**ENVIRONMENTAL PRODUCT DECLARATION**  
*as per ISO 14025 and EN 15804*

<table>
<thead>
<tr>
<th>Owner of the Declaration</th>
<th>Vector Foiltec GmbH; Nowofol Kunststoffprodukte GmbH; Dyneon GmbH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programme holder</td>
<td>Institut Bauen und Umwelt e.V. (IBU)</td>
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<td>Publisher</td>
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<tr>
<td>Declaration number</td>
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<td>ECO-00000022</td>
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<td>Issue date</td>
<td>06.05.2014</td>
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<tr>
<td>Valid to</td>
<td>05.05.2020</td>
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</tbody>
</table>

**Texlon®-System**

**Vector Foiltec GmbH**  
**Nowofol Kunststoffprodukte GmbH & Co. KG**  
**Dyneon GmbH**

www.bau-umwelt.com / https://epd-online.com
1. General Information

Vector Foiltec GmbH
Nowofol Kunststoffprodukte GmbH & Co. KG
Dyneon GmbH

Programme holder
IBU - Institut Bauen und Umwelt e.V.
Panoramastr. 1
10178 Berlin
Germany

Owner of the Declaration
Vector Foiltec GmbH,
Steinacker 3, 28717 Bremen
Nowofol Kunststoffprodukte GmbH & Co. KG,
Breslauer Str. 15, 83313 Siegsdorf
Dyneon GmbH,
Industrieparkstr. 1, 84508 Burgkirchen

Declaration number
EPD-DVN-20140043-IBE1-EN

Declared product / Declared unit
1 m² of standard foil cushion (weight per unit area 0.896 kg/m²) and the associated frame materials

This Declaration is based on the Product Category Rules:
ETF E construction element, 07.2014 (PCR tested and approved by the SVR)

Issue date
06.05.2014

Valid to
05.05.2020

Scope:
This EPD refers to individual building elements manufactured from ethylene tetrafluoroethylene (ETFE). It is valid for the German production facilities. The building elements are manufactured by Vector Foiltec GmbH and traded under the brand trade name Texlon®. The entire product chain associated with manufacturing of the ETFE building elements includes the following companies:
- Dyneon GmbH (ETFE granulate)
- NOWOFOL Kunststoffprodukte GmbH & Co. KG (ETFE foil)
- Vector Foiltec GmbH (ETFE foil cushions)

Foil cushions are designed, fabricated and packaged for specific projects. This EPD calculates the life cycle analysis (LCA) for a representative product.

This document is translated from the German Environmental Product Declaration into English. It is based on the German original version EPD-DVN-20140043-IBE1-DE. The verifier has no influence on the quality of the translation. The owner of the declaration shall be liable for the underlying information and evidence; the IBU shall not be liable with respect to manufacturer information, life cycle assessment data and evidences.

Verification
The CEN Norm /EN 15804/ serves as the core PCR
Independent verification of the declaration according to /ISO 14025/

Internally [x] Externally

Prof. Dr.-Ing. Horst J. Bossenmayer
(President of Institut Bauen und Umwelt e.V.)

Dr. Burkhard Lehmann
(Managing Director IBU)

Matthias Schult
(Independent verifier appointed by SVR)

2. Product

2.1 Product description

The Texlon® System is based on the following principle: - pneumatically stabilised foil elements are fixed to a sub-structure by means of a high-quality...
aluminium frame system. The system can consist of between two and five layers of ETFE foil (ethylene tetrafluoroethylene) depending on the building physics, static or design requirements and specifications. The g-values and U-values are determined by the number of layers and also the type of coating used. The ETFE foil thickness vary between 80 µm and 300 µm depending on the static construction requirements. The individual layers are welded together at the edges and stabilised to approximately 220 Pa (220 N/m²) by means of a low-pressure air system.

This EPD is based on a typical 3-layer system with the following build up:

Upper: 200 µm // Middle: 100 µm // Lower: 200 µm

The LCA for a representative product is calculated in this EPD.

2.2 Application

Texlon® systems are building elements used for the cladding of roofs and facades. The Texlon® system is suitable for new buildings and refurbishment projects looking to create additional spaces (such as courtyards). Well known examples of Texlon® include:

- Leisure centres: Center Parcs in Moselle, France
- Retail & entertainment: Khan Shatyr Entertainment Centre in Astana, Kazakhstan
- Artificial biospheres: Eden Project in Cornwall, Great Britain
- Zoological gardens: Gondwanaland Tropical Hall Leipzig, Germany
- Atria: Frankfurt Holm, Germany
- Canopies: Domaquaree in Berlin, Germany
- Stadia: Forsyth Barr Stadium in Dunedin, New Zealand
- Airports: Baufeld H in Frankfurt, Germany
- Hospitals: Chelsea & Westminster Hospital in London, Great Britain
- Kindergartens: Plappersnut in Wismar, Germany
- Schools: Neues Gymnasium in Bochum, Germany
- Office buildings: Festo in Esslingen, Germany
- Exhibitions: Mobile Chanel Pavilion in Paris, France

2.3 Technical Data

The following technical data must indicate the relevant standard for the declared product at the time of delivery. Unless otherwise stated this data refers to an ETFE foil with a thickness of 200 µm.

| DIN EN ISO 527-1/ | Tensile stress at 10% strain in accordance to /DIN EN ISO 527-1/ | > 18 | N/mm² |
| DIN EN ISO 527-1/ | Tensile stress at break in accordance to /DIN EN ISO 527-1/ | > 300 | % |
| DIN 53363/ | Tear Resistance in accordance to /DIN 53363/ | > 300 | N/mm² |
| DIN 527-1/ | Weld strength in accordance to /DIN 527-1/ | ≥ 33 | N/mm² |
| ISO 15099/ | Total energy transmittance in accordance to /ISO 15099/ 3 layers ETFE | 75±5 | % |
| ISO 4892-1/ and ISO 4892-2/ 3 layers ETFE | Weathering resistance in accordance to /ISO 4892-1/ and ISO 4892-2/ 3 layers ETFE | no mechanical changes - |

2.4 Placing on the market / Application rules

In Germany, Texlon® foil cushions are regarded as non-regulated building products in terms of the state building regulations and as such require fit for purpose proof in the form of a general construction approval by the Deutsches Institut für Bautechnik Berlin or appropriate authorisation by the responsible Department of Building Regulation in individual cases.

2.5 Delivery status

From an economic and technical perspective, the maximum ETFE cushion dimensions span 3.7 metres (width) by 40 metres (length). The cushion area should not exceed 120 m².

2.6 Base materials / Ancillary materials

The essential base products are Nowoflon® ET foil, F16.2 aluminium frame and sealing materials.

<table>
<thead>
<tr>
<th>Primary products</th>
<th>Mass percentage rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nowoflon - ET foil</td>
<td>12.0-24.5</td>
</tr>
<tr>
<td>ETFE valves</td>
<td>0.03-0.04</td>
</tr>
<tr>
<td>aluminium frame</td>
<td>06.7-78.1</td>
</tr>
<tr>
<td>PP keder</td>
<td>0.51-0.57</td>
</tr>
<tr>
<td>silicone gasket</td>
<td>3.48-9.54</td>
</tr>
</tbody>
</table>

Nowoflon® ET foil: Nowoflon® ET foil is a flexible and strong fluorinated copolymer foil. These foils are transparent over the entire solar range. They can be transparent, printed or dyed.

ETFE valves: These valves are small parts made of the same base material as the foil but they are not transparent and display a lower purity level.

Aluminium frames: The aluminium frame comprises of an extruded base element and a cap.

Polypropylene (keder) ropes: The cord edge welding comprises of flexible polypropylene (keder) ropes with a diameter of ~ 8 mm.

Silicone seals: Silicone seals are made from a waterproof rubber silicone material.
No substances used in the manufacture of Texlon® foil cushions are included in the SVHC list of candidates or in Annex XIV of the EU REACH Directive 1907/2006. No fire retardants, plasticizers or biocidals are used.

2.7 Manufacture

Manufacture of ETFE granulate:

Raw materials and monomers: Mineral fluor spar and natural gas are used to manufacture R22 (chlorine-di-fluoromethane), which is delivered by special road tankers. This is used to manufacture the perfluorinated monomers, such as tetrafluoroethylene (TFE), hexafluoropropylene (HFP) and perfluoro (propyl vinyl ether), by thermal conversion, which are in turn freed of ancillary products by means of distillation.

Polymerisation: These monomers together with ethene are converted to a thermoplastic dispersion by means of emulsion polymerisation. Non-converted monomers and polymerisation auxiliaries such as emulsifiers are returned to the monomer plant after distillation and reused.

Recycling (Reprocessing): The degassed thermoplastic dispersion is precipitated and the ensuing powder is dried. Floatation and the low pourability of this powder mean it is difficult to process so it is melted to granulate prior to shipping. The granulate is subjected to quality control to determine whether the product complies with customer requirements.

Production of Nowoflon® ET foils:

ETFE foils are manufactured by cast film extrusion where the granulate is fed into the extruder via a funnel. The granulate is melted in the extruder where it is also homogenised. A downstream extrusion tool, fishtail nozzle, extrudes the melted plastic onto a chill roller from which it is peeled off. The next stage involves an inline inspection of the foil thickness and trimming of the foil edges. These trimmings are immediately ground down and redirected to the extrusion process by means of the funnel. The last step of the foil extrusion process involves winding the foil onto a cardboard roll.

Foil waste that cannot be directly recycled passes through a second stage on a regeneration machine before being processed into foil, the application of the recycled material is always subject to a so-called "down-cycling" process.

Fabrication of the foil cushions:

The foil rolls are produced in 1550 mm (width) and – depending on the foil thickness – a length of approximately 200 metres. The rolls are cut in line with the project specifications. The individual cushion sections are cut to size on a cutting plotter. The positions of other components such as valves are also drawn. In order to create larger areas the individual sheets are welded together (area welding) and subsequently the valves are installed. The welded foil sheets are placed on top of each other in two or more layers and welded in place by means of a hand-held welding tongs. Edge welding involves a polypropylene (keder) rope being welded along the edges of the cushions in order to seal the cushions.

The large cushion is folded to form a sheet of approx. 30 cm in width and 2.5 metres in length and wrapped in protective polyethylene foil. Between three to six cushions are placed in a wooden crate in preparation for shipping. The remaining project components (aluminium profiles, keder profiles, gaskets, screws) are packaged separately for shipping.

2.8 Environment and health during manufacturing

The appropriate measures are taken in accordance with the current technology. To date, no environmental pollution as a direct result of the processing of the declared products is known.

The Texlon® quality management system was implemented with the purpose of internal monitoring. The QM system is based on ISO 9001 and the provisions of the general construction approval
and/or the Building Regulation in individual cases. In addition to safety supervision education and risk assessment by the body for social insurance against occupational accidents (SOZV), Vector Foiltec commissions an external consultant to educate employees on health and safety and industrial protection issues.

At Nowofol, the primary health and safety focus during the manufacture of fluoropolymer foil is on evaluating gases and vapours. In 2011, TÜV SÜD was appointed to determine the concentration of smoke, fluorides and fluorocarbons as well as volatile organic compounds in air at the workplace during the extrusion of fluoropolymers in line with the occupational exposure limits according to TRGS 900. This exposure assessment found that the existing protective measures (extraction for the purpose of air purification) are sufficient.

Within the framework of the Occupational Health and Risk Management System (Ohris), Dyneon is certified under register number 09-00015 (OHRIS 2009).

2.9 Product processing/Installation

Prior to installation of the roof areas, a risk assessment must be drawn up in accordance with §5 of the German Occupational Safety Act (ArbSchG, §5):

a Environment-related risks
- Mechanical hazard
- Electrical hazard
- Hazardous substances
- Biological hazard
- Fire and explosion hazard
- Thermal hazard
- Hazards attributed to physical impact
- Hazard/Load due to working environment conditions
- Physical strain
- Other hazards/risks
- Psychological strain

b Planning the access equipment

c Site related inductions
In areas where there is a risk of falling, trained personnel are equipped with personal protective equipment (PPE) as well as working and safety ropes. In the event of tools or materials falling, the hazardous areas under the installation areas are secured.

2.10 Packaging

The packaging materials (wooden crates, PE foil) are thermally recycled. The waste incurred can be allocated to the following waste codes (AVV 2012):

15 01 05: Mixed packaging
15 01 03: Wood
15 01 01: Paper and cardboard
17 09 04: Mixed construction & demolition waste excluding waste covered by 17 09 01 to 17 09 03
20 03 01: Mixed municipal waste

2.11 Condition of use

No significant changes in the product characteristics are expected during its design life. To compensate for deviations in cushion pressure caused by changing external conditions (temperature, wind pressure loads/wind suction loads), the cushions are continuously supplied by one or more inflation units. The size of the roof determines the number of inflation units required. The units are controlled by a pressure sensor and internal pressure is maintained within 180 Pa and 250 Pa range. An average output of 60 W is required for a roof area of 1000 m². If required an air drier can be used in certain air/humidity conditions.

2.12 Environment and health during use

In accordance with the evidence outlined in section 7, the emissions to air during the use phase fall below of the limit values as per the AgBB scheme.

2.13 Reference service life

Guaranteed service life is 25 years (up to 50 years are possible).

2.14 Extraordinary effects

Fire Reaction to fire
In accordance with EN 13501 – 1, Nowoflon® ET foil is specified as follows:

<table>
<thead>
<tr>
<th>Fire safety</th>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building material class</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Burning droplets</td>
<td>d0</td>
<td></td>
</tr>
<tr>
<td>Smoke gas development</td>
<td>s1</td>
<td></td>
</tr>
</tbody>
</table>

Water
Nowoflon® ET foil is not effected by water.

Mechanical destruction
The foils and cushions are extremely resistant to exterior pressure and tensile loads owing to their extraordinary elongation properties.

In the case of fire, explosions or even extreme hailstones, the system is extremely fault-tolerant and is resistant to consequential damage. The cushions can, however, be damaged by direct mechanical influences (or vandalism) with sharp or pointed items. Destruction of the exterior layer of foil does not lead to system failure. For example if the upper foil of a three-layer systems is damaged, a two-layer system is retained and the interior chamber remains protected from environmental influences. Minor damage can be easily repaired using Texlon® tape.

2.15 Re-use phase

As a general rule, the aluminium caps and base profiles of the Texlon® system can be re-used for new buildings and/or refurbishment projects. These components are usually recycled (statistic value for buildings: 85%).
Texlon® cushions that have reached the end of their useful phase and ETFE offcuts are recycled by external companies into valves and other small parts that can be used for manufacture of new ETFE systems. Recycling is currently only carried out in Europe but will be extended to other regions in future. Waste is thermally recycled in other countries.

2.16 Disposal

The waste incurred can be allocated to the following waste codes:

17 02 03: Plastic

17 04 02: Aluminium

17 09 04: Mixed construction and demolition waste with the exception of waste covered by 17 09 01, 17 09 02 and 17 09 03

Silicone seals are thermally recycled but alternative recycling possibilities are currently being examined.

Polypropylene is recyclable but is usually thermally recycled.

2.17 Further information

Additional information is available on the Vector Foiltec homepage: www.vector-foiltec.com.

3. LCA: Calculation rules

3.1 Declared Unit

This declaration refers to the production of 1 m² of a representative foil cushion (average values from 2012).

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declared unit</td>
<td></td>
<td>m²</td>
</tr>
<tr>
<td>Conversion factor to 1 kg</td>
<td>0.195</td>
<td>-</td>
</tr>
</tbody>
</table>

3.2 System boundary

In addition to production, this LCA considers installation, energy consumption during use and disposal. It represents a cradle-to-plant gate scenario with two options for foil cushion waste disposal:

1. Waste incineration
2. Recycling

Waste processing is considered for scenario 2. In both cases, the seal is incinerated while the aluminium frame is recycled. The life cycle stages are explained in detail below:

- Production (A1 - A3) including the upstream chain associated with manufacturing of the preliminary products, transport thereof to the respective plant and expenses involved in producing granulate, foil and foil cushions
- Transport to the construction site (A4): average distances by truck, ship and/or air
- Installation on the construction site (A5): energy for inflating foil cushions as well as disposal of packaging
- Energy consumption during use (B6): energy requirements for maintaining the interior cushion pressure
- Transport to disposal (C2)
- Waste treatment for recycling (C3): processing foil waste for scenario 2
- Disposal (C4): incineration of seals and for scenario 1 incineration of foil cushions
- Credits (D): from energy for treatment of packaging waste (A5) and the silicone seals, recycling of aluminium profiles and expenses associated with processing (remelting) and the energy credit in scenario 2 for thermal recycling of the ETFE granulate

3.3 Estimates and assumptions

Estimates need to be made for the following cases:

- ETFE production: Characterisation factors for the Global Warming Potential for the organic HFP and TFE emissions are applied from a publication (ACERBONI ET AL. 2001) as no information is available yet from CML (CML 2010) (HFP: 0.25 kg CO2 equiv.; TFE: 0.021 kg CO2 equiv.).
- Dyeing the granulate: "Compound" and "Masterbatch" pigments are estimated.
- Printing of foil: The composition of the water-based varnish is estimated.
- Aluminium frame: No manufacturer information is available. According to a certificate, some post-consumer secondary material is available which is used.

- ETFE material recycling (scenario 2): The recycled granulate cannot be used to produce foil cushions but is used to produce valves. This down-cycling is depicted via a correction factor for the material credit based on current market prices.
- Processing sulphuric acid in the manufacture of ETFE granulate.

3.4 Cut-off criteria

All data from operational data collation at Vector Foiltec, Nowofol and Dyneon has been taken into consideration, i.e. all base materials used in accordance with the recipe formula. Transport is recorded for all essential preliminary products, transporting the products to the site and in the End-of-Life scenario. The LCA considers production waste incurred directly during production as well as the associated electrical and thermal energy and packaging materials.

Machinery, plant and infrastructure as well as the transport of packaging materials required for the manufacturing process are ignored.
Material mass and energy flows less than 1 per cent are also considered.

3.5 Background data

The GaBi 6 software was used to model the life cycle associated with Texlon® ETFE systems. The basic data in the GaBi databank is applied for energy, transport, auxiliary products and preliminary products.

The headquarters of the respective companies are in Germany, so the LCA is prepared with Germany as the reference country. Transport to construction sites is modelled internationally. The power consumption for installation and utilization phases relate to Europe and can be adapted for other countries as required.

3.6 Data quality

The data was collated by the three companies on the manufacture of foil cushions, foil and granulate. Information was obtained from external manufacturers to prepare estimates concerning the dyeing and printing processes. The background data was revised in 2013. The data quality is classified as very good as the primary data was collated for manufacturing of the foil cushions as well as the foil and granulate.

3.7 Period under review

The data for this Life Cycle Assessment is based on records from 2012 for each company. The volumes of raw materials, energy, auxiliary materials used are considered as average annual values in the respective plant.

3.8 Allocation

Economic allocations based on the market price for the ancillary products are used for the manufacture of chlorine-di-fluoromethane, perfluoropropyl vinyl ether as well as production of the ETFE granulate base.

Economic allocation is not applied to waste production at Vector Foiltec as it only makes a minor contribution (< 1%) to turnover. Aluminium profiles with a post-consumer recycling share of 45% (in accordance with supplier's certificate), are modelled as scrap input (open-loop recycling).

For incineration processes the credits for electrical and thermal energy are evaluated by taking the elementary composition and calorific value into account.

3.9 Comparability

Basically, a comparison or an evaluation of EPD data is only possible if all the data sets to be compared were created according to /EN 15804/ and the building context, respectively the product-specific characteristics of performance, are taken into account.

4. LCA: Scenarios and additional technical information

The following information forms the basis for the declared modules. It can be used to develop specific scenarios in the context of a building evaluation if modules are not declared (MND).

Transport to site (A4)

Average distance per mode of transport refer to global international transport data (2012).

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litres of fuel truck</td>
<td>0.00156</td>
<td>l/100km</td>
</tr>
<tr>
<td>Transport distance truck</td>
<td>1026</td>
<td>km</td>
</tr>
<tr>
<td>Capacity utilisation (including empty runs) truck</td>
<td>85</td>
<td>%</td>
</tr>
<tr>
<td>Capacity utilisation volume factor container</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>Litres of ship fuel ship</td>
<td>0.00147</td>
<td>l/100 km</td>
</tr>
<tr>
<td>Ship transport distance ship</td>
<td>16291</td>
<td>km</td>
</tr>
<tr>
<td>Ship capacity utilisation (incl. empty runs) ship</td>
<td>65</td>
<td>%</td>
</tr>
<tr>
<td>Litres of air fuel airplane</td>
<td>0.0190</td>
<td>l/100 km</td>
</tr>
<tr>
<td>Air transport distance airplane</td>
<td>10683</td>
<td>km</td>
</tr>
<tr>
<td>Air capacity utilisation (incl. empty runs) airplane</td>
<td>66</td>
<td>%</td>
</tr>
</tbody>
</table>

Installation Process (A5)

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliary</td>
<td>0</td>
<td>kg</td>
</tr>
<tr>
<td>Water consumption</td>
<td>0</td>
<td>m³</td>
</tr>
<tr>
<td>Other resources</td>
<td>0</td>
<td>kg</td>
</tr>
<tr>
<td>Electricity consumption pro a*m²</td>
<td>0.00018</td>
<td>kWh</td>
</tr>
<tr>
<td>Other energy carriers</td>
<td>0</td>
<td>MJ</td>
</tr>
<tr>
<td>Material loss</td>
<td>0</td>
<td>kg</td>
</tr>
<tr>
<td>Output substances following</td>
<td>0</td>
<td>kg</td>
</tr>
</tbody>
</table>

Reference service life

Guaranteed service life is 25 years (50 years possible).

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference service life</td>
<td>25 - 50</td>
<td>a</td>
</tr>
</tbody>
</table>

Operational energy (B6) and water (B7)

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water consumption</td>
<td>0</td>
<td>m³</td>
</tr>
<tr>
<td>Electricity consumption pro a*m²</td>
<td>0.274</td>
<td>kWh</td>
</tr>
<tr>
<td>Other energy carriers</td>
<td>0</td>
<td>MJ</td>
</tr>
<tr>
<td>Equipment output</td>
<td>0</td>
<td>kW</td>
</tr>
</tbody>
</table>

End of Life (C1-C4)

Conservative estimate for transport to EoL: 1,000 km for transport in Europe (material recycling is currently only performed in Europe). Shorter transport distance for thermal recycling.

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collected separately (total product)</td>
<td>5.13</td>
<td>kg</td>
</tr>
<tr>
<td>Collected as mixed construction waste</td>
<td>0</td>
<td>kg</td>
</tr>
<tr>
<td>Reuse</td>
<td>0</td>
<td>kg</td>
</tr>
<tr>
<td>Recycling aluminium profile</td>
<td>4.02</td>
<td>kg</td>
</tr>
<tr>
<td>Thermal recycling Seals</td>
<td>0.212</td>
<td>kg</td>
</tr>
<tr>
<td>Recycling: Scenario 1, foil</td>
<td>0.896</td>
<td>kg</td>
</tr>
<tr>
<td>cushions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>Thermal recycling: Scenario 2, foil cushions</td>
<td>0.896 kg</td>
<td></td>
</tr>
<tr>
<td>Landfilling</td>
<td>0 kg</td>
<td></td>
</tr>
</tbody>
</table>

**Re-use, recovery and recycling potential (D), relevant scenario information**

Module D includes credits from incineration processes of packaging waste (A5), seals, and the foil cushions in scenario 2 (C4) and from recycling the aluminium frames as well as foil cushions in scenario 1. A waste incineration plant with an R1 value of < 0.6 is assumed.
The following table depicts the results of the indicators concerning the estimated impact, use of resources as well as waste and other output flows in relation to 1 m² of Texlon® system.

### RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: 1 m² Texlon®-System

<table>
<thead>
<tr>
<th>PRODUCT STAGE</th>
<th>CONSTRUCTION/PROCESS STAGE</th>
<th>USE STAGE</th>
<th>END OF LIFE STAGE</th>
<th>BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material</td>
<td>Supply</td>
<td>Transport</td>
<td>Manufacturing</td>
<td>Assembly</td>
</tr>
<tr>
<td>A1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### RESULTS OF THE LCA - RESOURCE USE: 1 m² Texlon®-System

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>A1-A3</th>
<th>A4</th>
<th>A5</th>
<th>B6</th>
<th>C2</th>
<th>C3/1</th>
<th>C3/2</th>
<th>C4</th>
<th>C4/1</th>
<th>C4/2</th>
<th>D1</th>
<th>D2</th>
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<tbody>
<tr>
<td>GWP</td>
<td>[kg CO₂-Eq.]</td>
<td>4.07E+1</td>
<td>1.83E+1</td>
<td>5.75E-1</td>
<td>1.32E-1</td>
<td>1.05E-1</td>
<td>5.75E-1</td>
<td>0.00E+0</td>
<td>2.53E-1</td>
<td>1.50E+0</td>
<td>-2.48E+1</td>
<td>-1.97E+1</td>
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<tr>
<td>ODP</td>
<td>[kg CFC-11-Eq.]</td>
<td>1.85E-6</td>
<td>1.18E-10</td>
<td>3.57E-12</td>
<td>1.18E-10</td>
<td>1.84E-12</td>
<td>3.22E-10</td>
<td>0.00E+0</td>
<td>2.67E-11</td>
<td>4.28E-11</td>
<td>-8.37E-7</td>
<td>-5.89E-9</td>
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<tr>
<td>AP</td>
<td>[kg SO₂-Eq.]</td>
<td>1.73E-1</td>
<td>3.00E-2</td>
<td>3.21E-6</td>
<td>3.92E-4</td>
<td>2.73E-4</td>
<td>1.03E-3</td>
<td>0.00E+0</td>
<td>5.02E-4</td>
<td>1.61E-2</td>
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<td>-1.08E-1</td>
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<tr>
<td>EP</td>
<td>[kg PO₄₃⁻-Eq.]</td>
<td>1.02E-2</td>
<td>1.10E-3</td>
<td>1.08E-5</td>
<td>1.29E-5</td>
<td>5.70E-5</td>
<td>1.44E-4</td>
<td>0.00E+0</td>
<td>2.34E-5</td>
<td>5.62E-5</td>
<td>-4.30E-3</td>
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<td>PCOP</td>
<td>[kg ethene-Eq.]</td>
<td>1.26E-2</td>
<td>4.98E-3</td>
<td>5.09E-6</td>
<td>3.60E-5</td>
<td>6.98E-5</td>
<td>5.78E-5</td>
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<td>4.23E-5</td>
<td>-7.18E-3</td>
<td>-5.95E-3</td>
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<tr>
<td>ADPE</td>
<td>[kg SB-Eq.]</td>
<td>9.54E-5</td>
<td>6.11E-7</td>
<td>5.18E-9</td>
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<td>9.54E-8</td>
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<td>-2.52E-6</td>
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<tr>
<td>ADPF</td>
<td>[MJ]</td>
<td>9.54E+2</td>
<td>2.58E+2</td>
<td>1.00E+1</td>
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<td>1.18E+1</td>
<td>-2.71E+2</td>
<td>-1.94E+2</td>
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</tbody>
</table>

Caption: GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; PCOP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-ferrous resources; ADPF = Abiotic depletion potential for fossil resources

### RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: 1 m² Texlon®-System

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>A1-A3</th>
<th>A4</th>
<th>A5</th>
<th>B6</th>
<th>C2</th>
<th>C3/1</th>
<th>C3/2</th>
<th>C4</th>
<th>C4/1</th>
<th>C4/2</th>
<th>D1</th>
<th>D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>HWD</td>
<td>[kg]</td>
<td>5.67E-2</td>
<td>0.00E+0</td>
<td>9.88E-4</td>
<td>0.00E+0</td>
<td>0.00E+0</td>
<td>2.30E-3</td>
<td>0.00E+0</td>
<td>8.99E-3</td>
<td>9.02E-3</td>
<td>-1.47E-2</td>
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<td>NHNO</td>
<td>[kg]</td>
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<td>5.18E-5</td>
<td>1.01E-3</td>
<td>1.69E-4</td>
<td>9.97E-3</td>
<td>0.00E+0</td>
<td>1.93E-2</td>
<td>2.91E-1</td>
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<tr>
<td>RWG</td>
<td>[kg]</td>
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<td>0.00E+0</td>
<td>0.00E+0</td>
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<td>MFR</td>
<td>[kg]</td>
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<td>0.00E+0</td>
<td>4.02E-6</td>
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<tr>
<td>MEN</td>
<td>[kg]</td>
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<td>0.00E+0</td>
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</tr>
<tr>
<td>EEE</td>
<td>[MJ]</td>
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<tr>
<td>EET</td>
<td>[MJ]</td>
<td>0.00E+0</td>
<td>0.00E+0</td>
<td>1.92E+0</td>
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<td>4.95E+0</td>
<td>0.00E+0</td>
<td>0.00E+0</td>
<td></td>
</tr>
</tbody>
</table>

Caption: HWD = Hazardous waste disposed; NHNO = Non-hazardous waste disposed; RWG = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MEN = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy

Note: The values in Module B6 refer to a period of use of one year. When using the values in the building, they must be scaled to the building’s total useful life.

Note on caption: The first reference to EEE (Exported Electrical Energy) is correct. The second reference to EEE should read either ETE (Exported Thermal Energy) or EET (Exported Energy Thermal).
6. LCA: Interpretation

The majority of environmental impacts and the use of primary energy are caused by the upstream chain, i.e. manufacture of the preliminary products, whereby a large percentage is credited again during recycling. Manufacture of the aluminium frame in particular represents a significant percentage of the overall mass and is clearly apparent during the production phase. The actual foil cushion also contributes a significant impact on the life cycle. This is particularly attributable to the production of granulate. Production at Vector Foiltec has barely any effect on the impact categories under review (up to max. 6% of the overall production phase).

The other impact categories essentially follow this breakdown for the entire production phase too. Transport to the construction site is modelled in accordance to the international distribution of the Texlon® system and is based on average values for 2012. Since some of the distances are long, the effects are apparent; in the case of the Eutrification Potential, they even exceed those for production of the declared product on account of emissions incurred by such transport. But transport can also be significantly less intensive for specific projects.

Neither the energy required for initial inflation of the foil cushion (Module A5) nor for maintaining the internal cushion pressure during the utilization phase (Module B6) contribute significantly to the overall life cycle in any of the impact categories. It must be noted that these values relate to a life cycle of one year and need to be adapted to the requisite service life of a building LCA. For calculations extending over 25 years, the contribution is less than 15% in relation to the entire life cycle of the foil cushion. Two scenarios are presented for the End of Life:

1. Material recycling of the foil cushion
2. Thermal recycling of the foil cushion

In both cases the aluminium frame is recycled. Credits are incurred for both scenarios but are higher for material recycling.

7. Requisite evidence

7.1 VOC emissions

Inspection of the Nowoflon® ET foil for VOC emissions in accordance with the AgBB scheme (AgBB 2010) was carried out in December 2009 by the Bremer Umweltinstitut – Gesellschaft für Schadstoffanalysen und Begutachtung mbH.

Measurement conditions:
- Temperature: 23°C
- Area specific air flow rate: 0.5 m³/(m²h)
- Loading: 2 m²/m³

VOC without NIK: 27 µg/m³
Cancerogens: n.d: not detected

8. References

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Institut Bauen und Umwelt e.V., Berlin (pub.): Generation of Environmental Product Declarations (EPDs);

General principles for the EPD range of Institut Bauen und Umwelt e.V. (IBU), 2013/04
www.bau-umwelt.de

ISO 14025
DIN EN ISO 14025:2011-10: Environmental labels and declarations — Type III environmental declarations — Principles and procedures

EN 15804
EN 15804:2012-04+A1 2013: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products

PCR guideline texts for building-related products and services, Part B: Requirements on the EPD for ETFE components, 2012-07

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Data base for comprehensive analysis LBP, University of Stuttgart and PE International, Documentation of GaBi 6 data sets http://documentation.gabi-software.com/, 2013

CML 2010: CML 2001 – November 2010: Characterisation factors developed by Institute of Environmental Sciences (CML); University Leiden http://www.cml.leiden.edu/software/data-cmlia.html

DIN EN ISO 9001:2008-12: Quality management systems — Requirements

EN 13501-1: 2012-1, Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests
BRUMI H2954fs: Emission tests of ETFE foils for VVOC, VOC and SVOC according to AgBB/DIBt requirements for building materials, Bremer Umweltinstitut, Bremen, Germany, 2009

AgBB 2010: Procedure for health-related evaluation of the emissions of volatile organic compounds (VOC and SVOC) from construction products, Committee for health-related evaluation of construction products, Dessau-Roßlau, Germany, May 2010

ArbSchG §5: §5 of the German Occupational Safety Act, Assessment of working conditions, in: Law on implementing occupational safety measures for improving the safety and health protection of employees in the workplace


REACH: Registration, Evaluation, Authorization and Restriction of Chemicals, 2007


ISO-2286-2(1998): Rubber or plastics coated fabrics - Determination of roll characteristics Part 2: Methods for determination of total mass per unit area, mass per unit area of coating and mass per unit area of substrate

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OHRIS 2009: Registration office of the State institute for occupational safety and product safety (AP) of the Bavarian State Office for Health and Food Safety (LGL), Munich, www.lgl.bayern.de/arbeitsschutz
