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Novel Cellulose Composites for Automotive Applications

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Volkswagen Group of America / ICC - Innovation Hub Knoxville

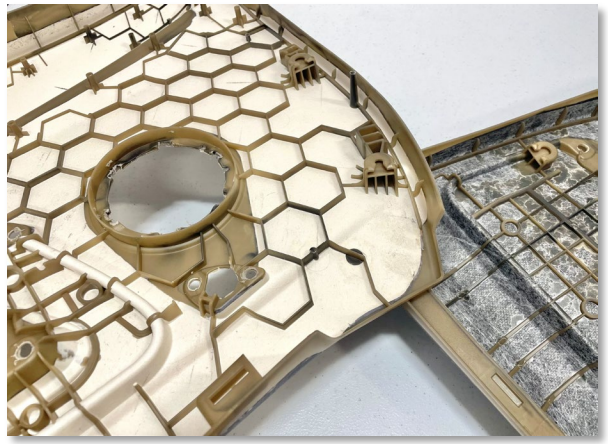
Carbon Footprint Reduction

Why Natural Fibers

Material emissions to account for 60% of total vehicle life cycle emissions by 2040*

- Most industrial natural fibers stem from dedicated plants – grow only in specific regions
- Approx. 25% of all solid waste is paper and cardboard (46 million tons in USA, 2018**)
- Well-established supply chain for paper making and recycling
- Paper not competing with food crops

Image source: RecyclingInside



*World Economic Forum - Paving the Way: EU Policy Action for Automotive Circularity
**www.epa.gov

State of the Art

NFPP & Similar Materials in the Industry

Automotive Industry:

- Natural fiber (non-paper) composites, mostly non-visible parts
- Exterior body panels made of thermoset resin and woven flax reinforcement on Porsche Cayman GT4 CS
- Cotton fibers in sound deadening applications

Paper Fibers:

- Paper composites with phenolic resin used for kitchen countertops and architectural cladding (limited to flat panels)
- Sandwich honeycomb core structures is several thermoset applications

Porsche Cayman GT4 CS
(Source: Porsche Newsroom/ BCOMP)

Volkswagen Golf Mk7 natural fiber applications
(Source: VW Newsroom / a2mac1.com)

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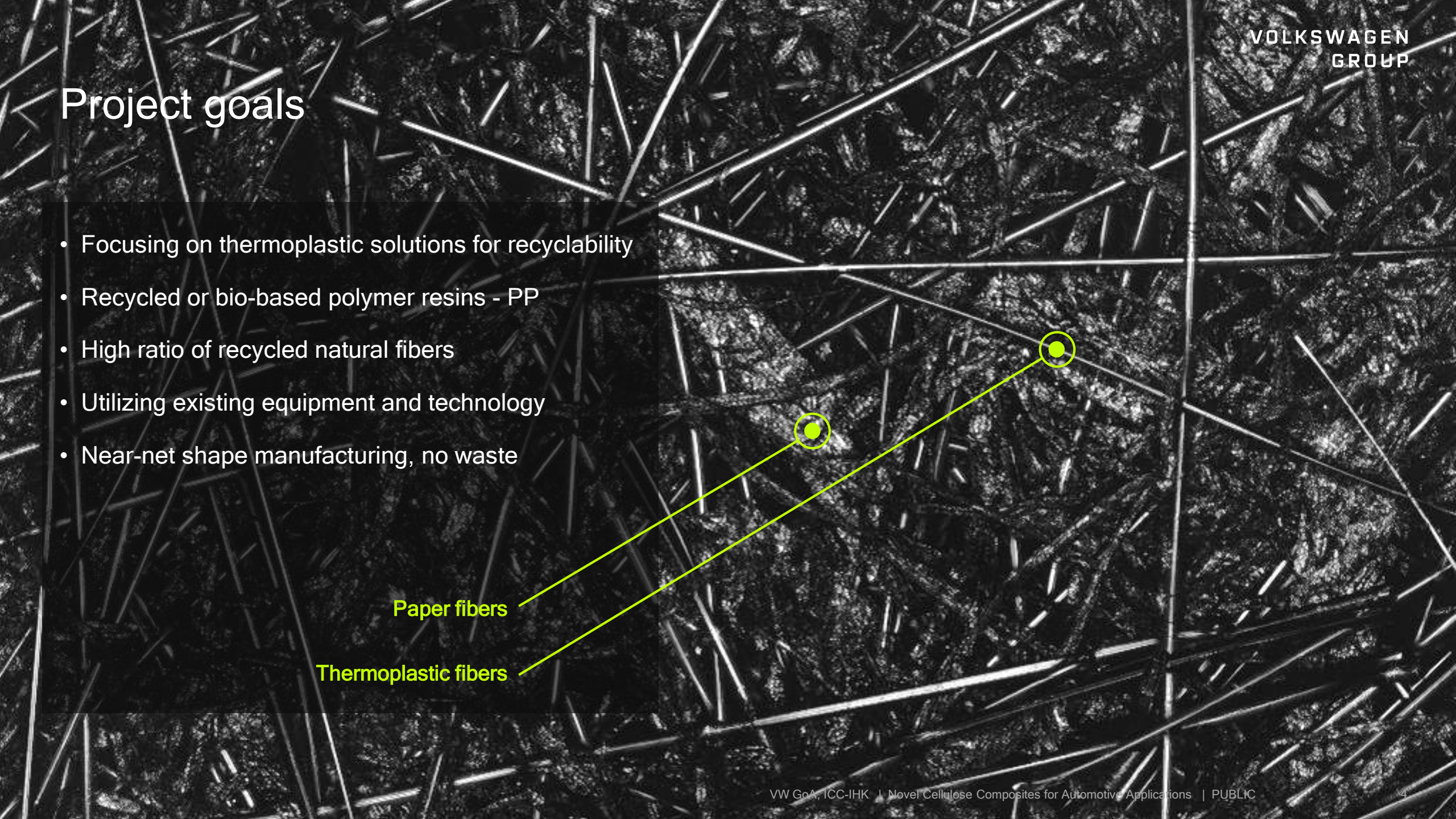
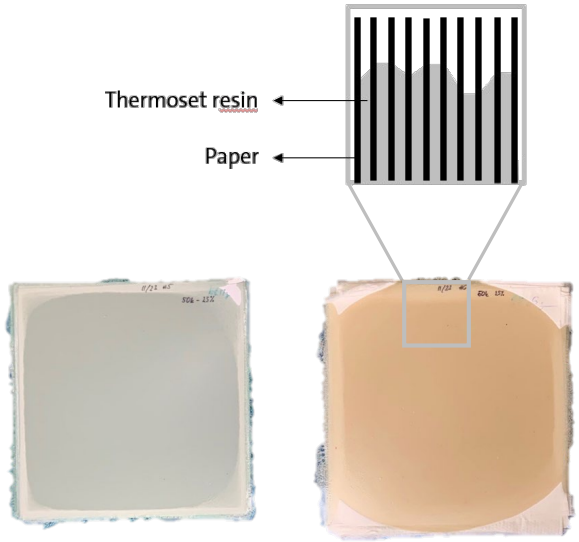
Project goals

- Focusing on thermoplastic solutions for recyclability
- Recycled or bio-based polymer resins - PP
- High ratio of recycled natural fibers
- Utilizing existing equipment and technology
- Near-net shape manufacturing, no waste



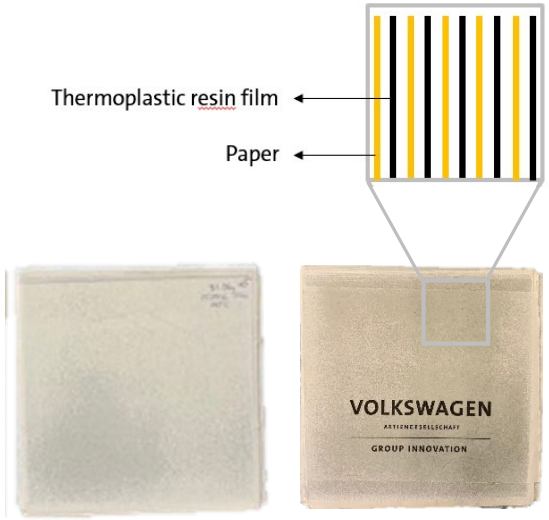
Process Development

Infusion Trials



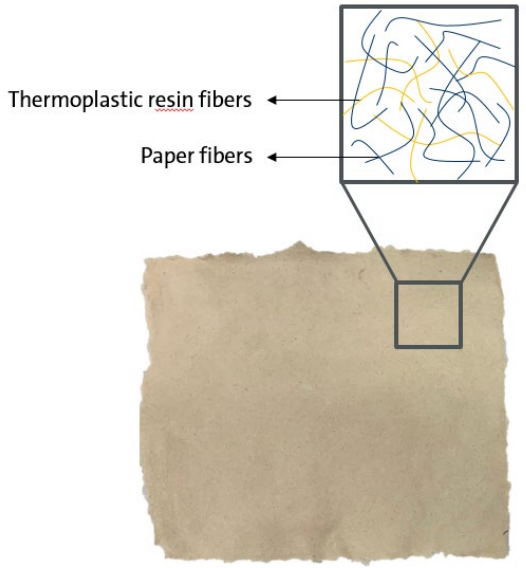
Thermoset wet compression molding

- Successful impregnation
- Non-recyclable matrix
- No drapability of dry preform



Film stacking

- High pressure process
- Heavily time dependent impregnation
- No drapability of dry preforms



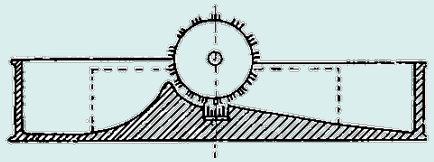
Wet laying – Fiber molding

- Mixing polypropylene and paper in fiber form
- Wet-stage processing
- Free shaping of preforms

Process Development

Lab-Scale Production

1



Fiber preparation

Valley beater / pulp processing and refining

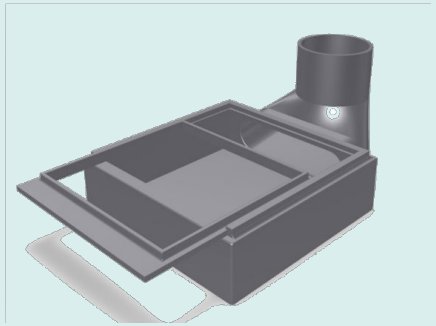
(Source: VGpaper.com)

2

Fiber mixing

Wet-stage homogenization and mixing with additives

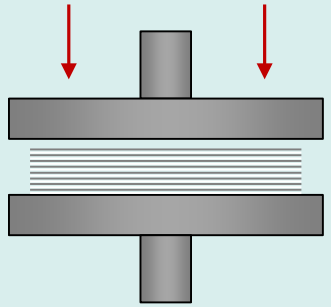
3



Preforming

Slurry-based preform making and drying

4



Hot pressing

Consolidation under pressure and temperature

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Process development

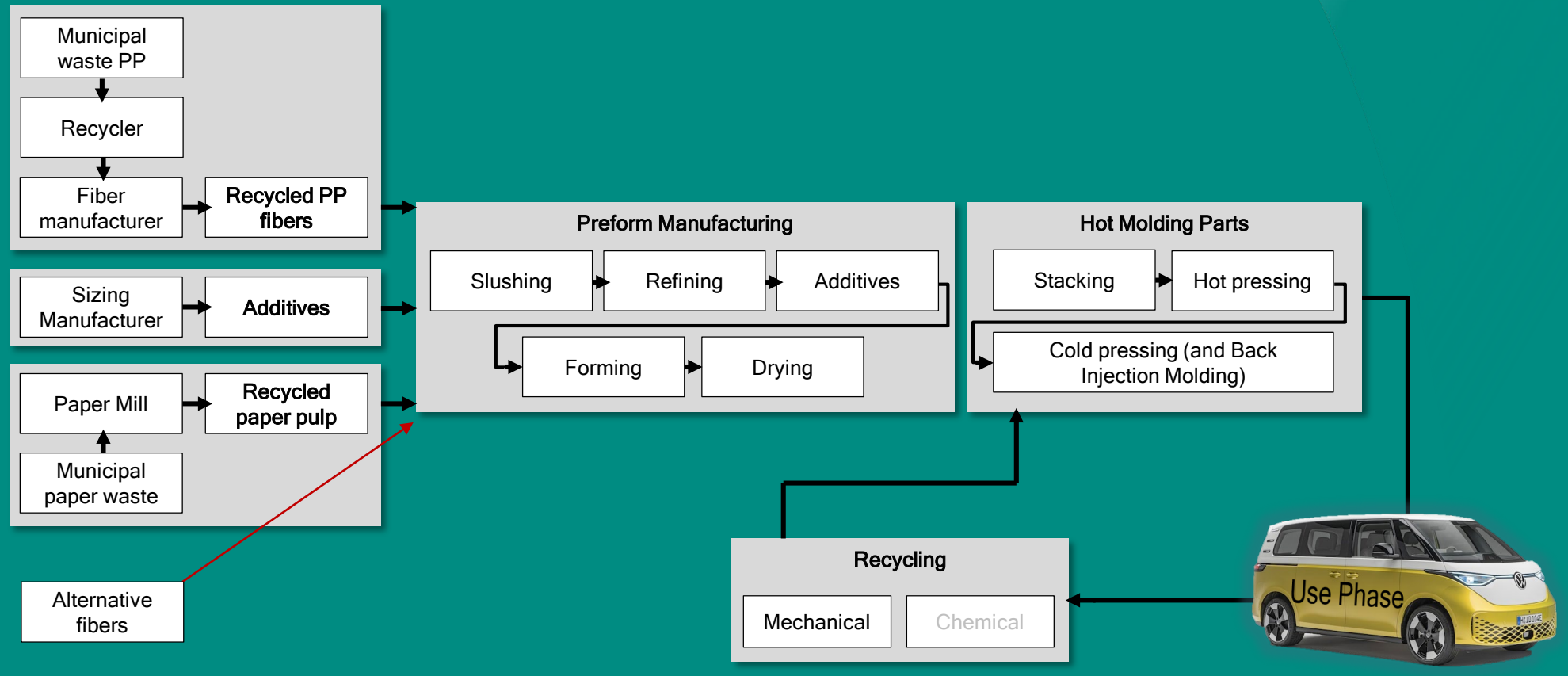
Proof of Concept

Initial lab-scale trials delivered outstanding results

- Improved drapability through 3D preforming
- Reduced water uptake compared to state-of-the-art
- Fine textured surfaces possible
- Fiber types can be combined
- Proof of concept for technology scalability / automation
  - Back-injection molding trials
  - Recyclability tested

Early stage paper composite demonstrators

Manufacturing & Supply Chain

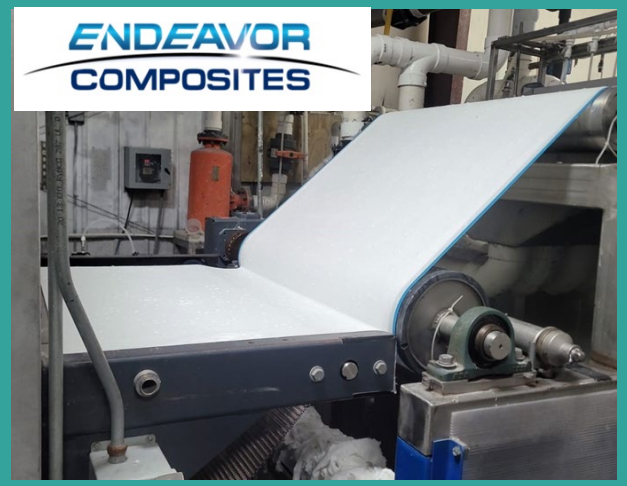


Industrial Scale Preforming

Scalability & Reproducibility

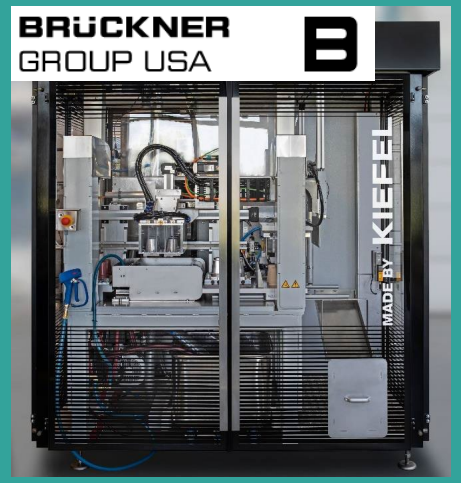
Flat preforming (roll):

- Continuous process
- Homogeneous sheets
- Material on rolls for large area parts
- Drop in solution for conventional NFPP



Near-net-shape preforming

- Fiber molding process
- Batch process, fast cycles
- No waste, no cutoffs, less forming limitations
- Tooling necessary for preforming process



Material Comparison

Paper Makes It Better

	Conventional NFPP	VW Paper Composite
Composition	50% bast fibers + 50% PP	60% rec. paper + 40% PP
Potential recycled content	50%	100%
Flexural Modulus	3100 MPa*	3400 MPa
Water Uptake	20 wt.%	12 wt.%

*Conventiaonal NFPP material data sheet

Paper fiber NFPPs: Improved properties over state of the art with higher recycled content.

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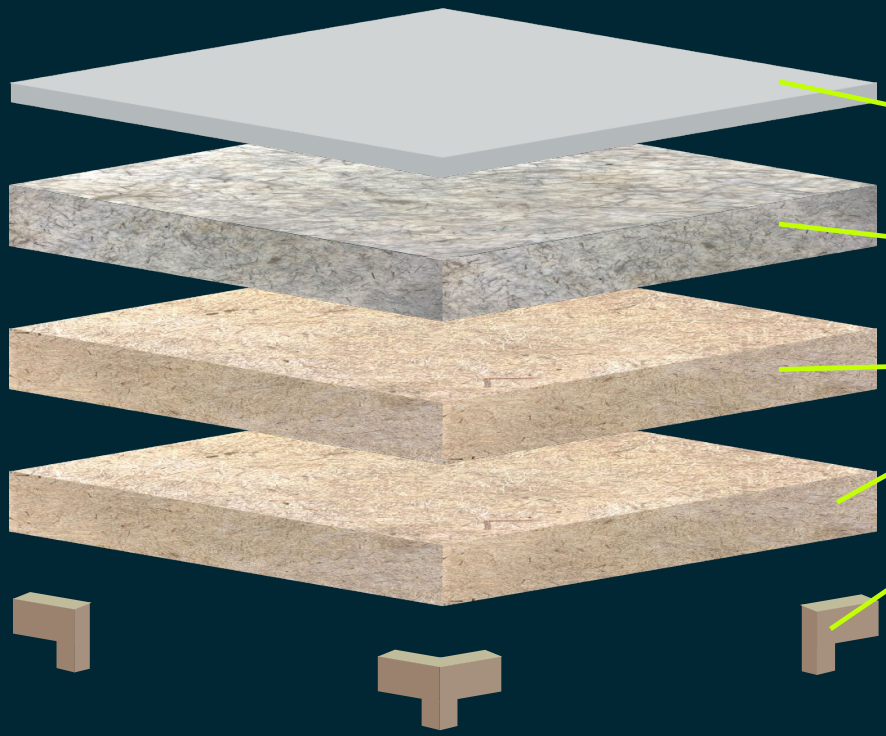
Layer by Layer Structure

Inherent Tailorability

The layered structure allows for tailoring the material for given applications, including individualization according to customer wishes. Ratio of natural fibers to thermoplastic can be varied depending on application specific needs.



PP thin film (UV & scratch protection)

Application specific visible layer (60% paper)

Substrate material (60% paper)

Back injection molded features (rPP-WF 20-60)

PP-WF60

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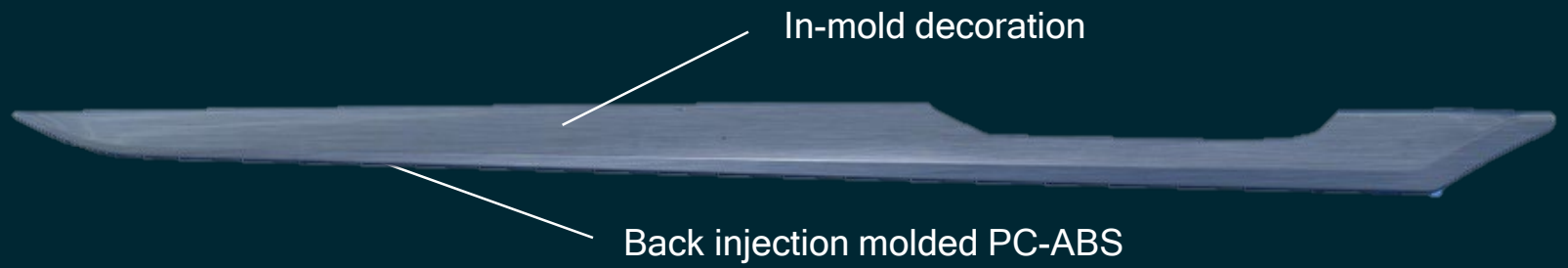
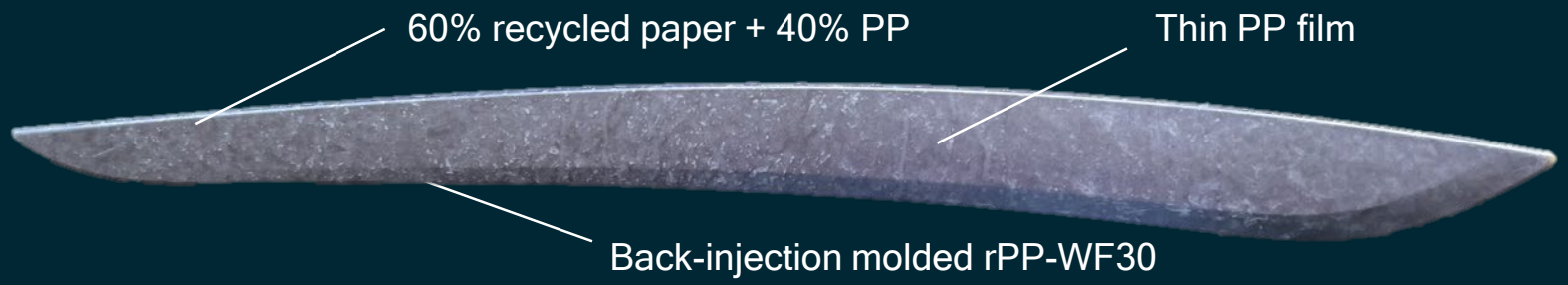
Technology Demonstrator

Innovative Parts Competition



VW Golf VIII door trim

Paper Composite prototype



Displayed at part competition table

Acknowledgements

Project Partners and Supporters

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Thank you

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