Key role of polymers to meet SDGs

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Neue Materialien Bayreuth

POLYMER ENGINEERING University of Bayreuth

New Materials Bayreuth & Polymer Engineering (University of Bayreuth)

	New Materials Bayreuth GmbH (Research Institute of Free State of Bavaria)	Polymer Engineering (University of Bayreuth)
Employees	~ 60	~ 35
Materials	Polymers, Metals, Hybrids	Polymers
- thereof polymers	Thermoplastic Composites, Bead Foams, Additive Manufacturing, Injection Molding	Resins and Composites, Foams, Functional Thermoplastics
Operating budget	~ 5.2 m€	~ 2.5 m€
Equipment value	~ 30 m€	~ 11 m€
Focus	Application-oriented research + Sustainability + Digitalization	

How to define sustainable development?

„Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs“

Deduced sustainable development goals (SDG)

Polymers play a key role for meeting the SDGs

Polymers in packaging & agriculture

Polymers in medicine & med tech

Future generation of polymer experts

Polymer in filtration & purification

Polymers in energy generation & storage

Energy-efficient processes

Circular Economy

Polymers in construction & insulation

Polymers in light-weight transport

Driving innovation

National & international cooperations

Polymers are more climate-friendly vs. next best alternatives

% difference in total greenhouse gas contribution in United States, 2020[1]

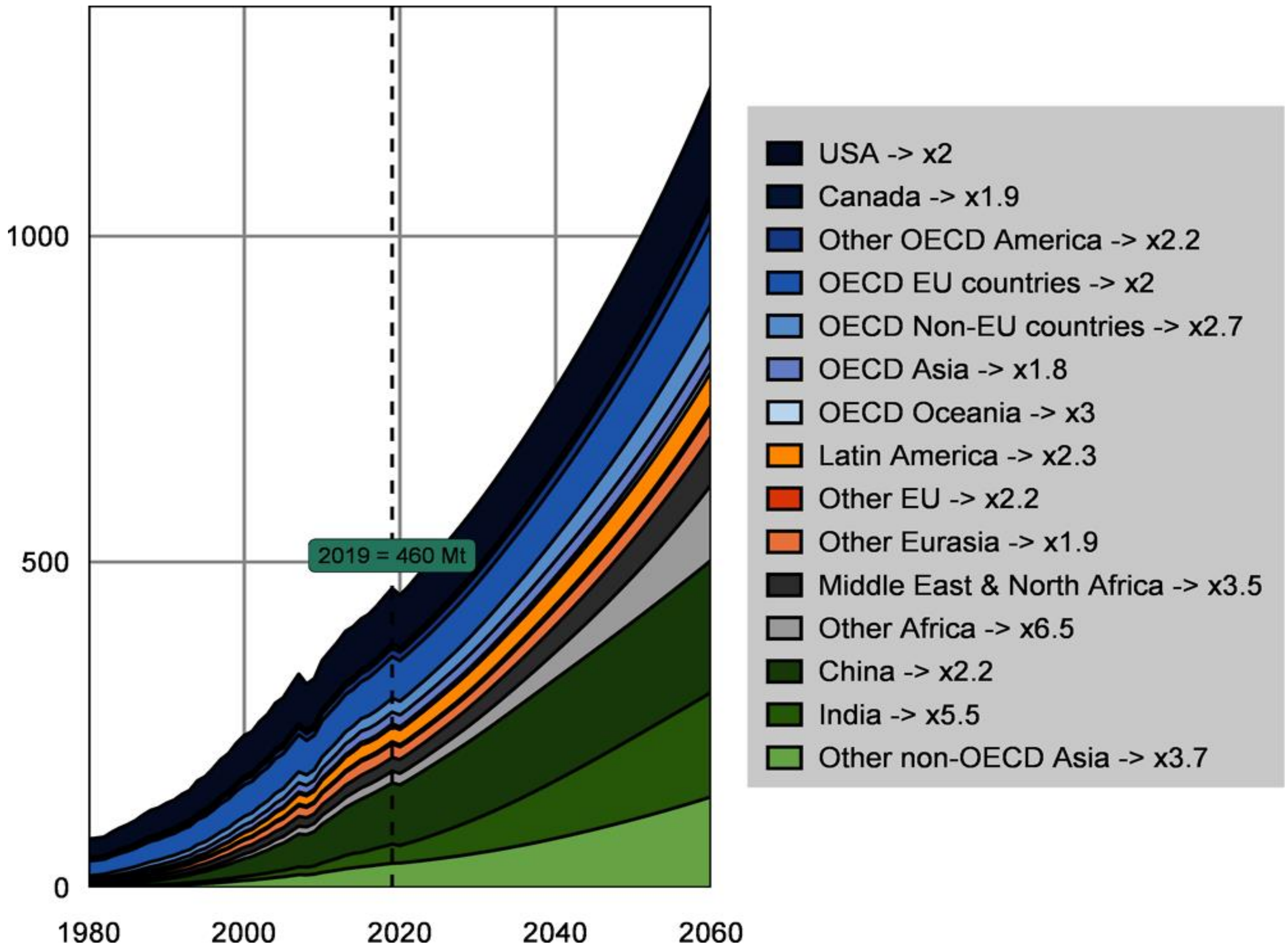
Comparison	**Sector**	**Application**	*Plastic vs*	*Next-best alternative*	
Plastics vs alternative materials	Packaging	Grocery bag	HDPE[3]	Paper	80
		Wet pet food packaging	PET/PP[4]	Aluminum or steel	70
		Soft drink container	PET	Aluminum	50
		Fresh-meat packaging	EPS/PVC[5]	Paper	35
		Industrial drum	HDPE	Steel	–30
		Soap container	HDPE	Glass	15
	Building and construction	Municipal sewer pipe	PVC	Concrete or ductile iron	35–45
		Residential water pipe	PEX[6]	Copper	25
		Insulation	PU[7]	Fiberglass	80
	Consumer goods	Furniture	PP	Wood	50
	Automotive	Hybrid fuel tank	HDPE	Steel	90
		BEV[2] battery top enclosure	PP/glass fiber	Steel	10
	Textiles	Carpet	PET/nylon	Wool	80
		T-shirt	PET	Cotton	15
Plastics vs plastics-enabled mixed materials	Packaging	Milk container	HDPE	Paper	20
	Consumer goods	Water cup	EPS	Paper	0

[1] Emissions include indirect impacts. [2] Battery electric vehicle. [3] High-density polyethylene. [4] PET is polyethylene terephthalate; PP is polypropylene. [5] Expanded polystyrene/polyvinyl chloride. [6] Cross-linked polyethylene. [7] Polyurethane.

In 13 out of 14 cases, plastics show (significantly) lower greenhouse gas contribution!

Market for polymers will further grow

Annual consumption of plastics (Mt)



Growth demonstrates success, but there exist also downsides and limitations …

WHY …

… further focussing on sustainability of plastics?

Challenges and limitations of plastics

Fossil resources

- > 85% of all plastics are produced from limited fossil resources
- Less than 10% based on plastic waste (recycled polymers)

Carbon dioxide emissions

- Polymers contribute 4% to the global emission of carbon dioxide
- Main reasons: Processing and fossil raw material base

Inefficient design base

- Currently polymer research often based on intuition and experience (try-and-error)
- For design, holistic view in not prominent or even not feasible

Challenges and limitations of plastics (continued)

Degradation

Microplastics

Plastic waste

- Polymer degradation limits lifetime
- Steadily increasing requirements further drive damage and / or necessitate additives

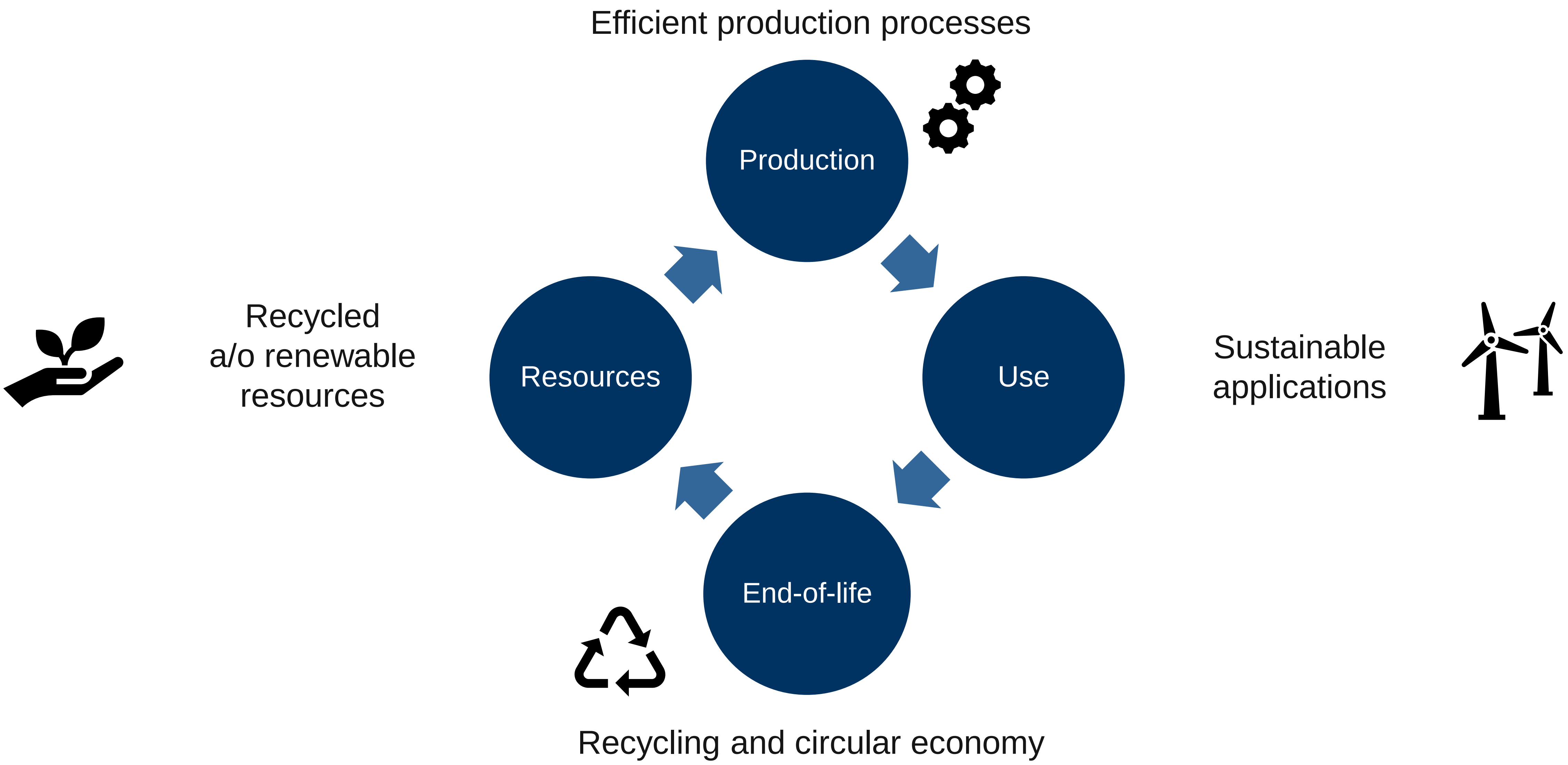
- Microplastics generated during and after use impacting the environment
- More harmful substances are eventually released

- Only minor share of plastics is recycled today
- Low costs and high durability act as a disadvantage

WHAT…

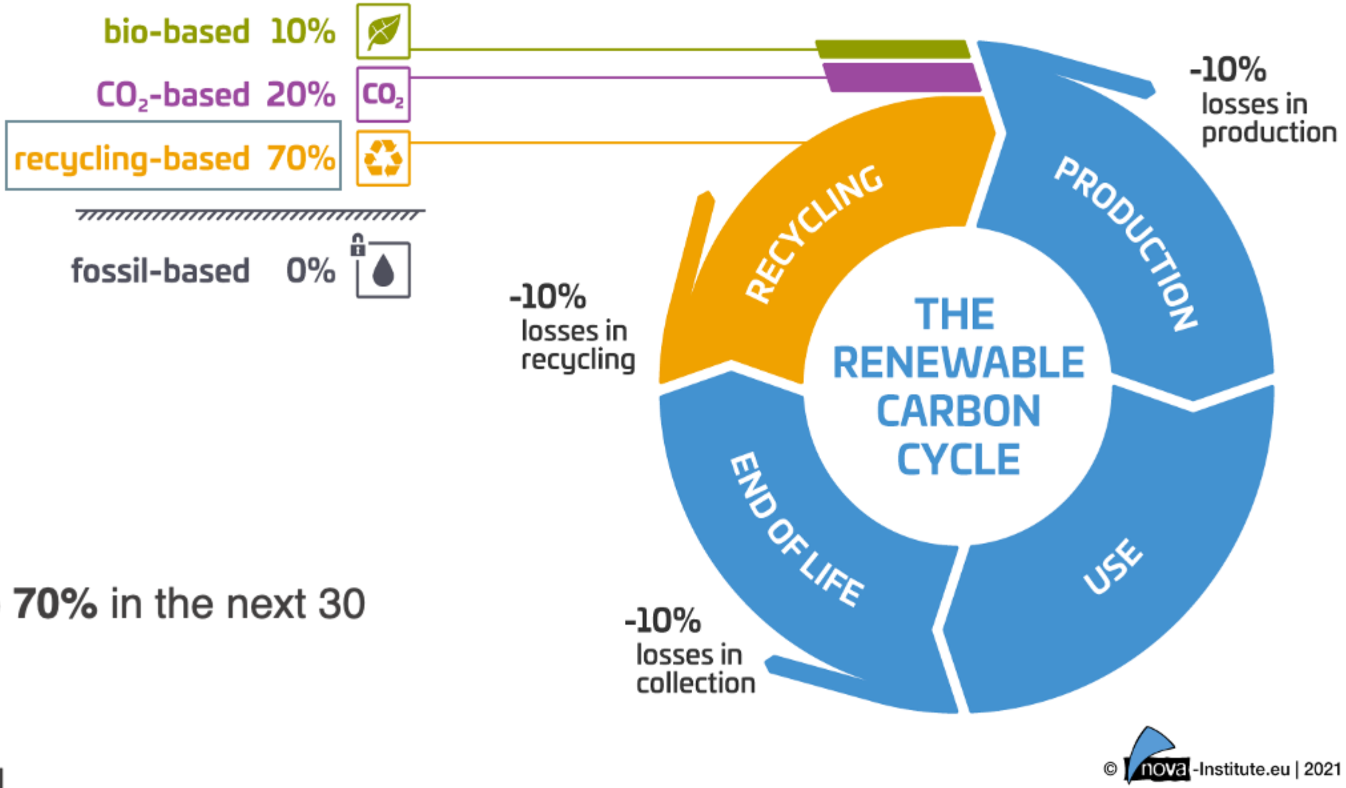
… are potential measures,
enabling technologies,
fields to act?

Innovations to address the complete life cycle of polymers



Resources: The feedstock topic of polymers

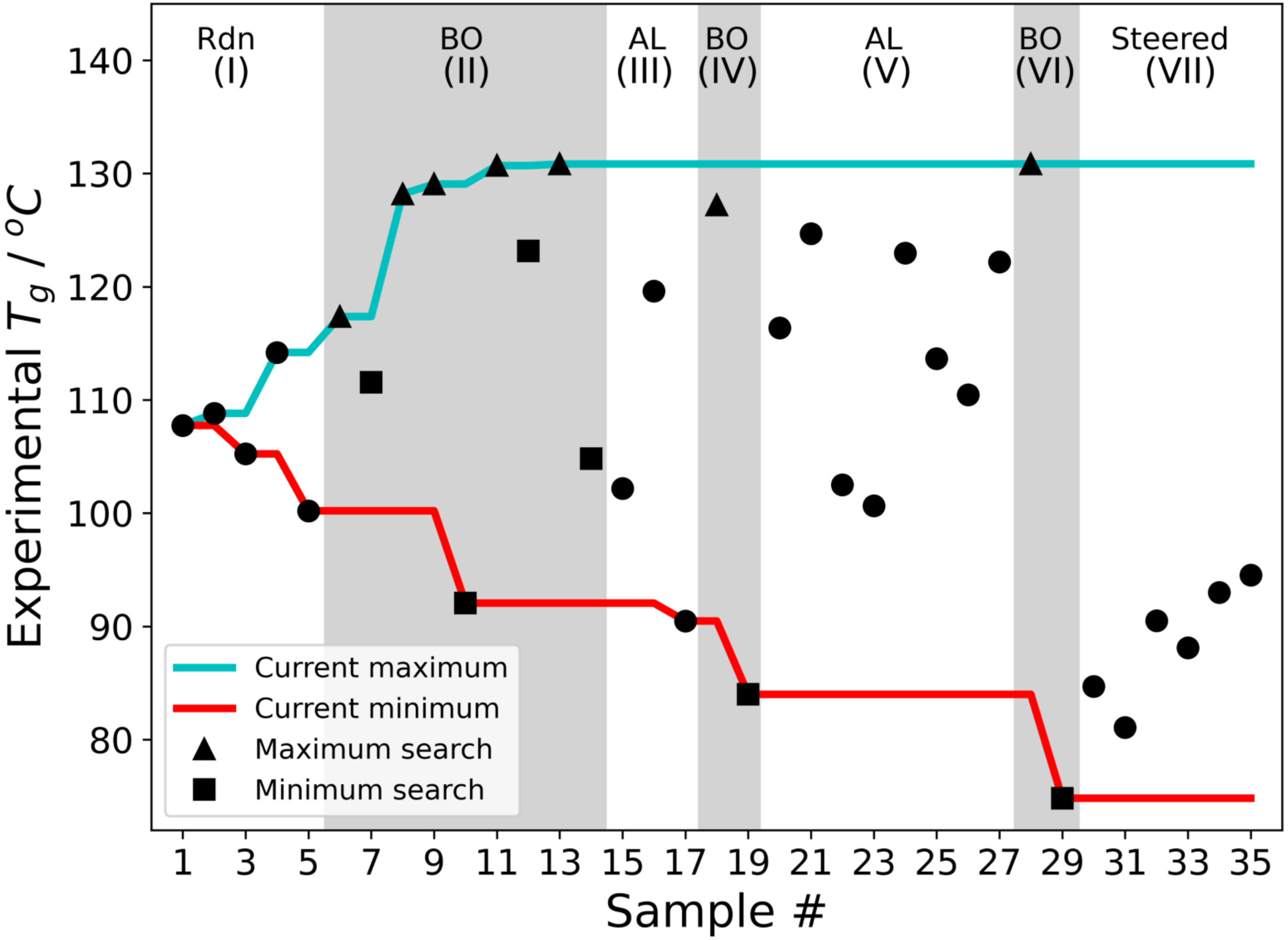
Recycling options are available, but **current recycling rates of <15%** for mechanical and chemical recycling combined are too low.



To ensure a sustainable supply of plastics

- the **recycling rate needs to increased to 70%** in the next 30 years
- **Fossil-based** plastics need to be **replaced**

Resources: AI to develop biobased formulations



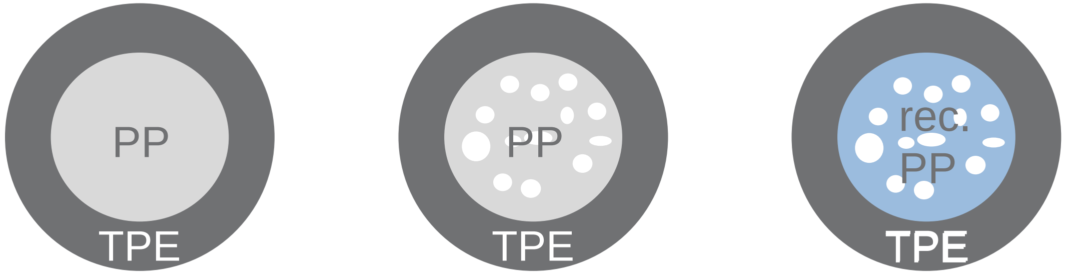
Formulation based on one epoxy resin and eight different amino acid hardeners

Target to find minima and maxima in glass transition temperature with only 15 – 30 trials!

Processing: Use of recycled material in co-injection molded parts

Target

Compare ecological footprint of injection molded parts produced by distinct material and processing concepts



Functional unit

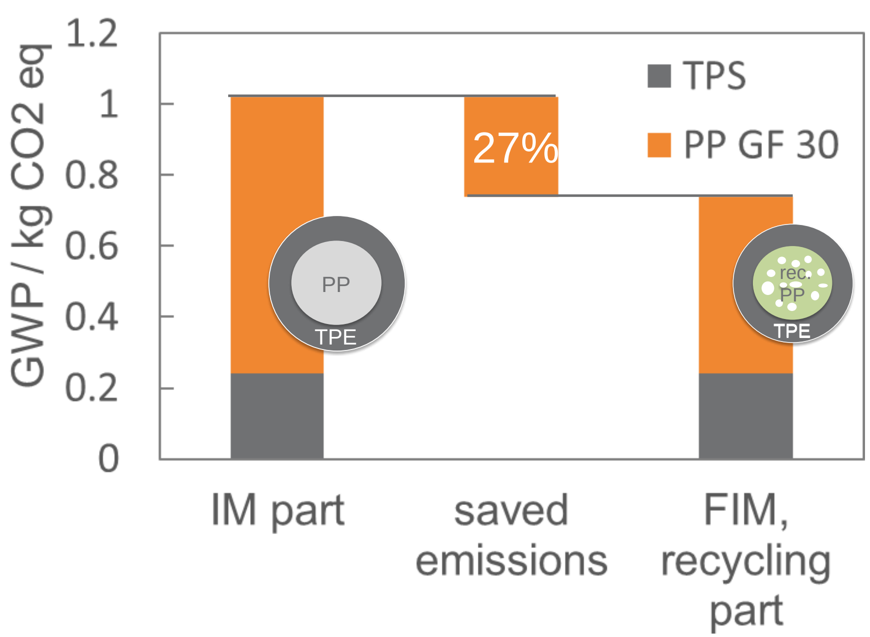
One injection-molded **part**

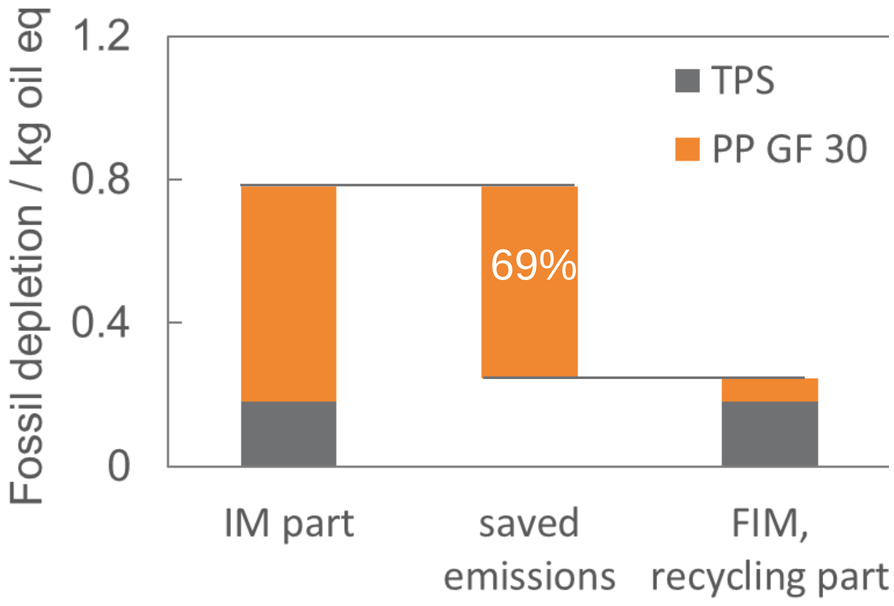
Product system

Material consumption to manufacture one functional unit

Processing: Potential of recycled material in injection molding

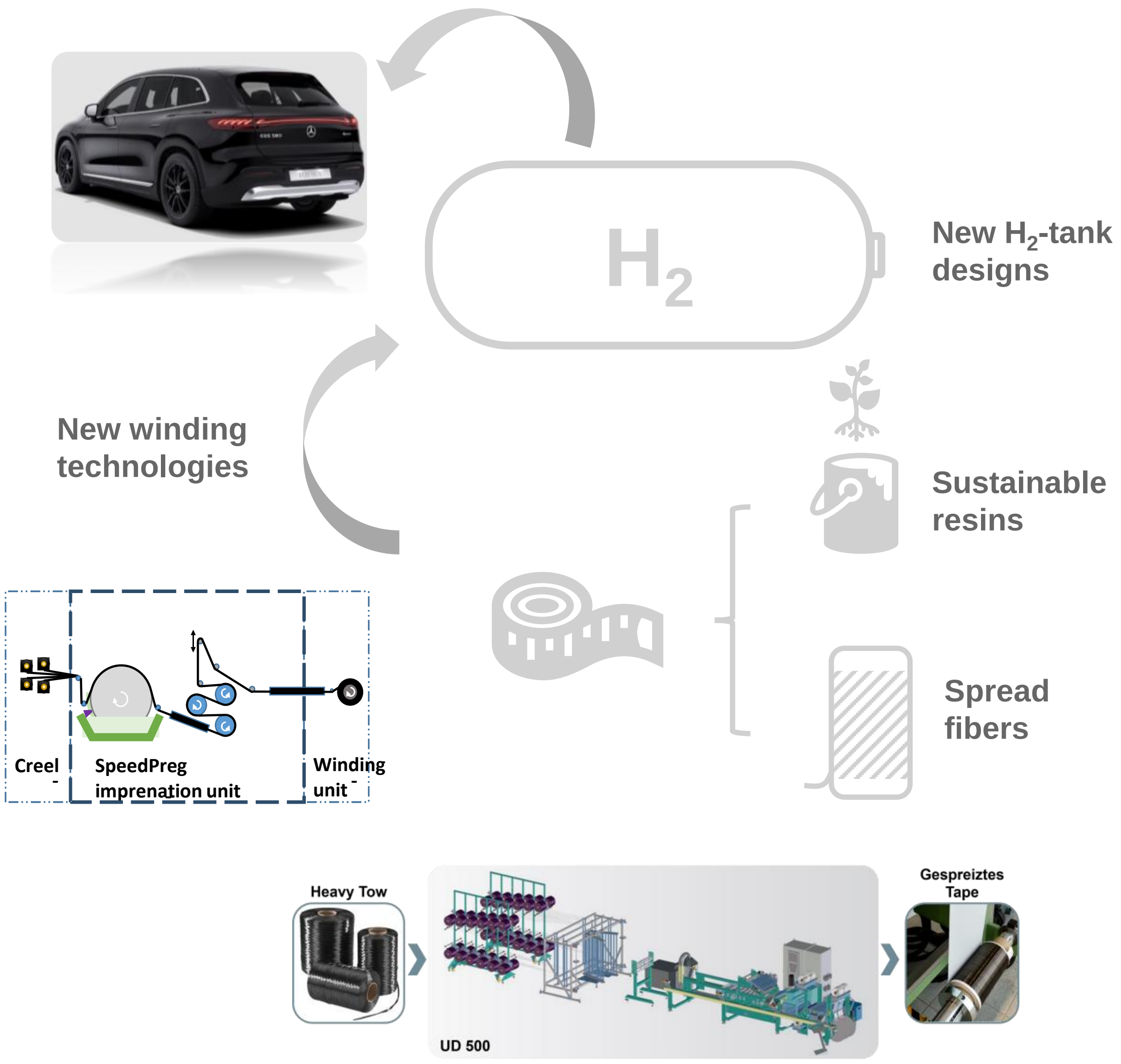
Comparison of **GWP** and **Fossil Depletion** between **injection-molded** part (**virgin PP**) and **foam injection-molded** part (**recycled PP**)





Significant reduction of carbon footprint possible

Use: Hydrogen vessels in transportation (here: automotive)



Why

Increasing importance of hydrogen in fuel cell-based vehicles for sustainable transportation

What

Development of new concepts for modelling, design, production and certification of hydrogen pressure vessels and their periphery

How

- Development of sustainable resin for fast wet winding of Type 4 tanks
- Development of a towpreg system for Type 5 pressure vessels, specifically for permeation and mechanical optimization utilizing fiber spreading

Use: Evaluating the impact of microplastics

Collaborative Research Center in Bayreuth (about 25 PIs)

Understanding the mechanisms and processes of **biological effects**, **transport** and **formation** of microplastic:

From models to complex systems as a basis for new solution approaches

A-Column

"**Biological effects** of MP on limnic and terrestrial ecosystems"

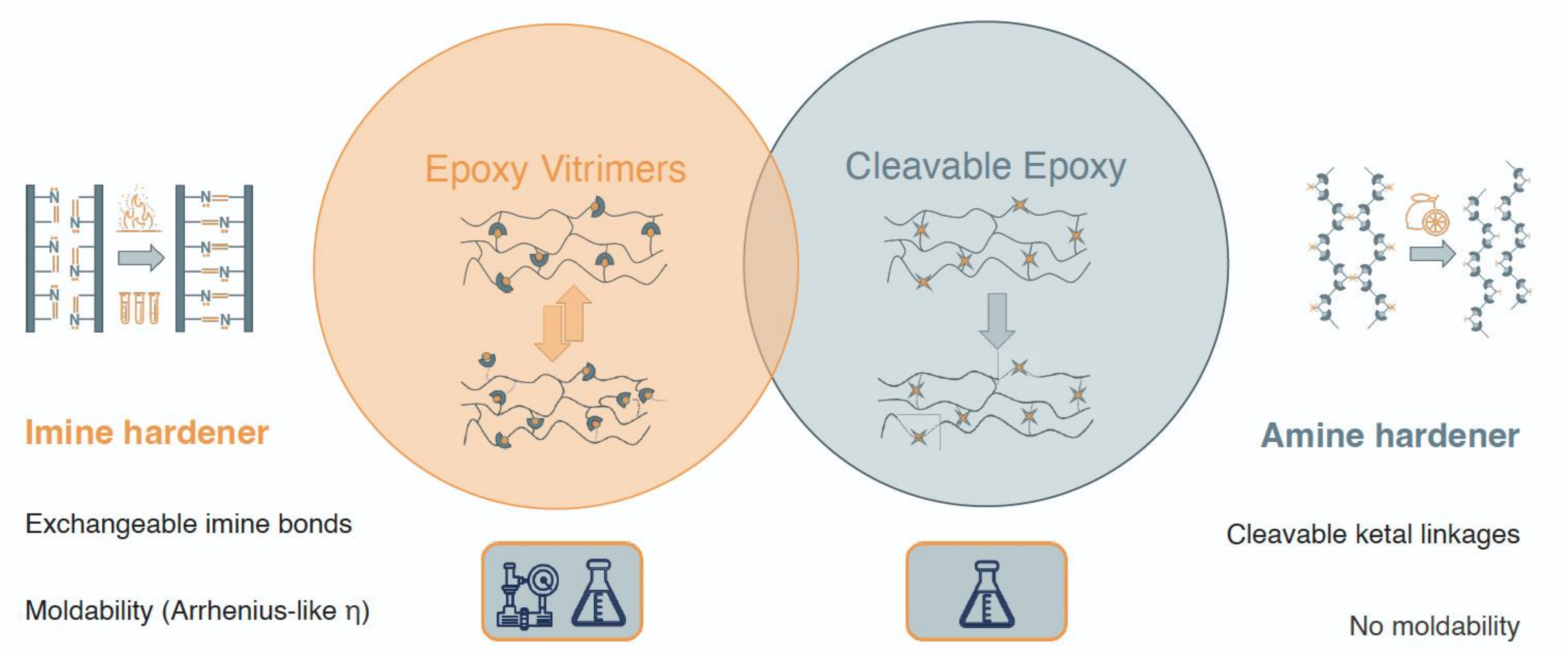
B-Column

"**Migration** of MP in and between environmental compartments"

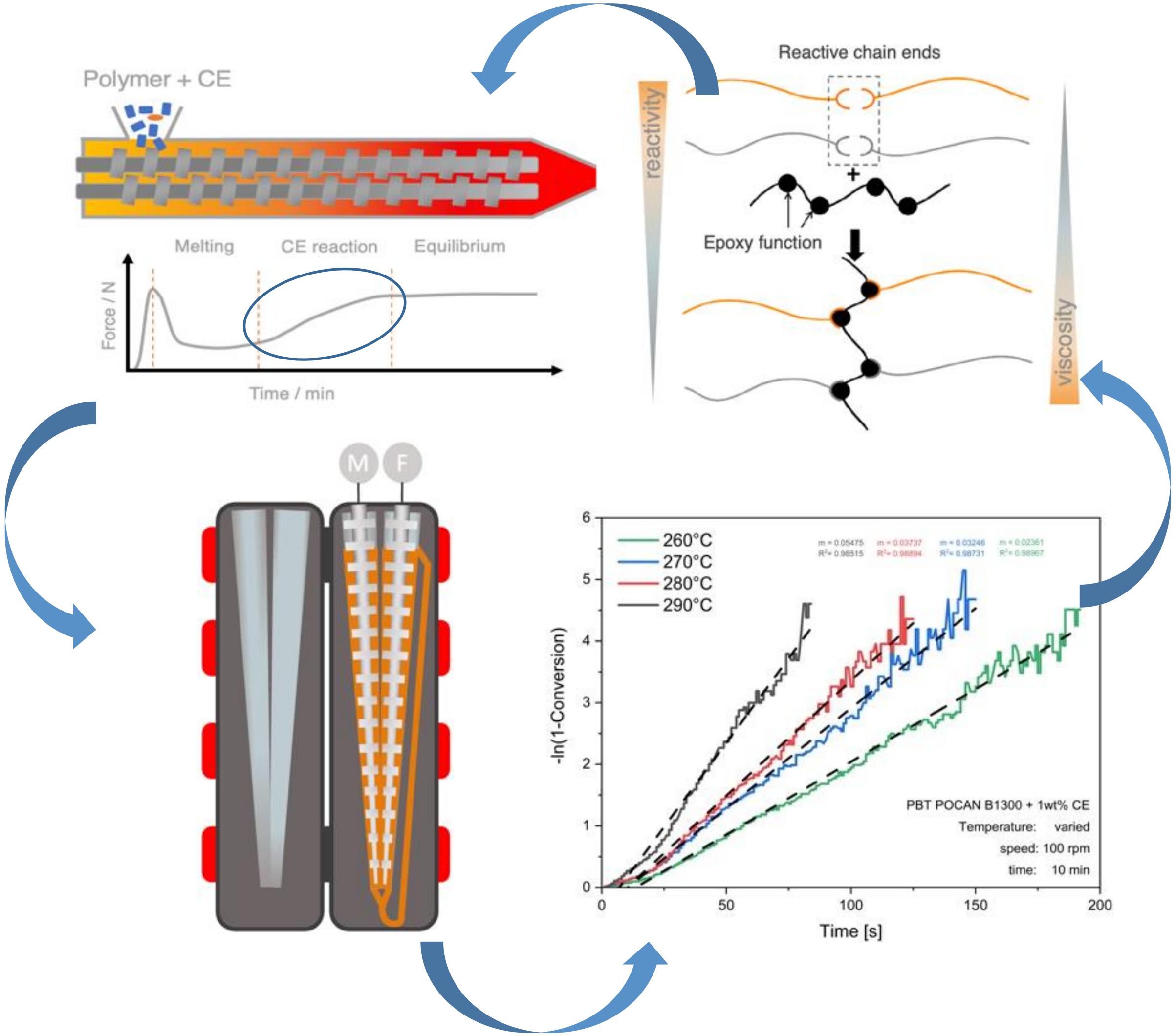
C-Column

"**Formation and degradation** of MP starting from macroscopic plastics"

End-of-life: Routes to recycle epoxy-based thermosets



End-of-life: Model-based & AI-driven reactive recycling



Why

Mechanical recycling of post-consumer-easte often requires reactive processing to maintain performance level

What

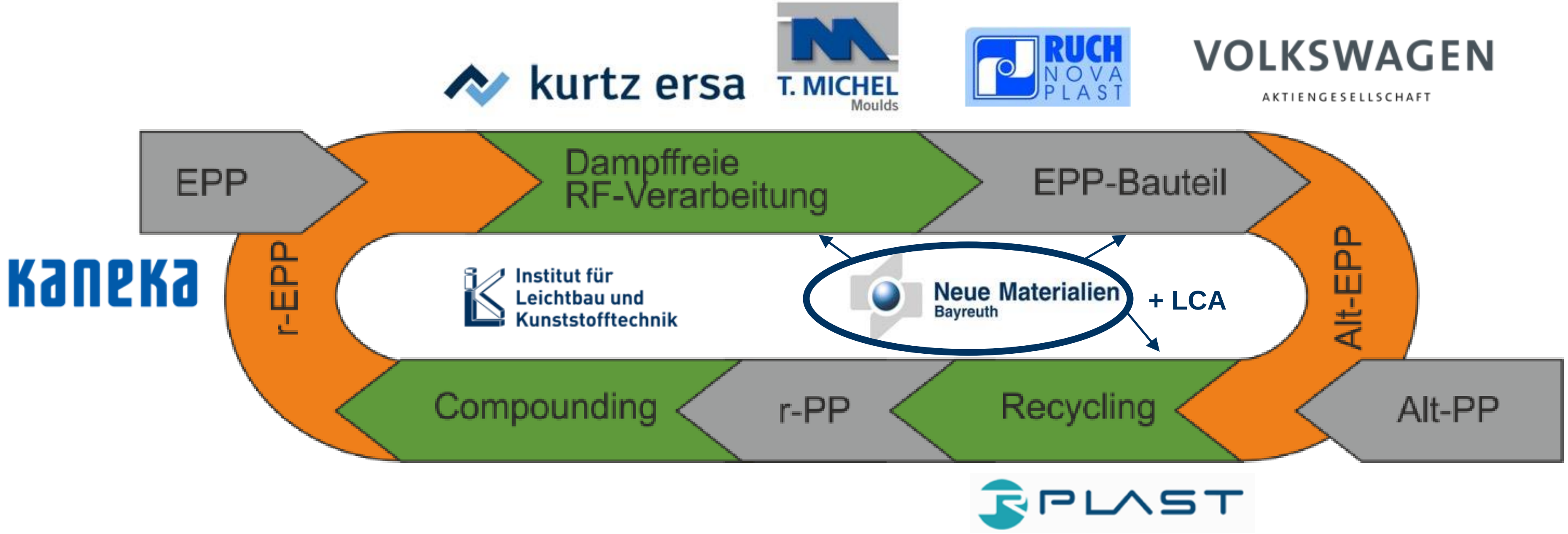
Basic understanding for reactive compounding of polyesters (incl. chain extenders)

How

- Compounding and analysis of reaction mechanisms and kinetics
- Correlation to resulting properties
- Use in models and machine learning

Circular economy: EPP bead foams

Gefördert durch:
Bundesministerium für Wirtschaft und Energie



- Establish **circularity for EPP**
- Resource-efficient processing via steamless **RF technology**

  ➔ **Reduction of CO_2 emissions of moulded EPP parts**

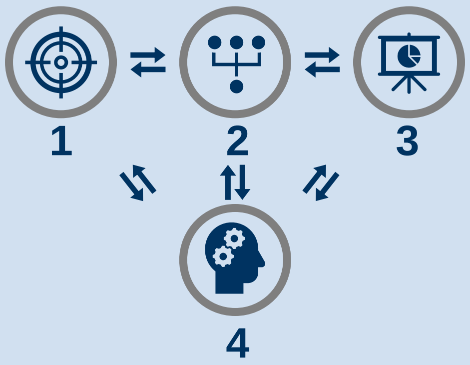
HOW …

… to measure impact?

Life cycle analysis as one of our competencies

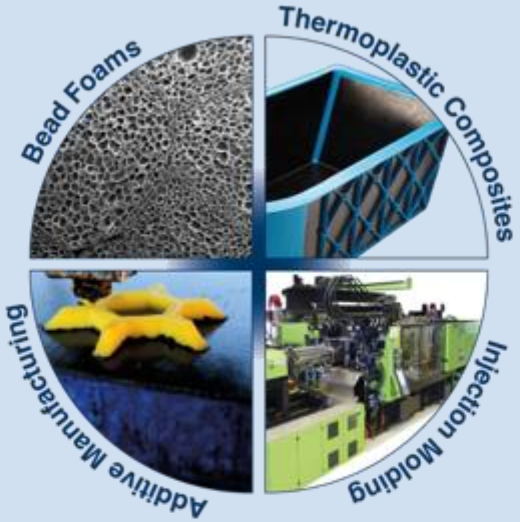
LCA acc. to ISO

Full Life Cycle Analysis acc. to ISO 14044 via **trained employees**



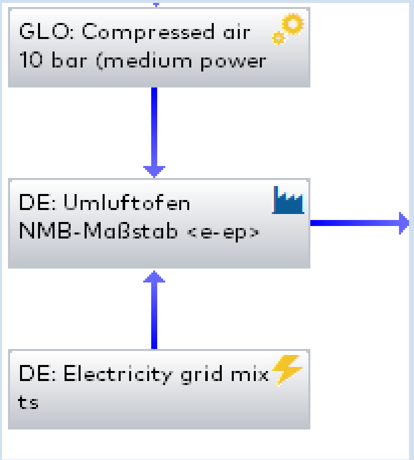
Data generation

Own data to complement data base information (via plants of NMB)

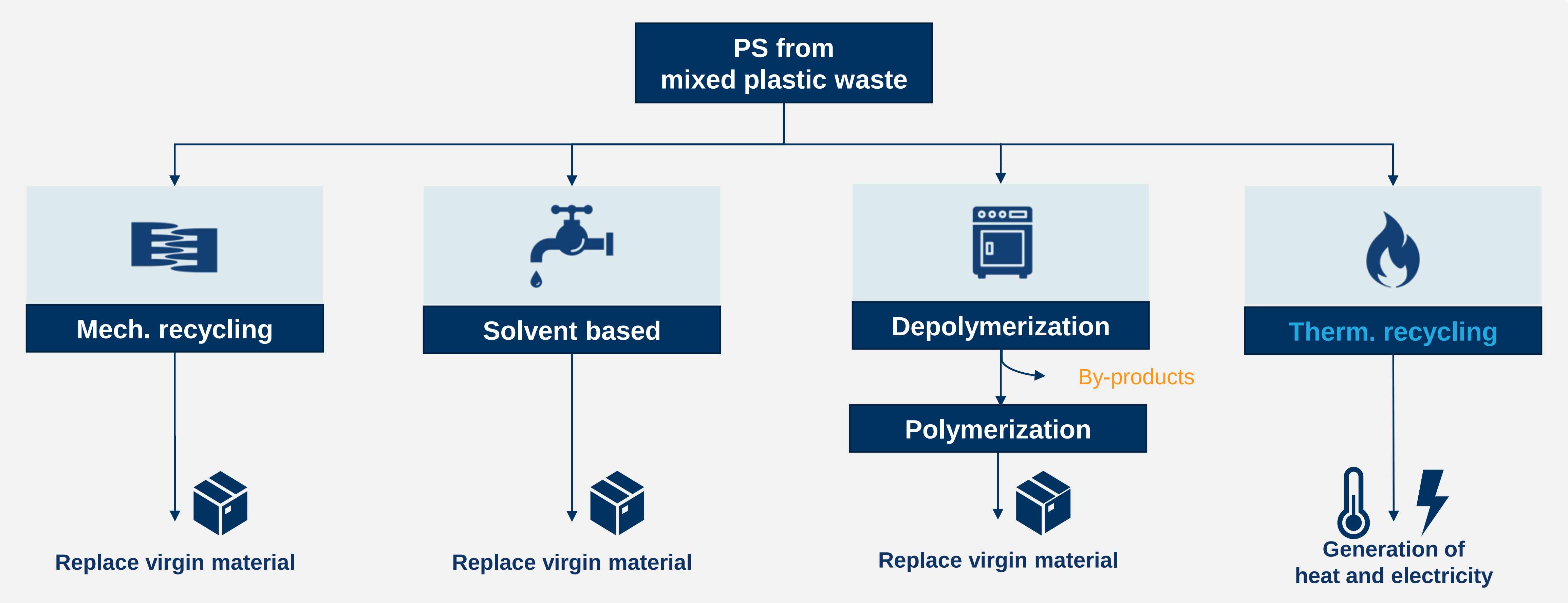


GABI / modelling

LCA model und **GABI software** with access to massive **data bases**



Routes to recycle PS-based waste

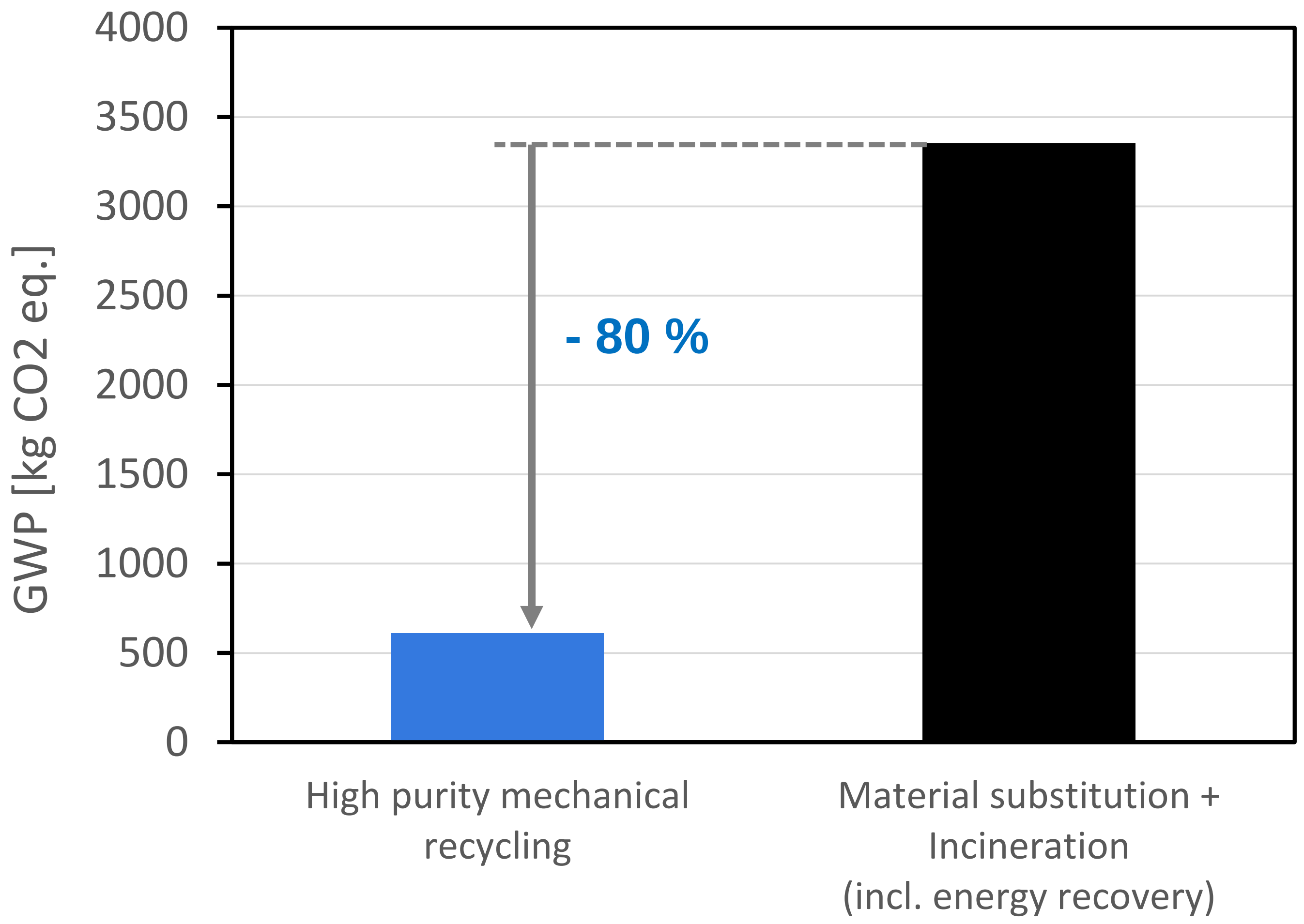


Process date from: Polystyvert

Process data from: agilyx

Styrenics Circular Solutions

Mechanical recycling - Savings



Mechanical recycling vs. virgin material and incineration

- Significant CO_2 savings feasible
- Downcycling avoided by suitable material preparation

Functional unit: Use of 1 t of PS waste / production of HIPS pellets

HOW …

… to leverage impact?

Significant investments into equipment & people ongoing (excerpt)*

Inline processing analytics

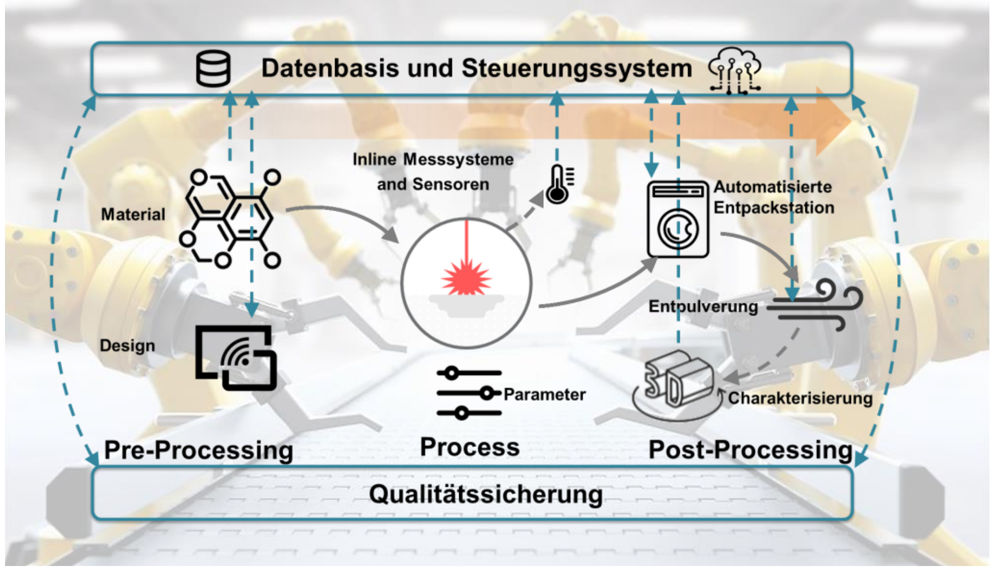
Digitally connected & automated SLS factory

Digitalized mechanical testing lab

Accelerated formulation development

Recycling technologies for plastics

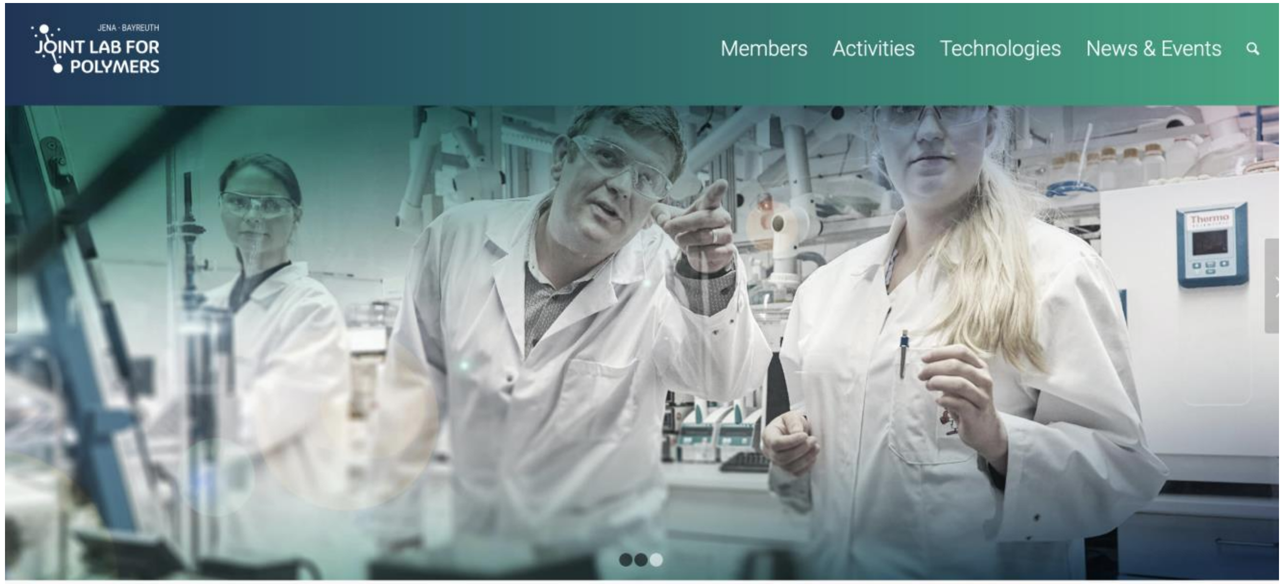
Further investments in preparation a/o ongoing



* Total investment volume 2023 – 2025 min. 6.5 m€

Joint lab to tackle challenges and to drive innovation

JENA - BAYREUTH
JOINT LAB FOR POLYMERS



Bundling forces between Friedrich-Schiller-University of Jena and University of Bayreuth

Coordination:

- Uli Schubert (Jena)
- Holger Ruckdäschel (Bayreuth)

Conlusions

- **Polymers are already strongly contributing to sustainability**

- **Technologies for a circular, carbon-free plastics economy are available**

  (and ideas for even more sustainable concepts around)

- **Bundling of forces between institutes & companies needed to drive transformation**

Thank you

for your attention

Thanks also to all my co-authors at
New Materials Bayreuth & University of Bayreuth

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Thank you

Prof. Steinbichler,
a role model for
sustainability in
industry & academia