ENVIRONMENTAL PRODUCT DECLARATION

CORAL BRUSH

FORBO FLOORING SYSTEMS
ENTRANCE FLOORING SYSTEM

FLOORING SYSTEMS

A well designed entrance flooring system incorporating a Coral clean-off zone is a highly effective way to cut your future costs. By stopping up to 94% of walked-in dirt and moisture from reaching your main floor coverings, Forbo Coral can reduce your cleaning bills by up to 65% and prolong the life of your floor finishes and coverings. And the bigger the area fitted with Forbo Coral entrance flooring, the bigger the benefit.

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 Coral Classic into the true value and benefits to all our customers and stakeholders alike.

For more information visit;

www.forbo-flooring.com

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

FLOORING SYSTEMS

Coral Brush
Entrance Flooring system

According to ISO 14025 & EN 15804

This declaration is an environmental product declaration in accordance with ISO 14025 and EN15804 that describes the environmental characteristics of the aforementioned product. It promotes the development of sustainable products. This is a certified declaration and all relevant environmental information is disclosed. This EPD may not be comparable to other declarations if they do not comply with ISO 14025, EN 15804 and the reference PCR.

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	12CA64879.118.1
DECLARED PRODUCT	Coral Brush
REFERENCE PCR	Flooring: Carpet, Resilient, Laminate, Ceramic, and Wood (NSF 2012)

DATE OF ISSUE	October 20, 2014
PERIOD OF VALIDITY	5 Years

CONTENTS 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:	NSF International Accepted by PCR Review Panel ncss@nsf.org
This declaration was independently verified in accordance with ISO 14025 and EN 15804 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	Wade Stout, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044, EN 15804 and the reference PCR by:	Trisha Montalbo, PE International

Environment

Product Definition

Product Classification and description

This declaration covers Coral Brush, a functional entrance flooring system. Coral Brush stops up to 94% of the walked in dirt and moister. Coral entrance systems are a textile floor covering complying with all the requirements of the EN1307 Class 33 Specification. All Coral entrance systems are manufactured using green electricity.

Coral Brush is built up in 3 layers as illustrated in the following image :

Figure 1 : Illustration of Coral Brush

1. **Yarn :** Combination of three types of yarn for maximum moisture absorption and effective dirt removal.
2. **Primary backing :** Made from a combination of polyester and Nylon 6.
3. **Backing :** Everfort vinyl

Range of application

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

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Product Standard

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

- Meets or exceeds all technical requirements EN1307 Class 33

CE

Coral Brush meet the requirements of

EN 14041	Essential characteristics	
EN 13501-1	Reaction to fire	Bfl - s1
EN 13893	Slip resistance	DS
ISO 6356	Anti-static	<2kV

Accreditation

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- AgBB requirements
- French act Grenelle A+
- CHPS section 01350

Delivery status

Table 1: Specification of delivered product

Characteristics	Nominal Value	Unit
Product thickness	9	mm
Product Weight	3400	g/m^2

Material Content

Material Content of the Product

Table 2: Composition of Coral Brush

Component	Material	Availability	Amount [%]	Origin
Yarn	Regenerated Nylon 6	Limited	27	Italy
Primary backing	Nylon 6 Polyester	Limited Limited	< 1 2	Netherlands Netherlands
Backing	PVC Calcium Carbonate DINP Pigments	Limited Mineral abundant Limited Limited	25 25 20 > 1	Germany Germany Germany Netherlands

Production of Main Materials

Yarn : This is made from Econyl, made with 100% Regenerated Nylon

Primary backing : This is made from a combination of polyester and Nylon 6.

PVC : Polymer which is manufactured by the polymerisation of vinyl chloride monomer.

DINP: Plasticiser manufactured by the reaction of phthalic anhydride and alcohol. Plasticizer is added to increase the flexibility, durability and longevity of the floor covering.

Calcium carbonate: An abundant mineral found in all parts of the world as the chief substance in rocks (i.e., marble and limestone). It can be ground to varying particle sizes and is widely used as filler.

Pigments : Most of the pigments used come from a natural source

Production of the Floor Covering

Coral Brush is a cut pile entrance flooring system. Yarn is precisely inserted into the primary backing to create a plain/coloured blend design velour top-cloth. The residual yarn is subsequently rewound and recycled. The cloth is then backed with everfort Vinyl to anchor the bottom loop of the pile yarn in the backing.
Finally the tufted and backed entrance flooring system can be cut in any desired dimension, any cutting waste is subsequently recycled.

Health, Safety and Environmental Aspects during Production

- ISO 14001 Environmental Management System

Production Waste

All product rejected at final inspection stage is either re-cycled through the manufacturing process or re-used 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 Coral Brush is transported as follows:

- Transport distance 40 t truck — 326 km
- Transport distance 7.5 t truck (Fine distribution) — 213 km
- Capacity utilization trucks (including empty runs) — 85 %
- Transport distance Ocean ship — 194 km
- Capacity utilization Ocean ship — 48%

Installation

During the installation of Coral product an average of 2% of the material becomes installation waste. For the installation of Coral sheet 0.25 kg/m^2 of adhesive is required. 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 majority of Coral is sold in Europe the European electricity grid mix is used in the calculations for the energy recovery during incineration.

Health, Safety and Environmental Aspects during Installation

Forbo flooring recommends the use of (low) zero emission adhesives for installing Coral.

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

Packaging

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

Use stage

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

Cleaning and Maintenance

Level of use	Cleaning Process	Cleaning Frequency	Consumption of energy and resources
Commercial/Residential/Industrial	Vacuuming	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 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

Coral Brush comply with:

- AgBB requirements
- French act Grenelle A+
- CHPS section 01350

End of Life

The deconstruction of installed Coral Brush from the floor is a manual process.
For the end of life stage 20% landfill And 80% incineration is taken into account, since the vast majority of the countries in which Coral Brush are sold have a non landfill policy.

Life Cycle Assessment

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

The following Life Cycle Stages are assessed :

- Production Stage (Raw material acquisition, transportation to Manufacturing and Manufacturing)
- Transport Gate to User
- Installation Stage
- Use Stage
- End of Life Stage

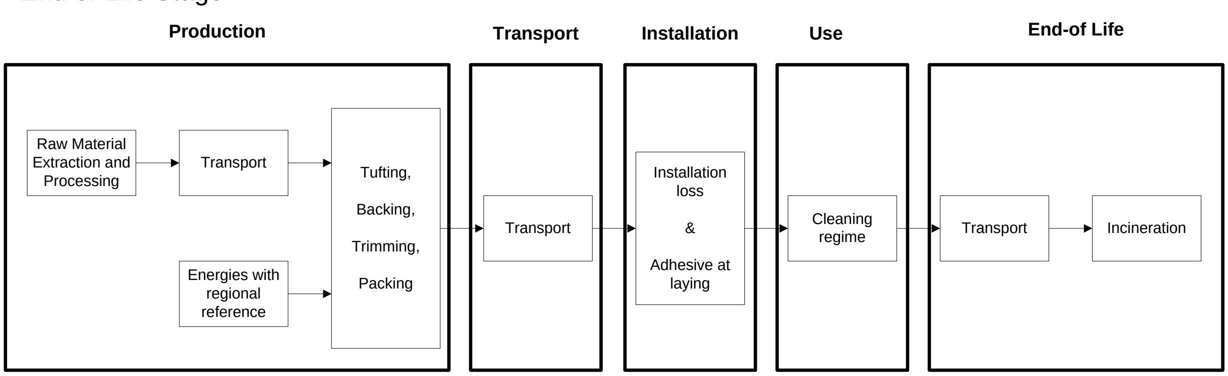

Figure 2: Flow chart of the Life Cycle Assessment

Description of the Declared Functional Unit

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

Cut off Criteria

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

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

Allocations

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

Co-product allocation

No co-product allocation occurs in the product system.

Allocation of multi-input processes

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

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

Allocation procedure of reuse, recycling and recovery

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

Description of the allocation processes in the LCA report

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

LCA Data

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

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

Data Quality

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

Foreground data are based on 1 year averaged data (year 2013). The reference ages of LCA datasets vary but are given in the table in the Appendix. The time period over which inputs to and outputs from the system is accounted for is 100 years from the year for which the data set is deemed representative. The technological LCA of the collected data reflects the physical reality of the declared product. The datasets are complete, conform to the system boundaries and the criteria for the exclusion of inputs and outputs and are geographical representative for the supply chain of Forbo flooring.

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

System Boundaries

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

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

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

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

Power mix

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

The product is manufactured at Forbo Flooring Coral, Krommenie, the Netherlands. The GaBi 6 Hydropower dataset has therefore been used (reference year 2010). 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

The total primary energy for one square meter installed Coral Brush is presented in table 3 with their specific energy resources.

Table 3: Primary energy for all life cycle stages for Coral Brush for one year

Non-renewable primary energy by resources	Unit	Total Life cycle (MJ)	Total Life cycle (%)	Production	Transport	Installation	Use (1 yr)	End of Life
Total non-renewable primary energy	MJ	186.09	100	171.38	1.23	6.72	16.32	-9.56
Crude oil	MJ	63.37	34%	54.45	1.13	2.93	0.79	4.07
Hard coal	MJ	16.96	9%	12.46	0	0.18	3.13	1.19
Lignite	MJ	8.92	5%	5.67	0	0.15	2.46	0.64
Natural gas	MJ	81.77	44%	89.88	0.09	3.33	4.02	-15.55
Uranium	MJ	15.03	8%	8.91	0	0.13	5.88	0.11

Renewable primary energy by resources	Unit	Total Life cycle (MJ)	Total Life cycle (%)	Production	Transport	Installation	Use (1 yr)	End of Life
Total renewable primary energy	MJ	11.63	100	8.94	0.04	0.10	2.97	-0.42
Geothermical	MJ	0.05	0.5%	0.01	0	0	0.05	-0.01
Hydro power	MJ	6.71	58%	5.75	0	0.01	1.11	-0.16
Solar energy	MJ	2.94	25%	2.01	0.04	0.06	0.98	-0.15
Wind power	MJ	1.91	16.5%	1.14	0	0.03	0.83	-0.09

The total amount of renewable and non-renewable primary energy is predominated by the production stage for a one year usage; within the production stage the main contributors are the raw material production and energy generation.

Waste and non-renewable resource consumption

In table 4 the non-renewable resource consumption and waste production are shown for all life cycle stages for a one year usage.

Table 4: Waste categories and non-renewable resources for Coral Brush (one year)

Wastes	Unit	Total Life cycle	Production	Transport	Installation	Use (1yr)	End of Life
Hazardous waste	[kg]	3.75E-03	1.86E-03	2.67E-06	1.84E-04	2.25E-03	-5.43E-04
Non-hazardous waste	[kg]	1.89E+01	1.30E+01	4.18E-03	3.34E-01	3.60E+00	2.05E+00
Radioactive waste	[kg]	5.70E-03	3.33E-03	1.60E-06	9.71E-05	2.34E-03	-6.91E-05
Resources	**Unit**	**Total Life cycle**	**Production**	**Transport**	**Installation**	**Use (1yr)**	**End of Life**
Nonrenewable resources	[kg]	2.14E+01	1.44E+01	1.00E-02	3.30E-01	3.62E+00	3.03E+00

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Life Cycle Assessment

In table 5 the environmental impacts for one lifecycle are presented for Coral Brush. In table 6 the environmental impacts are presented for all the lifecycle stages.

Table 5: Results of the LCA – Environmental impacts one lifecycle (one year) – Coral Brush

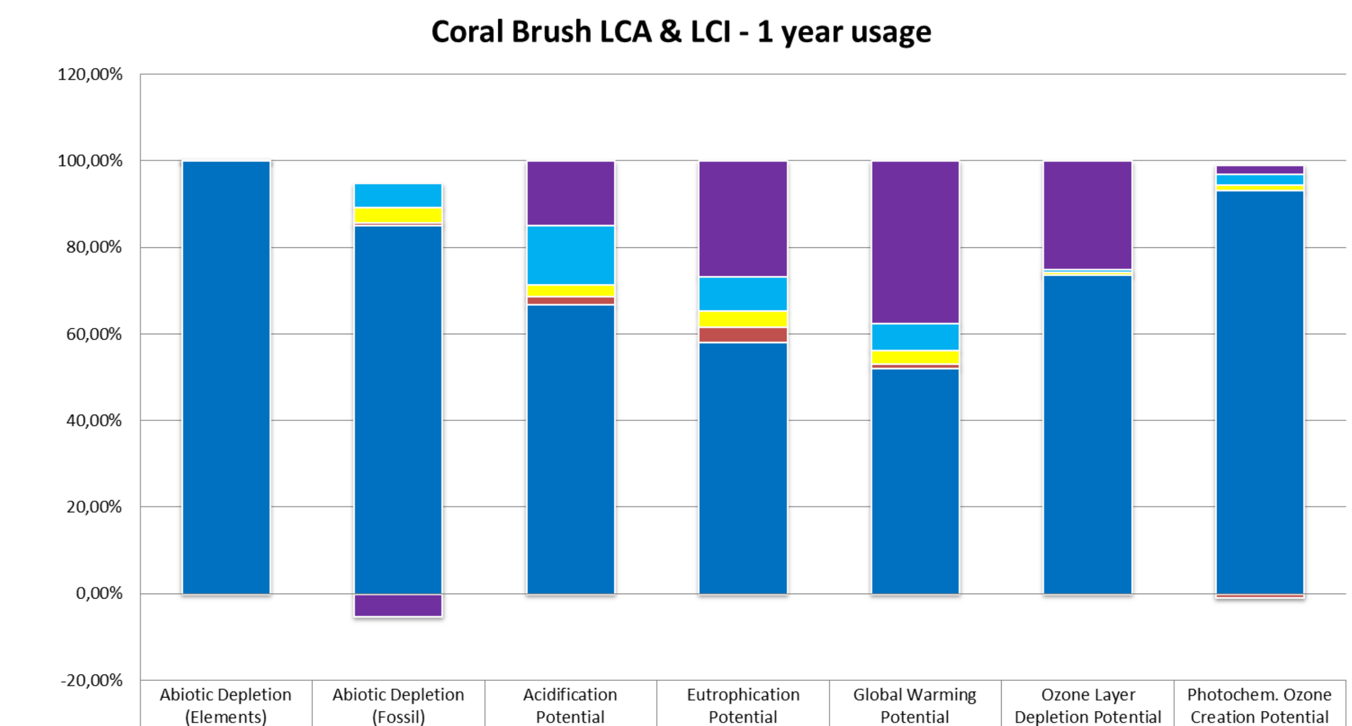
Impact Category : CML 2001 – Apr. 2013	Coral Brush	Unit
Global Warming Potential (GWP 100 years)	1.48E+01	kg CO2-Equiv.
Ozone Layer Depletion Potential (ODP. steady state)	1.61E-07	kg R11-Equiv.
Acidification Potential (AP)	3.13E-02	kg SO2-Equiv.
Eutrophication Potential (EP)	3.06E-03	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	1.04E-02	kg Ethene-Equiv.
Abiotic Depletion Potential Elements (ADPE)	2.91E-02	kg Sb-Equiv.
Abiotic Depletion Potential Fossil (ADPF)	1.70E+02	[MJ]

Table 6: Results of the LCA – Environmental impact for Coral Brush (one year)

Impact Category : CML 2001 – Apr. 2013	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Global Warming Potential	kg CO2-Equiv.	7.72E+00	1.63E-01	4.62E-01	9.16E-01	5.58E+00
Ozone Layer Depletion Potential	kg R11-Equiv.	1.18E-07	4.19E-13	1.11E-09	7.89E-10	4.03E-08
Acidification Potential	kg SO2-Equiv.	2.09E-02	6.32E-04	8.35E-04	4.31E-03	4.65E-03
Eutrophication Potential	kg PSO4-Equiv.	1.78E-03	1.05E-04	1.12E-04	2.44E-04	8.19E-04
Photochem. Ozone Creation Potential	kg Ethene-Equiv.	9.48E-03	-9.46E-05	1.33E-04	2.57E-04	2.34E-04
Abiotic Depletion Elements	kg Sb-Equiv.	2.91E-02	3.27E-09	1.29E-07	1.14E-07	2.21E-06
Abiotic Depletion Fossil	MJ	1.62E+02	1.23E+00	6.58E+00	1.04E+01	-9.95E+00

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

Figure 3: relative contribution of each process stage to each impact category for Coral Brush 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	0,01%	-5,24%	14,86%	26,76%	37,59%	25,12%	2,21%
Use	0,00%	5,50%	13,76%	7,96%	6,18%	0,49%	2,43%
Installation	0,00%	3,47%	2,67%	3,66%	3,12%	0,69%	1,26%
Transport	0,00%	0,65%	2,02%	3,45%	1,10%	0,00%	-0,90%
Production	99,99%	85,14%	66,70%	58,17%	52,02%	73,69%	93,20%

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 impact categories the production stage has the main contribution to the overall impact. For each category, except POCP, the main contributor in the production stage is the Raw material supply with a share of 80-100% of total impacts from the production stage. For POCP the contribution of the manufacturing of Forbo is slightly bigger than the raw material supply, this is mainly caused by the use of thermal energy.

Although Forbo declares in the EPD a worldwide distribution by truck (539km) and container ship (194 km) the transport stage has a very small effect on the total impacts.

The environmental impact the Installation stage has a minor impact of less than 4% of the total environmental impact of Coral Brush. This is mostly caused by the adhesive used for the installation, but also the impact of the incineration of installation waste is significant.

In the Use stage ADPF, AP, EP and GWP have a share between 5.5 to 14% of the total impacts. This is mainly caused by the fact that an entrance flooring needs to be vacuumed daily for their best performance. In this way the cleaning of the floor coverings in the rest of the building can be reduced by 65%.

Energy recovery from incineration and the respective energy substitution at the end of life results in a credit for ADPF in the End of Life stage. For AP, EP, GWP and ODP the End of Life stage has an impact of 15 – 38% of the total. This is mainly due to the fact that 80% of the waste at the End of Life stage is considered as being incinerated.

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 modelling 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) – Coral Brush

Impact Category : USEtox	Coral Brush	Unit
Eco toxicity	5.72E-01	PAF m3.day
Human toxicity, cancer	6.19E-09	Cases
Human toxicity, non-canc.	5.69E-07	Cases

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

Table 8: Results of the LCA – Environmental impact for Coral Brush (one year)

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Eco toxicity	PAF m3.day	4.48E-01	1.87E-02	2.69E-02	2.82E-02	5.08E-02
Human toxicity, cancer	cases	5.13E-09	6.44E-11	2.19E-10	2.53E-10	5.24E-10
Human toxicity, non-canc.	cases	3.94E-07	2.12E-08	2.21E-08	3.34E-08	9.75E-08

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.

All the impacts are predominated by the production stage (69 – 83%) in which the raw materials are having a big impact with a share of around 96 - 97%.

The Use and Installation stage have got a similar impact on the total for all Toxicity impacts. For the Installation this is largely caused by the adhesive used to install the entrance system, for the Use stage it is mainly caused by the fact that an entrance floor needs to be cleaned more regularly than other floor coverings for their best performance. In this way the cleaning of the floor coverings in the rest of the building can be reduced by 65%.

The incineration of 80% of the waste in the End of Life stage is having a significant impact of approximately 9% for Eco toxicity and Human toxicity (cancer), the impact of Human toxicity (non-canc) is ± 17% of the total impacts.

EN15804 Results

In this section the calculations have been conducted and verified according to the requirements of the European Standard EN 15804. In addition, calculations followed the document “Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Background Report”, however, Part A was not included as a part of the verification.

Table 9: Results of the LCA – Environmental impact for Coral Brush (one year)

		Manufacturing	Installation		Use (1yr)	End of Life				Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
GWP	[kg CO_2-Equiv]	7.72E+00	1.63E-01	5.22E-01	9.16E-01	1.42E-02	9.32E-02	6.68E+00	1.17E-01	-1.39E+00
ODP	[kg CFC11-Equiv]	1.18E-07	4.19E-13	1.12E-09	7.89E-10	9.75E-12	4.46E-13	3.89E-08	1.61E-09	-1.61E-10
AP	[kg SO_2-Equiv]	2.09E-02	6.32E-04	9.53E-04	4.31E-03	6.72E-05	4.72E-04	5.87E-03	1.31E-04	-2.00E-03
EP	[kg PO_4^{3-}- Equiv]	1.78E-03	1.05E-04	1.21E-04	2.44E-04	3.780E-06	1.08E-04	8.60E-04	1.55E-05	-1.77E-04
POCP	[kg Ethen Equiv]	9.84E-03	-9.46E-05	1.44E-04	2.57E-04	3.99E-06	5.28E-05	3.72E-04	3.04E-05	-2.37-04
ADPE	[kg Sb Equiv]	2.91E-02	3.27E-09	1.32E-07	1.14E-07	1.74E-09	3.50E-09	2.27E-06	4.95E-09	-6.80E-08
ADPF	[MJ]	1.62E+02	1.23E+00	7.46E+00	1.04E+01	1.62E-01	1.28E+00	8.70E+00	4.99E-01	-2.15E+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

Table 10: Results of the LCA – Resource use for Coral Brush (one year)

		Manufacturing	Installation		Use (1yr)	End of Life				Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
PERE	[MJ]	-	-	-	-	-	-	-	-	-
PERM	[MJ]	-	-	-	-	-	-	-	-	-
PERT	[MJ]	8.95E+00	4.39E-02	1.56E-01	2.97E+00	4.63E-02	5.06E-02	1.79E-01	1.58E-02	-7.67E-01
PENRE	[MJ]	-	-	-	-	-	-	-	-	-
PENRM	[MJ]	-	-	-	-	-	-	-	-	-
PENRT	[MJ]	1.71E+02	1.23E+00	7.72E+00	1.63E+01	2.54E-01	1.29E+00	1.03E+01	5.83E-01	-2.30E+01
SM	[kg]	0.00E+00	-	-	-	-	-	-	-	-
RSF	[MJ]	2.37E-03	7.85E-06	8.38E-05	3.38E-04	5.29E-06	8.26E-06	0.00E+00	3.30E-04	-2.51E-04
NRSF	[MJ]	2.49E-02	8.23E-05	8.12E-04	3.54E-03	5.54E-05	8.66E-05	0.00E+00	4.78E-04	-2.63E-03
FW	[kg]	-5.74E+00	3.15E-02	1.25E+00	7.57E+00	1.14E-01	3.57E-02	-1.20E+00	-6.79E-01	-1.94E+00

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 nonrenewable primary energy excluding nonrenewable primary energy resources used as raw materials; PENRM = Use of nonrenewable primary energy resources used as raw materials; PENRT = Total use of nonrenewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of nonrenewable secondary fuels; FW = Use of net fresh water

Table 11: Results of the LCA – Output flows and Waste categories for Coral Brush (one year)

		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits				
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
HWD	[kg]	1.86E-03	2.76E-06	1.84E-04	2.25E-03	3.51E-05	2.94E-06	0.00E+00	0.00E+00	-5.81E-04
NHWD	[kg]	1.30E+01	4.18E-03	3.34E-01	3.60E+00	5.62E-02	4.54E-03	2.18E+00	7.46E-01	-9.35E-01
RWD	[kg]	3.33E-03	1.60E-06	9.71E-05	2.34E-03	3.65E-05	1.69E-06	4.76E-04	1.9E-05	-6.03E-04
CRU	[kg]	-	-	-	-	-	-	-	-	-
MFR	[kg]	-	-	-	-	-	-	-	-	-
MER	[kg]	-	-	-	-	-	-	2.90E+00	-	-
EE Power	[MJ]	-	-	3.98E-02	-	-	-	1.88E+00	-	-
EE Thermal energy	[MJ]	-	-	4.72E-01	-	-	-	2.31E+01	-	-

HWD = Hazardous waste disposed; NHWD = Nonhazardous 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

Interpretation

The interpretation of the environmental impacts calculated according to EN 15804 are similar to the interpretation according to ISO 14025. A more detailed interpretation is published in the appendix.

FLOORING SYSTEMS

Coral Brush
Entrance Flooring system

According to ISO 14025 & EN 15804

References

GABI 6 2012	PE INTERNATIONAL AG; GaBi 6: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2012.
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NSF International May 22, 2012	Product Category Rule for Environmental Product Declarations *Flooring: Carpet, Resilient, Laminate, Ceramic, Wood*
UL ENVIRONMENT	UL Environment's Program Operator Rules
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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 15804	EN 15804: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products
ISO 24011	Resilient floor coverings - Specification for plain and decorative linoleum
CPR	REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC
EN-ISO 10874	Resilient, textile and laminate floor coverings - Classification

Life Cycle Assessment

Coral Brush

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

September 2014

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Nomenclature

Abbreviation	Explanation
ADP	Abiotic Depletion Potential
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
FW	Use of net fresh water
GWP	Global Warming Potential
HWD	Hazardous waste disposed
LCA	Life Cycle 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 under support of PE International and has been conducted according to the requirements of the European Standard EN15804 following the document "Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Background Report". The LCA report was sent to verification on 08/05/14

Scope

This document is the LCA report for the "Environmental Product Declaration" (EPD) of "Coral Brush".
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 and EN15804.

Goal of the study

The reason for performing this LCA study is to publish an EPD based on EN 15804 and ISO 14025.
This study contains the calculation and interpretation of the LCA results for Coral Brush complying with EN 1307.

Manufactured by
Forbo Flooring Coral N.V.
Vlietsend 20a
1561 AC Krommenie
The Netherlands
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.
Coral Brush is produced at the following manufacturing site:
Forbo Flooring Coral N.V.
Vlietsend 20a
1561 AC Krommenie
The Netherlands

Product Definition

Product Classification and description

This declaration covers Coral Brush, a functional entrance flooring system. Coral Brush stops up to 94% of the walked in dirt and moister. Coral entrance systems are a textile floor covering complying with all the requirements of the EN1307 Class 33 Specification. All Coral entrance systems are manufactured using green electricity.

Coral Brush is built up in 3 layers as illustrated in the following image :

Figure 1 : Illustration of Coral Brush

1. **Yarn :** Combination of three types of yarn for maximum moisture absorption and effective dirt removal.
2. **Primary backing :** Made from a combination of polyester and Nylon 6.
3. **Backing :** Everfort vinyl

Range of application

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

Product Standard

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

- o Meets or exceeds all technical requirements EN1307 Class 33

CE

Coral Brush meet the requirements of

EN 14041	Essential characteristics	
EN 13501-1	Reaction to fire	Bfl - s1
EN 13893	Slip resistance	DS
ISO 6356	Anti-static	<2kV

Accreditation

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- AgBB requirements
- French act Grenelle A+
- CHPS section 01350

Delivery status

Characteristics	Nominal Value	Unit
Product thickness	9	mm
Product Weight	3400	g/m^2

Material Content

Component	Material	Availability	Mass %	Origin of raw material
Yarn	Regenerated Nylon 6	Limited	27	Italy
Primary backing	Nylon 6 Polyester	Limited Limited	< 1 2	Netherlands Netherlands
Backing	PVC Calcium Carbonate DINP Pigments	Limited Mineral abundant Limited Limited	25 25 20 > 1	Germany Germany Germany Netherlands

Production of Main Materials

Yarn : This is made from Econyl, made with 100% Regenerated Nylon

Primary backing : This is made from a combination of polyester and Nylon 6.

PVC : Polymer which is manufactured by the polymerisation of vinyl chloride monomer.

DINP: Plasticiser manufactured by the reaction of phthalic anhydride and alcohol. Plasticizer is added to increase the flexibility, durability and longevity of the floor covering.

Calcium carbonate: An abundant mineral found in all parts of the world as the chief substance in rocks (i.e., marble and limestone). It can be ground to varying particle sizes and is widely used as filler.

Pigments : Most of the pigments used come from a natural source

Production of the Floor Covering

Coral Brush is a cut pile entrance flooring system. Yarn is precisely inserted into the primary backing to create a plain/coloured blend design velour top-cloth. The residual yarn is subsequently rewound and recycled. The cloth is then backed with everfort Vinyl to anchor the bottom loop of the pile yarn in the backing.

Finally the tufted and backed entrance flooring system can be cut in any desired dimension, any cutting waste is subsequently recycled.

Health, Safety and Environmental Aspects during Production

- ISO 14001 Environmental Management System

Production Waste

All product rejected at final inspection stage is either re-cycled through the manufacturing process or re-used 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 Coral Brush is transported as follows:

o Transport distance 40 t truck	326 km
o Transport distance 7.5 t truck (Fine distribution)	213 km
o Capacity utilization trucks (including empty runs)	85 %
o Transport distance Ocean ship	194 km
o Capacity utilization Ocean ship	48%

Installation

During the installation of Coral product an average of 2% of the material becomes installation waste. For the installation of Coral sheet 0.25 kg/m^2 of adhesive is required. 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 majority of Coral is sold in Europe the European electricity grid mix is used in the calculations for the energy recovery during incineration.

Health, Safety and Environmental Aspects during Installation

Forbo flooring recommends the use of (low) zero emission adhesives for installing Coral.

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

Packaging

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

Use stage

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

Cleaning and Maintenance

Level of use	Cleaning Process	Cleaning Frequency	Consumption of energy and resources
Commercial/Residential/Industrial	Vacuuming	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 cleaning regime used in the calculations is suitable for high traffic areas. An entrance floor needs to be cleaned more regularly than other floor coverings for their best performance. In this way the cleaning of the floor coverings in the rest of the building can be reduced by 65%.

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

Coral Brush comply with:

- o AgBB requirements
- o French act Grenelle A+
- o CHPS section 01350

End of Life

The deconstruction of installed Coral Brush from the floor is a manual process.

For the end of life stage 20% landfill And 80% incineration is taken into account, since the vast majority of the countries in which Coral Brush are sold have a non landfill policy.

Life Cycle Assessment

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

The following Life Cycle Stages are assessed :

- o Production Stage (Raw material acquisition, transportation to Manufacturing and Manufacturing)
- o Transport Gate to User
- o Installation Stage
- o Use Stage
- o End of Life Stage

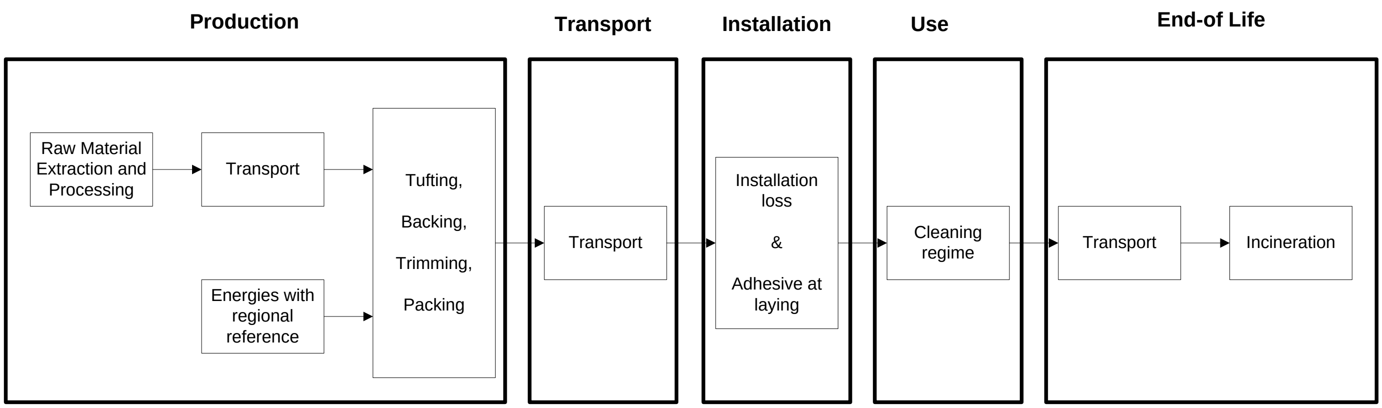


Figure 2 : Flow chart of the Life Cycle Assessment

Description of the declared Functional Unit

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

Cut off Criteria

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

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

LCA Data

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

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

Data Quality

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

Foreground data are based on 1 year averaged data (year 2013). The reference ages of LCA datasets vary but are given in the table in the Appendix. The time period over which inputs to and outputs from the system is accounted for is 100 years from the year for which the data set is deemed representative. The technological LCA of the collected data reflects the physical reality of the declared product. The datasets are complete, conform to the system boundaries and the criteria for the exclusion of inputs and outputs and are geographical representative for the supply chain of Forbo flooring.

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

Table 1: LCA datasets used in the LCA model

Data set	Region	Reference year
Regenerated Polyamide 6 yarn	Germany	2013
Calcium Carbonate	Germany	2012
Fire retardant	Europe	2012
Polyvinyl chloride granulate	Germany	2012
Di-Isononyl Phthalate (DINP)	Germany	2010
Stabilizer	Europe	2010
Carbon black (Pigment)	Germany	2005
Coral (Waste for recovery)	The Netherlands	2006
Polyester fleece	Europe	2005
Polyethylene film	Europe	2005
Cardboard	Europe	2002
Water (desalinated; deionised)	Germany	2010
Detergent (ammonia based)	Germany	2006
Adhesive for resilient flooring	Germany	2012
Waste incineration of Coral	Europe	2010
Land fill of Coral	Europe	2010
Electricity from Hydro power	The Netherlands	2010
Power grid mix	Europe	2010
Thermal energy from natural gas	The Netherlands	2010
Thermal energy from natural gas	Europe	2010
Trucks	Global	2010
Municipal waste water treatment (Sludge incineration).	Europe	2011
Container ship	Global	2012
Diesel mix at refinery	Europe	2010
Heavy fuel oil at refinery (1.0wt.% S)	Europe	2010

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 Krommenie, the Netherlands. The GaBi 6 Hydro power dataset has therefore been used (reference year 2010). 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 (2%):

Table 2: Composition of Coral Brush

Process data	Unit	Coral Brush
Nylon 6	kg/m^2	0.918
Polyester	kg/m^2	0.068
PVC	kg/m^2	0.850
Calcium Carbonate	kg/m^2	0.850
DINP	kg/m^2	0.680
Pigments	kg/m^2	> 0.034

Table 3: Production related inputs/outputs

Process data	Unit	Coral Brush
INPUTS		
Coral Brush	kg	3.424
Electricity	MJ	4.05
Thermal energy from natural gas	MJ	23.90
OUTPUTS		
Coral Brush	kg	3.400
Waste	kg	0.0244

Table 4: Packaging requirements (per m² manufactured product)

Process data	Unit	Coral Brush
Cardboard	kg	0.0353
Polyethylene film	kg	0.0127

Table 5: Transport distances (same for both products)

Process data	Unit	Road	Truck size	Ship
Regenerated Polyamide 6 yarn	km	1210	14 - 20t gross weight / 11,4t payload capacity	-
Calcium Carbonate	km	230		-
Fire retardant	km	440		-
Polyvinyl chloride granulate	km	392		-
Di-Isononyl Phthalate (DINP)	km	523		-
Stabilizer	km	481		-
Carbon black (Pigment)	km	538		-
Coral (Waste for recovery)	km	0		-
Polyester fleece	km	116		-
Polyethylene film	km	126		-
Cardboard	km	271		-
Transport to construction site : -Transport distance 40 t truck -Transport distance 7.5t truck (Fine distribution)	km	539 326 213	 34 - 40 t gross weight / 27t payload capacity 7,5 t - 12t gross weight / 5t payload capacity	194
Waste transport to incineration & landfill	km	200	7,5 t - 12t gross weight / 5t payload capacity	-

Table 6: Inputs/outputs from Installation

Process data	Unit	Coral Brush
INPUTS		
Coral Brush	kg	3.40
Adhesive (30% water content) - Water - Acrylate co-polymer - Styrene Butadiene co-polymer - Limestone flour - Sand	kg	0.25
OUTPUTS		
Installed Coral Brush	kg	3.332
Installation Waste	kg	0.068

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

Process data	Unit	Coral Brush
Detergent	kg/year	0.0032
Electricity	kWh/year	1.92
Water	kg/year	0.248

Table 8: Disposal

Process data	Unit	Coral Brush
Post-consumer Coral Brush to landfill	%	20
Post-consumer Coral Brush to incineration	%	80

Life Cycle Inventory Analysis

In table 9 the environmental impacts for one lifecycle are presented for Coral Brush. In tables 11 the environmental impacts are presented for all the lifecycle stages.

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

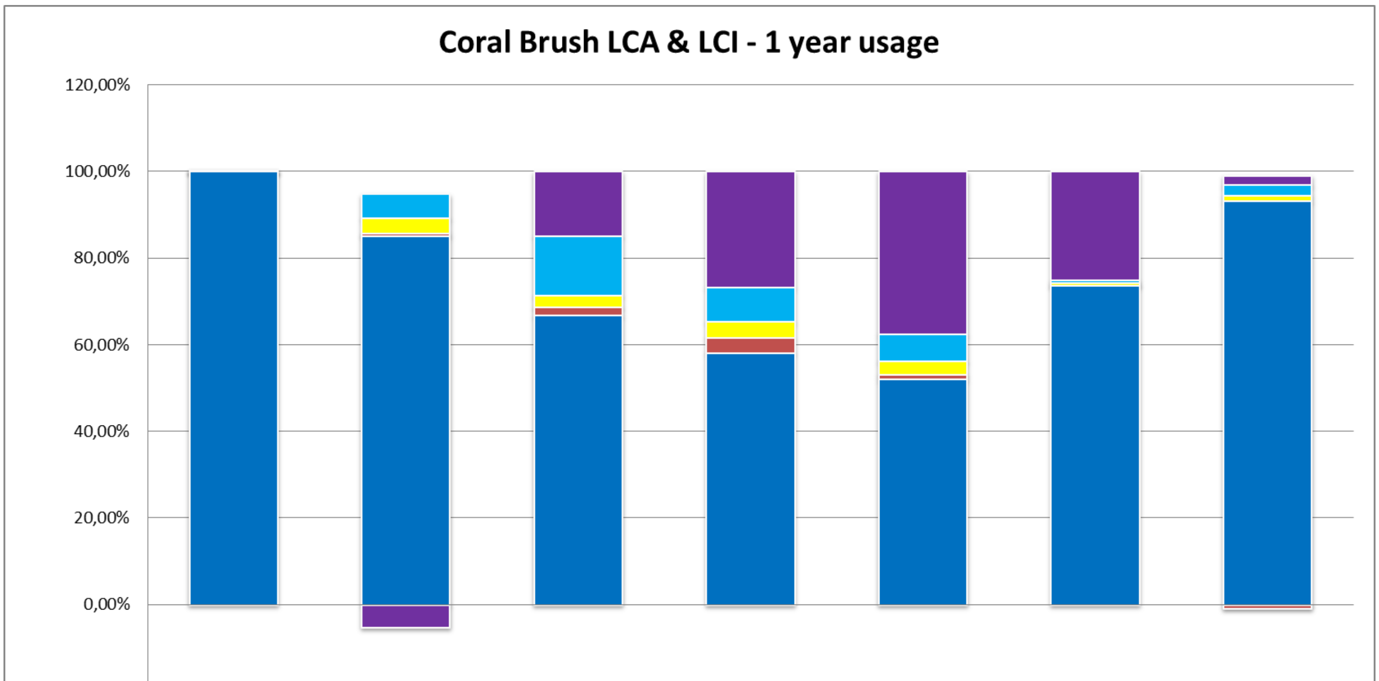
Impact Category : CML 2001 – Apr. 2013	Coral Brush	Unit
Global Warming Potential (GWP 100 years)	1.48E+01	kg CO2-Equiv.
Ozone Layer Depletion Potential (ODP. steady state)	1.61E-07	kg R11-Equiv.
Acidification Potential (AP)	3.13E-02	kg SO2-Equiv.
Eutrophication Potential (EP)	3.06E-03	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	1.04E-02	kg Ethene-Equiv.
Abiotic Depletion Potential Elements (ADPE)	2.91E-02	kg Sb-Equiv.
Abiotic Depletion Potential Fossil (ADPF)	1.70E+02	[MJ]

Table 10: Results of the LCA – Environmental impact for Coral Brush (one year)

Impact Category : CML 2001 – Apr. 2013	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Global Warming Potential	kg CO2-Equiv.	7.72E+00	1.63E-01	4.62E-01	9.16E-01	5.58E+00
Ozone Layer Depletion Potential	kg R11-Equiv.	1.18E-07	4.19E-13	1.11E-09	7.89E-10	4.03E-08
Acidification Potential	kg SO2-Equiv.	2.09E-02	6.32E-04	8.35E-04	4.31E-03	4.65E-03
Eutrophication Potential	kg PSO4-Equiv.	1.78E-03	1.05E-04	1.12E-04	2.44E-04	8.19E-04
Photochem. Ozone Creation Potential	kg Ethene-Equiv.	9.48E-03	-9.46E-05	1.33E-04	2.57E-04	2.34E-04
Abiotic Depletion Elements	kg Sb-Equiv.	2.91E-02	3.27E-09	1.29E-07	1.14E-07	2.21E-06
Abiotic Depletion Fossil	MJ	1.62E+02	1.23E+00	6.58E+00	1.04E+01	-9.95E+00

The relative contribution of each process stage to each impact category for Coral Brush is shown in figures 3.

Figure 3: relative contribution of each process stage to each impact category for Coral Brush 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	0,01%	-5,24%	14,86%	26,76%	37,59%	25,12%	2,21%
Use	0,00%	5,50%	13,76%	7,96%	6,18%	0,49%	2,43%
Installation	0,00%	3,47%	2,67%	3,66%	3,12%	0,69%	1,26%
Transport	0,00%	0,65%	2,02%	3,45%	1,10%	0,00%	-0,90%
Production	99,99%	85,14%	66,70%	58,17%	52,02%	73,69%	93,20%

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 impact categories the production stage has the main contribution to the overall impact. For each category, except POCP, the main contributor in the production stage is the Raw material supply with a share of 80-100% of total impacts from the production stage. For POCP the contribution of the manufacturing of Forbo is slightly bigger than the raw material supply, this is mainly caused by the use of thermal energy.

Although Forbo declares in the EPD a worldwide distribution by truck (539km) and container ship (194 km) the transport stage has a very small effect on the total impacts.

The environmental impact the Installation stage has a minor impact of less than 4% of the total environmental impact of Coral Brush. This is mostly caused by the adhesive used for the installation, but also the impact of the incineration of installation waste is significant.

In the Use stage ADPF, AP, EP and GWP have a share between 5.5 to 14% of the total impacts. This is mainly caused by the fact that an entrance flooring needs to be vacuumed daily for their best performance. In this way the cleaning of the floor coverings in the rest of the building can be reduced by 65%.

Energy recovery from incineration and the respective energy substitution at the end of life results in a credit for ADPF in the End of Life stage. For AP, EP, GWP and ODP the End of Life stage has an impact of 15 – 38% of the total. This is mainly due to the fact that 80% of the waste at the End of Life stage is considered as being incinerated.

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:

- o Level I (recommended and satisfactory),
- o Level II (recommended but in need of some improvements)
- o 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 11: Results of the LCA – Environmental impacts one lifecycle (one year) – Coral Brush

Impact Category : USEtox	Coral Brush	Unit
Eco toxicity	5.72E-01	PAF m3.day
Human toxicity, cancer	6.19E-09	Cases
Human toxicity, non-canc.	5.69E-07	Cases

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

Table 12: Results of the LCA – Environmental impact for Coral Brush (one year)

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Eco toxicity	PAF m3.day	4.48E-01	1.87E-02	2.69E-02	2.82E-02	5.08E-02
Human toxicity, cancer	cases	5.13E-09	6.44E-11	2.19E-10	2.53E-10	5.24E-10
Human toxicity, non-canc.	cases	3.94E-07	2.12E-08	2.21E-08	3.34E-08	9.75E-08

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.

All the impacts are predominated by the production stage (69 – 83%) in which the raw materials are having a big impact with a share of around 96 - 97%.

The Use and Installation stage have got a similar impact on the total for all Toxicity impacts. For the Installation this is largely caused by the adhesive used to install the entrance system, for the Use stage it is mainly caused by the fact that an entrance floor needs to be cleaned more regularly than other floor coverings for their best performance. In this way the cleaning of the floor coverings in the rest of the building can be reduced by 65%.

The incineration of 80% of the waste in the End of Life stage is having a significant impact of approximately 9% for Eco toxicity and Human toxicity (cancer), the impact of Human toxicity (non-canc) is ± 17% of the total impacts.

EN15804 results

In this section the calculations have been conducted according to the requirements of the European Standard EN 158024 following the document "Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Background Report".

Table 13: Results of the LCA – Environmental impact for Coral Brush (one year)

		Manufacturing	Installation		Use (1yr)	End of Life				Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
GWP	[kg CO_2-Equiv.]	7.72E+00	1.63E-01	5.22E-01	9.16E-01	1.42E-02	9.32E-02	6.68E+00	1.17E-01	-1.39E+00
ODP	[kg CFC11-Equiv.]	1.18E-07	4.19E-13	1.12E-09	7.89E-10	9.75E-12	4.46E-13	3.89E-08	1.61E-09	-1.61E-10
AP	[kg SO_2-Equiv.]	2.09E-02	6.32E-04	9.53E-04	4.31E-03	6.72E-05	4.72E-04	5.87E-03	1.31E-04	-2.00E-03
EP	[kg PO_4^{3-}- Equiv.]	1.78E-03	1.05E-04	1.21E-04	2.44E-04	3.780E-06	1.08E-04	8.60E-04	1.55E-05	-1.77E-04
POCP	[kg Ethen Equiv.]	9.84E-03	-9.46E-05	1.44E-04	2.57E-04	3.99E-06	5.28E-05	3.72E-04	3.04E-05	-2.37-04
ADPE	[kg Sb Equiv.]	2.91E-02	3.27E-09	1.32E-07	1.14E-07	1.74E-09	3.50E-09	2.27E-06	4.95E-09	-6.80E-08
ADPF	[MJ]	1.62E+02	1.23E+00	7.46E+00	1.04E+01	1.62E-01	1.28E+00	8.70E+00	4.99E-01	-2.15E+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

Table 14 Results of the LCA – Resource use for Coral Brush (one year)

		Manufacturing	Installation		Use (1yr)	End of Life				Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
PERE	[MJ]	-	-	-	-	-	-	-	-	-
PERM	[MJ]	-	-	-	-	-	-	-	-	-
PERT	[MJ]	8.95E+00	4.39E-02	1.56E-01	2.97E+00	4.63E-02	5.06E-02	1.79E-01	1.58E-02	-7.67E-01
PENRE	[MJ]	-	-	-	-	-	-	-	-	-
PENRM	[MJ]	-	-	-	-	-	-	-	-	-
PENRT	[MJ]	1.71E+02	1.23E+00	7.72E+00	1.63E+01	2.54E-01	1.29E+00	1.03E+01	5.83E-01	-2.30E+01
SM	[kg]	0.00E+00	-	-	-	-	-	-	-	-
RSF	[MJ]	2.37E-03	7.85E-06	8.38E-05	3.38E-04	5.29E-06	8.26E-06	0.00E+00	3.30E-04	-2.51E-04
NRSF	[MJ]	2.49E-02	8.23E-05	8.12E-04	3.54E-03	5.54E-05	8.66E-05	0.00E+00	4.78E-04	-2.63E-03
FW	[kg]	-5.74E+00	3.15E-02	1.25E+00	7.57E+00	1.14E-01	3.57E-02	-1.20E+00	-6.79E-01	-1.94E+00

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 nonrenewable primary energy excluding nonrenewable primary energy resources used as raw materials; PENRM = Use of nonrenewable primary energy resources used as raw materials; PENRT = Total use of nonrenewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of nonrenewable secondary fuels; FW = Use of net fresh water

Table 15: Results of the LCA – Output flows and Waste categories for Coral Brush (one year)

		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits				
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
HWD	[kg]	1.86E-03	2.76E-06	1.84E-04	2.25E-03	3.51E-05	2.94E-06	0.00E+00	0.00E+00	-5.81E-04
NHWD	[kg]	1.30E+01	4.18E-03	3.34E-01	3.60E+00	5.62E-02	4.54E-03	2.18E+00	7.46E-01	-9.35E-01
RWD	[kg]	3.33E-03	1.60E-06	9.71E-05	2.34E-03	3.65E-05	1.69E-06	4.76E-04	1.9E-05	-6.03E-04
CRU	[kg]	-	-	-	-	-	-	-	-	-
MFR	[kg]	-	-	-	-	-	-	-	-	-
MER	[kg]	-	-	-	-	-	-	2.90E+00	-	-
EE Power	[MJ]	-	-	3.98E-02	-	-	-	1.88E+00	-	-
EE Thermal energy	[MJ]	-	-	4.72E-01	-	-	-	2.31E+01	-	-
HWD = Hazardous waste disposed; NHWD = Nonhazardous 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										

Interpretation

The interpretation of the environmental impacts calculated according to EN 15804 are similar to the interpretation according to ISO 14025. A more detailed interpretation for a one year useage is presented in following figures and tables.

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

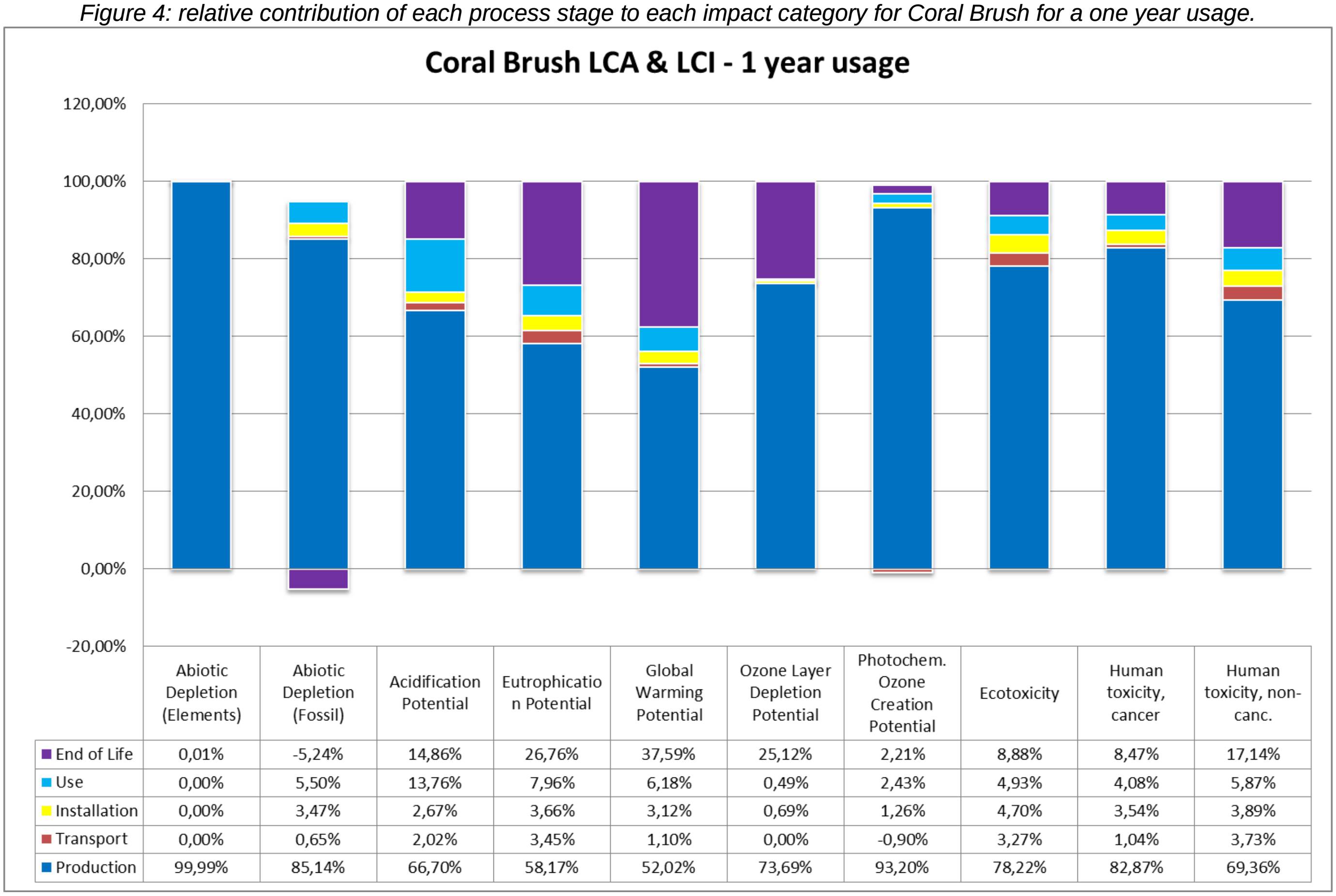


Table 16: Main modules and flows contributing to the total impact in each impact category for Coral Brush for a one year usage

Impact Category	Stage	Module		Main contributor	Main contributing flows
GWP	Production	Raw Material Extraction	6.16 kg CO_2-equiv.	Polyester (1.1 kg CO_2-eq.) DINP (2.31 kg CO_2-eq.) PVC (1.94 kg CO_2-eq.)	Production : Inorganic emissions to air, Carbon dioxide
		Transport of Raw materials	0.02 kg CO_2-equiv.	Means of transport (truck, container ship) and their fuels	
		Manufacturing	1.54 kg CO_2-equiv.	95% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, Carbon dioxide

Impact Category	Stage	Module		Main contributor	Main contributing flows
	Installation	Installation		59% Adhesive 27% Disposal/Recycling of installation waste	
	Use	Use		99.5% Electricity	Use : Inorganic emissions to air, Carbon dioxide
	EOL	EOL		Incineration of post-consumer Coral Brush Energy substitution from incineration	EOL : Inorganic emissions to air, Carbon dioxide
ODP	Production	Raw Material Extraction	97%	78% Polyester fleece 16% Fire retardant	Production : Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane), Halon (1301)
		Transport of Raw materials	< 0.01%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	3%	89% Packaging end product	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane)
	Installation	Installation		26% Adhesive 71% Incineration of PVC installation waste	
	Use	Use		79% Electricity 21% Detergent	Use : Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane)
	EOL	EOL		Incineration of post-consumer Coral Brush Energy substitution from incineration	EOL: Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane)
AP	Production	Raw Material Extraction	95%	13% Polyester 44% Fire retardant 22% DINP 19% PVC	Production : Inorganic emissions to air, NO_x and Sulphur dioxide
		Transport of Raw materials	< 0.3%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	5%	70% Thermal energy 25% Packaging end product	
	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		85% Adhesive 13% Incineration of PVC installation waste	
	Use	Use		100% Electricity	Use : Inorganic emissions to air, NO_x and Sulphur dioxide
	EOL	EOL		Incineration of post-consumer Coral Brush Energy substitution from incineration	EOL : Inorganic emissions to air, NO_x and Sulphur dioxide
EP	Production	Raw Material Extraction	88%	16% Polyester 29% PVC 27% DINP 24% Fire retardant	Production : Inorganic emissions to air, Ammonia, NO_x Production : Inorganic emissions to fresh water, Nitrate , Ammonium/Ammonia
		Transport of Raw materials	< 0.5%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	12%	18% Packaging end product 78% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, NO_x Transport & Installation : Inorganic emissions to fresh water, Ammonium / ammonia
	Installation	Installation		81% Adhesive 15% Incineration of installation waste	
	Use	Use		99% Electricity	Use : Inorganic emissions to air, NO_x
	EOL	EOL		Incineration of post-consumer Coral Brush Energy substitution from incineration	EOL : Inorganic emissions to air, NO_x
POCP	Production	Raw Material Extraction	44%	16% Polyester 27% PVC 47% DINP	Production : Inorganic emissions to air, Carbon monoxide, NO_x , Sulphur dioxide Production : Organic emissions to air (Group VOC), Butane (n-butane), VOC (unspecified), NMVOC (unspecified)
		Transport of Raw materials	< 0.2%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	56%	85% Thermal energy	
	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 : Organic emissions to air (Group VOC), NMVOC (unspecified)
	Installation	Installation		93% Adhesive	

Impact Category	Stage	Module		Main contributor	Main contributing flows
	Use	Use		99% electricity	Use : Inorganic emissions to air, Sulphur dioxide, Nitrogen dioxide Use : Organic emissions to air (Group VOC), NMVOC (unspecified)
	EOL	EOL		Incineration of post-consumer Coral Brush Energy substitution from incineration	EOL : Inorganic emissions to air, Carbon monoxide , NO_x, Sulphur dioxide EOL : Organic emissions to air (Group VOC), Methane, NMVOC (unspecified)
ADPe	Production	Raw Material Extraction	100%	100% Fire retardant	Production : Nonrenewable resources, Antimony – Gold – Ore (0.09%)
		Transport of Raw materials	<0,1%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	<0.1%	76% Electricity	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Nonrenewable resources, Sodium chloride (rock salt), Magnesium Chloride leach (40%)
	Installation	Installation		64% Adhesive 35% Incineration of PVC installation waste	
	Use	Use		98% Electricity	Use : Nonrenewable resources, Sodium chloride (Rock salt) Use : Nonrenewable elements, Chromium, Copper, Gold, Lead, Molybdenum
	EOL	EOL		Incineration of post-consumer Coral Brush Energy substitution from incineration	EOL : Nonrenewable resources, Magnesium Chloride leach (40%) EOL : Nonrenewable elements, Copper, Lead, Chromium
ADPf	Production	Raw Material Extraction	84%	13% Polyester 48% DINP 32% PVC	Production : Crude oil resource, Crude oil (in MJ) Production : Natural gas (resource), Natural gas (in MJ)
		Transport of Raw materials	<0.2%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	16%	95% Thermal energy	
	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		97% Adhesive	
	Use	Use		99% electricity	Use : Hard coal (resource), Natural gas (resource), Uranium (resource)
	EOL	EOL		Incineration of post-consumer Coral Brush Energy substitution from incineration	EOL : Natural gas (resource), Uranium (resource), Crude oil (resource)
Eco toxicity	Production	Raw Material Extraction	97%	32% PVC 31% Fire retardant 15% DINP 14% Stabilizer	Production : Heavy metals to fresh water, Arsenic (+V), Copper (+II), Zinc (+II), Nickel (+II) Production : Heavy metals to agricultural soil, Copper (+II), Zinc (+II)
		Transport of Raw materials	1%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	2%	65% Packaging end product 22% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & installation : Heavy metals to fresh water, Copper (+II), Nickel (+II), Zinc (+II)
	Installation	Installation		95% Adhesive	
	Use	Use		99% Electricity	Use : Heavy metals to fresh water, Copper (+II), Zinc (+II) Use : Heavy metals to agricultural soil, Copper (+II), Zinc (+II)
	EOL	EOL		Incineration of post-consumer Coral Brush Energy substitution from incineration	EOL : Heavy metals to fresh water, Copper (+II), Zinc (+II) EOL : Heavy metals to industrial soil, Zinc (+II) EOL : Heavy metals to agricultural soil, Zinc (+II), Copper (+II) EOL : Heavy metals to air, Antimony
Human toxicity, cancer	Production	Raw Material Extraction	96%	13% Polyester 45% PVC 28% Fire retardant	Production : Heavy metals to fresh water, Chromium (+VI), Arsenic (+V) Production : Organic emissions to air (Group VOC), Vinyl Chloride (VCM chloroethene), Formaldehyde (methanal)
		Transport of Raw materials	< 0.4%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	4%	88% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Heavy metals to air, Mercury (+II) Transport & Installation : Heavy metals to fresh water, Chromium (+VI), Nickel (+II)
	Installation	Installation		94% adhesive	

Impact Category	Stage	Module		Main contributor	Main contributing flows
	Use	Use		99% Electricity	Use : Heavy metals to air, Mercury (+II) Use : Heavy metals to fresh water, Chromium (+VI) Use : Heavy metals to agricultural soil, Mercury (+II)
	EOL	EOL		Incineration of post-consumer Coral Brush Energy substitution from incineration	EOL : Heavy metals to air, Mercury (+II) EOL : Heavy metals to agricultural soil, Mercury (+II)
Human toxicity, non canc.	Production	Raw Material Extraction	96%	31% CaZn stearate 25% PVC 32% Fire retardant	Production : Heavy metals to air, Mercury (+II) Production : Heavy metals to fresh water, Arsenic (+V), Zinc (+II) Production : Heavy metals to agricultural soil, Lead (+II), Mercury (+II), Zinc (+II)
		Transport of Raw materials	2%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	2%	67% Packaging end product 11% Hazardous waste 11% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Heavy metals to air, Mercury (+II) Transport & Installation : Heavy metals to agricultural soil, Lead (+II), Mercury (+II), Zinc (+II)
	Installation	Installation		90% adhesive	
	Use	Use		100% electricity	Use : Heavy metals to air, Mercury (+II), Zinc (+II) Use : Heavy metals to agricultural soil, Mercury (+II), Zinc (+II)
	EOL	EOL		Incineration of post-consumer Coral Brush Energy substitution from incineration	EOL : Heavy metals to agricultural soil, Mercury (+II), Zinc (+II) EOL : Heavy metals to air, Mercury (+II)

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 sludges, galvanic sludges, 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.

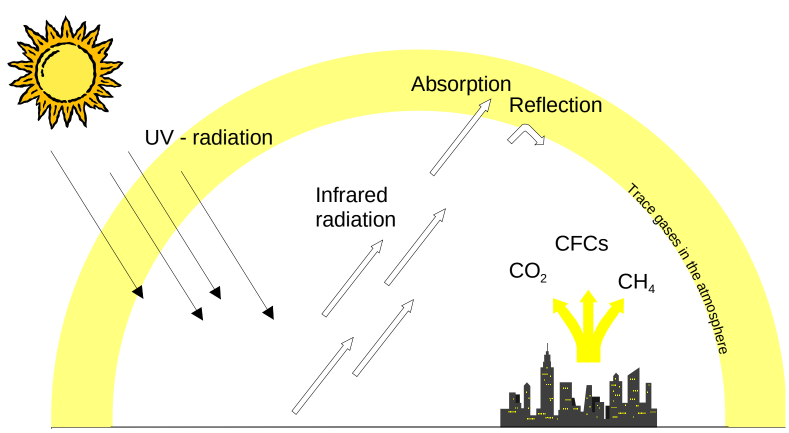


Figure A1: Greenhouse effect (Kreissig 1999)

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.

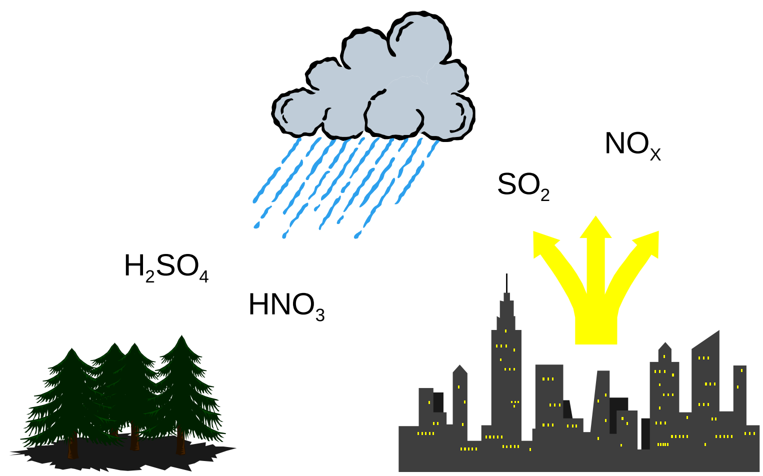


Figure A2: Acidification Potential (KREISSIG 1999)

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.

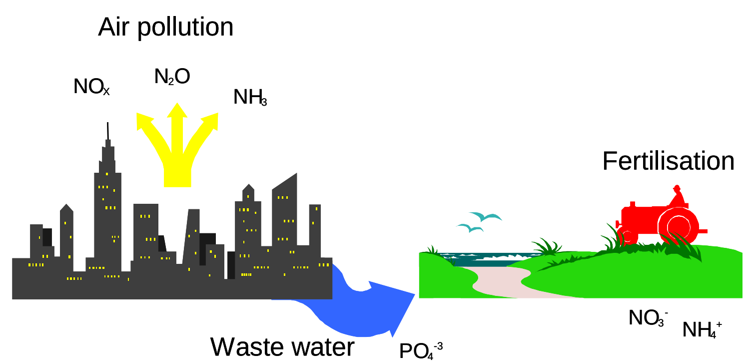


Figure A3: Eutrophication Potential (KREISSIG 1999)

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.

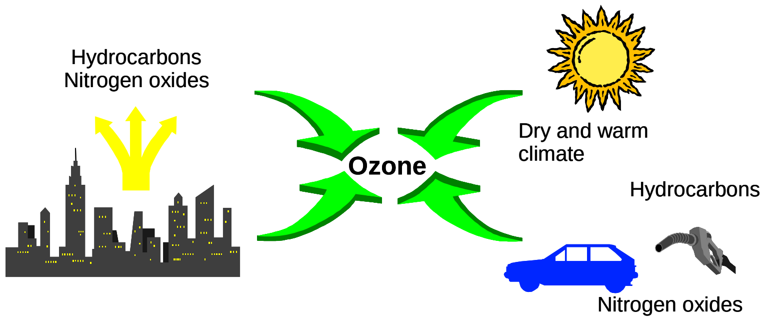


Figure A4: Photochemical Ozone Creation Potential

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.

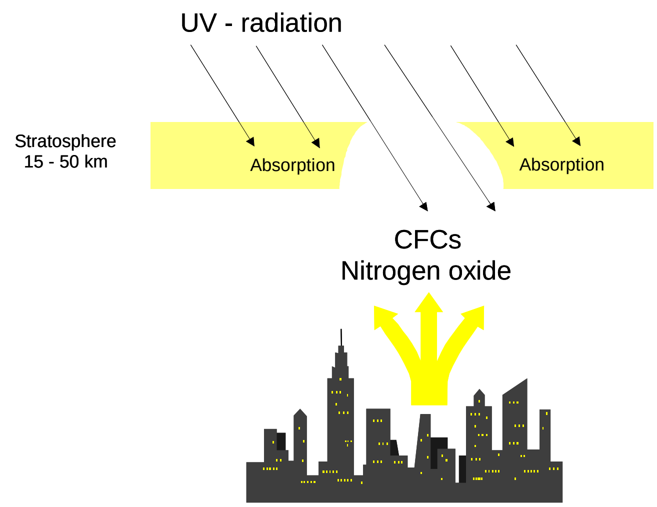


Figure A5: Ozone Depletion Potential (KREISSIG 1999)

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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 15804	EN 15804: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products
ISO 24011	Resilient floor coverings - Specification for plain and decorative Coral Brush
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	Resilient, textile and laminate floor coverings - Classification