Waste

All product rejected at final inspection stage is recycled externally. In coming packaging materials are collected, separated and recycled.

Delivery and Installation of the Floor Covering

Delivery

A worldwide distribution by truck and container ship is utilized. On average every square meter of Tessera Struktur 1 is transported as follows:

- | | |
|--|--------|
| ○ Transport distance 40 t truck | 290 km |
| ○ Transport distance 7.5 t truck | 84km |
| ○ Capacity utilization trucks (including empty runs) | 84 % |
| ○ Transport distance Ocean ship | 920 km |
| ○ Capacity utilization Ocean ship | 48% |

Although a worldwide distribution is taken into account, the average distance by Ocean ship is negligible.

Installation

During the installation of Tessera Struktur 1, an average of 3% of the material becomes installation waste. For the installation of Tessera Struktur 1 tiles 0.10 kg/m² of tackifier adhesive is required. Waste during the installation process can be thermally recycled in a waste incineration plant. The majority of Tessera Struktur 1 tile is sold in UK / 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 the use of (low) zero emission adhesives for installing Tessera Struktur 1.

Waste

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 Tessera Struktur 1 is sold in Europe the European electricity grid mix is used in the calculations for the energy recovery during incineration.

Packaging

Cardboard tile boxes, wooden pallets and PE-film 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.



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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 | Daily | Electricity |
| | Spot/spill clean | As spill occurs | Spotting agent |
| | Dry fusion clean Hot water extraction | Four times each year | Hot water 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 every day. This equates to 1.92 kWh/m²*year.
- Four times a year wet cleaning with 0.062 l/m² water and 0.0008 kg/m² detergent. This result in the use of 0.248 l/m²*year water and 0.0032 kg/m²*year detergent. The wet cleaning takes place without power machine usage. The waste water treatment of the arising waste water from cleaning is considered (Data source 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 steps 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.

Health Aspects during Usage

Tessera Struktur 1 complies with:

- o AgBB requirements
- o CHPS section 01350



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Textile Floor covering

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End of Life

The deconstruction of installed Tessera Struktur 1 from the floor is a manual process. For the end of life stage no landfilling is taken into account, since the vast majority of the countries in which Tessera Struktur 1 is sold have a non landfill policy. Because of the high calorific value of Tessera Struktur 1 the incineration is very profitable as a waste to energy conversion.

Life Cycle Assessment

A full Life Cycle Assessment has been 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)

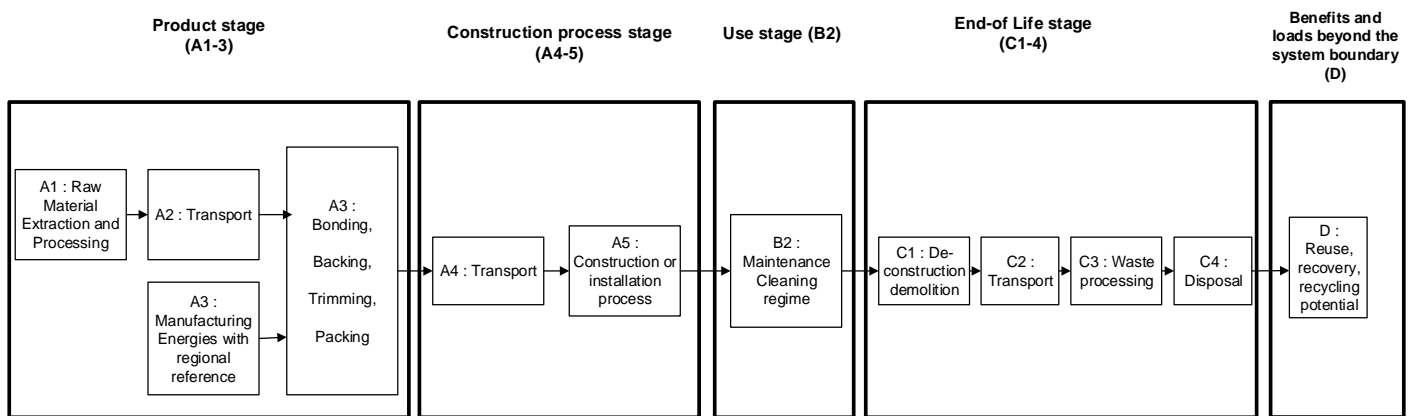


Figure 3 : Flow chart of the Life Cycle Assessment

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.



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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 9 Software System for Life Cycle Engineering, developed by SPHERA, has been used. All relevant LCA datasets are taken from the GaBi 9 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 2019). 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 9 Software System for Life Cycle Engineering, developed by Sphera, is used. All relevant LCA datasets are taken from the GaBi 9 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 |
|---------------------------------|----------------|----------------|
| Polyamide 6 | Europe | 2020 |
| Polyester | Europe | 2020 |
| Latex (SBR) | Germany | 2020 |
| Bitumen | Europe | 2019 |
| Calcium carbonate recycled | Europe | 2018 |
| Calcium Sulphate Recycled | Europe | 2018 |
| Polyester substrate | Germany | 2019 |
| Electricity from Biomass | United Kingdom | 2020 |
| Electricity from Wind power | United Kingdom | 2020 |
| Electricity from Hydro power | United Kingdom | 2020 |
| Thermal energy from biogas | Europe | 2020 |
| Detergent (ammonia based) | Germany | 2020 |
| Tap water | Europe | 2020 |
| Adhesive for resilient flooring | Germany | 2018 |
| Waste incineration of Textiles | Europe | 2020 |
| Textile landfill | Europe | 2020 |
| Power grid mix | Europe | 2020 |



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| Data set | Region | Reference year |
|--|----------------|----------------|
| Thermal energy from natural gas | United Kingdom | 2020 |
| Thermal energy from natural gas | Europe | 2020 |
| Trucks | Global | 2020 |
| Municipal waste water treatment (Sludge incineration). | Europe | 2020 |
| Container ship | Global | 2020 |
| Diesel mix at refinery | Europe | 2020 |
| Heavy fuel oil at refinery (1.0wt.% S) | Europe | 2020 |
| Polyethylene film | Germany | 2020 |
| Corrugated board | Europe | 2020 |
| Wooden pallet | Germany | 2020 |

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 Bamber Bridge, The United Kingdom. The GaBi 9 Hydro power, Biomass and Wind power datasets have therefore been used (reference year 2020). The energy supplier is providing Forbo with a certificate every year.

CO₂-Certificates

No CO₂-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.



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Tessera Struktur 1
Textile Floor covering

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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 (3%):

Table 2: Composition of Tessera Struktur 1

| Process data | Unit | Tessera Struktur 1 |
|----------------------------|-------------------|--------------------|
| Nylon 6 | kg/m ² | 0.34 |
| Polyester fiber | kg/m ² | 0.12 |
| Latex (SBR) | kg/m ² | 0.16 |
| Calcium carbonate recycled | kg/m ² | 0.51 |
| Bitumen | kg/m ² | 0.59 |
| Calcium Sulphate recycled | kg/m ² | 1.88 |
| Polyester substrate | kg/m ² | 0.12 |



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Table 3: Production related inputs/outputs

| Process data | Unit | Tessera Struktur 1 |
|----------------------------|------|--------------------|
| INPUTS | | |
| Tessera Struktur 1 | kg | 4.09 |
| Electricity | MJ | 3.19 |
| Thermal energy from biogas | MJ | 5.11 |
| OUTPUTS | | |
| Tessera Struktur 1 | kg | 3.72 |
| Waste | kg | 0.37 |

Table 4: Packaging requirements (per m² manufactured product)

| Process data | Unit | Tessera Struktur 1 |
|-------------------|------|--------------------|
| Polyethylene film | kg | 0.002 |
| Corrugated board | kg | 0.06 |
| Wooden pallet | kg | 0.33 |

Table 5: Transport distances

| Process data | Unit | Road | Truck size | Ship |
|--|------|------|---|-------|
| Nylon 6 | km | 1915 | 14 - 20t gross weight / 11,4t payload capacity | 77 |
| Polyester fiber | km | 410 | | 12230 |
| Latex (SBR) | km | 57 | | - |
| Calcium carbonate recycled | km | 69 | | - |
| Bitumen | km | 81 | | - |
| Calcium Sulphate recycled | km | 69 | | - |
| Polyester substrate | km | 1400 | | 77 |
| Corrugated board | km | 30 | | - |
| Wooden pallet | km | 21 | | - |
| Polyethylene film | km | 40 | | - |
| Transport to construction site : -Transport distance 40 t truck | km | 290 | 34 - 40 t gross weight / 27t payload capacity 7,5 t - 12t gross weight / 5t payload capacity | 920 |
| -Transport distance 7.5t truck (Fine distribution) | | 84 | | |
| Waste transport to landfill & incineration | km | 200 | 7,5 t - 12t gross weight / 5t payload capacity | - |



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Table 6: Inputs/outputs from Installation

| Process data | Unit | Tessera Struktur 1 |
|--------------------------------|------|--------------------|
| INPUTS | | |
| Tessera Struktur 1 | kg | 3.79 |
| Adhesive (30% water content) | kg | 0.10 |
| - Water | | |
| - Acrylate co-polymer | | |
| - Styrene Butadiene co-polymer | | |
| - Limestone flour | | |
| - Sand | | |
| OUTPUTS | | |
| Installed Tessera Struktur 1 | kg | 3.72 |
| Installation Waste | kg | 0.07 |

Table 7: Inputs from use stage (per m².year of installed product)

| Process data | Unit | Tessera Struktur 1 |
|--------------|----------|--------------------|
| Detergent | kg/year | 0.003 |
| Electricity | kWh/year | 0.768 |
| Water | kg/year | 0.248 |

Table 8: Disposal

| Process data | Unit | Tessera Struktur 1 |
|--|------|--------------------|
| Post-consumer Tessera Struktur 1 to incineration | % | 100 |

Life Cycle Inventory Analysis

In table 9 the environmental impacts for one lifecycle are presented for Tessera Struktur 1. 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) – Tessera Struktur 1

| Impact Category : CML 2001 – April 2015 | Tessera Struktur 1 | Unit |
|---|--------------------|----------------------------|
| Global Warming Potential (GWP 100 years) | 1,40E+01 | kg CO ₂ -Equiv. |
| Ozone Layer Depletion Potential (ODP. steady state) | 1,92E-07 | kg R11-Equiv. |
| Acidification Potential (AP) | 2,50E-02 | kg SO ₂ -Equiv. |
| Eutrophication Potential (EP) | 3,71E-03 | kg Phosphate-Equiv. |
| Photochem. Ozone Creation Potential (POCP) | 1,95E-03 | kg Ethene-Equiv. |
| Abiotic Depletion Potential Elements (ADPE) | 4,36E-06 | kg Sb-Equiv. |
| Abiotic Depletion Potential Fossil (ADPF) | 1,48E+02 | [MJ] |



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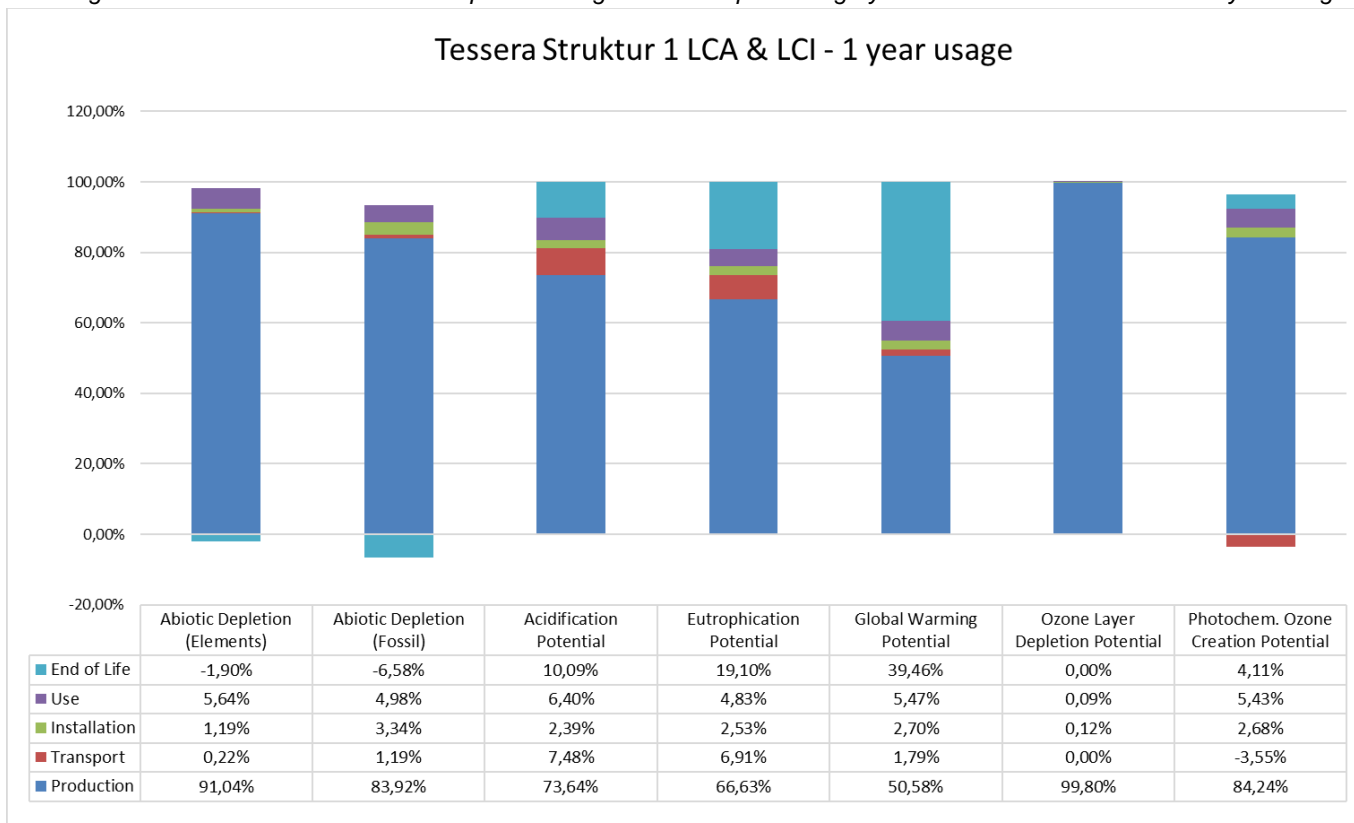
Table 10: Results of the LCA – Environmental impact for Tessera Struktur 1 (one year)

| 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.] | 7,06E+00 | 2,50E-01 | 3,77E-01 | 7,63E-01 | 0,00E+00 | 2,59E-02 | 6,46E+00 | -9,78E-01 |
| ODP | [kg CFC11-Eq.] | 1,92E-07 | 2,34E-17 | 2,27E-10 | 1,65E-10 | 0,00E+00 | 4,23E-18 | 1,44E-15 | -1,40E-14 |
| AP | [kg SO ₂ -Eq.] | 1,84E-02 | 1,87E-03 | 5,96E-04 | 1,60E-03 | 0,00E+00 | 6,16E-05 | 3,70E-03 | -1,24E-03 |
| EP | [kg PO ₄ ³⁻ - Eq.] | 2,47E-03 | 2,56E-04 | 9,38E-05 | 1,79E-04 | 0,00E+00 | 1,51E-05 | 8,48E-04 | -1,55E-04 |
| POCP | [kg Ethen Eq.] | 1,77E-03 | -7,46E-05 | 5,63E-05 | 1,14E-04 | 0,00E+00 | -2,17E-05 | 2,21E-04 | -1,13E-04 |
| ADPE | [kg Sb Eq.] | 4,13E-06 | 1,00E-08 | 5,42E-08 | 2,56E-07 | 0,00E+00 | 2,14E-09 | 9,58E-08 | -1,84E-07 |
| ADPF | [MJ] | 1,43E+02 | 2,02E+00 | 5,69E+00 | 8,48E+00 | 0,00E+00 | 3,51E-01 | 2,24E+00 | -1,38E+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 Tessera Struktur 1 is shown in figures 4.

Figure 4: relative contribution of each process stage to each impact category for Tessera Struktur 1 for a one year usage.



Interpretation

The interpretation of the results has been carried out considering the assumptions and limitations declared in the EPD,



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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, in particular PA 6, polyester and latex are the key contributors for all of these impact categories with a total share of 71 – 99% of the total impact of the production stage.

Forbo declares in the EPD a worldwide distribution which has a limited effect on most of the impact categories. Only for AP and EP there is a significant share of ± 7% of the total caused by the ships and trucks used to transport the product.

For AP, EP, GWP, POCP, and ADPF the adhesive as main contributor for the flooring installation has a minor impact of 2 – 3.5% of the total environmental impact of Tessera Struktur 1.

In the Use stage the electricity needed to vacuum the floor is causing an impact of 5 – 6.5% for ADPE, ADPF, AP, EP, GWP and POCP. 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 small credit for ADPF and ADPE in the End of Life stage. For EP and GWP the End of Life stage has a significant impact on the total of respectively 19 and 40%. This is mainly due to the fact that the waste at the End of Life stage is considered as being incinerated.

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 Tessera Struktur 1 (one year)

| Parameter | Unit | Manufacturing | Installation | | Use (1yr) | End of Life | | | Credits |
|-----------|-------------------|---------------|--------------|----------|-----------|-------------|----------|----------|-----------|
| | | A1-3 | A4 | A5 | B2 | C1 | C2 | C3 | D |
| PERE | [MJ] | 2,61E+01 | - | - | - | - | - | - | - |
| PERM | [MJ] | 0,00E+00 | - | - | - | - | - | - | - |
| PERT | [MJ] | 2,61E+01 | 8,25E-02 | 2,28E-01 | 6,02E+00 | 0,00E+00 | 1,98E-02 | 3,31E-01 | -3,72E+00 |
| PENRE | [MJ] | 1,45E+02 | - | - | - | - | - | - | - |
| PENRM | [MJ] | 9,80E+00 | - | - | - | - | - | - | - |
| PENRT | [MJ] | 1,55E+02 | 2,02E+00 | 5,80E+00 | 1,37E+01 | 0,00E+00 | 3,52E-01 | 2,47E+00 | -1,70E+01 |
| SM | [kg] | 1,94E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| RSF | [MJ] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| NRSF | [MJ] | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| FW | [m ³] | 3,76E-01 | 9,68E-05 | 1,25E-03 | 6,97E-03 | 0,00E+00 | 2,29E-05 | 1,75E-02 | -4,30E-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



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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 Tessera Struktur 1 (one year)

| Parameter | Unit | Manufacturing | Transport | Installation | Use (1yr) | End of Life/credits | | | |
|-------------------|------|---------------|-----------|--------------|-----------|---------------------|----------|----------|-----------|
| | | A1-3 | A4 | A5 | B2 | C1 | C2 | C3 | D |
| HWD | [kg] | 3,81E-08 | 6,68E-08 | 1,95E-09 | 5,63E-09 | 0,00E+00 | 1,64E-08 | 1,92E-09 | -6,77E-09 |
| NHWD | [kg] | 3,34E-02 | 2,80E-04 | 3,59E-03 | 9,91E-03 | 0,00E+00 | 5,39E-05 | 8,36E-02 | -7,86E-03 |
| RWD | [kg] | 2,88E-03 | 2,43E-06 | 4,39E-05 | 2,06E-03 | 0,00E+00 | 4,36E-07 | 9,18E-05 | -1,27E-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 | 2,55E-01 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 1,15E+01 | 0,00E+00 |
| EE Thermal energy | [MJ] | 0,00E+00 | 0,00E+00 | 4,59E-01 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 2,08E+01 | 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 transparent 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 USEtox™ 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. USEtox™ is classified as Level II / III, unlike for example the CML impact categories which are classified as Level I.



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Table 13: Results of the LCA – Environmental impacts one lifecycle (one year) – Tessera Struktur 1

| Impact Category : USEtox | Tessera Struktur 1 | Unit |
|---------------------------|--------------------|------------|
| Eco toxicity | 3,48E-02 | PAF m3.day |
| Human toxicity, cancer | 8,16E-10 | Cases |
| Human toxicity, non-canc. | 5,88E-11 | Cases |

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

Table 14: Results of the LCA – Environmental impact for Tessera Struktur 1 (one year)

| Impact Category : USEtox | Unit | Production | Transport | Installation | Use (1yr) | End of Life |
|---------------------------|------------|------------|-----------|--------------|-----------|-------------|
| Eco toxicity | PAF m3.day | 3,29E-02 | 4,74E-04 | 6,26E-04 | 1,31E-03 | -5,02E-04 |
| Human toxicity, cancer | cases | 7,95E-10 | 5,34E-13 | 1,23E-11 | 1,01E-10 | -9,23E-11 |
| Human toxicity, non-canc. | cases | 2,07E-11 | 1,77E-13 | 3,73E-11 | 1,87E-12 | -1,18E-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 Ecotoxicity and Human toxicity (cancer) the production stage is the main contributor to the total overall impact. The major impact for Ecotoxicity is coming from the manufacturing stage where the biogas used to produce Tessera is having a share of 98%. The raw material supply has a share of 73% of the production stage for Human toxicity (cancer), mainly caused by the manufacturing of polyamide 6. Human toxicity (non-canc) has a significant impact of 34%, mainly influenced by the production of Polyamide 6.

The transport stage is negligible for Human toxicity (cancer and non-canc.). For Ecotoxicity a small impact of 1,32% is seen, mainly caused by the use of diesel for the trucks.

The adhesive used for the installation of Tessera Struktur 1 is the dominant contributor for all toxicity categories, where Ecotoxicity and Human toxicity (cancer) are having a small contribution to the total impacts of the life cycles. The contribution for Human toxicity (non-canc.) is very high with a share of 61%.

The Use stage has a minor impact for all the toxicity impacts and 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 small credit for all three of the toxicity impact 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.



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Figure 5: relative contribution of each process stage to each impact category for Tessera Struktur 1 for a one year usage.

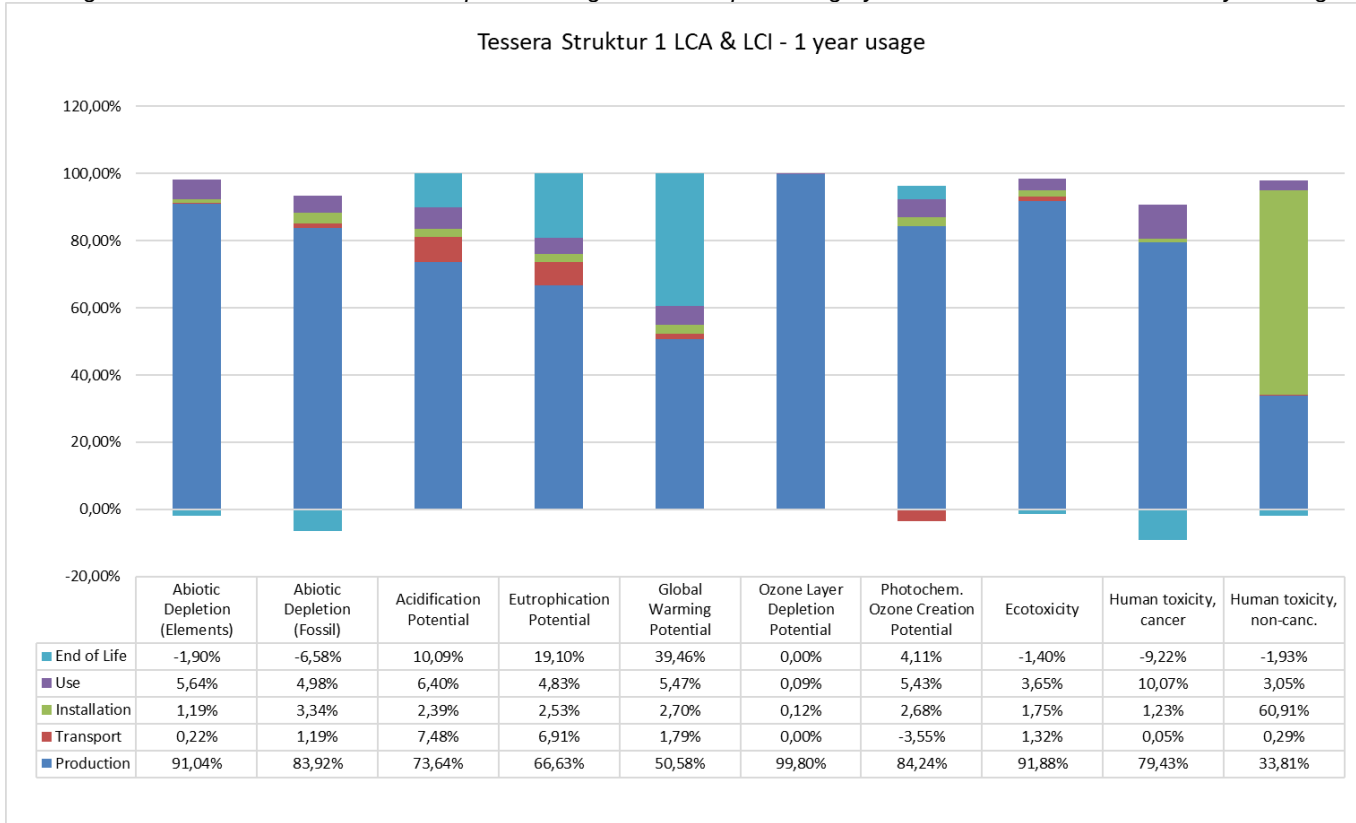


Table 16: Main modules and flows contributing to the total impact in each impact category for Tessera Struktur 1 for a one year usage

| Impact Category | Stage | Module | Main contributor | Main contributing flows |
|-----------------|--------------|----------------------------|---|---|
| GWP | Production | Raw Material Extraction | 7.29 kg CO ₂ -equiv. PA 6 (6.35 kg CO ₂ -eq.) | Production : Inorganic emissions to air, Carbon dioxide |
| | | Transport of Raw materials | 0.04 kg CO ₂ -equiv. Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 0.02 kg CO ₂ -equiv. 74% Thermal energy biogas | |
| | Transport | Transport Gate to User | Means of transport (truck, container ship) and their fuels | Transport & Installation : Inorganic emissions to air, Carbon dioxide |
| | Installation | Installation | 62% Adhesive 38% Disposal of Carpet installation waste | |
| | Use | Use | 99% Electricity | Use : Inorganic emissions to air, Carbon dioxide |
| | EOL | EOL | Incineration of post-consumer Tessera Struktur 1 Energy substitution from incineration | EOL : Inorganic emissions to air, Carbon dioxide |



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| Impact Category | Stage | Module | | Main contributor | Main contributing flows |
|-----------------|--------------|----------------------------|---|--|---|
| ODP | Production | Raw Material Extraction | 98% | 100% PA 6 | Production : Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane), R12 (dichlorodifluoromethane) Halon (1301) |
| | | Transport of Raw materials | < 0.05% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 2 % | 100% Wooden pallets for 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 | | 100% Detergent | Use : Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane), |
| EOL | EOL | | Incineration of post-consumer Tessera Struktur 1 Energy substitution from incineration | EOL: Halogenated organic emissions to air, R22 (chlorodifluoromethane) | |
| AP | Production | Raw Material Extraction | 79% | 66% PA 6 23% Latex | Production : Inorganic emissions to air, NO _x and Sulphur dioxide, Ammonia |
| | | Transport of Raw materials | 4% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 17% | 96% Thermal energy biogas | |
| | 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 | | 86% Adhesive | |
| | Use | Use | | 99% Electricity | Use : Inorganic emissions to air, NO _x and Sulphur dioxide |
| EOL | EOL | | Incineration of post-consumer Tessera Struktur 1 Energy substitution from incineration | EOL : Inorganic emissions to air, NO _x and Sulphur dioxide | |
| EP | Production | Raw Material Extraction | 71% | 67% PA 6 21% Latex | Production : Inorganic emissions to air, Ammonia, NO _x Production : Inorganic emissions to fresh water, Nitrate, Ammonium/Ammonia, Nitrogen organic bound, Phosphate |
| | | Transport of Raw materials | 3% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 26% | 96% Thermal energy biogas | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Inorganic emissions to air, NO _x |
| | Installation | Installation | | 80% Adhesive | |
| | Use | Use | | 98% Electricity | Use : Inorganic emissions to air, NO _x Use : Inorganic emissions to fresh water, Nitrate, Ammonium/Ammonia, Nitrogen organic bound, Phosphate |
| EOL | EOL | | Incineration of post-consumer Tessera Struktur 1 Energy substitution from incineration | EOL : Inorganic emissions to air, NO _x and Ammonia | |
| POCP | Production | Raw Material Extraction | 91% | 62% PA 6 19% PET 12% Latex | Production : Inorganic emissions to air, Carbon monoxide, NO _x , Sulphur dioxide Production : Halogenated organic emissions to air, Butane (n-butane), NMVOC (Unspecified), Propane, Methane, Ethane, VOC (Unspecified) |
| | | Transport of Raw materials | 1% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 8% | 88% Thermal energy biogas | |
| | 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 Transport & Installation : Halogenated organic emissions to air, NMVOC (Unspecified), |
| | Installation | Installation | | 92% Adhesive | |
| | Use | Use | | 99% electricity | Use : Inorganic emissions to air, Sulphur |



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| Impact Category | Stage | Module | | Main contributor | Main contributing flows |
|-----------------|--------------|----------------------------|--------|---|---|
| | EOL | EOL | | Incineration of post-consumer Tessera Struktur 1 Energy substitution from incineration | dioxide, Nitrogen dioxide EOL : Inorganic emissions to air, Carbon monoxide , NO _x , Sulphur dioxide EOL : Halogenated organic emissions to air, Butane (n-butane), NMVOC (Unspecified), Propane, Methane, Ethane, VOC (Unspecified) |
| ADPe | Production | Raw Material Extraction | 87% | 79% PA 6 16% PET | Production : Nonrenewable resources, Lead-Zinc ore, Sodium chloride (Rock salt) Production : Nonrenewable elements, Sulphur |
| | | Transport of Raw materials | < 0.1% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 13% | 94% Thermal energy biogas | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Nonrenewable resources, Sodium chloride (rock salt) |
| | Installation | Installation | | 96% Adhesive | Transport & Installation : Nonrenewable elements, Lead, Silver, Copper |
| | Use | Use | | 99% Electricity | Use : Nonrenewable elements, Copper, Gold, Lead, Silver |
| | EOL | EOL | | Incineration of post-consumer Tessera Struktur 1 Energy substitution from incineration | EOL : Nonrenewable resources, Magnesium chloride leach (40%), Sodium chloride (Rock salt) EOL : Nonrenewable elements, Copper, Gold, Lead, Silver |
| ADPf | Production | Raw Material Extraction | 99% | 70% PA 6 13% Bitumen 15% PET | Production : Crude oil resource, Crude oil (in MJ) Production : Natural gas (resource), Natural gas (in MJ) |
| | | Transport of Raw materials | <0.5% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 1% | 57% Thermal energy biogas 43% Packaging | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Crude oil (resource) |
| | Installation | Installation | | 99% Adhesive | Transport & Installation : Natural gas (resource), |
| | Use | Use | | 99% electricity | Use : Hard coal (resource), Natural gas (resource), Lignite (resource), hard coal (resource) |
| | EOL | EOL | | Incineration of post-consumer Tessera Struktur 1 Energy substitution from incineration | EOL : Hard coal (resource), Natural gas (resource), Crude oil (resource) |
| Eco toxicity | Production | Raw Material Extraction | 31.5% | 25% PA 6 31% PET 43% Bitumen | Production : Hydrocarbons to fresh water, Phenol (hydroxy benzene), Methanol, Anthracene Production : Pesticides to fresh water, Alachlor |
| | | Transport of Raw materials | 0.5% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 68% | 98% Thermal energy biogas | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & installation : Hydrocarbons to fresh water, Phenol (hydroxy benzene), Anthracene, Methanol |
| | Installation | Installation | | 99% Adhesive | Transport & installation : Pesticides to fresh water, Alachlor |
| | Use | Use | | 100% Electricity | Use : Hydrocarbons to fresh water, Phenol (hydroxy benzene), Anthracene Use : Pesticides to fresh water, Alachlor |
| | EOL | EOL | | Incineration of post-consumer Tessera Struktur 1 Energy substitution from incineration | EOL : Hydrocarbons to fresh water, Phenol (hydroxy benzene), Anthracene, Benzene, Toluene (Methyl benzene) EOL : Pesticides to fresh water, Alachlor |



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| Impact Category | Stage | Module | | Main contributor | Main contributing flows |
|---------------------------|--------------|----------------------------|---|---|--|
| Human toxicity, cancer | Production | Raw Material Extraction | 73% | 88% PA 6 | Production : Organic emissions to air (Group VOC), Formaldehyde (Methanal) |
| | | Transport of Raw materials | < 0.1% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 27% | 99% Thermal energy biogas | |
| | 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 | | 98% adhesive | |
| | Use | Use | | 99% Electricity | Use : Organic emissions to air (Group VOC), Formaldehyde (Methanal) |
| EOL | EOL | | Incineration of post-consumer Tessera Struktur 1 Energy substitution from incineration | EOL : Organic emissions to air (Group VOC), Formaldehyde (Methanal) | |
| Human toxicity, non-canc. | Production | Raw Material Extraction | 83% | 82% PA 6 | Production : Organic emissions to air (Group VOC), Formaldehyde (Methanal) Production : Hydrocarbons to fresh water, Methanol |
| | | Transport of Raw materials | < 0.5% | Means of transport (truck, container ship) and their fuels | |
| | | Manufacturing | 17% | 99% Thermal energy biogas | |
| | Transport | Transport Gate to User | | Means of transport (truck, container ship) and their fuels | Transport & Installation : Organic emissions to air (Group VOC), Formaldehyde (Methanal), 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 Tessera Struktur 1 Energy substitution from incineration | EOL : Organic emissions to air (Group VOC), Formaldehyde (Methanal) | |



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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



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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 SiedIABf.

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 (CO₂-Eq.). This means that the greenhouse potential of an emission is given in relation to CO₂. 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.

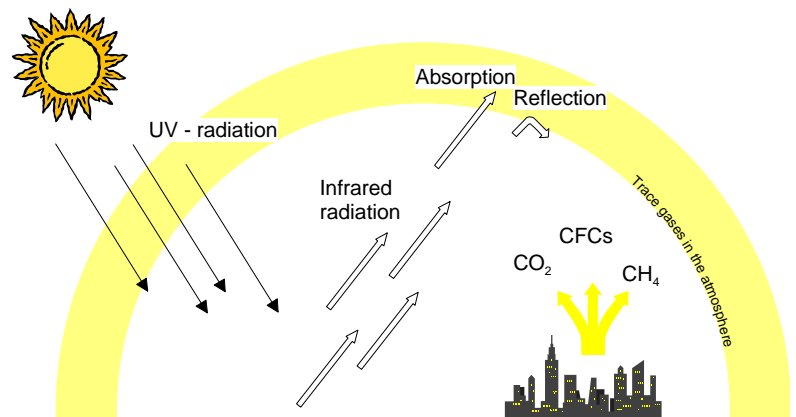


Figure A1: Greenhouse effect (KREISSIG 1999)



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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 (SO_2 -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.

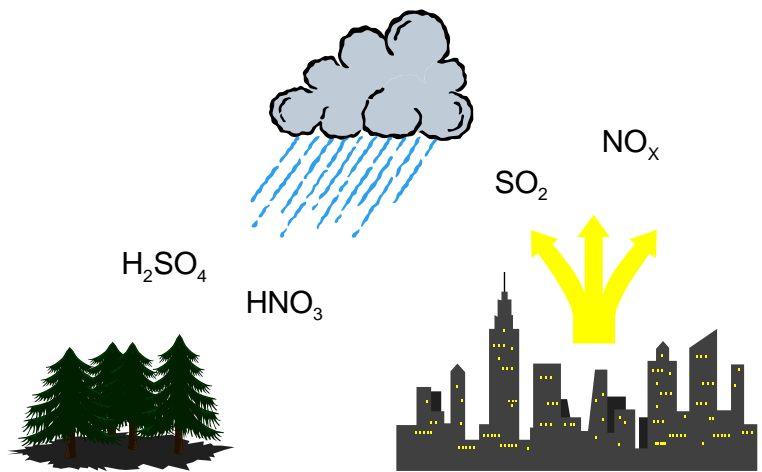


Figure A2: Acidification Potential (KREISSIG 1999)

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 nitrification 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.



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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.

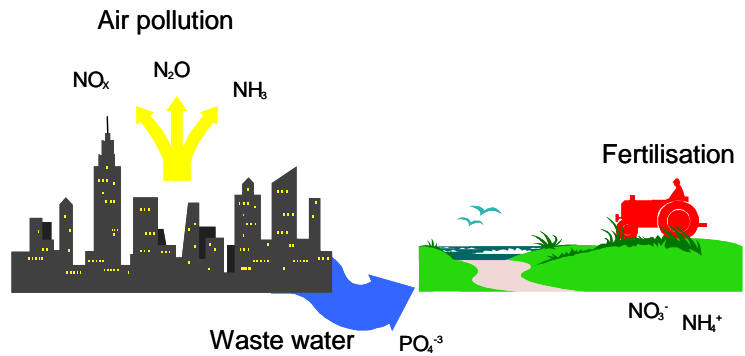


Figure A3: Eutrophication Potential (KREISSIG 1999)

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.

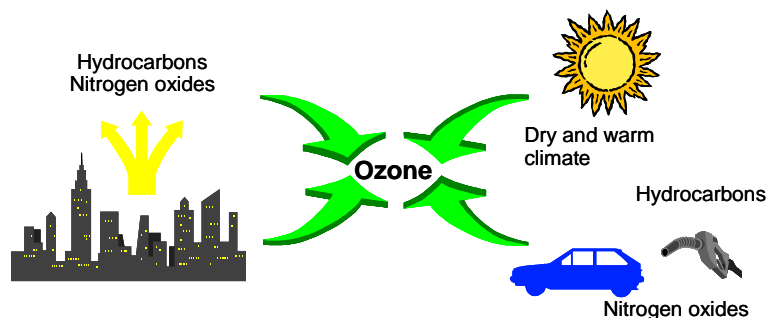


Figure A4: Photochemical Ozone Creation Potential

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



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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.

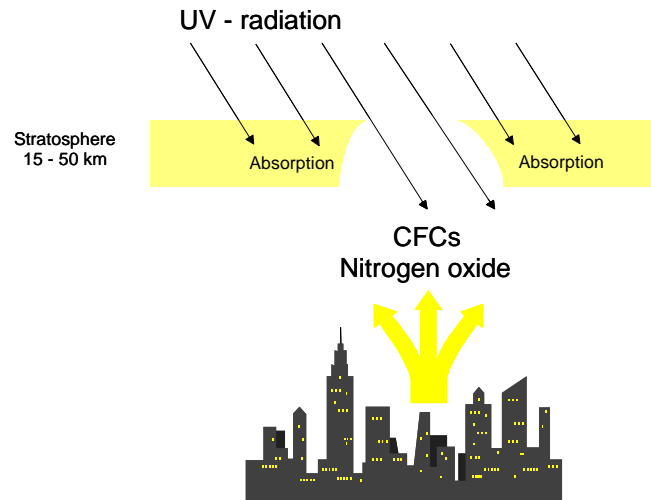


Figure A5: Ozone Depletion Potential (KREISSIG 1999)

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