TensiAet

WELCOME

TensiNet LCA Webinar

Organised by TensiNet and the Working Group Sustainability & Comfort

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06-03-2026

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TensiAet

The first TensiNet webinar was about **PFAS**

Chemservice will collect information on the socio & economical impact

of a PFAS ban and

will prepare, on behalf of TensiNet, the dossier to reply to SEAC

Chemservice has prepared a questionnaire.

Return this questionnaire no later than Friday 20th March 2026,

to assure a timely development of the TensiNet response to SEAC

https://www.tensinet.com/index.php/call-questionnaire-on-the-socio-economical-impact-of-a-pfas-ban-deadline-for-submission-20-03-2026

(under news)

CHEMSERVICE

2

TensiNet

TensiNet will be holding more webinars

on a monthly basis, at lunchtime

Todays webinar is about

Membrane Architecture - Life Cycle Assessment - Environmental Impacts

More in depth case studies and

comparative analyses will be presented in the next webinars

Suggestions are welcome

3

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Programme

13.05 – 13.20 What is the Life Cycle Assessment? And what does it mean in Membrane Architecture Field? - *Carol Monticelli*

13.20 – 13.35 Environmental Product Declarations in Tensile Architecture: Available Datasets and Environmental Impact based on Global Warming Potential - *Zehra Eryuruk*

13.35 – 13.55 Q&A - *Katja Bernert*

13.55 – 14.00 Closure of the meeting - *Marijke Mollaert*

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Handouts will be made available after the webinar

During this webinar, participants will be muted

Please type your questions in the Q&A area

and indicate which speaker you are addressing

Katja Bernert will ask the questions in due course

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Next webinars will be announced on the TensiNet website and on linkedin

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Marijke Mollaert

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(under news)

CHEMSERVICE

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What is the Life Cycle Assessment?

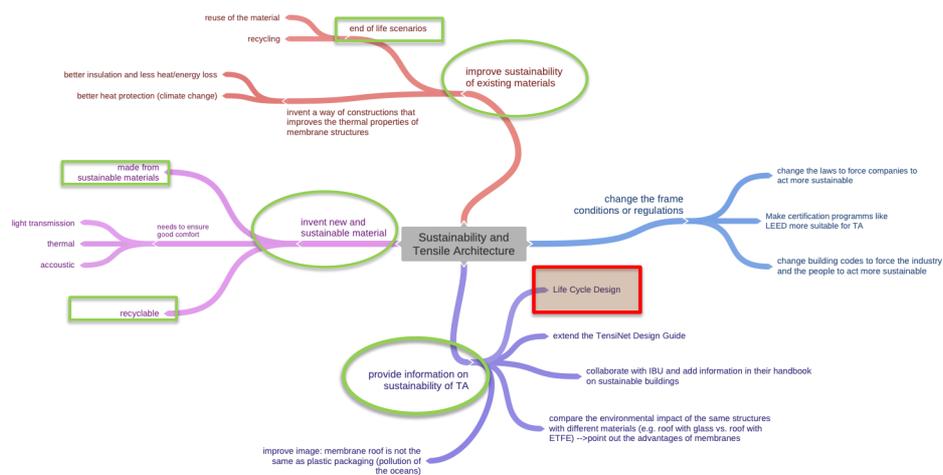And what does it mean in Membrane Architecture Field?

Carol.Monticelli@polimi.it

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06-03-2026

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1

WG Sustainability & Comfort: Life Cycle Design

reuse of the material

recycling

end of life scenarios

better insulation and less heat/energy loss

better heat protection (climate change)

improve sustainability of existing materials

invent a way of constructions that improves the thermal properties of membrane structures

made from sustainable materials

change the laws to force companies to act more sustainable

light transmission

thermal

accoustic

needs to ensure good comfort

invent new and sustainable material

Sustainability and Tensile Architecture

change the frame conditions or regulations

Make certification programs like LEED more suitable for TA

change building codes to force the industry and the people to act more sustainable

recyclable

Life Cycle Design

extend the TensiNet Design Guide

provide information on sustainability of TA

collaborate with IBU and add information in their handbook on sustainable buildings

compare the environmental impact of the same structures with different materials (e.g. roof with glass vs. roof with ETFE) -->point out the advantages of membranes

improve image: membrane roof is not the same as plastic packaging (pollution of the oceans)

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2

New Materials and Technologies: More Lightness & Energy Saving?

Frei Otto's words (2004)

"*Our time needs more lightness, more energy saving, more mobility and adaptability*"

"*doing more with less*" Buckminster Fuller *Minimal impact*

"*minimum mass and minimum energy*" Frei Otto *Maximal efficiency*

"*touching the Earth lightly*" Glen Murcutt *Lightness*

Less **matter** less **environmental impact** towards **LIGHTNESS**

Does LIGHTWEIGHT really mean
a strategy to reduce the use energy and resources

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3

Eco efficiency Design Strategies

Lightness becomes a paradigm to reduce the environmental impacts starting from the design process till the execution

The **lightness** paradigm is meaningful in a two-fold:

- high shape efficiency on one side
- high matter efficiency on the other one

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Eco efficiency Design Strategies for Membranes   TensiNet

❖ *Doing more with less* - Minimal structures in nature only use the raw material needed in relation to the duration foreseen for the system.

PRE – USE PHASE

❖ *Time-based structures* - The durability of membranes and foils employed to build up structural skins is object of analysis

OPERATIONAL PHASE

❖ *Closing the loop* - New technology seeks to integrate polymeric waste in the production cycle of new structural materials (down- or up-cycling) and to find a new life for old, dismantled membrane structures (reuse or recycling).

END OF LIFE CYCLE

❖ *Life Cycle design* - The Life Cycle Analysis methodology plays a fundamental role to obtain more sustainable procedures in design, building and renovation.

THE WHOLE LIFE CYCLE

Architectural Membranes suit perfectly!

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Life Cycle Assessment & Building sector   TensiNet

Life Cycle Design is based on

Life Cycle Assessment LCA

Important tool for the environmental impact assessment of alternative materials and technical solutions in order to **help the design choices**

Ceramics   Metals

Polymers   Natural materials

Composites
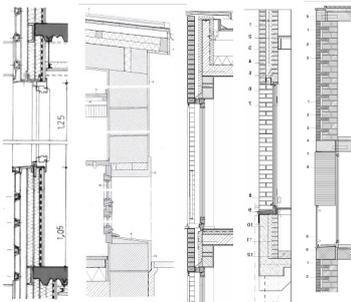
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Life Cycle Assessment & Building sector

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Strategy of Sustainability of the project

MEANS: *from Cradle to Grave*

to consider all the stages of the life cycle of a design product or a building materials and component manufacture

❖ construction
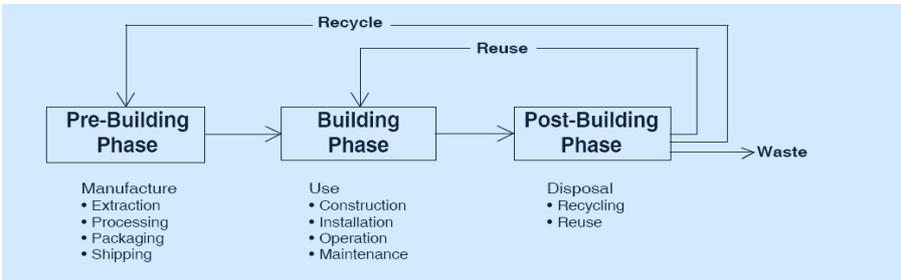❖ use
❖ management/maintenance
❖ disassembling
❖ end of life

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Life Cycle Assessment & Building sector

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To investigate which stage of the building systems manufacturing chain has the greatest environmental impact, by assessing embodied energy, embodied carbon, and other environmental indicators

Recycle

Reuse

Pre-Building Phase → **Building Phase** → **Post-Building Phase** → Waste

Manufacture
• Extraction
• Processing
• Packaging
• Shipping

Use
• Construction
• Installation
• Operation
• Maintenance

Disposal
• Recycling
• Reuse

from Cradle to Cradle

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Life Cycle Assessment & Building sector

Source: C. Vertua

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Standards behind LCA

ISO 14040:2006 – Principles and Framework

- The phases of an LCA (goal and scope, inventory analysis, impact assessment, and interpretation)
- General requirements and guidelines
- Limitations and applications

BS EN ISO 14040:2006+A1:2020
Incorporating corrigendum August 2006

BSI Standards Publication

Environmental management — Life cycle assessment — Principles and framework

ISO 14044:2006 – Requirements and Guidelines

- Defining the goal and scope
- Performing life cycle inventory (LCI)
- Life cycle impact assessment (LCIA)
- Interpretation of results
- Reporting and critical review
- Data quality, assumptions, and limitations

BS EN ISO 14044:2006+A2:2020
Incorporating corrigendum May 2018

BSI Standards Publication

Environmental management — Life cycle assessment — Requirements and guidelines

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Life Cycle Assessment (LCA) Methodology

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Life cycle assessment (LCA)

is a tool
for analyzing the environmental implications of a product
throughout all stages of its life cycle

from raw material extraction, to material processing,
to product assembly, the use phase and the end-of-life scenario

The negative impacts on the environment encompass all types of impact:

- resource consumption
- energy consumption   **INPUT**
- water consumption

- air emissions
- water emissions   **OUTPUT**
- soil emissions (solid waste)

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Phases of LCA Analysis

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Definition:
- goals
- system boundaries
- functional unit
- system function

Materials   Processes   Energies

Inventory Analysis   2

Impact Assessment   3

Emissions - resources

Classification

Characterization

Normalization

Damage Assessment

feedback   feedback   feedback

Sensitivity and Improvement Analysis   4

Support tools for damage assessment
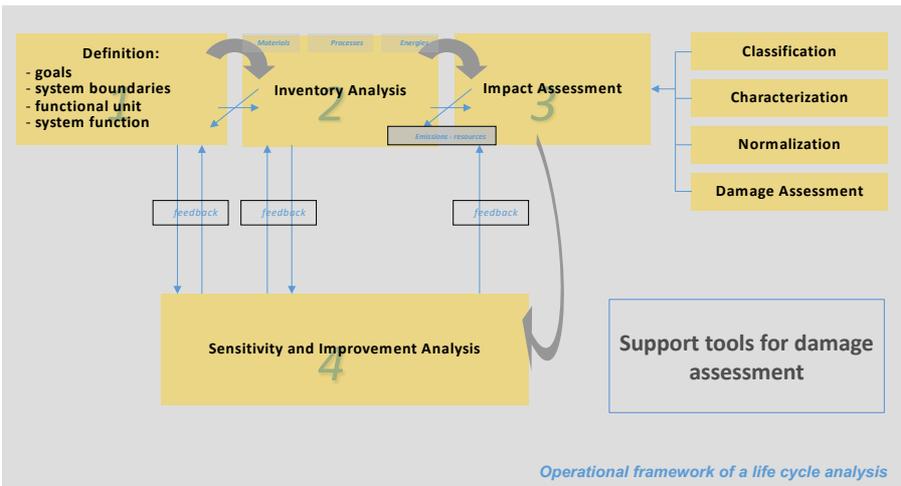
Operational framework of a life cycle analysis

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Second phase – Inventory Analysis

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ACCOUNTING PHASE *- Life Cycle Inventory*

Quantity calculation for each investigation element

- ❖ **resource consumption**   **g   (sand, clay, bauxite,...)**
- ❖ **energy consumption**   **MJ (renewable, non-renewable,...)**
- ❖ **water consumption**   **l**
- ❖ **air emissions**   **g (CO2, CH4, SOx, NOX, HCl, HF...)**
- ❖ **water emissions**   **g (BOD, COD, N,...)**
- ❖ **soil emissions**   **(solid waste) g (hazardous, non-hazardous)**

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Second phase – Inventory Analysis

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Primary Data   Collection of quantitative data relating to:
         - substances/energies input into the production process
         - substances/energies emitted during processing

EPD   Information from manufacturing companies

Secondary Data   From database:
- selection of entries appropriate to the process to
  analyze
- construction of characteristic processes for products
  composed of multiple elements
- quantification of flows to match the entries from
  database

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Key tools for LCA

MAJOR COMMERCIAL & ENTERPRISE TOOLS

SimaPro
SimaPro (by PRé Sustainability)
- Industry-Leading for Research and Academic Use
- Transparent Modeling with Monte Carlo Analysis
- Extensive Datasets (ecoinvent, EPDs, World Food)

GaBi (by Sphera)
- Enterprise Scale & Compliance
- Industry-Specific Solutions (Auto, Chem, Elec)
- Robust Reporting & Automation

KEY TRENDS
AI/Automation • Interoperability • Regulation Compliance (CSRD/EPD)

SPECIALIZED, STREAMLINED, & OPEN-SOURCE TOOLS

Open Source — openLCA
- Free & Flexible for Professionals
- Broad Database Compatibility

Construction-Focused — One Click LCA
- Automated Building LCAs & EPDs
- 250,000+ Verified Datasets

Streamlined for SMEs — Ecochain Mobius
- Fast, Easy Product Footprints
- Benchmarking & Scenario Analysis

Niche Sector — Carbon Trail
- Fashion & Retail Footprinting
- AI-Driven Data Management

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Third Phase – Impact Assessment (LCIA)

A technical-quantitative (and/or qualitative) process
with the aim of:

identifying, classifying, and characterizing the effects induced by human activity on resource consumption, environmental conservation, and human health

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Third Phase – Impact Assessment (LCIA)

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An impact is associated with one or more environmental effects that are difficult to correlate

The Life Cycle Inventory (LCI) phase provides quantitative data on material and energy flows associated with the product system.
In the subsequent Life Cycle Impact Assessment (LCIA), these flows are translated into potential environmental impacts using scientifically established characterization models.

However, the resulting impact indicators represent potential environmental effects based on modelling assumptions and conventions and therefore may not be directly verifiable in real-world environmental outcomes.

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Why LCA for Membrane Architecture?

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Academic Research & Investigations
- **Embodied Energy | Embodied Carbon Awareness:** Focus on quantifying the energy footprint of lightweight materials during the design phase.
- **Systemic Evaluation:** Prioritizing the **final eco-performance properties** of the entire building system rather than analyzing materials in isolation.

Membrane Designers & Structure Suppliers
- **Integrated Design Factors:** Assessing environmental profiles as a primary choice factor, alongside:
  - Thermal performance
  - Acoustic properties
  - Structural resistance

Producers & Material Suppliers
- **Innovation:** Developing new bio-based products and lightweight components.
- **Circular Economy:** Closing the production chain to minimize waste.
- **Emission Goals:** Controlling hazardous outputs to achieve **"nearly zero dangerous emissions."**

The NEED: HARMONISATION instead of FRAGMENTATION

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SoTA of the LCA use on Membrane Buildings

Analysis levels – system boundaries

material production phase

Life cycle of matter
from cradle to gate
Analysis

The application of a comparative LCA in the membrane architecture is the appropriate procedure to quantify and compare the environmental impacts and consumption of materials and energy throughout the whole life cycle, within the following levels:

manufacturing and system production phase

Life Cycle of building components
from cradle to grave
Comparison

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Membrane Building in the construction sector

The distribution of the uses of membranes in different architectural configurations highlights the diffusion of membrane architecture with permanent functions (more than 30 years) and close shaped buildings
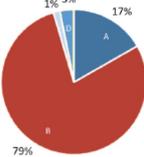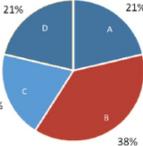
A Permanent open   C Temporary open
B Permanent closed   D Temporary closed

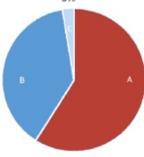ETFE foil
353 cases
1% 3%
17%
A
B
79%

PES/PVC
61 cases
21% 21%
D   A
C
20% B
38%

FIBER GLASS/PTFE
39 cases
3%
B
38%   A
59%

PTFE fabric
6 cases
17%
C   A
33%
B
50%
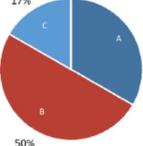
Elaboration of the authors with arch. Lisa Busi

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Membrane Building in the construction sector

The case of **permanent** buildings

Production impacts

Service life

Priority to the operational phase
(energy requirements for heating and cooling, for pumping, ordinary or extra maintenance)

Attention to:
⊙ What material and technological solutions?
⊙ How much do they environmentally impact?

The case of **temporary** buildings

Production impacts

Production impacts   Service life   Service life

Priority to pre-use phase   A.   B.

the impact of building components
(in some situations, energy heating and cooling plants and consumption during the service phase are not required)

Attention to: the expected life span (almost always known and definable)
⊙ the expected life span (almost always known and definable)
⊙ The durability of the materials and components

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A proposal of principles
for an optimized LCA approach

Looking on the world of professional design and construction
is perceived a great difficulty to disentangle in structured, often divergent requirements to
be fulfilled, and specifically in application a LCA methodology during the project

On one hand, **the research** assumes

the task of contemplating exhaustively the eco-environmental performance of structural
membranes, despite the extreme complexity and richness of different aspects
Versus biased and simplistic approaches

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**A proposal of principles
for an optimized LCA approach**

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Looking on the world of professional design and construction
is perceived a great difficulty to disentangle in structured, often divergent requirements to
be fulfilled, and specifically in application a LCA methodology during the project

On the other hand, **the operative attitudes of the design field** are various:

presumably, with a view to Life cycle thinking, the completeness of the systemic problem
is not embraced, however reveals an approach to extremes design, focusing with the
design technical choices partially on the optimization of individual lifecycle phases

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**A proposal of principles
for an optimized LCA approach**

The approaches seen from the eco-efficiency point of view

According to a methodological approach for the environmental impact
assessment,

it is essential that the designer defines and delimits

✓ the scope,
✓ its object to be designed
✓ the contextual problems and
✓ the more stringent best technique for dealing with
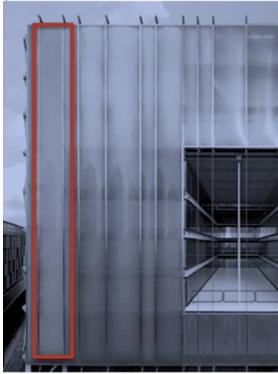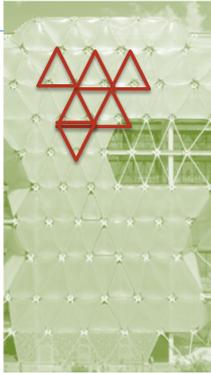
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Carol Monticelli

Definition of LCA Statements
starting from the research advancements

as reference to set up the LCA of membrane structures

1st **principle:** verification of the ratio Frame Perimeter/Covered Surface
→ the case of roofs or entire building envelope

Doing more with less

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The 1st LCA Statements
starting from the research advancements
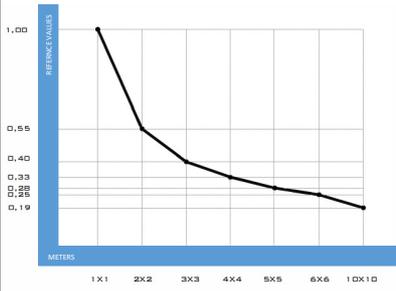
Roof A
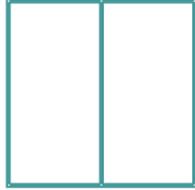
Roof B

Roof covering area 25 m²

Fixing lines perimeter **25 m**

Roof covering area 25 m²
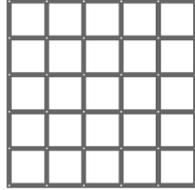
Fixing lines perimeter **60 m**

Chilton J., Pezeshkzadeh S. A. and Afrin S., *Embodied energy in ETFE foil construction*, in: H. Bogner-Balz, M. Mollaert, E. Pusat (ed) *[RE]THINKING Lightweight Structures*, Tensinet Syposium Proceedings 2013, pp. 457-466.

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Definition of LCA Statements
starting from the research advancements

as reference to set up the LCA of membrane structures

2nd principle: verification of the ratio Fixing System (or Primary Structure)/Membrane
→ the case of façades

Doing more with less
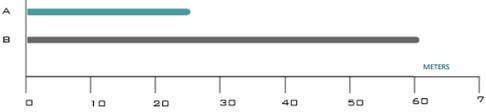
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Conclusions

The emerged results, globally, are the **first steps towards the establishment of criteria** for application of the LCA to evaluate membrane structures in the building life cycle.

⊙ The framework highlights **the dimension *time* as a supporting paradigm** to orientate the level of detail in the application of the LCA to the design.

⊙ The importance of the **definition of the *life span*** of the building and its function, from the first steps of the design process, emerges and has to be considered between the first design requirements.

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Carol Monticelli

Thank you for your kind attention

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06-03-2026

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Carol Monticelli

**ENVIRONMENTAL PRODUCT DECLARATIONS IN TENSILE ARCHITECTURE:
AVAILABLE DATASETS AND CLIMATE INSIGHT BASED ON GWP**

Zehra Eryuruk
Ir. Arch. PhD. Candidate
Zehra.Eryuruk@vub.be

Tensi/\et

VUB VRIJE UNIVERSITEIT BRUSSEL

Prof. Marijke Mollaert , Prof. Lincy Pyl, Prof. Lars De Laet

1

LCA

MATERIAL   SYSTEM   PROJECT

EPD   CERTIFICATION

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| 2

2

WHAT IS AN EPD?

Definition:

- A standardised document
- Provides quantifiable data about the environmental impact of a product throughout its lifecycle.
- It's a transparent way of reporting environmental performance in a consistent and verified format.

Wat is included in an EPD:

- Carbon Footprint
- Energy usage
- Water Usage
- End-of-Life impact

Key Aspects of an EPD:

- EPDs are based on LCAs
- EPDs follow international standards, such as ISO 14025 & EN 15804
- Third-Party Verification

Purpose of an EPD:

- Comparing the environmental impacts of materials and products

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3

WHY EPDS MATTER?

Polyester-PVC

Glass-PTFE

ETFE cushion system

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4

METHODOLOGICAL CAUTION

Not all EPDs are directly comparable:

- EN 15804 +A1 vs +A2

- Material level vs System level
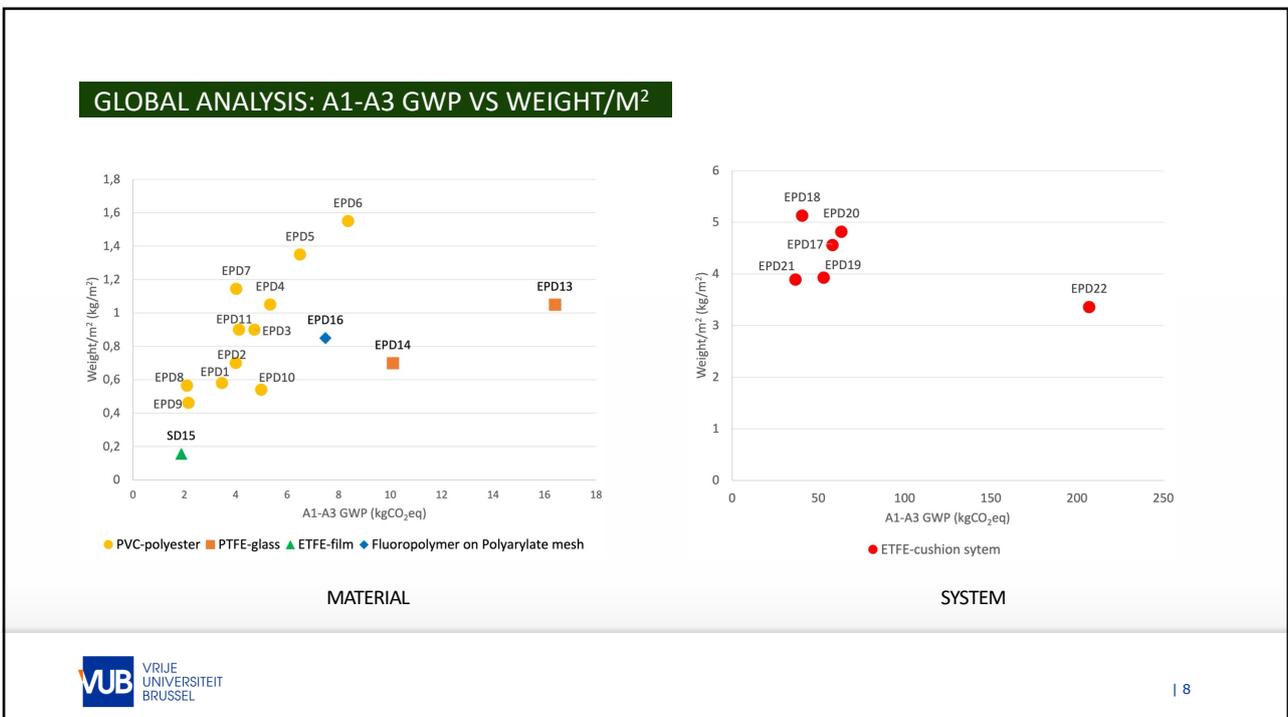
- Same declared unit, different content

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5

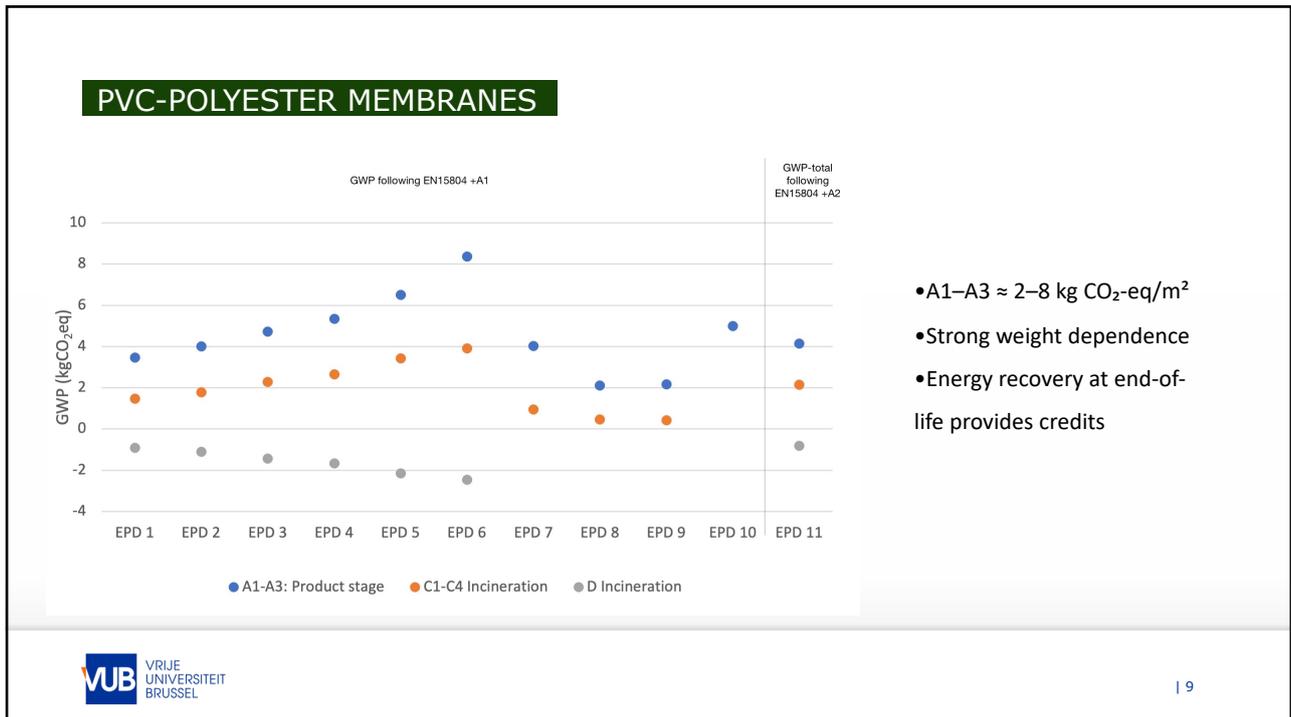|	EPD or SD	EPD-Number	EPD-Holder	Published by	Validity	Norm	Membrane Material (EPD title)	(kg/m²)
PVC-polyester fabric	EPD 1	EPD-MTX-20130164-IBA1-EN [1]	Mehler Texnologies	IBU	2013-2018	EN15804+A1	PVC-polyester: Valmex FR580	0,58
	EPD 2	EPD-MTX-20130165-IBA1-EN [2]	Mehler Texnologies	IBU	2013-2018	EN15804+A1	PVC-polyester: Valmex FR700	0,70
	EPD 3	EPD-MTX-20130166-IBA1-EN [3]	Mehler Texnologies	IBU	2013-2018	EN15804+A1	PVC-polyester: Valmex FR900	0,90
	EPD 4	EPD-MTX-20130019-IBA1-EN [4]	Mehler Texnologies	IBU	2013-2018	EN15804+A1	PVC-polyester: Valmex FR1000	1,05
	EPD 5	EPD-MTX-20130167-IBA1-EN [5]	Mehler Texnologies	IBU	2013-2018	EN15804+A1	PVC-polyester: Valmex FR1400	1,35
	EPD 6	EPD-MTX-20130168-IBA1-EN [6]	Mehler Texnologies	IBU	2013-2018	EN15804+A1	PVC-polyester: Valmex FR1600	**1,55**
	EPD 7	4-536:2021 [7]	Serge Ferrari	INIES	2021-2026	EN15804+A1	PVC-polyester: Heavyweight composite membranes 1,144 kg/m2	1,14
	EPD 8	4-535:2021 [8]	Serge Ferrari	INIES	2021-2026	EN15804+A1	PVC-polyester: Lightweight composite membranes 0,564 kg/m2	0,56
	EPD 9	4-534:2021 [9]	Serge Ferrari	INIES	2021-2026	EN15804+A1	PVC-polyester mesh: Tensile composite membranes for interior and exterior applications SOLAR PROTECTION	**0,46**
	EPD 10	S-P-01441[10]	Serge Ferrari	EPD	2018-2023	EN15804+A1	PVC-polyester mesh: Frontside view 381	0,54
	EPD 11	EPD-SIO-20220324-IBJ1-EN [11]	Sioen Industries NV	IBU	2023-2028	EN15804+A2	PVC-polyester: Technical textile type II	0,90
PTFE-glass fabric	EPD 12	4787277976.101.1 [12]	Saint Gobain, Sheerfill		2017-2023	EN15804+A1	PTFE: Sheerfill II	1,31
	EPD 13	EPD-SER-20240197-IBI1-EN [13]	Verseidag - Serge Ferrari	IBU	2024-2029	EN15804+A2	PTFE: PTFE coated glass fabrics for Tensile Architecture	1,05
	EPD 14	EPD-SER-20240198-IBI1-EN [14]	Verseidag - Serge Ferrari	IBU	2024-2029	EN15804+A2	PTFE mesh: PTFE coated glass fabrics for Tensile Architecture	0,70
ET-Film	SD 15	ETFE-film 0,09mm, 0,157 kg/m², 1744,4 kg/m³ [21]	Nowofol Kunststoffprodukte			EN15804+A1	ETFE: Nowoflon ® - ET Film	0,16
Fluoro-polymer on Poly-arylate mesh	EPD 16	EPD-SER-20230502-IBB2-EN [22]	Serge Ferrari	IBU	2024-2029	EN15804+A2	STFE50: Transparent and structural membrane for tensile architecture	0,85

6

	EPD or SD	EPD-Number	EPD-Holder	Published by	Validity	Norm	Frame Material for systems	Membrane Material (EPD title)	(kg/m²)
ETFE-cushion system	EPD 17	EPD-VFA-20170121-IBE1-EN [15]	VECTOR FOILTEC	IBU	2018-2023	EN15804+A1	Alu	ETFE: AGC Fluon	4,56
	EPD 18	EPD-DVN-20140043-IBE1-EN [16]	VECTOR FOILTEC	IBU	2014-2019	EN15804+A1	Alu	ETFE: NOWOFLON	5,13
	EPD 19	EPD-TAI-20190092-ICB1-EN [17]	TAIYO	IBU	2019-2024	EN15804+A1	Alu	ETFE: AGC Fluon	3,93
	EPD 20	EPD-NMG-20170152-IBC1-EN [18]	NOVUM	IBU	2017-2023	EN15804+A1	Alu	ETFE: Generic data	4,82
	EPD 21	EPD-DVN-20210122-IBJ2-EN [19]	VECTOR FOILTEC	IBU	2021-2026	EN15804+A2	Alu	ETFE: NOWOFLON	3,89
	EPD 22	EPD-PFE-20220207-IBC2-EN [20]	PFEIFER	IBU	2023-2028	EN15804+A2	Alu	ETFE: Generic data	3,36

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GLOBAL ANALYSIS: A1-A3 GWP VS WEIGHT/M²

MATERIAL

- PVC-polyester ● PTFE-glass ▲ ETFE-film ◆ Fluoropolymer on Polyarylate mesh

SYSTEM

- ETFE-cushion sytem

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PVC-POLYESTER MEMBRANES

- A1–A3 ≈ 2–8 kg CO_2-eq/m²
- Strong weight dependence
- Energy recovery at end-of-life provides credits

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PTFE-GLASS MEMBRANES

- A1–A3 ≈ 10–16 kg CO_2-eq/m²
- Higher impact from glass fibre + fluoropolymer
- Limited end-of-life recovery

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ETFE MATERIAL & SYSTEM

ETFE film:
≈ 2 kg CO_2-eq/m² → very low

ETFE cushion system:
≈ 40–60 kg CO_2-eq/m² → much higher
Drivers: aluminium + operation

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FLUOROPOLYMER ON POLYARYLATE MESH: STFE50

- A1–A3 ≈ 7.5 kg CO_2-eq/m²
- Intermediate position between PVC and PTFE
- Limited end-of-life benefit

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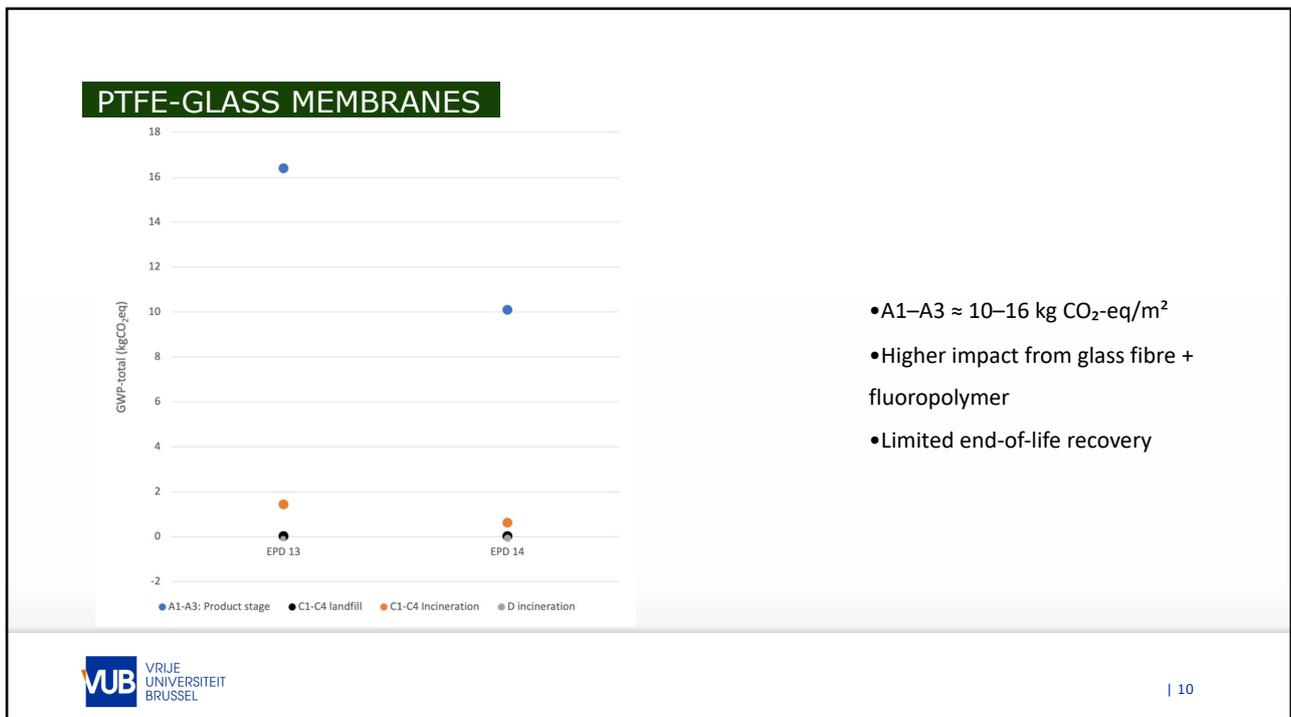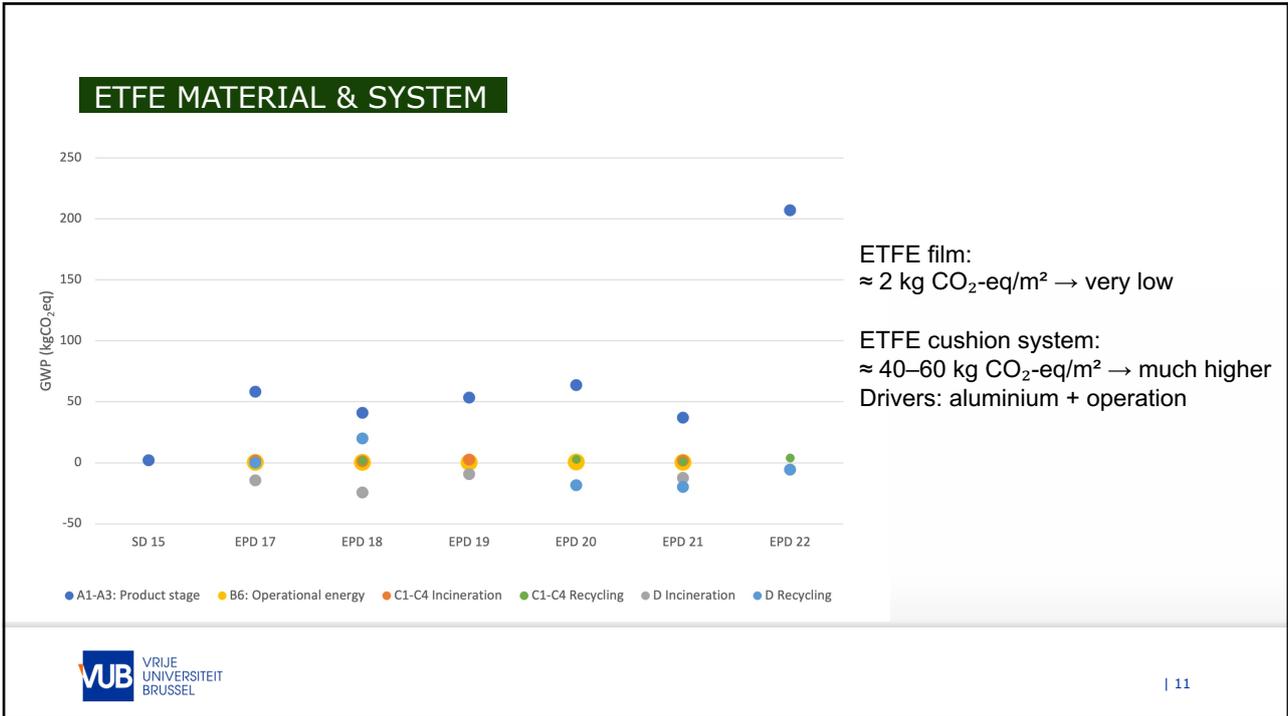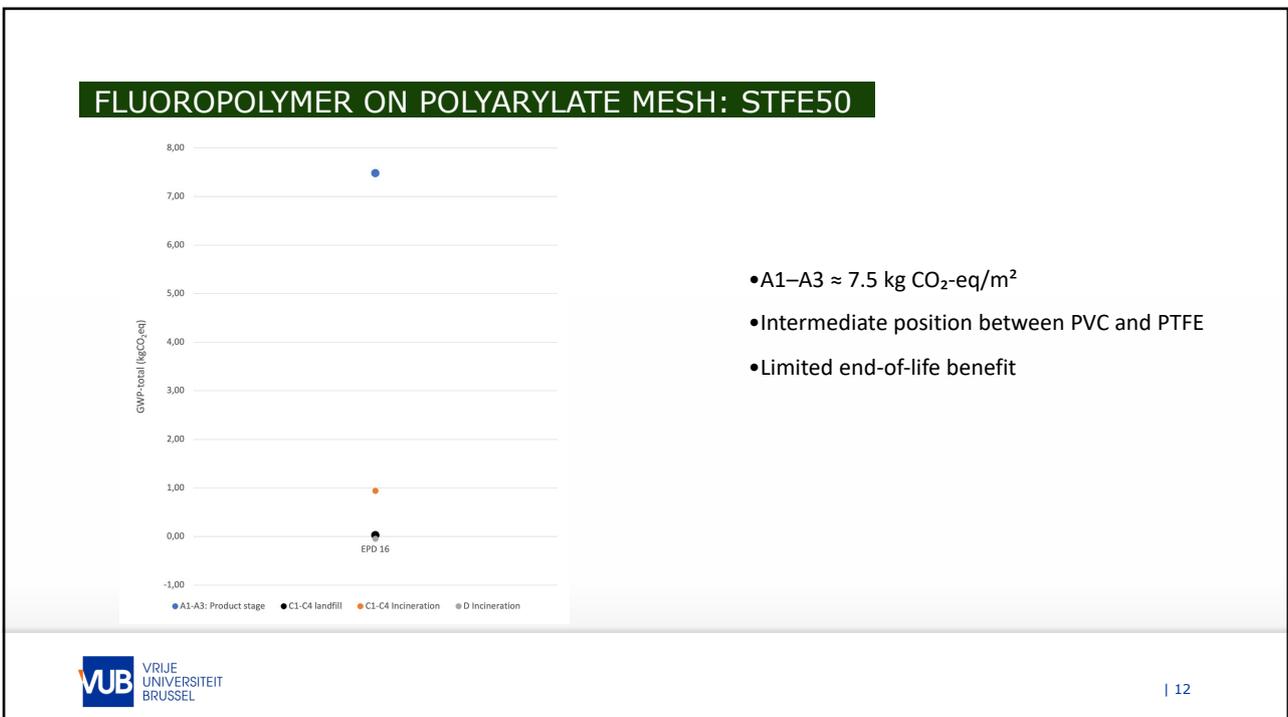
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KEY CONCLUSION

Sustainability in tensile architecture is not determined by material chemistry alone —

it depends on design requirements:

If we need **high transparency and thermal insulation**, ETFE cushions may be justified.

For **temporary or retractable structures**, PVC membranes may be more appropriate.

For **long service life and durability**, PTFE-glass can be the correct solution.

Therefore, material efficiency does not automatically equal system sustainability.

Aluminium structure, operational energy, lifespan, and end-of-life scenarios all influence the overall result.

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There is no universally "best" membrane.

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Sustainability in tensile architecture is determined by design, not material alone

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