ENVIRONMENTAL PRODUCT DECLARATION

ETERNAL

FORBO FLOORING SYSTEMS
RESILIENT FLOOR COVERING

FLOORING SYSTEMS

From the spills and tumbles of a nursery through to the large scale thoroughfares in a modern university, there is a common need for attractive, functional products. Forbo's Eternal has the performance and product properties to satisfy such a diverse range of needs.

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 publishing Environmental Product Declarations (EPD) for all products including full LCA reports. This EPD uses recognized flooring Product Category Rules and includes 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 Eternal into true value and benefits for all our customers and stakeholders alike.

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

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

FLOORING SYSTEMS

Eternal
Resilient Floor Covering

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	12CA64879.107.1
DECLARED PRODUCT	Eternal
REFERENCE PCR	Flooring: Carpet, Resilient, Laminate, Ceramic, and Wood (NSF 2012)

DATE OF ISSUE	19 June 2013
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	Loretta Tam, ULE EPD Program Manager
This life cycle assessment was independently verified in accordance with ISO 14044, EN 15804 and the reference PCR by:	Trisha Montalbo, PE International

Product Definition

Product Classification and Description

This declaration covers the Eternal collection of Project Vinyl floorcoverings. The Eternal collection consists of a range of products of different designs and colors. Eternal sheet from Forbo Flooring is a resilient floor covering complying with all the requirements of EN-ISO 10582: Resilient floor coverings – Heterogeneous polyvinyl chloride floor coverings - Specification. The key raw materials include PVC, plasticizer, mineral filler, stabilizers and glass fiber.

Eternal is produced by Forbo Flooring and is sold worldwide.

This declaration refers to Eternal sheet of 2.0mm nominal thickness with a 0,70mm wear layer.

Eternal is built up in 5 layers:

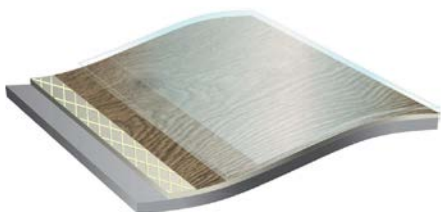
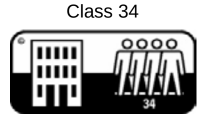
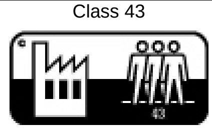


Figure 1: Typical construction

1. **Lacquer surface:** This PU lacquer coating for easy cleaning & maintenance gives enhanced protection against scuffing, scratching, dirt pick up and staining.
2. **Wear layer:** The 0.70mm wear layer meets the requirement for Type 1 wear layer according to EN-ISO10582. This topcoat layer is generally transparent but for certain ranges will be pigmented and may also contain design enhancing decorative PVC chips or spheres.
3. **Printed layer:** The decorative design is printed, using environmentally friendly water-based inks, on to a thin white PVC plastisol coating. Printed design is not required with pigmented wear layers.
4. **Intermediate layer:** Non-woven glass fleece that is impregnated with a highly filled PVC plastisol to give the product strength & excellent dimensional stability.
5. **Backing layer**: Calendered layer containing a minimum of 45% recycled production waste.

Range of Applications

Eternal is classified in accordance with EN-ISO 10582 to be installed in the following use areas defined in EN-ISO 10874:

Area of application	
Commercial	Class 34 
Industrial	Class 43 

Product Standard

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

- Meets or exceeds all technical requirements in EN-ISO 10582 Resilient floor coverings – Heterogeneous polyvinyl chloride floor coverings - Specification

Eternal meets the requirements of EN 14041

EN 13501-1	Reaction to fire	B_{fl} – s1
EN 13893	Slip resistance	DS: ≥ 0,30
EN 1815	Body voltage	< 2 kV
EN ISO10456	Thermal conductivity	0,25 W/mK

Accreditation

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- AgBB requirements
- CHPS section 01350

Delivery Status

Table 1: Specification of delivered product

Characteristics	Nominal Value	Unit
Product thickness	2.00	mm
Product Weight	2.80	kg/m^2
Rolls Width Length	2.00 25	meter

FLOORING SYSTEMS

Eternal
Resilient Floor Covering

According to ISO 14025 & EN 15804

Material Content

Material Content of the Product

Table 2: Composition of Eternal

Component	Material	Availability	Amount [%]	Origin of raw material
Binder	PVC DINP & Dibenzoates	Non-renewable – limited Non-renewable - limited	39 17	Europe Europe
Filler	Dolomite	Abundant mineral	22	Europe
Stabilizers and process additives	Epoxidized esters & proprietary mixtures & lubricants	1.7% natural oils, others non-renewable - limited	4	Europe
Carrier	Glass fiber tissue	Non-renewable - limited	2	Netherlands/Germany
Pigments	Titanium Dioxide (main pigment) plus others	Non-renewable - limited	0.5	Europe
Finish	PU lacquer	Non-renewable - limited	<0.5	Europe
Recycle	Post production waste		15	

Production of Main Materials

PVC: Polymer which is produced by the polymerization of vinyl chloride monomer.

Plasticizers: Plasticizer is obtained by esterification of an alcohol and acid. Plasticizer is added to increase the flexibility, durability and longevity of the floor covering.

Stabilizer Ba/Zn: Mixed metal stabilizer made from Barium and Zinc stearate. It is used to avoid PVC degradation during processing at relative high temperature.

Dolomite: An abundant mineral mined in northern Norway.

Glass fleece: Glass fibers are mixed with a binder to produce a glass fleece which is used as a substrate for floor coverings and imparts excellent dimensional stability to the finished product.

Titanium dioxide: A white pigment produced from the mineral rutile, a naturally occurring form of titanium dioxide. The production of the pigment is a large-scale chemical process.

Various chemicals:

- **Lacquer** : thermally cross linked polyurethane coating
- **Inks:** water-based gravure inks.

Production of the Floor Covering

Eternal is produced in stages:

- Preparation of PVC plastisols (mixture of PVC, plasticizer and additives, may also contain filler and pigments)
- Impregnation of the glass fleece with a highly filled plastisol followed by the application of a thin white plastisol coating.
- Rotogravure printing, if required, to produce wood, stone or abstract designs.
- Application of PVC plastisol topcoat and PU lacquer. PVC topcoat may be transparent or pigmented and may also contain decorative PVC particles depending on the design type. After fusion at ~195^{0}C the topcoat is mechanically embossed to enhance the decorative effect.
- A calendered back layer is then applied to the product. This layer contains a minimum of 45% of process waste.
- The finished product is then trimmed, inspected and cut into saleable rolls (nominal length – 25 meters). Trimmings & rejected product are recycled back into the calendered backing layer.

Health, Safety and Environmental Aspects during Production

- ISO 14001 Environmental Management System

Production Waste

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

Delivery and Installation of the Floor Covering

Delivery

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

- Transport distance 40 t truck — 553 km
- Transport distance 7.5t truck (Fine distribution) — 277 km
- Capacity utilization trucks (including empty runs) — 85 %
- Transport distance Ocean ship — 1974 km
- Capacity utilization Ocean ship — 48%

Installation

Because of the specific techniques used during the installation of Eternal approximately 6% of the material is cut off as installation waste. For installation of Eternal on the floor a scenario has been modeled assuming 0.30 kg/m^2 of adhesive is applied to the sub-floor. Waste during the installation process may be recycled through the manufacturer's facility or disposed of via landfill or incineration.

Health, Safety and Environmental Aspects during Installation

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

Waste

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

Packaging

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

Use stage

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

Cleaning and Maintenance

Level of use	Cleaning Process	Cleaning Frequency	Consumption of energy and resources
Commercial/Residential	Vacuuming	Twice a week	Electricity
	Wet Cleaning	Once a week	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, twice a week. This equates to 0.55 kWh/m^2*year.
- Once a week wet cleaning with 0.062 l/m^2 water and 0.0008 kg/m^2 detergent. This result in the use of 3.224 l/m^2*year water and 0.04 kg/m^2*year detergent. The wet cleaning takes place without power machine usage. Waste water treatment of the arising waste water from cleaning is considered (Data sourced from Forbo GABI model).

The cleaning regime that is recommended in practice will be highly dependent on the use of the premises where the floor covering is installed. In high traffic areas more frequent cleaning will be needed compared to areas where there is low traffic. The use of an entrance mat of at least four 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. Use protective feet on chairs and tables to reduce scratching. Castor wheels should be suitable for resilient floor coverings

Health Aspects during Usage

Eternal is complying with:
- o AgBB requirements
- o CHPS section 01350

End of Life

The deconstruction of installed Eternal from the floor is done mechanically and the electrical energy needed for this is estimated to be 0.03 kWh/sqm. This amount of energy is included into the calculations. For the End of Life stage, 20% landfill and 80% incineration is taken into account, the average distance to the incineration plant or landfill facility per lorry is set to 200 km.

Life Cycle Assessment

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

The following Life Cycle Stages are assessed :
- 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

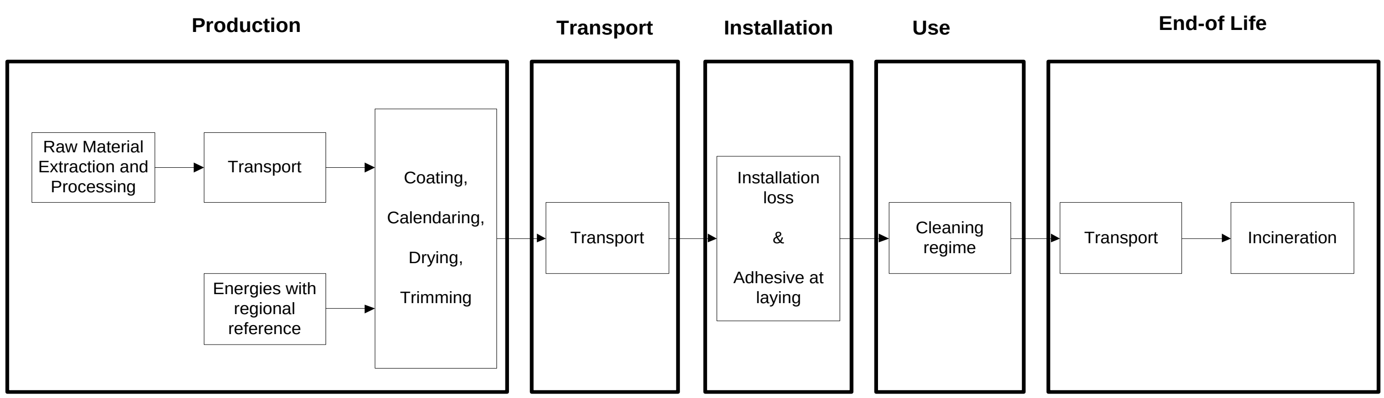


Figure 2: Flow chart of the Life Cycle Assessment

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.

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.

Background 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 2012). 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 products are manufactured in Coevorden, the Netherlands. The GaBi 6 Hydropower dataset has therefore been used (reference year 2009). 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 Eternal is presented in table 3 with their specific energy resources.

Table 3: Primary energy for all life cycle stages for Eternal 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	180.80	100	160.78	2.37	13.07	5.84	-1.26
Crude oil	MJ	64.5	36	54.08	2.18	4.72	0.63	2.89
Hard coal	MJ	11.66	6	8.12	0.01	0.29	0.98	2.26
Lignite	MJ	8.90	5	6.66	0.00	0.32	0.74	1.17
Natural gas	MJ	84.40	47	83.87	0.17	7.51	1.74	-8.90
Uranium	MJ	11.33	6	8.04	0.01	0.23	1.74	1.31
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	12.17	100	11.33	0.05	0.17	0.79	-0.17
Geothermical	MJ	0.03	0.2	0.02	0.00	0.00	0.01	0.00
Hydro power	MJ	4.65	39	4.28	0.00	0.01	0.32	0.03
Solar energy	MJ	5.70	47	5.40	0.05	0.10	0.23	-0.08
Wind power	MJ	1.7	14	1.54	0.00	0.06	0.23	-0.12

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 is shown for all life cycle stages for a one year usage.

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

Wastes	Unit	Total Life cycle	Production	Transport	Installation	Use (1yr)	End of Life
Hazardous waste	[kg]	4.12E-03	2.55E-03	0.00E+00	1.57E-03	0.00E+00	0.00E+00
Non-hazardous waste	[kg]	1.34E+01	9.90E+00	7.09E-03	6.14E-01	1.12E+00	1.75E+00
Radioactive waste	[kg]	4.46E-03	3.02E-03	3.12E-06	1.94E-04	7.12E-04	5.32E-04
Resources	**Unit**	**Total Life cycle**	**Production**	**Transport**	**Installation**	**Use (1yr)**	**End of Life**
Nonrenewable resources	[kg]	1.86E+01	1.28E+01	1.00E-02	6.10E-01	1.13E+00	4.05E+00

Life Cycle Assessment

In table 5 the environmental impacts for one lifecycle are presented for Eternal. 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) – Eternal

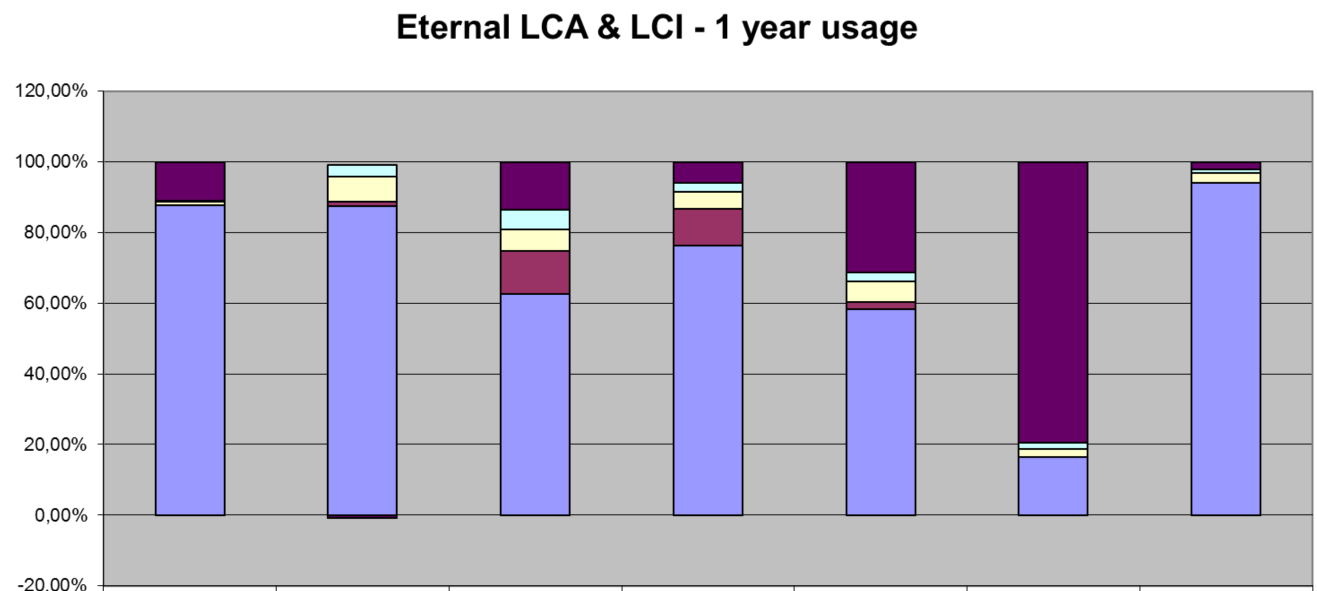
Impact Category : CML 2001 – Nov. 2010	Eternal	Unit
Global Warming Potential (GWP 100 years)	1.29E+01	kg CO2-Equiv.
Ozone Layer Depletion Potential (ODP. steady state)	1.34E-07	kg R11-Equiv.
Acidification Potential (AP)	2.42E-02	kg SO2-Equiv.
Eutrophication Potential (EP)	3.38E-03	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	1.03E-02	kg Ethene-Equiv.
Abiotic Depletion Potential Elements (ADPE)	3.19E-05	kg Sb-Equiv.
Abiotic Depletion Potential Fossil (ADPF)	1.98E+02	[MJ]

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

Impact Category : CML 2001 – Nov. 2010	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Global Warming Potential	kg CO2-Equiv.	7.52E+00	2.68E-01	7.64E-01	3.22E-01	4.05E+00
Ozone Layer Depletion Potential	kg R11-Equiv.	2.20E-08	2.34E-12	3.24E-09	2.30E-09	1.06E-07
Acidification Potential	kg SO2-Equiv.	1.52E-02	2.94E-03	1.48E-03	1.35E-03	3.27E-03
Eutrophication Potential	kg PSO4-Equiv.	2.58E-03	3.48E-04	1.65E-04	8.29E-05	2.03E-04
Photochem. Ozone Creation Potential	kg Ethene-Equiv.	9.69E-03	1.36E-05	2.94E-04	9.17E-05	2.28E-04
Abiotic Depletion Elements	kg Sb-Equiv.	2.80E-05	5.72E-09	2.81E-07	6.36E-08	3.55E-06
Abiotic Depletion Fossil	MJ	1.60E+02	2.37E+00	1.30E+01	5.78E+00	-1.73E+00

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

Figure 3: relative contribution of each process stage to each impact category for Eternal 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	11,12%	-0,95%	13,49%	6,00%	31,31%	79,45%	2,21%
Use	0,20%	3,15%	5,55%	2,45%	2,49%	1,71%	0,89%
Installation	0,88%	7,12%	6,12%	4,89%	5,91%	2,42%	2,85%
Transport	0,02%	1,29%	12,15%	10,30%	2,08%	0,002%	0,13%
Production	87,78%	87,49%	62,69%	76,37%	58,21%	16,42%	93,93%

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 most of the impact categories (ADPE, ADPF, AP, EP, GWP and POCP) the production stage has the main contribution to the overall impact and except for POCP the raw material supply is the key contributor with a share of 84 – 98%. For POCP the share of the Forbo manufacturing stage is 63%, caused by the use of energy during the manufacturing of Eternal.

For the transportation stage a significant contribution comes from the categories AP and EP in which the container ship used for a worldwide distribution is the major contributor.

For GWP, AP, EP and ADPF the adhesive for the flooring installation has an impact of approximately 5 – 7% of the total. Also for the use stage these are the main impact categories, mainly caused by the use of electricity for cleaning.

At the End of Life stage the main impact categories are AP, ADPE, GWP and ODP, this is mainly due to the fact that 80% of the waste is 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:

- 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) – Eternal

Impact Category : USEtox	Eternal	Unit
Eco toxicity	9.65E-01	PAF m3.day
Human toxicity, cancer	8.06E-09	Cases
Human toxicity, non-canc.	1.70E-06	Cases

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

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

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Eco toxicity	PAF m3.day	9.13E-01	1.31E-02	1.44E-02	2.78E-02	-3.66E-03
Human toxicity, cancer	cases	7.49E-09	5.38E-11	2.49E-10	2.66E-10	3.62E-12
Human toxicity, non-canc.	cases	1.61E-06	2.40E-08	2.05E-08	5.50E-08	-1.32E-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.

In all the Toxicity categories the production stage is the main contributor to the total overall impact. The raw material supply has a share of more than 97% of the production stage, therefore the choice of raw materials can highly influence the Toxicity categories.

The Use stage has a minor impact of ± 3% for all three impact categories. This is mainly due to the use of electricity for the cleaning of the floor. The used cleaning regime of vacuuming twice a week is very conservative and will in practice most of the times be lower.

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 Eternal (one year)

		Manufacturing	Installation		Use (1yr)	End of Life				Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
GWP	[kg CO2-Equiv.]	6.62E+00	2.68E-01	8.50E-01	3,22E-01	1.70E-02	7.27E-02	3.84E+00	1.12E-01	-8.55E-02
ODP	[kg CFC11-Equiv.]	2.19E-08	2.34E-12	3.27E-09	2,30E-09	4.31E-09	1.52E-12	1.00E-07	1.82E-09	-3.56E-11
AP	[kg SO2-Equiv.]	1.32E-02	2.94E-03	1.70E-03	1,35E-03	1.16E-04	3.65E-04	2.74E-03	4.93E-05	-2.20E-04
EP	[kg PO43-- Equiv.]	2.38E-03	3.48E-04	1.80E-04	8,29E-05	4.21E-06	8.79E-05	1.00E-04	1.04E-05	-1.45E-05
POCP	[kg Ethen Equiv.]	8.90E-03	1.36E-05	3.12E-04	9,17E-05	5.96E-06	3.90E-05	1.53E-04	3.01E-05	-1.75E-05
ADPE	[kg Sb Equiv.]	2.61E-05	5.72E-09	2.88E-07	6,36E-08	1.17E-09	3.35E-09	3.54E-06	-8.44E-10	-7.10E-09
ADPF	[MJ]	1.38E+02	2.37E+00	14.50E+00	5,78E+00	3.26E-01	9.96E-01	-3.14E+00	8.83E-02	-1.45E+00
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 Eternal (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]	11.04E+00	5.43E-02	2.86E-01	7.88E-01	2.55E-02	5.89E-02	-2.40E-01	-1.16E-02	-1.16E-01
PENRE	[MJ]	-	-	-	-	-	-	-	-	-
PENRM	[MJ]	-	-	-	-	-	-	-	-	-
PENRT	[MJ]	13.80E+01	2.37E+00	1.45E+01	5.84E+00	3.30E-01	9.96E-01	-2.69E+00	1.01E-01	-1.45E+00
SM	[kg]	2.71E-01	-	-	-	-	-	-	-	-
RSF	[MJ]	2.34E-03	1.45E-05	2.14E-04	9.54E-05	0.00E+00	7.41E-06	-1.97E-04	-3.53E-06	-2.10E-05
NRSF	[MJ]	2.45E-02	1.52E-04	2.24E-03	9.99E-04	0.00E+00	7.74E-05	-2.07E-03	-3.70E-05	-2.20E-04
FW	[kg]	2.20E+01	8.02E-02	2.79E+00	5.28E+00	-7.97E-02	5.68E-02	-2.93E+00	-3.99E-01	-3.23E-01
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										

Table 11: Results of the LCA – Output flows and Waste categories for Eternal (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]	2.55E-03	0.00E+00	1.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NHWD	[kg]	9.90E+00	7.09E-03	6.14E-01	1.12E+00	6.04E-02	6.16E-03	1.51E+00	1.30E-02	1.58E-01
RWD	[kg]	3.02E-03	3.21E-06	1.94E-04	7.12E-04	5.41E-05	1.43E-06	3.57E-04	1.72E-05	1.02E-04
CRU	[kg]	-	-	-	-	-	-	-	-	-
MFR	[kg]	-	-	-	-	-	-	-	-	-
MER	[kg]	-	-	-	-	-	-	2.29E+00	-	-
EE Power	[MJ]	-	-	1.57E-01	-	-	-	1.72E+00	-	-
EE Thermal energy	[MJ]	-	-	2.92E-01	-	-	-	1.43E+01	-	-
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										

Interpretation

The interpretation of the environmental impacts calculated according to EN 15804 are similar to the interpretation according to ISO 14025 on page 11. A more detailed interpretation is published in the appendix.

References

GABI 6 2012	PE INTERNATIONAL AG; GaBi 6: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2012.
GABI 6 2012D	GaBi 6: Documentation of GaBi 6: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2012. http://documentation.gabi-software.com/
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
ERFMI 2008	Final report: LCA, Environmental Information Sheet and Eco design Model of Resilient Flooring by order of ERFMI, PE International, 2008
IBU 2011	PCR - Part A: Calculation rules for the Life Cycle Assessment and Requirements on the Background Report, Institut Bauen und Umwelt e.V.
PE 2012	Description of Selected Impact Categories, PE International AG, 2012
ILCD Handbook: General guide for Life Cycle Assessment - Detailed guidance	European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union; 2010
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 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

Appendix

The following life cycle assessment 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 /EN 15804/ following the document "Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Background Report" /IBU 2011/.

LCA Report for Environmental Product Declarations (EPD)

Eternal

Forbo Flooring

Title of the study:

Environmental product declarations of Eternal

Part of the project: Life Cycle assessment (LCA)

LCA study conducted by:

Forbo Flooring

Industrieweg 12

1566 JP Assendelft

The Netherlands

June 2013

Supported by:

PE INTERNATIONAL AG

Authors:
Floris Zeitler, Forbo
Supported by Peter Shonfield, Julia Goerke

Forbo Flooring BV

Industrieweg 12
1566 JP Assendelft, The Netherlands
Tel. +31 (0) 75 6477477
Fax +31 (0) 75 6477707
E-mail floris.zeitler@forbo.com
Internet www.forbo-flooring.com

Supported by:

PE INTERNATIONAL AG
Hauptstraße 111 – 115
D – 70771 Leinfelden – Echterdingen
Tel. +49 (0) 711 34 18 17 – 0
Fax +49 (0) 711 34 18 17 – 25
E-mail info@pe-international.com
Internet www.pe-international.com

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 06/17/13.

Scope

This document is the LCA report for the "Environmental Product Declaration" (EPD) of "Eternal". 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 Eternal complying with EN-ISO 10582: Resilient floor coverings – Heterogeneous polyvinyl chloride floor coverings - Specification.

Manufactured by
Forbo-Novilon B.V.
De Holwert 12
7741 KC Coevorden
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.

Eternal is produced at the following manufacturing site:

Forbo-Novilon B.V.
De Holwert 12
7741 KC Coevorden
The Netherlands

Product Definition

Product Classification and Description

This declaration covers the Eternal collection of Project Vinyl floorcoverings. The Eternal collection consists of a range of products of different designs and colors. Eternal sheet from Forbo Flooring is a resilient floor covering complying with all the requirements of EN-ISO 10582: Resilient floor coverings – Heterogeneous polyvinyl chloride floor coverings - Specification. The key raw materials include PVC, plasticizer, mineral filler, stabilizers and glass fiber.

Eternal is produced by Forbo Flooring and is sold worldwide.

This declaration refers to Eternal sheet of 2.0mm nominal thickness with a 0,70mm wear layer.

Eternal is built up in 5 layers:

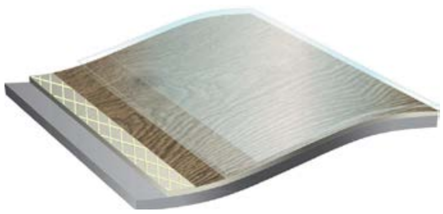


Figure 1: Typical construction

1. **Lacquer surface:** This PU lacquer coating for easy cleaning & maintenance gives enhanced protection against scuffing, scratching, dirt pick up and staining.
2. **Wear layer:** The 0.70mm wear layer meets the requirement for Type 1 wear layer according to EN-ISO10582. This topcoat layer is generally transparent but for certain ranges will be pigmented and may also contain design enhancing decorative PVC chips or spheres.
3. **Printed layer:** The decorative design is printed, using environmentally friendly water-based inks, on to a thin white PVC plastisol coating. Printed design is not required with pigmented wear layers.
4. **Intermediate layer:** Non-woven glass fleece that is impregnated with a highly filled PVC plastisol to give the product strength & excellent dimensional stability.
5. **Backing layer**: Calendered layer containing a minimum of 45% recycled production waste.

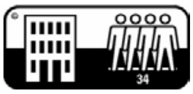
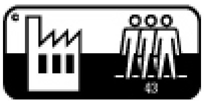
FLOORING SYSTEMS

Step – Safety Vinyl
Resilient Floor Covering

According to ISO 14025 & EN 15804

Range of Applications

Eternal is classified in accordance with EN-ISO 10582 to be installed in the following use areas defined in EN-ISO 10874:

Area of application	
Commercial	Class 34 
Industrial	Class 43 

Product Standards

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

- Meets or exceeds all technical requirements in EN-ISO 10582 Resilient floor coverings – Heterogeneous polyvinyl chloride floor coverings - Specification

CE

Eternal meets the requirements of EN 14041

EN 13501-1	Reaction to fire	B_{fl} – s1
EN 13893	Slip resistance	DS: ≥ 0,30
EN 1815	Body voltage	< 2 kV
EN ISO10456	Thermal conductivity	0,25 W/mK

Accreditations

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- AgBB requirements
- CHPS section 01350

Delivery status

Characteristics	Nominal Value	Unit
Product thickness	2.00	mm
Product Weight	2.80	kg/m^2
Rolls Width Length	2.00 25	meter

Material Content

Component	Material	Availability	Mass %	Origin of raw material
Binder	PVC DINP & Dibenzoates	Non-renewable – limited Non-renewable - limited	39 17	Europe Europe
Filler	Dolomite	Abundant mineral	22	Europe
Stabilizers and process additives	Epoxidized esters & proprietary mixtures & lubricants	1.7% natural oils, others non-renewable - limited	4	Europe
Carrier	Glassfiber tissue	Nonrenewable - limited	2	Netherlands/Germany
Pigments	Titanium Dioxide (main pigment) plus others	Nonrenewable - limited	0.5	Europe
Finish	PU lacquer	Nonrenewable - limited	<0.5	Europe
Recycle	Post production waste		15	

Production of Main Materials

PVC: Polymer which is produced by the polymerization of vinyl chloride monomer.

Plasticizers: Plasticizer is obtained by esterification of an alcohol and acid. Plasticizer is added to increase the flexibility, durability and longevity of the floor covering.

Stabilizer Ba/Zn: Mixed metal stabilizer made from Barium and Zinc stearate. It is used to avoid PVC degradation during processing at relative high temperature.

Dolomite: An abundant mineral mined in northern Norway.

Glass fleece: Glass fibers are mixed with a binder to produce a glass fleece which is used as a substrate for floor coverings and imparts excellent dimensional stability to the finished product.

Titanium dioxide: A white pigment produced from the mineral rutile, a naturally occurring form of titanium dioxide. The production of the pigment is a large-scale chemical process

Various chemicals:

- **Lacquer** : thermally cross linked polyurethane coating
- **Inks:** water-based gravure inks.

Production of the Floor Covering

Eternal is produced in stages:

- Preparation of PVC plastisols (mixture of PVC, plasticizer and additives, may also contain filler and pigments)
- Impregnation of the glass fleece with a highly filled plastisol followed by the application of a thin white plastisol coating.
- Rotogravure printing, if required, to produce wood, stone or abstract designs.
- Application of PVC plastisol topcoat and PU lacquer. PVC topcoat may be transparent or pigmented and may also contain decorative PVC particles depending on the design type. After fusion at ~195^{0}C the topcoat is mechanically embossed to enhance the decorative effect.
- A calendered back layer is then applied to the product. This layer contains a minimum of 45% of process waste.
- The finished product is then trimmed, inspected and cut into saleable rolls (nominal length – 25 meters). Trimmings & rejected product are recycled back into the calendered backing layer.

Health, Safety and Environmental Aspects during Production

- ISO 14001 Environmental Management System

Production Waste

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

Delivery and Installation of the Floor Covering

Delivery

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

Transport distance 40 t truck	553 km
Transport distance 7.5t truck (Fine distribution)	277 km
Capacity utilization trucks (including empty runs)	85 %
Transport distance Ocean ship	1974 km
Capacity utilization Ocean ship	48%

Installation

Because of the specific techniques used during the installation of Eternal approximately 6% of the material is cut off as installation waste. For installation of Eternal on the floor a scenario has been modeled assuming 0.30 kg/m^2 of adhesive is applied to the sub-floor. Waste during the installation process may be recycled through the manufacturer's facility or disposed of via landfill or incineration.

Health, Safety and Environmental Aspects during Installation

Forbo flooring recommends using (low) zero emission adhesives for installing Eternal.

Waste

Waste during the installation process may be recycled as floor covering through the manufacturers' facilities or land filled.

Packaging

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

Use stage

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

Cleaning and Maintenance

Level of use	Cleaning Process	Cleaning Frequency	Consumption of energy and resources
Commercial/Residential/Industrial	Vacuuming	Twice a week	Electricity
	Damp mopping	Once a week	Hot water 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, twice a week. This equates to 0.55 kWh/m^2*year.
- Once a week wet cleaning with 0.062 l/m^2 water and 0.0008 kg/m^2 detergent. This result in the use of 3.224 l/m^2*year water and 0.04 kg/m^2*year detergent. The wet cleaning takes place without power machine usage. Waste water treatment of the arising waste water from cleaning is considered.

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

Prevention of Structural Damage

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

Health Aspects during Usage

Eternal is complying with:

- AgBB requirements
- CHPS section 01350

End of Life

The deconstruction of installed Eternal from the floor is done mechanically and the electrical energy needed for this is estimated to be 0.03 kWh/sqm. This amount of energy is taken into account for the calculations.

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

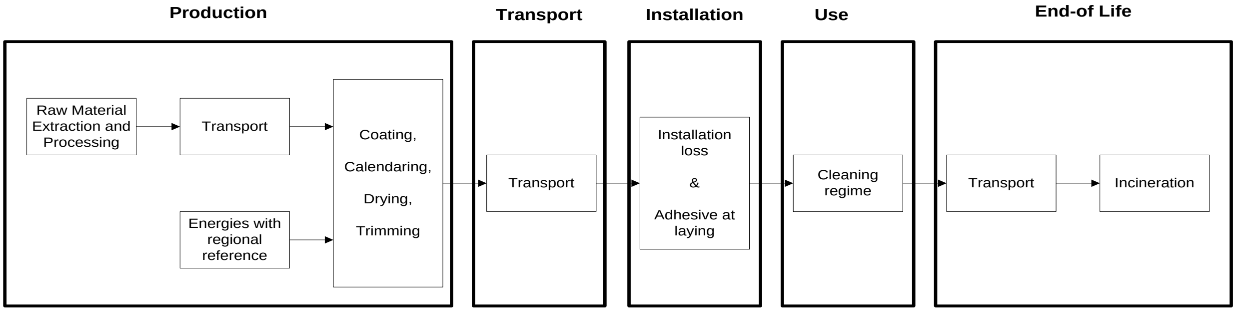


Figure 2 : Flow chart of the Life Cycle Assessment

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.

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 2012). 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
Benzoates	Europe	2012
ESBO	Europe	2006
Polyvinyl chloride granulate	Germany	2012
Di-Isononyl Phthalate (DINP)	Germany	2010
Titanium dioxide	Europe	2010
Inorganic pigment	Germany	2007
Barium-Zinc Stearate	Europe	2010
Fat Acid Esters	Europe	2007
Dolomite	Germany	2006
PVC recycling	Internal	2006
Diphenylmethane-4.4 di-isocyanate (MDI)	Europe	2005
Calcium-Zinc Stearate	Europe	2010
Acrylic resin	Germany	2010
Glass fibers	Germany	2011
Water (desalinated; deionised)	Germany	2010
Detergent (ammonia based)	Germany	2006
Adhesive for resilient flooring	Germany	2010
Waste incineration of Eternal	Europe	2006
Electricity from Hydro power	The Netherlands	2009
Power grid mix	Europe	2009
Thermal energy from natural gas	The Netherlands	2009
Thermal energy from natural gas	Europe	2009
Trucks	Global	2010
Municipal waste water treatment (Sludge incineration).	Europe	2011
Container ship	Global	2010
Diesel mix at refinery	Europe	2009
Heavy fuel oil at refinery (1.0wt.% S)	Europe	2009
Polyethylene film	Europe	2005
Corrugated board	Europe	2002
Kraft liner (Paper)	Europe	2006

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 products are manufactured in Coevorden, the Netherlands. The GaBi 6 Hydro power datasets has therefore been used (reference year 2009). 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 PC*R.

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 (6%):

Table 2: Composition of Eternal

Process data	Unit	Eternal
PVC	kg/m2	1.065
DINP & Dibenzoates	kg/m2	0.464
Dolomite	kg/m2	0.601
Epoxidized esters & proprietary mixtures & lubricants	kg/m2	0.109
Glass fiber tissue	kg/m2	0.055
Titanium Dioxide (main pigment) plus others	kg/m2	0.014
PU lacquer	kg/m2	< 0.014
Post production waste	kg/m2	0.410

Table 3: Production related inputs/outputs

Process data	Unit	Eternal
INPUTS		
Eternal	kg	3.147
Electricity	MJ	5.47
Thermal energy from natural gas	MJ	12.12
Water	kg	1.45
OUTPUTS		
Eternal	kg	2.731
Waste	kg	0.416
Water	kg	0.64

Table 4: Packaging requirements (per m² manufactured product)

Process data	Unit	Eternal
Polyethylene film	kg	0.002
Corrugated board	kg	0.055
Wrapping paper	kg	0.011

Table 5: Transport distances

Process data	Unit	Road	Truck size	Ship
Dolomite	km	1300	14 - 20t gross weight / 11,4t payload capacity	-
PVC	km	976		-
DINP & Dibenzoates	km	412		-
Titanium dioxide	km	2100		-
Epoxidized esters, proprietary mixtures & lubricants	km	300		-
PVC waste recycling	km	1		-
Glass fibers	km	110		-
Lacquer	km	180		-
Corrugated board	km	50		-
Wrapping paper	km	180		-
Polyethylene film	km	2		-
Transport to construction site :	km	830		1974
-Transport distance 40 t truck		553	34 - 40 t gross weight / 27t payload capacity	
-Transport distance 7.5t truck (Fine distribution)		277	7,5 t - 12t gross weight / 5t payload capacity	
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	Eternal
INPUTS		
Eternal	kg	2.731
Adhesive (30% water content) - Water - Acrylate co-polymer - Styrene Butadiene co-polymer - Limestone flour - Sand	kg	0.300
OUTPUTS		
Installed Eternal	kg	2.567
Installation Waste	kg	0.164

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

Process data	Unit	Eternal
Detergent	kg/year	0.04
Electricity	kWh/year	0.55
Water	kg/year	3.224

Table 8: Disposal

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

Life Cycle Inventory Analysis

In table 9 the environmental impacts for one lifecycle are presented for Eternal. 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) – Eternal

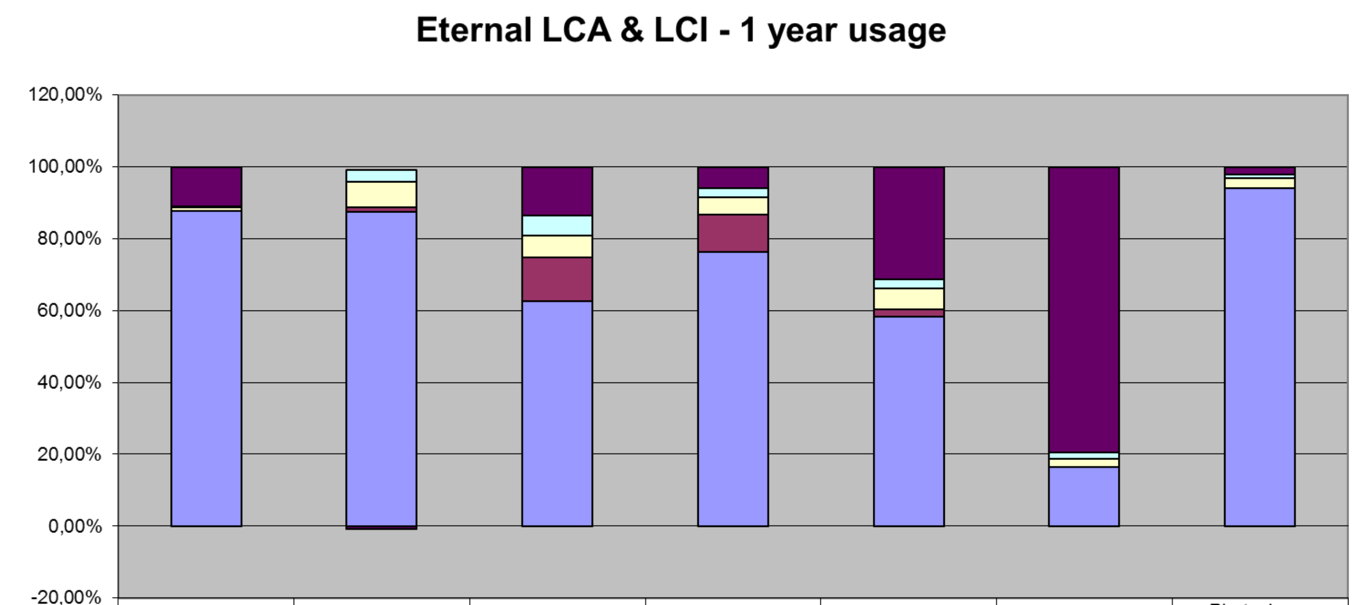
Impact Category : CML 2001 – Nov. 2010	Eternal	Unit
Global Warming Potential (GWP 100 years)	1.29E+01	kg CO2-Equiv.
Ozone Layer Depletion Potential (ODP. steady state)	1.34E-07	kg R11-Equiv.
Acidification Potential (AP)	2.42E-02	kg SO2-Equiv.
Eutrophication Potential (EP)	3.38E-03	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	1.03E-02	kg Ethene-Equiv.
Abiotic Depletion Potential Elements (ADPE)	3.19E-05	kg Sb-Equiv.
Abiotic Depletion Potential Fossil (ADPF)	1.98E+02	[MJ]

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

Impact Category : CML 2001 – Nov. 2010	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Global Warming Potential	kg CO2-Equiv.	7.52E+00	2.68E-01	7.64E-01	3.22E-01	4.05E+00
Ozone Layer Depletion Potential	kg R11-Equiv.	2.20E-08	2.34E-12	3.24E-09	2.30E-09	1.06E-07
Acidification Potential	kg SO2-Equiv.	1.52E-02	2.94E-03	1.48E-03	1.35E-03	3.27E-03
Eutrophication Potential	kg PSO4-Equiv.	2.58E-03	3.48E-04	1.65E-04	8.29E-05	2.03E-04
Photochem. Ozone Creation Potential	kg Ethene-Equiv.	9.69E-03	1.36E-05	2.94E-04	9.17E-05	2.28E-04
Abiotic Depletion Elements	kg Sb-Equiv.	2.80E-05	5.72E-09	2.81E-07	6.36E-08	3.55E-06
Abiotic Depletion Fossil	MJ	1.60E+02	2.37E+00	1.30E+01	5.78E+00	-1.73E+00

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

Figure 3: relative contribution of each process stage to each impact category for Eternal 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	11,12%	-0,95%	13,49%	6,00%	31,31%	79,45%	2,21%
Use	0,20%	3,15%	5,55%	2,45%	2,49%	1,71%	0,89%
Installation	0,88%	7,12%	6,12%	4,89%	5,91%	2,42%	2,85%
Transport	0,02%	1,29%	12,15%	10,30%	2,08%	0,002%	0,13%
Production	87,78%	87,49%	62,69%	76,37%	58,21%	16,42%	93,93%

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 most of the impact categories (ADPE, ADPF, AP, EP, GWP and POCP) the production stage has the main contribution to the overall impact and except for POCP the raw material supply is the key contributor with a share of 84 – 98%. For POCP the share of the Forbo manufacturing stage is 63%, caused by the use of energy during the manufacturing of Eternal.

For the transportation stage a significant contribution comes from the categories AP and EP in which the container ship used for a worldwide distribution is the major contributor.

For GWP, AP, EP and ADPF the adhesive for the flooring installation has an impact of approximately 5 – 7% of the total. Also for the use stage these are the main impact categories, mainly caused by the use of electricity for cleaning.

At the End of Life stage the main impact categories are AP, ADPE, GWP and ODP, this is mainly due to the fact that 80% of the waste is 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:

- 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 11: Results of the LCA – Environmental impacts one lifecycle (one year) – Eternal

Impact Category : USEtox	Eternal	Unit
Eco toxicity	9.65E-01	PAF m3.day
Human toxicity, cancer	8.06E-09	Cases
Human toxicity, non-canc.	1.70E-06	Cases

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

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

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Eco toxicity	PAF m3.day	9.13E-01	1.31E-02	1.44E-02	2.78E-02	-3.66E-03
Human toxicity, cancer	cases	7.49E-09	5.38E-11	2.49E-10	2.66E-10	3.62E-12
Human toxicity, non-canc.	cases	1.61E-06	2.40E-08	2.05E-08	5.50E-08	-1.32E-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.

In all the Toxicity categories the production stage is the main contributor to the total overall impact. The raw material supply has a share of more than 97% of the production stage, therefore the choice of raw materials can highly influence the Toxicity categories.

The Use stage has a minor impact of ± 3% for all three impact categories. This is mainly due to the use of electricity for the cleaning of the floor. The used cleaning regime of vacuuming twice a week is very conservative and will in practice most of the times be lower.

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 Eternal (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.]	6.62E+00	2.68E-01	8.50E-01	3,22E-01	1.70E-02	7.27E-02	3.84E+00	1.12E-01	-8.55E-02
ODP	[kg CFC11-Equiv.]	2.19E-08	2.34E-12	3.27E-09	2,30E-09	4.31E-09	1.52E-12	1.00E-07	1.82E-09	-3.56E-11
AP	[kg SO_2-Equiv.]	1.32E-02	2.94E-03	1.70E-03	1,35E-03	1.16E-04	3.65E-04	2.74E-03	4.93E-05	-2.20E-04
EP	[kg PO_4^{3-}- Equiv.]	2.38E-03	3.48E-04	1.80E-04	8,29E-05	4.21E-06	8.79E-05	1.00E-04	1.04E-05	-1.45E-05
POCP	[kg Ethen Equiv.]	8.90E-03	1.36E-05	3.12E-04	9,17E-05	5.96E-06	3.90E-05	1.53E-04	3.01E-05	-1.75E-05
ADPE	[kg Sb Equiv.]	2.61E-05	5.72E-09	2.88E-07	6,36E-08	1.17E-09	3.35E-09	3.54E-06	-8.44E-10	-7.10E-09
ADPF	[MJ]	1.38E+02	2.37E+00	14.50E+00	5,78E+00	3.26E-01	9.96E-01	-3.14E+00	8.83E-02	-1.45E+00

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 Eternal (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]	11.04E+00	5.43E-02	2.86E-01	7.88E-01	2.55E-02	5.89E-02	-2.40E-01	-1.16E-02	-1.16E-01
PENRE	[MJ]	-	-	-	-	-	-	-	-	-
PENRM	[MJ]	-	-	-	-	-	-	-	-	-
PENRT	[MJ]	13.80E+01	2.37E+00	1.45E+01	5.84E+00	3.30E-01	9.96E-01	-2.69E+00	1.01E-01	-1.45E+00
SM	[kg]	2.71E-01	-	-	-	-	-	-	-	-
RSF	[MJ]	2.34E-03	1.45E-05	2.14E-04	9.54E-05	0.00E+00	7.41E-06	-1.97E-04	-3.53E-06	-2.10E-05
NRSF	[MJ]	2.45E-02	1.52E-04	2.24E-03	9.99E-04	0.00E+00	7.74E-05	-2.07E-03	-3.70E-05	-2.20E-04
FW	[kg]	2.20E+01	8.02E-02	2.79E+00	5.28E+00	-7.97E-02	5.68E-02	-2.93E+00	-3.99E-01	-3.23E-01

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

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

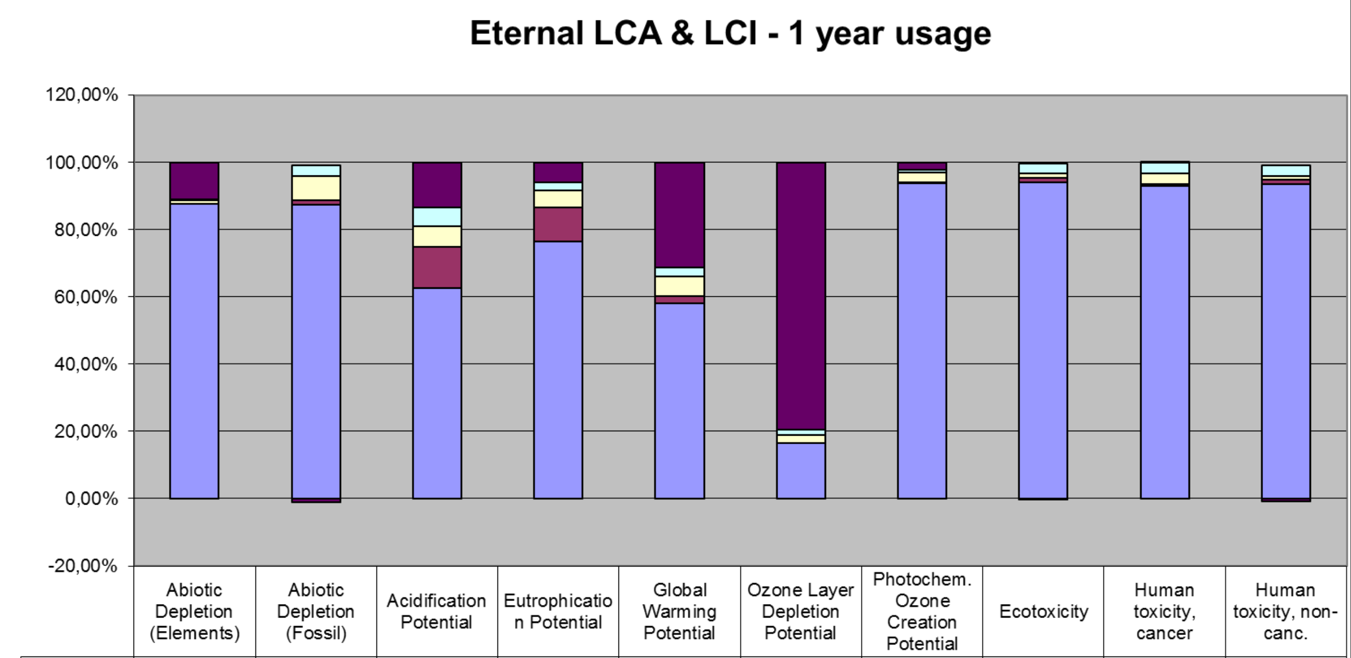
		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits				
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**C4**	**D**
HWD	[kg]	2.55E-03	0.00E+00	1.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NHWD	[kg]	9.90E+00	7.09E-03	6.14E-01	1.12E+00	6.04E-02	6.16E-03	1.51E+00	1.30E-02	1.58E-01
RWD	[kg]	3.02E-03	3.21E-06	1.94E-04	7.12E-04	5.41E-05	1.43E-06	3.57E-04	1.72E-05	1.02E-04
CRU	[kg]	-	-	-	-	-	-	-	-	-
MFR	[kg]	-	-	-	-	-	-	-	-	-
MER	[kg]	-	-	-	-	-	-	2.29E+00	-	-
EE Power	[MJ]	-	-	1.57E-01	-	-	-	1.72E+00	-	-
EE Thermal energy	[MJ]	-	-	2.92E-01	-	-	-	1.43E+01	-	-

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

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 Eternal 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	11,12%	-0,95%	13,49%	6,00%	31,31%	79,45%	2,21%	-0,38%	0,04%	-0,77%
Use	0,20%	3,15%	5,55%	2,45%	2,49%	1,71%	0,89%	2,86%	3,30%	3,19%
Installation	0,88%	7,12%	6,12%	4,89%	5,91%	2,42%	2,85%	1,48%	3,10%	1,19%
Transport	0,02%	1,29%	12,15%	10,30%	2,08%	0,002%	0,13%	1,34%	0,67%	1,39%
Production	87,78%	87,49%	62,69%	76,37%	58,21%	16,42%	93,93%	93,94%	92,89%	93,47%

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

Impact Category	Stage	Module		Main contributor	Main contributing flows
GWP	Production	Raw Material Extraction	5.6 kg CO_2-equiv.	DINP (1.08 kg CO_2-eq.) PVC {E & S} (3.25 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	1.02 kg CO_2-equiv.	77% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, Carbon dioxide
	Installation	Installation		65% Adhesive 22% Disposal of PVC installation waste	
	Use	Use		82% Electricity 18% Detergent	Use : Inorganic emissions to air, Carbon dioxide
	EOL	EOL		Incineration and land filling of post-consumer Eternal Energy substitution from incineration	EOL : Inorganic emissions to air, Carbon dioxide
ODP	Production	Raw Material Extraction	59%	23.8% DINP 20.3% Dolomite 18.2% Fat Acid Ester	Production : Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane), Halon (1301)
		Transport of Raw materials	< 0.05%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	41%	82% Paper and cardboard packaging	
	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), Halon (1301)
	Installation	Installation		83% Disposal of PVC installation waste	
	Use	Use		10% Electricity 90% Detergent	Use : Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane)
	EOL	EOL		Incineration and land filling of post-consumer Eternal Energy substitution from incineration	EOL: Halogenated organic emissions to air, R11 (trichlorofluoromethane), R114 (Dichlorotetrafluorethane), Halon (1301)
AP	Production	Raw Material Extraction	94%	49% PVC 16% DINP 9% TiO2	Production : Inorganic emissions to air, NO_x and Sulphur dioxide, Ammonia
		Transport of Raw materials	<0.5%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	6%	52% Thermal energy 38% Paper and cardboard packaging	
	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		92% Adhesive	
	Use	Use		93% Electricity 7% Detergent	Use : Inorganic emissions to air, NO_x and Sulphur dioxide
	EOL	EOL		Incineration and land filling of post-consumer Eternal Energy substitution from incineration	EOL : Inorganic emissions to air, Hydrogen chloride, NO_x and Sulphur dioxide
EP	Production	Raw Material Extraction	93%	40% Fat Acid Ester 33% PVC	Production : Inorganic emissions to air, Ammonia, NO_x Production : Inorganic emissions to fresh water, Nitrate
		Transport of Raw materials	<0.5%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	7%	54% Thermal energy 40% Paper and cardboard packaging	
	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		94% Adhesive	

Impact Category	Stage	Module		Main contributor	Main contributing flows
	Use	Use		80% Electricity 20% Detergent	Use : Inorganic emissions to air, NO_x Use : Inorganic emissions to fresh water, Ammonium / ammonia, Nitrate
	EOL	EOL		Incineration and land filling of post-consumer Eternal Energy substitution from incineration	EOL : Inorganic emissions to air, NO_x and Ammonia
POCP	Production	Raw Material Extraction	37%	59% PVC 29% DINP	Production : Inorganic emissions to air, Carbon monoxide, NO_x , Sulphur dioxide Production : Halogenated organic emissions to air, Butane (n-butane), NMVOC (Unspecified), VOC (Unspecified)
		Transport of Raw materials	< 0.2%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	63%	99% 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 : Halogenated organic emissions to air, NMVOC (Unspecified),
	Installation	Installation		97% Adhesive	
	Use	Use		81% electricity 19% Detergent	Use : Inorganic emissions to air, Sulphur dioxide, Nitrogen dioxide
	EOL	EOL		Incineration and land filling of post-consumer Eternal Energy substitution from incineration	EOL : Inorganic emissions to air, Carbon monoxide , NO_x, Sulphur dioxide EOL : Organic emissions to air (Group VOC), NMVOC (Unspecified)
ADPe	Production	Raw Material Extraction	98%	46% PVC 29% Glass fiber 21% BaZn stearate	Production : Nonrenewable resources, Colemanite ore, Sodium chloride (Rock salt) Production : Nonrenewable elements, Lead
		Transport of Raw materials	<0,1%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	2%	81% 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		65% Adhesive 35% Disposal of PVC installation waste	
	Use	Use		57% Electricity 43% Detergent	Use : Nonrenewable resources, Sodium chloride (Rock salt) Use : Nonrenewable elements, Chromium, Copper, Gold, Lead, Molybdenum
	EOL	EOL		Incineration and land filling of post-consumer Eternal Energy substitution from incineration	EOL : Nonrenewable resources, Magnesium chloride leach (40%)
ADPf	Production	Raw Material Extraction	89%	64% PVC 25% DINP	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	11%	91% 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		81% electricity 19% Detergent	Use : Hard coal (resource), Natural gas (resource), Uranium (resource)
	EOL	EOL		Incineration and land filling of post-consumer Eternal Energy substitution from incineration	EOL : Natural gas (resource)
Eco toxicity	Production	Raw Material Extraction	98%	48% Fat Acid Ester 30% BaZn-stearate	Production : Heavy metals to industrial soil, Copper (+II), Zinc (+II) Production : Heavy metals to agricultural soil, Copper (+II), Zinc (+II) Production : Heavy metals to fresh water, Copper (+II), Zinc (+II)
		Transport of Raw materials	0.5%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	1.5%	16% Waste water treatment 68% Paper and cardboard packaging	
	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		96% Adhesive	

Impact Category	Stage	Module		Main contributor	Main contributing flows
					Transport & installation : Heavy metals to agricultural soil, Zinc (+II), Copper (+II)
	Use	Use		7% Detergent 93% Electricity	Use : Heavy metals to air, Zinc (+II) Use : Heavy metals to agricultural soil, Copper (+II), Zinc (+II)
	EOL	EOL		Incineration and land filling of post-consumer Eternal Energy substitution from incineration	EOL : Heavy metals to fresh water, Copper (+II), Cadmium (+II) EOL : Heavy metals to agricultural soil, Copper (+II), Zinc (+II)
Human toxicity, cancer	Production	Raw Material Extraction	97%	52% PVC 19% Fat Acid Ester 15% BaZn-stearate	Production : Heavy metals to industrial soil, Lead (+II), Mercury (+II) Production : Heavy metals to agricultural soil, Lead (+II), Mercury (+II) Production : Heavy metals to air, Mercury (+II) Production : Halogenated organic emissions to air, Vinyl chloride (VCM; chloroethene) Production : Heavy metals to fresh water, Chromium (+VI)
		Transport of Raw materials	< 0.2%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	3%	55% Thermal energy 30% Waste water treatment	
	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		97% adhesive	
	Use	Use		85% Electricity 15% Detergent	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 and land filling of post-consumer Eternal 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	99%	51% Fat Acid Ester 34% BaZn-stearate	Production : Heavy metals to industrial soil, Zinc (+II), Lead (+II), Mercury (+II) Production : Heavy metals to agricultural soil, Zinc (+II), Lead (+II), Mercury (+II)
		Transport of Raw materials	0.4%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	0.6%	81% Paper and cardboard packaging	
	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		97% adhesive	
	Use	Use		99% electricity	Use : Heavy metals to air, Mercury (+II), Zinc (+II) Use : Heavy metals to agricultural soil, Mercury (+II), Zinc (+II)
	EOL	EOL		Incineration and land filling of post-consumer Eternal Energy substitution from incineration	EOL : Heavy metals to agricultural soil, Lead (+II), 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 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.

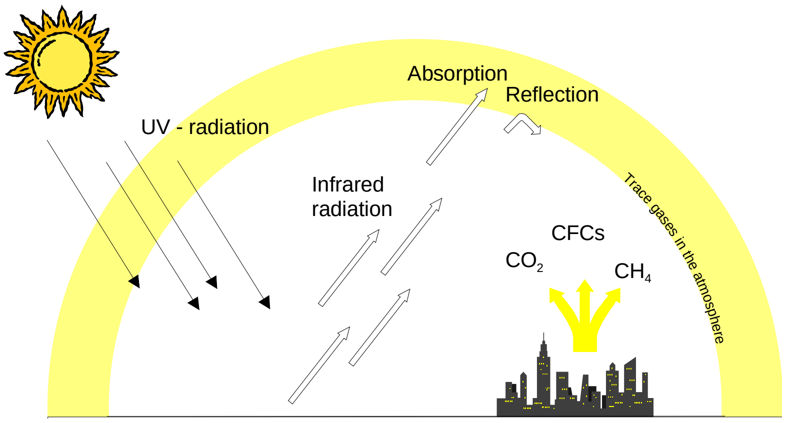


Figure A1: Greenhouse effect (KREISSIG 1999)

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.

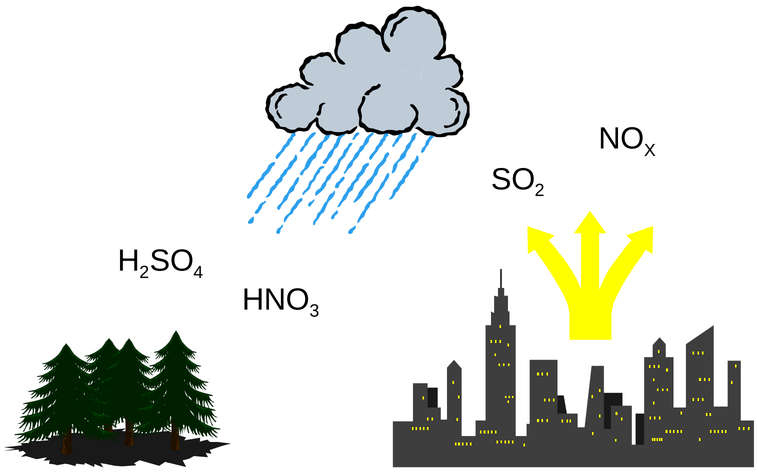


Figure A2: Acidification Potential (KREISSIG 1999)

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.

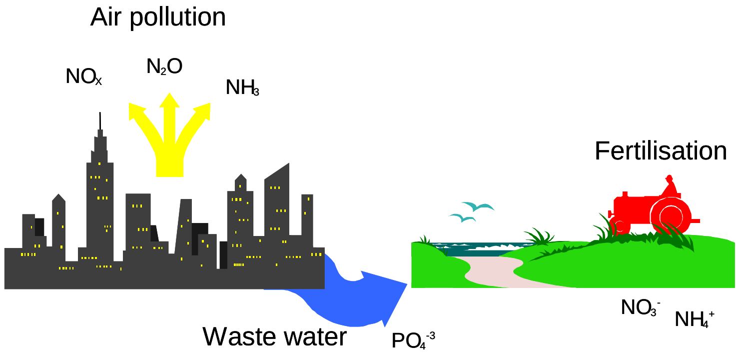


Figure A3: Eutrophication Potential (KREISSIG 1999)

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.

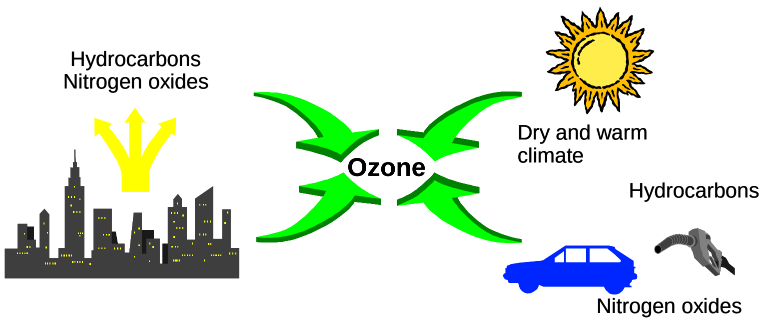


Figure A4: Photochemical Ozone Creation Potential

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.

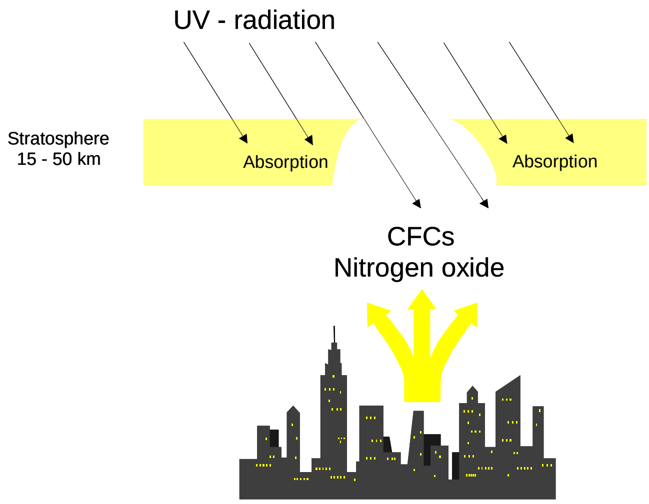


Figure A5: Ozone Depletion Potential (KREISSIG 1999)

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