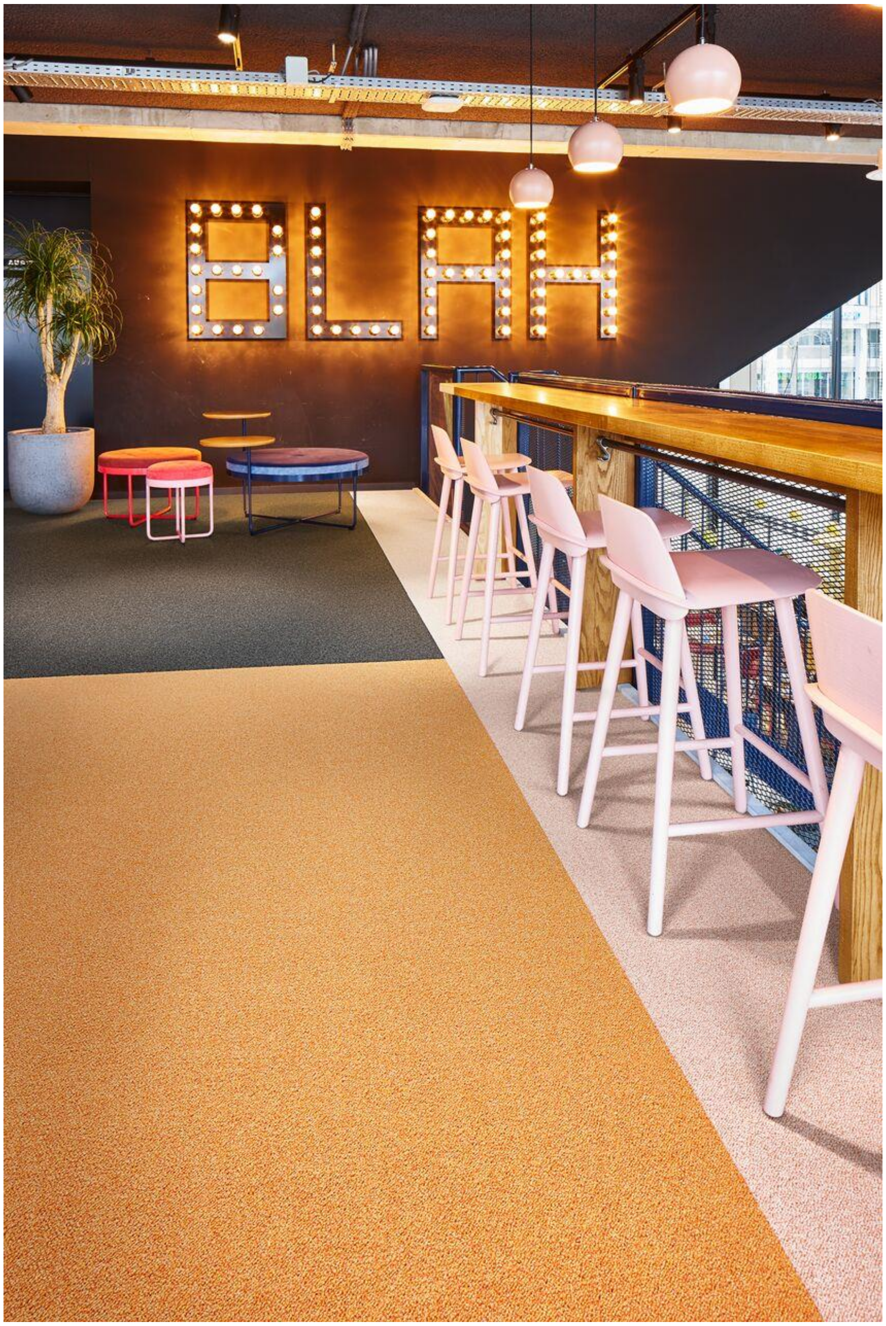
ENVIRONMENTAL PRODUCT DECLARATION

TESSERA CHROMA

FORBO FLOORING SYSTEMS
TEXTILE FLOOR COVERING

Tessera Chroma – 3606 Tuxedo, 3621 Camisole & 3623 Tangerine



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 eco-toxicity. By offering the complete story we hope that our stakeholders will be able to use this document as a tool that will translate the environmental performance of 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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ENVIRONMENTAL PRODUCT DECLARATION
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ENVIRONMENTAL PRODUCT DECLARATION

FLOORING SYSTEMS

Tessera Chroma
Textile Floor covering

According to ISO 14025 and EN 15804

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	4789471078.142.1
DECLARED PRODUCT	Tessera Chroma 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 ☐ INTERNAL ☒ EXTERNAL	María José Monteagudo Arrebola
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	Thomas P. Gloria, Industrial Ecology Consultants

This EPD conforms with EN 15804

Product Definition

Product Classification and description

This declaration covers Tessera Chroma carpet tiles. Tessera Chroma 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 Chroma carpet tiles are manufactured using renewable electricity and biogas.

The recycled content of the product is 62%

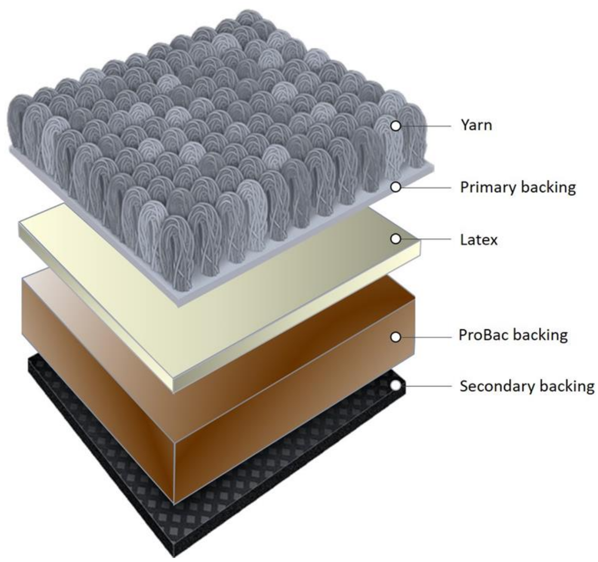


Figure 1: Illustration of Tessera Carpet tile

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

Range of application

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

FLOORING SYSTEMS

Tessera Chroma
Textile Floor covering

According to ISO 14025 and EN 15804

Product Standard

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

- Meets or exceeds all technical requirements EN1307 Class 33

Chroma carpet tiles meet the requirements of EN 14041		
Reaction to fire	EN 13501-1	B_{fl}-s1
Slip resistance	EN 13893	$\mu \geq 0.30$
Body voltage	EN1815	$<$ 2kV

EN 14041

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	6.4 ± 10%	mm
Product Weight	4065	g/m²
Tile size	50 x 50	cm

Material Content

Material Content of the Product

Table 2: Composition of Tessera Chroma

Component	Material	Availability	Amount [%]	Origin
Yarn	Nylon 6	Limited	15.5	Belgium
	Recycled nylon 6	Postindustrial recycled	3	Italy
Primary backing	Polyester	Limited	3	Thailand
Pre-coat	Synthetic latex Calcium carbonate	Limited Postindustrial recycled	3.5 11	United Kingdom United Kingdom
Backing	Bitumen Calcium Sulphate	Limited Postindustrial recycled	15 47	Global United Kingdom
Secondary backing	Polyester	Limited	2	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

Chroma is level loop pile tufted 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.

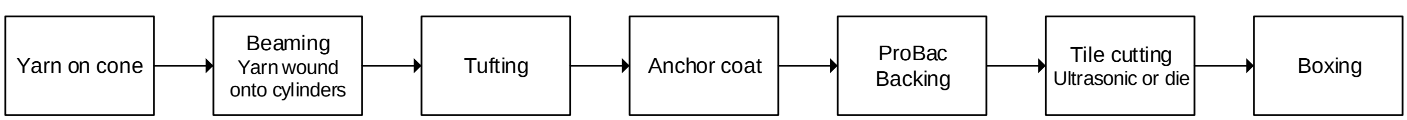


Figure 2: Production process of Tessera Chroma

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 Chroma 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 Chroma, an average of 3% of the material becomes installation waste. For the installation of Tessera Chroma 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 Chroma 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 Chroma.

Waste

Waste during the installation process can be thermally recycled in a waste incineration plant. Since the major part of Tessera Chroma 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.

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 occcurs	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/m^2 every day. This equates to 1.92 kWh/m^2*year.
- Four times a year wet cleaning with 0.062 l/m^2 water and 0.0008 kg/m^2 detergent. This result in the use of 0.248 l/m^2*year water and 0.0032 kg/m^2*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 Chroma complies with:

- AgBB requirements
- CHPS 01350

End of Life

The deconstruction of installed Tessera Chroma 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 Chroma is sold have a non landfill policy. Because of the high calorific value of Tessera Chroma 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)

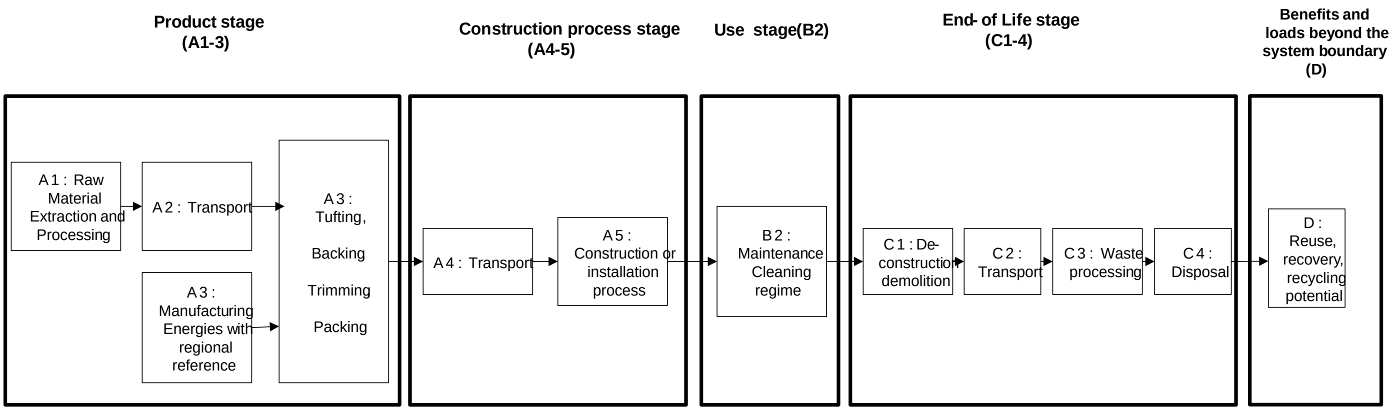


Figure 3: Flow chart of the Life Cycle Assessment

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 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 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.

CO_2-Certificates

No CO_2-certificates are considered in this study.

Life Cycle Inventory Analysis

In table 3 the environmental impacts for one lifecycle are presented for Tessera Chroma. 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 Chroma

Impact Category : CML 2001 – Jan. 2016	Tessera Chroma	Unit
Global Warming Potential (GWP 100 years)	1,94E+01	kg CO2-Equiv.
Ozone Layer Depletion Potential (ODP. steady state)	3,38E-07	kg R11-Equiv.
Acidification Potential (AP)	3,25E-02	kg SO2-Equiv.
Eutrophication Potential (EP)	4,71E-03	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	2,68E-03	kg Ethene-Equiv.
Abiotic Depletion Potential Elements (ADPE)	6,44E-06	kg Sb-Equiv.
Abiotic Depletion Potential Fossil (ADPF)	2,21E+02	[MJ]

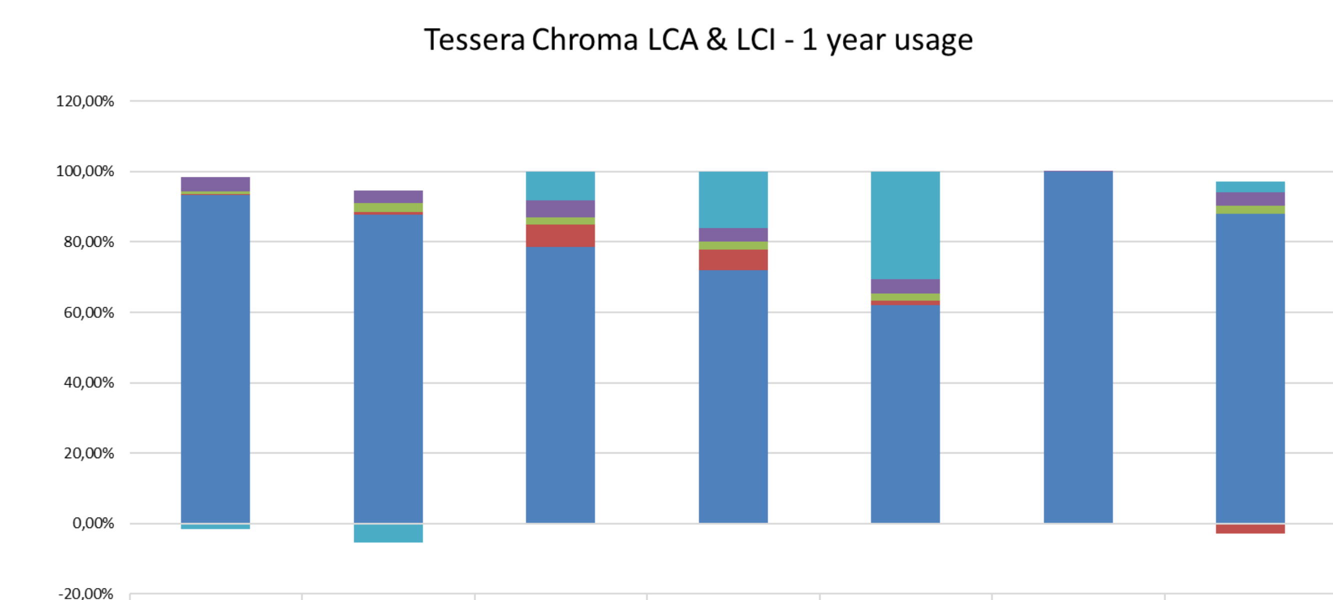
Table 4: Results of the LCA – Environmental impact for Tessera Chroma (one year)

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.]	1,20E+01	2,74E-01	4,12E-01	7,63E-01	0,00E+00	2,83E-02	7,07E+00	-1,17E+00
ODP	[kg CFC11-Eq.]	3,38E-07	2,56E-17	2,49E-10	1,65E-10	0,00E+00	4,63E-18	1,57E-15	-1,66E-14
AP	[kg SO_2-Eq.]	2,56E-02	2,05E-03	6,52E-04	1,60E-03	0,00E+00	6,74E-05	4,05E-03	-1,48E-03
EP	[kg PO_4^{3-}- Eq.]	3,39E-03	2,80E-04	1,03E-04	1,79E-04	0,00E+00	1,65E-05	9,28E-04	-1,84E-04
POCP	[kg Ethen Eq.]	2,50E-03	-8,16E-05	6,16E-05	1,14E-04	0,00E+00	-2,37E-05	2,42E-04	-1,35E-04
ADPE	[kg Sb Eq.]	6,23E-06	1,10E-08	5,94E-08	2,56E-07	0,00E+00	2,34E-09	1,05E-07	-2,19E-07
ADPF	[MJ]	2,18E+02	2,21E+00	6,23E+00	8,48E+00	0,00E+00	3,84E-01	2,45E+00	-1,64E+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 Chroma is shown in figure 4.

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



	Abiotic Depletion (Elements)	Abiotic Depletion (Fossil)	Acidification Potential	Eutrophication Potential	Global Warming Potential	Ozone Layer Depletion Potential	Photochem. Ozone Creation Potential
End of Life	-1,67%	-5,46%	8,11%	16,14%	30,59%	0,00%	2,93%
Use	3,84%	3,41%	4,92%	3,80%	3,94%	0,05%	4,01%
Installation	0,89%	2,51%	2,00%	2,19%	2,13%	0,07%	2,17%
Transport	0,16%	0,89%	6,30%	5,94%	1,41%	0,00%	-2,87%
Production	93,43%	87,73%	78,67%	71,94%	61,93%	99,88%	88,01%

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 76 – 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 ± 6% 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 – 2.5% of the total environmental impact of Tessera Chroma.

In the Use stage the electricity needed to vacuum the floor is causing an impact of 3.5 – 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 16 and 31%. 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 Chroma (one year)

		Manufacturing	**Installation**		**Use (1yr)**	**End of Life**			**Credits**
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
PERE	[MJ]	2,84E+01	-	-	-	-	-	-	-
PERM	[MJ]	0,00E+00	-	-	-	-	-	-	-
PERT	[MJ]	2,84E+01	9,03E-02	2,50E-01	6,02E+00	0,00E+00	2,16E-02	3,63E-01	-4,43E+00
PENRE	[MJ]	2,21E+02	-	-	-	-	-	-	-
PENRM	[MJ]	1,73E+01	-	-	-	-	-	-	-
PENRT	[MJ]	2,38E+02	2,21E+00	6,35E+00	1,37E+01	0,00E+00	3,85E-01	2,71E+00	-2,02E+01
SM	[kg]	1,85E+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]	3,30E-01	1,06E-04	1,36E-03	6,97E-03	0,00E+00	2,50E-05	1,91E-02	-5,13E-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 Chroma (one year)

		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits			
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
HWD	[kg]	4,02E-08	7,31E-08	2,14E-09	5,63E-09	0,00E+00	1,79E-08	2,10E-09	-8,07E-09
NHWD	[kg]	3,34E-02	3,06E-04	3,93E-03	9,91E-03	0,00E+00	5,89E-05	9,15E-02	-9,36E-03
RWD	[kg]	4,70E-03	2,66E-06	4,80E-05	2,06E-03	0,00E+00	4,77E-07	1,00E-04	-1,51E-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	2,79E-01	0,00E+00	0,00E+00	0,00E+00	1,26E+01	0,00E+00
EE Thermal energy	[MJ]	0,00E+00	0,00E+00	5,02E-01	0,00E+00	0,00E+00	0,00E+00	2,27E+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 transparant Forbo Flooring does not only want to declare the environmental impacts required in the PCR, but also the impacts on human health and eco-toxicity. Furthermore the outcome of the calculations according to the european Standard EN15804 are published in this section.

Toxicity

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

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

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

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

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

Impact Category : USEtox	Tessera Chroma	Unit
Eco toxicity	3,88E-02	PAF m3.day
Human toxicity, cancer	1,22E-09	Cases
Human toxicity, non-canc.	7,33E-11	Cases

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

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

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Eco toxicity	PAF m3.day	3,70E-02	5,19E-04	6,85E-04	1,31E-03	-6,34E-04
Human toxicity, cancer	cases	1,21E-09	5,85E-13	1,34E-11	1,01E-10	-1,11E-10
Human toxicity, non-canc.	cases	3,19E-11	1,94E-13	4,08E-11	1,87E-12	-1,46E-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 80% 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 42%, mainly influenced by the production of Polyamide 6.

The transport stage is almost negligible for Human toxicity (cancer and non-canc.). For Ecotoxicity a small impact of 1,29% is seen, mainly caused by the use of diesel for the trucks.

The adhesive used for the installation of Tessera Chroma 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 relatively high with a share of 54%.

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.

References

GaBi 9 2012	Sphera AG; GaBi 9: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2017.
GaBi 9 2012D	GaBi 9: Documentation of GaBi 9: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2017. http://documentation.gabi-software.com/
UL Environment	UL Environment's Program Operator Rules
PE 2012 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

Life Cycle Assessment

Tessera Chroma

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

July 2020

Environment

FLOORING SYSTEMS

Tessera Chroma
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

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

Content, structure and accessibility of the LCA report

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

Goal of the study

The reason for performing this LCA study is to publish an EPD based on EN 16810, EN 15804 and ISO 14025.
This study contains the calculation and interpretation of the LCA results for Tessera Chroma 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

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 Chroma is produced at the following manufacturing site:
Forbo Flooring UK Ltd.
Unit 92, Seedlee Road
Walton Summit
Preston, Lancashire
PR5 8AE
United Kingdom

forbo FLOORING SYSTEMS

Tessera Chroma
Textile Floor covering

According to ISO 14025 and EN 15804

Product Definition

Product Classification and description

This declaration covers Tessera Chroma carpet tiles. Tessera Chroma 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 Chroma carpet tiles are manufactured using renewable electricity and biogas.

The recycled content of the product is 62%

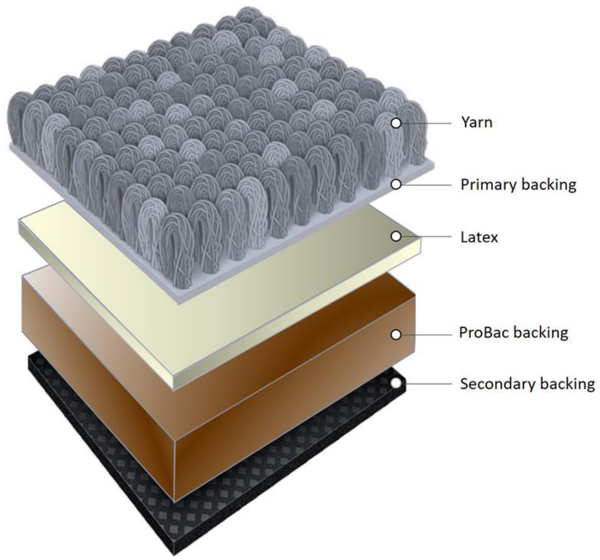


Figure 1: Illustration of Tessera Chroma

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

Range of application

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

Tessera Chroma
Textile Floor covering

According to ISO 14025 and EN 15804

Product Standard

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

- Meets or exceeds all technical requirements EN1307 Class 33

Chroma carpet tiles meet the requirements of EN 14041

Reaction to fire	EN 13501-1	B_{fl}-s1
Slip resistance	EN 13893	μ ≥ 0.30
Body voltage	EN1815	< 2kV

CE EN 14041

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	6.4 ± 10%	mm
Product Weight	4065	g/m^2
Tile size	50 x 50	cm

Material Content

Material Content of the Product

Table 2: Composition of Tessera Chroma

Component	Material	Availability	Amount [%]	Origin
Yarn	Nylon 6	Limited	15.5	Italy
	Recycled nylon 6	Postindustrial recycled	3	Italy
Primary backing	Polyester	Limited	3	Thailand
Pre-coat	Synthetic latex	Limited	3.5	United Kingdom
	Calcium carbonate	Postindustrial recycled	11	United Kingdom
Backing	Bitumen	Limited	15	Global
	Calcium Sulphate	Postindustrial recycled	47	United Kingdom
Secondary backing	Polyester	Limited	2	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

Chroma is level loop pile tufted 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.

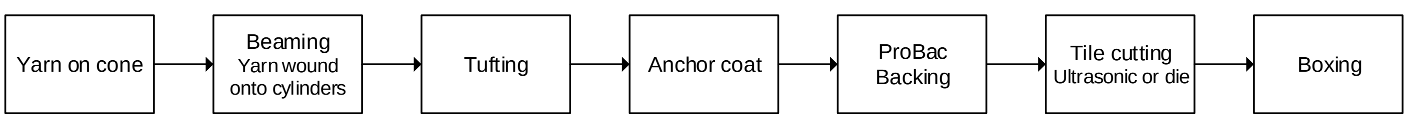


Figure 2: Production process of Tessera Chroma

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 Chroma 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 Chroma, an average of 3% of the material becomes installation waste. For the installation of Tessera Chroma 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 Chroma 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 Chroma.

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 Chroma 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.

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 occcurs	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 Chroma complies with:

- AgBB requirements
- CHPS 01350

End of Life

The deconstruction of installed Tessera Chroma 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 Chroma is sold have a non landfill policy. Because of the high calorific value of Tessera Chroma 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)

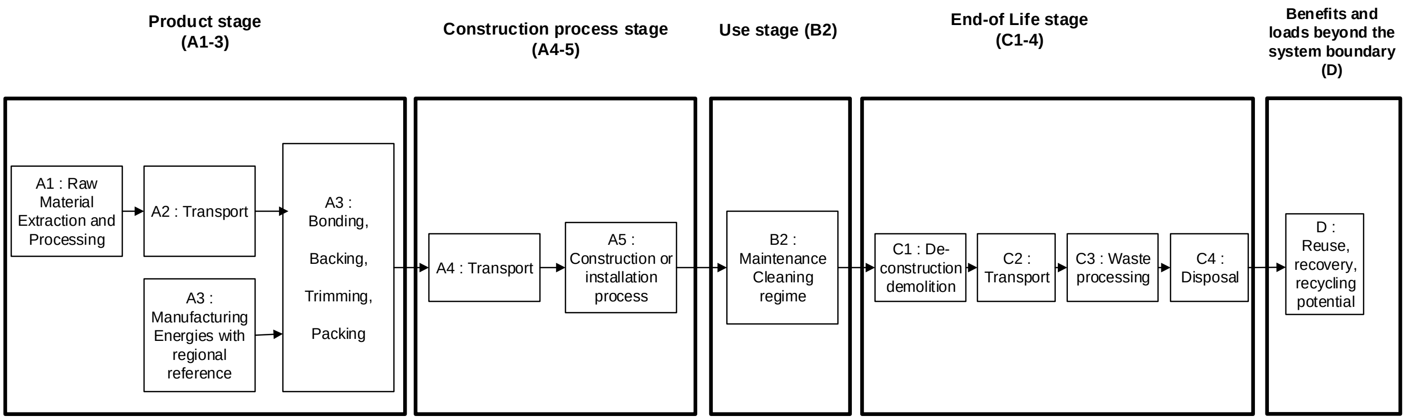


Figure 3 : Flow chart of the Life Cycle Assessment

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 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
Recycled polyamide 6	Europe	2013
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
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

Data set	Region	Reference year
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.

CO_2-Certificates

No CO_2-certificates are considered in this study.

Allocations

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

Co-product allocation

No co-product allocation occurs in the product system.

Allocation of multi-Input processes

The Production and End of Life stage include incineration plants. In these processes different products are treated together within a process. The allocation procedures followed in these cases are based on a physical classification of the mass flows or calorific values.
Credits from energy substitution are allocated to the production stage, because the gained energy from energy substitution is lower than the energy input in this stage. The same quality of energy is considered.

Allocation procedure of reuse, recycling and recovery

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

Description of the allocation processes in the LCA report

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

Description of the unit processes in the LCA report

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

In the following tables the type and amount of the different input and output flows are listed for 1m² produced flooring; installed flooring includes the material loss during installation (3%):

Table 2: Composition of Tessera Chroma

Process data	Unit	Tessera Chroma
Nylon 6	kg/m2	0.64
Recycled nylon 6	kg/m2	0.11
Polyester fiber	kg/m2	0.12
Latex (SBR)	kg/m2	0.14
Calcium carbonate recycled	kg/m2	0.45
Bitumen	kg/m2	0.62
Calcium Sulphate recycled	kg/m2	1.90
Polyester substrate	kg/m2	0.09

Table 3: Production related inputs/outputs

Process data	Unit	Tessera Chroma
INPUTS		
Tessera Chroma	kg	4.33
Electricity	MJ	3.19
Thermal energy from biogas	MJ	5.11
OUTPUTS		
Tessera Chroma	kg	4.07
Waste	kg	0.26

Table 4: Packaging requirements (per m^2 manufactured product)

Process data	Unit	Tessera Chroma
Polyethylene film	kg	0.002
Corrugated board	kg	0.07
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 -Transport distance 7.5t truck (Fine distribution)	km	 290 84	34 - 40 t gross weight / 27t payload capacity 7,5 t - 12t gross weight / 5t payload capacity	920
Waste transport to landfill & incineration	km	200	7,5 t - 12t gross weight / 5t payload capacity	-

Table 6: Inputs/outputs from Installation

Process data	Unit	Tessera Chroma
INPUTS		
Tessera Chroma	kg	4.15
Adhesive (30% water content) - Water - Acrylate co-polymer - Styrene Butadiene co-polymer - Limestone flour - Sand	kg	0.10
OUTPUTS		
Installed Tessera Chroma	kg	4.07
Installation Waste	kg	0.08

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

Process data	Unit	Tessera Chroma
Detergent	kg/year	0.003
Electricity	kWh/year	0.768
Water	kg/year	0.248

Table 8: Disposal

Process data	Unit	Tessera Chroma
Post-consumer Tessera Chroma to incineration	%	100

Life Cycle Inventory Analysis

In table 9 the environmental impacts for one lifecycle are presented for Tessera Chroma. 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 Chroma

Impact Category : CML 2001 – April 2015	Tessera Chroma	Unit
Global Warming Potential (GWP 100 years)	1,94E+01	kg CO2-Equiv.
Ozone Layer Depletion Potential (ODP. steady state)	3,38E-07	kg R11-Equiv.
Acidification Potential (AP)	3,25E-02	kg SO2-Equiv.
Eutrophication Potential (EP)	4,71E-03	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	2,68E-03	kg Ethene-Equiv.
Abiotic Depletion Potential Elements (ADPE)	6,44E-06	kg Sb-Equiv.
Abiotic Depletion Potential Fossil (ADPF)	2,21E+02	[MJ]

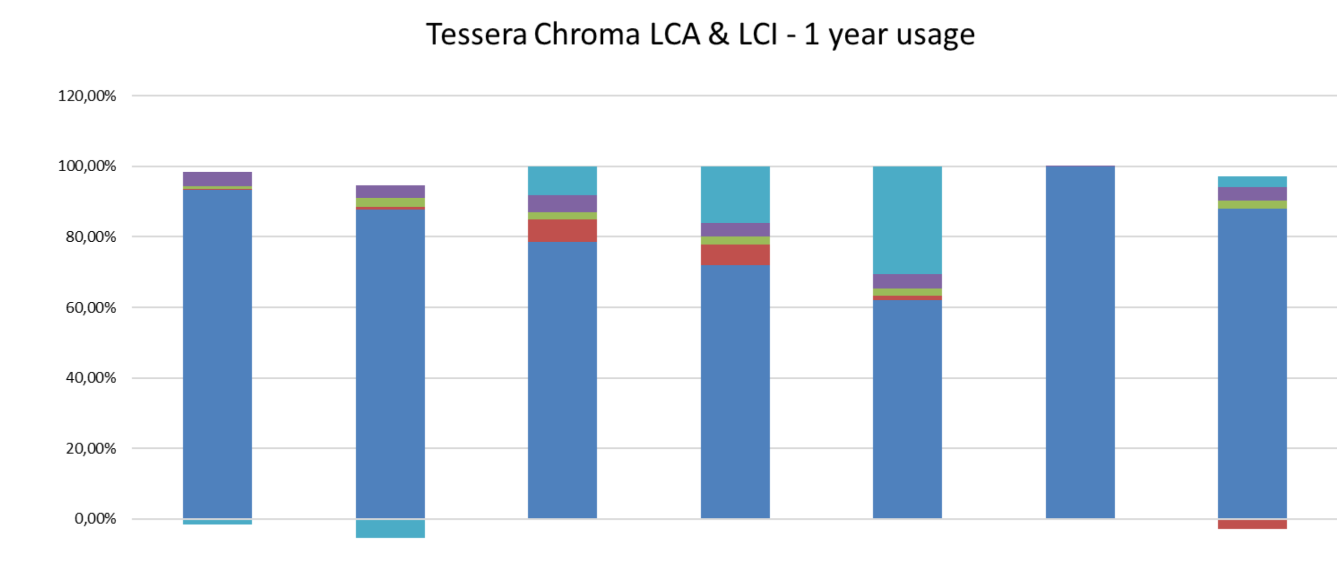
Table 10: Results of the LCA – Environmental impact for Tessera Chroma (one year)

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.]	1,20E+01	2,74E-01	4,12E-01	7,63E-01	0,00E+00	2,83E-02	7,07E+00	-1,17E+00
ODP	[kg CFC11-Eq.]	3,38E-07	2,56E-17	2,49E-10	1,65E-10	0,00E+00	4,63E-18	1,57E-15	-1,66E-14
AP	[kg SO_2-Eq.]	2,56E-02	2,05E-03	6,52E-04	1,60E-03	0,00E+00	6,74E-05	4,05E-03	-1,48E-03
EP	[kg PO_4^{3-}- Eq.]	3,39E-03	2,80E-04	1,03E-04	1,79E-04	0,00E+00	1,65E-05	9,28E-04	-1,84E-04
POCP	[kg Ethen Eq.]	2,50E-03	-8,16E-05	6,16E-05	1,14E-04	0,00E+00	-2,37E-05	2,42E-04	-1,35E-04
ADPE	[kg Sb Eq.]	6,23E-06	1,10E-08	5,94E-08	2,56E-07	0,00E+00	2,34E-09	1,05E-07	-2,19E-07
ADPF	[MJ]	2,18E+02	2,21E+00	6,23E+00	8,48E+00	0,00E+00	3,84E-01	2,45E+00	-1,64E+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 Chroma is shown in figures 4.

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



	Abiotic Depletion (Elements)	Abiotic Depletion (Fossil)	Acidification Potential	Eutrophication Potential	Global Warming Potential	Ozone Layer Depletion Potential	Photochem. Ozone Creation Potential
End of Life	-1,67%	-5,46%	8,11%	16,14%	30,59%	0,00%	2,93%
Use	3,84%	3,41%	4,92%	3,80%	3,94%	0,05%	4,01%
Installation	0,89%	2,51%	2,00%	2,19%	2,13%	0,07%	2,17%
Transport	0,16%	0,89%	6,30%	5,94%	1,41%	0,00%	-2,87%
Production	93,43%	87,73%	78,67%	71,94%	61,93%	99,88%	88,01%

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 76 – 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 ± 6% 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 – 2.5% of the total environmental impact of Tessera Chroma.

In the Use stage the electricity needed to vacuum the floor is causing an impact of 3.5 – 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 16 and 31%. 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 Chroma (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
PERE	[MJ]	2,84E+01	-	-	-	-	-	-	-
PERM	[MJ]	0,00E+00	-	-	-	-	-	-	-
PERT	[MJ]	2,84E+01	9,03E-02	2,50E-01	6,02E+00	0,00E+00	2,16E-02	3,63E-01	-4,43E+00
PENRE	[MJ]	2,21E+02	-	-	-	-	-	-	-
PENRM	[MJ]	1,73E+01	-	-	-	-	-	-	-
PENRT	[MJ]	2,38E+02	2,21E+00	6,35E+00	1,37E+01	0,00E+00	3,85E-01	2,71E+00	-2,02E+01
SM	[kg]	1,85E+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]	3,30E-01	1,06E-04	1,36E-03	6,97E-03	0,00E+00	2,50E-05	1,91E-02	-5,13E-03

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

Waste categories and output flows

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

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

		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits			
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
HWD	[kg]	4,02E-08	7,31E-08	2,14E-09	5,63E-09	0,00E+00	1,79E-08	2,10E-09	-8,07E-09
NHWD	[kg]	3,34E-02	3,06E-04	3,93E-03	9,91E-03	0,00E+00	5,89E-05	9,15E-02	-9,36E-03
RWD	[kg]	4,70E-03	2,66E-06	4,80E-05	2,06E-03	0,00E+00	4,77E-07	1,00E-04	-1,51E-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	2,79E-01	0,00E+00	0,00E+00	0,00E+00	1,26E+01	0,00E+00
EE Thermal energy	[MJ]	0,00E+00	0,00E+00	5,02E-01	0,00E+00	0,00E+00	0,00E+00	2,27E+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 transparant Forbo Flooring does not only want to declare the environmental impacts required in the PCR, but also the impacts on human health and eco-toxicity. Furthermore the outcome of the calculations according to the european Standard EN15804 are published in this section.

Toxicity

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

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

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

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

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

Impact Category : USEtox	Tessera Chroma	Unit
Eco toxicity	3,88E-02	PAF m3.day
Human toxicity, cancer	1,22E-09	Cases
Human toxicity, non-canc.	7,33E-11	Cases

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

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

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Eco toxicity	PAF m3.day	3,70E-02	5,19E-04	6,85E-04	1,31E-03	-6,34E-04
Human toxicity, cancer	cases	1,21E-09	5,85E-13	1,34E-11	1,01E-10	-1,11E-10
Human toxicity, non-canc.	cases	3,19E-11	1,94E-13	4,08E-11	1,87E-12	-1,46E-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 80% 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 42%, mainly influenced by the production of Polyamide 6.

The transport stage is almost negligible for Human toxicity (cancer and non-canc.). For Ecotoxicity a small impact of 1,29% is seen, mainly caused by the use of diesel for the trucks.

The adhesive used for the installation of Tessera Chroma 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 relatively high with a share of 54%.

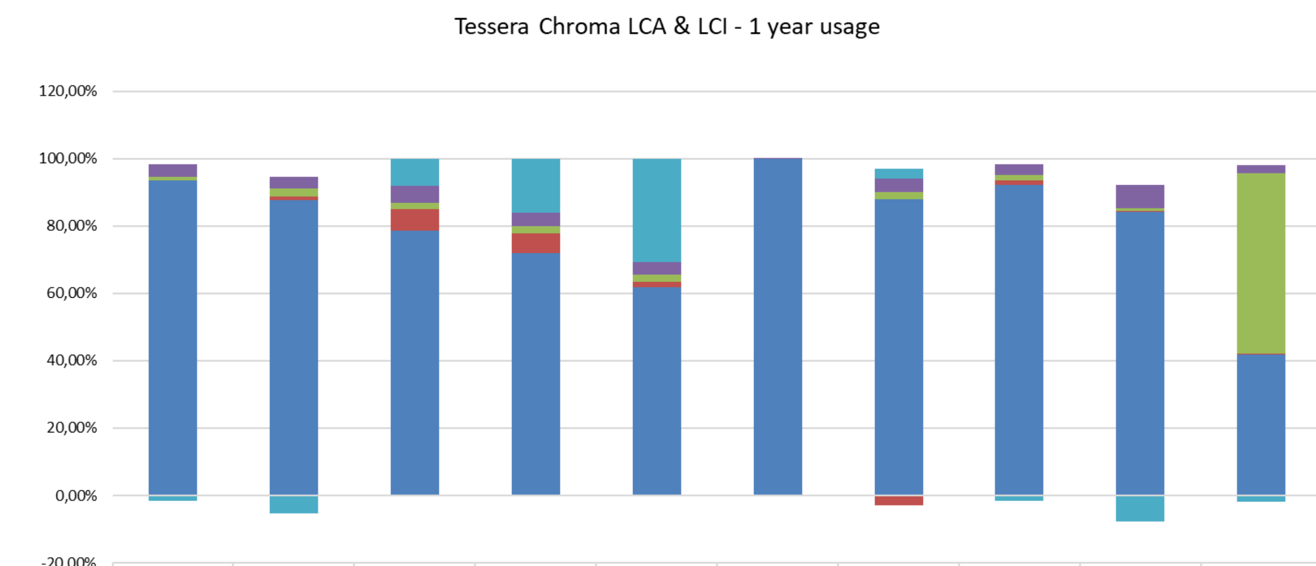
The Use stage has a minor impact for all the toxicity impacts and is mainly due to the use of electricity for the cleaning of the floor. The cleaning regime used in the calculations is a worst-case scenario which will be in practice almost always be lower.

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.

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



	Abiotic Depletion (Elements)	Abiotic Depletion (Fossil)	Acidification Potential	Eutrophication Potential	Global Warming Potential	Ozone Layer Depletion Potential	Photochem. Ozone Creation Potential	Ecotoxicity	Human toxicity, cancer	Human toxicity, non-canc.
End of Life	-1,67%	-5,46%	8,11%	16,14%	30,59%	0,00%	2,93%	-1,58%	-7,71%	-1,92%
Use	3,84%	3,41%	4,92%	3,80%	3,94%	0,05%	4,01%	3,26%	7,01%	2,45%
Installation	0,89%	2,51%	2,00%	2,19%	2,13%	0,07%	2,17%	1,71%	0,93%	53,49%
Transport	0,16%	0,89%	6,30%	5,94%	1,41%	0,00%	-2,87%	1,29%	0,04%	0,25%
Production	93,43%	87,73%	78,67%	71,94%	61,93%	99,88%	88,01%	92,16%	84,31%	41,88%

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

Impact Category	Stage	Module		Main contributor	Main contributing flows
GWP	Production	Raw Material Extraction	12.2 kg CO_2-equiv.	PA 6 (11.3 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	-0.2 kg CO_2-equiv.	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 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 Chroma Energy substitution from incineration	EOL : Inorganic emissions to air, Carbon dioxide

Impact Category	Stage	Module		Main contributor	Main contributing flows
ODP	Production	Raw Material Extraction	99%	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	1 %	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 Chroma Energy substitution from incineration	EOL: Halogenated organic emissions to air, R22 (chlorodifluoromethane)
AP	Production	Raw Material Extraction	84%	79% PA 6 13% Latex	Production : Inorganic emissions to air, NO_x and Sulphur dioxide, Ammonia
		Transport of Raw materials	3%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	13%	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 Chroma Energy substitution from incineration	EOL : Inorganic emissions to air, NO_x and Sulphur dioxide
EP	Production	Raw Material Extraction	76%	81% PA 6 12% 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	21%	97% 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		99% 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 Chroma Energy substitution from incineration	EOL : Inorganic emissions to air, NO_x and Ammonia
POCP	Production	Raw Material Extraction	93%	77% PA 6 11% PET 7% 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	6%	89% 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

Impact Category	Stage	Module		Main contributor	Main contributing flows
					dioxide, Nitrogen dioxide
	EOL	EOL		Incineration of post-consumer Tessera Chroma Energy substitution from incineration	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	90%	90% PA 6 8% 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	10%	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) Transport & Installation : Nonrenewable elements, Lead, Silver, Copper
	Installation	Installation		96% Adhesive	
	Use	Use		99% Electricity	Use : Nonrenewable elements, Copper, Gold, Lead, Silver
	EOL	EOL		Incineration of post-consumer Tessera Chroma 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%	81% PA 6 9% Bitumen 8% 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%	58% Thermal energy biogas 42% Packaging	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Crude oil (resource) Transport & Installation : Natural gas (resource),
	Installation	Installation		99% Adhesive	
	Use	Use		99% electricity	Use : Hard coal (resource), Natural gas (resource), Lignite (resource), hard coal (resource)
	EOL	EOL		Incineration of post-consumer Tessera Chroma Energy substitution from incineration	EOL : Hard coal (resource), Natural gas (resource), Crude oil (resource)
Eco toxicity	Production	Raw Material Extraction	33%	39% PA 6 23% PET 38% 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	67%	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 Transport & installation : Pesticides to fresh water, Alachlor
	Installation	Installation		99% Adhesive	
	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 Chroma Energy substitution from incineration	EOL : Hydrocarbons to fresh water, Phenol (hydroxy benzene), Anthracene, Benzene, Toluene (Methyl benzene) EOL : Pesticides to fresh water, Alachlor

Impact Category	Stage	Module		Main contributor	Main contributing flows
Human toxicity, cancer	Production	Raw Material Extraction	80%	94% PA 6	Production : Organic emissions to air (Group VOC), Formaldehyde (Methanal)
		Transport of Raw materials	1%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	19%	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		100% Electricity	Use : Organic emissions to air (Group VOC), Formaldehyde (Methanal)
	EOL	EOL		Incineration of post-consumer Tessera Chroma Energy substitution from incineration	EOL : Organic emissions to air (Group VOC), Formaldehyde (Methanal)
Human toxicity, non-canc.	Production	Raw Material Extraction	88%	94% 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	12%	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 Chroma Energy substitution from incineration	EOL : Organic emissions to air (Group VOC), Formaldehyde (Methanal)

Description of Selected Impact Categories

Abiotic Depletion Potential

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

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

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

Primary energy consumption

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

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

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

Waste categories

There are various different qualities of waste. For example, waste can be classed according to German and European waste directives. The modeling principles have changed with the last GaBi4 database update in October 2006. Now all

LCA data sets (electricity generation, raw material etc.) already contain the treatment of the waste with very low waste output at the end of the stage. So the amount of waste is predominantly caused by foreground processes during the production phase. This is important for the interpretation of waste amounts.

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

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

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

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

Global Warming Potential (GWP)

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

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

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

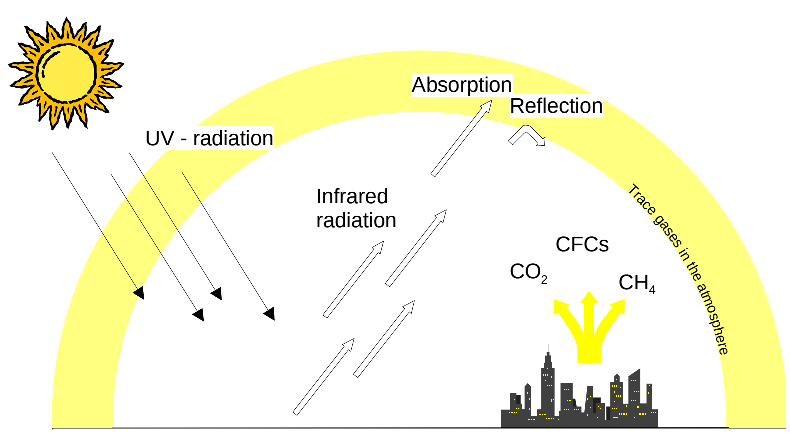


Figure A1: Greenhouse effect (KREISSIG 1999)

Acidification Potential (AP)

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

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

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

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

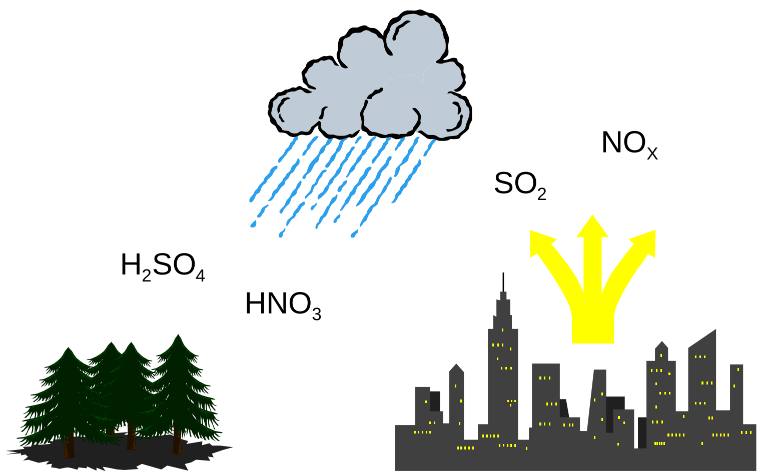


Figure A2: Acidification Potential (Kreissig 1999)

Eutrophication Potential (EP)

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

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

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

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

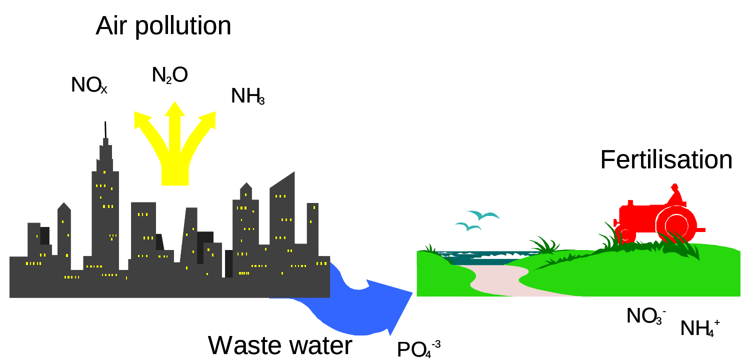


Figure A3: Eutrophication Potential (KREISSIG 1999)

Photochemical Ozone Creation Potential (POCP)

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

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

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

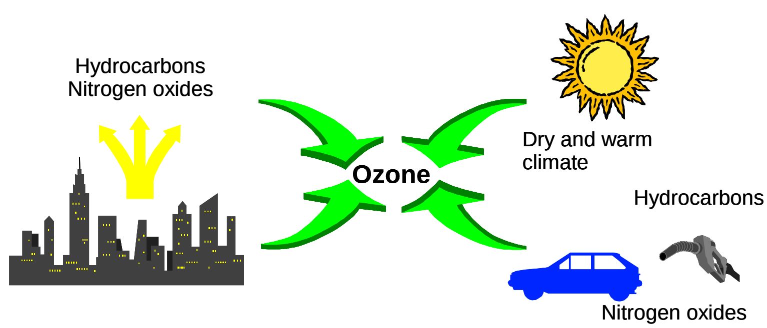


Figure A4: Photochemical Ozone Creation Potential

Ozone Depletion Potential (ODP)

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

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

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

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

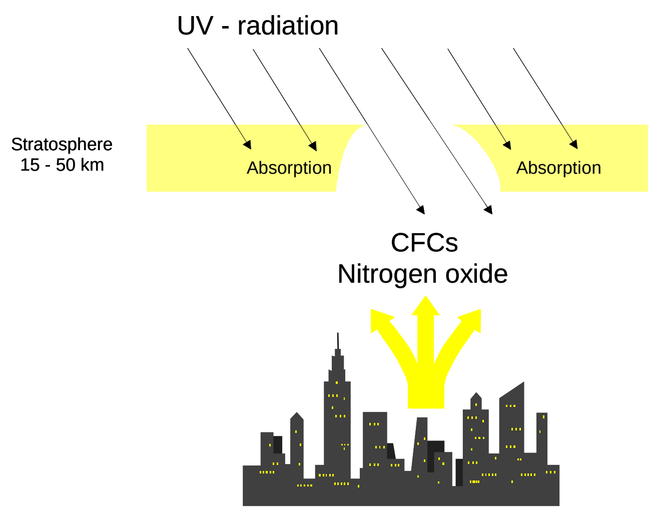


Figure A5: Ozone Depletion Potential (KREISSIG 1999)

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