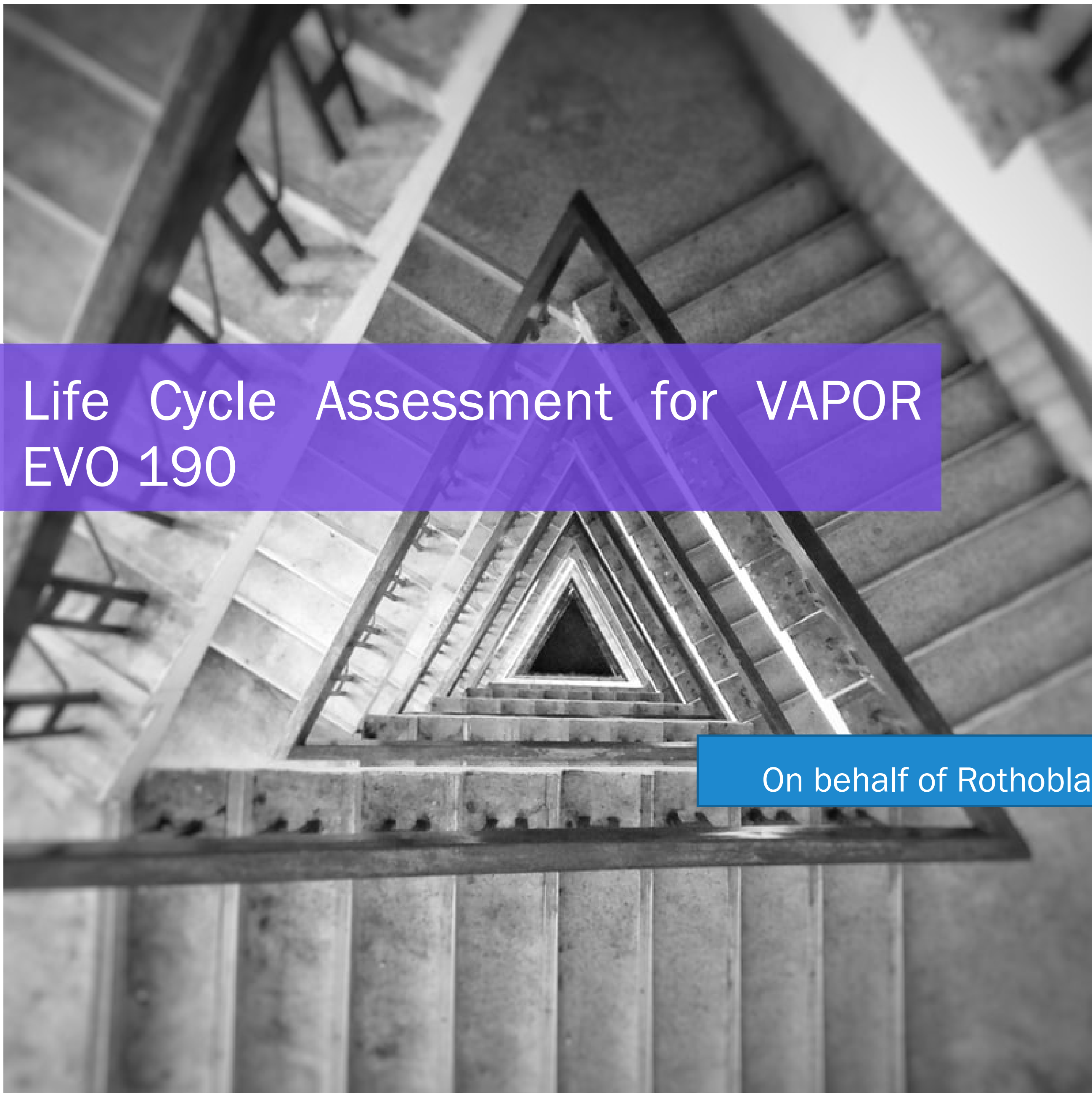
# Life Cycle Assessment for VAPOR EVO 190



On behalf of Rothoblaas s.r.l.

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On behalf of Sphera Solutions, Inc., and its subsidiaries


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# List of Acronyms

| | |
|---|---|
| ADPE | Abiotic Depletion Potential (elementary) |
| ADPF | Abiotic Depletion Potential (fossil) |
| AP | Acidification Potential |
| BLBSB | Benefits and Loads Beyond the System Boundary |
| CML | Centre of Environmental Science at Leiden |
| CRU | Components for Re-use |
| EEE | Exported Electrical Energy |
| EET | Exported Thermal Energy |
| ELCD | European Life Cycle Database |
| EPD | Environmental Product Declaration |
| EoL | End-of-Life |
| EP | Eutrophication Potential |
| FW | Use of net Fresh Water |
| GaBi | Ganzheitliche Bilanzierung (German for holistic balancing) |
| GHG | Greenhouse Gas |
| GWP | Global Warming Potential |
| HWD | Hazardous Waste Disposed |
| IBU | Institut Bauen und Umwelt e.V. (Institute of Construction and Environment) |
| ILCD | International Cycle Data System |
| ISO | International Organization for Standardization |
| LCA | Life Cycle Assessment |
| LCI | Life Cycle Inventory |
| LCIA | Life Cycle Impact Assessment |
| MER | Materials for Energy Recovery |
| MFR | Materials for Recycling |
| NHWD | Non Hazardous Waste Disposed |
| NMVOC | Non-Methane Volatile Organic Compound |
| NRSF | Use of Non-renewable Secondary Fuels |
| ODP | Ozone Depletion Potential |
| PCR | Product Category Rules |
| 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 |
| POCP | Photochemical Ozone Creation Potential |
| R1-value | Factor for the efficiency evaluation of a waste incineration plant according European Waste Framework Directive |
| RSF | Use of Renewable Secondary Fuels |
| RSL | Reference Service Life |
| RWD | Radioactive Waste Disposed |
| SM | Use of Secondary Material |
| VOC | Volatile Organic Compound |
| WIP | Waste Incineration Plant |

| Abbreviation (EN 15804+A2) | Explanation |
|---|---|
| ADPE | Abiotic depletion potential (element) |
| ADPF | Abiotic depletion potential (fossil) |
| AP | Acidification terrestrial and freshwater |
| CRU | Components for re-use |
| EEE | Exported electrical energy |
| EET | Exported thermal energy |
| EP - freshwater | Eutrophication potential (freshwater) |
| EP - marine | Eutrophication potential (marine) |
| EP- terrestric | Eutrophication potential (terrestrial) |
| ETF-fw | Eco-toxicity (freshwater) |
| FW | Use of net fresh water |
| GWP - biogenic | Global warming potential (biogenic) |
| GWP - fossil | Global warming potential (fossil fuel only) |
| GWP - luluc | Global warming potential (land use only) |
| GWP - total | Global warming potential |
| HTP-c | Human toxicity, cancer effects |
| HTP-nc | Human toxicity, non-cancer effects |
| HWD | Hazardous waste disposed |
| IR | Ionizing radiation, human health |
| MER | Materials for energy recovery |

| | |
|---|---|
| MFR | Materials for recycling |
| NHWD | Non hazardous waste disposed |
| NRSF | Use of non renewable secondary fuels |
| ODP | Ozone 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 |
| PM | Particulate matter emissions |
| POCP | Photochemical ozone formation |
| RSF | Use of renewable secondary fuels |
| RWD | Radioactive waste disposed |
| SM | Use of secondary material |
| SQP | Soil quality potential/ Land use related impacts |
| WDP | Water deprivation potential |

# 1. General Information

This document is the “Life cycle Assessment” (LCA) report of VAPOR EVO 190.

The owner of the LCA is Rothoblaas s.r.l.

This document shows how the calculation rules were applied and details the background requirements for the Life Cycle Assessment in accordance with /EN 15804+A2/. This LCA study does not support any reference EPD even though the results are based on /EN 15804+A2/ and no EPD has been verified for the product under study. At the time of the analysis the product had not been produced yet by the producer company.

The present LCA study of Rothoblaas s.r.l. (IT) has been performed by the external practitioner Sphera AG.

# 2. Goal and Scope

## 2.1. Goal of the study

The reason to perform this study is to conduct a Life Cycle Assessment of VAPOR EVO 190. At the time of the analysis the product had not yet been produced by the company.Rothoblaas s.r.l.

The study has been conducted according to ISO 14040/44, the international standards on life cycle assessment (LCA). This LCA study does not support any reference EPDs even though the results were based on /EN 15804+A2/.

The LCA was conducted:

1. To understand the environmental performance of VAPOR EVO 190 production;
2. To identify areas with high potential for improvement of environmental sustainability performance;
3. To respond to customer requests for environmental information.

## 2.2. Products description

VAPOR EVO 190 is realized both as plain membranes (that during installation are being joined together by means of metal clips and adhesive tape) and with double tape (the so-called “TT” version) that means that during production a dedicate adhesive tape is added to the product so that during installation the adhesive component is already part of the membrane. As the bill of material is the same apart from some added adhesive component, the “TT” version with double tape is taken as representative of the product (conservative choice) as also shown in tables with comparative results.

Table 2-1: Product under study

| Products | Versions included | Representative version |
|---|---|---|
| VAPOR EVO 190 | Standard and with double tape (also named as "TT") both 1.5m *50m | Double tape version |

### 2.2.1. Technical data

In the table below the technical properties of the products under study.

Table 2-2: Technical properties

| | | | VAPOR EVO 190 |
|---|---|---|---|
| Monolithic/Evo | | | ✓ |
| Microporous/Standard | | | |
| Bituminous | | | |
| | | | |
| Reinforcing grid | | | |
| Variable Sd | | | |
| Reflective | | | |
| Self-adhesive | | | |
| Permanent UV stability | | | |
| | | | |
| | Mass per unit area [EN 1849] | g/m2 | 190 |
| | Water vapour transmission (Sd) [EN 1931] | m | 5 |
| | Reaction to fire [EN 13501-1] | steel | E |
| | Maximum tensile force MD/CD [EN 12311] | N/50mm | 480<br>500 |
| | Elongation MD/CD [EN 12311] | % | 65<br>65 |
| | Resistance to nail tearing MD/CD [EN 12310] | N | 265<br>320 |
| | | | |
| ? | internal | | ✓ |
| | external | | ✓ |
| | roof | | ✓ |
| | wall | | ✓ |
| Waste classification (2014/955/EU) | | | 17 02 03 |

## 2.3. Application area

The above-mentioned products can be for internal or external use, both for roof and wall application.

## 2.4. Production process

### 2.4.1. ROTHOBLAAS PLANT

Rothoblaas is a multinational Italian company that has made innovative technology its mission, making its way to the forefront for timber buildings and construction safety in just a few years. Thanks to its comprehensive product range and the technically-prepared and widespread sales network, the company promotes the transfer of its knowhow to the customers and aims to be a prominent and reliable partner in developing and innovating products and building methods. All of this contributes to a new culture of sustainable construction, focused on increasing comfortable living and reducing CO2 emissions.

## 2.5. Functional unit and reference flow

The functional unit is defined as 1 $m^2$ of membrane as described in the Table 2-3.

In the Table 2-3 the functional unit and conversion factor to 1 kg are shown and in Table 2-4 the products' area are indicated.

Table 2-3: Reference flow

| Functional unit – reference flow | Mass [kg/FU] | FU [$m^2$][1] | Conversion factor di 1 kg |
|---|---|---|---|
| VAPOR EVO 190 | 0.219 | 1 | 4,6 |

Table 2-4: Products rolls areas

| Product | Height [m] | Length [m] | Membrane area [m2] |
|---|---|---|---|
| VAPOR EVO 190 | 1.5 | 50 | 75 |

[1] Functional unit does not include packaging.

## 2.6. Scope of the study

In the EPD the following life cycle stages are considered:

- Production
- Installation
- Use stage
- End-of-life
- Benefits and loads beyond the product system boundary

The system boundary of the EPD follows the modular design defined by /EN 15804+A2/. The table below identifies the modules included in this study:

Table 2-5: Modules of the production life cycle included in the EPD (X = declared module; MND = module not declared)

| Production | | | Installation | | Use stage | | | | | | | End-of-Life | | | | Next product system |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Raw material supply (extraction, processing, recycled material) | Transport to manufacturer | Manufacturing | Transport to building site | Installation into building | Use / application | Maintenance | Repair | Replacement | Refurbishment | Operational energy use | Operational water use | Deconstruction / demolition | Transport to EoL | Waste processing for reuse, recovery or recycling | Disposal | Reuse, recovery or recycling potential |
| A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
| X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

Impacts and aspects related to waste are considered in the module in which the waste occurs.

The system boundaries are chosen that way, that material and energy offering processes, the following manufacturing processes and transport processes as well as the treatment of all involved wastes are part of the system.

## 2.7. Reference service life

The reference service life time amounts to 50 years /RLS/. There is not a specific rule on reference service life for membranes, but we assume same reference service life as the building roof.

## 2.8. Data collection for the foreground system

Data on membrane production [A1] are collected by the supplier and because of confidentiality agreements all primary data and information are included in a confidential annex.

Data on storage, additional packaging, distribution to client and installation [A2-A3-A4-A5-B-C-D] are collected by Rothoblaas s.r.l.

For the data collection a specifically by Sphera prepared questionnaire is applied.

The collection of the foreground data refer to the year 2019.

The data acquisition was done by the supplier and Rothoblaas considering the following data sources:

- Measurements of technical machines/equipment, in particular electrical consumption of production lines
- Bill of materials
- Wastes registers.

## 2.9. Allocation and Recycling

### 2.9.1. Allocation of background data

Information about single datasets is documented in http://database-documentation.gabi-software.com/support/gabi/.

### 2.9.2. Allocation in the foreground data – Rothoblaas

Allocation approach listed below refers to the Rothoblaas activities. The overall set of products sold by Rothoblaas comprises further products beside the product considered in this study. Data for thermal and electrical energy as well as auxiliary material and wastes refer to the complete company portfolio that includes tapes and sealants, roof and ventilation element, membranes and tools. Once an allocation factor based on the mass has been applied to separate the membranes products from the overall portfolio, a second allocation based on mass has been performed so to consumption/waste for 1 kg of product sold. As last step the allocated value is then multiplied by the specific product grammage in order to get the consumption/waste related to the functional unit (1 m$^2$).

Table 2-6: Mass allocation

| | | Comment |
|---|---|---|
| Overall portfolio mass | 9'474'238.00 [kg/year] | |
| Membranes mass | 1'600'147 [kg/year] | |
| Percentage of membranes on all portfolio in mass | 1'600'147/9'474'238<br>16.9 % | Membranes mass percentage raised by bitumen-based products |

Table 2-7: Allocation based on 1 kg of membranes sold

| | Membranes sold |
|---|---|
| Membranes sold | 1'600'147 [kg] |
| Allocation factor based on kg sold | 1/1'600'147 kg=6.25E-07 1/ kg |

### 2.9.3. Allocation for energy consumption– Rothoblaas

Rothoblass is not able to measure the electricity in different areas, then an allocation has been done, as described above (a first allocation based on membranes turnover and a second allocation by mass). Rothoblaas does have photovoltaic panels and produces electrical energy that entirely consumes (see details in chapter 3.3)

Table 2-8: Electrical Energy allocation

| | Overall Plant [kwh/year] | Only Membranes [kwh] | [kwh/ kg] |
|---|---|---|---|
| Electrical consumption | 494'102 | 494'102*16.9/100=83'451.13 | 83'451.13*6.25E-07 =0.0521 |

Table 2-9: Natural gas allocation

| | Overall Plant [Sm³/year] | Only Membranes [Sm³] | [Sm³/kg] | [kg/kg] |
|---|---|---|---|---|
| Natural gas consumption | 16'378 | 16'378*16.9/100= 2'766.15 | 2'766.15*6.25E-07 =0.00173 | =0.00173/1.055*(1/1.2446)= 0.00132 |

### 2.9.4. Allocation for waste materials– Rothoblaas

Rothoblass is not able to allocate the waste production to different areas, then an allocation has been done, as described below (a first allocation based on membranes turnover and a second allocation by mass). Production waste is mainly packaging waste (following statistical percentages) and exhausted batteries (sent to hazardous wastes treatment plant). Wastes not linked to membranes are not included.

Table 2-10: Wastes allocation

| | Overall Plant [kg/year] | Only Membranes [kg/year] | [kg/kg] |
|---|---|---|---|
| Paper and cardboard | 55'460 | 55'460*16.9/100= 9'366.89 | 9'366.89*6.25E-07 =5.85E-03 |
| Wooden pallets | 62'320 | 62'320*16.9/100= 10'525.51 | 10'525.51*6.25E-07 =6.58E-03 |
| Packaging plastic | 12'760 | 12'760*16.9/100= 2'155.09 | 2'155.09*6.25E-07 =1.35E-03 |
| Exhausted batteries | 1'457,14 | 1'457.14*16.9/100=246.10 | 246.10*6.25E-07=1.54E-04 |

All applied incineration processes are displayed via a partial stream consideration for the combustion process, according to the specific composition of the incinerated material. For the waste incineration plant an R1-value >0.6 is assumed. the potential benefits for thermal and electrical energy have been calculated via inversion of the life cycle inventory of European average data.

The environmental burden of the product in the end of life scenario are assigned to the system (C3).

The resulting potential benefits for thermal and electrical energy are declared in module D. A waste incineration plant with an R1 value >0.6 is assumed (as the R value is unknown for the chosen datasets).

The potential benefits from recovering thermal and electrical energy are calculated via inversion of the life cycle inventory of European average data.

The environmental burden of the incineration of packaging and the product in the end of life scenario are assigned to the system (A5 or C4); resulting potential benefits for thermal and electrical energy are declared in module D.

### 2.9.5. Allocation for packaging– Rothoblaas

Rothoblaas adds additional packaging when the pallets from suppliers are not sold as they are. Amount of acquired packaging is available as yearly annual consumption and it has been allocated based on mass as for waste and energy consumption. In the table below allocation steps are shown:

Table 2-11: Packaging allocation

| | Overall Plant [kg/year] | Only Membranes [kg/year] | [kg/kg] |
|---|---|---|---|
| Paper and cardboard | 0 | 0 | 0 |
| Wooden pallets [only 120*80 cm] | 67'878 | 67'878*16.9/100= 11’464.14 | 11’464.14*6.25E-07 =7.16E-03 |
| PE Packaging | 2'523 | 2'523*16.9/100= 426.12 | 426.12*6.25E-07 =2.66E-04 |
| PET Packaging | 2'670 | 2'670*16.9/100=451 | 451*6.25E-07=2.82E-04 |

### 2.9.6. Allocation for waste paper– Rothoblaas

Paper/corrugated board is used as packaging material and this usually includes a mix of recycled and virgin fibres. In accordance with /EN 15804+A2/ no impacts have been allocated to the scrap paper production that is used in the paper production process.

When modelling the production of paper, the scrap paper that is used in this process has been assumed to be burden free. Similarly, waste paper arising in the product life cycle is assumed to be recycled. Robust data on paper and cardboard recycling are not promptly and refer to a very complex system. Hence, to apply this methodology consistently throughout the model, a cut-off approach has been applied. I.e., input of waste paper is considered without environmental burden, resulting waste paper is not credited. The recycling process and the production process of paper are merged in the production process. The C-balance referring to fresh fibre is corrected via CO2 emissions (biotic) (assumption of final rotting or incineration in the time frame of 100 years).

### 2.9.7. Recycling

Material recycling: Open scrap inputs from the production stage are subtracted from scrap to be recycled at end of life to give the net scrap output from the product life cycle. This remaining net scrap is sent to material recycling. The original burden of the primary material input is allocated between the current and subsequent life cycle using the mass of recovered secondary material to scale the substituted primary material, i.e., the potential benefits from the substitution of primary material are calculated so as to distribute burdens appropriately among different product life cycles and are assigned to module D. These subsequent process steps are modelled using industry average inventories.

In case of polypropylene-based materials, that are mainly coloured, as a 5% pigment has been assumed, the avoided burden has been calculated only on the 95% pure polypropylene percentage. For other polymers an 100% avoided burden is considered for the recycling scenario.

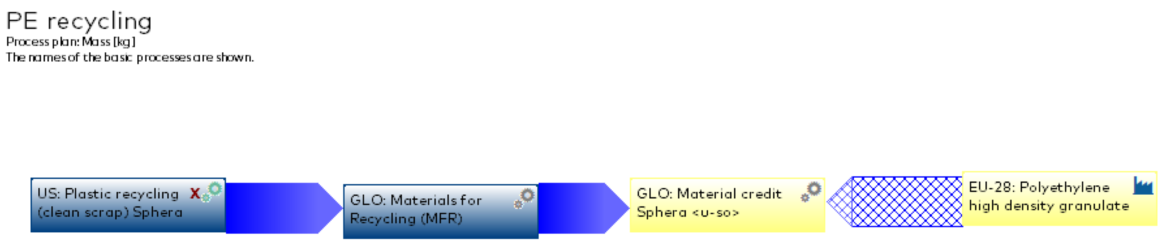



Figure 1: Scheme displaying the methodological approach for the recycling (PE end of life)

## 2.10. Cut-off criteria

In the assessment, all available data from production process are considered, i.e. all raw materials used, utilised thermal energy, and electric power consumption using best available LCI datasets. Only wastes not considered are tones as far below <1% of the functional unit mass involved.

Production of capital equipment, facilities and infrastructure required for manufacture are outside the scope of this assessment, together with wastes linked to activities not related to membranes.

## 2.11. Assumptions and approximations

Where possible, a conservative approach has been adopted, overestimating burdens to prove irrelevance. In other cases, proxy data were selected based on scientific experience, in order to improve the accuracy of the model. Where it was not possible to know the precise composition of materials in the supply chain (due to commercial or industrial confidential suppliers' reasons or due to missing datasets), these have been approximated with LCIs of similar materials, estimated by the combination of available dataset or reconstructed with literature data.

1. Lead batteries have been taken into account as a conservative choice
2. Where potential benefits from energy recovery in A5 and C modules are considered, for rest of world countries (other than Europe) these are calculated based on the European grid mix
3. For boilers (natural gas fed) an efficiency factor equal to 0,95 is considered
4. For distribution an estimated distance of 500 km by truck is added to the transport via ship (whose distance (6520 km) is taken from the /PCR: CERAMIC TILES AND PANELS/ for countries belonging to Rest of Wold area). For European countries the distance is calculated as distance between Rothoblaas plant and the capital city.
5. The functional unit is defined without packaging
6. In case of transports on truck where the payload was neither available nor conceivable, utilization factor of 0,61 has been considered (empty way back)
7. For the polypropylene-based textile material, mainly coloured, a 5% pigment is assumed (as no precise composition was available). In case of black textile a 10% carbon black is used
8. PET band amount as additional packaging added by Rothoblaas is assumed to be 50 g per pallet

9. When a specific distribution scenario (A4) were unavailable, a scenario of a similar product has been considered
10. For end of life scenarios, as Building&Construction update percentage for Italy did only consider the overall recovery percentage, not distinguishing between recycling and energy recovery, the relative proportion has been assumed to be the same as in /ISPRA/ containing specific information for 2010.
11. We assume that supplier packaging waste are raw materials' packaging and they are also input in the manufacturing process.
12. Distance to disposal site after demolition is assumed to be 100 km

Table 2-12: Declared substances and GaBi LCI approximations

| Declared substances | GaBi LCI as approximation |
|---|---|
| TECHNOMELT PS 8528 | Hot-melt based on EVA (estimation) |
| Printing ink white | 89.75% Titanium dioxide<br>0.25% Ammonia<br>10% Ethanol |
| Pigment grey in Polypropylene textiles | 50% Titanium dioxide<br>50% carbon black |
| Pigment black in Polypropylene textiles | 100% Carbon black |

## 2.12. Software and database

The LCA model is created using the GaBi ts Software system for life cycle engineering, developed by Sphera AG. The GaBi LCI database /GABI TS/ provides the life cycle inventory data for several of the raw and process materials obtained from the background system. The most recent of the database was 2021.

## 2.13. Data quality

The foreground data collected by the manufacturer are based on yearly production amounts and extrapolations of measurements on specific machines and plants. The production data refer to an average of the year 2019.

The necessary life cycle inventories for the basic materials (assumptions in chapter 2.11) are available in the GaBi ts database /GABI TS/. The last update of the database was 2021.

Further LCIs for materials of the supply chain of the basic materials are approximated with LCIs of similar materials or estimated by the combination of available LCIs (Table 2-12).

### 2.13.1. Representativeness

Technological: All primary and secondary data are modelled to be specific to the technologies or technology mixes under study. Where technology-specific data are unavailable, proxy data are used (see chapter 2.11). Technological representativeness is considered to be good.

Geographical: All primary and secondary data are collected specific to the countries / regions under study. Where country / region specific data are unavailable, proxy data are used. Geographical representativeness is considered to be good.

Temporal: All primary data are collected for the year 2019. All secondary data come from the GaBi 2021 databases and are representative of the years 2020-2023. As the study intended to compare the product systems for the reference year 2019, temporal representativeness is good.

### 2.13.2. Completeness

All relevant process steps are considered and modelled to represent the specific situations. The process chain is considered sufficiently complete with regard to the goal and scope of this study. Omitted material and energy flows are described in chapter 2.10 and 2.11.

### 2.13.3. Reliability

Primary data are collected by SUPPLIER'S supplier and Rothoblaas using a specifically adapted spreadsheet for all studied products. The Sphera AG supported the data collection by preparing a specific questionnaire, an on-site meeting and support by phone.

Cross-checks concerning the plausibility of mass and energy flows are carried out on the data received. Similar checks are made on the software model developed during the study.

Overall the data quality can be described as good. The primary data collection has been done thoroughly, all relevant flows are considered.

### 2.13.4. Consistency

To ensure consistency, all primary data are collected with the same level of detail, while all background data are sourced from the GaBi databases. Allocation and other methodological choices are made consistently throughout the model.

# 3. Life cycle inventory (LCI) analysis

In the following chapters the software model is described with screenshots and respective explanations. The life cycle impact assessment resulting from the life cycle inventory is displayed in chapter 4 of this report.

## 3.1. Overview on the GaBi Software model

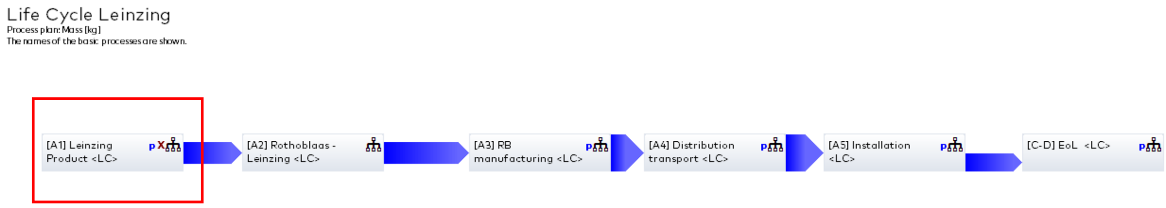
A software model is generated with the GaBi software. The software model is a mathematical algorithm, which covers all potential input and output flows for material and energy for the considered scenarios.

Figure 2 displays the highest level of plan hierarchy in the software model.

The reference quantity is 1 $m^2$ of membrane.

In the following chapters details and single parts are explained. The used background datasets are listed in 3.9.

Figure 2: GaBi plan for the life cycle of the product




Because of confidentiality agreements all details on membrane production (see red square) are included in a confidential annex.

## 3.2. Production - Module A1

### 3.2.1. Membranes production (supplier)

Because of confidentiality issue membrane foreground data are included in a confidential annex.

### 3.2.2. Electricity (Rothoblaas)

Rothoblaas does have PV panels whose electricity is self-consumed. Only exceeding amount is sent to grid based, as shown in table below.

Table 3-1: A1 Electricity mix and yearly need

| | [kWh/year] | Comment |
|---|---|---|
| Electricity need [A] | 494’102 | [A] = [B] + [C] |
| Electricity from grid [B] | 343’144 | |

| | | |
|---|---|---|
| Electricity produced by PV panels - total | 195’714 | Base for impact calculation of electricity from PV |
| Of which self-consumed [C] | 150’958 | Self-consumed not sent to grid |
| Of which sent to grid | 44'756 | |

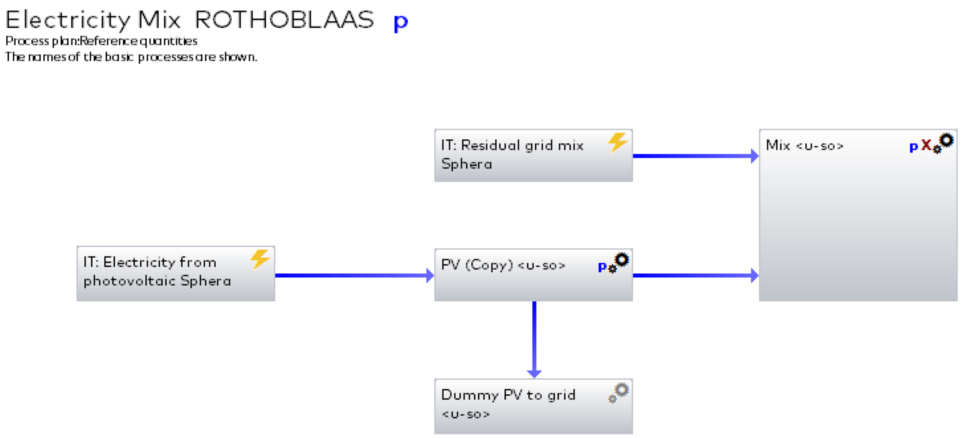



Figure 3: GaBi plan for electricity mix in Rothoblaas

## 3.3. Production - Module A3

The Figure 4 shows the GaBi plan of the manufacturing process.

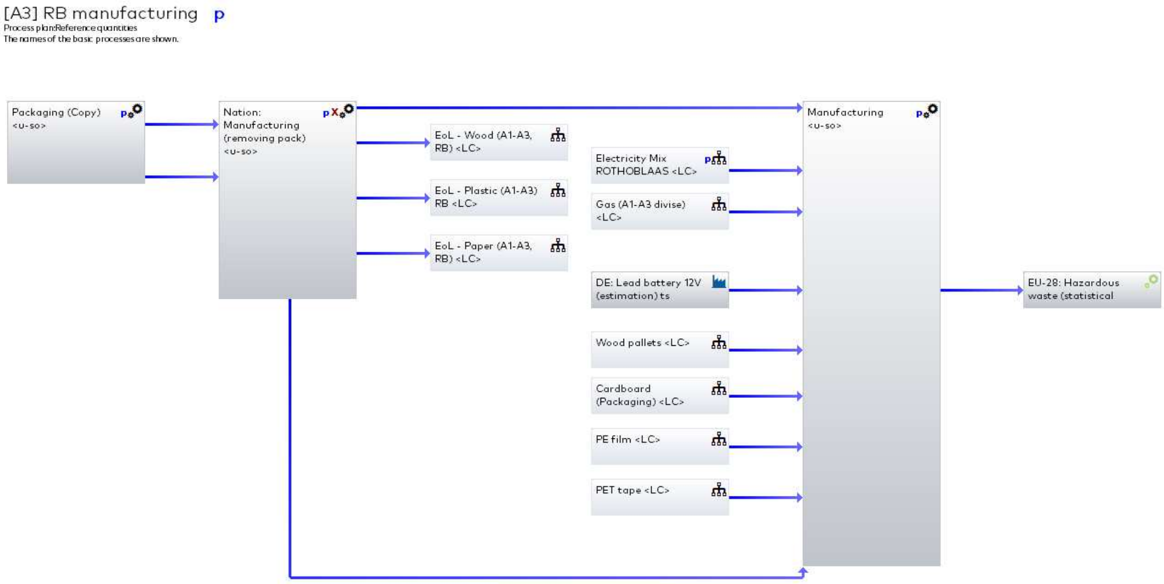



Figure 4: GaBi plan for the storage and additional packaging

Rothoblaas distributes membranes produced by SUPPLIER'S supplier and, based on the clients' requirements, add some additional packaging to the one provided by the supplier or not. Rothoblaas activities consist of:

- Removing supplier packaging, entirely or only partially
- Adding additional packaging
- Keeping goods in the warehouse
- Using forklifts for goods moving
- Prepare goods for delivery to client.

For detailed description on transport processes see chapter 3.4.

## 3.4. Transport processes – integrated in module A2, A4 and C1

Transport processes for the basic material, i.e. the delivery to supplier in CENTRAL EUROPE is considered in module A1, while the transport of membranes from the supplier in CENTRAL EUROPE to Rothoblaas warehouse in Cortaccia Bolzano (Italy) is accounted in A2. The transport for the disposal of production waste is integrated in module A1 while transport for warehouse wastes to disposal site is in A2.

The environmental burdens of transport of the packaged product, i.e. from the Rothoblaas warehouse in Cortaccaia (Bolzano) to the construction site are assigned to module A4.

Table 3-2: A2 Transport distances – transport from SUPPLIER'S supplier to Rothoblaas

| Transport distances | | | |
|---|---|---|---|
| Material | Sea transport [km] | Truck transport [km] | Rail transport [km] |
| VAPOR EVO 190 | 0 | 384 | 0 |

In the table below the distribution scenario is shown for the studied product both in terms of percentage distribution to Italy and Europe (the complementary percentage is considered to be Rest of Wold) and in terms of average distances. For assumptions on distances calculation see chapter Assumptions and approximations.

Table 3-3: A4 Transport distances and distribution percentages

| Product | IT | EU | Truck [km] | Ship [km] |
|---|---|---|---|---|
| VAPOR EVO 190 | 80% | 10% | 758 | 652 |

In the GaBi software model, generic LCIs for transport processes are chosen and adapted respectively:

- Truck, Euro 5, more than 32t gross weight / 24.7t payload capacity, 61% average utilisation by mass; fuel type: diesel.

This dataset is used for raw material transport.

As for distribution dataset used are the following (see Figure 5 below):

- Sea transport: Container ship, 5,000 to 200,000 dwt payload capacity, ocean going, 48% average utilisation, fuel type: heavy fuel oil
- Truck, Euro 5, up to 28t gross weight / 12.4t payload capacity, 61% average utilisation by mass; fuel type: diesel.

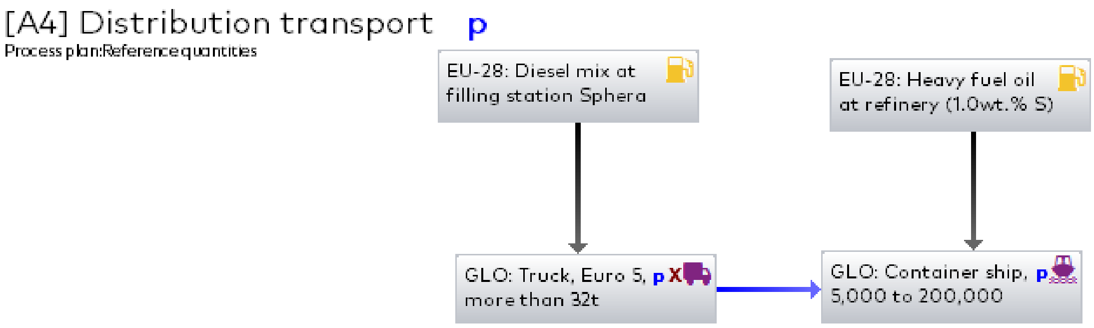



Figure 5: GaBi plan for distribution

## 3.5. Packaging – integrated in Module A1-A3

As documented by the logistics department, 66.5% of the pallets are sold as they are received from the supplier, without any changes on the packaging. For the remaining cases an additional packaging is added and the amount is available as primary data referring to packaging materials bought in 2019. Allocation has been performed as described at chapter 2.9.5. Model automatically multiplies the packaging amount related to 1 kg of product for the product grammage to get the packaging value for 1 m² of membrane.

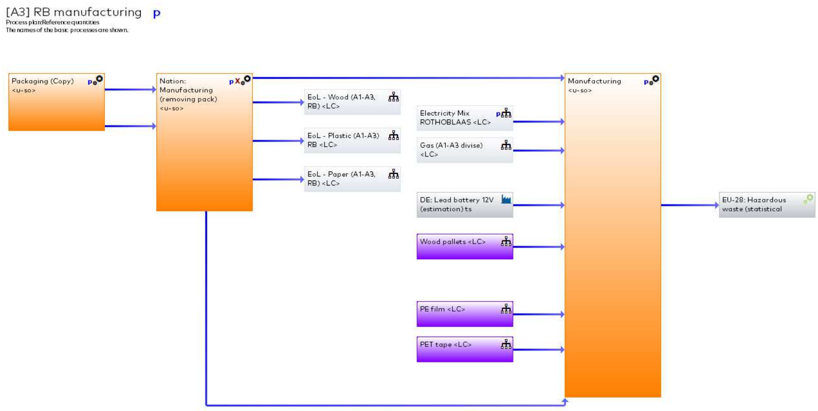



Figure 6: GaBi plan for additional packaging (in purple additional packaging)

In the Table 3-4 a synthesis of the final packaging:

Table 3-4: Final product packaging

| Material | Final packaging |
|---|---|
| Wooden pallet | 66.5/100*Wood Supplier packaging + Rothoblaas wood packaging |
| PE film packaging | PE Supplier packaging + Rothoblaas PE packaging |
| PET film packaging | 66.5/100* PET Supplier packaging + Rothoblaas PET packaging |
| Cardboard packaging | 66.5/100* Cardboard Supplier packaging |

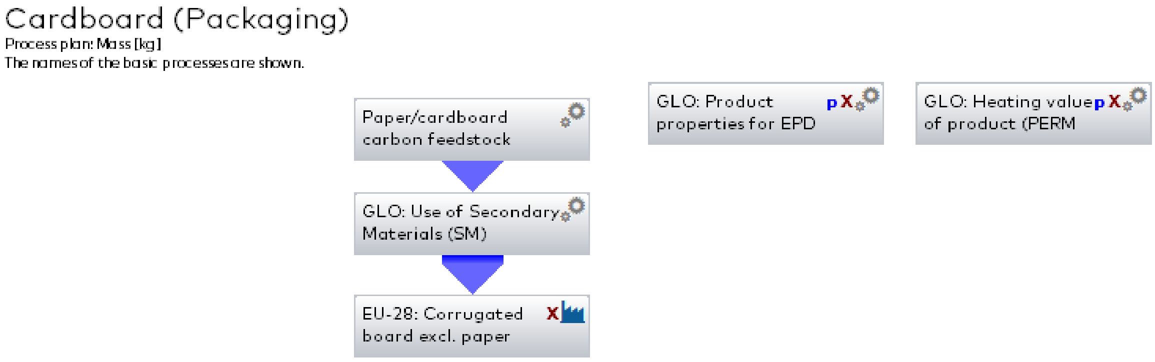



Figure 7: GaBi plan of cardboard packaging process

The methodological approach regarding modelling of paper/cardboard is explained in chapter 2.11.

## 3.6. Installation –Module A5

The membrane installation requires only steel clips as the “TT” version with double tape is taken as representative product for both standard and TT version (that means that during production a dedicate adhesive tape is added to the product so that during installation the adhesive component is already part of the membrane).

Neither water nor electrical energy is used to install the products. A 10% scrap is considered in the installation phase that means that an additional 10% product is added and related impact contribution belongs to the installation phase.

Table 3-5: Installation

| Installation | | |
|---|---|---|
| Material | Amount | Note |
| Stainless steel clips | 0.10 g/m$^2$ | For all products |

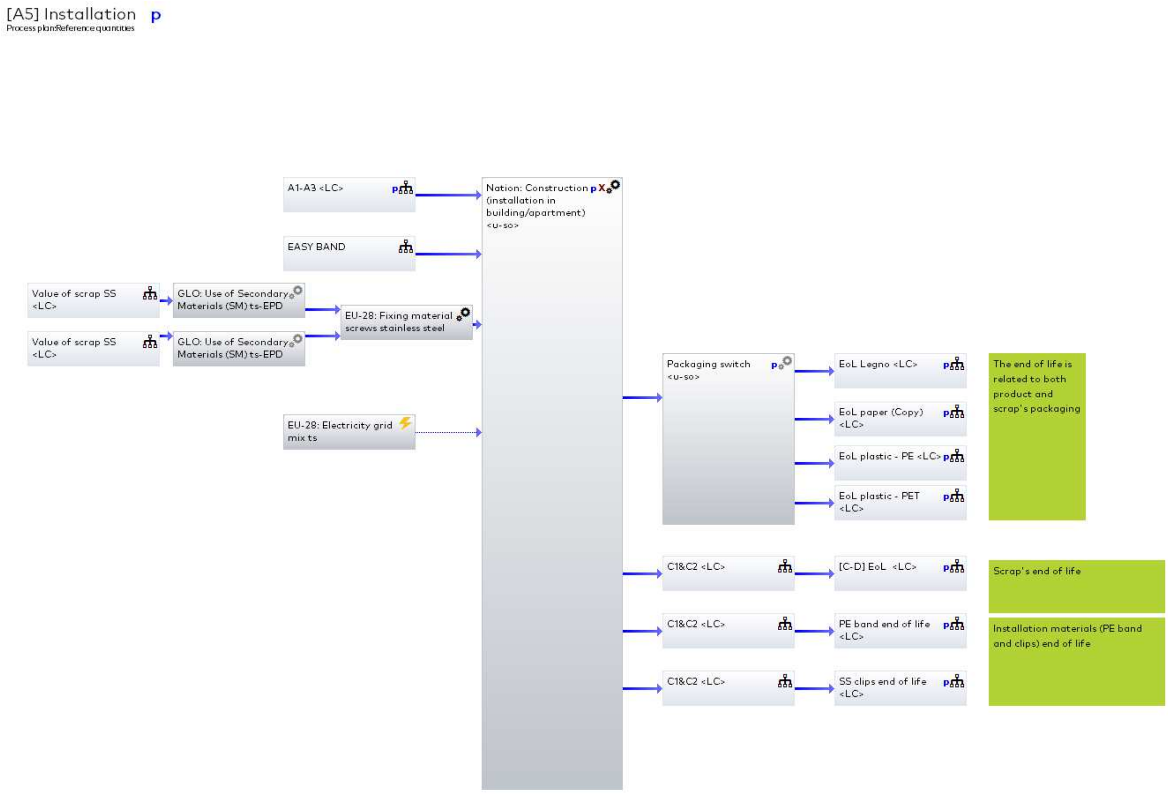



Figure 8: GaBi plan for the installation

## 3.7. Use stage – Module B1-B7

Operational use for the membranes under study is not relevant and no maintenance is required along the reference service life of the membranes equal to 50 years (same as the building). Impact coming from B modules is assumed to be irrelevant.

## 3.8. End-of-Life scenario and benefits for the next system – Module C and D

The end of life stage refers to four EPD modules: C1, C2, C3, C4, and module D, which collect all resulting loads and recycling potentials arising within the studied system. For coloured polypropylene-based materials (whose pigment content has been assumed to be 5% of the overall amount) the avoided burden due to recycling has been calculated only on the polypropylene amount, while the recycling impact linked to the regranulation process has been assigned to the whole amount.

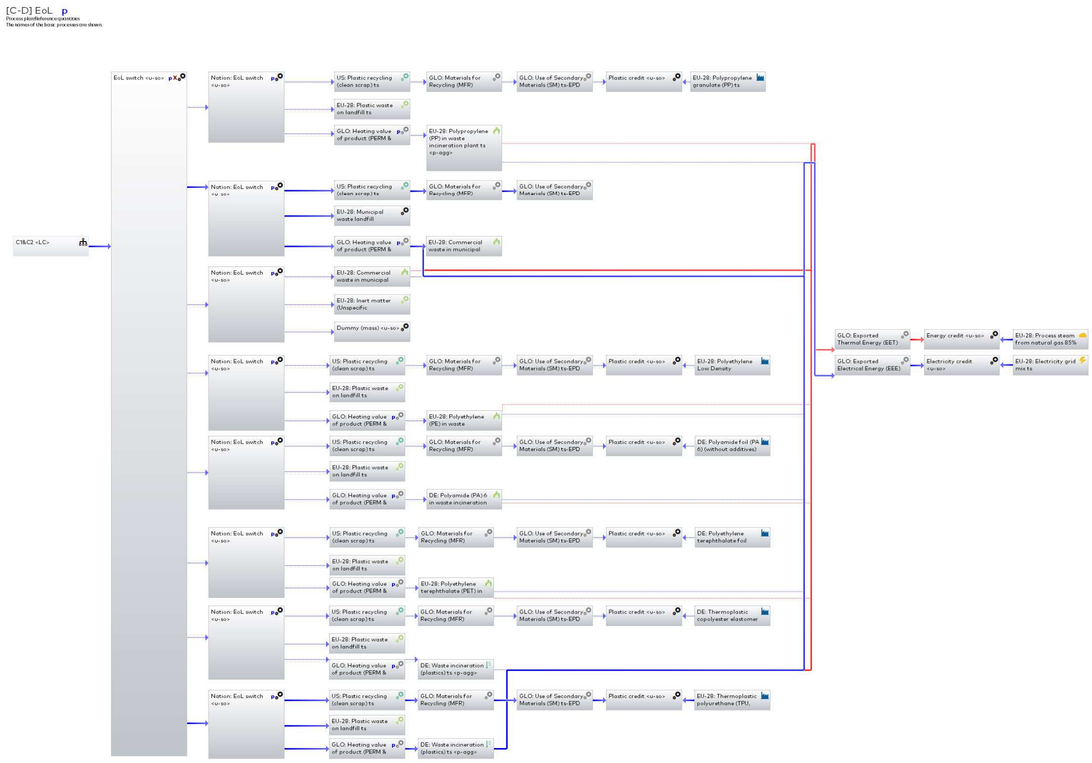


Figure 9: GaBi plan for the end-of-life scenario

For end of life scenarios, statistics data have been considered related to Building&Construction wastes for Italy and Europe and percentages have been calculated as weighted average of the product sold in Italy, Europe and Rest of World. For countries outside Europe a conservative scenario has been considered (100% landfill).

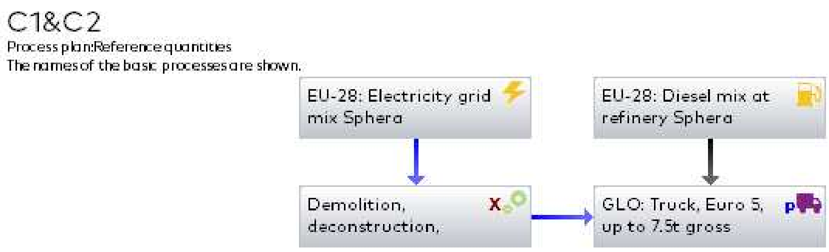



Figure 10: GaBi plan for C1 and C2 modules

Table 3-6: End of life scenarios for plastics

| Scenario | Italy | Europe | Rest of World |
|---|---|---|---|
| Source | /PLASTIC EUROPE (2010)/ /ISPRA/ | / PLASTIC WASTE FROM B&C IN EU 2018 / | / |
| Recycling | 12.5[2]/16.2[3]*36%=28% | 26% | 0 |
| Incineration | 3.7[4]/16.2*36%=8% | 47.5% | 0 |
| Landfill | 64% | 26.5% | 100% |

## 3.9. Background datasets used in the LCA model

In the table below, the background datasets used in the model.

Table 3-7: Background datasets

[2] Recycling percentage for B&C waste in Italy /PLASTIC EUROPE (2010)/

[3] Recycling + Energy recovery for B&C waste in Italy /PLASTIC EUROPE (2010)/

[4] Energy recovery for B&C waste in Italy /PLASTIC EUROPE (2010)/

| Background datasets | | | | | | |
|---|---|---|---|---|---|---|
| Reference year | Owner of the data set | Nation | Object name without nation | Technological representativeness | Time representativeness | Geographical representative-ness |
| 2019 | Sphera Solutions GmbH | DE | Ammonia (high purity) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | DE | BF Steel billet / slab / bloom | vg | g | vg |
| 2020 | Sphera Solutions GmbH | DE | Carbon black (furnace black; deep black pigment) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Commercial waste in municipal waste incineration plant | vg | g | vg |
| 2020 | Sphera Solutions GmbH | GLO | Compounding (plastics) | vg | g | vg |
| 2017 | Sphera Solutions GmbH | GLO | Compressed air 7 bar (medium power consumption) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | GLO | Container ship, 5,000 to 200,000 dwt payload capacity, ocean going | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Corrugated board excl. paper production (2018), open paper input, average composition | vg | g | vg |
| 2016 | Sphera Solutions GmbH | EU-28 | Diesel at refinery | vg | g | vg |
| 2017 | Sphera Solutions GmbH | EU-28 | Diesel mix at filling station | vg | g | vg |
| 2017 | Sphera Solutions GmbH | EU-28 | Diesel mix at refinery | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Glass/inert waste on landfill | vg | g | vg |
| 2020 | Sphera Solutions GmbH | DE | EAF Steel billet / Slab / Bloom | vg | g | vg |

| Background datasets | | | | | | |
|---|---|---|---|---|---|---|
| Reference year | Owner of the data set | Nation | Object name without nation | Technological representativeness | Time representativeness | Geographical representative-ness |
| 2020 | Sphera Solutions GmbH | GLO | Electricity credit | vg | g | vg |
| 2017 | Sphera Solutions GmbH | IT | Electricity from photovoltaic | vg | g | vg |
| 2017 | Sphera Solutions GmbH | EU-28 | Electricity grid mix | vg | g | vg |
| 2019 | Sphera Solutions GmbH | EU-28 | Ethanol (96%) (hydrogenation with nitric acid) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Ferro metals on landfill | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Fixing material screws stainless steel (EN15804 A1-A3) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Hazardous waste (statistical av-erage) (C rich, worst case sce-nario incl. landfill) | vg | g | vg |
| 2017 | Sphera Solutions GmbH | EU-28 | Heavy fuel oil at refinery (1.0wt.% S) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Hot-melt based on EVA (estima-tion) {0434e648-1abc-44fd-9fac-59834f6e345d} | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Inert matter (Unspecific con-struction waste) on landfill | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Kraftliner (2018) - for use in avoided burden EoL scenario cases | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Kraftliner (2018) - for use in cut-off EoL scenario cases | vg | g | vg |
| 2019 | Sphera Solutions GmbH | DE | Lead battery 12V (estimation) | vg | g | vg |

| Background datasets | | | | | | |
|---|---|---|---|---|---|---|
| Reference year | Owner of the data set | Nation | Object name without nation | Technological representativeness | Time representativeness | Geographical representative-ness |
| 2017 | Sphera Solutions GmbH | EU-28 | Lubricants at refinery | vg | g | vg |
| 2019 | Sphera Solutions GmbH | EU-28 | Methylene diisocyanate (MDI) by-product hydrochloric acid, methanol (estimate) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Municipal waste landfill (EN15804 C4) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Commercial waste (AT, DE, IT, LU, NL, SE, CH) on landfill | vg | g | vg |
| 2017 | Sphera Solutions GmbH | IT | Natural gas mix | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Paper and board (water 0%) in waste incineration plant | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Paper waste on landfill | vg | g | vg |
| 2020 | Sphera Solutions GmbH | GLO | Plastic extrusion profile (unspecific) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Plastic granulate secondary (low metal contamination) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Plastic granulate secondary (no metal contamination) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | GLO | Plastic injection moulding (parameterized) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Plastic packaging in municipal waste incineration plant | vg | g | vg |
| 2020 | Sphera Solutions GmbH | US | Plastic recycling (clean scrap) | vg | g | vg |

| Background datasets | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Reference year | Owner of the data set | Nation | Object name without nation | Technological representativeness | Time representativeness | Geographical representative-ness |
| 2019 | Sphera Solutions GmbH | DE | Plastic Waste Incineration Plant | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Plastic waste on landfill | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Polyethylene (PE) in waste in-cineration plant | vg | g | vg |
| 2019 | Sphera Solutions GmbH | EU-28 | Polyethylene Film (PE-LD) with-out additives | vg | g | vg |
| 2019 | Sphera Solutions GmbH | EU-28 | Polyethylene high density gran-ulate (HDPE/PE-HD) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Polyethylene Low Density Gran-ulate (LDPE/PE-LD) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Polyethylene terephthalate (PET) in waste incineration plant | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Polyethylene terephthalate fi-bres (PET) | vg | g | vg |
| 2019 | Sphera Solutions GmbH | DE | Polyethylene terephthalate foil (PET) (without additives) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Polypropylene (PP) in waste in-cineration plant | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Polypropylene fibers (PP) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | DE | Polypropylene Film (PP) without additives | vg | g | vg |
| 2019 | Sphera Solutions GmbH | EU-28 | Polypropylene granulate (PP) | vg | g | vg |

| Background datasets | | | | | | |
|---|---|---|---|---|---|---|
| Reference year | Owner of the data set | Nation | Object name without nation | Technological representativeness | Time representativeness | Geographical representative-ness |
| 2020 | Sphera Solutions GmbH | EU-28 | Polyurethane (PU) in waste in-cineration plant | vg | g | vg |
| 2017 | Sphera Solutions GmbH | EU-28 | Process steam from natural gas 85% | vg | g | vg |
| 2017 | Sphera Solutions GmbH | IT | Residual grid mix | vg | g | vg |
| 2017 | Sphera Solutions GmbH | AT | Residual grid mix | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Semichemical Fluting (2018) - for use in cut-off EoL scenario cases | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Tap water from groundwater | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Testliner (2018) - for use in avoided burden EoL scenario cases | vg | g | vg |
| 2017 | Sphera Solutions GmbH | CN | Thermal energy from natural gas | vg | g | vg |
| 2017 | Sphera Solutions GmbH | AT | Thermal energy from natural gas | vg | g | vg |
| 2017 | Sphera Solutions GmbH | IT | Thermal energy from natural gas | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Titanium dioxide pigment (sul-phate process) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | GLO | Truck, Euro 0 - 6 mix, 20 - 26t gross weight / 17.3t payload capacity | vg | g | vg |
| 2020 | Sphera Solutions GmbH | GLO | Truck, Euro 6, more than 32t gross weight / 24.7t payload capacity | vg | g | vg |

| Background datasets | | | | | | |
|---|---|---|---|---|---|---|
| Reference year | Owner of the data set | Nation | Object name without nation | Technological representativeness | Time representativeness | Geographical representative-ness |
| 2020 | Sphera Solutions GmbH | GLO | Truck, Euro 6, up to 7.5t gross weight / 2.7t payload capacity | vg | g | vg |
| 2020 | Sphera Solutions GmbH | GLO | Truck-trailer, Euro 6, up to 28t gross weight / 12.4t payload capacity | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Untreated wood on landfill | vg | g | vg |
| 2020 | Sphera Solutions GmbH | DE | Waste incineration (plastics) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Water (deionised) | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Wellenstoff / Fluting (2018) - for use in cut-off EoL scenario cases | vg | g | vg |
| 2020 | Sphera Solutions GmbH | EU-28 | Wood (natural) in municipal waste incineration plant | vg | g | vg |
| 2019 | Sphera Solutions GmbH | EU-28 | Wooden pallets (EURO, 40% moisture) | vg | g | vg |

# 4. Life cycle impact assessment (LCIA)

## 4.1. Assessment indicators according /EN 15804+A2/

The LCA study described in this product does not support any reference EPDs even though the results are based on /EN 15804+A2/.

At the time of the analysis the product had not been produced yet by the producer company. The following environmental parameters apply data based on the LCI. They describe the use of renewable and non-renewable material resources, renewable and non-renewable primary energy and water.

Table 4-1: Life cycle inventory indicators on use of resources

| | |
|---|---|
| Use of renewable primary energy excluding the renewable primary energy resources used as raw materials (PERE) | MJ ([$H_i$] lower calorific value) |
| Use of renewable primary energy used as raw materials (PERM) | MJ ([$H_i$] lower calorific value) |
| Total use of renewable primary energy (primary energy and renewable primary energy resources used as raw materials) (PERT) | MJ ([$H_i$] lower calorific value) |
| Use of non-renewable primary energy excluding the non-renewable primary energy resources used as raw materials (PENRE) | MJ ([$H_i$] lower calorific value) |
| Use of non-renewable primary energy resources used as raw materials (PENRM) | MJ ([$H_i$] lower calorific value) |
| Total use of non-renewable primary energy (primary energy and non-renewable primary energy resources used as raw materials) (PENRT) | MJ ([$H_i$] lower calorific value) |
| Use of secondary materials (SM) | kg |
| Use of renewable secondary fuels (RSF) | MJ ([$H_i$] lower calorific value) |
| Use of non-renewable secondary fuels (NRSF) | MJ ([$H_i$] lower calorific value) |
| Use of fresh water resources (FW) | $m^3$ |

<u>Note regarding the calculation of the value for primary energy used as raw material</u>

The inventories for the basic materials contain the information on the “Total use of renewable/non-renewable primary energy”. The indicators “Use of primary energy as raw materials” are assessed via the net calorific value of the product.

The “Use of primary energy as energy carrier” can be calculated as the “Total primary energy” minus the “Use of primary energy as raw materials”.

The product considered in this study only contains basic materials based on fossil (non-renewable) resources. The heating value has been calculated as weighted value based on the composition in each product. The only renewable materials are in packaging (paper and cardboard and wooden pallets).

As there are several different materials having a different heating value, in the model for each material the heating value is declared so that the model automatically calculated the overall heating value of the finale product as weighted average of single components.

In addition, the standard /EN 15804+A2/requires the declaration of waste materials and components for re-use and recycling (Table 4-2 and Table 4-3).

Table 4-2: Life cycle inventory indicators on waste categories

| Indicator | Unit |
|---|---|
| Hazardous waste disposed (HWD) | kg |
| Non-hazardous waste disposed (NHWD) | kg |
| Radioactive waste disposed (RWD) | kg |

Table 4-3: Life cycle inventory indicators on output flows

| Indicator | Einheit |
|---|---|
| Components for re-use (CRU) | kg |
| Materials for recycling (MFR) | kg |
| Materials for energy recovery (MER) | kg |
| Exported electrical energy (EEE) | MJ |
| Exported thermal energy (EET) | MJ |

## 4.2. Uncertainty of LCIA results

Data quality and uncertainty are mutually dependent. The precision of the data depends on measuring tolerance, assumptions, completeness, and comprehensiveness of the considered system and on the representativeness of the used data.

Uncertainty is also introduced in the impact assessment phase of the study – and this will vary according the impact categories considered. Some impact categories, such as global warming, are considered relatively robust regarding the aspects completeness of potential contributing emissions and degree of properly characterised impact per species. In contrast, impact categories for toxicity are much less developed.

At least +/- 10% uncertainty appear to be the minimum overall uncertainty, even if the model is set up with data of high quality containing few errors. This should be kept in mind when interpreting the results.

## 4.3. Impact assessment results

As VAPOR EVO 190 is produced both as standard and as TT version, the conservative option has been taken as representative of the product, after check of both indicators results.

### 4.3.1. VAPOR EVO 190

Table 4-4: Environmental impact: comparison between the standard version and the TT version for 1 m² [VAPOR EVO 190]

| | VAPOR EVO 190 | VAPOR EVO 190TT | Delta |
|---|---|---|---|
| GWP - total | 8.33E-01 | 8.59E-01 | 3% |
| ODP | 4.95E-15 | 5.30E-15 | 7% |
| AP | 1.49E-03 | 1.51E-03 | 1% |
| EP - freshwater | 2.83E-06 | 3.01E-06 | 6% |
| EP - marine | 3.55E-04 | 3.68E-04 | 4% |
| EP - terrestrial | 3.82E-03 | 3.95E-03 | 3% |
| POCP | 1.38E-03 | 1.40E-03 | 2% |
| ADPE | 1.98E+01 | 2.03E+01 | 3% |
| ADPF | 1.69E-07 | 1.78E-07 | 6% |
| WDP | 1.09E-01 | 1.08E-01 | -1% |

As shown in the table above, the TT version does have a contribution higher than the standard one. Given that, the TT version has been taken as representative for the VAPOR EVO 190 product.

Table 4-5: Environmental impact: 1 m² VAPOR EVO 190

| Parameter | Unit | A1 | A2 | A3 | A4 | A5 | B1-B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GWP total | [kg $CO_2$-eq.] | 7.41E-01 | 5.77E-03 | 1.91E-03 | 4.82E-03 | 8.40E-02 | 0 | 2.68E-03 | 6.70E-03 | 6.46E-02 | 1.08E-02 | -6.35E-02 |
| GWP fossil | [kg $CO_2$-eq.] | 7.50E-01 | 5.73E-03 | 1.88E-03 | 4.80E-03 | 7.64E-02 | 0 | 2.66E-03 | 6.66E-03 | 6.45E-02 | 8.89E-03 | -6.32E-02 |
| GWP biogenic | [kg $CO_2$-eq.] | -9.05E-03 | 0 | 2.90E-05 | 0 | 7.49E-03 | 0 | 2.26E-05 | 0 | 9.10E-05 | 1.93E-03 | -3.08E-04 |
| GWP luluc | [kg $CO_2$-eq.] | 3.78E-04 | 4.67E-05 | 1.01E-06 | 2.26E-05 | 4.50E-05 | 0 | 3.76E-06 | 5.46E-05 | 6.81E-06 | 6.22E-06 | -2.69E-05 |
| ODP | [kg CFC-11-eq.] | 4.99E-15 | 1.13E-18 | 5.21E-18 | 7.54E-19 | 5.10E-16 | 0 | 6.36E-17 | 8.53E-19 | 1.07E-16 | 1.62E-17 | -3.93E-16 |
| AP | [mole of $H^+$-eq.] | 1.30E-03 | 1.84E-05 | 3.73E-06 | 8.74E-05 | 1.34E-04 | 0 | 5.53E-06 | 1.89E-05 | 1.99E-05 | 2.50E-05 | -1.06E-04 |
| EP - freshwater | [kg P eq.] | 1.16E-06 | 1.70E-08 | 5.69E-09 | 8.65E-09 | 1.37E-07 | 0 | 7.13E-09 | 1.98E-08 | 8.52E-08 | 1.64E-06 | -7.48E-08 |
| EP - marine | [kg N eq.] | 3.04E-04 | 8.43E-06 | 1.07E-06 | 2.42E-05 | 3.17E-05 | 0 | 1.31E-06 | 8.51E-06 | 5.78E-06 | 1.02E-05 | -2.76E-05 |
| EP - terrestrial | [mole of N eq.] | 3.28E-03 | 9.42E-05 | 1.15E-05 | 2.66E-04 | 3.41E-04 | 0 | 1.38E-05 | 9.57E-05 | 7.13E-05 | 7.03E-05 | -2.96E-04 |
| POCP | [kg NMVOC eq.] | 1.24E-03 | 1.66E-05 | 3.66E-06 | 6.41E-05 | 1.28E-04 | 0 | 3.56E-06 | 1.69E-05 | 1.54E-05 | 2.20E-05 | -1.06E-04 |
| ADPF | [kg Sb eq.] | 1.96E+01 | 7.61E-02 | 1.48E-02 | 6.14E-02 | 1.95E+00 | 0 | 4.73E-02 | 8.88E-02 | 1.45E-01 | 1.06E-01 | -1.80E+00 |
| ADPE | [MJ] | 9.70E-08 | 5.07E-10 | 5.56E-08 | 3.05E-10 | 2.97E-08 | 0 | 7.82E-10 | 5.08E-10 | 1.70E-09 | 4.87E-10 | -8.63E-09 |
| WDP | [m³ world eq.] | 9.85E-02 | 5.30E-05 | 1.61E-04 | 2.87E-05 | 1.03E-02 | 0 | 4.26E-04 | 5.80E-05 | 6.29E-03 | 1.03E-05 | -8.14E-03 |

| | |
|---|---|
| Caption | 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; WDP=Water (user) deprivation potential, deprivation-weighted water consumption |

Table 4-6: Resource use: 1 m² VAPOR EVO 190

| Parameter | Unit | A1 | A2 | A3 | A4 | A5 | B1-B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PERE | [MJ] | 1.18E00 | 4.38E-03 | -1.04E-04 | 2.20E-03 | 1.27E-01 | 0 | 2.18E-02 | 4.96E-03 | 3.73E-02 | 7.27E-03 | -1.32E-01 |
| PERM | [MJ] | 1.00E-01 | 0 | 2.35E-02 | 0 | 7.55E-03 | 0 | 0 | 0 | 0 | 0 | 0 |
| PERT | [MJ] | 1.28E00 | 4.38E-03 | 2.34E-02 | 2.20E-03 | 1.35E-01 | 0 | 2.18E-02 | 4.96E-03 | 3.73E-02 | 7.27E-03 | -1.32E-01 |
| PENRE | [MJ] | 1.06E01 | 7.64E-02 | 1.09E-02 | 6.16E-02 | 1.08E00 | 0 | 4.73E-02 | 8.90E-02 | 8.05E-01 | 1.06E-01 | -1.80E00 |
| PENRM | [MJ] | 9.05E00 | 0 | 3.93E-03 | 0 | 8.74E-01 | 0 | 0 | 0 | -6.60E-01 | 0 | 0 |
| PENRT | [MJ] | 1.96E01 | 7.64E-02 | 1.48E-02 | 6.16E-02 | 1.95E00 | 0 | 4.73E-02 | 8.90E-02 | 1.45E-01 | 1.06E-01 | -1.80E00 |
| SM | [kg] | 6.60E-04 | 0 | 0 | 0 | 1.43E-04 | 0 | 0 | 0 | 0 | 0 | 0 |
| RSF | [MJ] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NRSF | [MJ] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FW | [kg] | 3.96E-03 | 5.02E-06 | 4.83E-06 | 2.56E-06 | 4.05E-04 | 0 | 2.12E-05 | 5.67E-06 | 1.66E-04 | 3.07E-06 | -2.94E-04 |

| | |
|---|---|
| Caption | PERE = Use of renewable primary energy as energy carrier; PERM = Use of renewable primary energy as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy as energy carrier; PENRM = Use of non-renewable primary energy 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 4-7: Output flows and waste categories: 1 m² VAPOR EVO 190

| Parameter | Unit | A1 | A2 | A3 | A4 | A5 | B1-B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HWD | [kg] | 3.94E-09 | 4.03E-12 | 6.41E-11 | 2.13E-12 | 3.95E-10 | 0 | 1.25E-11 | 4.48E-12 | 3.05E-11 | 1.89E-11 | -3.73E-10 |
| NHWD | [kg] | 1.96E-02 | 1.20E-05 | 5.28E-04 | 8.26E-06 | 4.07E-03 | 0 | 3.35E-05 | 1.32E-05 | 2.27E-03 | 1.03E-01 | -4.68E-04 |
| RWD | [kg] | 2.78E-04 | 1.39E-07 | 3.55E-07 | 9.43E-08 | 2.90E-05 | 0 | 7.04E-06 | 1.08E-07 | 1.22E-05 | 1.07E-06 | -4.13E-05 |
| CRU | [kg] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MFR | [kg] | 0 | 0 | 0 | 0 | 8.56E-04 | 0 | 0 | 0 | 2.64E-02 | 0 | 0 |
| MER | [kg] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| EEE | [MJ] | 0 | 0 | 0 | 0 | 6.83E-03 | 0 | 0 | 0 | 9.30E-02 | 0 | 0 |
| EET | [MJ] | 0 | 0 | 0 | 0 | 9.38E-03 | 0 | 0 | 0 | 1.53E-01 | 0 | 0 |

| | |
|---|---|
| Caption | 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; EEE = Exported electrical energy; EET = Exported thermal energy |

Table 4-8: Biogenic carbon content of product and packaging: 1 $m^2$ VAPOR EVO 190

| Parameter | Unit | A1 | A2 | A3 | A4 | A5 | B1-B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Biog. C in packaging | [kg] | 2.4E-003 | 0 | 5.6E-004 | 0 | 2.9E-004 | 0 | 0 | 0 | 0 | 0 | 0 |
| Biog. C in product | [kg] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | |
|---|---|
| Caption | Biog. C in packaging = Biogenic carbon content in packaging; Biog. C in product = Biogenic carbon content in product |
| | |

# 5. Interpretation

Some key points from the EPD results are described below. They are based on the results from the chapter above and therefore related to 7 representative membranes. This chapter includes the interpretation of LCA and LCI results. with a special focus on the identification of the main contributors by process stage or module. The interpretation allows conclusions to be drawn based on observations of the LCA results.

Results will be displayed separately for each representative product.

See below labels explanations as shown in the second graph:

- Distribution to client includes the impacts from Rothblaas site to final client
- Installation includes the impact production of all materials needed for the installation including the 10% installation scraps production
- Manufacturing RB includes energy consumption and wastes treatment in the Rothblaas (RB) site
- Manufacturing Supplier includes energy consumption. waste treatment (both internal and external treatments) and emissions related to the SUPPLIER SITE.
- Packaging includes any type of packaging both from the supplier and from Rothoblaas as additional packaging
- Product end of life includes all impacts related to final product end of life treatments without including the avoided burden
- Product transport Supplier-RB includes transport emissions from SUPPLIER SITE to Rothoblaas site
- RM transport includes the transport impacts related to raw materials transportation from the SUPPLIER's supplier to SUPPLIER SITE in CENTRAL EUROPE.
- Raw material [Additives]-Raw material [Glue]-Raw material [PE]-Raw material [PP]-Raw material [TPE]-RM [Plastic film] : these tags include raw materials production

## 5.1. Contribution VAPOR EVO 190

A1 is the module with most of the impacts. The percentage below are referred to the overall life cycle except D module (A1-C4).

- Overall most of the impact categories and LCI parameters are dominated by the membrane production.
- GWP: for global warming potential (100y) around 47% is due to polypropylene production followed by plastic film production (16%). Product end of life (polypropylene and PET film incineration) contributes to GWP with a 8% contribution similarly to the installation that considers a 10% scraps production and does have around 10% contribution. Glue production contributes to 9%. while supplier manufacturing contributes with around 7% because of electricity consumed.
- ODP: this impact is driven by raw materials production (33% PP, 16% plastic film and 8% glue) followed by Rothoblaas manufacturing (around 22% contribution due to grid mix). Almost 9% of the overall impact is due to installation because of the 10% scrap production, while the manufacturing supplier does have a 8% impact.
- AP: polypropylene production contributes around 52% followed by plastic film production (11%) and glue production (9%). The installation process (considering a 10% scrap) contributes with 9%

of the overall impact while the distribution to client (container ship emissions) does have a 5% impact.

- EP - freshwater: this impact is particularly influenced by product at end of life (51%) because of the plastic and glue landfill followed by the raw material production (around 34% because of polypropylene. plastic film and glue production). Installation contributes with 10% impact due to the scrap production.
- EP - marine- terrestrial: this impact is driven by raw materials production (44% contribution due to polypropylene production, around 13% because of plastic film production and 11% due to glue production). Installation (because of the 10% installation scrap) has an impact of 9%, while product end of life and distribution transport (due to the container ship emissions) contribute both around 6% of the overall impact.
- POCP: is mainly generated polypropylene production (53%). plastic film production (11%) and glue production (11%). Installation (again due to the 10% scrap production) contributes with 9% of the overall impact. More than 4% is due to the distribution to client (container ship emissions)
- ADPe: this impact is particularly influenced by battery production process for about 35%, while almost 27% because of polypropylene production. 16% comes from the installation not only because of the scrap production, but also because of the metal fixing materials used. Minor impacts are due to of plastic film production (11% ) and glue production (6%).
- ADPf: polypropylene production contributes with 59% followed by plastic film production (16%) and glue production (10%). Installation contributes with 9% because of the scrap production.
- WDP: this impact is driven by polypropylene production (almost 56%). followed by glue production (14%) and installation (9%).

The figures below represent the analysis contribution according with the system boundaries of the /EN 15804+A2/.

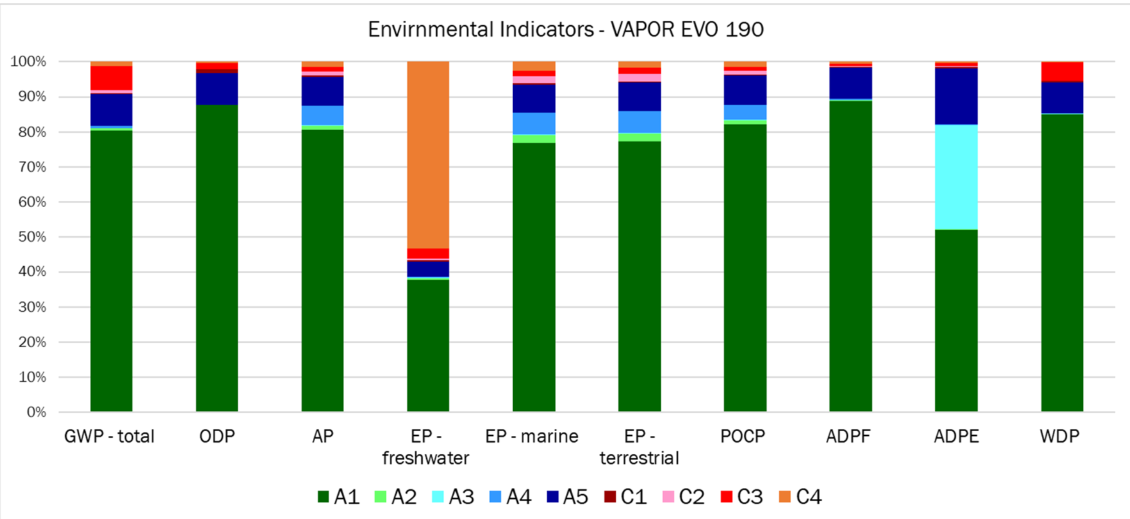



Figure 11. Relative contribution [%] of A1-C4 environmental indicators for VAPOR EVO 190

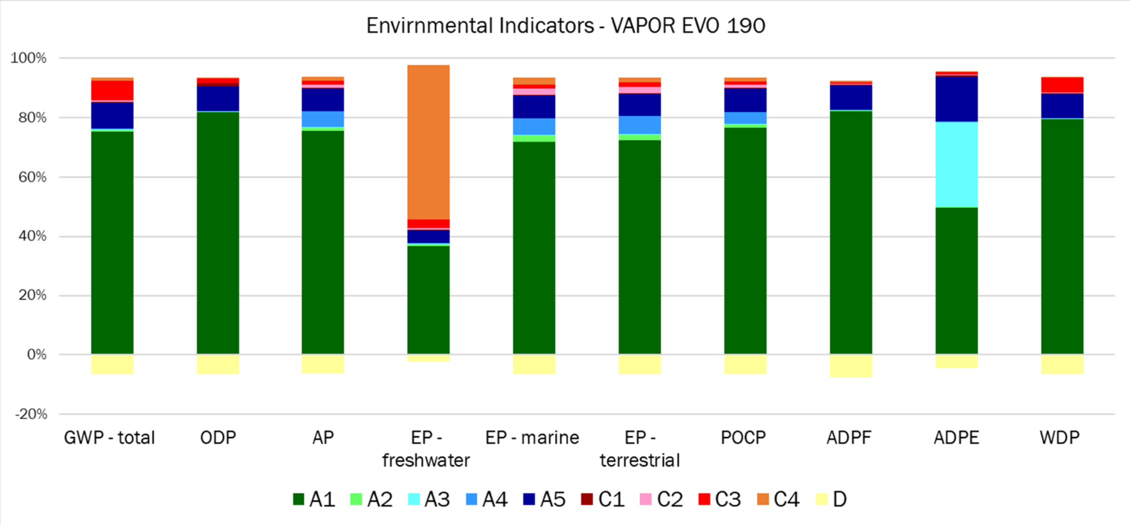
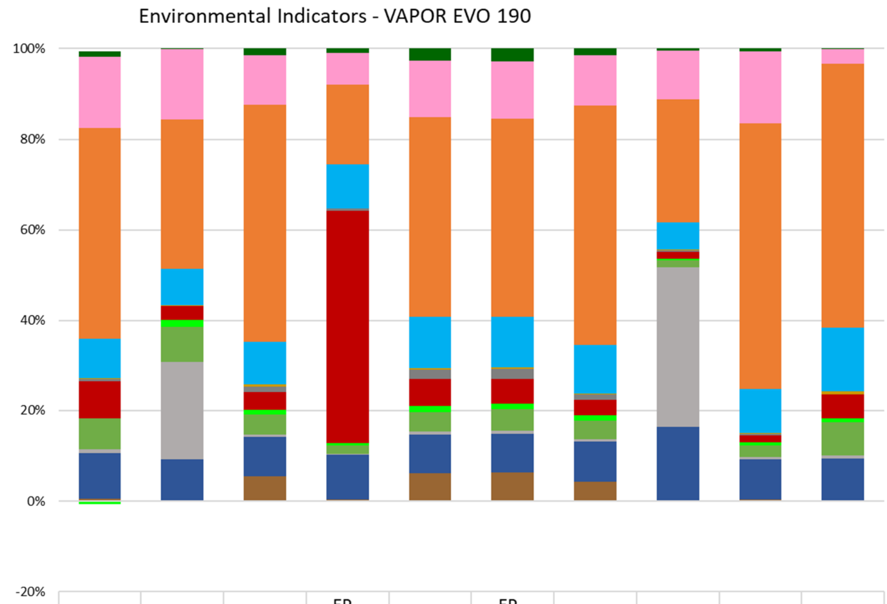



Figure 12. Relative contribution [%] of A1-D environmental indicators for VAPOR EVO 190

The Figure 11 shows for most categories that the highest impacts are given by A1, followed by landfill disposal (for Eutrophication freshwater) and Rothoblass contribution because of the batteries production (ADPe). The Figure 12 shows D contribution. The Figure 13 shows the relative contribution based on the main processes and materials involved, without including load and credits, namely value of scrap or benefits after recycling or incineration.




| | GWP - total | ODP | AP | EP - freshwater | EP - marine | EP - terrestrial | POCP | ADPE | ADPF | WDP |
|---|---|---|---|---|---|---|---|---|---|---|
| RM transport | 1% | 0% | 2% | 1% | 3% | 3% | 1% | 1% | 1% | 0% |
| RM [Plastic film] | 16% | 16% | 11% | 7% | 13% | 13% | 11% | 11% | 16% | 3% |
| Raw material [PP] | 47% | 33% | 52% | 17% | 44% | 44% | 53% | 27% | 59% | 58% |
| Raw material [Glue] | 9% | 8% | 9% | 10% | 11% | 11% | 11% | 6% | 10% | 14% |
| Raw material [Additives] | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% |
| Product transport Supplier-RB | 1% | 0% | 1% | 1% | 2% | 2% | 1% | 0% | 0% | 0% |
| Product end of life | 8% | 3% | 4% | 51% | 6% | 5% | 3% | 2% | 2% | 5% |
| Packaging | -1% | 2% | 1% | 0% | 1% | 1% | 1% | 0% | 1% | 1% |
| Manufacturing Supplier | 7% | 8% | 4% | 2% | 4% | 5% | 4% | 1% | 3% | 7% |
| Manufacturing RB | 1% | 22% | 1% | 0% | 1% | 1% | 1% | 35% | 0% | 1% |
| Installation | 10% | 9% | 9% | 10% | 9% | 9% | 9% | 16% | 9% | 9% |
| Distribution to client | 1% | 0% | 5% | 0% | 6% | 6% | 4% | 0% | 0% | 0% |

Figure 13. Relative contribution [%] processes-based  environmental indicators for VAPOR EVO 190

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| | |
|---|---|
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# Annex A: Description of result parameters

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. geosphere or energy source without any anthropogenic change. For fossil fuels and uranium. this is 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 is reported. For hydropower. it is based on the amount of energy that is gained from the change in the potential energy of the 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 be used both 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.

Abiotic Depletion Potential

The abiotic depletion potential (ADP) covers all natural resources 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. The abiotic depletion potential is split into two sub-categories.

Abiotic depletion potential (elements) covers an evaluation of the availability of natural elements like minerals and ores. incl. uranium ore. The reference substance for the characterisation factors is antimony.

The second sub-category abiotic depletion potential (fossil) includes the fossil energy carriers (crude oil. natural gas. coal resources). The respective unit is the Megajoule.

## Global Warming Potential (GWP)

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

In addition to the natural mechanism. the greenhouse effect is enhanced by human activities. Greenhouse gases that are considered to be caused. or increased. anthropogenically include carbon dioxide. methane and CFCs. Figure B-1 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..

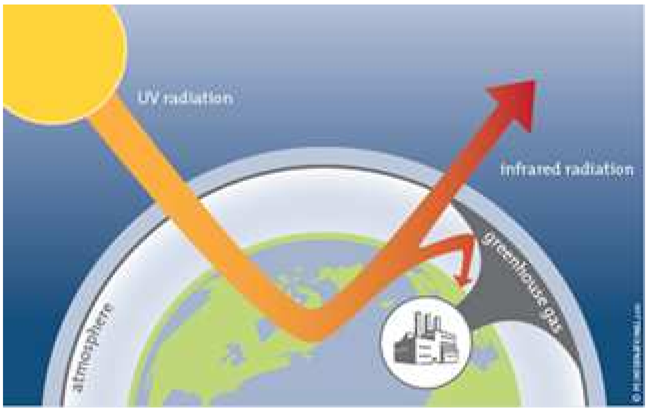


Figure B-1: Greenhouse effect

## Acidification Potential (AP)

The acidification of soils and waters occurs predominantly 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 washed out of 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 B-2 displays the primary impact pathways of acidification.

The acidification potential is given in sulphur dioxide equivalents ($SO_2$-Eq.). The acidification potential is described as the ability of certain substances to build and release $H^+$ - ions. Certain emissions can also be considered to have an acidification potential. if the given S-. N- and halogen atoms are set in proportion to the molecular mass of the emission. The reference substance is sulphur dioxide.

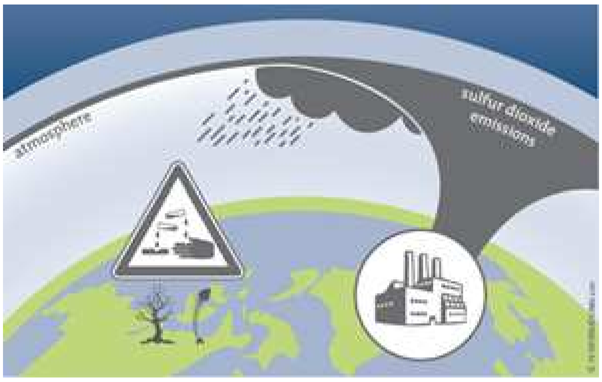


Figure B-2: Acidification Potential

## 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 overly nutrified 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 B-3. The eutrophication potential is calculated in phosphate equivalents ($PO_4$-Eq). As with acidification potential. it's important to remember that the effects of eutrophication potential differ regionally.

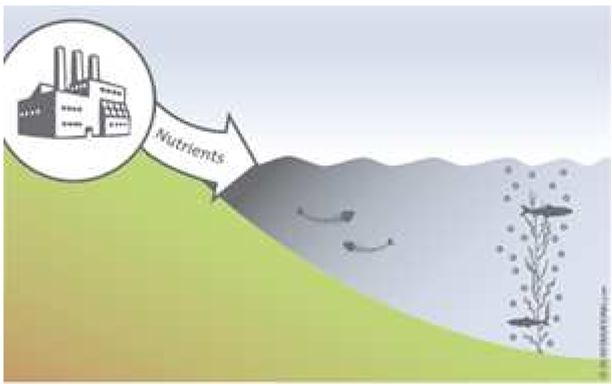


Figure B-3: Eutrophication Potential

## 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 existence of NO and CO reduces the accumulated ozone to $NO_2$. $CO_2$ and $O_2$. This means. that high concentrations of ozone do not often occur near hydrocarbon emission sources. Higher ozone concentrations more commonly arise in areas of clean air. such as forests. where there is less NO and CO (Figure B-4).

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

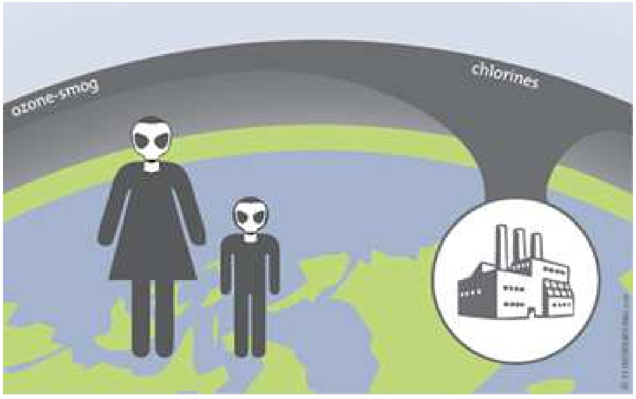


Figure B-4: Photochemical Ozone Creation Potential

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 ozone depletion can be also identified. albeit not to the same extent. over the mid-latitudes (e.g. Europe). Substances that have a depleting effect on ozone can be divided into two groups; the fluorine-chlorine-hydrocarbons (CFCs) and the nitrogen oxides (NOX). Figure B-5 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 tumours (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.

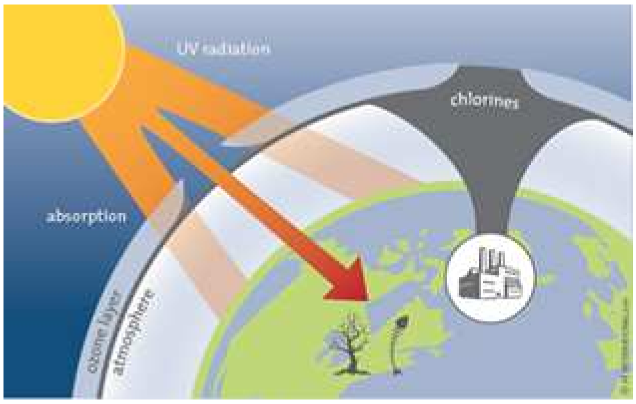


Figure B-5: Ozone Depletion Potential

# Annex B: Quality assurance at Sphera

This document describes guidelines and principles for Sphera project work. To ensure the quality of the performed life cycle assessment. many checks and screenings are carried out. Check-lists help the Sphera consultants fulfil the quality requirements during the whole process of developing an LCA.

Data collection

Since LCA projects are based on industry data. the quality management begins with the data collection step at the respective plants. The questionnaire that is required to be completed by the client is adapted to the technology applied and reviewed before being sent out. The level of details and the covered modules are discussed with the clients before. The first step is to guarantee the accuracy and the reliability of the collected data. Therefore everyone at Sphera has to make sure that the data collector at the plants has enough background information to fulfil the task and has all information to collect the data in the required way. At the same time the Sphera consultant must have enough product specific know-how. Since Sphera covers projects spanning many industry sectors the respective Sphera consultant team is selected dependent on their scientific/engineering background. Permanent knowledge exchange between the customer and Sphera avoids any misunderstandings.

After receiving the completed questionnaire. the data are checked for plausibility and the mass. energy and substance balances are assessed. The data are compared to both product specific published data and data internal to Sphera. For plausibility. client specific processes are compared with known GaBi processes. Estimated processes are checked using a combination of specialist knowledge and comparable processes.

Databases

Each life cycle assessment is based on the background data used in the model. The generation of any relevant result by Sphera is based on a solid. comprehensive and high quality Life Cycle Inventory foundation.

The development of the GaBi life cycle databases began over 20 years ago and continues today with the same momentum and meticulous attention to detail. More than 60 life cycle experts contribute to the development of GaBi databases. The databases include over 4000 ready-to-use datasets while any customer-specific datasets can be added.

All datasets contained in GaBi databases are documented in writing. a previous internal quality check before publication is performed (eg. plausibility. mass balance. etc.) and they comply with DIN EN ISO 14044 and DIN EN ISO 14025.

Data gaps

Where data gaps occur. a sensitivity analysis is carried out. Similar LCA-studies already completed or published are used for cross- checking and identifying differences. In most cases. data gaps can be remedied using calculations. but some of these calculations are based on assumptions and estimations. The assumptions and estimations are discussed in depth by the relevant team as well as with the customer. They are then fully documented and their basis justified. Cut-offs also are justified and documented. If processes are generated with estimations. they are checked by an experienced colleague. The consistence of the data sources with regard to time coverage or geographical relation and the mass and energy balance of unit processes are checked. Special attention is paid to the direct emissions and waste streams.

Modelling

The next step is assuring the quality processes during modelling in GaBi. It must be checked whether the GaBi model has been structured to allow the planned assessment of the results and whether the used datasets for modelling are suitable for the goal and scope of the project. Technical knowledge of the methods and technologies within the processes allows for a detailed analysis. Comments on the processes and plans are carefully documented.

If a consultant is required to choose between different GaBi datasets. the impact is first estimated with a quick GaBi balance. after that a worst case approach is applied (impact smaller than cut off) or further analyses are applied (impact higher than cut off) to detect details which allow for the selection or creation of an appropriate dataset.

All LCA projects at Sphera are performed in a team. therefore minimising mistakes in the workflow. since all numbers are always double checked by the team. Team work within Sphera strives to deliver results with the highest grade of accuracy and quality.

The model is then checked for completeness. accuracy and representativeness by another colleague. who is not part of the regular project team. This allows an external view on the model as to whether:

- the correct datasets are used in terms of technology. representativeness. geographical coverage and time coverage.
- the data are consistent.
- all processes and flows are connected.
- there are any broken flows.
- the allocations are set appropriately.
- comments to the parameters are written unambiguously.
- the plans are scaled properly. and if
- comments for the plan-parameters exist which explain the inputs.

An analysis of critical points reveals the ‘hot spots’ within the model. These can then be subject to parameter variations which ensure the stability of the results under changed boundary conditions or assumptions. The results are then crosschecked by calculations that ensure plausibility.

Interpretation

Once the modelling has been completed. the evaluation and interpretation of the model is carried out. The environmental problem fields for evaluation are selected regarding the specific technology and the goal and scope of the study. After that. the reports are checked by the project manager.

The documents and data are saved on the server in the proposed structure in order to allow constant free and easy access to the latest documents.

It is always ensured that the evaluated impact categories are in line with the respective Standard (PAS2050. ISO 14040/44 and PCR documents).