Miika Nikinmaa, VTT
Lead, Biomaterial solutions

Halusin vaikuttaa uusien teknologioiden syntyyn ja päästä mukaan ratkaisemaan maailman isoimpia ongelmia. VTT on hyvin mielenkiintoinen ”blue ocean” jossa riittää seilattavaa ja voi kohdata uusia haasteita päivittäin.

Tekninen ydinosaamiseni on kuitukankaissa ja kuitu- ja polymeeritekniikassa. Tehtäväni ovat vieneet minua vahvasti projektin hallinnan, tutkimushankkeiden rakentamisen ja liiketoiminnankehittämisen suuntaan.

Uskon vahvasti yhdessä tekemiseen, joten tulkaa juttelemaan. Parempi tehdä yhdessä isoa kuin useampi pieni.

Novel cellulose plastic composites by papermaking

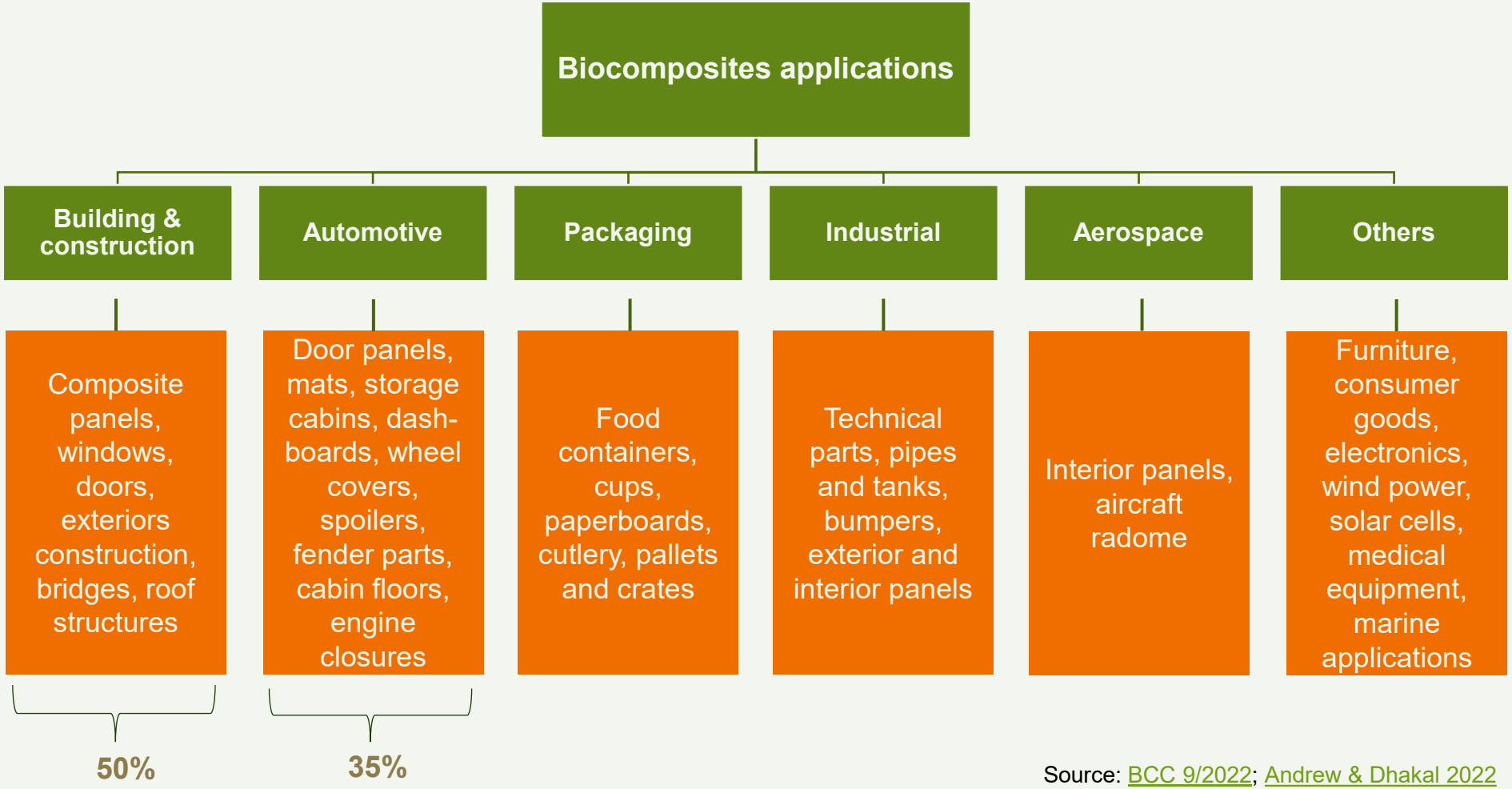
Miika Nikinmaa, Kristian Salminen, Kirsi Immonen, Timo Lappalainen, Baranivignesh Prakash, Marjo Järvinen, Janika Viitala, Tiinamari Seppänen, Jaakko Asikainen. (VTT Technical Research Centre of Finland)

HiPer - Project

The work was supported by Valmet, CH polymers, Koskisen, Metsä Fibre, NMC, Paptic, ISKU, Sulzer, Volar Plastics and Business Finland

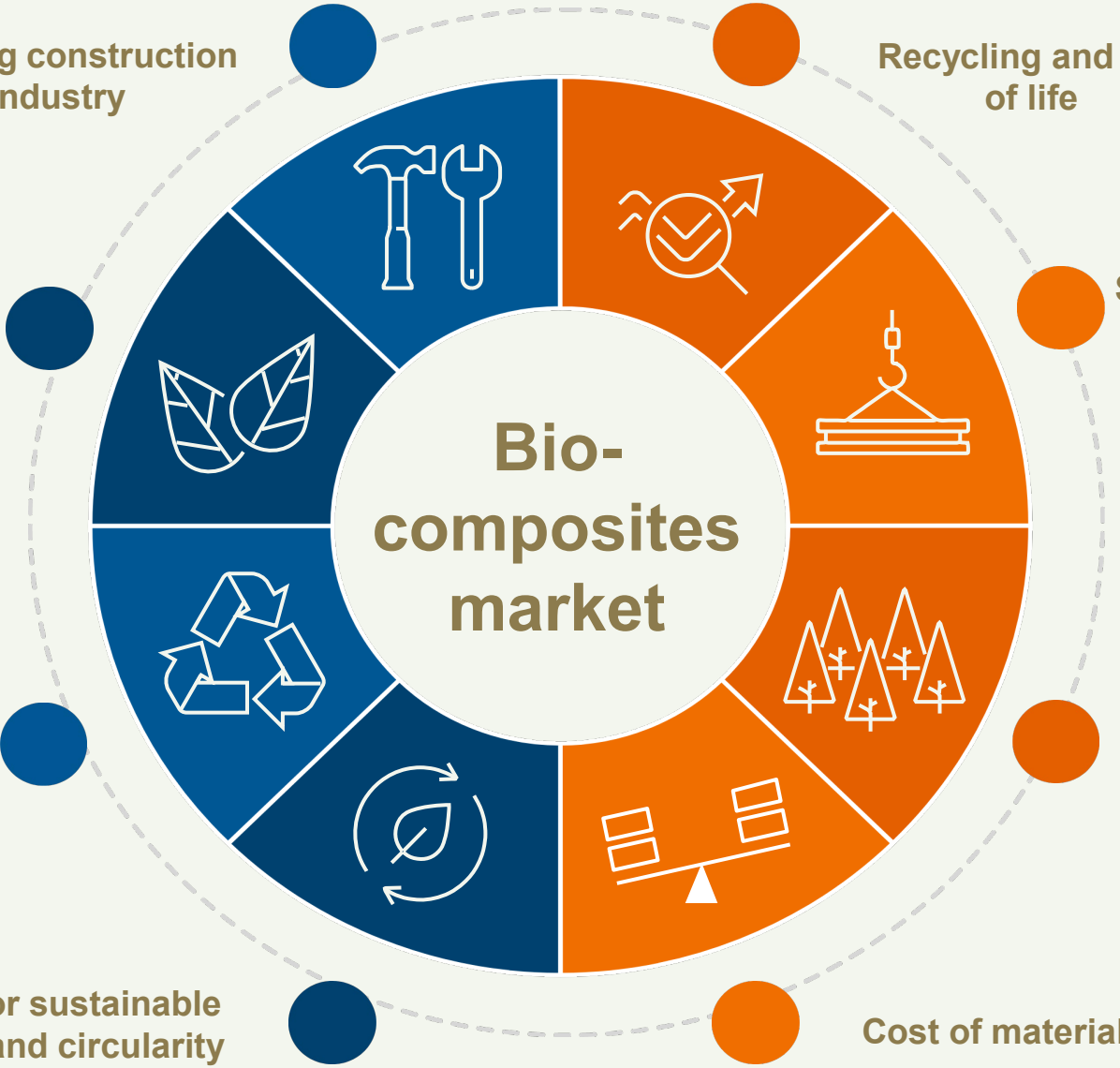
Market

Overview of biocomposites applications



Source: BCC 9/2022; Andrew & Dhakal 2022

Market Dynamics



Drivers

Growing construction industry

Demand for environmentally friendly manufacturing materials

Policies regarding reusability and recyclability of materials

Demand for sustainable materials and circularity

Restraints

Recycling and end of life

Strength and performance issues of natural fibres

Inconsistency in natural fibres

Cost of material

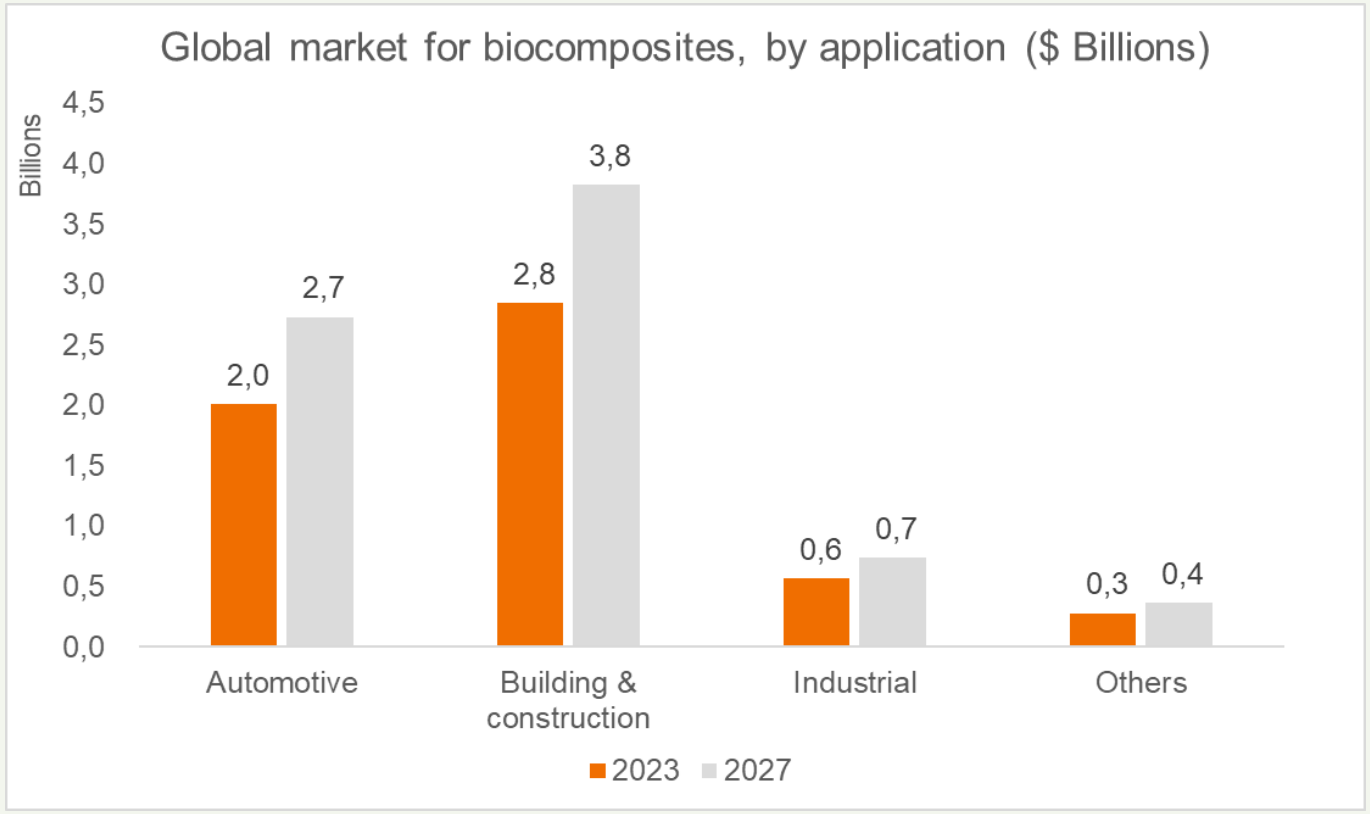
Global market size and growth by application

Global **thermoplastic composites** market is expected to reach USD $14.0 billion by 2026 at a CAGR of 6.9 %.

Global **thermoset composites** market is anticipated to reach USD $19.3 billion by 2026 at a CAGR of 5.4 %.

Biocomposites are growing between 7 -16% annually depending on the report

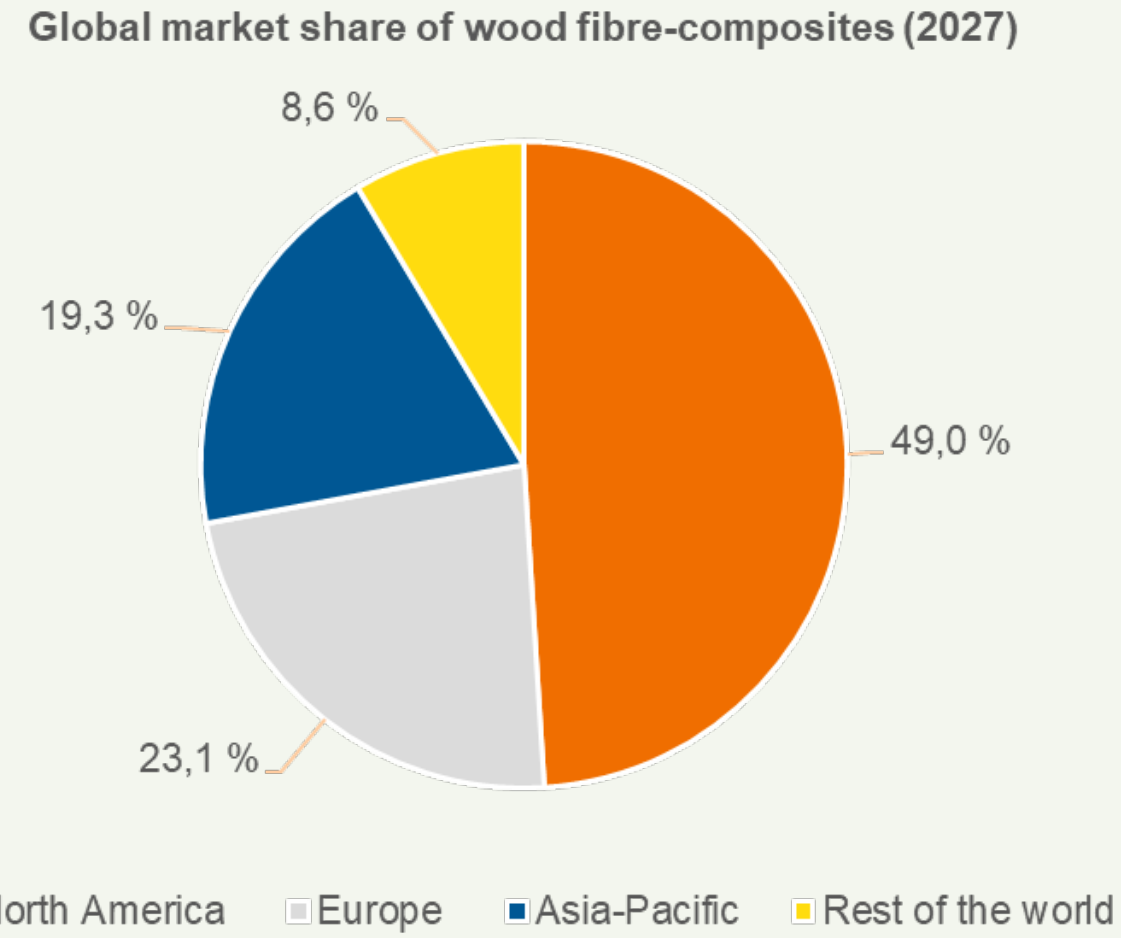
Thermoplastic composites are smaller market, but experience higher growth



*Other applications include, medical, aerospace etc.

Source: BCC 9/2022; Statzon/The Insight Partners 6/2022; BCC 3/2022

Global market for wood fibre composites

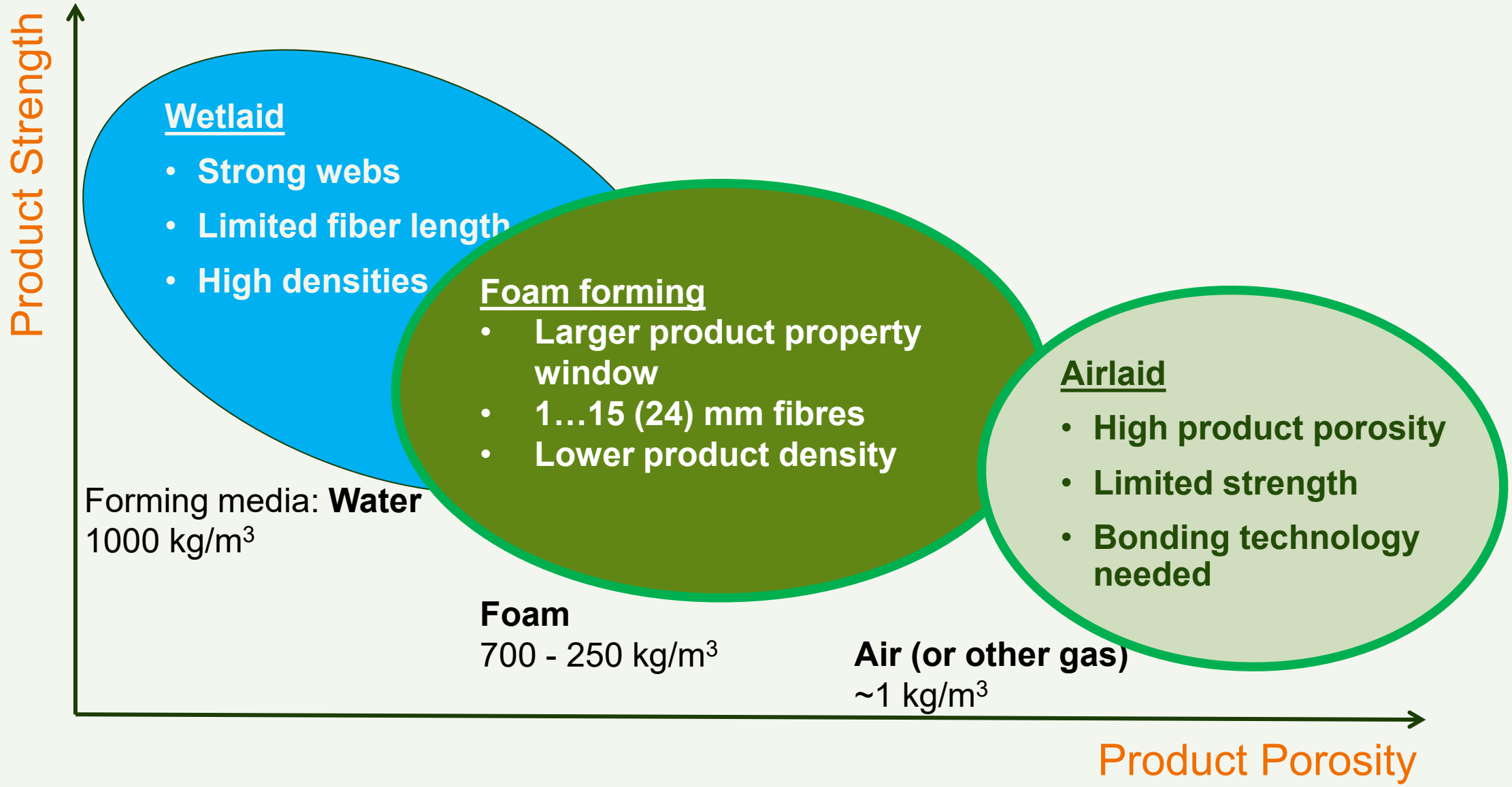


- Wood fibre accounts for the highest natural fibre market share (85% in 2021) due to high demand and the rise in the use of natural fibres in the construction and automotive sectors.
- As various regulations require the use of environmentally friendly materials for the parts manufacturing, wood fibre is expected to see good growth.

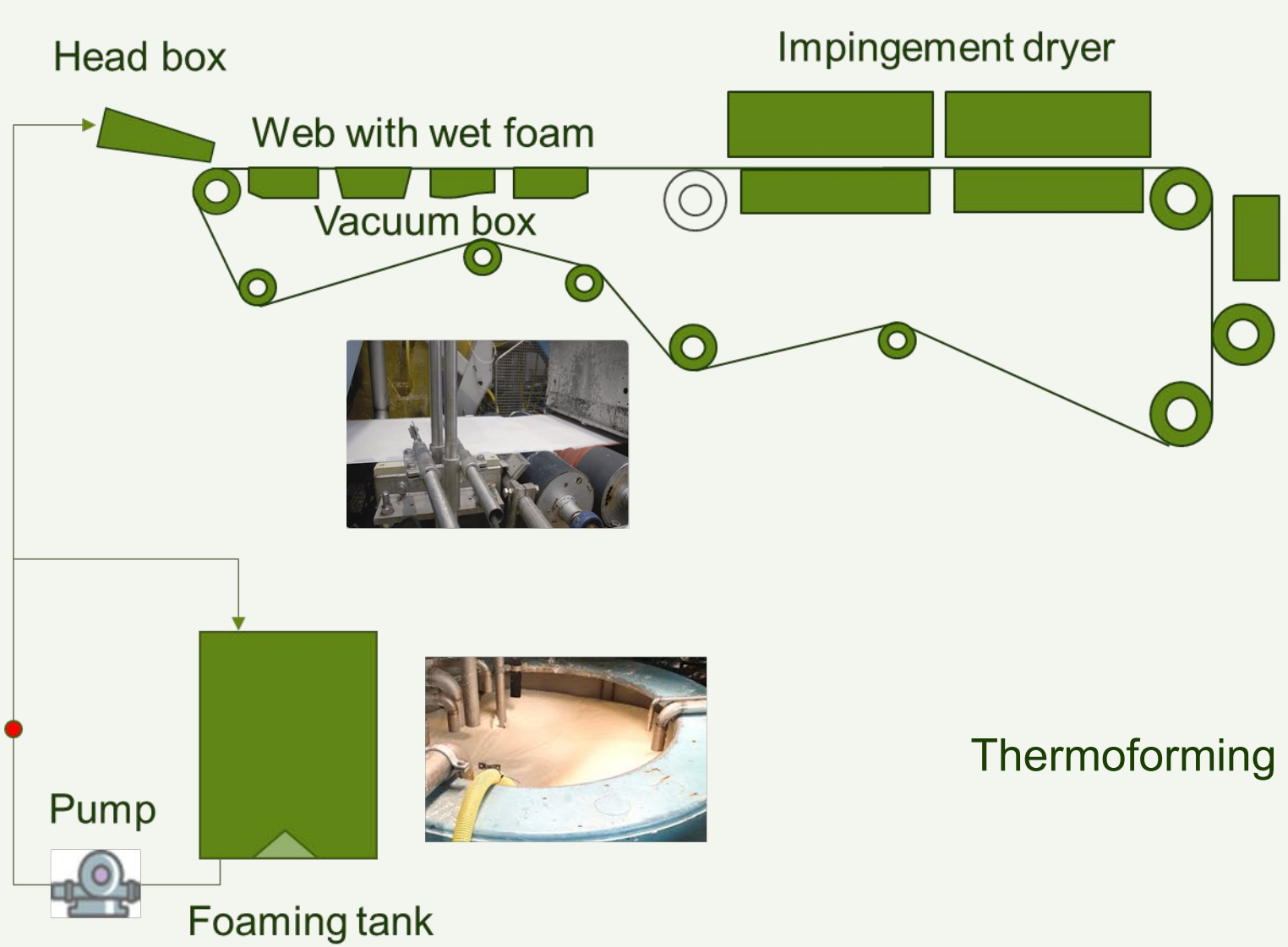
Source: BCC 9/2022

Technology

Forming technology for nonwovens at VTT



Composite making procedure in pilot scale



Sample roll for offline drying

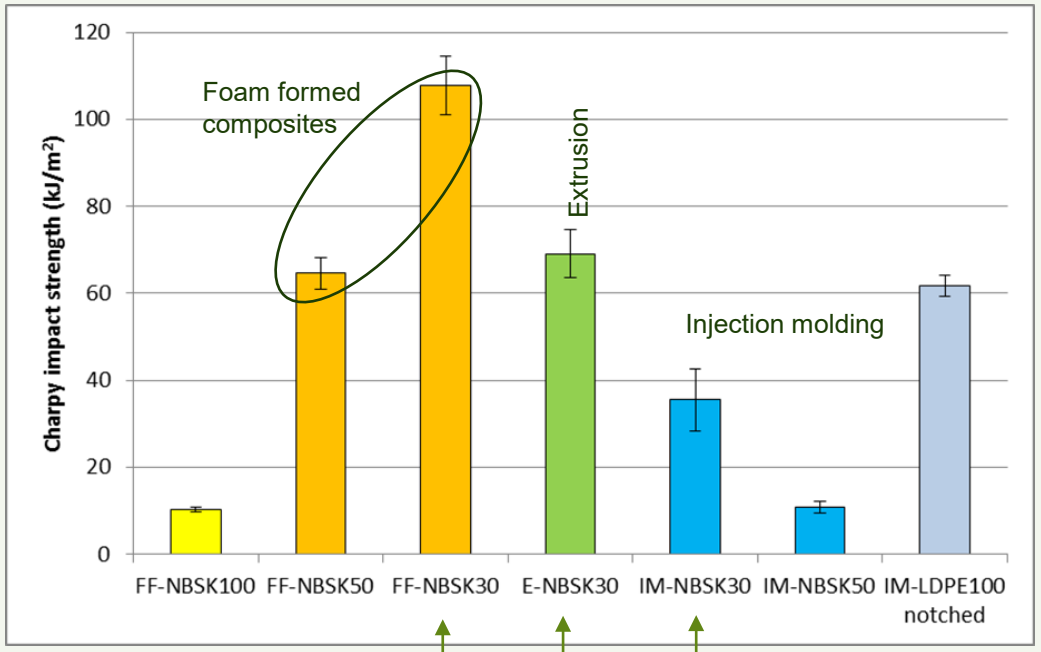
Thermoforming

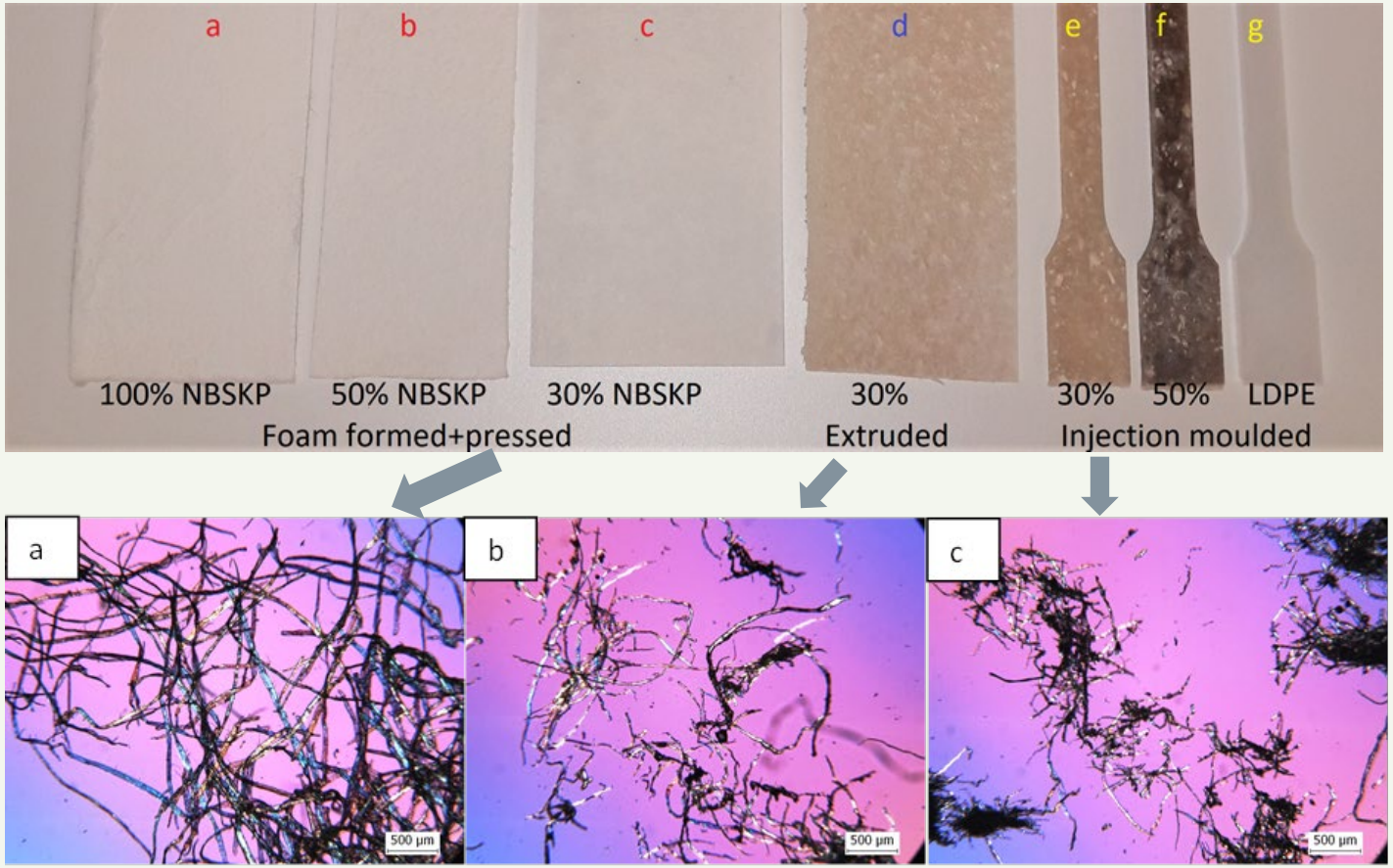
VTT SAMPO

Thermoplastic cellulose-based composites using different manufacturing methods

Benefits of foam formed materials compared to extruded and injection molded materials

- Good visual appearance
- No fiber degradation
- High impact strength

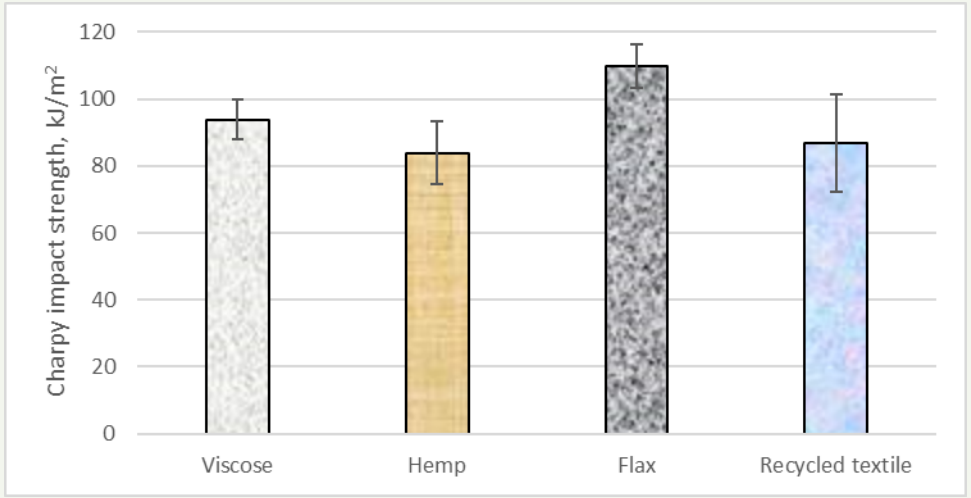




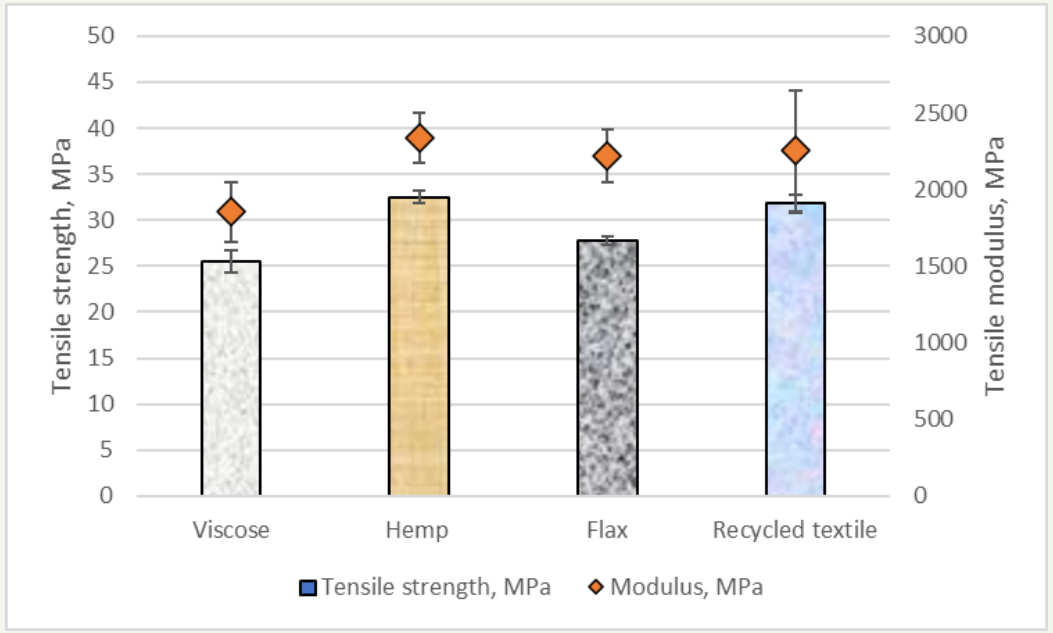
Ref. Kirsi Immonen, Petri Jetsu, Janne Keränen, Katariina Torvinen, Feasibility of Foam Forming Technology for Producing Wood Plastic Composites, 3 Jun 2020, Journal of Applied Polymer Science. 137, 45, 12 p., 49404.

Strength properties of composites with different type of long fibers

Notched Charpy Impact Strength



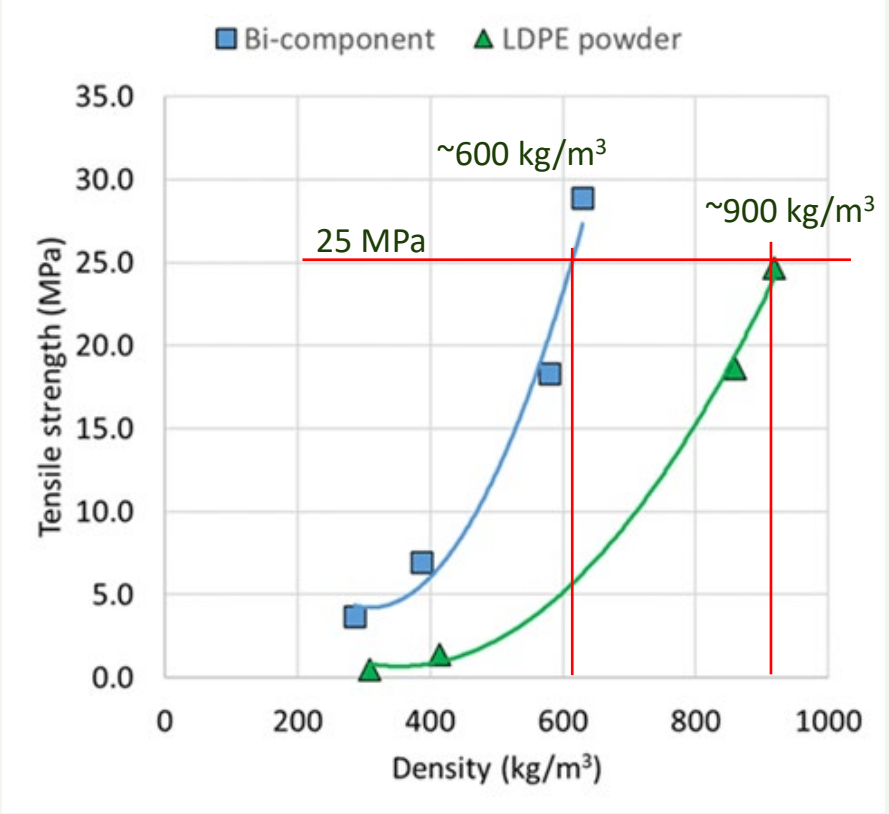
Tensile Strength



- Thermoformed sheets with square weight of 1500 g/m^2 (density 750 kg/m^3 with used parameters)
- Long fibers with length of 5…20 mm, polyolefin-based fibers as binder

Thermoforming into composites of different thicknesses

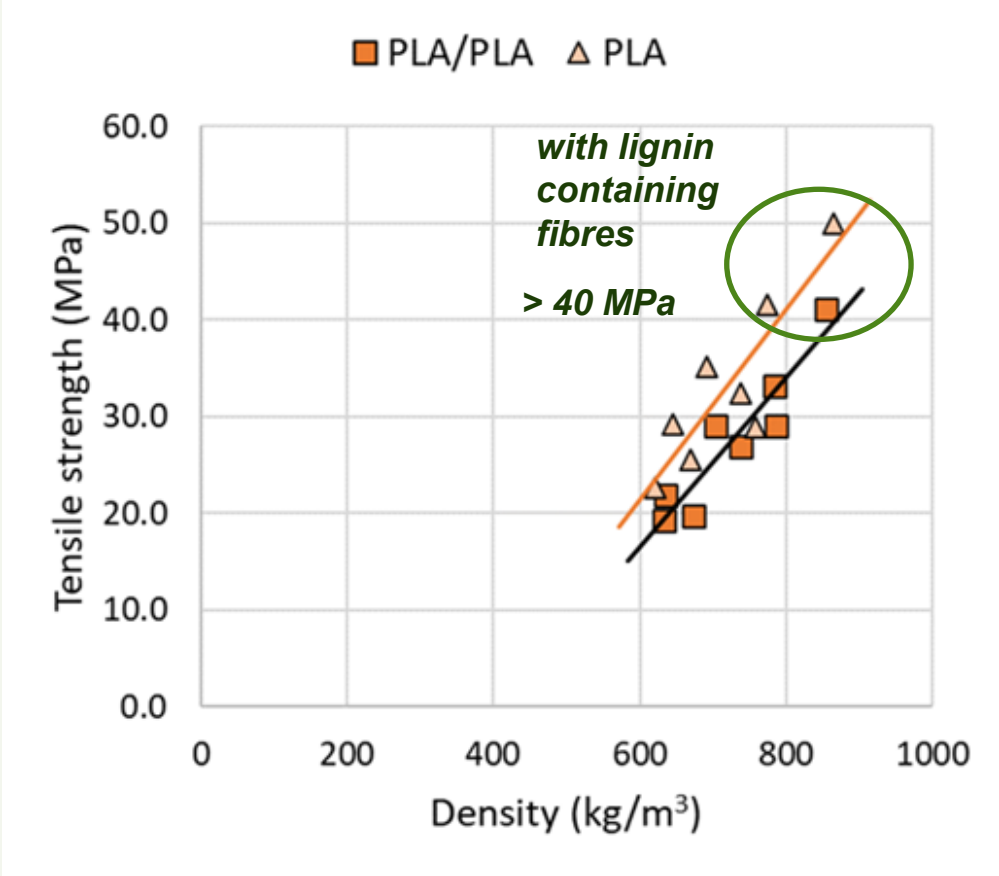
- Samples with a grammage of **2000 g/m²** were produced.
- Thermoformed to several different thicknesses.
  - By using metallic spacers of different thicknesses.
  - Thickness from 1.9 to 7.2 mm.
- The **dependence between tensile strength and density** differs when using different shapes of thermoplastic particles.
- In the case of **LDPE powder**, the individual plastic particles are ~ 350 µm in diameter.
- The **PE/PP bi-component fibers**, conversely, are thin (12 µm) but long (12 mm) and large in number. Therefore, they can form a more uniform matrix at a low density of composite than powdery particles.



Share of PE/PP bi-component fiber: 30 mass-%
Share of LDPE powder: 50 mass-%

The use of PLA fibres

- **PLA** is an **environmentally friendly, compostable** thermoplastic derived **from renewable resources.**
- **Mono-component PLA fiber** (4 mm, 1.7 dtex) was intended for water-laid applications. The melting point was 160 °C.
- **The bi-component PLA/PLA fiber** (6 mm, 2.2 dtex) intended for air-laid applications. The melting point of the core was 175 °C, and melting point of the sheath was 130 °C.
- Thermoforming was done at 6.2 and 12.4 bar pressures. **Densities were up to 20% higher when a higher** (12.4 bar) **thermoforming pressure was used.**
- Higher strengths were achieved when using a mono-component PLA fiber (targeted to wet-laid process).

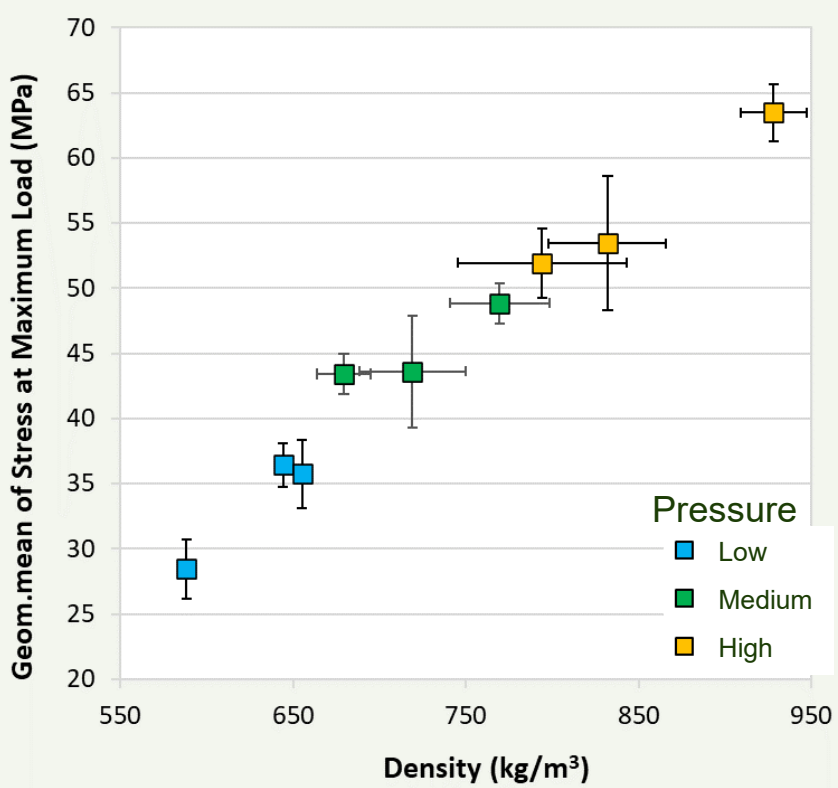


Effect of thermoforming parameters on tensile strength

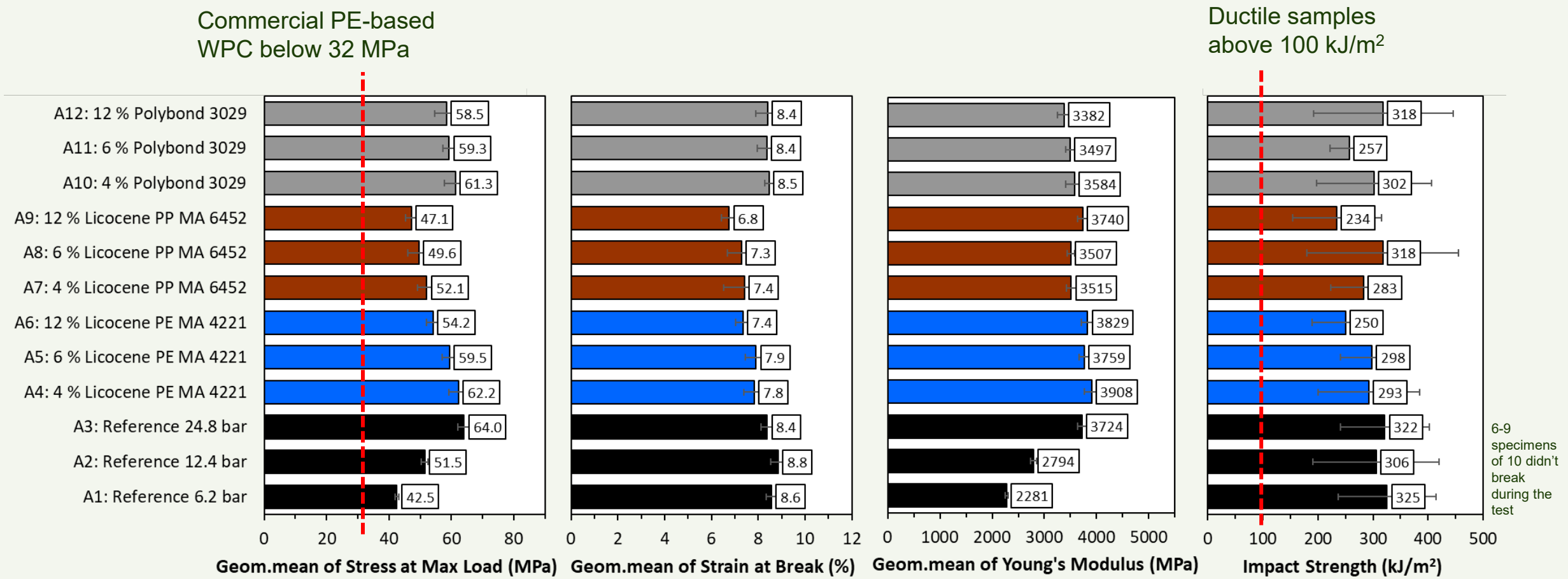
- Samples with 70% cellulosic fiber were heat pressed using three different temperatures over plastic melting point and three different pressures

➔Tensile strength increase from 29 to 63 MPa only by changing the process parameters during thermoforming

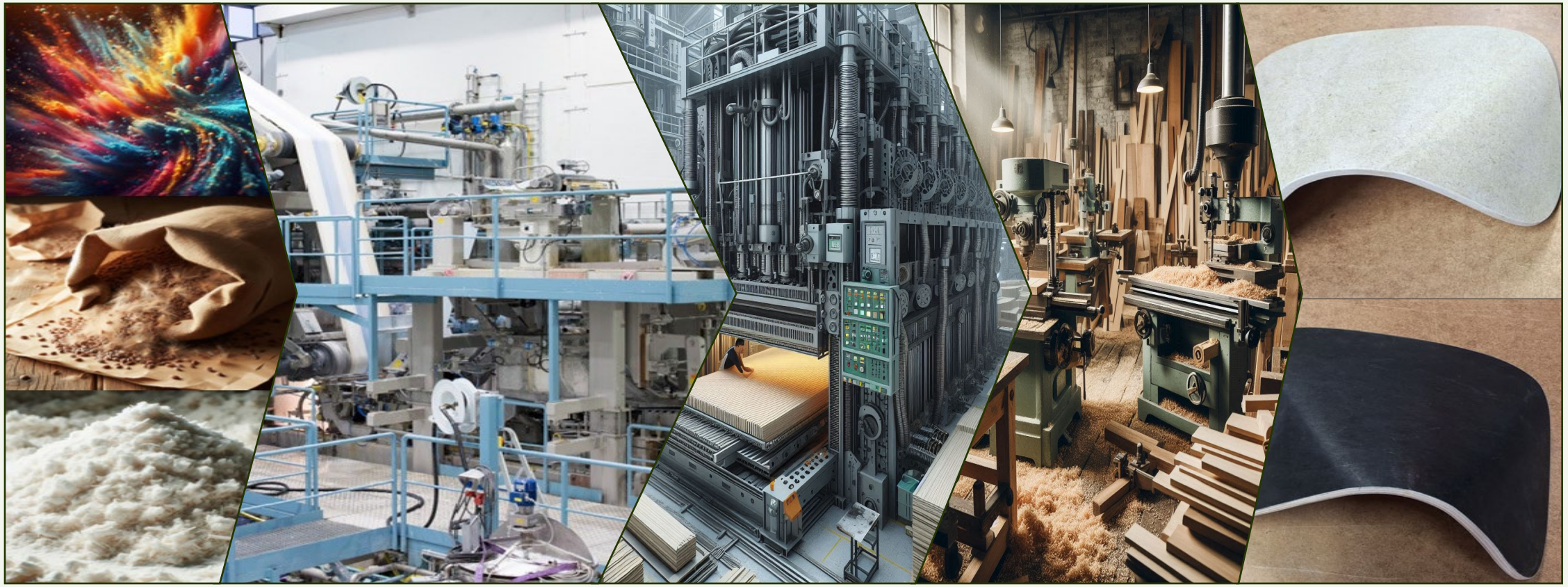
➔ Enables product density variation



Maleic anhydride grafted thermoplastic polymers – Strength properties



- Excellent strength properties compared to commercial PE-based WPC
- Added chemicals didn't enhance the compatibility of fibers and matrix



Images are AI generated or VTT's

Demonstrated in industrial process

- Complex shapes with up to 70% cellulose
- Thermoplastic material is needed but can be non plastic depending on the legal definition

- Nearly any raw materials can be used
  - PP, PE, PLA, PET
  - Pulps
  - Man made cellulose, recycled fibers, PET..
  - Fibers and granulates

- Layers are self adhesive due to uniform distribution

- High Performance due to uniform distribution
  - Tensile strengths up to 63MPa (nearly 2x typical wood plastic composites)
  - High impact strength (+300kJ/m²)

Design by ISKU

Demonstrated at VTT

Next steps

HiPER+ to meet the full potential

Objectives:

- Optimizing the cost vs. performance of foam formed composites
- LCA and market studies for selected cases
- Expanding the raw material base for composites
- Demonstration of produced materials in industrial applications

Target industry:

- Plastic and composite industry, paper and board producers, machine suppliers, technology providers, converters, chemical suppliers & brand owners

Implementation

- The work will be carried out mainly in pilot scale at VTT. Work is supported by laboratory examinations.

Schedule and budget:

- Target budget 2 - 3 M€
- Funding application submission to Business Finland in January 2025
- Project starts in June 2025

Contact persons for HiPer+

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Thank you for listening

beyond

the obvious

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