JEC

CONNECTING THE WORLD WITH COMPOSITES

June 11th, 2025

Tool4LIFE and ZeroWasteLIFE:
Innovative solutions to improve the sustainability of composite material products

Tool4Life
A Life Project

ZEROWASTELIFE
A Life Project

These projects have received funding from the European Union’s Programme for Environment and Climate Action (LIFE) under grant agreement N° 101074299 and 101114149

Topics

- Bercella in short
- Tool4LIFE Project
- Introduction to LCA and sustainability
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- ZeroWasteLIFE Project
- Espected impacts (KPIs) in ZeroWasteLIfe
- Take home messages

Bercella in short

1996 – Mr. Franco Bercella starts Bercella srl in Varano de' Melegari (IT)

First Autoclave and move to a 600 sqm plant

2000 – Main supplier to Italian Racecar OEMs

2002 – First Aerospace certification
First Space Project (Rosetta)

2008 – First Aerospace export project (Israel)

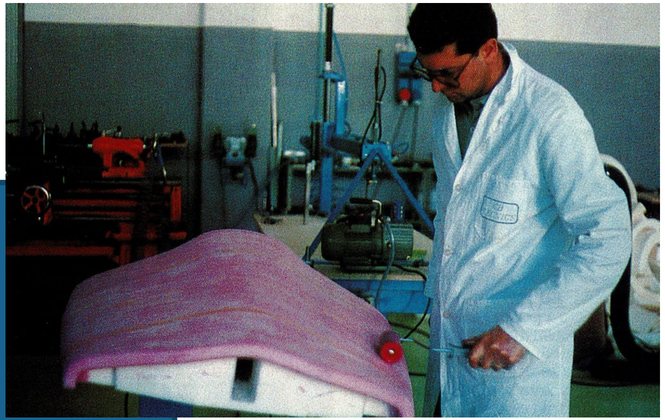
2009 – New 2.000 m2 plant with 3,8m diameter autoclave

2012 – The second generation joins the company

2015 – Expansion in the Space Business

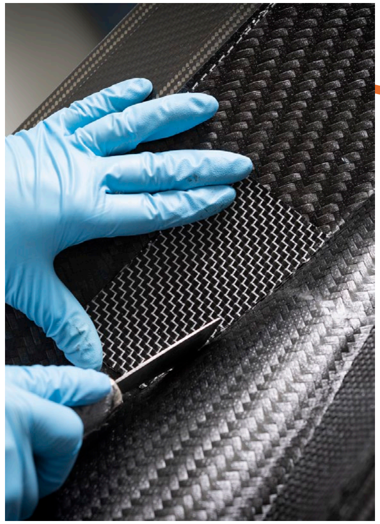
2019 – Exports reach 1/3 of the total revenues

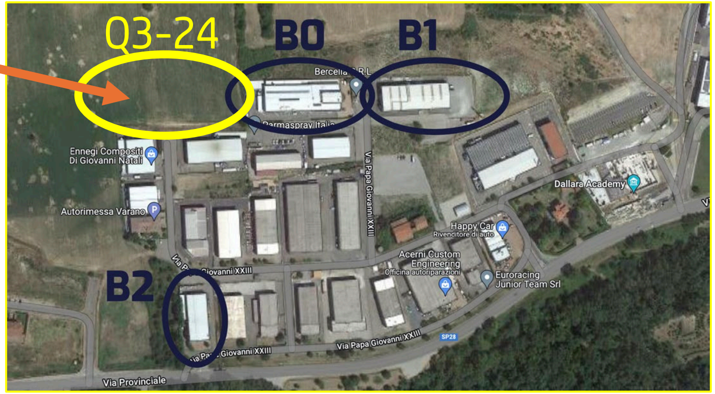
2022 – New Strategic Plan targeting Automotive, Space and Defence.



BERCELLA

Bercella in short





11+ M€

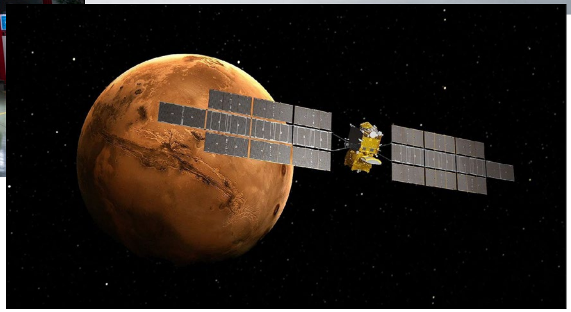
2023 Revenues, up 27,4% from 2022

11.500+

Parts produced in 2023

100+ Employees

Highly specialized resources, the key to our success



The Projects

Tool4Life
A Life Project

Co-funded by the European Union

TOOLing materials, design, and process engineering, leading to improved sustainability and wider applications for the composites of tomorrow

Budget: 3 563 350.38 €

EC Co-Funding: ~ 60%

Duration: Start: 01/08/22 - End: 31/07/25

The Consortium:

BERCELLA · MARBO Chemical specialities for industry · RINA · CENTEXBEL

ZEROWASTELIFE
A Life Project

Co-funded by the European Union

Materials, 2D-3D flattening and Processing to optimize the topology and create breakthrough zero-waste Composite structural solutions

Budget: 1.8 M €

EC Co-Funding: ~ 60%

Duration: Start: 01/07/23 - End: 30/06/26

The Consortium:

BERCELLA · RINA · NOBRAK

Introduction to Tool4LIFE Project

Composites materials

Properties
- ✓ Light material
- ✓ High mechanical performances
- ✗ Difficult to recycle thermosetting resin matrix

Applications
Automotive
Aeronautics
Space
Nautical
...

95% of toolings are made of non-recyclable materials and landfilled after their use (Polyurethans, epoxies,..)
In Italy it corresponds to more than 2.000 tons/year of non-recyclable thermosetting materials.

The project aims to enhance the sustainability of composite materials by radically transforming tooling design and manufacturing methods, converting from a linear to a circular value chain, through the shift from thermoset tables stacked and milled, to a hybrid (Additive Manufacturing and Milling) technology for manufacturing tooling in recyclable thermosetting materials.

Objective and Scope

Composite Tooling

Master Model → **Mold** → **Composite Product**

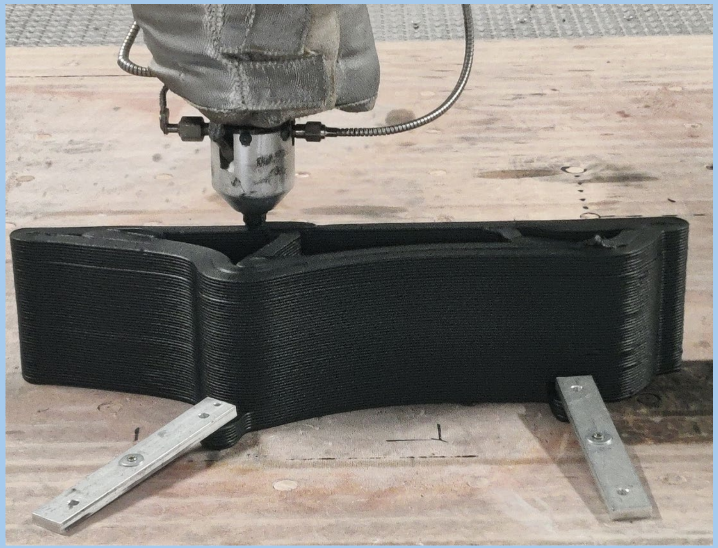
Tool4Life is developing a hybrid process combining additive manufacturing and milling to produce fully recyclable thermoplastic molds

- ✓ No compromise in the final product's performance
- ✓ Parts optimization to reduce material use
- ✓ Possible direct mold printing without master model
- ✓ Shifting from thermoset to recyclable thermoplastic materials
- ✓ Shifting to water-based sealer and release agent
- ✓ Reducing overall cost and time to produce tools and, as consequence, composite products

Tool4LIFE Methodology

Recycling

Tooling production by AM



Milling to final shape

Use

Shredding, compounding pelletizing

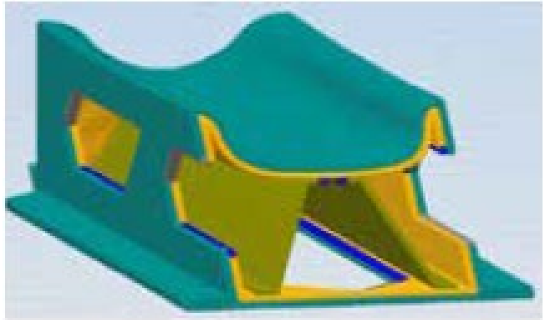
Large Scale Additive Manufacturing

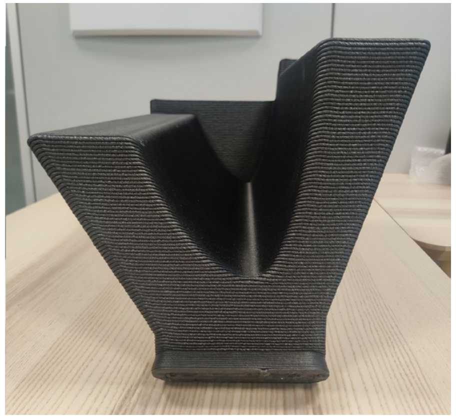
BERCELLA
Varano dè Melegari
(Parma, Italy)

- Hybrid machine for AM and milling

(Printing volume: 3000x2000x1000 mm)

- **TOOL4LIFE**: direct printing of models, tools and parts with thermoplastic recyclable polymers





Expected impacts

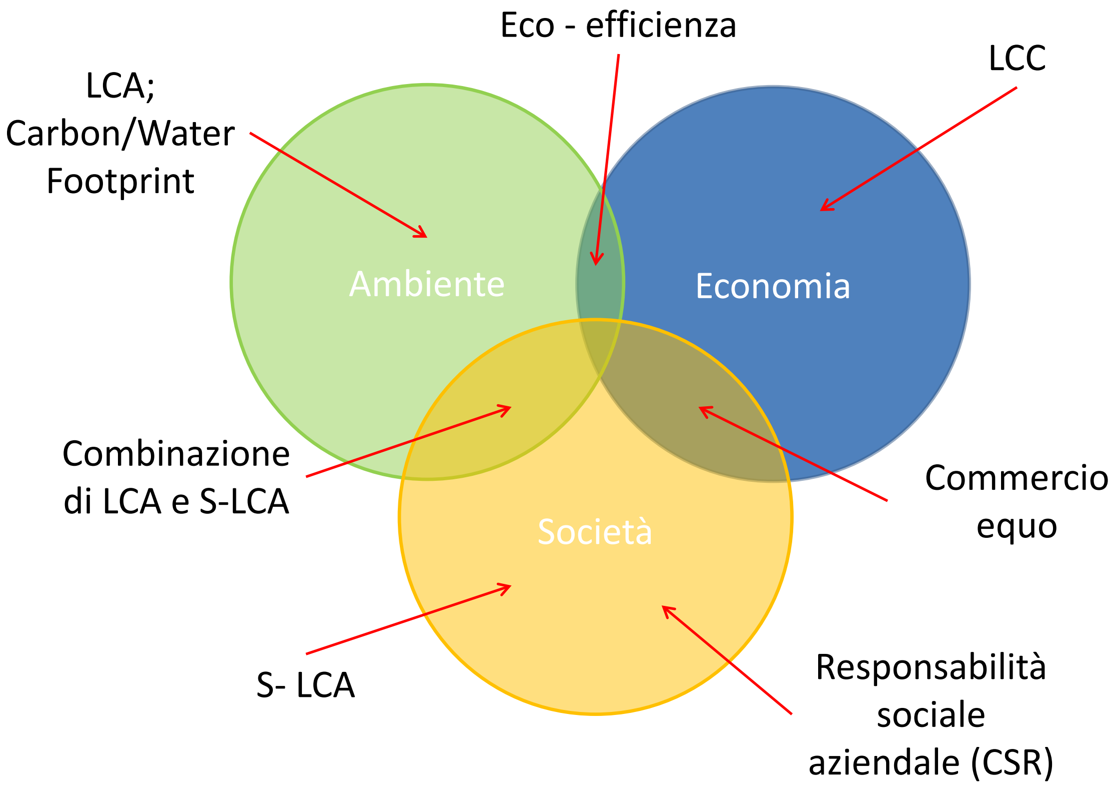
Waste management	Cut polymer use by up to 80%, thanks to part optimization and addictive manufacturing Avoid landfilling thanks to thermosetting material recycling to produce new tools
Energy saving	The use of Additive Manufacturing reduces the energy consumption due to the machining of the toolings, reducing up to 30% (depending on the specific case)
Chemicals	Elimination of toxic chemicals used in thermosetting materials production such as Isocyanates to produce PU foam
GHG Emissions	Reduction of CO_2 equivalent emissions thanks to the overall new process, up to 80%
Employment	The project will generate new businesses and increase the existing ones, this will create new job opportunities

Sustainability Assessment

Life Cycle Thinking

Three pillars of sustainability:

Life Cycle Assessment:
Environmental sustainability
Life Cycle Cost:
Economic sustainability
Social Life Cycle Assessment:
Social sustainability



Life Cycle Assessment (LCA)

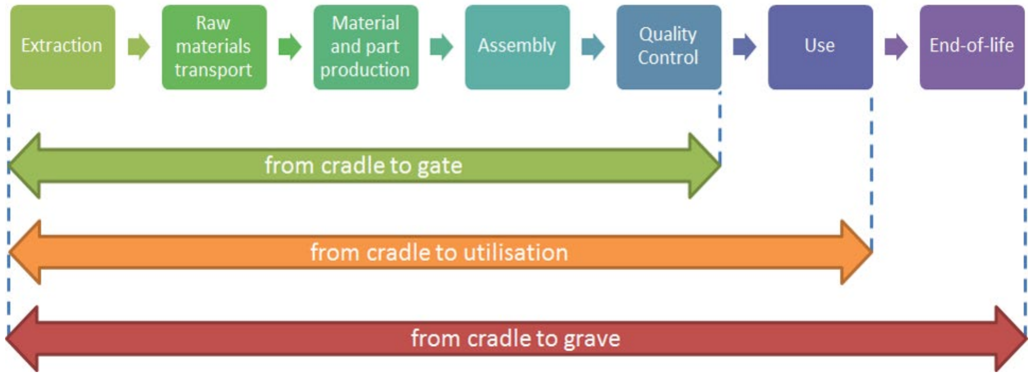
Quantify the **potential environmental impacts** of the molds and **compare** with benchmark technologies, "**cradle to grave**"

In accordance to **ISO 14040** and **14044** Standards

Four phases:

1. Goal and scope
2. Life Cycle Inventory (collection of data)
3. Life Cycle Impact assessment
4. Interpretation of the results

LCA evaluates potential environmental effects across various **impact categories**:
Global Warming Potential (kg CO_2 equivalent), Water use, Human health, Acidification, Ozone depletion...



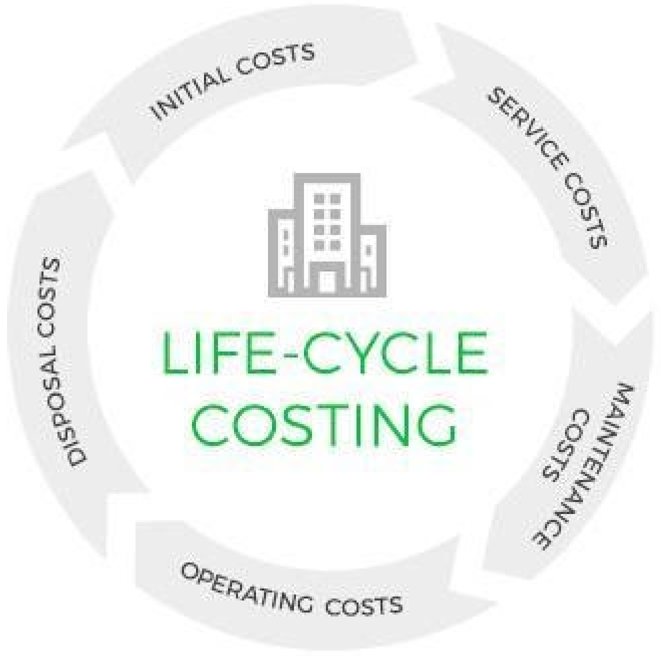
Life Cycle Cost (LCC)

Estimate the **costs** of the developed solutions and conduct a **comparison** with benchmark technologies, estimating savings

In accordance to ISO 15686-5:2008 and the **Code of Practice suggested by SETAC** “Environmental Life Cycle Costing”

Same hypothesis and framework of LCA

The LCC will enable the estimation of the total costs (**OPerating Expense, OPEX and CAPital Expenditure, CAPEX**) to be incurred in the design, development, production, operation, maintenance, and end of life of materials and components over their life cycle.



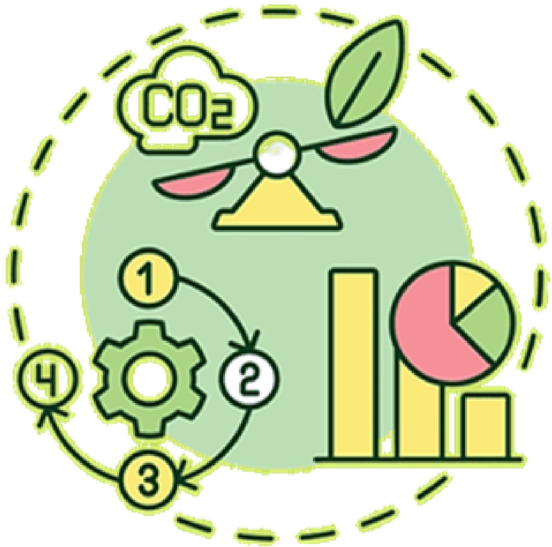
Social Life Cycle Assessment (SLCA)

Evaluate the **social and socio-economic aspects** of the developed materials and components.

In accordance to the recent **UNEP/SETAC guidelines for social life cycle assessment of products and organizations** (2020)

Same hypothesis and framework of LCA

The social sustainability assessment is aimed at identifying and managing impacts, **both positive and negative**, stakeholders could be potentially involved/affected by the life cycle of solutions in terms of **Human Right, Working conditions, Cultural heritage, poverty, and social repercussions** in general.



SLCA

Tool4Life preliminary LCA results

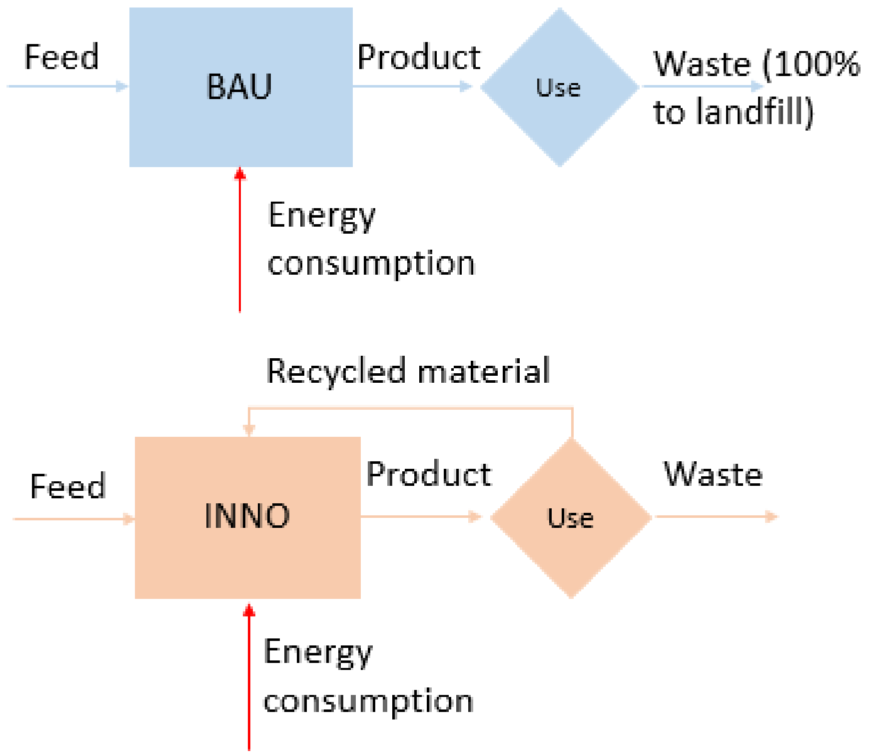
- **LCA-LCC-SLCA analyses are comparative: <u>Same functionality</u>**

- **Business as Usual (BAU) scenario** = master model made of epoxy resin and machined. Mold made of prepreg using the master model. Recyclable: NO

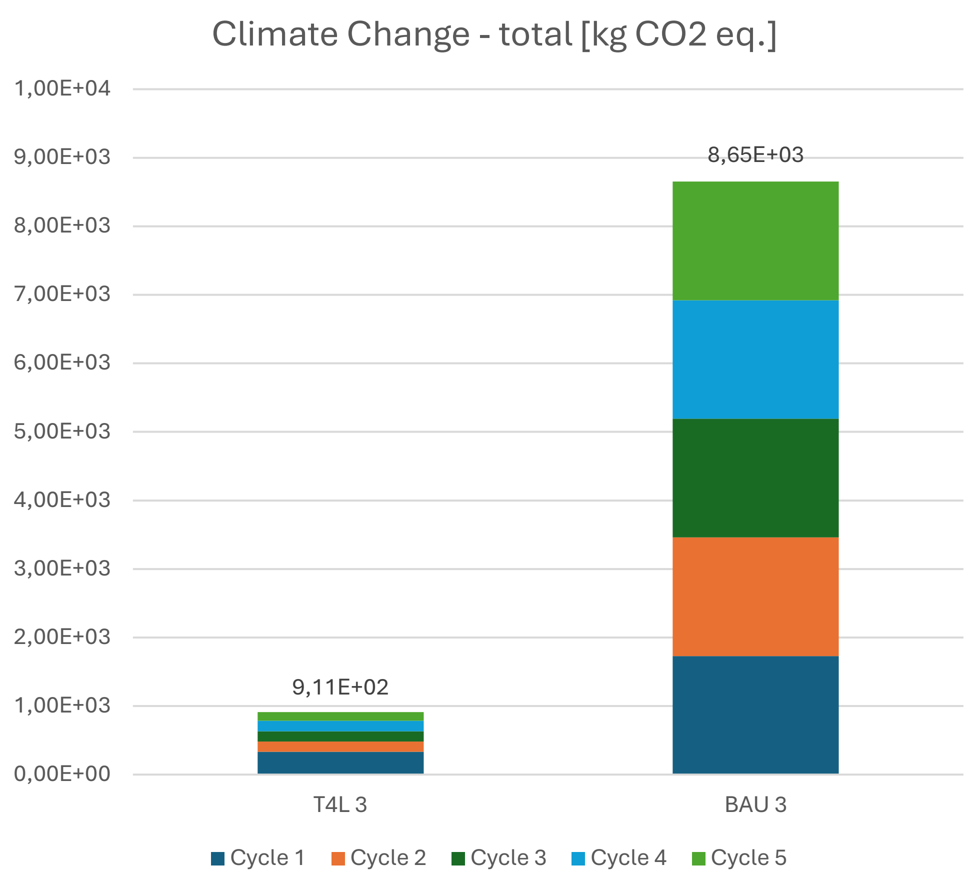
VS

- **Innovative scenario (INNO)** = master model **3D-printed**, in ABS+CF, or mold directly **3D-printed** in PC+CF. Model optimization → Lower mass. Recyclable: **YES**.

- **Functional unit (FU):** Production of n.1 mold, considering all the steps (including any master model) for its production. The BAU/T4L tools may be reusable. 5 tool production cycles are considered (with material recycling in the T4L scenario);
- **Boundary conditions:** cradle-to-grave approach



Tool4Life preliminary LCA results



	BAU 3	T4L 3
Mass of the finished **master model** (kg)	155	48
Virgin main raw material 1 cycle (kg)	311	60
Virgin main raw material 2-3-4-5 cycle (kg)	311	1.8
Total (KgCO2eq) 1 cycle	1730	332
kgCO2eq/kg finished master model	11.2	6.92

Example: T4L 3 vs BAU 3
(both **only master models**; same mold production)

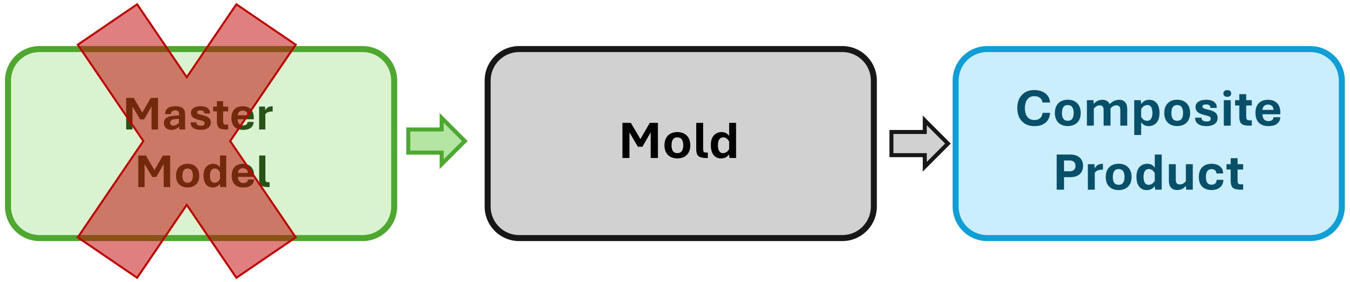
Already in the first cycle, transition from traditional process to innovative process results in:

- ✓ absolute reduction of CO_2eq from 1730 kg to 332 kg (Δ=80.8%)
- ✓ specific reduction of kgCO_2eq per kg of master model from 11.2 to 6.92 (Δ=38%),.

Further improvement is due to material recycling in the T4L scenario

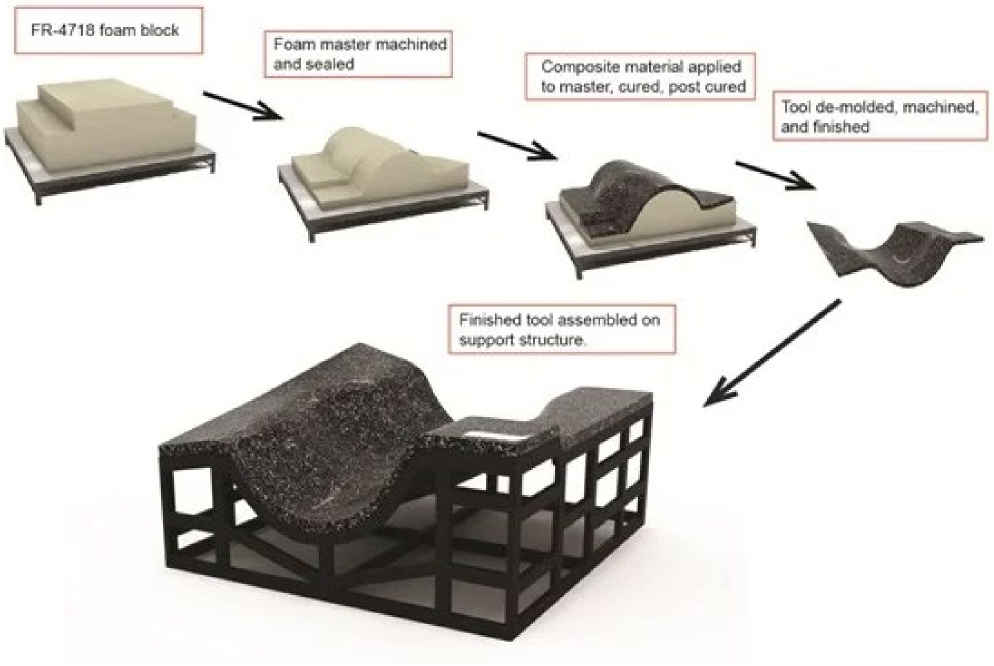
(No credits are attributed to avoided virgin material)

Tool4LIFE: LCA considerations



✓**Material recycling** reduces impacts

✓**Mold can be directly printed**, giving additional advantage in **energy savings** (no autoclave) and **environmental impacts reduction**



✓**New coatings** are water-based, without toxic components such as Butyl-tin (Impact on human health!)

✓Lower amount is needed

Tool4LIFE: LCC considerations

LCC will evaluate T4L prices compared to BAU, in terms of **Raw materials, energy consumptions, personnel, waste disposal, CAPEX**

The price for T4L is higher if strictly considering production cost, but:

Time is money!

- ✓**AM** reduces design time, allowing rapid prototyping, and logistics time (material supply)
- ✓**Molds can be directly printed**, cutting a step
- ✓**New coatings** require lower n° of layers

Introduction to ZeroWasteLIFE

The Problem: Waste in CFRP Manufacturing

High-quality composite parts are currently manufactured **cutting the model** from a sheet of **pre-impregnated fabrics or virgin fiber tows,** then placing them in molds, preparing vacuum bags, and initiating the curing process (in autoclaves or presses).

Despite precision and optimization, **30% to 50% of material is wasted** during the process.

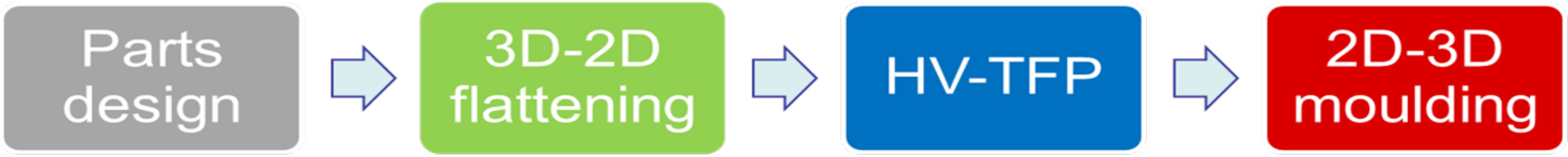
The project aims to enhance the sustainability of composite materials reducing composite waste by 90% using HV-TFP (High Volume Tailored Fiber Placement) and topological optimization for efficient material use.

Introduction to ZeroWasteLIFE Project

Tipical example of «problematic» geometry.
Cut materials are wasted.

Tipical example of nesting, showing **waste higher than 35%** of the total surface.

Objective and scope



ZeroWasteLIFE aims to reduce composite waste by 90% using HV-TFP (High Volume Tailored Fiber Placement) and topological optimization for efficient material use

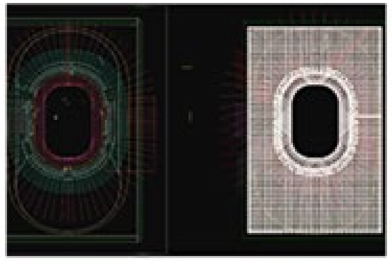
- ✓ Complete rethinking of the production process
- ✓ The use of materials is complete, no material is wasted
- → Cheaper process, the final product only needs finishing activities
- ✓ The new shapes combine 3 basic building blocks for complex final structures:
- → Beam, plate and shell, designed to allow flexible assembly

ZeroWasteLIFE Methodology

3 phases:

- ✓ Conversion of CAD 3D shape (**<u>flattening</u>**) in 2D with fiber placement optimization on the maximum strain lines
- ✓ **<u>Manufacturing of 2D preforms via HV-TFP</u>**, assembling the basic elements: plates, shells, beams
- ✓ Curing of the preform in the mold, to obtain the desired solid shape (2D→3D)

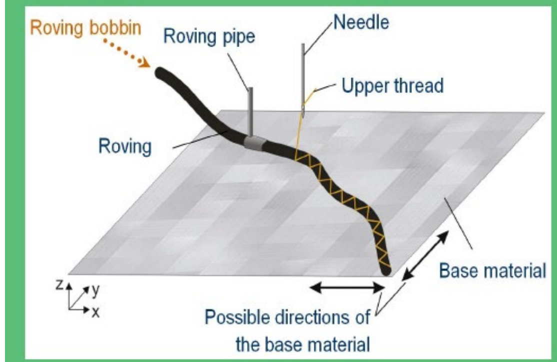
CAD della forma finale → Geometrie ottimizzate → 3D -> 2D → Costruzione preforma → Cottura del pezzo su stampo 3D → Pezzo finito



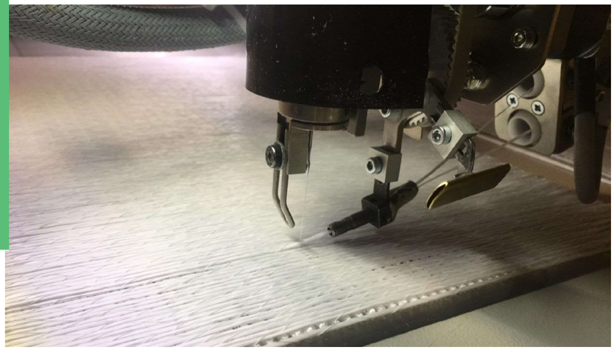
High Volume Tailored Fiber Placement (HV-TFP)

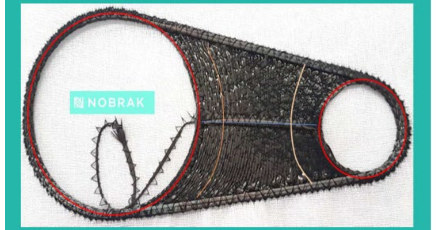
Combination of:

- ✓ **<u>High Volume Tailored Fiber Placement (HV-TFP)</u>**, a technology with «no waste», that places reinformnet fibers only where necessary
- ✓ Design of 2D structures (preforms), for the 3D shape of the real part, to maximise the rigidity-weight ratio

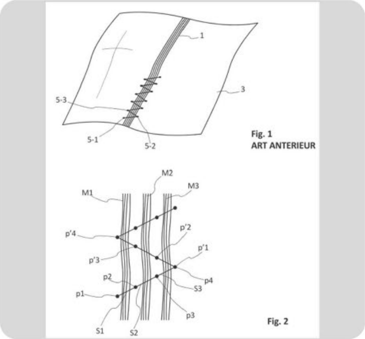


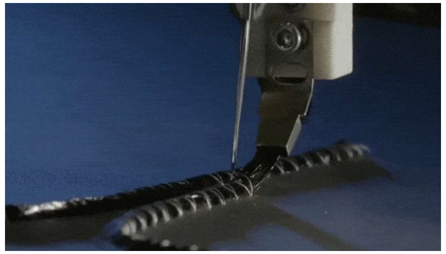
TFP : Positioning a fibre on a support material by stitching in any orientation



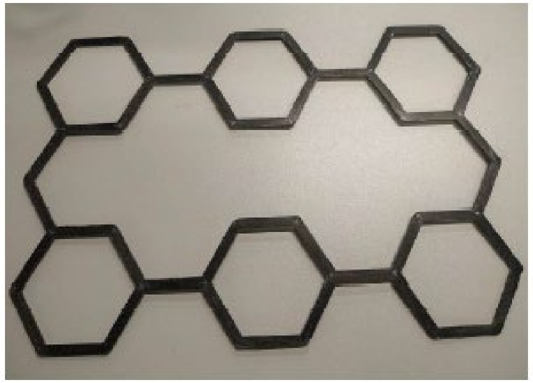


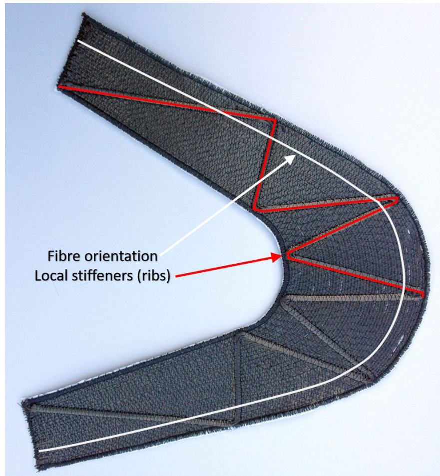
HV-TFP: beam preform with complex orientations

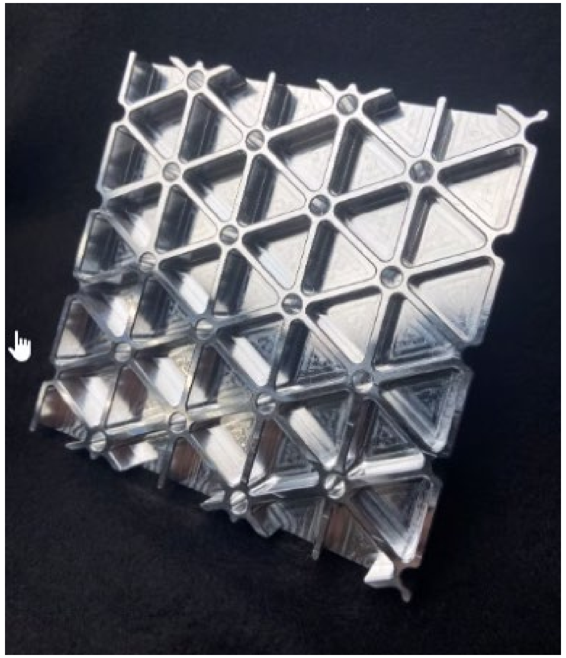




Examples of geometries







Expected impacts in ZeroWasteLife

KPIs as a preliminary sustainability assessment

Variable	Saving
Landfilled raw material	**90% of the production waste** ≈ **900 kg** if considering 10% of Bercella production
Energy saving	**TFP eliminates the cutting phase** ≈ **19.7 MWh/y** if considering 10% of Bercella production **If the autoclave is substituted with press, consumption can be cut up to 90%**
CO_2 equivalent emissions reduction	≈ **83 ton CO_2/y** if considering 10% of Bercella production ≈ **20 kgCO_2/kg product**

Environmental impacts reduction thanks to:

- **Reduced material use** (material impacts)
- **Avoided landfilled material** (landfill impacts)
- **Reduced energy consumption in manufacturing** (autoclave >>> thermopressing)
- Reduction of non-renewable, non-recyclable materials (thermosetting resins)

Expected impacts in ZeroWasteLife

Economic impacts reduction thanks to:

- ✓ **Avoided landfilled material** (cost of material; disposal taxes)
- ✓ **Reduced energy consumption** for manufacturing (autoclave >>> thermopressing)

Social impacts reduction thanks to:

- ✓ Improvement of **workers conditions** in the facilities implementing the process
- ✓ Improvement of the **quality of life of citizens in general** (thanks to the reduced emissions, reduced wastes and landfilling of materials, and the avoided handling and disposal)
- ✓ In the medium to long term, the possibility of **increasing workplaces** and the **new opportunities for formation, training and growth of skills** are expected as far as the profitability of the business is increased

Variable	Saving
Production cost/year	due to: - 40 % **reduction in raw materials** necessary for the manufacture of end products - **energy savings** for manufactured composite
Raw material /year	Due to 40% raw materials not wasted
Raw material disposal / year	Due to avoided taxes for material disposal

Take home messages

A strategy to **improve the sustainability performance** of composite manufacturing and composite material products:

- ✓ **New manufacturing technologies**
- ✓ Use of **recyclable materials** and **water-based additives**
- ✓ Reduction of **processing waste**
- ✓ **Model optimization** to reduce material use
- ✓ Reduction of production steps

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