



Science For A Better Life

RWTHAACHEN
UNIVERSITY

„From Dream Production to Dream Polymers“

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Bayer MaterialScience

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Alternative feedstock CO₂ – Motivation for chemical utilization



Sustainability

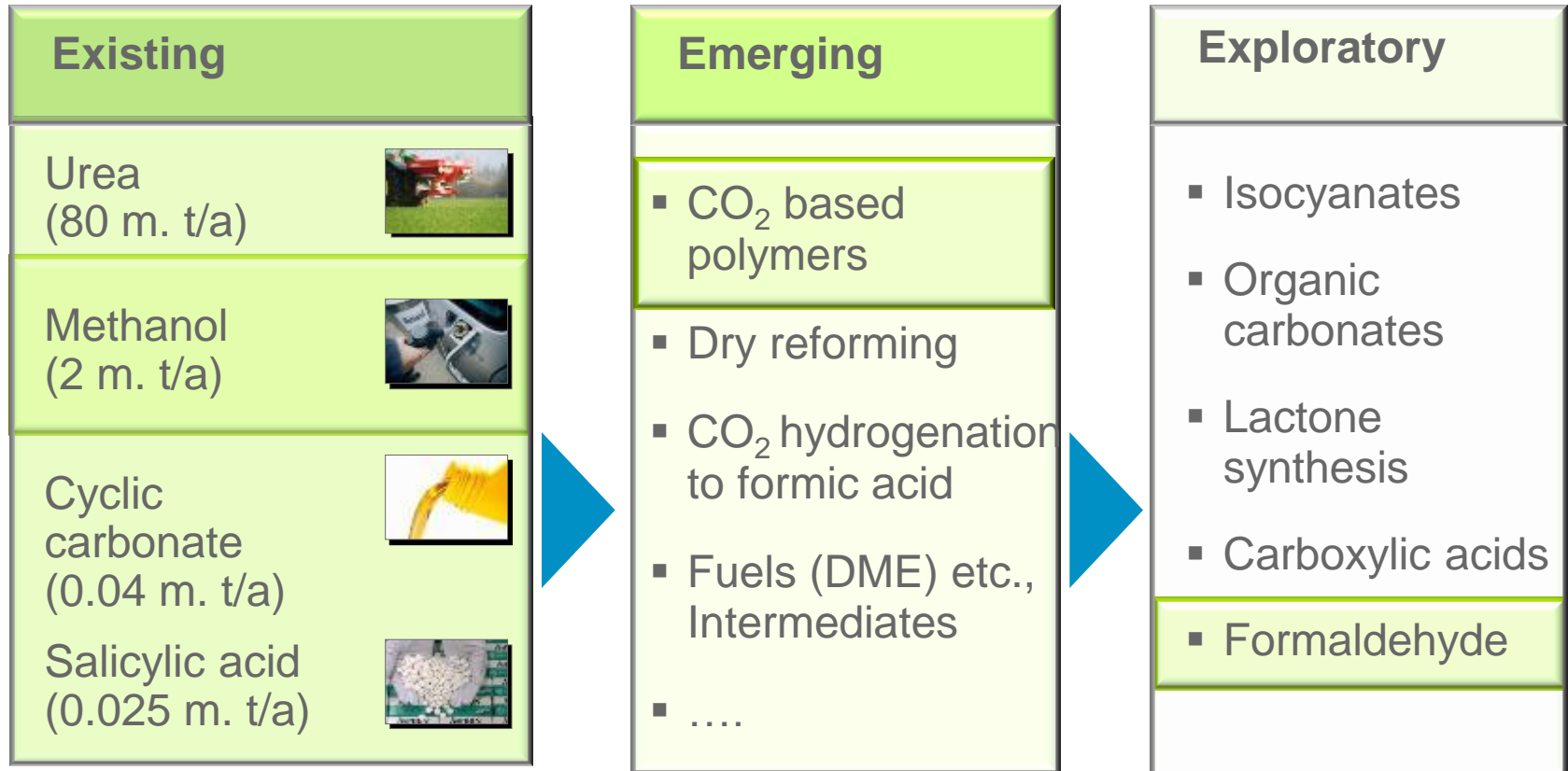
- Resource efficiency
- CO₂ recycling
- Climate protection



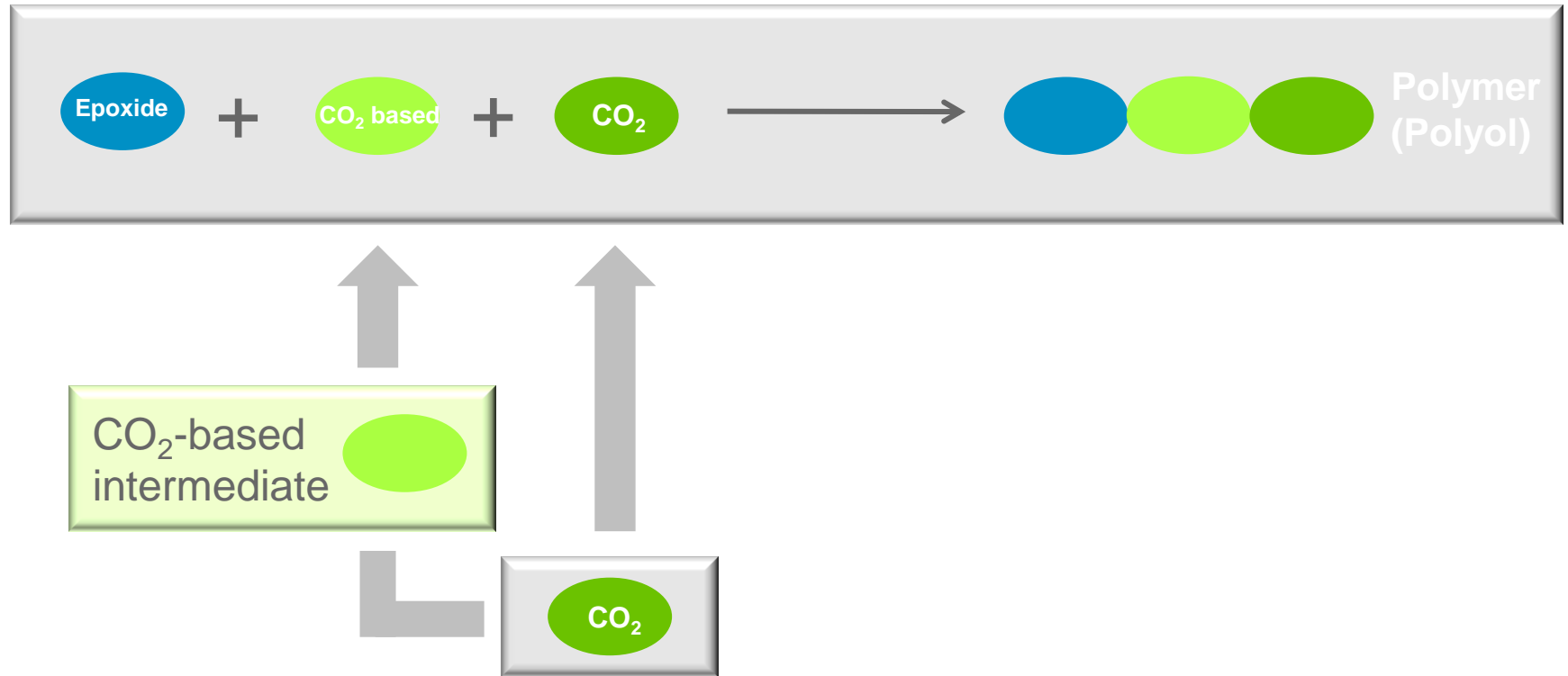
Industrial value creation

- Process improvement
- Market needs
- International competitiveness

Strategies for CO₂ conversion and utilization

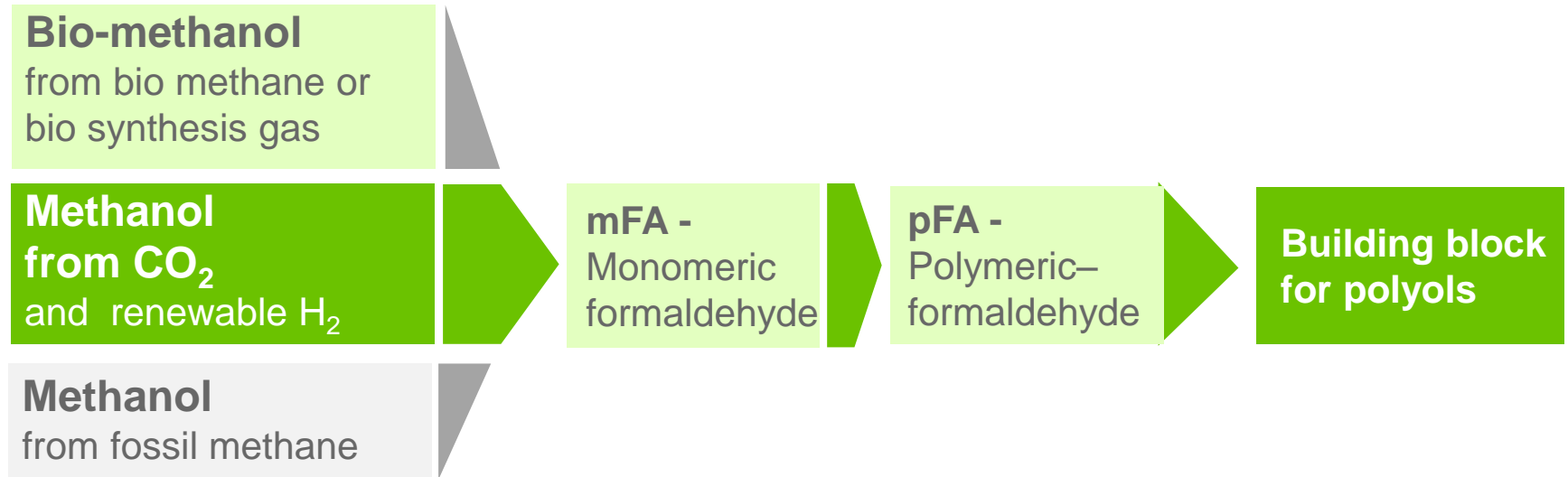


Dream Polymers – Direct and indirect use of CO₂



► New development: Direct and indirect usage of CO₂

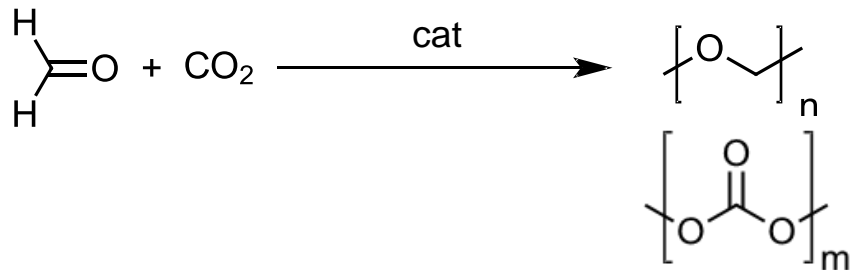
Polyoxymethylene-polyols – A renewable resource for PUR



- p-Formaldehyde as a polyoxymethylene building block for polyols
- Lower carbon footprint
- Lower raw material costs

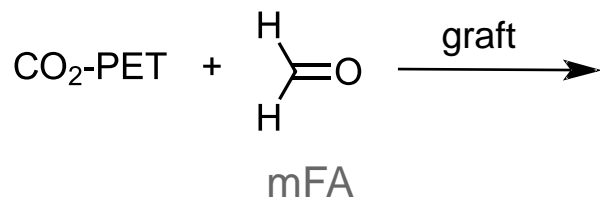
► Making C1 building blocks available for PUR chemistry and technology

Synthetic strategies pursued in Dream Polymers



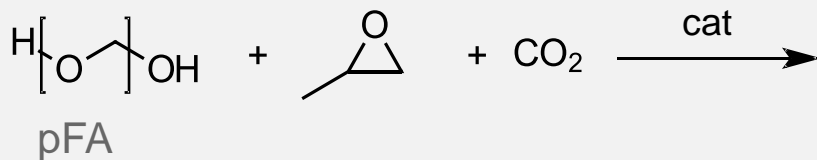
1. direct FA/CO₂ copolymerization

alternating / statistic copolymer



2. grafting of FA to obtain pFA segment

BAB block copolymer



3. pFA as starter-OH segment

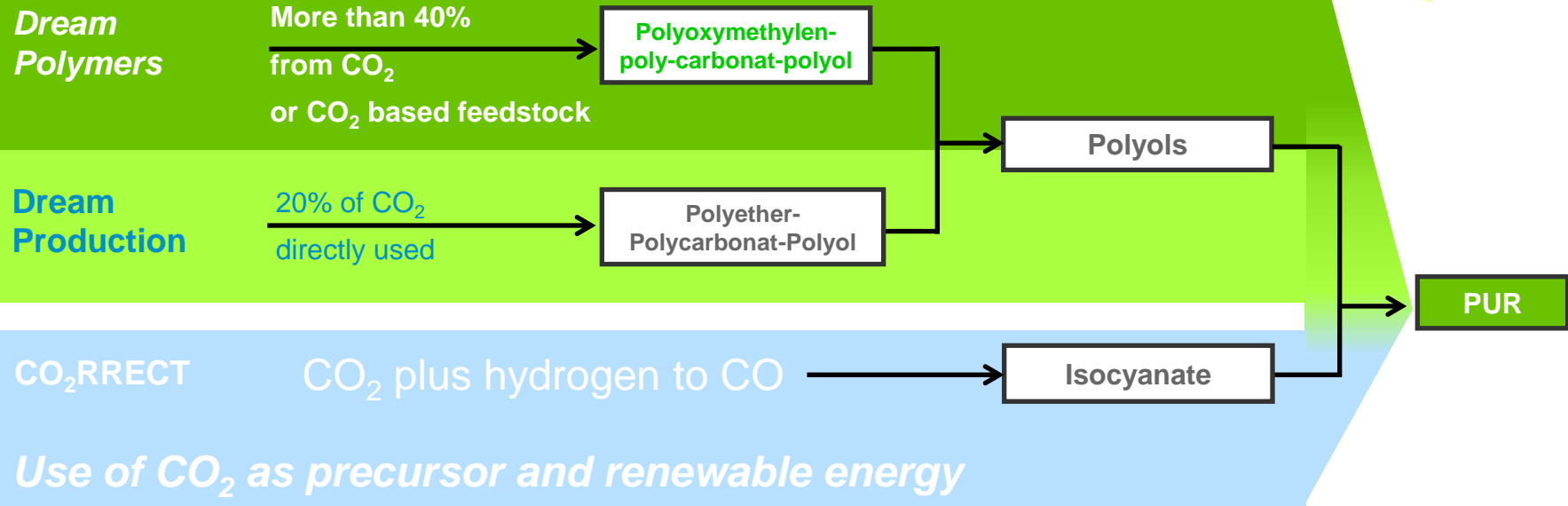
ABA block copolymer

PET = polyether polyol

An integral approach – Polyurethanes from sustainable sources



Direct and indirect use of CO₂ for polyols



► Direct and indirect use of CO₂ offers new opportunities

Dream Polymers: Polyols from CO₂

Research and development along the value chain



Scrubbing and supply of CO₂

VORWEG GEHEN



Process development and conversion of CO₂

 Bayer Technology Services



Production and testing of polyurethanes with CO₂

 Bayer MaterialScience



 Catalysis
Leibniz-Institut für Katalyse e.V.



 Fraunhofer
ICT



Fundamental research

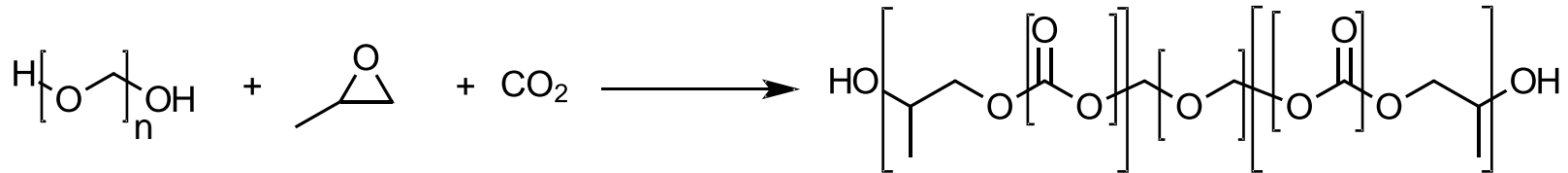
 CCT[®]
Catalytic Center

 RWTHAACHEN
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Life Cycle Assessment

Polymeric formaldehyde as starter-OH

Molecular architecture defines opportunities



- Evolutionary approach
- Block copolymer structure
- Saving potential for fossil materials

PET = polyether polyol

Scale-up of technology developed



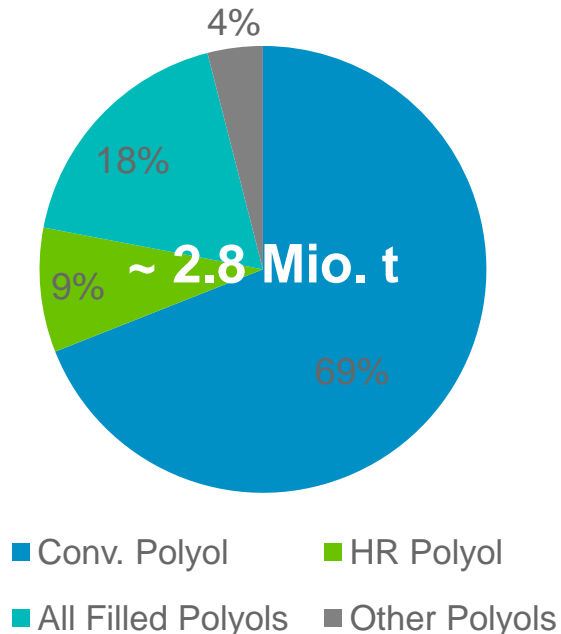
Bayer Technology Services, LEV

New pFA-CO₂-based polyols for PUR

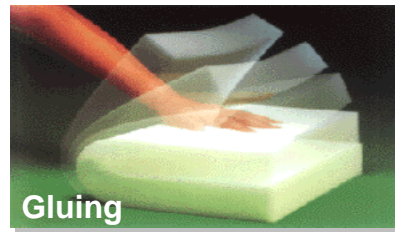
Focus on TPU, elastomers, adhesives first



Global polyether polyol market 2012*



* Estimate based on IAL studies

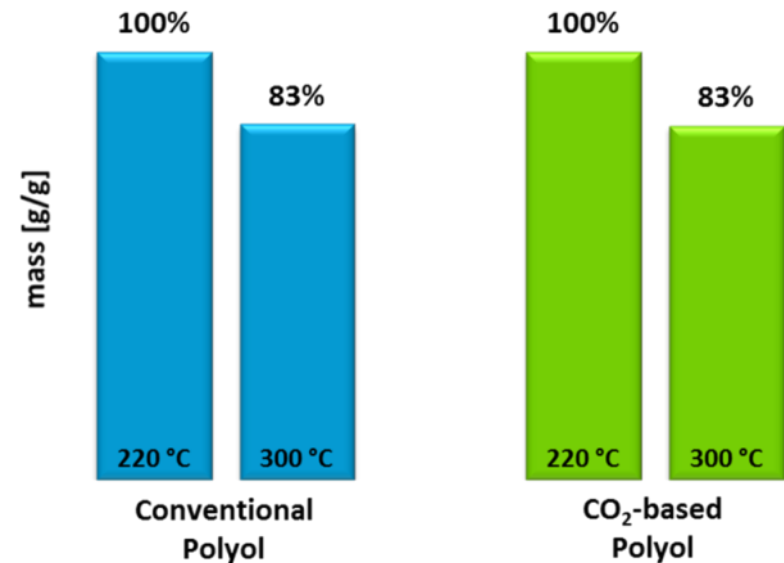
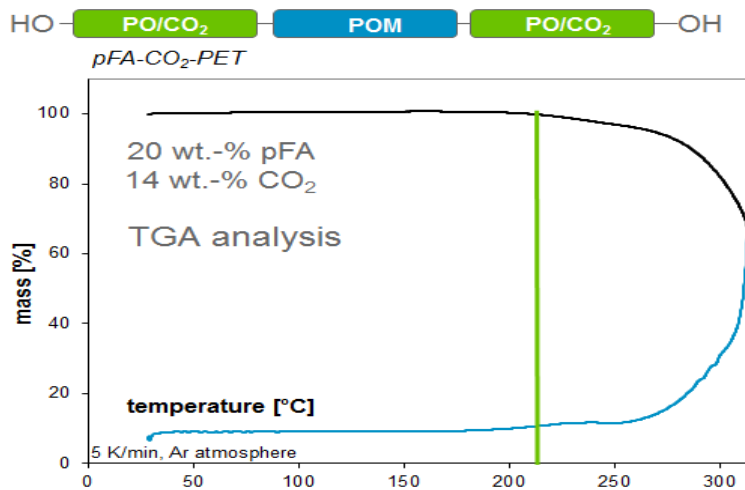


Thermal plastics stability test (TPU)

CO₂-pFA based plastics show good performance

- CO₂ and p-FA is chemically fixed inside the polyurethane backbone
- Thermal plastics stability matches that of conventional PO polyols

* TGA: Thermo-Gravimetric Analysis (heating rate: 10 K/min)



► No release of gaseous monomeric formaldehyde in final product

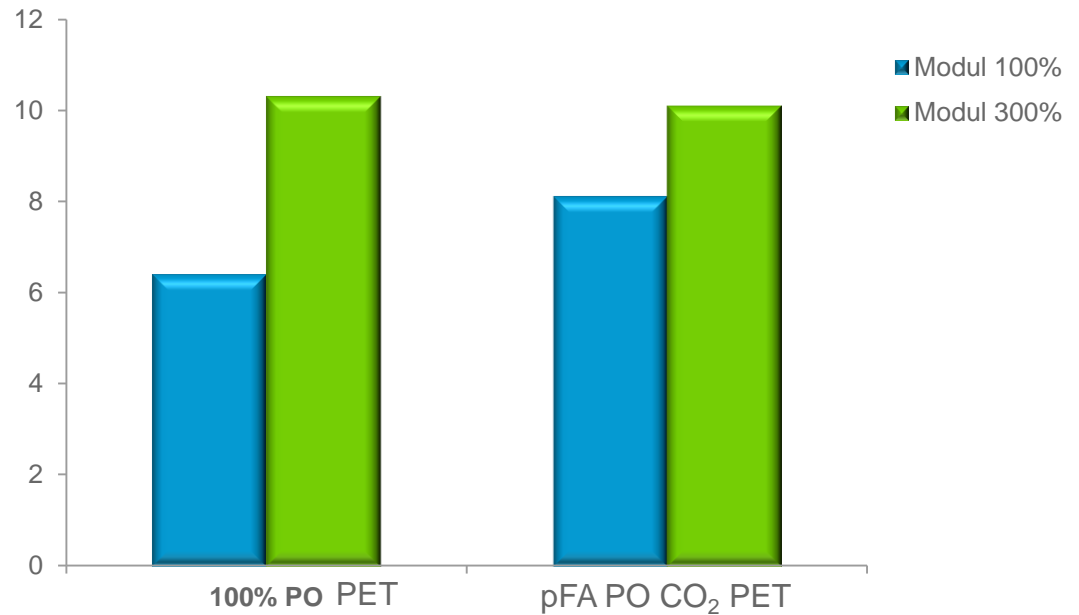
How does it perform?

Good properties in Thermoplastic Polyurethanes (TPU)



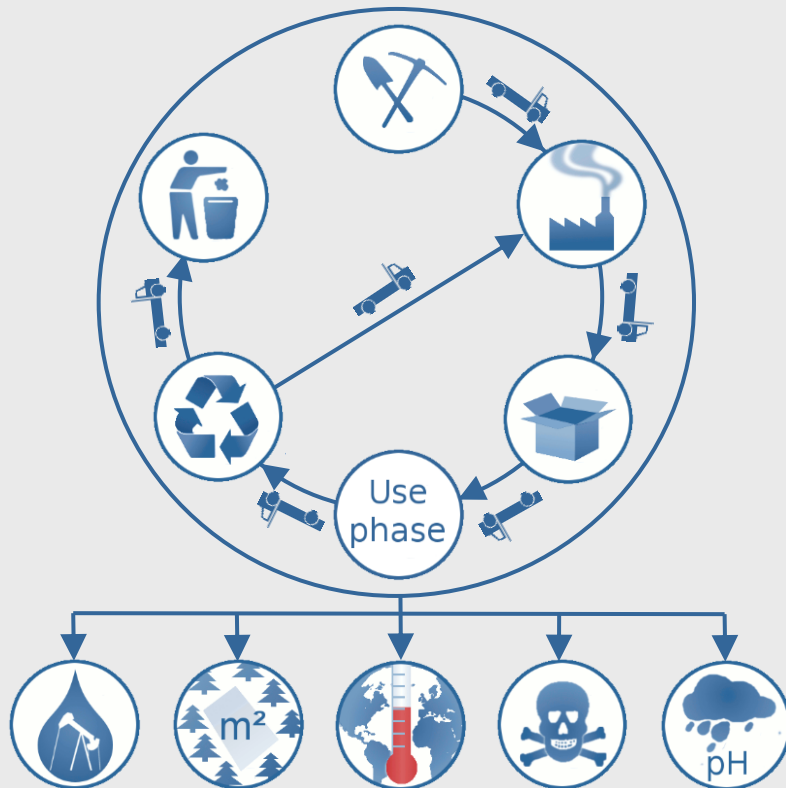
Shore A: 83-89,
MDI based TPU

Tensile strength > 500%



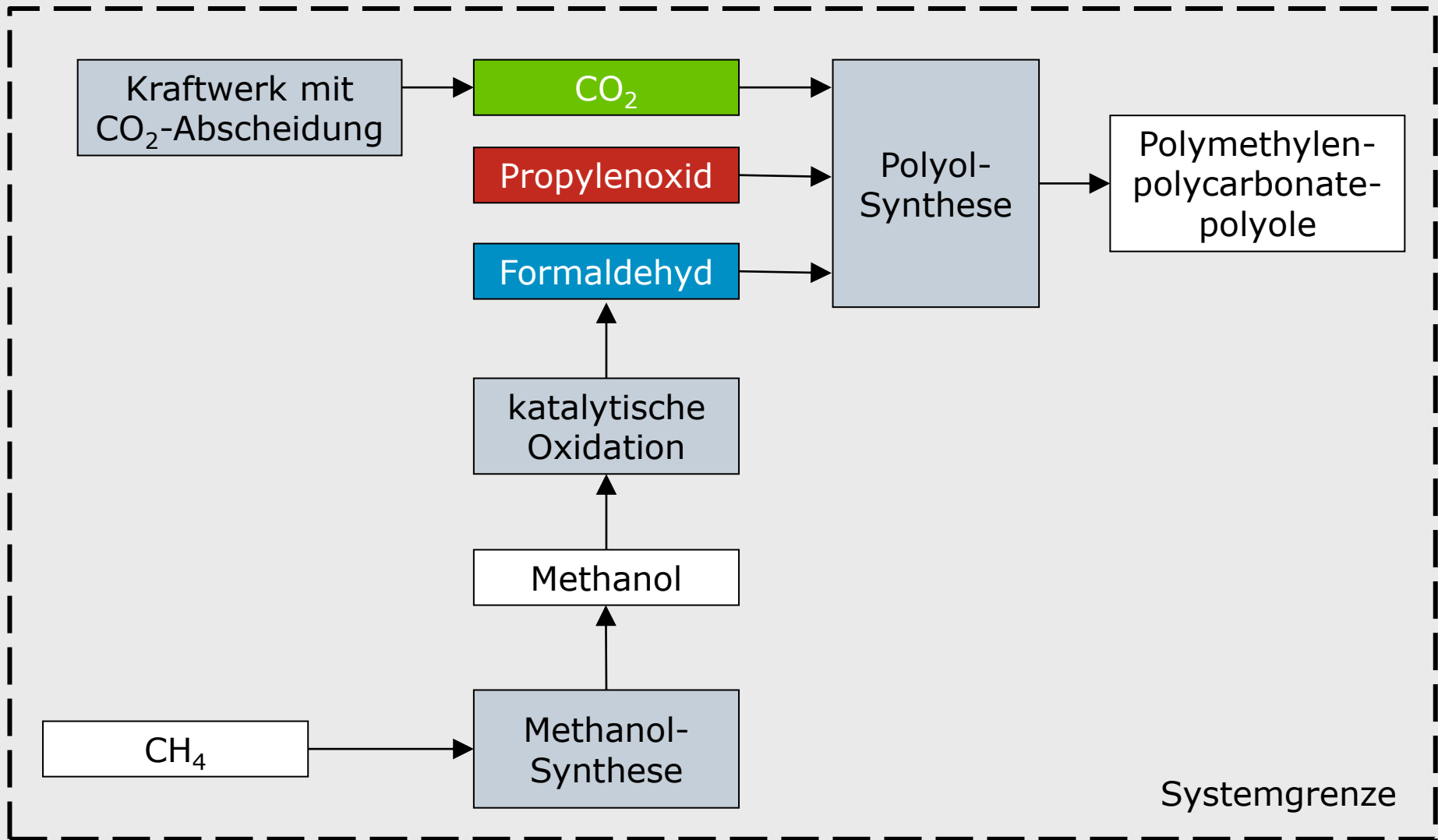
► p-FA PO CO₂ polyethers behave like PO/C3 polyethers in TPUs

► Addition but no substitute for Dream Production polyethers



- Betrachtung des gesamten Lebenszyklus (d.h. inkl. Vorketten)
- Analyse von potentiellen Umweltauswirkungen:
 - **Klimawirkung**
 - **Ressourcenbedarf**
 - Toxizität, Versauerung, Überdüngungen, ...

Referenzen: von der Assen et al., *Energy Environ. Sci.*, 2013, **6**, 2721-2734;
von der Assen et al., *Chem. Soc. Rev.*, 2014, DOI: 10.1039/C3CS60373C.



pFA	0%
CO ₂	0%



Legende:

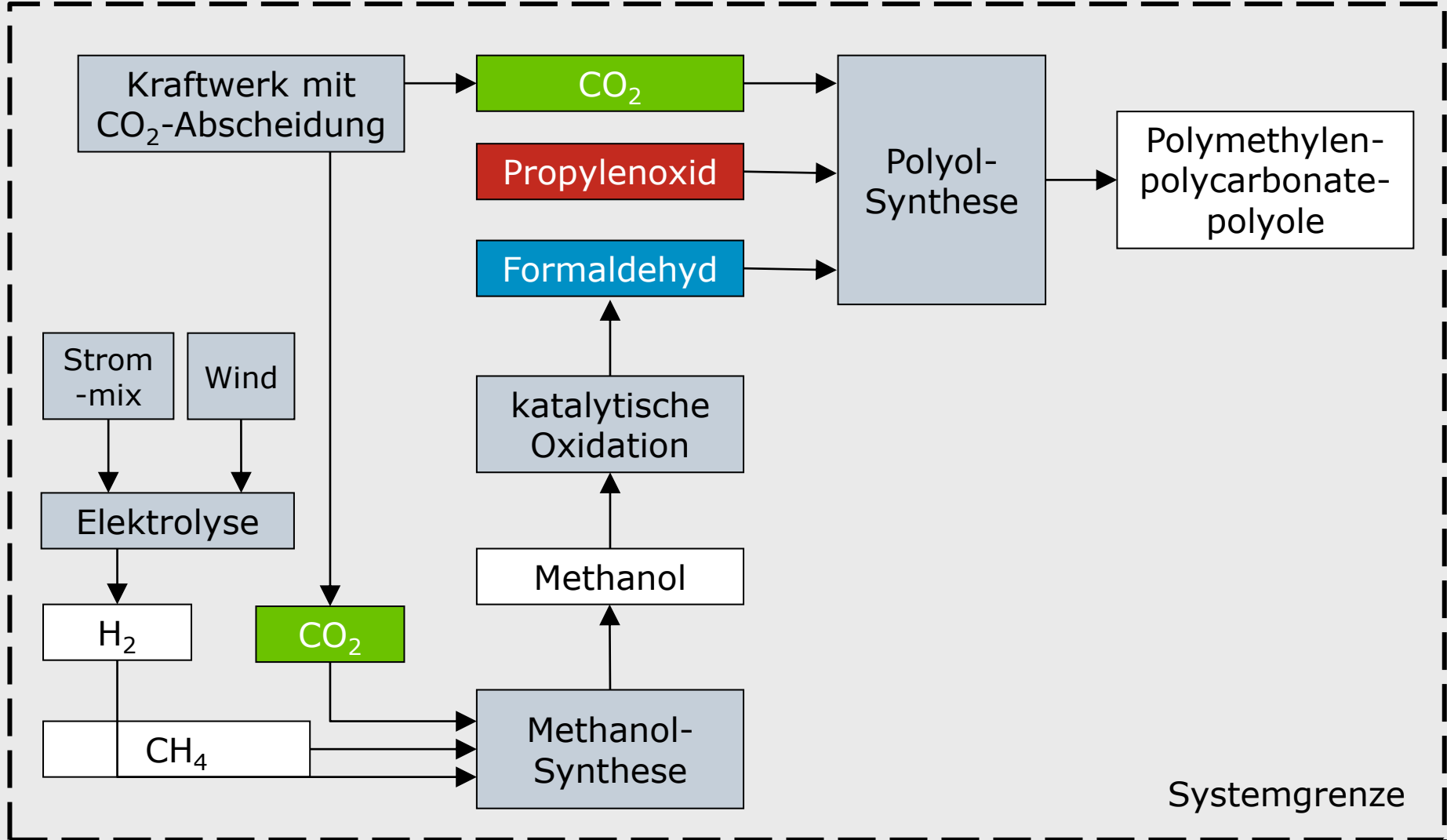
Andere

CO₂

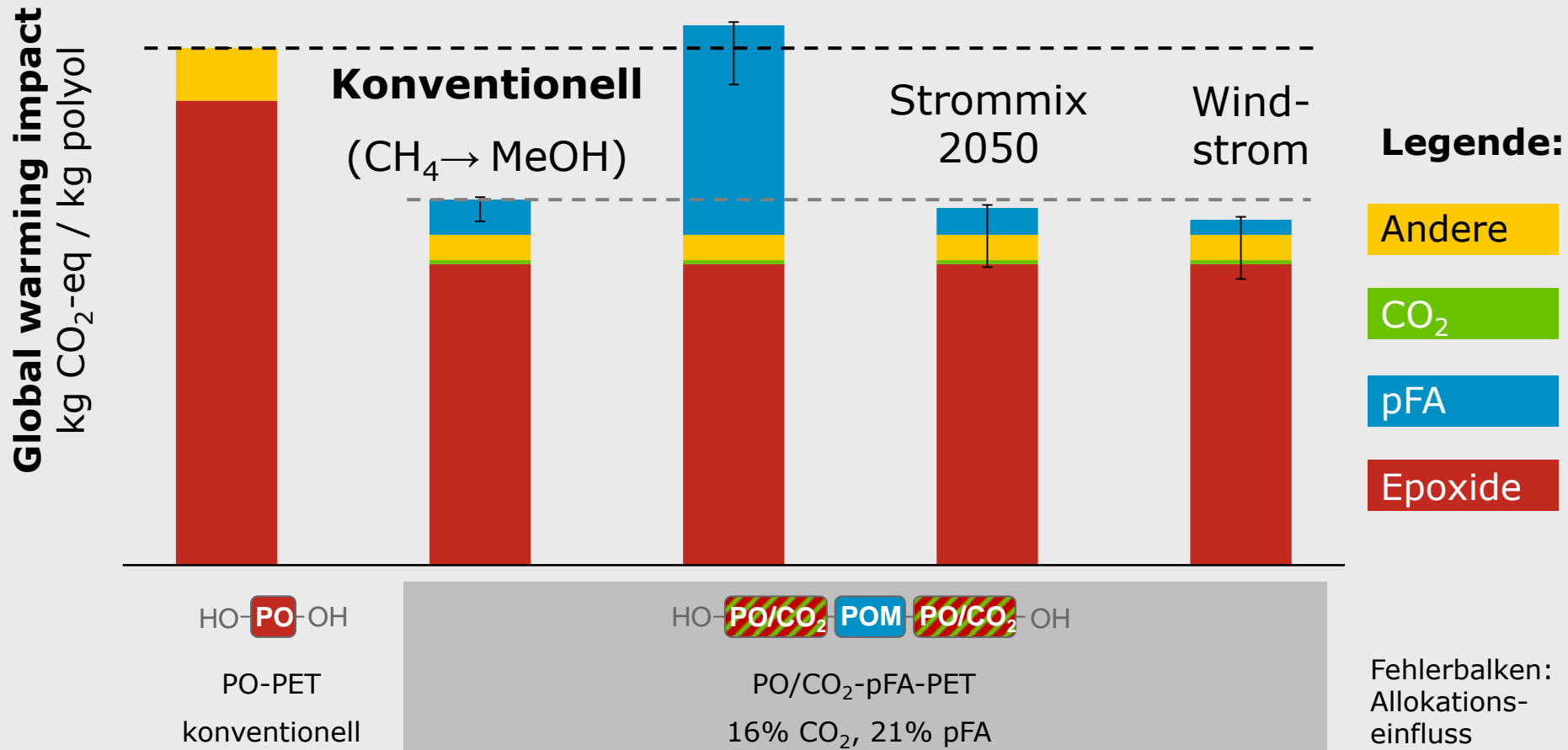
pFA

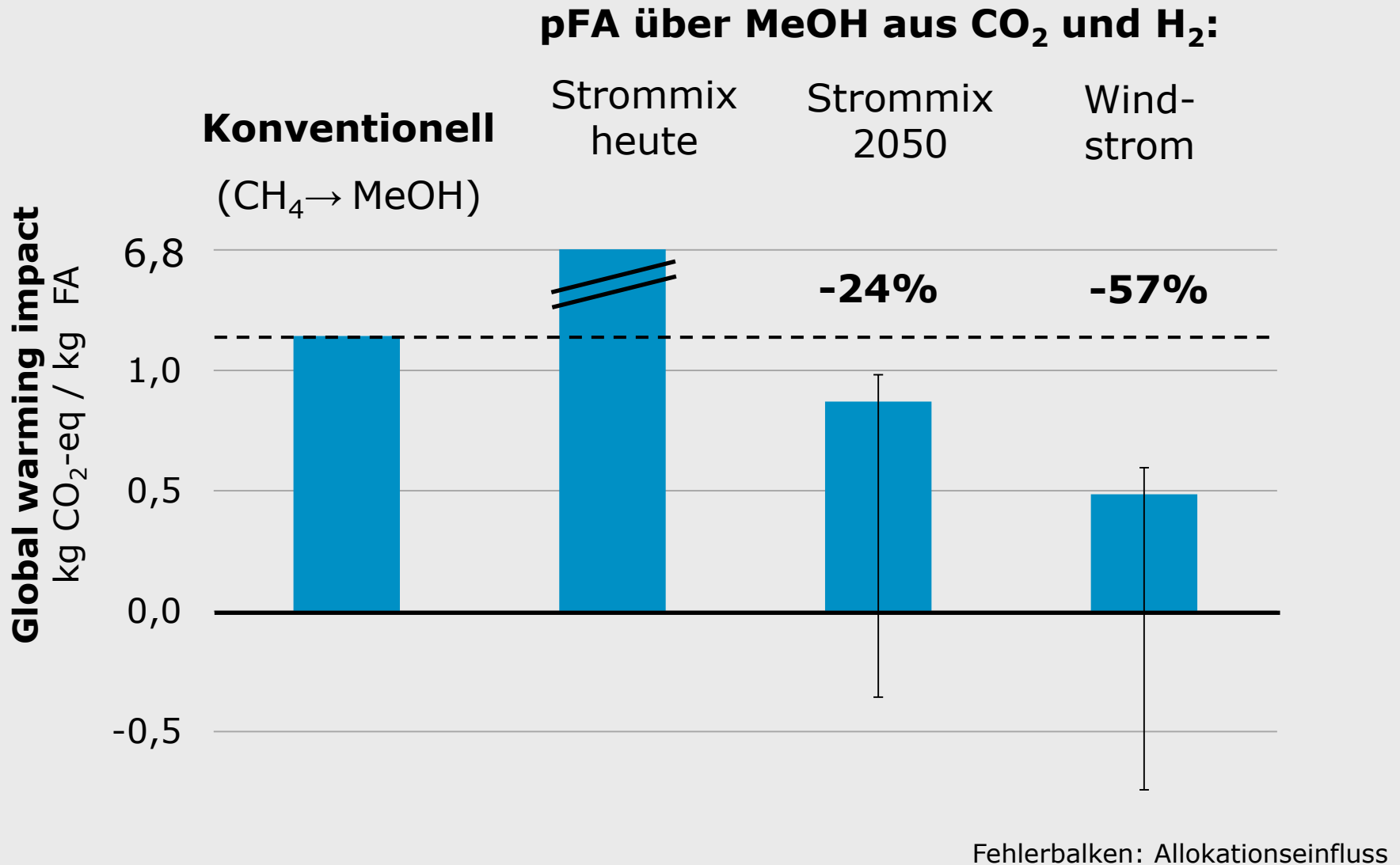
Epoxide

Fehlerbalken: Allokationseinfluss



pFA über MeOH aus CO₂ und H₂:







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Thank you!

- ✓ It works!
- ✓ Very good material properties
- ✓ Improved CO₂ footprint