WEBINAR

BIOBASED POLYMERS AND COMPOSITES FOR TECHNICAL APPLICATIONS

June 5th | 4 – 5 pm (CET)

June 26th | 10 – 11 am (CET)

IfBB
Institute for Bioplastics and Biocomposites

DLR

Bundesministerium für Bildung und Forschung

Fraunhofer WKI

Biobased Polymers and Composites for Technical Applications

Source: Fraunhofer WKI

M. Sc. Madina Shamsuyeva
Research Associate
Fraunhofer WKI
Application Center HOFZET

Source: China Hopson

Prof. Dr.-Ing. Hans-Josef Endres
Head of the Application Center HOFZET
Head of the IfBB

Source: China Hopson

Christian Schulz B. Eng
Public Relations
Hannover University of
Applied Sciences and Arts
IfBB

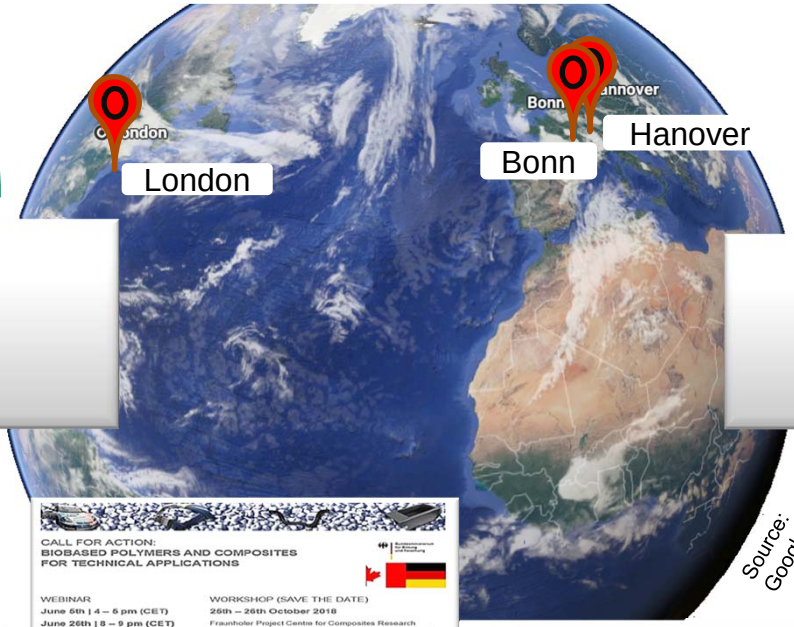
Fraunhofer WKI

Chronology of the relevant events

Collaborative projects

Workshop

25.-26.10.2018
in London ON



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BMBF Canada Day

17.-18.10.2017 in Bonn

Webinar

05. and 26.06.2018
from Hanover

Bundesministerium
für Bildung
und Forschung

Fraunhofer
WKI

Aim and motivation
Why should you join this webinar?

The following questions are going to be answered today:

- What are biopolymers and biocomposites?
- How are these materials manufactured and tested?
- What are current applications of these materials?
- What is sustainable production?
- What are the challenges?
- What is LCA and which factors are important?
- Where can you find information about performance characteristics and availability of biopolymers?
- Introduction into a consecutive workshop in London (CAN) in October 2018

Biobased polymers and composites for technical applications

Webinar

- Introduction
- IfBB and the HOFZET
- Introduction to bioplastics and biocomposites
- Selected research projects
- Sustainability assessment
- Databases
- Information about the consecutive workshop in London (CAN) in October 2018

Hans-Josef Endres

Born on 17th of April 1966, married, 2 daughters (23 and 18)

Educational background:

- Dipl.-Ing. graduate of the Ruhr University Bochum, 1985, mechanical engineering, strong focus on material research
- PhD (Dr.-Ing.) received from University of Bochum, 1995

Source: China Hopson

Professional experience and activities:

- 9 years of employment with industrial companies including a position as departmental director at Thyssen-Krupp, overseeing a staff of 230
- Professor at Hannover University of Applied Sciences & Arts, since 1999
- Director of the IfBB - Institute for Bioplastics and Biocomposites, 2011
- Head of Application Center for Wood Fiber Research, Fraunhofer Wilhelm-Klauditz-Institut WKI, 2012
- Co-opted Professor at Technical University of Braunschweig, 2016

Achievements:

- engaged in bioplastics and biocomposites research for more than 25 years;
- established the IfBB - Institute for Bioplastics and Biocomposites as a new institute;
- established a new Fraunhofer Application Center for Wood Fiber Research;
- authored various publications and received numerous honors and prizes for his research in bioplastics and biocomposites

IfBB and HOFZET

Fraunhofer WKI

Application Center for Wood Fiber Research
HOFZET

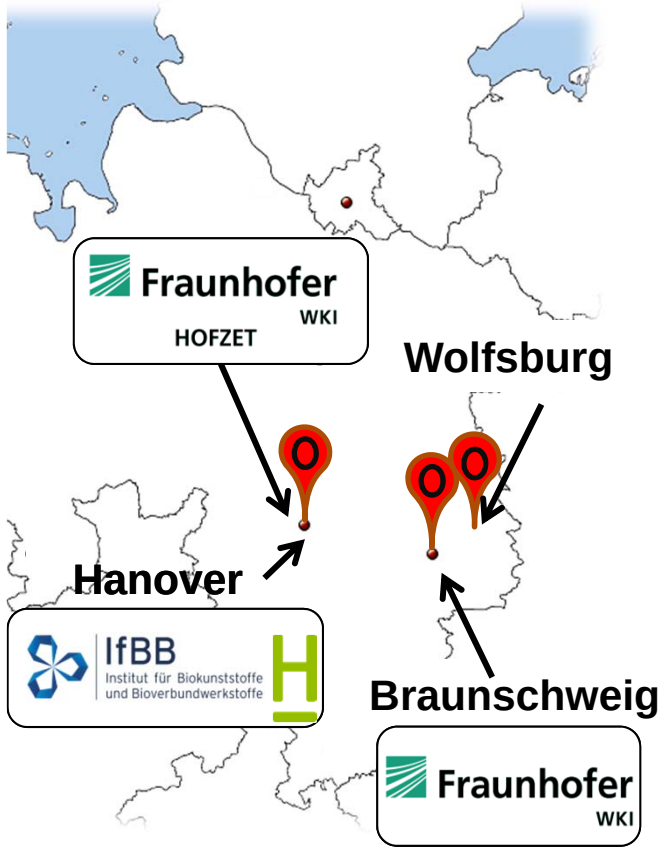
- Operating since 07/2013
- Today 15 employees
- Close collaboration with industry

Fraunhofer WKI

- Technology for Wood-based Panels
- Material Analysis and Indoor Chemistry
- Surface Technology
- Center for Light and Environmentally-Friendly Structures
- QA
- **HOFZET**

Fraunhofer HOFZET WKI

- Fiber analysis and modification
- Biobased (hybrid) composites
- Technical textiles
- Plastics and composites processing
- Recycling
- Material analysis



Fraunhofer WKI

Organizers of the events

Hochschule Hannover

IfBB

Fraunhofer-Gesellschaft

WKI

HOFZET

Western University

FPC@Western

Source: Google Maps

Webinar
05. and 26.06.2018

Workshop
25.-26.10.2018

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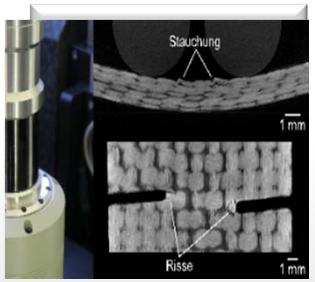
Research focus of the HOFZET



Material development

- Plastics
- Organic sheets
- …

Material processing

- Injection molding
- Compounding / extrusion
- 3D printing
- …

Manufacture of construction parts

- Autoclave
- Hot press
- Fiber-spraying
- …

Material and part analysis

- CT
- SEM
- Mechanical testing
- …

End of Life Eco balance

- Recycling
- Pyrolysis
- LCA
- …

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HOFZET
Research fields – process development

- Natural fibers
  - Surface modification
- Technical (hybrid) textiles
- Function integration
- Bio-hybrid composites
- Short fiber-reinforced composites
- Organic sheets
- Recycling

Surface modification of fibers

Fiber-spraying

Injection molding center

Extrusion center

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HOFZET

Research fields – material and product development

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Plastic compounding

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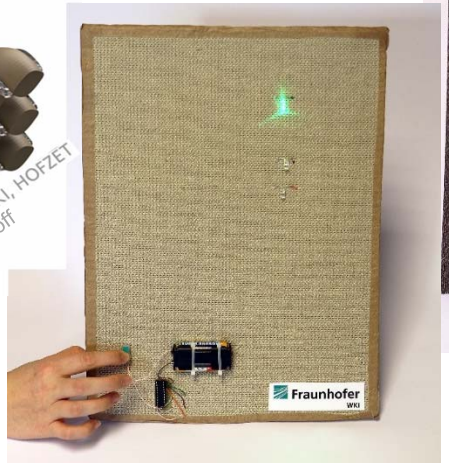

© M. Shamsuyeva

Hybrid textile fabrication
Function integration

Electrically conductive biocomposites

© Fraunhofer WKI M. Kruszewski |

Construction parts

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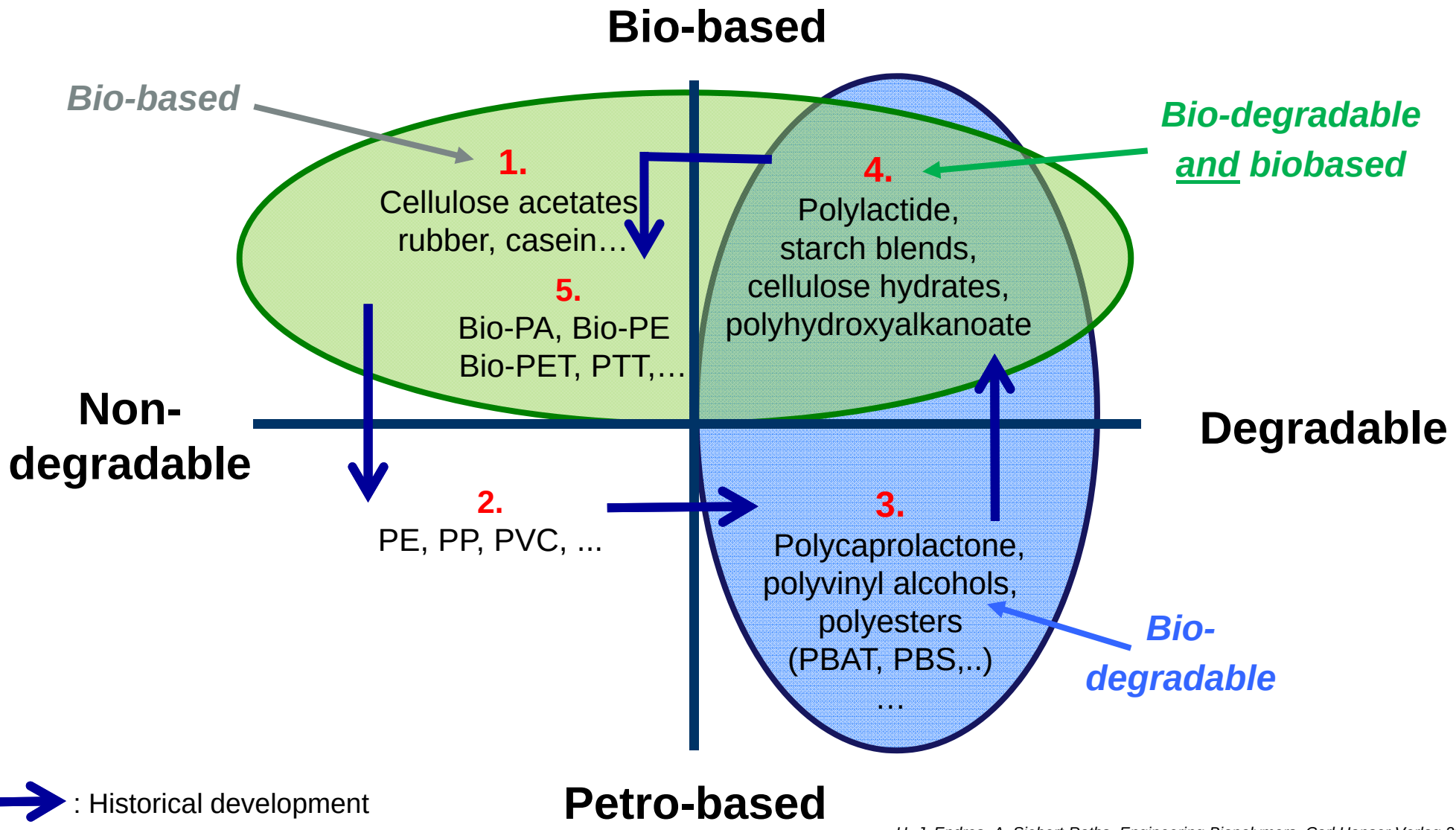
Introduction to bioplastics

What are bioplastics?



H.-J. Endres, A. Siebert-Raths, Engineering Biopolymers, Carl Hanser Verlag 2011

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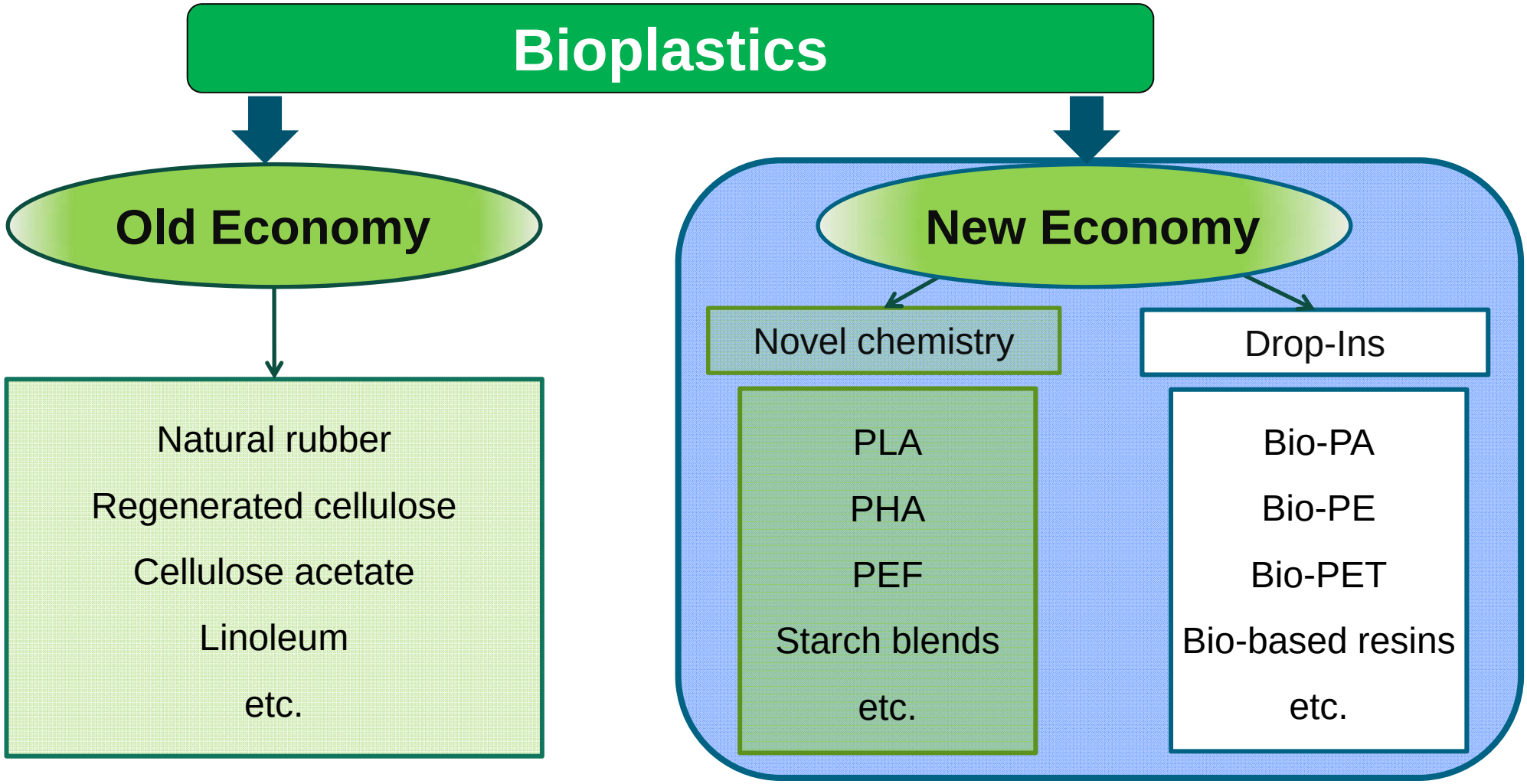
Generation comparison



Source: IfBB

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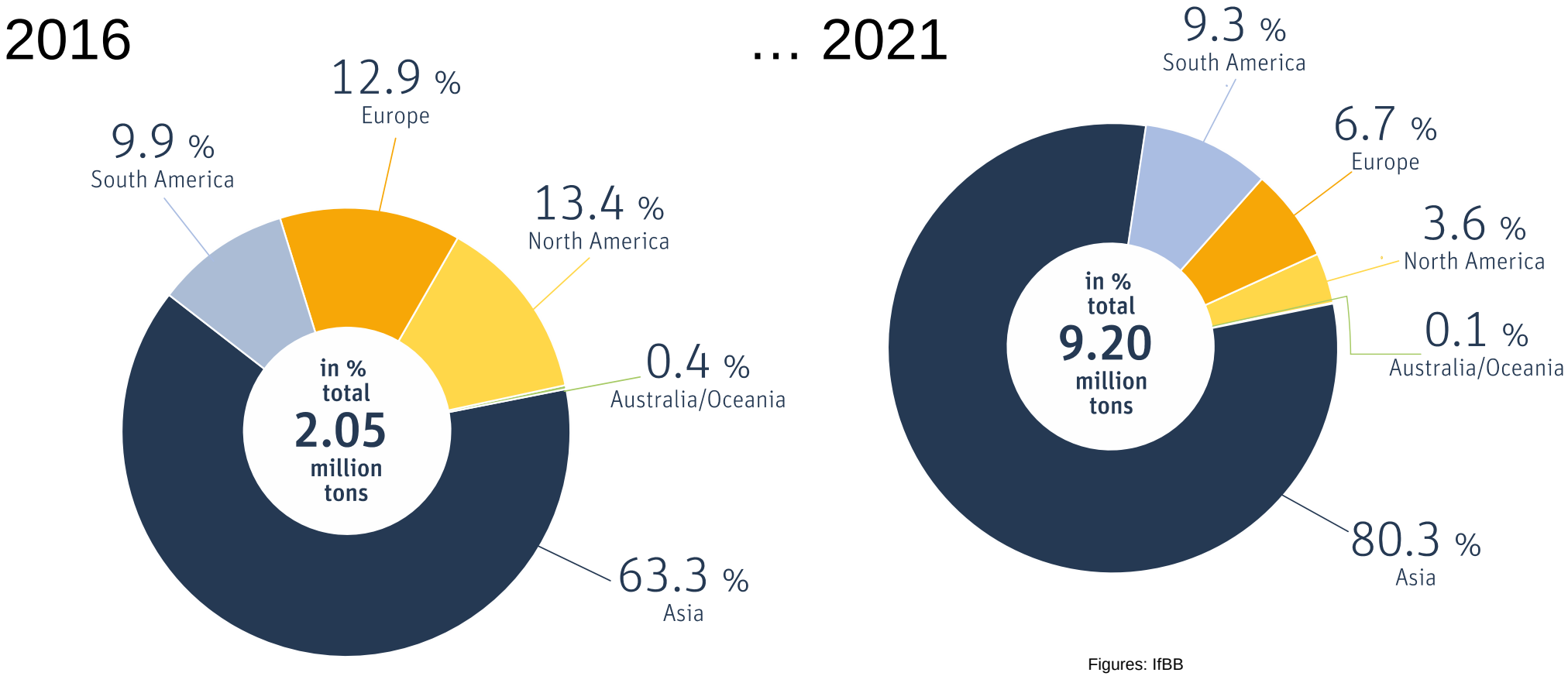
Trends
Geographical shift of production capacities

- Bioplastics production capacity New Economy



Figures: IfBB
Data sources: FAO, IfBB 2013 – 2017

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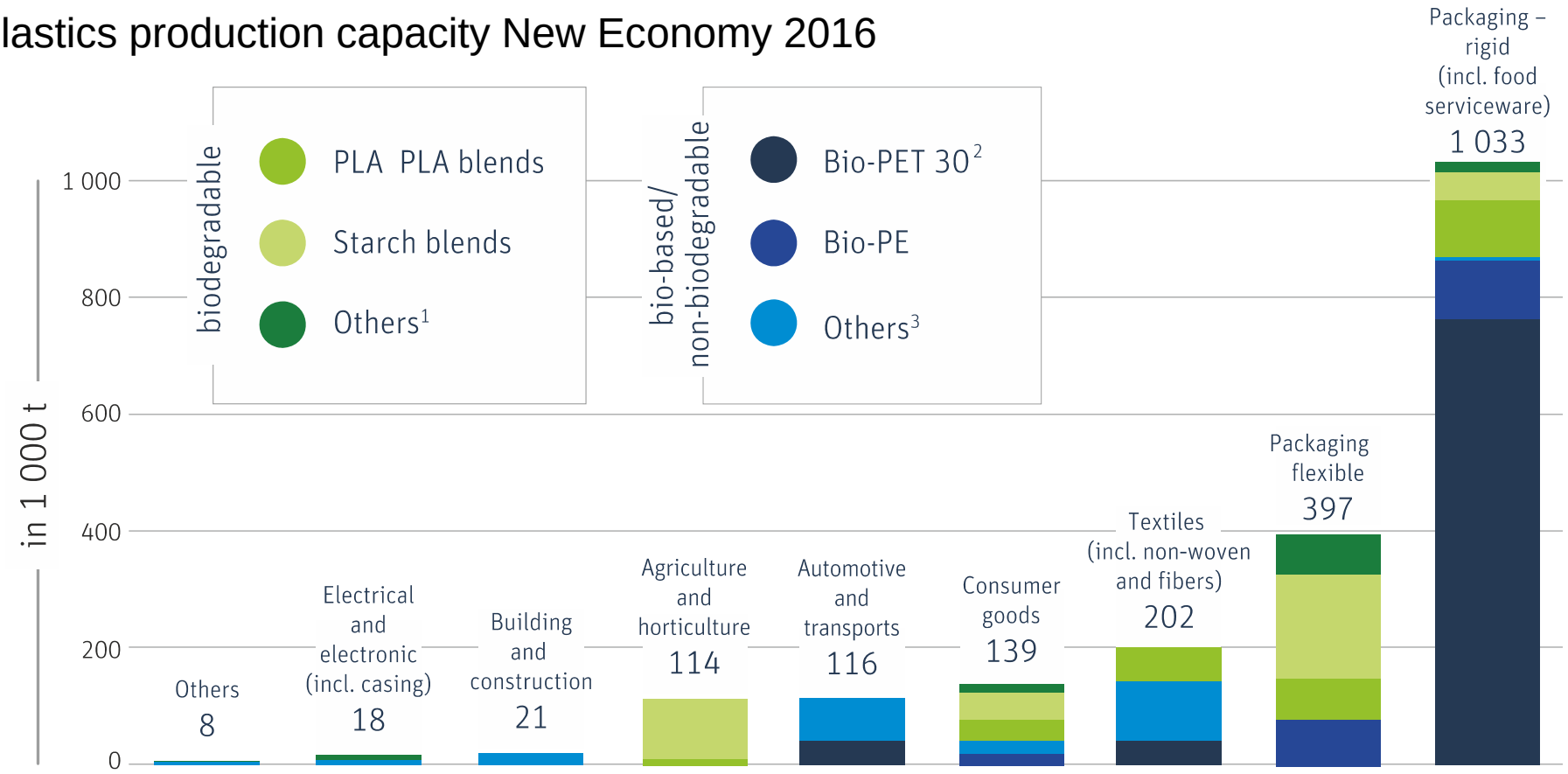
Trends
Market segments 2016

- Bioplastics production capacity New Economy 2016



1 Contains regenerated cellulose and biodegradable cellulose ester
2 Bio-based content amounts to 30%
3 Contains durable starch blends, Bio-PC, Bio-TPE, Bio-PUR (except thermosets), Bio-PA, PTT

Figures: IfBB
Data sources: FAO, IfBB 2013 – 2017

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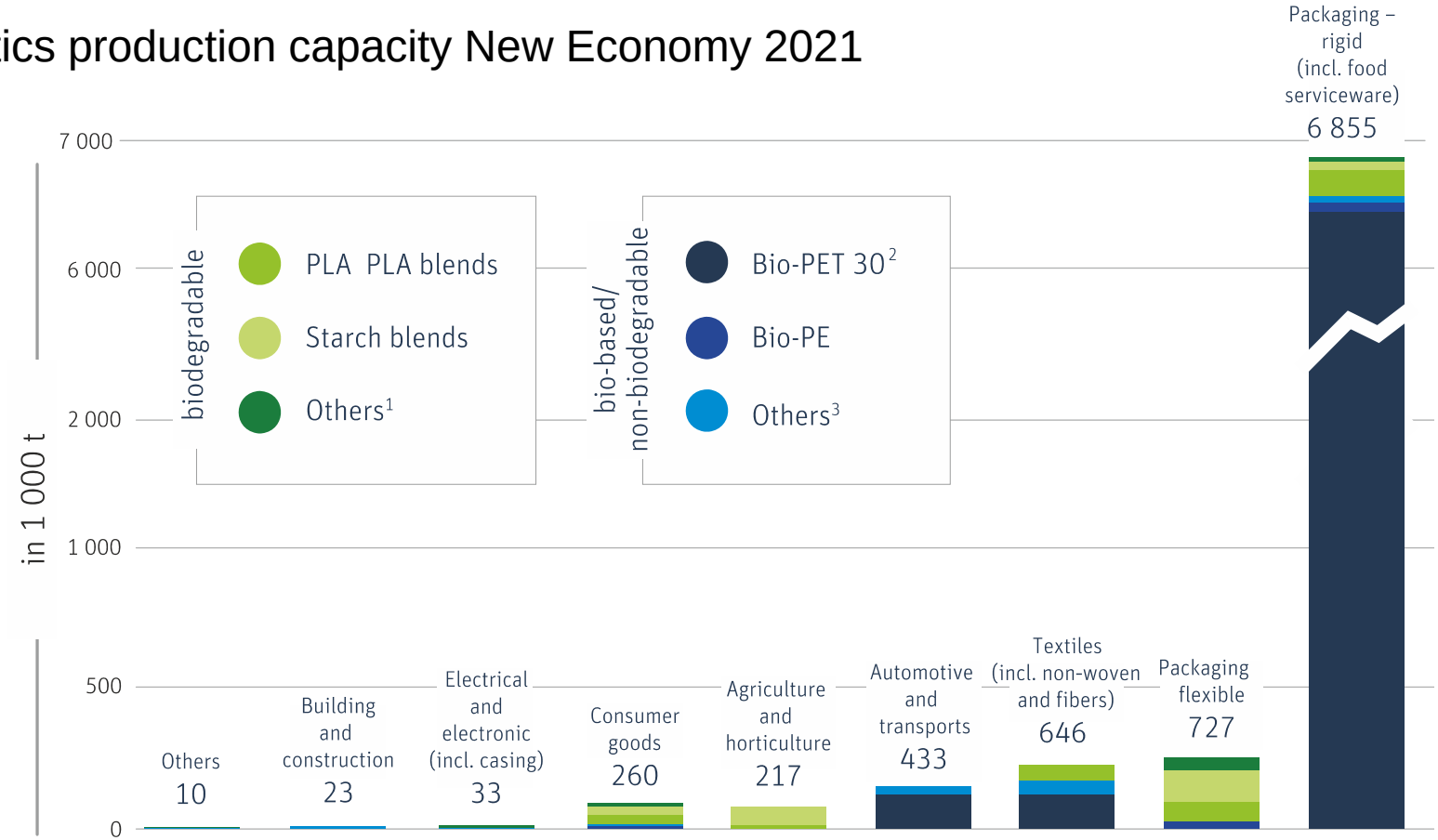
Trends
Market segments 2021

- Bioplastics production capacity New Economy 2021



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Figures: IfBB
Data sources: FAO, IfBB 2013 – 2017

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Market overview in summary

- Average growth of more than 350 %, mostly in Asia (> 80 % until 2021)*:
  2.0 m tonnes → 9.2 m tonnes
- Driver: Bio-based, non-biodegradable (Bio-PE, Bio-PET 30 etc.)*:
  63 % (2016) → 82 % (2021)
- Biodegradables (PLA, PHA, starch blends, etc.) growing steadily:
  0.7 m tonnes (2016) → 1.6 m tonnes (2021)
- Packaging still most important application sector:
  70 % (2016) → ~ 83 % (2021)*
- Land use doubles, but is overall low:
  670,000 ha (2016) → 1,320,000 ha (2021)*

Focus on long-term applications * … otherwise balanced

… 0.1 % of global arable land

* Deviations possible by changes in Coca-Cola's Bio-PET strategy.

Data sources: FAO, IfBB 2013 – 2017

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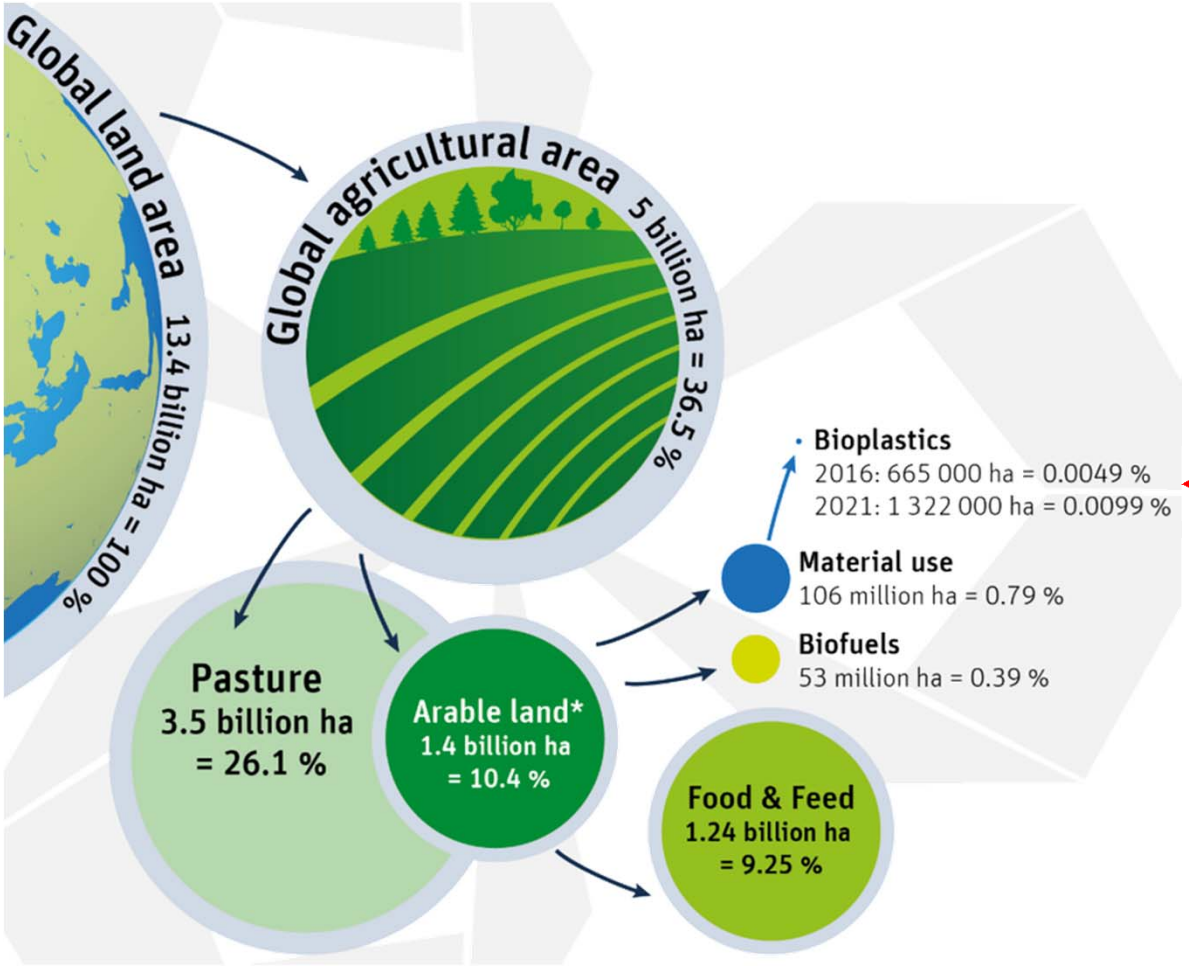
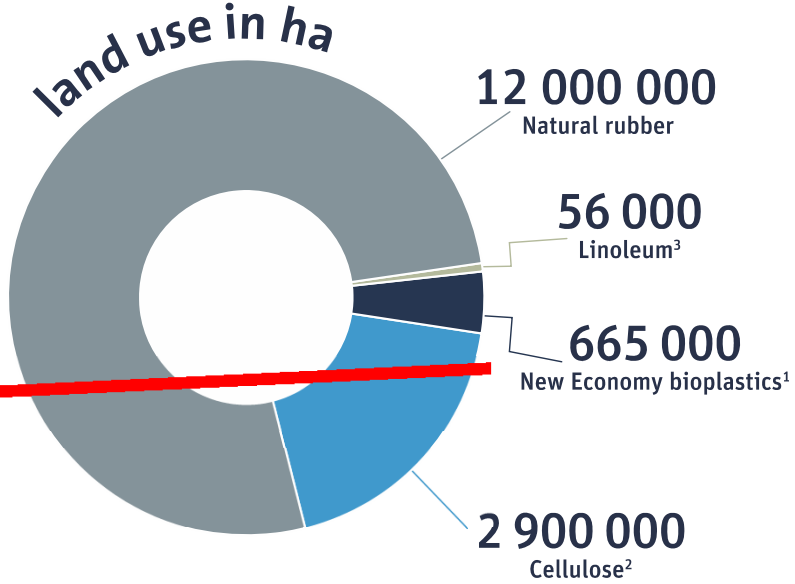
Global land use





[1] PLA, PHA, PTT, PBAT, starch blends, drop-ins (Bio-PE, Bio-PET, Bio-PA) and other
[2] Material use excl. paper industry
[3] Calculations include linseed oil only

*Also includes area growing permanent crops as well as approx. 1 % fallow land. Abandoned land resulting from shifting cultivation is not included.

Figures: IfBB
Data sources: FAO, IfBB 2013 – 2017

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Introduction to (hybrid) biocomposites

Composites

- Composite material is made from at least two constituents
- Main constituents:
  - Reinforcing fibers providing strength
  - Matrix holding the reinforcing fibers together and protecting from environmental damages

Short fiber-reinforced polymer composites

Wood fiber-reinforced PP (compound)

Carrier box made from wood fiber-reinforced PP

Long / endless fiber-reinforced polymer composites

Various natural fiber textiles

Tailgate made from various natural and carbon fiber-reinforced epoxy

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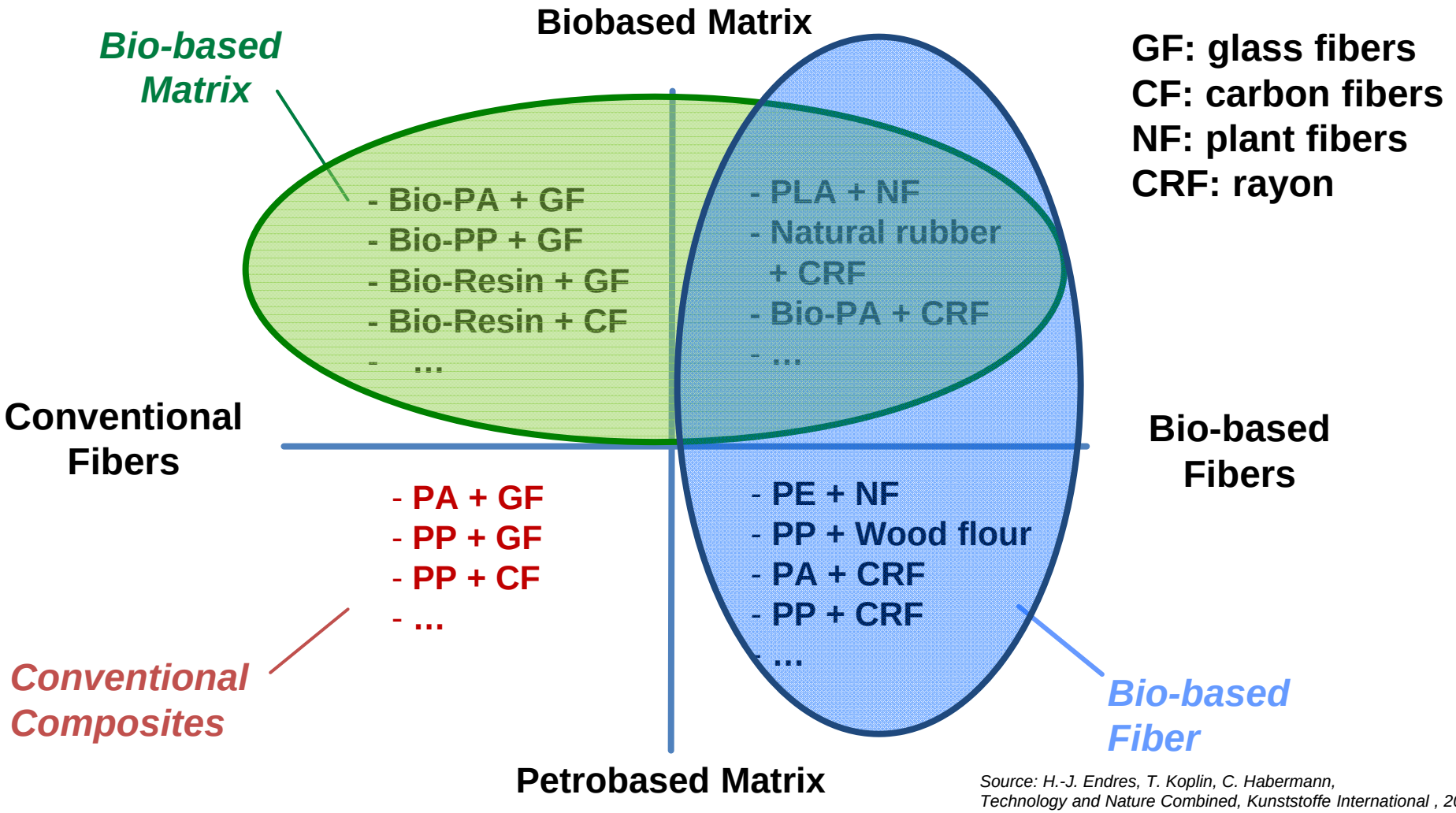
Biocomposites



Source: H.-J. Endres, T. Koplin, C. Habermann, Technology and Nature Combined, Kunststoffe International , 2012

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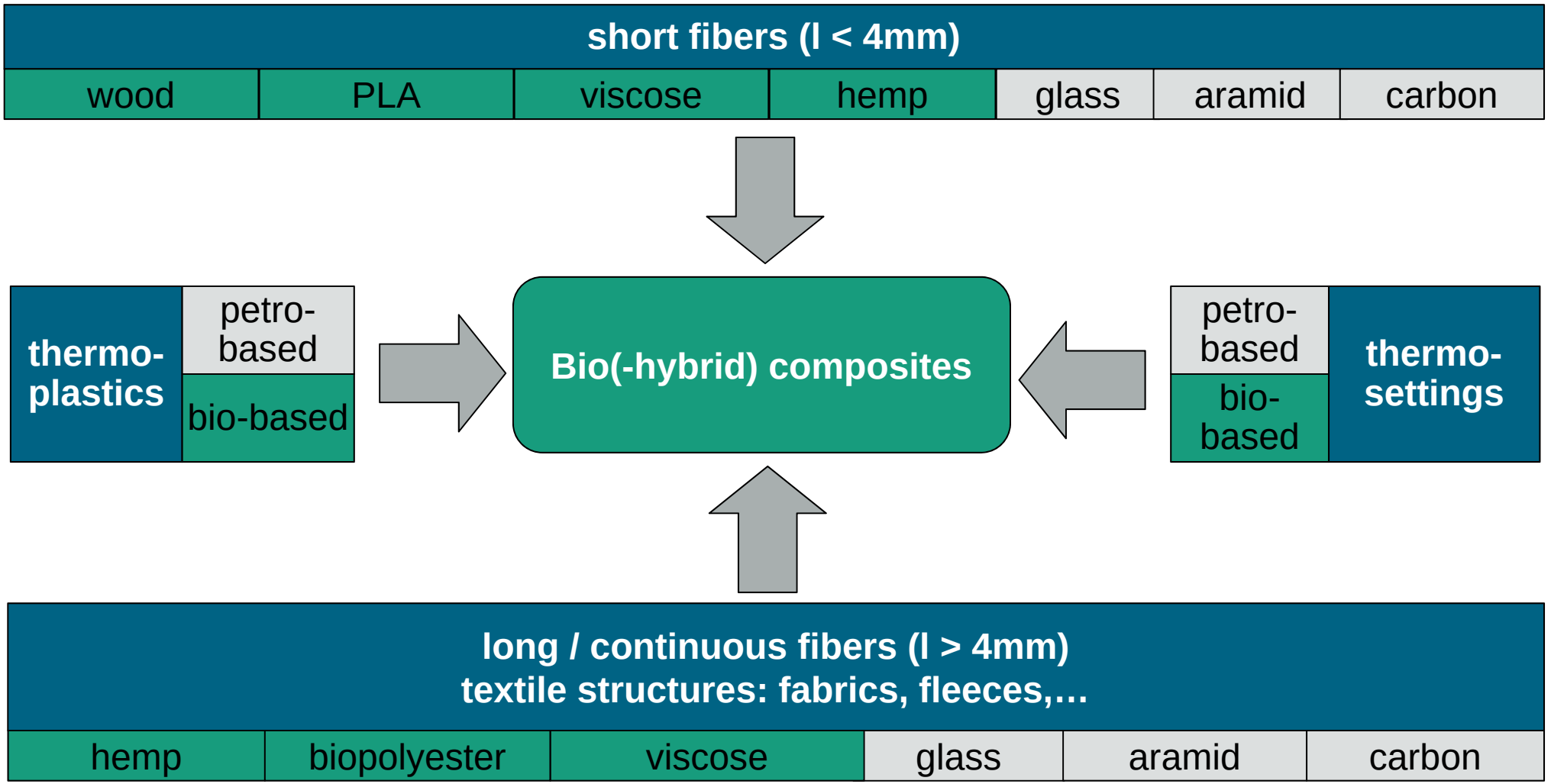
Bio(-hybrid) composites



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Bio-hybrid fiber-reinforced polymers
Motivation

- Flexibility regarding mechanical properties
  - Weaving technique, localized reinforcement, etc.
- Integration of new properties
  - Acoustic damping, etc.
- Large choice of reinforcing materials and matrices
- High material availability
- Sustainable production
- Good disposal / recycling possibilities

Aramid, carbon, glass and flax fiber-reinforced epoxide

Bio-hybrid fiber-reinforced polymers
Industrial applications

- Sport and leisure industry
- Automobile industry
- Building industry
- Furniture
- Design und Interior

©Jones Snowboards

The snowboard feature a combination of biax glass, triax glass, flax and basalt

Advantages and disadvantages of plant fibers

Advantages	Disadvantages
Renewable resources	Insufficient supply chains
Low density	Lack of data
Acoustical damping	New materials (e.g. simulation?)
New optical appearance	Low thermal resistance
Low price	Hydrophilicity / polarity
Disposal behavior	Variable fiber morphology
Extensive knowledge in textile technology	Inferior mechanical properties
etc.	etc.

Source: WKI

Selected projects

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Selected projects:
Next generation Bio-Hybrid-Car

- Demonstration of technical performance of bio-hybrid composites
- Ecological, technical and economic assessment
- Creation of database (material combinations, mechanical performance, …)
- Processability and industrial usability for automotive application
- Realization of > 500 Cars
- Project start: 09/2017
- Project partner: Porsche AG, Four Motors
- Project funding: BMEL (FNR)


© Four Motors


© Four Motors

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Selected projects:
Next generation Bio-Hybrid-Car

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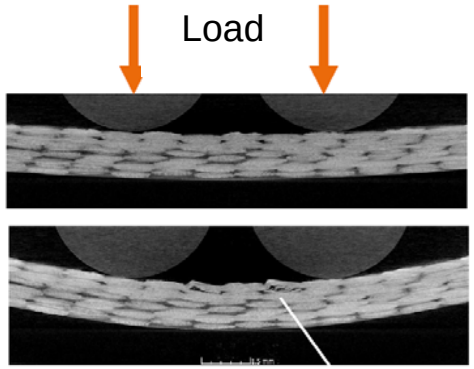
HOFZET / IfBB – selected projects
InteReSt

Aim: Function-**inte**grative and **re**source-saving lightweight construction **st**ructure for aviation

- Feasibility study on use of biobased hybrid parts instead of conventional parts made of petrol-based materials or metal
- Demonstration of the technology concept via manufacture of helicopter structure
- Duration: 2016 – 2019

Helicopter cabin CAD model

Exemplary helicopter model



In-situ CT analysis (3-point bending)

TECHNISCHE UNIVERSITÄT CHEMNITZ

Technische Universität München

DLR

Bundesministerium für Wirtschaft und Energie

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HOFZET / IfBB – selected projects
SLC (Small load carrier)

Aim: Development of a universal sustainable, biobased, small load lightweight carrier

- In order to optimize the logistics chain between automotive manufacturers, suppliers and service providers, a small load carrier system (SLC system, German: KLT) is utilized in industry
- Current SLC generation is produced from polypropylene (PP)
- In the project, a large proportion of the PP is going to be replaced with wood fibers or cellulose fibers
  - Economic and ecological advantages
  - Significant strengthening and stiffening effect
  - Reduction of the wall thicknesses leads to the lower weight

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New generation SLC

VDA | Verband der Automobilindustrie

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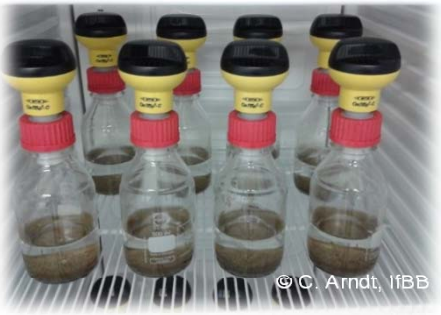
IfBB – selected projects
SeaArt

Aim: Development of marine biodegradable artificial seagrass to provide suitable conditions for the restoration of natural seagrass meadows

- Studies on marine biodegradability of bioplastics and natural materials
- Material characterization in terms of degradability, technical and mechanical properties and feasible production methods
- Material development regarding degradability and mechanical properties
- Duration: 2016 – 2020



INSTITUT FÜR GEOÖKOLOGIE Landschaftsökologie und Umweltsystemanalyse

IfBB Institut für Biokunststoffe und Bioverbundwerkstoffe

FZK Forschungszentrum Küste

SOILTEC GEOSYSTEMS

FRANZIUS-INSTITUTE for Hydraulic, Estuarine and Coastal Engineering

Niedersächsisches Ministerium für Wissenschaft und Kultur

VolkswagenStiftung

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ProBio

Functionally-integrated, three-dimensional and variable production of bio-hybrid components with maximum organic content (ProBio)

Niedersächsisches Ministerium
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FORSCHUNGS
CAMPUS
öffentlich-private Partnerschaft
für Innovationen

Open Hybrid
LabFactory e.V.

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ProBio

- Development of bio-hybrid-fiber-reinforced composites (bio-HFC) with the highest possible proportion of bio-based components
  - Reinforcing fibers and / or plastic matrices
- Technologies
  - Hot pressing
  - Fiber-spraying facility
  - Weaving machine
- Surface modification
  - Improvement of compatibility between fibers
  - Function integration

Weaving machine with Jacquard technology

Fiber-spraying facility

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Hybrid textile for composite applications

© Fraunhofer WKI | Carsten Aßhoff

Hybrid fabrics (CAD)

Multi-layer fabrics (CAD)

- Combination of various fiber types in one textile
  - Different reinforcing fibers (e.g. cellulose-based fibers and carbon)
  - Reinforcing fibers and matrix fibers (e.g. cellulose-based and polyamide)

DeFiCoat

Development of specially coated natural fibers for efficient application in engineering thermoplastics (DeFiCoat)

Bundesministerium für Bildung und Forschung

Projektträger Jülich Forschungszentrum Jülich

UNIVERSITY of GUELPH

BIOPRODUCTS DISCOVERY & DEVELOPMENT CENTRE

Funding code: 031B0502

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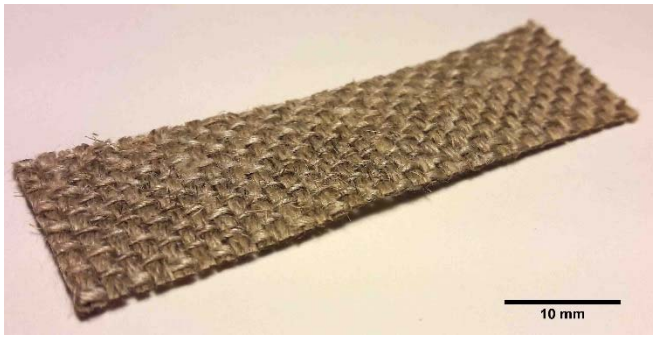
DeFiCoat

- **Aim**
  - Improvement of the thermal stability of cellulose-based fibers
  - Processability at temperatures > 200°C
  - Expansion of the application spectrum of natural fiber-reinforced composites (NFC)
  - Improved mechanical properties, thermal stability and chemical resistance

- **Pursued approach**
  - Coating of the natural fibers with an optimized thermosetting coating
  - Coating should act as an isolating layer between fibers and melted thermoplastics

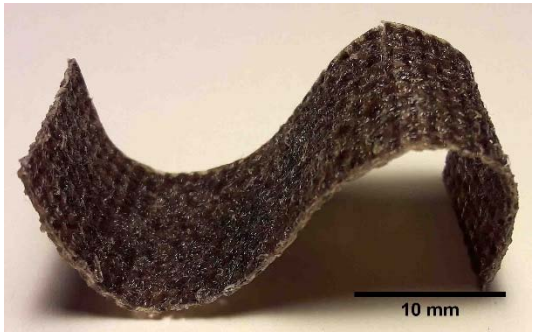
- Duration: 1.11.2017 – 31.10.2019

DeFiCoat
Flax fabrics – mechanical properties



Flax fabric, uncoated

Flax fabric, coated with diluted epoxy resin



Flax fabric, coated with diluted epoxy resin, in curved state

© Madina Shamsuyeva

- Preliminary results
  - It is possible to coat the fabrics homogeneously with diluted epoxy resin
  - The fabrics remain deformable

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Challenges in sustainability

- Environmental benefits of bioplastics/biocomposites in comparison to their (mainly fossile-based) conventional counterparts are one of the key drivers for their use and promotion

- Companies who intend to use bioplastics for their products are required to provide quantification and proof of the environmental benefits in order to avoid false claims and greenwashing

- Especially small and medium-sized enterprises are confronted with the challenge of generating this information in an effective, high-quality and low-cost way

Source: IfBB

Sustainability Assessment

LCSA
=

Life **C**ycle
Sustainability
Assessment

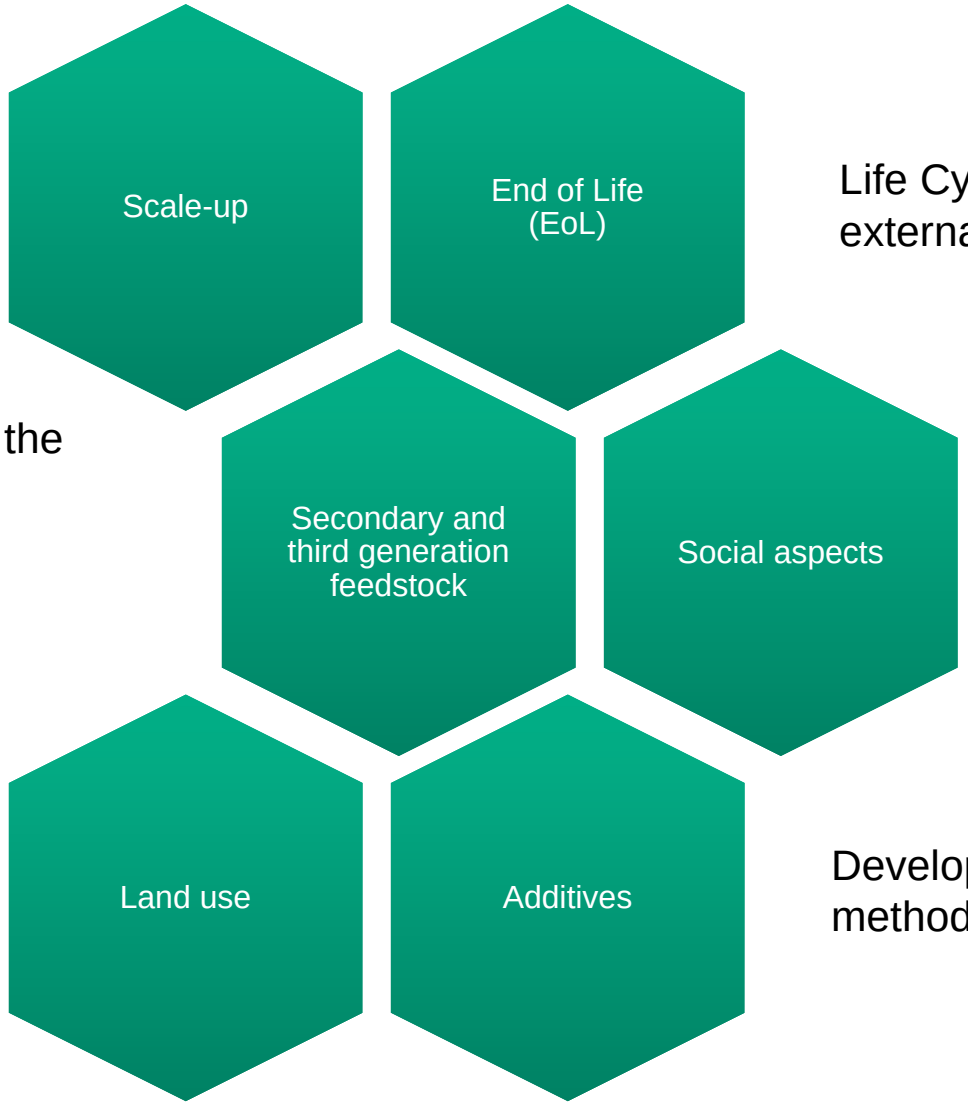
Environment		**Economic**		**Social**
LCA	+	LCC	+	SLCA
Life **C**ycle **A**ssessment		**L**ife **C**ycle **C**osting		**S**ocial **L**ife **C**ycle **A**ssessment

Source: IfBB

Sustainability

Life Cycle Assessment of the developed materials

- Screening LCA
- Hotspot analysis
- Material balance



Life Cycle Assessment of the external partners

Development of guidelines and methodology

Source: IfBB

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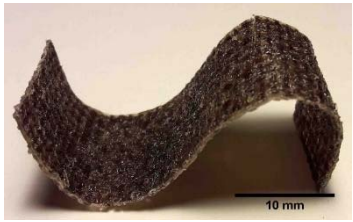
Sustainability in the context of the ongoing projects

- InteReSt
  - Project aim: Lightweight structures from biobased polymers and biocomposites for aerospace industry
  - Sustainability task: Development of recycling concept und ecological assessment of the developed materials

© edm aerotec

- DeFiCoat
  - Project aim: Development of specially coated natural fibers with improved thermal stability
  - Sustainability task: Life cycle assessment of the developed materials



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- SLC
  - Development of a universal sustainable, biobased, small load lightweight carrier
  - Sustainability task: Life cycle analysis of the developed product

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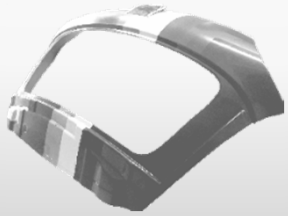
BioMat_LCA

Biobased plastics

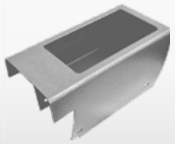
Natural fibers

Conventional plastics

Fillers & additives



Construction and processing of motive components



Source: IfBB

Recommendations for generalized application

Source: IfBB

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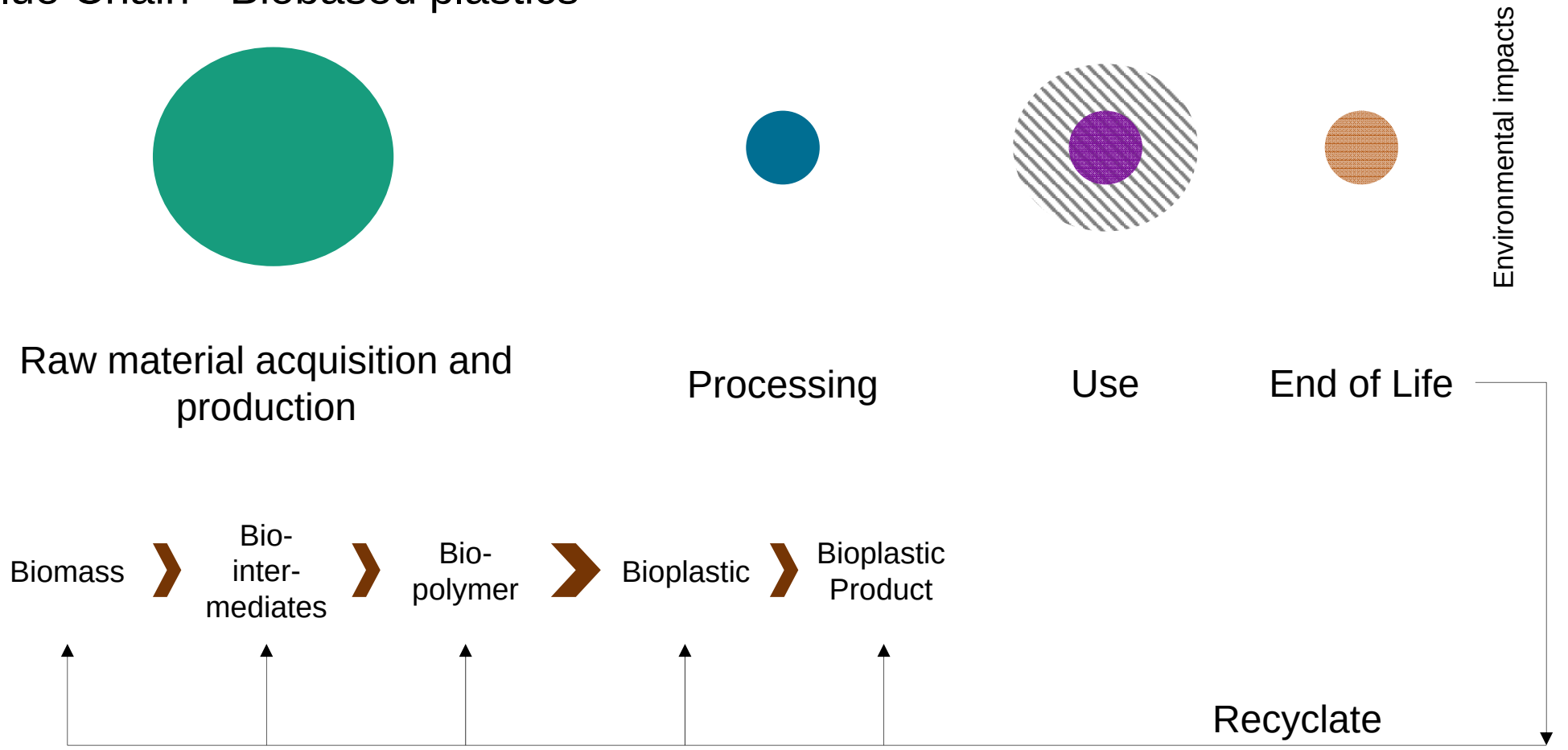
LCA of biobased plastics

Value Chain - Biobased plastics



Source: IfBB

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LCA of biobased plastics VI

Characterization factor	Tendency of biopolymers	Biopolymers	Conventional polymers
Energy demand		Different energy demand for different biopolymers	Different energy demand for different conventional polymers
Global-warming potential		High CO_2 storage during the plant growth	High CO_2 emission during burning
Abiotic resource depletion		Bio-based (renewable)	Crude oil-based (finite)
Eutrophication potential		Consumption of fertilizers and pesticides	Not necessary
Acidification potential		Consumption of fertilizers and pesticides	Not necessary
Land use		Agricultural field necessary	Agricultural field not necessary
Water consumption		Process water and water for irrigation	Only process water

Source: Source: PE INTERNATIONAL/ IfBB 2014

Thinkstep & IfBB Bioplastics LCA tool

For more information:
https://www.thinkstep.com

thinkstep

- Bioplastic-specific **GaBi database** (incl. feedstock, granulates, additives, conversions, auxiliaries, transport, end-of-life)
  - ✓ IfBB as scientific development partner for LCA data
- Base your decisions on consistent, high-quality, up-to-date and reliable background data
  - ✓ **Comparison of scenarios** (products, conversion/compounding processes, transport options, end-of-life (recycling, composting, incineration), bioplastics vs. conventional plastics)
- Know about the **environmental consequences before investing** in product and process changes
  - ✓ Easy-to-use interface, **instant result calculation** and reporting with customized content, tables, diagrams, format and company design
- Communicate **verifiable LCA results** created on your own without being an LCA expert
  - ✓ The tool covers all stages of the bioplastics supply chain
- Be prepared to answer questions from your clients and even questions asked to your clients

Source: Thinkstep

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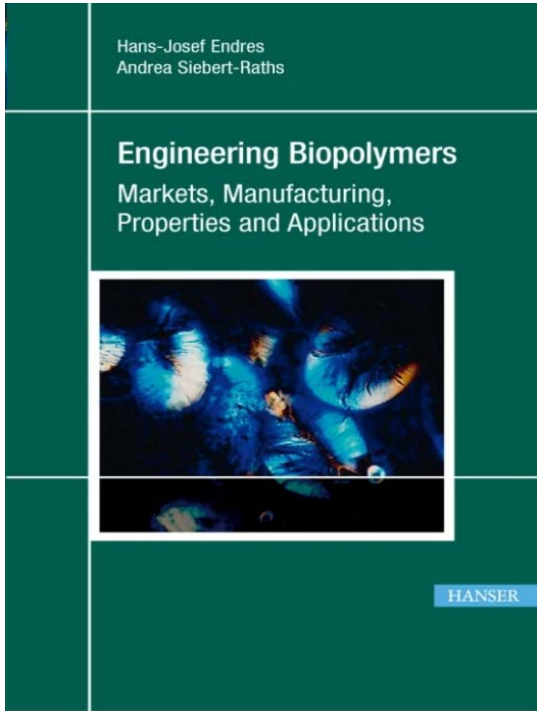
Further information on bioplastics

- Information on the widely-varying processing procedures for almost 100 bio-based plastics
  http://www.biokunststoffe-verarbeiten.de

- Procurement-relevant information on products made from bioplastics and biocomposites
  https://datenbank.fnr.de/

- Technical material characteristics and applications
  http://biopolymer.materialdatacenter.com

Source: IfBB, FNR, M-Base



http://www.hanser.de/buch.asp?isbn=978-3-446-42403-6&area=Technik

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Outlook on future research

- End-of-Life / New-Life Options
- Additives / Blending
- Hybridization
- Communication (awareness, social responsibility, etc.)
- Sustainability methods & LCA for bioplastics & biocomposites
  - Quality and availability of LCA data (manufacturers of fibers, biopolymers, etc.)
  - Cascade utilization and ecological assessment
  - Time horizon in LCA
  - Regional and global assessment of sustainable production
  - Competence exchange (material development, global wording, etc.)
  - Assessment of social sustainability

Organizers of the events

Hochschule Hannover

Fraunhofer-Gesellschaft

Western University

Western University · Canada

WKI

FPC@Western

IfBB

HOFZET

Source: Google Maps

Webinar
05. and 26.06.2018

Workshop
25.-26.10.2018

Fraunhofer WKI

WKI Workshop in Canada
Why should I join the workshop in London?

25.-26.10.2018 in London (CAN)

- Competence exchange between scientists and industry
- Identification of new ideas and topics for collaborative projects
- Efficient use of renewable resources for industrial applications
  - Optimization of reinforcement fibers and fabrics
  - Manufacture of biocomposites
  - State-of-the-art manufacturing technologies
  - Properties of the biobased products
  - Analytics
  - Recycling / End of Life scenarios
  - Life Cycle Analysis
- Registration will be opened in the middle of June

Fraunhofer
WKI

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