Environmental Impact of Membrane Materials and Structures

THE NEW TENSINET WORKING GROUP ON LIFE CYCLE ASSESSMENT FOR MEMBRANES

LCA

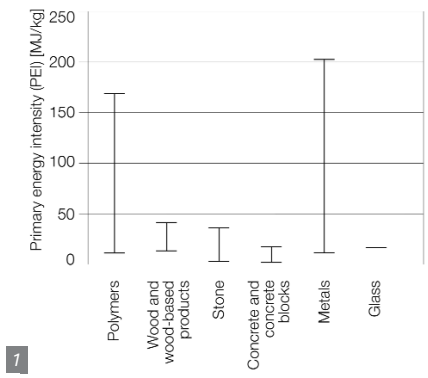
Increasing energy efficiency in the operation of buildings is a major challenge of our time. But we also have to focus on the energy consumption ("grey energy") and environmental impact of the materials and structures used for our buildings - with regard to their full life cycle, from the production to recycling or disposal. It is important to understand that the effects of our planning decisions extend deeply into the future. Most buildings are meant to last for decades. Our industry is proud to also offer this perspective to our clients when they embark on our materials and structures. In parallel, the planet's resources are shrinking and get more and more contested and hard-fought. Compared to other industry branches, the building sector is still lacking efficiency in the use of materials and rationalisation, the overall recycling rate is very low.
With regard to the membrane industry we see a Janus-faced discussion: On the one hand we apply polymers that use enormous amounts of energy for their production. They contain a high amount of primary energy in relation to their mass (Fig.1), and emissions from some of the materials can represent dangers for the environment and users. On the other hand, they have an undoubted potential for generating resource and energy savings through forms of construction that utilise these materials very efficiently. Membrane material's mass per area is very low.

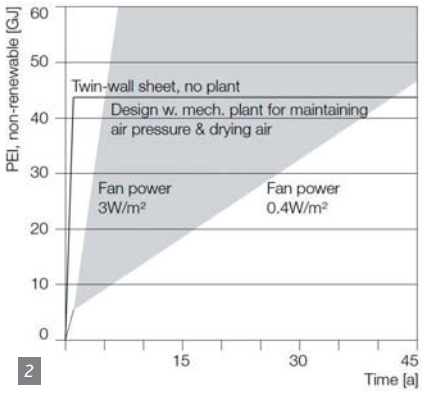
Life Cycle Assessment (LCA)

Some months ago, a new working group has been founded by an initiative of the author which will focus on the subject of Life Cycle Assessment (LCA) in our industry. The aim of this group is to review the current status on membrane materials and typical membrane structures with regard to LCA issues which can be used as a key evaluation criterion in the objectification of the discussion on membrane materials that our industry is based on (Fig. 2). The LCA approach aims for a transparent evaluation of the complex environmental impacts of products and processes involved. It looks at the stages of material or structure's life such as obtaining the raw materials, production, processing and transport, also use, reuse and disposal if applicable. LCA measures environmental impact across a range of issues such as impact: on air quality, on water usage and water quality, on toxicity to human life and to ecosystem functioning, on impact on global warming as well as resource use. There are "Cradle-to-grave" assessments that investigate the entire life cycle of a product, but also "cradle-to-gate" assessments that consider only the life of a product up to the time it leaves the factory (Fig. 6). DIN EN ISO 14040 describes the LCA method which can be split into four phases: definition of goal and scope, inventory analysis, impact assessment and interpretation (Fig. 3). In a final step all results like reports and declarations have to be scrutinised by an independent group of experts which is essential if comparative statements, e.g. with respect to rival products, are to be made or the results are to be made public.

Environmental Product Declarations (EPD)

Drafting a product LCA is a time-consuming and expensive process that is generally carried out for the product manufacturer or a group of manufacturers by a specialist company. The ecological characteristics of a product are communicated in the form of environmental declarations. According to the ISO 14020 family, these environmental product declarations (EPD) are classified as so called "type III" environmental labels which are highly regulated. Here, the most important environmental impacts of products are described systematically and in detail. The starting point is a product LCA, but further indicators specific to the product (e.g. contamination of the interior air) are also included. In this form of declaration it is not the individual results of measurements that are checked by independent institutes, but rather conformity with the product category rules (PCR) drawn up to ensure an equivalent description within that product category. An EPD describes a product throughout its entire life cycle – it contains all relevant environmental information. EPDs are third party verified and guarantee reliability of the information provided. Calculation Rules for EPDs are defined by EPD program holders – for building products EN 15804 is introduced as respective standard in Europe. EPDs help in early planning stage, they show environmental performance of a product or a product group, they are often used in political discussion and can be a basis for a company's internal benchmark and improvement.





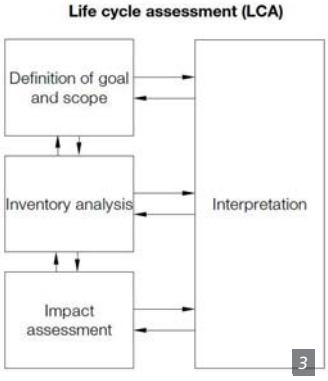


Figure 1. Primary energy spans of individual building material groups, PEI in [MJ/kg]
Figure 2. Development of primary energy consumption for pneumatic structures with air pressure maintained by mechanical plant compared with a system without any air supply
Figure 3. The sequence and phases of a life cycle assessment (LCA)

Why we? And why now?

Why it is important for our industry to pre-actively address the LCA issue now? There are a number of drivers, for example:

- Building assessment systems with country-specific priorities for indicating the building's, like for example LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), DGNB (German Sustainable Building Council). The latter was one of the first methods to prescribe a certification system that looks at the entire life cycle of a building and also includes a type of building LCA based on EPDs of the individual construction products (Fig. 4). This puts the focus of planners, users and investors to environmental impact of a whole building (including the LCAs of construction products). "Green Building" is a highly growing market share;
- Competitive situation by comparing membrane materials and structures to alternatives with LCA data available;
- Defence against prejudices based on missing, insufficient, misleading or wrong LCA data;
- Customers awareness. Communication on environmental product performance gains importance for manufacturers and will strengthen customer relationship;
- LCA data will become more and more important in tendering and award procedures. This also applies to the use for Construction Product Regulation;
- Existing and future legal regulations on waste concerning the building industry.

Although the importance of the various sustainability criteria may vary, issues considered to be important include:

- Energy and carbon dioxide emissions (from building operation);
- Materials and resource use (including embodied energy);
- Waste minimisation, including recycling;
- Transport (in relation to the use of the building);
- Water conservation and use (within the building);
- Land use and ecology;
- Minimising pollution;
- Construction and building management (including security);
- Health and well-being within the building.

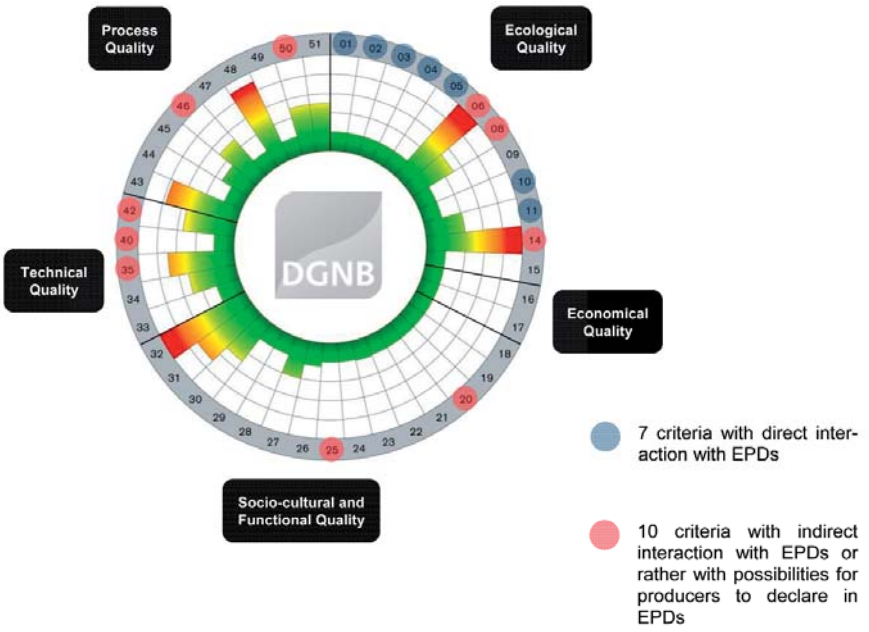


Figure 4. Sample result of DGNB assessment and interaction of criteria with EPDs

Material and building component selection has a direct impact on the building design and performance and hence affects the operational energy use and the health and well-being of its occupants. Therefore, the industry needs to quantify these benefits in order to maximise its sustainability credentials.

Some more background

With the advent of the European single market for construction products, the European Commission became concerned that national EPD schemes and building level assessment schemes would represent a barrier to trade across Europe. The EU therefore sought a mandate from the EU Member States to develop European standards for the assessment of the sustainability performance of construction works and of construction products. This mandate is called CEN/TC 350. From 2010 European standards began to emerge from this process and Standard BS EN15804 was published in February 2012 providing core rules for construction product EPD.

The Construction Products Directive of 1989 was one of the first Directives from the EU Commission to create a common framework for the regulations on buildings and construction products. It has been replaced by the Construction Products Regulation (CPR) and is legally binding throughout the EU. The CPR includes requirements for the sustainable use of natural resources, the reduction of greenhouse gas emissions over the life cycle and the use of EPD for assessing and reporting the impacts of construction products. If an EU Member State wishes to regulate in these areas of sustainability it must use European standards where they exist when regulating and must withdraw national standards. This means that in the case of the CPR a Member State must use the CEN/TC 350 suite of standards.

An EPD provides robust and consistent information that can be used in building level assessments and the guide elaborates on the variety of ways that this can be done. In addition a number of building level tools are emerging aimed at improving decisions at the design stage by combining embodied environmental impact data and whole life cost data (i.e. economic) and link them to BIM (Building Information Modelling) data.

Across Europe, the various environmental rating schemes are seeking to harmonise the ways in which they assess products and buildings. Increasingly models are emerging to link embodied impacts with operational data thus enabling a better understanding of the trade-off between operational and embodied impacts and in time benchmarks for different types of buildings will emerge. All of which contributes greatly to the goal of a low carbon, more resource efficient, sustainable built environment. [2]

Where we are and next steps

The status reached so far is rather heterogeneous and inconsistent for the typical materials we use. There are some forerunners, for example there is a first (but only company specific) EPD on ETFE (Fig. 5). On the level of structure types, there is hardly any information

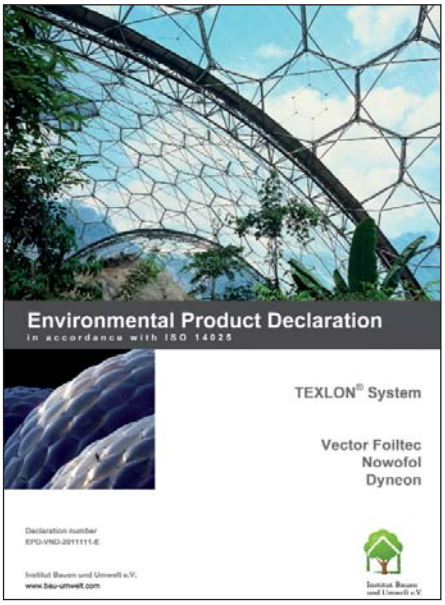


Figure 5. Company specific Environmental Product Declaration for ETFE: EPD-VND-2011111-E, 10-2011

available so far. The LCA Working Group will identify and describe steps that could be taken within the Tensinet association to achieve a coherent data base to work with. It should also be as open and transparent as possible to gain a maximum of credibility.

Kick-off workshop

As a next step we will have a kick-off workshop in Stuttgart with LCA-consultancy PE International on October 11th/12th. Aiming to define goal and scope of a common project, our topics are:

- discussion and agreement on the goals of the LCA/EPD membrane project;
- specific, average or template EPDs, value of an EPD calculator?;
- clustering of comparable products for EPDs;
- definition scope of the work;
- proposal for products to be included (PTFE/glass, ETFE, PVC/PES, PTFE fabric, PTFE glass laminate, silicone glass fabrics, others?);
- agreement on producers and sites to be included;
- agreement on contractual and financial solution.

The idea of having a common successful LCA/EPD membrane project is based on some assumptions:

- joint project of several producers and other players of the membrane sector;
- for each product group there is at least one producer of final product involved and willing to contribute;
- for each product group the key producers of raw material are involved and willing to contribute;
- the project is managed by a neutral third party (PE International) to allow for confidentiality in data handling, producers will supply data in agreed time schedule.

Following the workshop we intend to structure the LCA project in the following tasks:

- Development / adaption of the PCR-Documents;
- Data collection for the production of Membranes;
- Data collection for the End-of-Life Scenarios;
- Provision and development of the upstream data (supply chain data);
- System modelling and calculation of the LCA results;
- Documentation of the LCA and development of the EPDs.

So far, there are amongst others the following manufacturers involved: Dyneon, Verseidag-Indutex, Serge Ferrari, Saint-Gobain PP, and Sefar. We hope that even more relevant and important players in the membrane world understand the chance of this project, also with regard to economical benefits compared to individual actions on the subject. Thanks to the Tensinet Board, the kick-off workshop will be free of charge to all the participants.

If you are interested to join us for the workshop or generally for the group, please contact the author via email (jan.cremers@hft-stuttgart.de).

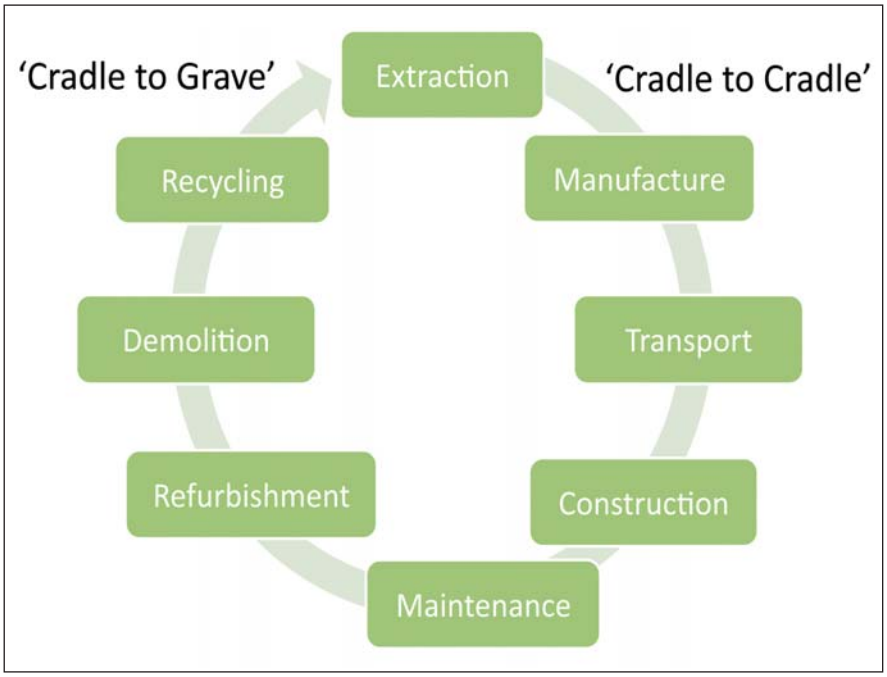


Figure 6. Life cycle of a construction product

about Hightex

Hightex Group is a specialist provider of large area architectural membranes for roofing and façade structures. Hightex has been involved in the construction of a number of high profile buildings including Cape Town Stadium and Soccer City Stadium in Johannesburg, the Wimbledon Centre Court retractable roof, the roof of the Suvarnabhumi International Airport in Bangkok. Recent projects include the new stadia of Warsaw, Kiev, Vancouver, and most recently Porto Alegre and Maracana in Brazil.

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[2] Anderson, J.; Thornback, J.: A guide to understanding the embodied impacts of construction products, Construction Products Association, 2012 (available online at www.constructionproducts-sustainability.org.uk)