Table of contents

Is Recycling Always the Sustainable Choice?

Evaluating End-of-Life Strategies Using Life Cycle Thinking Approaches (LCA/LCC)

I) What is the Challenge?

For decades, recycling often treated as inherently sustainable. **But is this always true?**

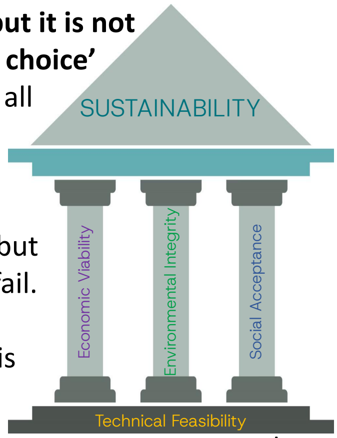
The scientific reality is more complex. The sustainability of recycling depends on a cascade of variables related to how we design, use, and manage them at end-of-life such as material composition, collection logistics, reprocessing technology, and final material value. Without rigorous analysis, good intentions can lead to **'wish-cycling'**.

To move beyond slogans, it's necessary to quantitatively evaluate different aspects of recycling to alternative EoL strategies.

II) What "Sustainable Choice" Means?

Recycling is a powerful tool, but it is not a magic wand. A **'sustainable choice'** in EoL pathways must balance all three pillars in addition to the technical feasibility.

- A pathway that is environmentally beneficial but economically unviable will fail.
- One that is profitable but environmentally damaging is not sustainable."



Thus, Its sustainability must be proven, not assumed.

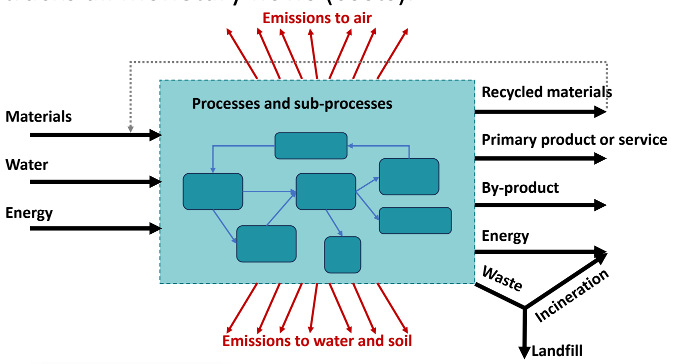
III) How We Find Answers?

Sustainability must be proven, not assumed.

This is why we apply quantitative life cycle-based methods: Life Cycle Assessment (LCA) to measure environmental performance, and Life Cycle Costing (LCC) to evaluate economic viability.

LCSA adopt a comprehensive perspective, accounting for all stages of the product life including EoL pathway from collection to the final secondary material.

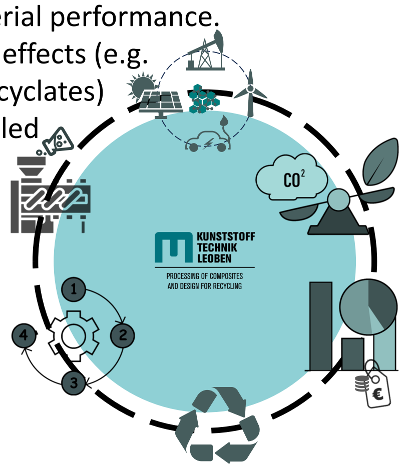
LCA maps all environmental inputs (energy, water) and outputs (emissions, waste) across these stages and LCC tracks all monetary flows (costs).



IV) Our Work at PoC-DfR (LVV)

At our research group, we replace assumptions with quantification. We apply standardized techniques and tools to assess the true sustainability of EoL strategies. Our research applies this framework to real-world polymer-based/composite waste streams via:

- Building detailed LCSA models for recycling and processing scenarios of polymeric products.
- Quantifying trade-offs between environmental impact, cost, and material performance.
- Exploring system-level effects (e.g. impact of increased recyclates)
- Characterizing of recycled materials (ea. physical properties, processing behaviour).



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Current Related Projects:

Wintrust — Oct 2023-Nov 2026
Wintersport Resource Efficiency and improved Circular Economy

BeyondRecycle — Apr 2026-Mar 2028
Valorization of Non-Recyclable Textile Waste

Where do my old skis go?

Estimating the annual winter sports waste in Austria

WINTRUST
WINTERSPORT RESOURCE EFFICIENCY AND IMPROVED CIRCULAR ECONOMY

About the WINTRUST project

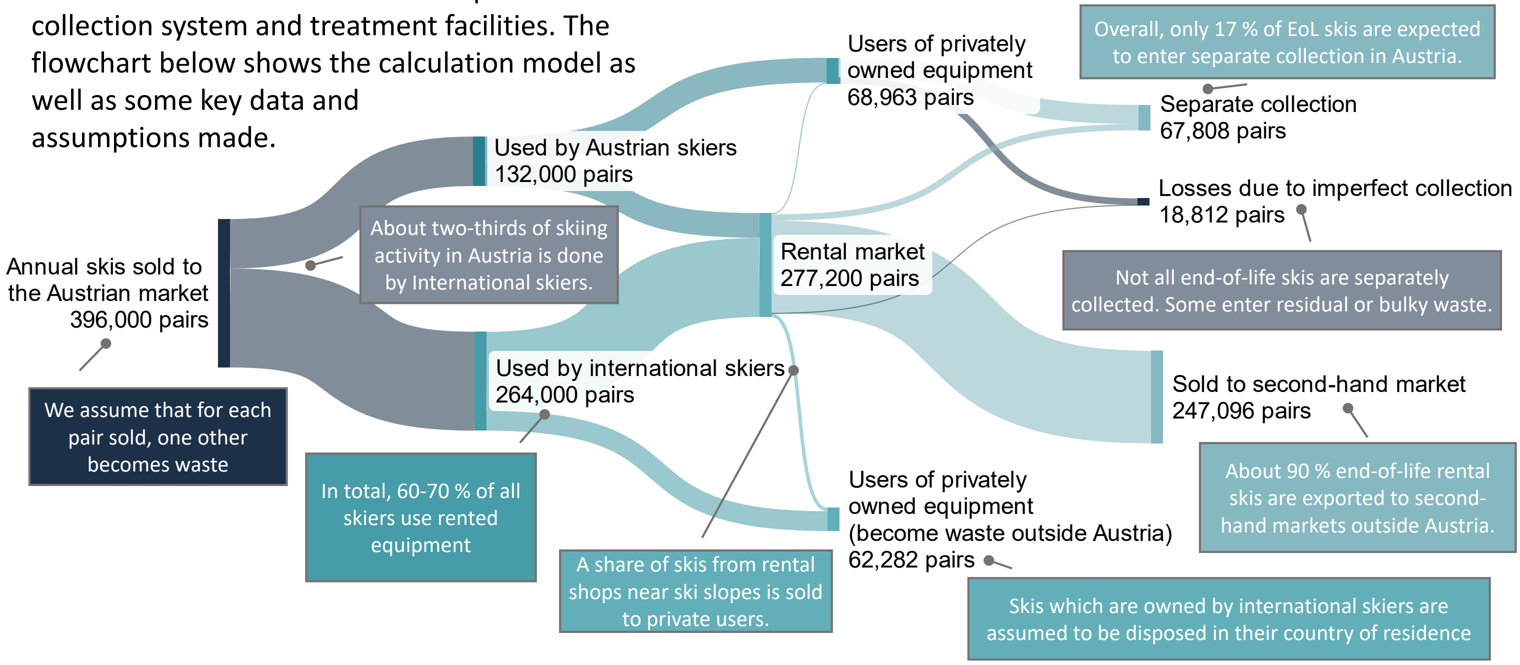
The aim of the research project WINTRUST is to develop recycling solutions for waste winter sports equipment such as skis, boots, helmets, and poles, which are currently mostly incinerated. The project brings together product manufacturers, retailers, waste treatment companies and academic research partners to establish collection, dismantling, and material recovery processes and to evaluate the feasibility and sustainability of these concepts.

What is shown on this poster?

One part of the project is to estimate the waste amounts that would occur annually in Austria, if a collection system for winter sports equipment was established. This is relevant to plan the collection system and treatment facilities. The flowchart below shows the calculation model as well as some key data and assumptions made.

What data was used?

The data for the model comes from industry and statistical data as well as a survey that was conducted within the project among ski manufacturers and retailers.



Key Takeaways

- The majority of "waste skis" end up as **second-hand products outside Austria.**
- To establish an efficient recycling system, the total collection rate of **only 17 %** needs to be increased, e.g., by collecting waste in other European countries.

YOUR TURN!
How would **YOU** like to dispose your winter sports waste?
Help us by answering this one-minute survey!

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Project **WINTRUST** is led by **ecoplus. Niederösterreichs Wirtschaftsagentur GmBH** and is co-financed by the **FFG.**

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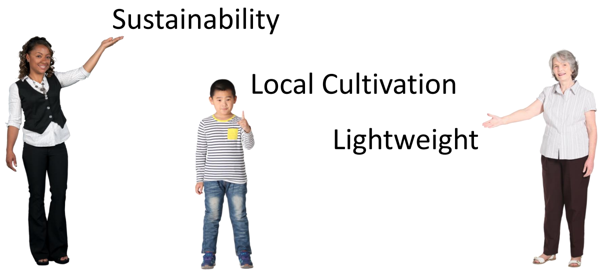
Research on Plant Fiber Reinforced Polymer Composites

Why does this work matter?



What is the problem?

Fiber quality

- Origin
- Harvest
- Treatment

Moisture absorption

- Change of properties
- Swelling
- Long-term stability
- Interfacial adhesion between fibers and matrix material

Process window

- Thermal degradation of fibers vs. required matrix viscosity

What do I do?

- Research on behavior of plant fibers in processing
- Focus on moisture absorption

Drying of plant fibers	Absorption of moisture from air	Absorption of fluid (water, oil, resin)	Swelling behavior

- Impact of absorption on properties of composite material

What do I change with my work?

- Gaining an understanding of the behavior of plant fibers
- Adapt process to manufacture natural fiber reinforced polymer composites according to behavior of plant fibers
- Creating the foundations for integrating plant fibers into the market

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Picture References
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Flax plant: flachs.de
Flax sliver: waltin.se
Woven textile: bcomp.com
Flax composite: bcomp.com
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Appl. Kayak: green-boats.de/
Appl. BMW: bcomp.com

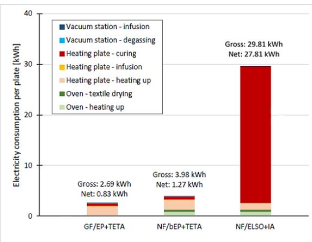
NEXT-GENERATION BIO-COMPOSITES

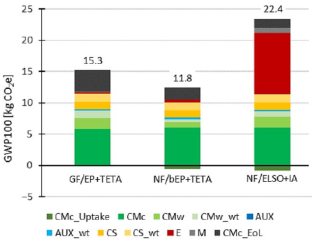
Bridging the gap between sustainability and Performance

MOTIVATION

Bio-based composites offer an alternative to fossil feedstock, but face two industrial bottlenecks:

1. Cycle Inefficiency: Curing times often exceed 20 hours, leading to high energy demand and increased GWP100.





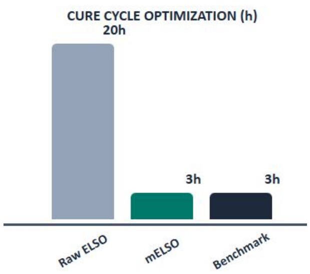
2. Performance Gap: Significant deficits in stiffness and strength compared to commercial available bio-epoxy counterparts.

OBJECTIVES

- **Parity:** Transform 100% bio-based resins into materials that match industrial cure cycles.
- **Integrity:** Achieve mechanical performance parity with fossil-based benchmarks.
- **Closing the Loop:** Design for a "Shred-Reform-Reuse" lifecycle

MOLECULAR TAILORING: ELSO

Optimization centers on the chemical modification of Epoxidized Linseed Oil (ELSO) Functionalization of triglyceride chains to lower activation energy and fasten curing.



MECHANICAL PERFORMANCE

Backbone tailoring allows bio-resins to perform better than baseline raw ELSO and commercially available bio-epoxy of mechanical properties

Tensile Strength

Optimized system improves performance by 14.5% over baseline, outperforming benchmarks

Flexural Strength

Optimized resin improves flexural performance 33% over raw ELSO.

CIRCULAR PATH: VITRIMERIC MECHANISM

Utilizing dynamic covalent bonds to valorize waste:

- Shred: Mechanical grinding of end-of-life ELSO parts into 2-4 mm recyclates.
- Re-form: Thermal reconsolidation (160°C, 4h) using the vitrimeric bond-swap mechanism.

CONCLUSION

Optimized ELSO deliver an 85% reduction in processing time, providing a scalable, circular alternative to fossil-based structural composites.

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Research Focus: Bio-based Composite; Processing; Repair; Recycle

Research Partners:
Kunststofftechnik Leoben – Verarbeitung von Verbundwerkstoffen
Kunststofftechnik Leoben – Werkstoffkunde und Prüfung der Kunststoffe
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