ENVIRONMENTAL PRODUCT DECLARATION

MARMOLEUM 2.0 AND 2.5MM

FORBO FLOORING SYSTEMS
RESILIENT LINOLEUM FLOOR COVERING

Marmoleum

Color 3566 "Silent Sulphur"

FLOORING SYSTEMS

Marmoleum the most globally used brand of linoleum has been manufactured by Forbo for more than 150 years. Marmoleum is produced having low environmental impacts as a result of the combination of natural renewable materials and high recycle content.

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

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

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION

FLOORING SYSTEMS

Marmoleum 2.0 and 2.5 mm
Resilient Linoleum 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	12CA64879.101.1
DECLARED PRODUCT	Marmoleum 2.0 and 2.5mm Resilient Linoleum Floor Covering
REFERENCE PCR	Flooring: Carpet, Resilient, Laminate, Ceramic, and Wood (NSF 2012)

DATE OF ISSUE	November 12th, 2012
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	[signature] 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:	[signature] Trisha Montalbo, PE International

Product Definition

Product Classification and description

This declaration covers a broad range of designs and colors. Marmoleum is a resilient floor covering complying with all the requirements of EN-ISO 24011: Specification for plain and decorative linoleum. Marmoleum is made from natural raw materials making it preferable ecological floor covering with a beautiful and colorful design. The key raw materials include linseed oil, which comes from the flax plant seeds, gum rosin from pine trees, recycled wood waste of wood from controlled forests, limestone and jute from the jute plant which is used for the backing. Because of the use of natural raw materials Marmoleum is biodegradable.

Linoleum is produced by Forbo Flooring for more than 150 years and our well-known brand Marmoleum is sold worldwide. This declaration refers to Marmoleum sheet of 2.0 and 2.5 mm nominal thickness.

Marmoleum is build up in 3 layers as illustrated in the figure 1.These three layers form one homogeneous product by the cross linking bondings formed during the oxidative curing process :

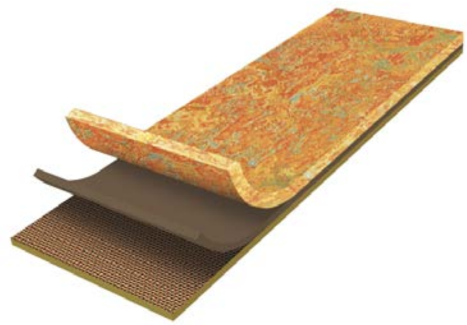
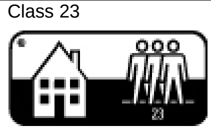
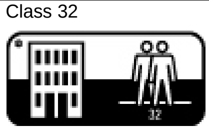
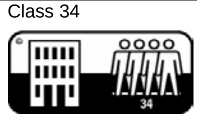
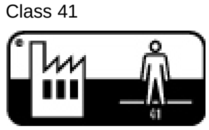
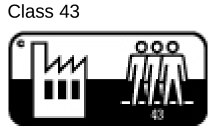


Figure 1: Illustration of Marmoleum

1. **Surface layer:** This layer gives Marmoleum its design and color. After finishing the product at the trimming department a factory finish is applied to protect the surface layer.
2. **Intermediate layer:** This layer is calendared on the jute.
3. **Backing:** The backing is woven jute.

Range of application

Marmoleum is classified in accordance with EN-ISO 24011 to be installed in the following use areas defined in EN–ISO 10874:

Area of application	2.0 mm thickness	2.5 mm thickness
Domestic	Class 23 	Class 23 
Commercial	Class 32 	Class 34 
Industrial	Class 41 	Class 43 

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Product Standard

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

- Meets or exceeds all technical requirements in ASTM F 2034 Standard Specification for Linoleum Sheet Flooring.
- Meets or exceeds all technical requirements in EN-ISO 24011 Specification for plain and decorative Linoleum.

CE

Marmoleum meets the requirements of EN 14041

EN 13501-1	Reaction to fire	C_{fl} - s1
EN 13893	Slip resistance	DS: ≥ 0.30
EN 1815	Body voltage	< 2 kV
EN 12524	Thermal conductivity	0.17 W/mK

Fire Testing:

- Class 1 when tested in accordance with ASTM E 648/NFPA 253, Standard Test Method for Critical Radiant Flux.
- Meets 450 or less when tested in accordance with ASTM E 662/NFPA 258, Standard Test Method for Smoke Density.
- Class C when tested in accordance to ASTM E 84/NFPA 255, Standard Test Method for Surface Burning Characteristics.
- FSC1-150; SD-160 when tested in accordance to CAN/ULC S102.2, Standard Test Method for Flame Spread Rating and Smoke Development.
- Compliant with CHPS 01350 requirements for VOC emissions and indoor air quality.

Accreditation

- ISO 9001 Quality Management System
- ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems
- SMART
- SWAN
- Nature Plus
- Good Environmental Choice Australia

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Delivery Status

Table 1: Specification of delivered product

Characteristics	Nominal Value	Unit
Product thickness	2.5 2.0	mm mm
Product Weight 2.5 mm 2.0 mm	 3000 2400	 g/m^2
Rolls Width Length	2.00 < 32	meter

Material Content

Material Content of the Product

Table 2: Composition of Marmoleum

Component	Material	Availability	Amount [%]	Origin
Binder	Linseed oil Gum rosin Tall oil	Bio based crop Bio based crop Bio based waste product from paper Industry	19 2 11	USA/Canada/Europe Indonesia/China USA
Filler	Wood flour Calcium carbonate Reused Marmoleum	Bio based waste product from wood processing Abundant mineral	22 24 10	Germany Germany Internal
Pigment	Titanium dioxide Various other pigments	Limited mineral Limited mineral	2 1	Global Global
Backing	Jute	Bio based crop	8	India/Bangladesh
Finish	Lacquer		1	Netherlands

Production of Main Materials

Linseed oil : Linseed oil is obtained by pressing the seeds of the flax plant. After filtering a clear golden yellow liquid remains.
Gum rosin : Rosin is obtained by wounding pine trees. The crude gum is collected and is separated into turpentine and rosin by distillation.
Tall oil : Tall oil is a post industrial waste product coming from the paper industry and is consisting of vegetable oil and rosin.
Wood flour : Postindustrial bio based soft wood waste from the wood industry, which is milled into flour.
Calcium carbonate : An abundant mineral found in all parts of the world as the chief substance in rocks (i.e., marble and limestone). It can be ground to varying particle sizes and is widely used as filler.
Reused Marmoleum : Waste material coming from the Marmoleum production which is reused.
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 other pigments : The vast majority of the used color pigments are iron oxide based.
Jute : Jute fiber is extracted from the stem of the jute plant by floating it in water. For yarn production fiber bands are obtained by carding, stretching, spinning, warping and sizing. Finally the yarn is woven.

Lacquer : The factory applied lacquer – Topshield 2 – is a waterborne UV cured double layer factory coating – acrylate hybrid dispersion.

Production of the Floor Covering

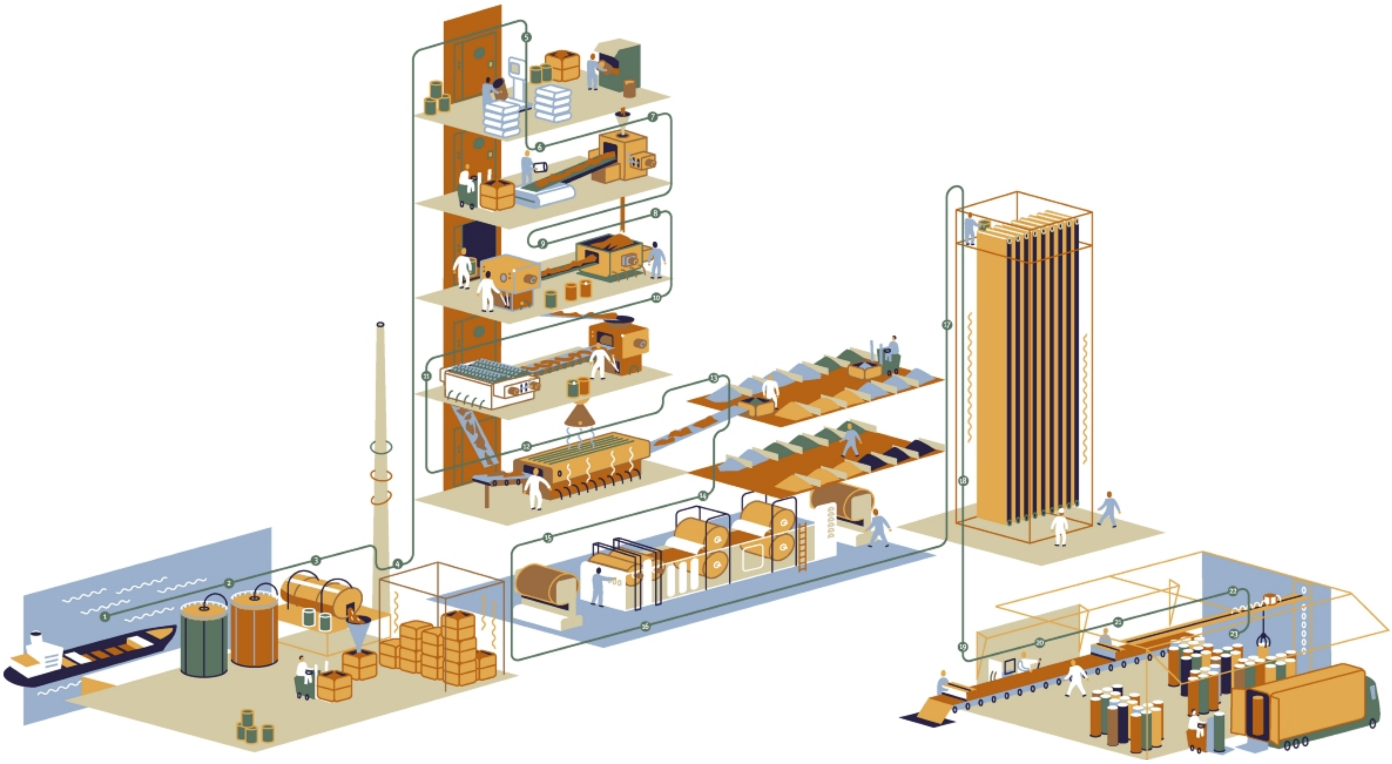

Figure 2: Illustration of the Production process

Marmoleum is produced in several stages starting with the oxidation of linseed oil mixed with tall oil and rosin. With the influence of oxygen from the atmosphere a tough sticky material is obtained called linoleum cement. The linoleum cement is stored in containers for a few days for further reaction and after this it is mixed with wood flour, calcium carbonate, reused waste (if applicable), titanium dioxide and pigments. This mixture is calendared on a jute substrate and stored in drying rooms, to cure till the required hardness is reached. After approximately 14 days the material is taken out from the drying room to the trimming department where the factory finish is applied on the surface of the product and the end inspection is done. Finally the edges are trimmed and the sheet is cut to length into rolls of approximately 32 meter. The trimmings and the rejected product are reused.

Health, Safety and Environmental Aspects during Production

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

Production Waste

Rejected material and the cuttings of the trimming stage are being reused in the manufacturing process. Packaging materials are being 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 Marmoleum is transported as follows:

- Transport distance 40 t truck — 694 km
- Transport distance 7.5t truck (Fine distribution) — 257 km
- Capacity utilization trucks (including empty runs) — 85 %
- Transport distance Ocean ship — 4916 km
- Capacity utilization Ocean ship — 48%

Installation

Because of the specific techniques used during the installation of Marmoleum 6% of the material is cut off as installation waste. For installation of Marmoleum on the floor a worst case scenario has been modeled (assuming 0.435 kg/m^2 of adhesive is required). In practice this amount will almost always be lower. Waste during the installation process may be recycled as floor covering through the manufacturers' facilities or thermally recycled in a waste incineration plant. Since the major part of Marmoleum is sold in Europe the European electricity grid mix is used in the calculations for the energy recovery during incineration.

Health, Safety and Environmental Aspects during Installation

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

Waste

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

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.

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

Marmoleum is complying with:

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

End of Life

The deconstruction of installed Marmoleum 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.
For the end of life stage no landfilling is taken into account, since the vast majority of the countries in which Marmoleum is sold are having a non landfill policy. Because of the high calorific value of Marmoleum the incineration is very profitable as a waste to energy conversion.

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

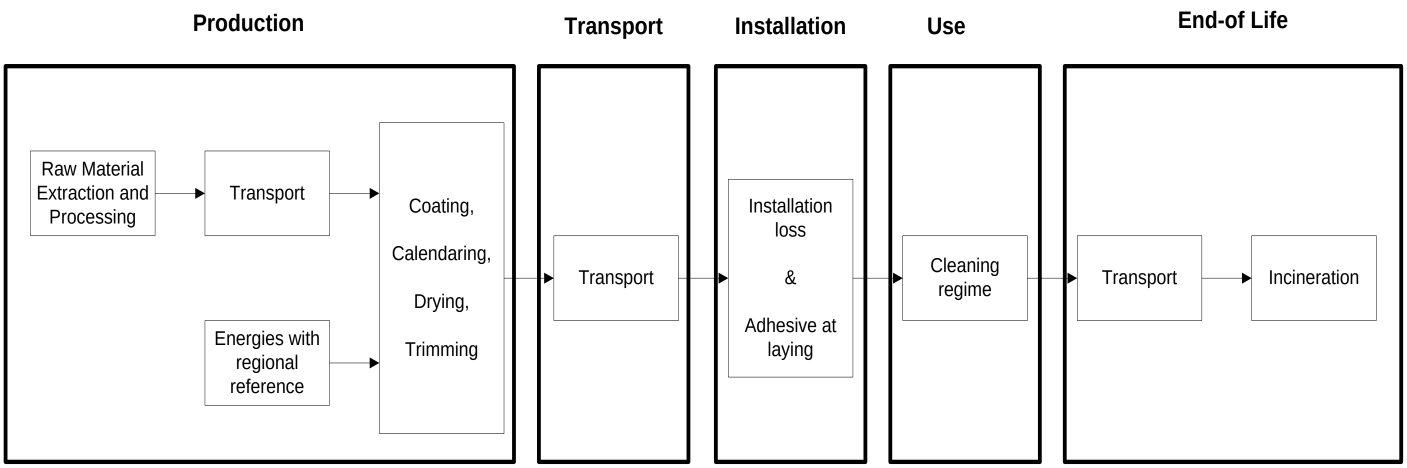

Figure 3: Flow chart of the Life Cycle Assessment

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.

The LCA dataset used to model the incineration of Marmoleum is based on data developed by European Resilient Flooring Manufacturers' Institute (ERFMI) and is specific to linoleum flooring products. This indicates that 250 kWh/tonne electricity and 9744 MJ/tonne thermal energy is recovered during incineration. This model is part of the ERFMI 2008 LCA study on resilient floorings; critical reviewed by Dr ir Jeroen Guinée (Institute of Environmental Sciences CML) /ERFMI 2008/.

Description of the allocation processes in the LCA report

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

LCA Data

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

For life cycle modeling of the considered products, the GaBi 5 Software System for Life Cycle Engineering, developed by PE INTERNATIONAL AG has been used. All relevant LCA datasets are taken from the GaBi 5 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 2011). 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 5 Software System for Life Cycle Engineering, developed by PE INTERNATIONAL AG, is used. All relevant LCA datasets are taken from the GaBi 5 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 Assendelft, the Netherlands. The GaBi 5 Hydropower dataset has therefore been used (reference year 2008). 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 Marmoleum 2.0 mm and 2.5 mm are presented in table 3 and 4 with their specific energy resources.

Table 3: Primary energy for all life cycle stages for Marmoleum 2.0 mm for one year

Non-renewable primary energy by resources	Unit	Total Life cycle	Production	Transport	Installation	Use (1 yr)	End of Life
Total non-renewable primary energy	MJ	55,91	53,23	3,95	15,91	6,12	-23,3
Crude oil	MJ	28,7	16,98	3,58	6,88	0,72	0,54
Hard coal	MJ	6,43	5,9	0,03	0,33	1,09	-0,91
Lignite	MJ	2,45	1,95	0,01	0,38	0,68	-0,57
Natural gas	MJ	15,01	25,59	0,29	8,09	1,89	-20,85
Uranium	MJ	3,3	2,81	0,04	0,24	1,72	-1,5

Renewable primary energy by resources	Unit	Total Life cycle	Production	Transport	Installation	Use (1 yr)	End of Life
Total renewable primary energy	MJ	57,61	57,24	0,08	0,2	0,71	-0,62
Geothermical	MJ	0,02	0,02	0	0	0,02	-0,02
Hydro power	MJ	9,69	9,66	0,01	0	0,31	-0,29
Solar energy	MJ	47,24	47,02	0,07	0,11	0,18	-0,14
Wind power	MJ	0,59	0,48	0	0,09	0,2	-0,18

Table 4: Primary energy for all life cycle stages for Marmoleum 2.5 mm for one year

Non-renewable primary energy by resources	Unit	Total Life cycle	Production	Transport	Installation	Use (1 yr)	End of Life
Total non-renewable primary energy	MJ	59,78	62,37	4,91	15,53	6,12	-29,15
Crude oil	MJ	33,85	21,12	4,45	6,89	0,72	0,68
Hard coal	MJ	7,62	7,34	0,03	0,31	1,09	-1,15
Lignite	MJ	2,76	2,42	0,02	0,37	0,68	-0,72
Natural gas	MJ	12	28,02	0,37	7,76	1,89	-26,05
Uranium	MJ	3,55	3,47	0,05	0,21	1,72	-1,9
Renewable primary energy by resources	**Unit**	**Total Life cycle**	**Production**	**Transport**	**Installation**	**Use (1 yr)**	**End of Life**
Total renewable primary energy	MJ	69,39	69,18	0,1	0,19	0,71	-0,78
Geothermical	MJ	0,02	0,02	0	0	0,02	-0,02
Hydro power	MJ	9,74	9,78	0,01	0	0,31	-0,36
Solar energy	MJ	58,9	58,7	0,08	0,11	0,18	-0,17
Wind power	MJ	0,66	0,6	0,01	0,09	0,2	-0,23

The renewable primary energy is mainly determined by the raw materials from renewable resources (linseed oil, jute hessian, tall oil).

The non-renewable primary energy is mainly determined by the production stage for a one year usage; within the production stage the main contributors are the raw material production and energy generation. Installation is also a significant contributor due to the use of adhesive. Energy substitution in the End of Life stage results to a credit in the total non-renewable primary energy.

Due to the fact that Forbo Flooring B.V. is producing with 100% renewable electricity the total amount of primary energy is reduced by approximately 6% for the total lifecycle for a one year usage.

Waste and non-renewable resource consumption

In the tables 5 and 6 the non-renewable resource consumption and waste production are shown for all life cycle stages for a one year usage.

Table 5: Waste categories and non-renewable resources for Marmoleum 2.0 mm (one year)

Wastes	Unit	Total Life cycle	Production	Transport	Installation	Use (1yr)	End of Life
Hazardous waste	[kg]	0	0	0	0	0	0
Non-hazardous waste	[kg]	5,20	4,47	0,03	0,76	1,11	-1,17
Radioactive waste	[kg]	1,31E-03	1,12E-03	1,49E-05	2,46E-04	7,03E-04	-7,73E-04
Resources	**Unit**	**Total Life cycle**	**Production**	**Transport**	**Installation**	**Use (1yr)**	**End of Life**
Non-renewable resources	[kg]	6,89	6,01	0,03	0,66	1,12	-0,93

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Table 6: Waste categories and non-renewable resources for Marmoleum 2.5 mm (one year)

	Unit	Total Life cycle	Production	Transport	Installation	Use (1yr)	End of Life
Hazardous waste	[kg]	0	0	0	0	0	0
Non-hazardous waste	[kg]	6,01	5,53	0,03	0,76	1,11	-1,43
Radioactive waste	[kg]	1,41E-03	1,39E-03	1,85E-05	2,46E-04	7,03E-04	-9,46E-04
Resources	**Unit**	**Total Life cycle**	**Production**	**Transport**	**Installation**	**Use (1yr)**	**End of Life**
Non-renewable resources	[kg]	8,07	7,45	0,03	0,65	1,12	-1,18

Life Cycle Assessment

In table 7 the environmental impacts for one lifecycle are presented for Marmoleum 2.0 and 2.5 mm. In the tables 8 and 9 the environmental impacts are presented for all the lifecycle stages.

Table 7: Results of the LCA – Environmental impacts one lifecycle (one year) – Marmoleum 2.0 mm & 2.5 mm

Impact Category : CML 2001 – Nov. 2010	Marmoleum 2.0 mm	Marmoleum 2.5 mm	Unit
Global Warming Potential (GWP 100 years)	5.45	6.16	kg CO2-Equiv.
Ozone Layer Depletion Potential (ODP. steady state)	2.59E-08	2.63E-08	kg R11-Equiv.
Acidification Potential (AP)	3.93E-02	4.81E-02	kg SO2-Equiv.
Eutrophication Potential (EP)	9.29E-03	1.15E-02	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	1.82E-03	2.12E-03	kg Ethene-Equiv.
Abiotic Depletion Potential Elements (ADPE)	2.87E-06	3.34E-06	kg Sb-Equiv.
Abiotic Depletion Potential Fossil (ADPF)	52.19	55.74	[MJ]

Table 8: Results of the LCA – Environmental impact for Marmoleum 2.5 mm (one year)

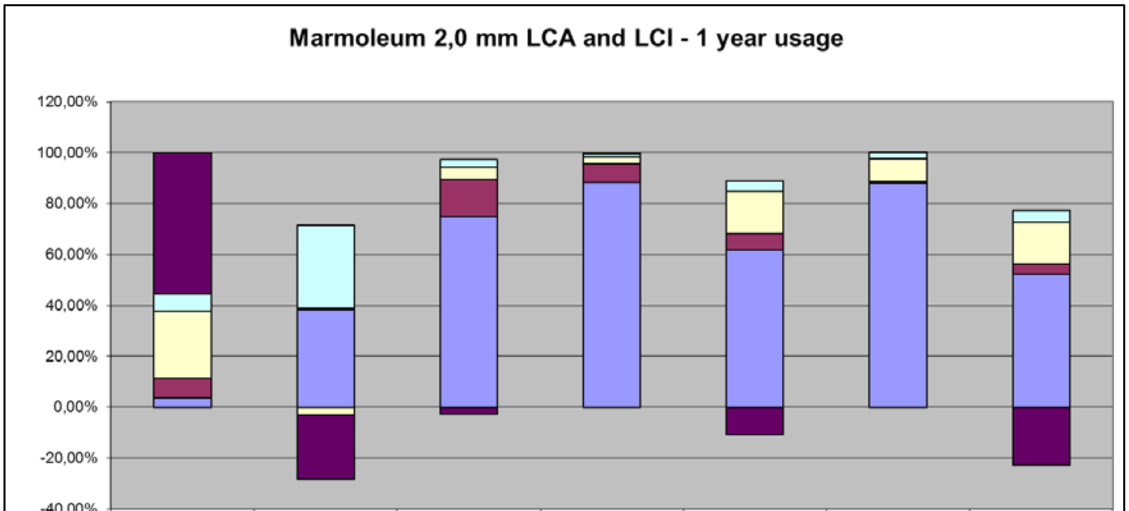
Impact Category : CML 2001 – Nov. 2010	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Global Warming Potential	kg CO2-Equiv.	0.022	0.51	1.48	0.36	3.78
Ozone Layer Depletion Potential	kg R11-Equiv.	2.75E-08	4.43E-10	-2.16E-09	1.97E-08	-1.92E-08
Acidification Potential	kg SO2-Equiv.	3.88E-02	7.54E-03	1.90E-03	1.29E-03	-1.44E-03
Eutrophication Potential	kg PSO4-Equiv.	1.02E-02	8.44E-04	2.53E-04	1.08E-04	6.65E-05
Photochem. Ozone Creation Potential	kg Ethene-Equiv.	1.77E-03	1.87E-04	3.85E-04	9.51E-05	-3.21E-04
Abiotic Depletion Elements	kg Sb-Equiv.	2.99E-06	1.24E-08	2.66E-07	5.90E-08	6.32E-09
Abiotic Depletion Fossil	MJ	58.70	4.86	15.29	4.35	-27.46

Table 9: Results of the LCA – Environmental impact for Marmoleum 2.0 mm (one year)

Impact Category : CML 2001 – Nov. 2010	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Global Warming Potential	kg CO2-Equiv.	0.20	0.41	1.44	0.36	3.03
Ozone Layer Depletion Potential	kg R11-Equiv.	2.30E-08	3.56E-10	-1.91E-09	1.97E-08	-1.52E-08
Acidification Potential	kg SO2-Equiv.	3.12E-02	6.06E-03	1.92E-03	1.29E-03	-1.14E-03
Eutrophication Potential	kg PSO4-Equiv.	8.20E-03	6.78E-04	2.52E-04	1.08E-04	5.41E-05
Photochem. Ozone Creation Potential	kg Ethene-Equiv.	1.44E-03	1.50E-04	3.89E-04	9.51E-05	-2.56E-04
Abiotic Depletion Elements	kg Sb-Equiv.	2.53E-06	9.99E-09	2.66E-07	5.90E-08	5.30E-09
Abiotic Depletion Fossil	MJ	50.26	3.91	15.64	4.35	-21.96

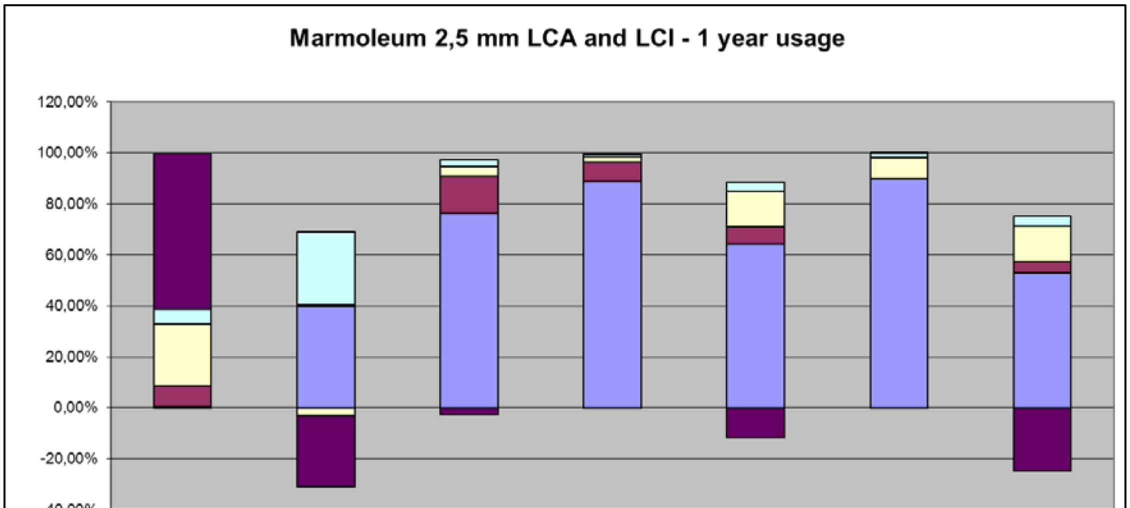
The relative contribution of each process stage to each impact category for Marmoleum 2.0 mm and 2.5 mm is shown in the figures 4 and 5.

Figure 4: relative contribution of each process stage to each impact category for Marmoleum 2.0 mm for a one year usage.



	Global Warming Potential	Ozone Layer Depletion Potential	Acidification Potential	Eutrophication Potential	Photochem. Ozone Creation Potential	Abiotic Depletion (Elements)	Abiotic Depletion (Fossil)
End of Life	55,68%	-25,28%	-2,74%	0,58%	-11,01%	0,18%	-22,85%
Use	6,66%	32,70%	3,11%	1,16%	4,09%	2,06%	4,52%
Installation	26,38%	-3,17%	4,61%	2,71%	16,72%	9,28%	16,27%
Transport	7,56%	0,59%	14,57%	7,30%	6,45%	0,35%	4,07%
Production	3,72%	38,26%	74,97%	88,25%	61,74%	88,13%	52,29%

Figure 5: relative contribution of each process stage to each impact category for Marmoleum 2.5 mm for a one year usage.



	Global Warming Potential	Ozone Layer Depletion Potential	Acidification Potential	Eutrophication Potential	Photochem. Ozone Creation Potential	Abiotic Depletion (Elements)	Abiotic Depletion (Fossil)
End of Life	61,35%	-27,84%	-2,82%	0,58%	-11,62%	0,19%	-24,81%
Use	5,89%	28,49%	2,54%	0,94%	3,44%	1,77%	3,93%
Installation	24,08%	-3,13%	3,72%	2,20%	13,94%	7,98%	13,82%
Transport	8,31%	0,64%	14,79%	7,35%	6,76%	0,37%	4,40%
Production	0,36%	39,90%	76,13%	88,93%	64,23%	89,69%	53,05%

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 impact categories (AP, EP, POCP, ADPE, ADPF) the production stage has the main contribution to the overall impact. For these categories the main contributor in the production stage is the Raw material supply with a share of 65-92% of total impacts from the production stage.

For GWP, POCP, and ADPF the adhesive for the flooring installation has a significant impact. The LCA for the installation is based on a conservative assumption of 435g/m² adhesive. In practice this amount will almost always be lower.

Forbo declares in the EPD a worldwide distribution by truck (951km) and container ship (4916 km). For this scenario the transport has a relevance of 7%-16% in the impact categories GWP, AP, EP, POCP and ADPF.

The LCA profile for the results of ODP is different. After the production stage (89-105%) the use stage accounts for the main contribution to ODP (76%). For the production stage the raw materials are responsible for most of the impact (78-82%) while for the use stage the contribution is mainly due to the consumption of electricity (EU power grid mix) for cleaning. The third main impact on ODP comes from the End Of Life stage.

The LCA for GWP reflects the use of renewable raw materials for the production of Marmoleum (linseed oil and jute). Carbon dioxide, a greenhouse gas, is locked in from the atmosphere in the course of the plant growth via photosynthesis and stored during the use stage. This carbon dioxide is not released until the end of life when it is incinerated with energy recovery – this process accounts for the greatest emission of greenhouse gases in the life cycle of the product.

Energy recovery from incineration and the respective energy substitution at the end of life results in a credit for all impact categories as reported in the End of Life stage.

Additional Environmental Information

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

Toxicity

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

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

- o Level I (recommended and satisfactory),
- o level II (recommended but in need of some improvements)

- o level III (recommended, but to be applied with caution).

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

Table 10: Results of the LCA – Environmental impacts one lifecycle (one year) – Marmoleum 2.0 mm & 2.5 mm

Impact Category : USEtox	Marmoleum 2.0 mm	Marmoleum 2.5 mm	Unit
Ecotoxicity	7.29E-01	8.84E-01	PAF m3.day
Human toxicity, cancer	3.37E-09	3.96E-09	Cases
Human toxicity, non-canc.	5.86E-07	7.14E-07	Cases

In the following two tables the impacts are subdivided into the lifecycle stages.

Table 11: Results of the LCA – Environmental impact for Marmoleum 2.5 mm (one year)

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Ecotoxicity	PAF m3.day	7.43E-01	4.67E-02	6.57E-02	1.94E-02	9.12E-03
Human toxicity, cancer	cases	3.05E-09	1.45E-10	5.05E-10	3.60E-10	-9.79E-11
Human toxicity, non-canc.	cases	5.96E-07	3.36E-08	5.28E-08	1.26E-08	1.89E-08

Table 12: Results of the LCA – Environmental impact for Marmoleum 2.0 mm

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Ecotoxicity	PAF m3.day	6.00E-01	3.75E-02	6.56E-02	1.94E-02	7.39E-03
Human toxicity, cancer	cases	2.46E-09	1.17E-10	5.07E-10	3.60E-10	-7.76E-11
Human toxicity, non-canc.	cases	4.78E-07	2.70E-08	5.26E-08	1.26E-08	1.532E-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.

The Eco-toxicity is predominated by the production stage in which the raw materials are having a big impact with a share of around 93%. The main contributors in the manufacturing are the thermal energy and the packaging of the end product. Other contributors are the transport to the customer and the adhesive used for installing the floor.

In the Human toxicity (cancer) the largest contribution is coming from the production stage where the raw material extraction is contributing 91% to the total impact. Other significant contributions come from the Installation (Adhesive) and Use stage (Waste water treatment and electricity).

Also for Human toxicity (non-canc.) by far the biggest impact is coming from the production stage, where the contribution of the raw material extraction (91-92%) is predominating this life cycle stage. A small but significant contribution to the total impact is coming from the transport to the customer and installation stage.

FLOORING SYSTEMS

Marmoleum 2.0 and 2.5 mm
Resilient Linoleum Floor Covering

According to ISO 14025 & EN 15804

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 13: Results of the LCA – Environmental impact for Marmoleum 2.5 mm (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
GWP	[kg CO_2-Eq.]	0.02	0.51	1.26	0.36	0.01	0.09	6.25	-2.34
ODP	[kg CFC11-Eq.]	2.75E-08	4.43E-10	1.96E-09	1.97E-08	9.57E-10	4.69E-12	2.08E-09	-2.64E-08
AP	[kg SO_2-Eq.]	3.88E-02	7.54E-03	2.28E-03	1.29E-03	6.25E-05	3.50E-04	8.28E-04	-3.06E-03
EP	[kg PO_4^{3-}- Eq.]	1.02E-02	8.44E-04	2.68E-04	1.08E-04	3.35E-06	8.36E-05	2.57E-04	-2.92E-04
POCP	[kg Ethen Eq.]	1.77E-03	1.87E-04	4.40E-04	9.51E-05	3.80E-06	-1.21E-04	1.09E-04	-3.68E-04
ADPE	[kg Sb Eq.]	2.99E-06	1.24E-08	2.73E-07	5.90E-08	1.20E-09	3.99E-09	9.86E-08	-1.04E-07
ADPF	[MJ]	58.70	4.86	20.50	4.35	0.17	1.20	2.24	-36.20
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 – Environmental impact for Marmoleum 2.0 mm (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
GWP	[kg CO_2-Eq.]	0.20	0.41	1.18	0.36	0.01	0.07	5.12	-1.92
ODP	[kg CFC11-Eq.]	2.30E-08	3.56E-10	1.94E-09	1.97E-08	9.57E-10	3.82E-12	1.71E-09	-2.17E-08
AP	[kg SO_2-Eq.]	3.12E-02	6.06E-03	2.26E-03	1.29E-03	6.25E-05	2.85E-04	6.78E-04	-2.51E-03
EP	[kg PO_4^{3-}- Eq.]	8.20E-03	6.78E-04	2.64E-04	1.08E-04	3.35E-06	6.82E-05	2.10E-04	-2.40E-04
POCP	[kg Ethen Eq.]	1.44E-03	1.50E-04	4.40E-04	9.51E-05	3.80E-06	-9.84E-05	8.95E-05	-3.02E-04
ADPE	[kg Sb Eq.]	2.53E-06	9.99E-09	2.72E-07	5.90E-08	1.20E-09	3.25E-09	8.08E-08	-8.54E-08
ADPF	[MJ]	50.30	3.91	20.40	4.35	0.17	0.98	1.83	-29.70
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 15: Results of the LCA – Resource use for Marmoleum 2.5 mm (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
PERE	[MJ]	30.13	-	-	-	-	-	-	-
PERM	[MJ]	39.07	-	-	-	-	-	-	-
PERT	[MJ]	69.20	0.10	0.36	0.71	0.04	0.05	0.01	-1.04
PENRE	[MJ]	45.65	-	-	-	-	-	-	-
PENRM	[MJ]	16.75	-	-	-	-	-	-	-
PENRT	[MJ]	62.40	4.91	21.10	6.12	0.26	1.21	2.54	-38.70
SM	[kg]	0.81	-	-	-	-	-	-	-
RSF	[MJ]	2.64E-03	3.39E-05	2.74E-04	3.40E-04	3.41E-06	1.02E-05	0.00E+00	-3.78E-04
NRSF	[MJ]	2.68E-02	3.56E-04	2.86E-03	3.56E-03	3.57E-05	1.07E-04	0.00E+00	-3.96E-03
FW	[kg]	4.93E+01	1.44E-01	3.79E+00	2.29E+00	1.14E-01	6.73E-02	-3.01E-02	-3.60E+00
PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of 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 16: Results of the LCA – Resource use for Marmoleum 2.0 mm (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
PERE	[MJ]	25.90	-	-	-	-	-	-	-
PERM	[MJ]	31.30	-	-	-	-	-	-	-
PERT	[MJ]	57.20	0.0775	0.355	0.706	0.0374	0.0391	0.00759	-0.854
PENRE	[MJ]	39.79	-	-	-	-	-	-	-
PENRM	[MJ]	13.41	-	-	-	-	-	-	-
PENRT	[MJ]	53.20	3.95	21	6.12	0.256	0.983	2.08	-31.7
SM	[kg]	0.65	-	-	-	-	-	-	-
RSF	[MJ]	2.39E-03	2.72E-05	2.74E-04	3.40E-04	3.41E-06	8.31E-06	0.00E+00	-3.10E-04
NRSF	[MJ]	2.43E-02	2.86E-04	2.86E-03	3.56E-03	3.57E-05	8.72E-05	0.00E+00	-3.25E-03
FW	[kg]	4.13E+01	1.01E-01	3.79E+00	2.29E+00	1.14E-01	5.49E-02	-2.47E-02	-2.96E+00

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of 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 17: Results of the LCA – Output flows and Waste categories for Marmoleum 2.5 mm (one year)

		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits			
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
HWD	[kg]	0	0	0	0	0	0	0	0
NHWD	[kg]	5.53	0.0315	0.763	1.11	0.0548	0.00637	0.0426	-1.53
RWD	[kg]	0.00139	0.0000185	0.000246	0.000703	0.0000366	0.0000017	0.0000253	-0.00101
CRU	[kg]	-	-	-	-	-	-	-	0
MFR	[kg]	-	-	-	-	-	-	-	0
MER	[kg]	-	-	-	-	-	-	-	3.30
EE Power	[MJ]	-	-	0.17	-	-	-	2.97	-
EE Thermal energy	[MJ]	-	-	1.87	-	-	-	32.20	-

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

Table 18: Results of the LCA – Output flows and Waste categories for Marmoleum 2.0 mm (one year)

		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits			
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
HWD	[kg]	0	0	0	0	0	0	0	0
NHWD	[kg]	4.47	0.0253	0.762	1.11	0.0548	0.00519	0.0349	-1.26
RWD	[kg]	0.00112	0.0000149	0.000246	0.000703	0.0000366	0.00000139	0.0000208	-0.000832
CRU	[kg]	-	-	-	-	-	-	-	0
MFR	[kg]	-	-	-	-	-	-	-	0
MER	[kg]	-	-	-	-	-	-	-	2.71
EE Power	[MJ]	-	-	0.138	-	-	-	2.44	-
EE Thermal energy	[MJ]	-	-	1.5	-	-	-	26.4	-

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 are similar to the interpretation on pages 14. A more detailed interpretation is published in the appendix.

References

GABI 5 2012	PE INTERNATIONAL AG; GaBi 5: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2012.
GABI 5 2012D	GaBi 5: Documentation of GaBi 5: 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 Ecodesign 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 harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC
EN-ISO 10874	Resilient, textile and laminate floor coverings - Classification

Life Cycle Assessment

Marmoleum 2.0 and 2.5 mm

FLOORING SYSTEMS

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

August 2012

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Nomenclature

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

General

The present LCA study of the company Forbo Flooring, a manufacturer of resilient floor coverings, has been performed by Forbo Flooring under support of PE International and has been conducted according to the requirements of the European Standard EN15804 following the document “Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Background Report”. The LCA report was sent to verification on 10/17/12

Scope

This document is the LCA report for the “Environmental Product Declaration” (EPD) of "Marmoleum 2.0 & 2.5 mm".
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 Marmoleum complying with EN-ISO 24011 in two different thicknesses:

- Marmoleum 2.5 mm
- Marmoleum 2.0 mm

Manufactured by
Forbo Flooring BV
Industrieweg 12
1566JP Assendelft
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.
These products are also known under the following brand names:

- Marmoleum
- Artoleum
- Striato
- Walton

They are produced at the following manufacturing site:
Forbo Flooring BV
Industrieweg 12
1566JP Assendelft
The Netherlands

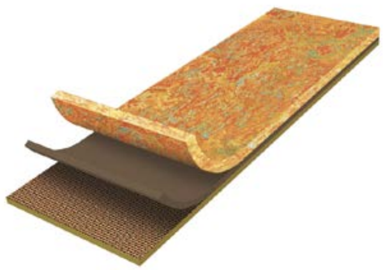
Product Definition

Product Classification and description

This declaration covers a broad range of designs and colors. Marmoleum is a resilient floor covering complying with all the requirements of EN-ISO 24011: Specification for plain and decorative linoleum. Marmoleum is made from natural raw materials making it preferable ecological floor covering with a beautiful and colorful design. The key raw materials include linseed oil, which comes from the flax plant seeds, gum rosin from pine trees, recycled wood waste of wood from controlled forests, limestone and jute from the jute plant which is used for the backing. Because of the use of natural raw materials Marmoleum is biodegradable.

Linoleum is produced by Forbo Flooring for more than 150 years and our well known brand Marmoleum is sold worldwide. This declaration refers to Marmoleum sheet of 2.0 and 2.5 mm nominal thickness.

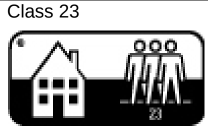
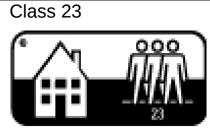
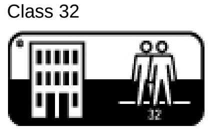
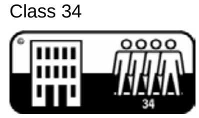
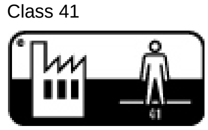
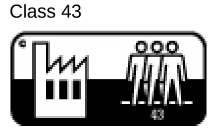
Marmoleum is build up in 3 layers as illustrated in the figure 1.These three layers form one homogeneous product by the cross linking bondings formed during the oxidative curing process :



1. **Surface layer:** This layer gives Marmoleum its design and color. After finishing the product at the trimming department a factory finish is applied to protect the surface layer.
2. **Intermediate layer:** This layer is calendared on the jute.
3. **Backing:** The backing is woven jute.

Range of application

Marmoleum is classified in accordance with EN-ISO 24011 to be installed in the following use areas defined in EN–ISO 10874:

Area of application	2.0 mm thickness	2.5 mm thickness
Domestic	Class 23 	Class 23 
Commercial	Class 32 	Class 34 
Industrial	Class 41 	Class 43 

Product Standard

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

- Meets or exceeds all technical requirements as set forth in ASTM F 2034 Standard Specification for Linoleum Sheet Flooring.
- Compliant with CHPS 01350 requirements for VOC emissions and indoor air quality.
- Meets or exceeds all technical requirements as set in EN-ISO 24011 Specification for plain and decorative Linoleum.

CE

Marmoleum meets the requirements of EN 14041

EN 13501-1	Reaction to fire	C_{fl} - s1
EN 13893	Slip resistance	DS: ≥ 0.30
EN 1815	Body voltage	< 2 kV
EN 12524	Thermal conductivity	0.17 W/mK

Fire Testing:

- Class 1 when tested in accordance with ASTM E 648/NFPA 253, Standard Test Method for Critical Radiant Flux.
- Meets 450 or less when tested in accordance with ASTM E 662/NFPA 258, Standard Test Method for Smoke Density.
- Class C when tested in accordance to ASTM E 84/NFPA 255, Standard Test Method for Surface Burning Characteristics.
- FSC1-150; SD-160 when tested in accordance to CAN/ULC S102.2, Standard Test Method for Flame Spread Rating and Smoke Development.

Accreditation

- ISO 9001 Quality Management System and ISO 14001 Environmental Management System
- OHSAS 18001 Occupational Health and Safety Management Systems
- SMART
- SWAN
- Nature Plus
- Good Environmental Choice Australia

Delivery status

Characteristics	Nominal Value	Unit
Product thickness	2.5 2.0	mm mm
Product Weight 2.5 mm 2.0 mm	 3000 2400	g/m^2
Rolls Width Length	2.00 < 32	meter

Material Content

Component	Material	Availability	Amount [%]	Origin
Binder	Linseed oil Gum rosin Tall oil	Bio based crop Bio based crop Bio based waste product from paper Industry	19 2 11	USA/Canada/Europe Indonesia/China USA
Filler	Wood flour Calcium carbonate Reused Marmoleum	Bio based waste product from wood processing Abundant mineral	22 24 10	Germany Germany Internal
Pigment	Titanium dioxide Various other pigments	Limited mineral Limited mineral	2 1	Global Global
Backing	Jute	Bio based crop	8	India/Bangladesh
Finish	Lacquer	Fossil limited	1	Netherlands

Production of Main Materials

- **Linseed oil** : Linseed oil is obtained by pressing the seeds of the flax plant. After filtering a clear golden yellow liquid remains.
- **Gum rosin** : Rosin is obtained by wounding pine trees. The crude gum is collected and is separated into turpentine and rosin by distillation.
- **Tall oil** : Tall oil is a post industrial waste product coming from the paper industry and is consisting of vegetable oil and rosin.
- **Wood flour** : Post industrial bio based soft wood waste from the wood industry, which is milled into flour.
- **Calcium carbonate** : An abundant mineral found in all parts of the world as the chief substance in rocks (i.e., marble and limestone). It can be ground to varying particle sizes and is widely used as filler.
- **Reused Marmoleum** : Waste material coming from the Marmoleum production which is reused.
- **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 other pigments** : The vast majority of the used colour pigments are iron oxide based.
- **Jute** : Jute fibre is extracted from the stem of the jute plant by floating it in water. For yarn production fibre bands are obtained by carding, stretching, spinning, warping and sizing. Finally the yarn is woven.
- **Lacquer** : The factory applied lacquer – Topshield 2 – is a waterborne UV cured double layer factory coating – acrylate hybrid dispersion.

Production of the Floor Covering

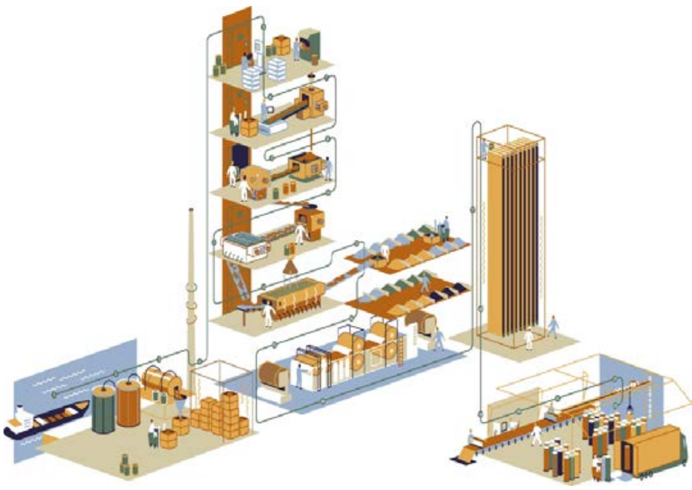


Figure 2 : Illustration of the Production process

Marmoleum is produced in several stages starting with the oxidation of linseed oil mixed with tall oil and rosin. With the influence of oxygen from the atmosphere a tough sticky material is obtained called linoleum cement. The linoleum cement is stored in containers for a few days for further reaction and after this it is mixed with wood flour, calcium carbonate, reused waste (if applicable), titanium dioxide and pigments. This mixture is calendared on a jute substrate and stored in drying rooms, to cure till the required hardness is reached. After approximately 14 days the material is taken out from the drying room to the trimming department where the factory finish is applied on the surface of the product and the end inspection is done. Finally the edges are trimmed and the sheet is cut to length into rolls of approximately 32 meter. The trimmings and the rejected product are reused.

Health, Safety and Environmental Aspects during Production

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

Production Waste

Rejected material and the cuttings of the trimming stage are being reused in the manufacturing process.
Packaging materials are being 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 Marmoleum is transported as follows:

Transport distance 40 t truck	694 km
Transport distance 7.5t truck (Fine distribution)	257 km
Capacity utilization trucks (including empty runs)	85 %
Transport distance Ocean ship	4916 km
Capacity utilization Ocean ship	48%

Installation

Because of the specific techniques used during the installation of Marmoleum 6% of the material is cut off as installation waste. For installation of Marmoleum on the floor a worst case scenario has been modeled (assuming 0.435 kg/m^2 of adhesive is required). In practice this amount will almost always be lower.
Waste during the installation process may be recycled as floor covering through the manufacturers' facilities or thermally recycled in a waste incineration plant. Since the major part of Marmoleum is sold in Europe the European electricity grid mix is used in the calculations for the energy recovery during incineration.

Health, Safety and Environmental Aspects during Installation

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

Waste

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

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.

Prevention of Structural Damage

All newly laid floors should be covered and protected from 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

Marmoleum is complying with:

- AgBB requirements
- French Act Grenelle: A+
- CHPS section 01350

End of Life

The deconstruction of installed Marmoleum 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.
For the end of life stage no landfilling is taken into account, since the vast majority of the countries in which Marmoleum is sold are having a non landfill policy. Because of the high calorific value of Marmoleum the incineration is very profitable as a waste to energy conversion.

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

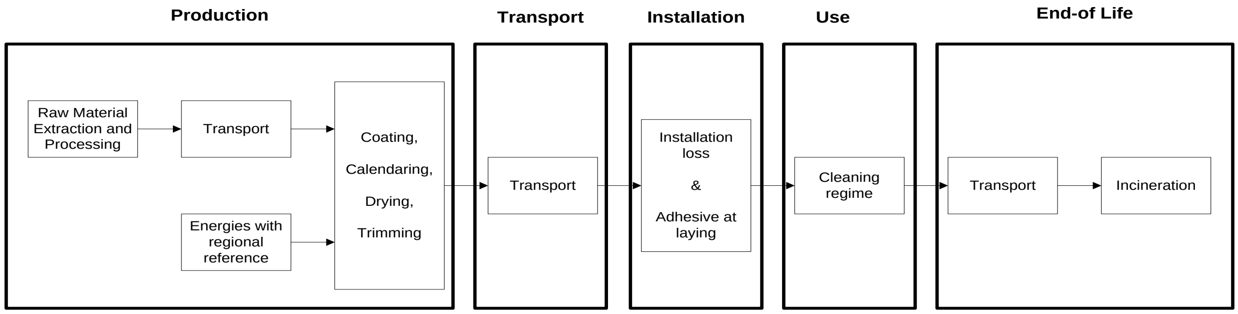


Figure 3 : Flow chart of the Life Cycle Assessment

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 5 Software System for Life Cycle Engineering, developed by PE INTERNATIONAL AG, has been used. All relevant LCA datasets are taken from the GaBi 5 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 2011). 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 5 Software System for Life Cycle Engineering, developed by

PE INTERNATIONAL AG, is used. All relevant LCA datasets are taken from the GaBi 5 software database. The last revision of the used data sets took place within the last 10 years.

Table 3: LCA datasets used in the LCA model

Data set	Region	Reference year
Linseed oil	Germany	2010
Limestone flour	Germany	2010
Tall oil	Europe	2010
Iron oxide	Germany	2010
Pigment	Germany	2007
Titanium dioxide	Europe	2010
Wood flour	Europe	2006
Colophony	France	2010
Jute	India	2010
Urethane / acrylic hybrid dispersion	Europe	2005
Water (desalinated; deionised)	Germany	2010
Detergent (ammonia based)	Germany	2006
Adhesive for resilient flooring	Germany	2010
Waste incineration of linoleum	Europe	2006
Electricity from Hydro power	Germany	2008
Power grid mix	Europe	2008
Thermal energy from natural gas	Netherlands	2008
Thermal energy from natural gas	Europe	2008
Trucks	Global	2010
Municipal waste water treatment (Sludge incineration).	Germany	2010
Container ship	Global	2010
Diesel mix at refinery	Europe	2008
Heavy fuel oil at refinery (1.0wt.% S)	Europe	2008
Corrugated board	Europe	2002
Kraftliner (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 selection of LCA data for the electricity generation is in line with the PCR.

The products are manufactured in Assendelft, the Netherlands. The GaBi 5 Hydropower dataset has therefore been used (reference year 2008). 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 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.

The LCA dataset used to model the incineration of Marmoleum is based on data developed by European Resilient Flooring Manufacturers' Institute (ERFMI) and is specific to linoleum flooring products. This indicates that 250 kWh/tonne electricity and 9744 MJ/tonne thermal energy is recovered during incineration. This model is part of the ERFMI 2008 LCA study on resilient floorings; critical reviewed by Dr ir Jeroen Guinée (Institute of Environmental Sciences CML).

Description of the allocation processes in the LCA report

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

Description of the unit processes in the LCA report

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

In the following tables the type and amount of the different input and output flows are listed for 1m² produced flooring; installed flooring includes the material loss during installation (6%):

Table 4: Composition of linoleum surface layer

Process data	Unit	Marmoleum (2.0 mm)	Marmoleum (2.5 mm)
Limestone flour	kg/m2	0.3788	0.4848
Linseed oil	kg/m2	0.3213	0.4111
Iron oxide (Fe_2O_3)	kg/m2	0.0108	0.0138
Pigment	kg/m2	0.0035	0.0044
Colophony (rosin)	kg/m2	0.0470	0.0601
Tall oil (Bio based waste product from paper Industry)	kg/m2	0.1873	0.2397
Titanium dioxide	kg/m2	0.0432	0.0553
Wood flour (Bio based waste product from wood processing)	kg/m2	0.5020	0.6424

Table 5: Composition of linoleum intermediate layer (same for both products)

Process data	Unit	Marmoleum (2.0 mm)	Marmoleum (2.5 mm)
Limestone	kg/m2	0.2051	0.2625
Linseed oil	kg/m2	0.1268	0.1623
Tall oil (Bio based waste product from paper Industry)	kg/m2	0.0577	0.0738
Wood flour (Bio based waste product from wood processing)	kg/m2	0.0260	0.0333
Linoleum for recycling	kg/m2	0.2246	0.2874

Table 6: Composition of linoleum substrate layer (same for both products)

Process data	Unit	Marmoleum
Jute	kg/m2	0.240

Table 7: Composition of lacquer (same for both products)

Process data	Unit	Marmoleum
Urethane / acrylic hybrid dispersion	kg/m2	0.012
Water (desalinated; demonized)	kg/m2	0.018

Table 8: Production related inputs/outputs

Process data	Unit	Marmoleum 2.0 mm	Marmoleum 2.5 mm
INPUTS			
Linoleum surface layer	kg	1.4938	1.9117
Linoleum intermediate layer	kg	0.6402	0.8193
Linoleum substrate layer	kg	0.240	0.240
Lacquer	kg	0.030	0.030
Electricity	MJ	7.165	7.165
Thermal energy from natural gas	MJ	12.975	12.975
OUTPUTS			
Marmoleum	kg	2.404	3.001
Waste	kg	0.351	0.438

Table 9: Packaging requirements (per m^2 manufactured product)

Process data	Unit	Marmoleum 2.0 mm	Marmoleum 2.5 mm
Corrugated board boxes	kg	0.0521	0.0521
Kraftliner (paper)	kg	0.0217	0.0217

Table 10: Transport distances (same for both products)

Process data	Unit	Road	Truck size	Ship
Limestone flour	km	568	14 - 20t gross weight / 11,4t payload capacity	-
Linseed oil	km	212		6330
Iron oxide (Fe_2O_3)	km	263		-
Pigment	km	379		-
Colophony (rosin)	km	246		15800
Tall oil	km	100		7060
Titanium dioxide	km	234		-
Wood flour	km	581		-
Jute	km	272		14800
Lacquer	km	6		-
Corrugated board boxes	km	115		-
Kraftliner (paper)	km	988		-
Transport to construction site : -Transport distance 40 t truck -Transport distance 7.5t truck (Fine distribution)	km	951 694 257	 34 - 40 t gross weight / 27t payload capacity 7,5 t - 12t gross weight / 5t payload capacity	4916
Waste transport to incineration	km	200	7,5 t - 12t gross weight / 5t payload capacity	-

Table 11: Inputs/outputs from Installation

Process data	Unit	Marmoleum 2.0 mm	Marmoleum 2.5 mm
INPUTS			
Marmoleum	kg	2.404	3.001
Adhesive (30% water content) - Water - Acrylate co-polymer - Styrene Butadiene co-polymer - Limestone flour - Sand	kg	0.435	0.435
OUTPUTS			
Installed Marmoleum	kg	2.260	2.821
Installation Waste	kg	0.144	0.180

Table 12: Inputs from use stage (per m^2.year of installed product)

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

Table 13: Disposal

Process data	Unit	Marmoleum
Post consumer Marmoleum to incineration	%	100

Life Cycle Inventory Analysis

In table 14 the environmental impacts for one lifecycle are presented for Marmoleum 2.0 and 2.5 mm. In the tables 15 and 16 the environmental impacts are presented for all the lifecycle stages.

Table 14: Results of the LCA – Environmental impacts one lifecycle (one year) – Marmoleum 2.0 mm & 2.5 mm

Impact Category : CML 2001 – Nov. 2010	Marmoleum 2.0 mm	Marmoleum 2.5 mm	Unit
Global Warming Potential (GWP 100 years)	5.45	6.16	kg CO2-Equiv.
Ozone Layer Depletion Potential (ODP. steady state)	2.59E-08	2.63E-08	kg R11-Equiv.
Acidification Potential (AP)	3.93E-02	4.81E-02	kg SO2-Equiv.
Eutrophication Potential (EP)	9.29E-03	1.15E-02	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	1.82E-03	2.12E-03	kg Ethene-Equiv.
Abiotic Depletion Potential Elements (ADPE)	2.87E-06	3.34E-06	kg Sb-Equiv.
Abiotic Depletion Potential Fossil (ADPF)	52.19	55.74	[MJ]

Table 15: Results of the LCA – Environmental impact for Marmoleum 2.5 mm (one year)

Impact Category : CML 2001 – Nov. 2010	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Global Warming Potential	kg CO2-Equiv.	0.022	0.51	1.48	0.36	3.78
Ozone Layer Depletion Potential	kg R11-Equiv.	2.75E-08	4.43E-10	-2.16E-09	1.97E-08	-1.92E-08
Acidification Potential	kg SO2-Equiv.	3.88E-02	7.54E-03	1.90E-03	1.29E-03	-1.44E-03
Eutrophication Potential	kg PSO4-Equiv.	1.02E-02	8.44E-04	2.53E-04	1.08E-04	6.65E-05
Photochem. Ozone Creation Potential	kg Ethene-Equiv.	1.77E-03	1.87E-04	3.85E-04	9.51E-05	-3.21E-04
Abiotic Depletion Elements	kg Sb-Equiv.	2.99E-06	1.24E-08	2.66E-07	5.90E-08	6.32E-09
Abiotic Depletion Fossil	MJ	58.70	4.86	15.29	4.35	-27.46

Table 9: Results of the LCA – Environmental impact for Marmoleum 2.0 mm (one year)

Impact Category : CML 2001 – Nov. 2010	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Global Warming Potential	kg CO2-Equiv.	0.20	0.41	1.44	0.36	3.03
Ozone Layer Depletion Potential	kg R11-Equiv.	2.30E-08	3.56E-10	-1.91E-09	1.97E-08	-1.52E-08
Acidification Potential	kg SO2-Equiv.	3.12E-02	6.06E-03	1.92E-03	1.29E-03	-1.14E-03
Eutrophication Potential	kg PSO4-Equiv.	8.20E-03	6.78E-04	2.52E-04	1.08E-04	5.41E-05
Photochem. Ozone Creation Potential	kg Ethene-Equiv.	1.44E-03	1.50E-04	3.89E-04	9.51E-05	-2.56E-04
Abiotic Depletion Elements	kg Sb-Equiv.	2.99E-06	1.24E-08	2.66E-07	5.90E-08	6.32E-09
Abiotic Depletion Fossil	MJ	58.70	4.86	15.29	4.35	-27.46

The relative contribution of each process stage to each impact category for Marmoleum 2.0 mm and 2.5 mm is shown in the figures 4 and 5.

Figure 4: relative contribution of each process stage to each impact category for Marmoleum 2.0 mm for a one year usage.

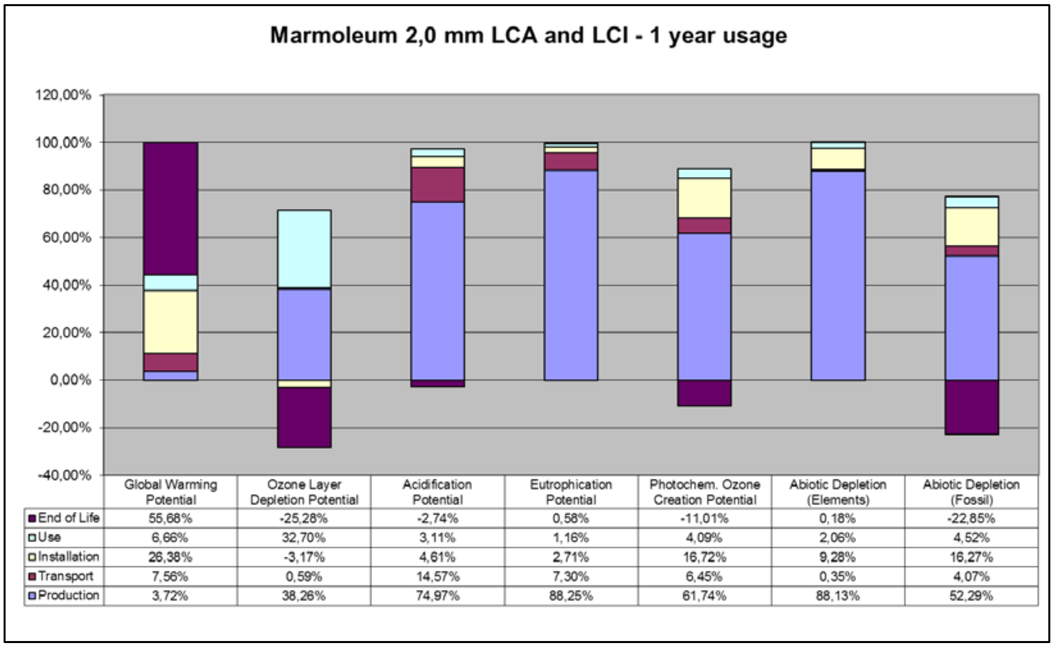
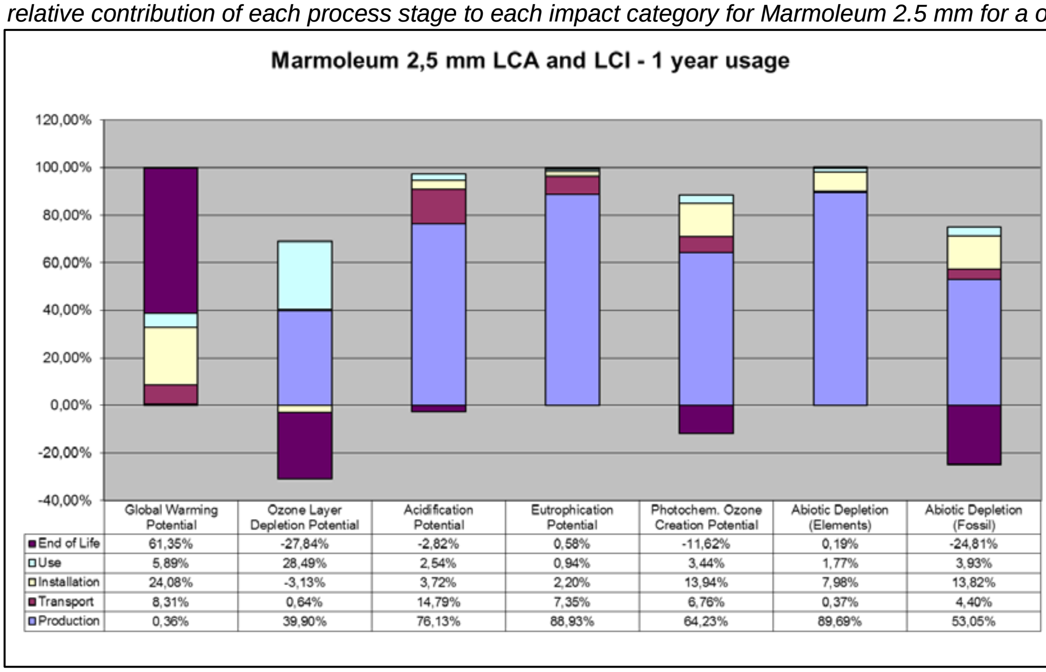


Figure 5: relative contribution of each process stage to each impact category for Marmoleum 2.5 mm for a one year usage.



Interpretation

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

In most impact categories (AP, EP, POCP, ADPE, ADPF) the production stage has the main contribution to the overall impact. For these categories the main contributor in the production stage is the Raw material supply with a share of 65-92% of total impacts from the production stage.

For GWP, POCP, and ADPF the adhesive for the flooring installation has a significant impact. The LCA for the installation is based on a conservative assumption of 435g/m² adhesive. In practice this amount will almost always be lower.

Forbo declares in the EPD a worldwide distribution by truck (951km) and container ship (4916 km). For this scenario the transport has a relevance of 7%-16% in the impact categories GWP, AP, EP, POCP and ADPF.

The LCA profile for the results of ODP is different. After the production stage (89-105%) the use stage accounts for the main contribution to ODP (76%). For the production stage the raw materials are responsible for most of the impact (78-82%) while for the use stage the contribution is mainly due to the consumption of electricity (EU power grid mix) for cleaning. The third main impact on ODP comes from the End Of Life stage.

The LCA for GWP reflects the use of renewable raw materials for the production of Marmoleum (linseed oil and jute). Carbon dioxide, a greenhouse gas, is locked in from the atmosphere in the course of the plant growth via photosynthesis and stored during the use stage. This carbon dioxide is not released until the end of life when it is incinerated with energy recovery – this process accounts for the greatest emission of greenhouse gases in the life cycle of the product.

Energy recovery from incineration and the respective energy substitution at the end of life results in a credit for all impact categories as reported in the End of Life stage.

Additional Environmental Information

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

Toxicity

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

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

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

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

Table 17: Results of the LCA – Environmental impacts one lifecycle (one year) – Marmoleum 2.0 mm & 2.5 mm

Impact Category : USEtox	Marmoleum 2.0 mm	Marmoleum 2.5 mm	Unit
Eco toxicity	7.29E-01	8.84E-01	PAF m3.day
Human toxicity, cancer	3.37E-09	3.96E-09	Cases
Human toxicity, non-canc.	5.86E-07	7.14E-07	Cases

In the following two tables the impacts are subdivided into the lifecycle stages.

Table 18: Results of the LCA – Environmental impact for Marmoleum 2.5 mm (one year)

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Eco toxicity	PAF m3.day	7.43E-01	4.67E-02	6.57E-02	1.94E-02	9.12E-03
Human toxicity, cancer	cases	3.05E-09	1.45E-10	5.05E-10	3.60E-10	-9.79E-11
Human toxicity, non-canc.	cases	5.96E-07	3.36E-08	5.28E-08	1.26E-08	1.89E-08

Table 19: Results of the LCA – Environmental impact for Marmoleum 2.0 mm

Impact Category : USEtox	Unit	Production	Transport	Installation	Use (1yr)	End of Life
Eco toxicity	PAF m3.day	6.00E-01	3.75E-02	6.56E-02	1.94E-02	7.39E-03
Human toxicity, cancer	cases	2.46E-09	1.17E-10	5.07E-10	3.60E-10	-7.76E-11
Human toxicity, non-canc.	cases	4.78E-07	2.70E-08	5.26E-08	1.26E-08	1.532E-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.

The Eco-toxicity is predominated by the production stage in which the raw materials are having a big impact with a share of around 93%. The main contributors in the manufacturing are the thermal energy and the packaging of the end product. Other contributors are the transport to the customer and the adhesive used for installing the floor.

In the Human toxicity (cancer) the largest contribution is coming from the production stage where the raw material extraction is contributing 91% to the total impact. Other significant contributions come from the Installation (Adhesive) and Use stage (Waste water treatment and electricity).

Also for Human toxicity (non-canc.) by far the biggest impact is coming from the production stage, where the contribution of the raw material extraction (91-92%) is predominating this life cycle stage. A small but significant contribution to the total impact is coming from the transport to the customer and installation stage.

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 20: Results of the LCA – Environmental impact for Marmoleum 2.5 mm (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	Unit	A1-3	A4	A5	B2	C1	C2	C3	D
GWP	[kg CO_2-Eq.]	0.02	0.51	1.26	0.36	0.01	0.09	6.25	-2.34
ODP	[kg CFC11-Eq.]	2.75E-08	4.43E-10	1.96E-09	1.97E-08	9.57E-10	4.69E-12	2.08E-09	-2.64E-08
AP	[kg SO_2-Eq.]	3.88E-02	7.54E-03	2.28E-03	1.29E-03	6.25E-05	3.50E-04	8.28E-04	-3.06E-03
EP	[kg PO_4^{3-}- Eq.]	1.02E-02	8.44E-04	2.68E-04	1.08E-04	3.35E-06	8.36E-05	2.57E-04	-2.92E-04
POCP	[kg Ethen Eq.]	1.77E-03	1.87E-04	4.40E-04	9.51E-05	3.80E-06	-1.21E-04	1.09E-04	-3.68E-04
ADPE	[kg Sb Eq.]	2.99E-06	1.24E-08	2.73E-07	5.90E-08	1.20E-09	3.99E-09	9.86E-08	-1.04E-07
ADPF	[MJ]	58.70	4.86	20.50	4.35	0.17	1.20	2.24	-36.20

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 21: Results of the LCA – Environmental impact for Marmoleum 2.0 mm (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
GWP	[kg CO_2-Eq.]	0.20	0.41	1.18	0.36	0.01	0.07	5.12	-1.92
ODP	[kg CFC11-Eq.]	2.30E-08	3.56E-10	1.94E-09	1.97E-08	9.57E-10	3.82E-12	1.71E-09	-2.17E-08
AP	[kg SO_2-Eq.]	3.12E-02	6.06E-03	2.26E-03	1.29E-03	6.25E-05	2.85E-04	6.78E-04	-2.51E-03
EP	[kg PO_4^{3-}- Eq.]	8.20E-03	6.78E-04	2.64E-04	1.08E-04	3.35E-06	6.82E-05	2.10E-04	-2.40E-04
POCP	[kg Ethen Eq.]	1.44E-03	1.50E-04	4.40E-04	9.51E-05	3.80E-06	-9.84E-05	8.95E-05	-3.02E-04
ADPE	[kg Sb Eq.]	2.53E-06	9.99E-09	2.72E-07	5.90E-08	1.20E-09	3.25E-09	8.08E-08	-8.54E-08
ADPF	[MJ]	50.30	3.91	20.40	4.35	0.17	0.98	1.83	-29.70

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 22: Results of the LCA – Resource use for Marmoleum 2.5 mm (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
PERE	[MJ]	30.13	-	-	-	-	-	-	-
PERM	[MJ]	39.07	-	-	-	-	-	-	-
PERT	[MJ]	69.20	0.10	0.36	0.71	0.04	0.05	0.01	-1.04
PENRE	[MJ]	45.65	-	-	-	-	-	-	-
PENRM	[MJ]	16.75	-	-	-	-	-	-	-
PENRT	[MJ]	62.40	4.91	21.10	6.12	0.26	1.21	2.54	-38.70
SM	[kg]	0.81	-	-	-	-	-	-	-
RSF	[MJ]	2.64E-03	3.39E-05	2.74E-04	3.40E-04	3.41E-06	1.02E-05	0.00E+00	-3.78E-04
NRSF	[MJ]	2.68E-02	3.56E-04	2.86E-03	3.56E-03	3.57E-05	1.07E-04	0.00E+00	-3.96E-03
FW	[kg]	4.93E+01	1.44E-01	3.79E+00	2.29E+00	1.14E-01	6.73E-02	-3.01E-02	-3.60E+00

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of 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 23: Results of the LCA – Resource use for Marmoleum 2.0 mm (one year)

		Manufacturing	Installation		Use (1yr)	End of Life			Credits
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
PERE	[MJ]	25.90	-	-	-	-	-	-	-
PERM	[MJ]	31.30	-	-	-	-	-	-	-
PERT	[MJ]	57.20	0.0775	0.355	0.706	0.0374	0.0391	0.00759	-0.854
PENRE	[MJ]	39.79	-	-	-	-	-	-	-
PENRM	[MJ]	13.41	-	-	-	-	-	-	-
PENRT	[MJ]	53.20	3.95	21	6.12	0.256	0.983	2.08	-31.7
SM	[kg]	0.65	-	-	-	-	-	-	-
RSF	[MJ]	2.39E-03	2.72E-05	2.74E-04	3.40E-04	3.41E-06	8.31E-06	0.00E+00	-3.10E-04
NRSF	[MJ]	2.43E-02	2.86E-04	2.86E-03	3.56E-03	3.57E-05	8.72E-05	0.00E+00	-3.25E-03
FW	[kg]	4.13E+01	1.01E-01	3.79E+00	2.29E+00	1.14E-01	5.49E-02	-2.47E-02	-2.96E+00

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of 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 24: Results of the LCA – Output flows and Waste categories for Marmoleum 2.5 mm (one year)

		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits			
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
HWD	[kg]	0	0	0	0	0	0	0	0
NHWD	[kg]	5.53	0.0315	0.763	1.11	0.0548	0.00637	0.0426	-1.53
RWD	[kg]	0.00139	0.0000185	0.000246	0.000703	0.0000366	0.0000017	0.0000253	-0.00101
CRU	[kg]	-	-	-	-	-	-	-	0
MFR	[kg]	-	-	-	-	-	-	-	0
MER	[kg]	-	-	-	-	-	-	-	3.30
EE Power	[MJ]	-	-	0.17	-	-	-	2.97	-
EE Thermal energy	[MJ]	-	-	1.87	-	-	-	32.20	-

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

Table 25: Results of the LCA – Output flows and Waste categories for Marmoleum 2.0 mm (one year)

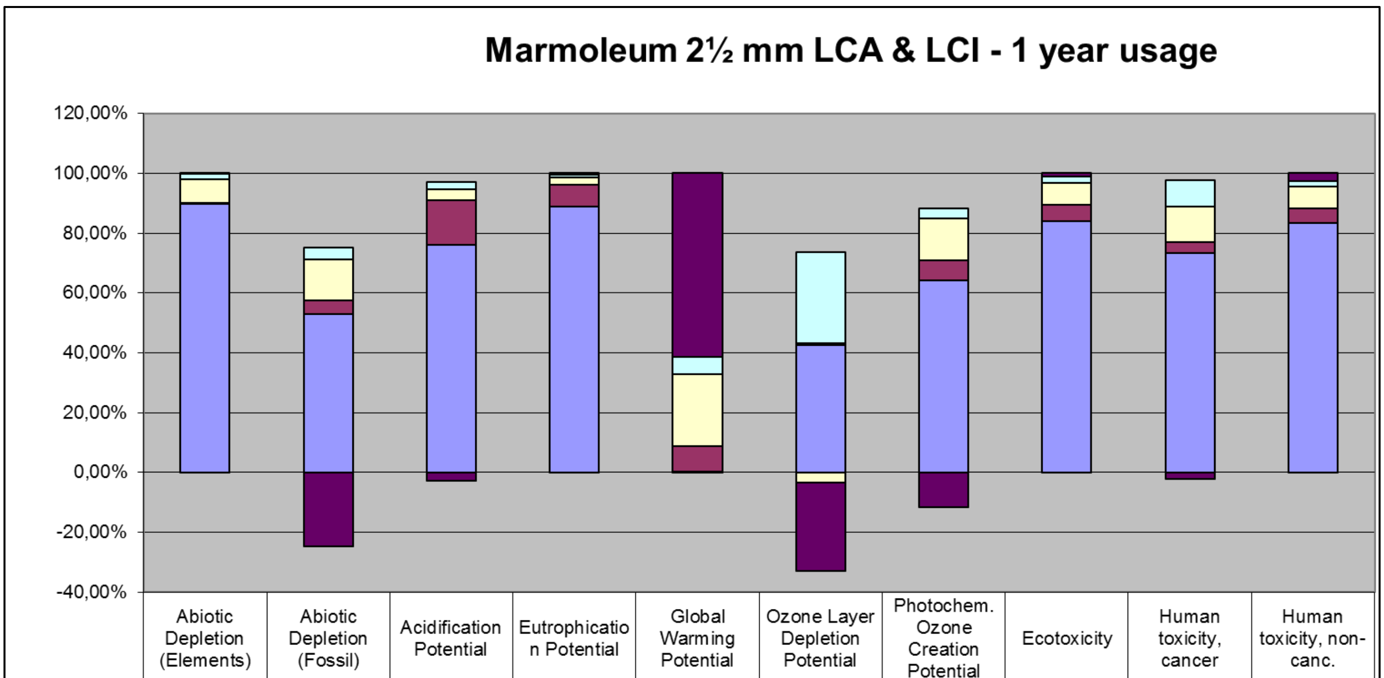
		Manufacturing	Transport	Installation	Use (1yr)	End of Life/credits			
Parameter	**Unit**	**A1-3**	**A4**	**A5**	**B2**	**C1**	**C2**	**C3**	**D**
HWD	[kg]	0	0	0	0	0	0	0	0
NHWD	[kg]	4.47	0.0253	0.762	1.11	0.0548	0.00519	0.0349	-1.26
RWD	[kg]	0.00112	0.0000149	0.000246	0.000703	0.0000366	0.00000139	0.0000208	-0.000832
CRU	[kg]	-	-	-	-	-	-	-	0
MFR	[kg]	-	-	-	-	-	-	-	0
MER	[kg]	-	-	-	-	-	-	-	2.71
EE Power	[MJ]	-	-	0.138	-	-	-	2.44	-
EE Thermal energy	[MJ]	-	-	1.5	-	-	-	26.4	-

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 on pages 49/50. A more detailed interpretation for a one year useage is presented in following figures and tables.

Figure 6: relative contribution of each process stage to each impact category for Marmoleum 2.5 mm 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	0,19%	-24,81%	-2,82%	0,58%	61,35%	-29,70%	-11,62%	1,03%	-2,36%	2,65%
Use	1,77%	3,93%	2,54%	0,94%	5,89%	30,40%	3,44%	2,19%	8,66%	1,77%
Installation	7,98%	13,82%	3,72%	2,20%	24,08%	-3,34%	13,94%	7,44%	12,16%	7,39%
Transport	0,37%	4,40%	14,79%	7,35%	8,31%	0,69%	6,76%	5,29%	3,50%	4,70%
Production	89,69%	53,05%	76,13%	88,93%	0,36%	42,56%	64,23%	84,05%	73,33%	83,48%

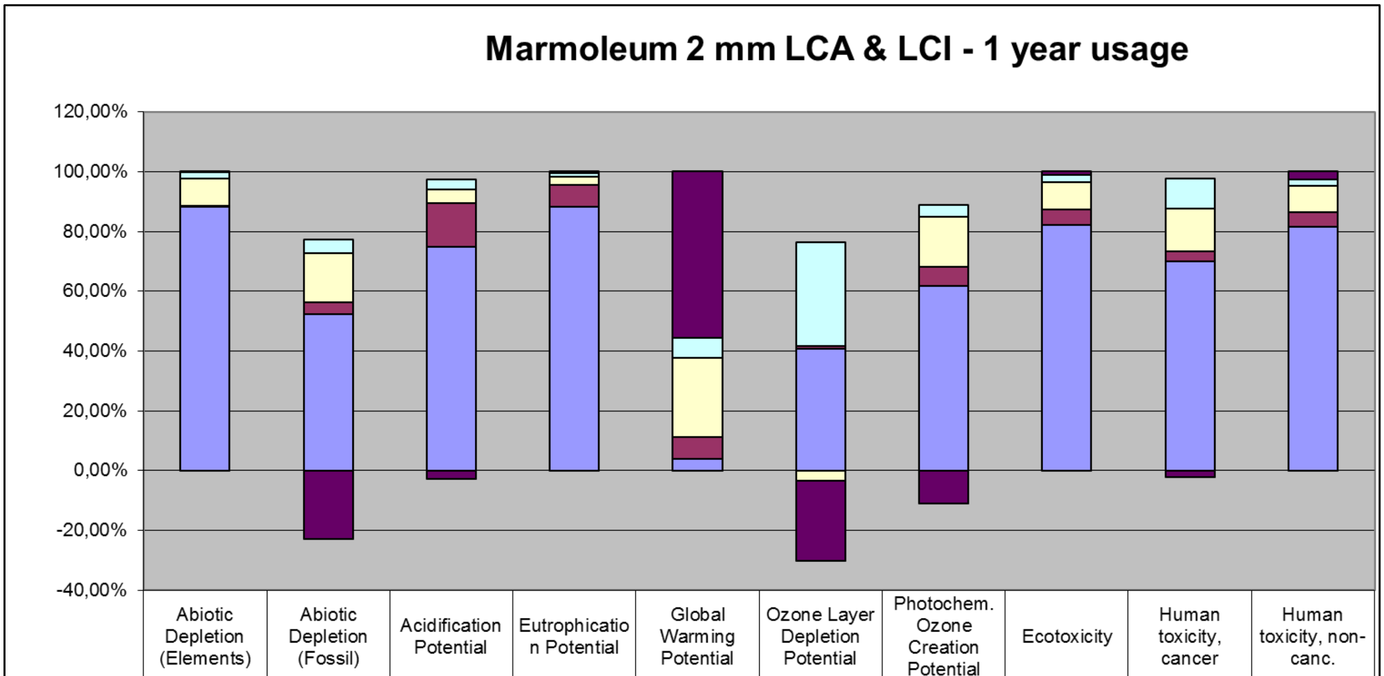
Table 26: Main modules and flows contributing to the total impact in each impact category for Marmoleum 2.5 mm for a one year usage

Impact Category	Stage	Module		Main contributor	Main contributing flows
GWP	Production	Raw Material Extraction	-1.25 kg CO_2-equiv.	Linseed oil (-1.80 kg CO_2 eq.) Titanium dioxide (0.28 kg CO_2eq.)	Production : Renewable resources, Carbon dioxide Production : Inorganic emissions to air, Carbon dioxide
		Transport of Raw materials	0.27 kg CO_2-equiv.	Means of transport (truck, container ship) and their fuels	
		Manufacturing	1.00 kg CO_2-equiv.	83% 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		66% Adhesive	
	Use	Use		74% Electricity 26% Detergent and waste water	Use : Inorganic emissions to air, Carbon dioxide

Impact Category	Stage	Module		Main contributor	Main contributing flows
				treatment	
	EOL	EOL		Incineration of post-consumer linoleum flooring Energy substitution from incineration	EOL : Inorganic emissions to air, Carbon dioxide
ODP	Production	Raw Material Extraction	82%	31% Tall oil 17% Titanium dioxide 14% Colophony 14% Linseed oil	Production : Halogenated organic emissions to air, R114 (Dichlorotetrafluorethane)
		Transport of Raw materials	< 0.05%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	18%	96% Paper and card packaging	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Halogenated organic emissions to air, Halon (1301)
	Installation	Installation		92% Adhesive	
	Use	Use		89% Electricity 10% Detergent and waste water treatment	Use : Halogenated organic emissions to air, R114 (Dichlorotetrafluorethane)
	EOL	EOL		Energy substitution from incineration	EOL: Halogenated organic emissions to air, R114 (Dichlorotetrafluorethane)
AP	Production	Raw Material Extraction	83%	48% Linseed oil 31% Titanium dioxide	Production : Inorganic emissions to air, Ammonia, NO_x , Sulphur dioxide Production : inorganic emissions to fresh water, Hydrogen chloride
		Transport of Raw materials	15%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	2%	68% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, Ammonia, NO_x , Sulphur dioxide
	Installation	Installation		96% Adhesive	
	Use	Use		88% Electricity 12% Detergent and waste water treatment	Use : Inorganic emissions to air, Ammonia, NO_x , Sulphur dioxide
	EOL	EOL		Incineration of post-consumer linoleum flooring Energy substitution from incineration	EOL : Inorganic emissions to air, Ammonia, NO_x , Sulphur dioxide
EP	Production	Raw Material Extraction	92%	88% Linseed oil	Production : Inorganic emissions to air, Ammonia, NO_x Production : Inorganic emissions to fresh water, Nitrate , Nitrogen organic bounded, Phosphate
		Transport of Raw materials	6%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	1%	66% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, NO_x
	Installation	Installation		92% Adhesive	
	Use	Use		57% Electricity 43% Detergent and waste water treatment	Use : Inorganic emissions to air, NO_x
	EOL	EOL		Incineration of post-consumer linoleum flooring Energy substitution from incineration	EOL : Inorganic emissions to air, NO_x
POCP	Production	Raw Material Extraction	86%	49% Linseed oil 24% Titanium dioxide	Production : Inorganic emissions to air, Carbon monoxide, NO_x , Sulphur dioxide Production : Group NMVOC to air, NMVOC (unspecified)
		Transport of Raw materials	10%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	4%	68% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, NO_x Transport & Installation : Group NMVOC to air, NMVOC (unspecified)
	Installation	Installation		100% Adhesive	
	Use	Use		73% electricity 27% Detergent and waste water treatment	Use : Inorganic emissions to air, Sulphur dioxide
	EOL	EOL		Energy substitution from incineration	EOL : Inorganic emissions to air, Carbon monoxide , NO_x, Sulphur dioxide EOL : Group NMVOC to air, NMVOC (unspecified) , Methane
ADPe	Production	Raw Material Extraction	79%	42% Tall oil 28% Titanium dioxide	Production : Nonrenewable elements, Chromium, Copper Production : Nonrenewable resources, Sodium chloride (Rock salt)
		Transport of Raw materials	<0,5%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	20%	93% Electricity	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Non renewable resources, Lead-zinc ore

Impact Category	Stage	Module		Main contributor	Main contributing flows
	Installation	Installation		97% Adhesive	
	Use	Use		37% Electricity 63% Detergent and waste water treatment	Use : Nonrenewable resources, Sodium chloride (Rock salt)
	EOL	EOL		Incineration of post-consumer linoleum flooring Energy substitution from incineration	EOl : Magnesium Chloride leach (40%) EOL : Nonrenewable elements, Chromium, Copper, Lead
ADPf	Production	Raw Material Extraction	69%	40% Linseed oil 19% Jute hessian 16% Tall oil	Production : Crude oil resource, Crude oil (in MJ) Production : Hard coal resource, hard coal (in MJ) Production : Natural gas (resource), Natural gas (in MJ)
		Transport of Raw materials	6%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	25%	96% 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		99% Adhesive	
	Use	Use		71% electricity 29% Detergent and waste water treatment	Use : Hard coal resource, hard coal (in MJ), Natural gas (in MJ)
	EOL	EOL		Energy substitution from incineration	EOL : Natural gas (resource), Natural gas (in MJ)
Ecotoxicity	Production	Raw Material Extraction	93%	74% Linseed oil 5% Jute hessian 9% Rosin	Production : Hydrocarbons to fresh water, Methanol, Phenol Production : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
		Transport of Raw materials	6%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	1%	65% Packaging end product 24% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & installation : Hydrocarbons to fresh water, Phenol, Methanol
	Installation	Installation		96% Adhesive	
	Use	Use		49% Waste water treatment 42% Electricity	Use : Hydrocarbons to fresh water, Phenol, Methanol Use : Group NMVOC to air, NMVOC (unspecified), formaldehyde (Methanal)
	EOL	EOL		Energy substitution from incineration	EOL : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
Human toxicity, cancer	Production	Raw Material Extraction	91%	57% Linseed oil 8% Jute hessian 13% Tall oil 12% Rosin	Production : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
		Transport of Raw materials	5%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	4%	88% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
	Installation	Installation		98% adhesive	
	Use	Use		69% Waste water treatment 20% Electricity	Use : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
	EOL	EOL		Energy substitution from incineration	EOL : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
Human toxicity, non canc.	Production	Raw Material Extraction	92%	52% Linseed oil 24% Rosin 13% Tall oil	Production : Group NMVOC to air, NMVOC (unspecified), Methyl Methacrylate (MMA)
		Transport of Raw materials	7%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	1%	94% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Group NMVOC to air, NMVOC (unspecified), Hexane, Methyl Methacrylate (MMA)
	Installation	Installation		94% adhesive	
	Use	Use		76% electricity 21% Waste water treatment	Use : Group NMVOC to air, NMVOC (unspecified), Xylene
	EOL	EOL		Energy substitution from incineration	EOL : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)

Figure 7: relative contribution of each process stage to each impact category for Marmoleum 2.0 mm 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	0,18%	-22,85%	-2,74%	0,58%	55,68%	-26,99%	-11,01%	1,01%	-2,20%	2,61%
Use	2,06%	4,52%	3,11%	1,16%	6,66%	34,91%	4,09%	2,66%	10,21%	2,15%
Installation	9,28%	16,27%	4,61%	2,71%	26,38%	-3,39%	16,72%	8,99%	14,37%	8,97%
Transport	0,35%	4,07%	14,57%	7,30%	7,56%	0,63%	6,45%	5,15%	3,31%	4,61%
Production	88,13%	52,29%	74,97%	88,25%	3,72%	40,85%	61,74%	82,20%	69,90%	81,66%

Table 27: Relevant modules and flows contributing to the impact in each impact category for Marmoleum 2.0 mm for a one year usage

Impact Category	Stage	Module		Main contributor	Main contributing flows
GWP	Production	Raw material extraction	-0.99 kg CO_2-equiv.	Linseed oil (-1.48 kg CO_2 eq.) Titanium dioxide (0.22kg CO_2 eq.)	Production : Renewable resources, Carbon dioxide Production : Inorganic emissions to air, Carbon dioxide
		Transport of Raw material	0.22 kg CO_2-equiv.	Means of transport (truck, container ship) and their fuels	
		Manufacturing	0.97 kg CO_2-equiv.	86% 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		70% adhesive 30% Impact from Incineration of installation waste and packaging	
	Use	Use		74% Electricity 26% detergent and waste water treatment	Use : Inorganic emissions to air, Carbon dioxide
	EOL	EOL		Energy substitution from incineration	EOL : Inorganic emissions to air, Carbon dioxide
ODP	Production	Raw Material Extraction	78%	31% Tall oil 17% Titanium dioxide 14% Wood flour 14% Linseed oil	Production : Halogenated organic emissions to air, R114 (Dichlorotetrafluorethane)
		Transport of Raw materials	<0,1%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	22%	Paper and card production	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Halogenated organic emissions to air, Halon (1301)
	Installation	Installation		94% Adhesive	
	Use	Use		89% Electricity 11% detergent and waste water treatment	Use : Halogenated organic emissions to air, R114 (Dichlorotetrafluorethane)
	EOL	EOL		Energy substitution from incineration	EOL: Halogenated organic emissions to air, R114 (Dichlorotetrafluorethane)
AP	Production	Raw Material Extraction	83%	48% Linseed oil 31% Titanium dioxide	Production : Inorganic emissions to air, Ammonia, NO_x , Sulphur dioxide

Impact Category	Stage	Module		Main contributor	Main contributing flows
		Transport of Raw materials	15%	Means of transport (truck, container ship) and their fuels	Production : inorganic emissions to fresh water, Hydrogen chloride
		Manufacturing	2%	69% Thermal energy 26% Paper and card production	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport 7 Installation : Inorganic emissions to air, Ammonia, NO_x , Sulphur dioxide
	Installation	Installation		97% Adhesive	
	Use	Use		88% Electricity 12% detergent and waste water treatment	Use : Inorganic emissions to air, Ammonia, NO_x , Sulphur dioxide
	EOL	EOL		Incineration of post-consumer linoleum flooring Energy substitution from incineration	EOL : Inorganic emissions to air, Ammonia, NO_x, Sulphur dioxide
EP	Production	Raw Material Extraction	92%	88% Linseed oil	Production : Inorganic emissions to air, Ammonia, NO_x Production : Inorganic emissions to fresh water, Nitrate , Nitrogen organic bounded, Phosphate
		Transport of Raw materials	6%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	2%	67% Thermal energy 27% Paper and card production	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, NO_x
	Installation	Installation		93% Adhesive	
	Use	Use		57% electricity 43% detergent and waste water	Use : Inorganic emissions to air, NO_x
	EOL	EOL		Truck and diesel to incineration plant Incineration of post-consumer linoleum flooring Energy substitution from incineration	EOL : Inorganic emissions to air, NO_x
POCP	Production	Raw Material Extraction	85%	49% Linseed oil 24% Titanium dioxide	Production : Inorganic emissions to air, Carbon monoxide, NO_x , Sulphur dioxide Production: Group NMVOC to air, NMVOC (unspecified)
		Transport of Raw materials	10%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	5%	69% Thermal energy 24% Paper and card production	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Inorganic emissions to air, NO_x Transport & Installation : Group NMVOC to air, NMVOC (unspecified)
	Installation	Installation		100% Adhesive	
	Use	Use		73% electricity 27% detergent and waste water	Use : Inorganic emissions to air, Sulphur dioxide
	EOL	EOL		Energy substitution from incineration	EOL : Inorganic emissions to air, Carbon monoxide , NO_x, Sulphur dioxide EOL : Group NMVOC to air, NMVOC (unspecified) , Methane
ADPe	Production	Raw Material Extraction	76%	42% Tall oil 28% Titanium dioxide	Production : Nonrenewable elements, Chromium, Copper Production : Nonrenewable resources, Sodium chloride (Rock salt)
		Transport of Raw materials	< 0.5	Means of transport (truck, container ship) and their fuels	
		Manufacturing	24%	93% Electricity	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Non renewable resources, Lead-zinc ore
	Installation	Installation		98% Adhesive	
	Use	Use		37% Electricity 63% detergent and waste water	Use : Nonrenewable resources, Sodium chloride (Rock salt)
	EOL	EOL		Energy substitution from incineration	EOL : Nonrenewable elements, Chromium, Copper, Lead
ADPf	Production	Raw Material Extraction	65%	39% Linseed oil 19% Jute Hessian 16% Tall oil	Production : Crude oil resource, Crude oil (in MJ) Production : Hard coal resource, hard coal (in MJ) Production : Natural gas (resource), Natural gas (in MJ)
		Transport of Raw materials	6%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	29%	96% 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		99% Adhesive	
	Use	Use		71% electricity 29% detergent and waste water	Use : Hard coal resource, hard coal (in MJ), Natural gas (in MJ)
	EOL	EOL		Energy substitution from incineration	EOl : Natural gas (resource), Natural gas (in MJ)

Impact Category	Stage	Module		Main contributor	Main contributing flows
Ecotoxicity	Production	Raw Material Extraction	93%	74% Linseed oil 9% Rosin	Production : Hydrocarbons to fresh water, Methanol, Phenol Production : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
		Transport of Raw materials	6%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	1%	25% Thermal energy 65% Packaging end product	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & installation : Hydrocarbons to fresh water, Phenol, Methanol
	Installation	Installation		97% Adhesive	
	Use	Use		49% Waste water treatment 42% Electricity	Use : Hydrocarbons to fresh water, Phenol, Methanol Use : Group NMVOC to air, NMVOC (unspecified), formaldehyde (Methanal)
	EOL	EOL		Energy substitution from incineration	EOL : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
Human toxicity, cancer	Production	Raw Material Extraction	91%	57% Linseed oil 8% Jute hessian 13% Tall oil 12% Rosin	Production : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
		Transport of Raw materials	5%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	4%	88% Thermal energy	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
	Installation	Installation		98% adhesive	
	Use	Use		20% Electricity 69% Waste water treatment	Use : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
	EOL	EOL		Energy substitution from incineration	EOL : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)
Human toxicity, non canc.	Production	Raw Material Extraction	92%	52% Linseed oil 24% Rosin 13% Tall oil	Production : Group NMVOC to air, NMVOC (unspecified), Methyl Methacrylate (MMA)
		Transport of Raw materials	7%	Means of transport (truck, container ship) and their fuels	
		Manufacturing	1%	74% Packaging end product 16% Electricity	
	Transport	Transport Gate to User		Means of transport (truck, container ship) and their fuels	Transport & Installation : Group NMVOC to air, NMVOC (unspecified), Hexane, Methyl Methacrylate (MMA)
	Installation	Installation		95% adhesive	
	Use	Use		76% electricity 21% Waste water treatment	Use : Group NMVOC to air, NMVOC (unspecified), Xylene
	EOL	EOL		Energy substitution from incineration	EOL : Group NMVOC to air, NMVOC (unspecified), Formaldehyde (Methanal)

Description of Selected Impact Categories

Abiotic Depletion Potential

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

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

Are fossil energy carriers included in the impact category, it is ADP (fossil). Fossil fuels are used similarly to the primary energy consumption; the unit is therefore also MJ. In contrast to the primary fossil energy ADP fossil does ot 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-characterised 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 characterises 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 characterised 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 modelling principles have changed with the last GaBi4 database update in October 2006. Now all LCA data sets (electricity generation, raw material etc.) already contain the treatment of the waste with very low waste output at the end of the stage. So the amount of waste is predominantly caused by foreground processes during the production phase. This is important for the interpretation of waste amounts.

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

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

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

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

Global Warming Potential (GWP)

The mechanism of the greenhouse effect can be observed on a small scale, as the name suggests, in a greenhouse. These effects are also occurring on a global scale. The occuring 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 activites. 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.

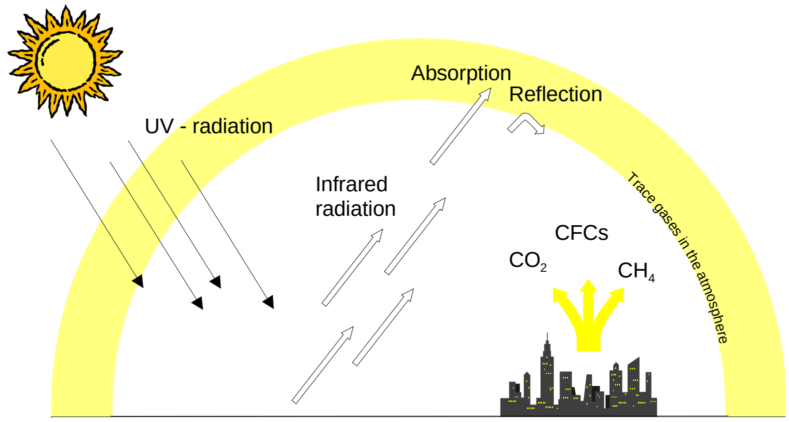


Figure A1: Greenhouse effect (KREISSIG 1999)

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 analysing 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.

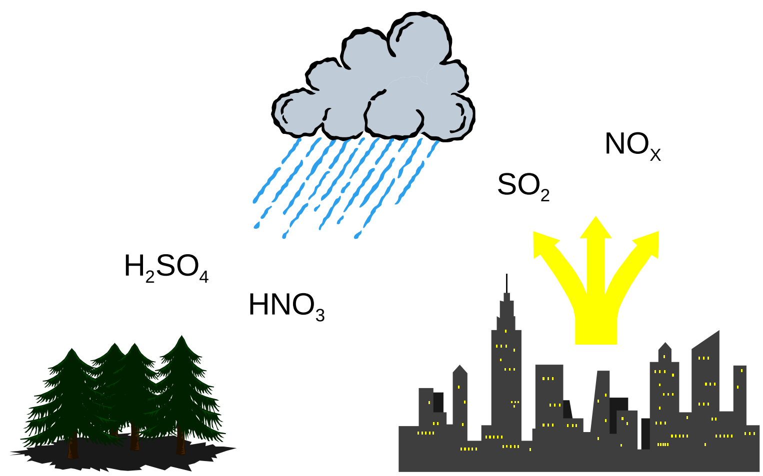


Figure A2: Acidification Potential (KREISSIG 1999)

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.

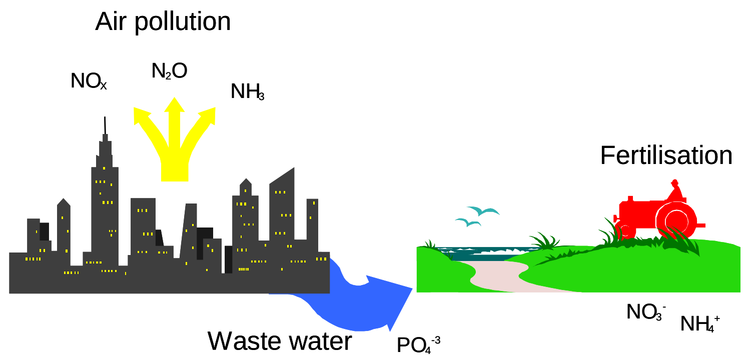


Figure A3: Eutrophication Potential (KREISSIG 1999)

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, refuelling 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 existance 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-Eq.). When analyzing, it's important to remember that the actual ozone concentration is strongly influenced by the weather and by the characterristics of the local conditions.

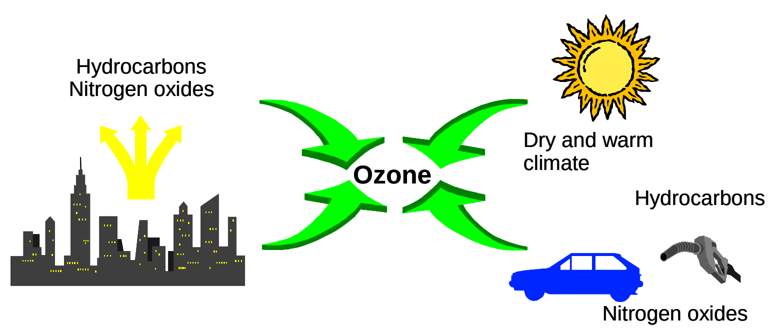


Figure A4: Photochemical Ozone Creation Potential

Ozone Depletion Potential (ODP)

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

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

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

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

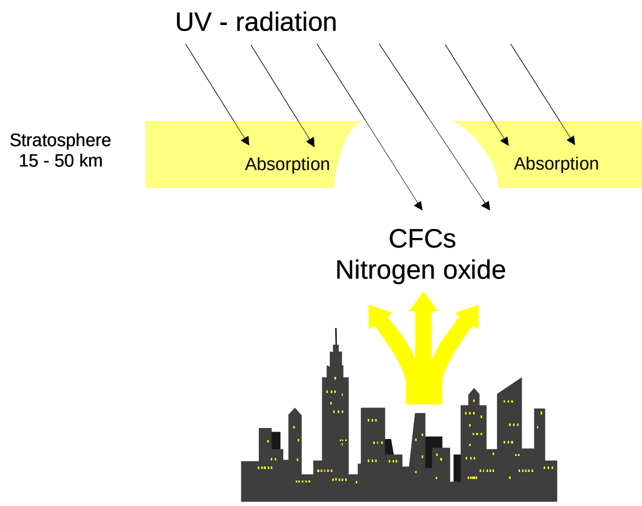


Figure A5: Ozone Depletion Potential (Kreissig 1999)

References

GaBi 5 2012	PE INTERNATIONAL AG; GaBi 5: Software-System and Database for Life Cycle Engineering. Copyright, TM. Stuttgart, Echterdingen, 1992-2012.
GaBi 5 2012D	GaBi 5: Documentation of GaBi 5: 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 Ecodesign 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 harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC
EN-ISO 10874	Resilient, textile and laminate floor coverings - Classification