FIBRE4YARDS
SHIPYARD FOR THE FUTURE

AIDIC

Lodz University of Technology

ENVIRONMENTAL IMPACT OF FIBRE-REINFORCED POLYMERS APPLICATION IN SHIPBUILDING INDUSTRY

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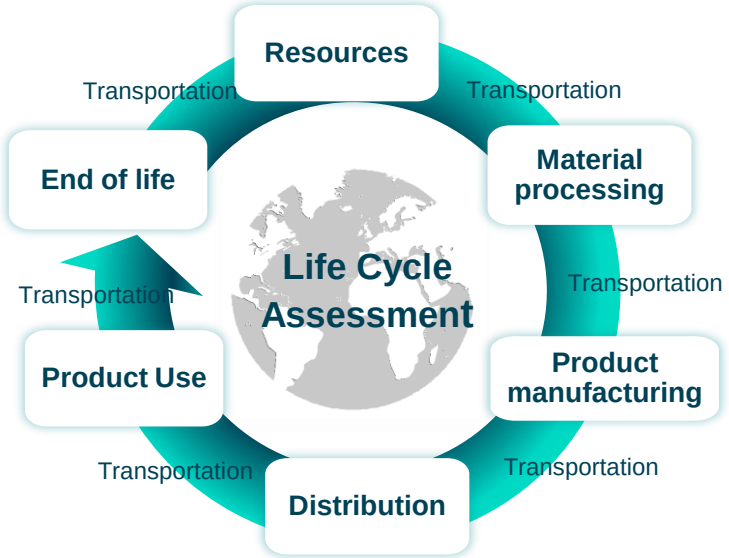
Content of presentation

- Life cycle assessment (LCA) the quantitative measure of sustainability
- LCA methodology (goals & scope, inventory analysis, impact assessment, interpretation)
- Fibre4Yards Project
- Results
- Conclusions

Life Cycle Assessment - LCA

“Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle” (ISO 14040, section 3.2)[1]



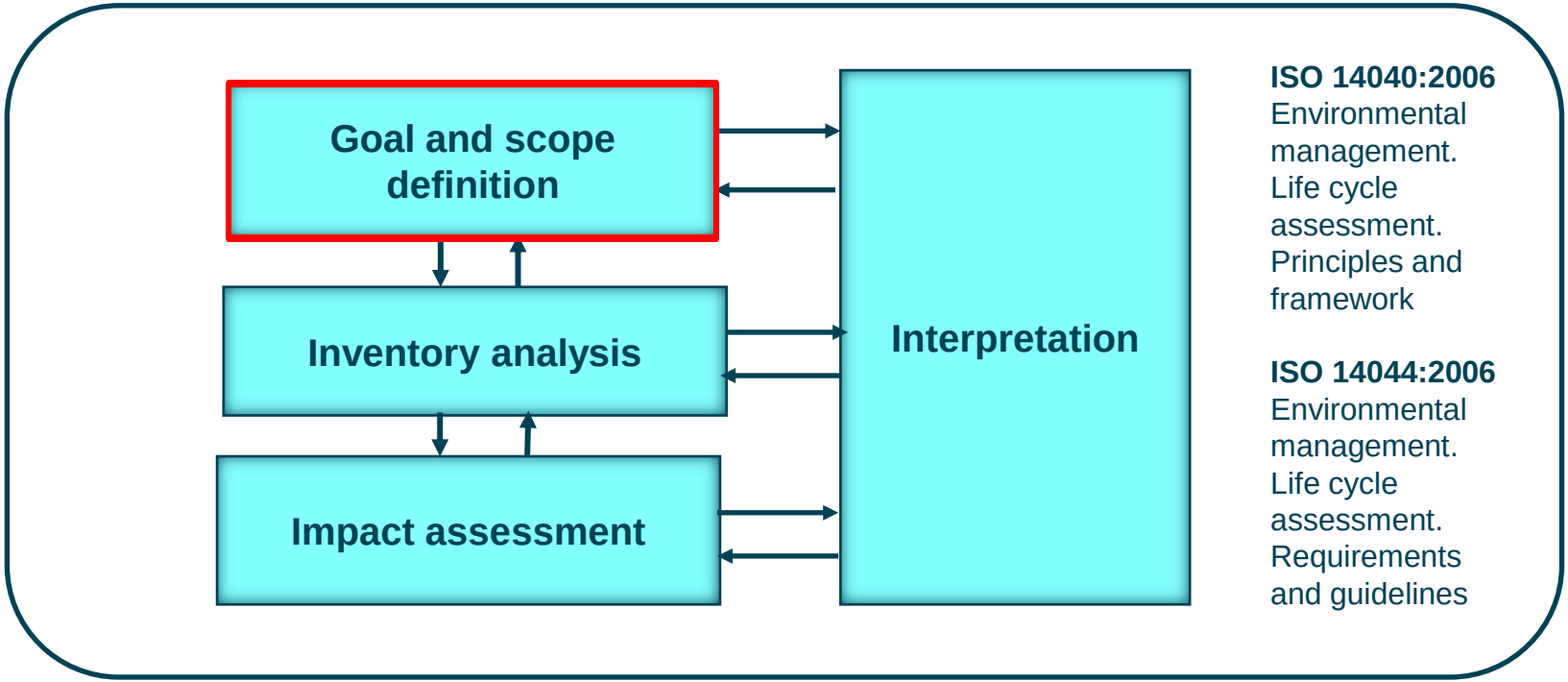
International Organization for Standardization

[1] **ISO standards:**
14040 Principles and Framework
14044 Requirements and Guidelines

Benefits of Life Cycle Assessment for Company Product/Service/Technology

- Assess most impactful processess
- Gain competitive advantage
- Attract, encourage invertots
- Early stage decision-making

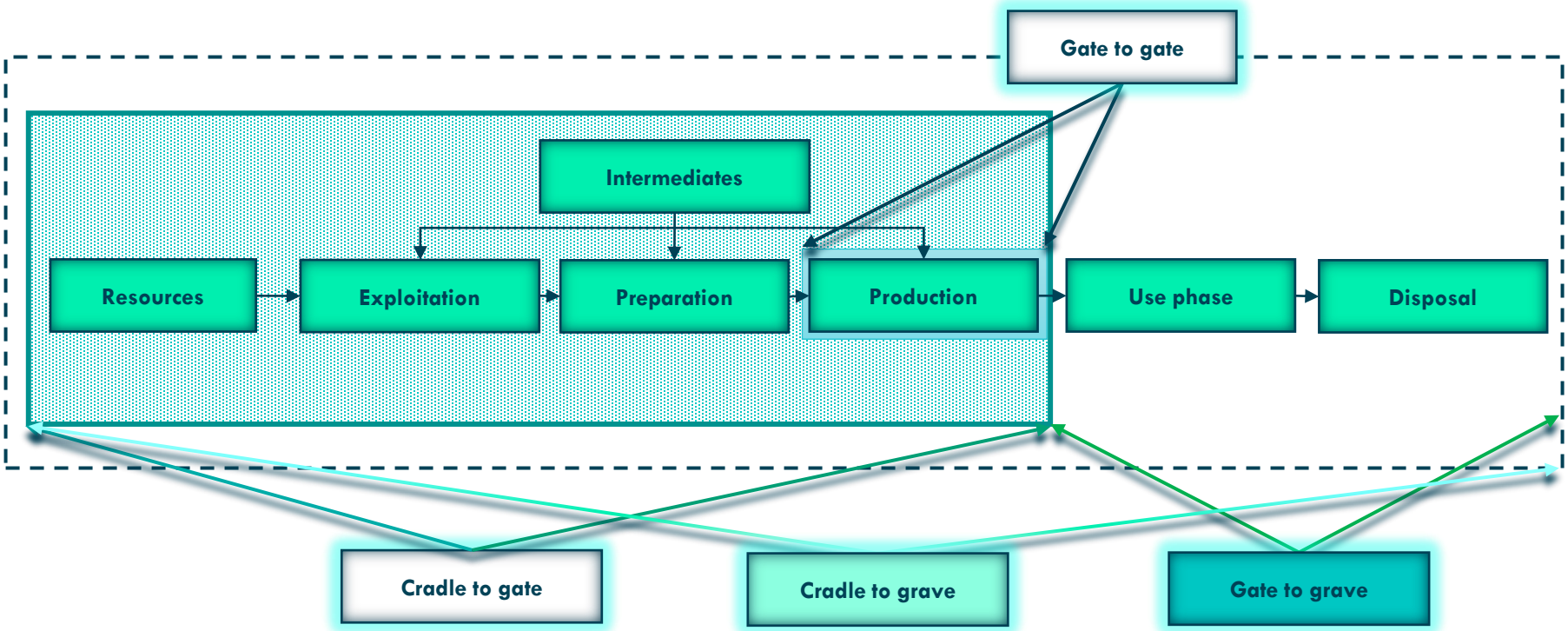
Life Cycle Assessment framework



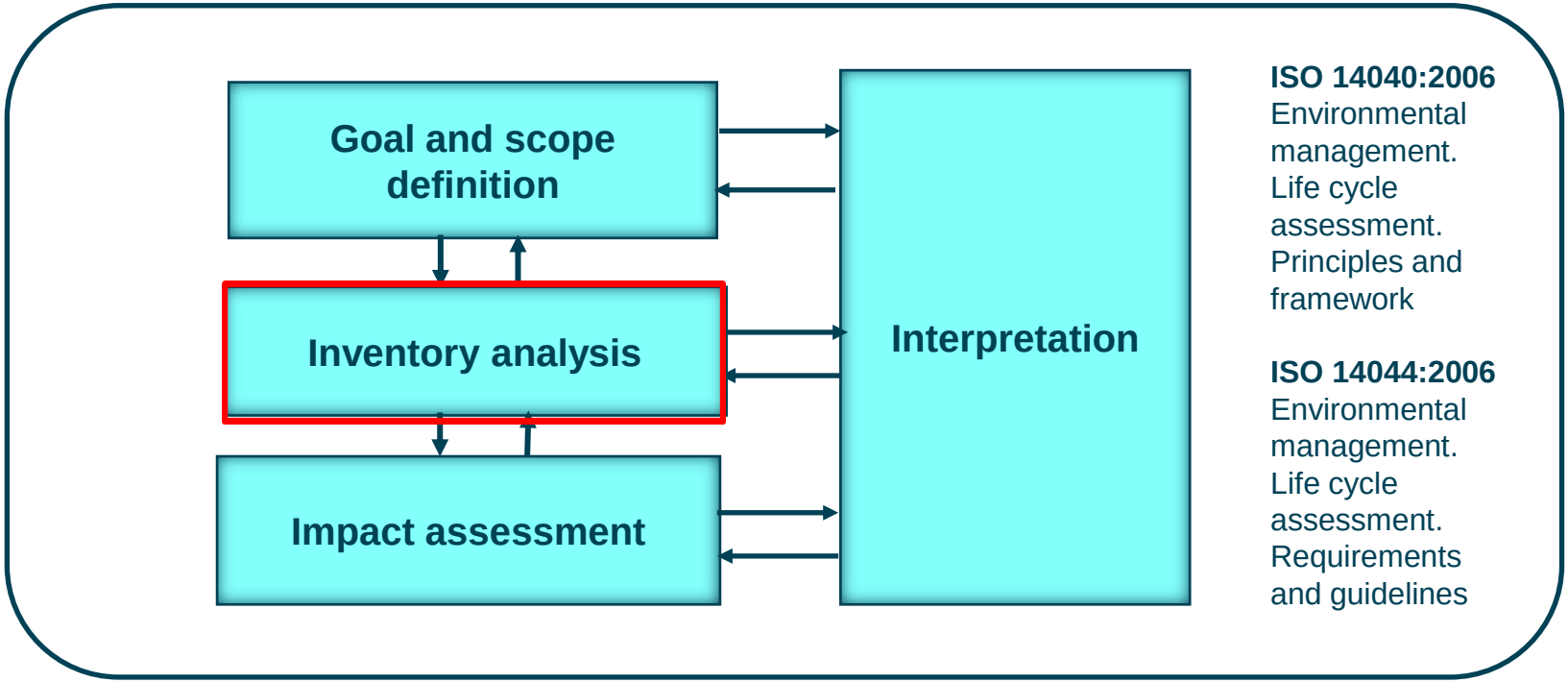
ISO 14040:2006
Environmental management. Life cycle assessment. Principles and framework

ISO 14044:2006
Environmental management. Life cycle assessment. Requirements and guidelines

Scope of LCA


Gate to gate
Intermediates
Resources
Exploitation
Preparation
Production
Use phase
Disposal
Cradle to gate
Cradle to grave
Gate to grave

Life Cycle Assessment framework



ISO 14040:2006
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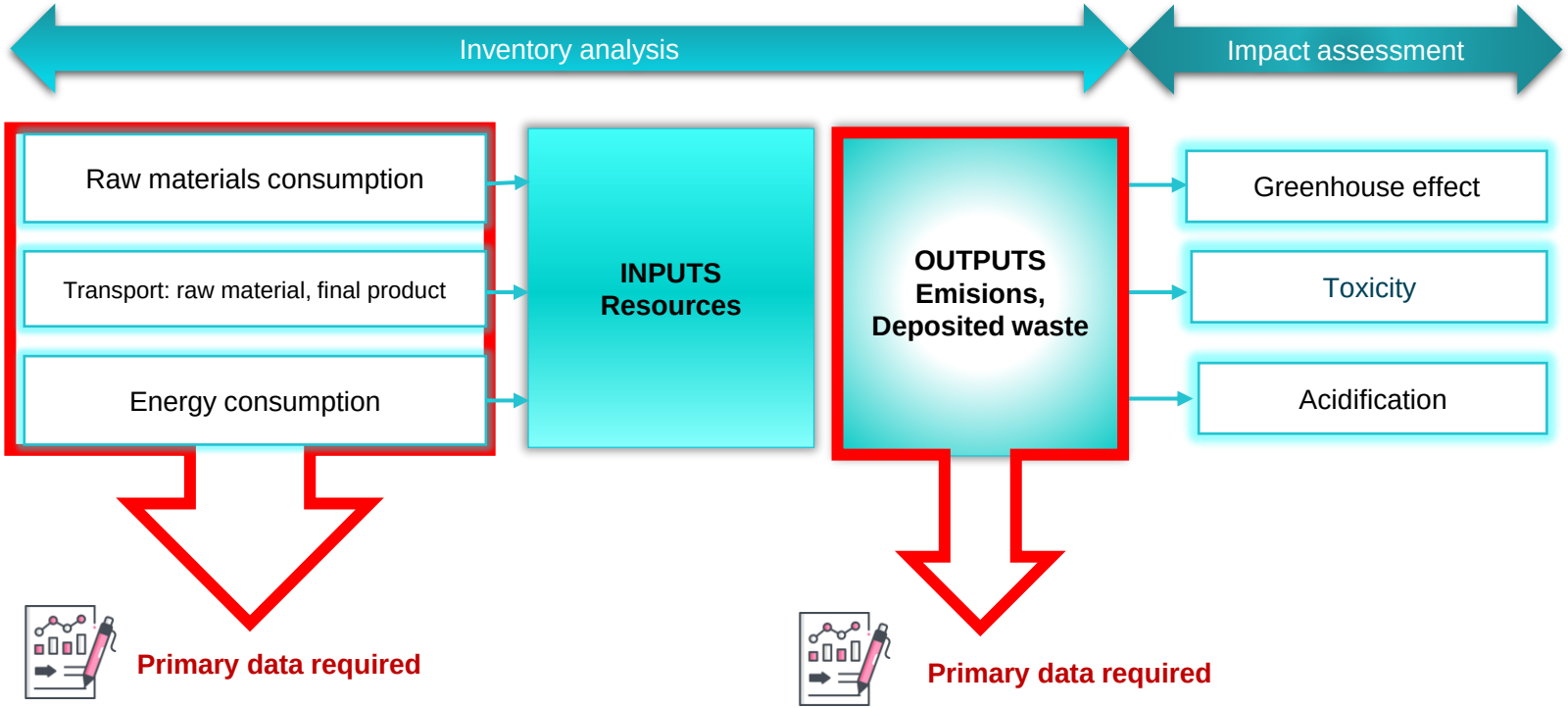
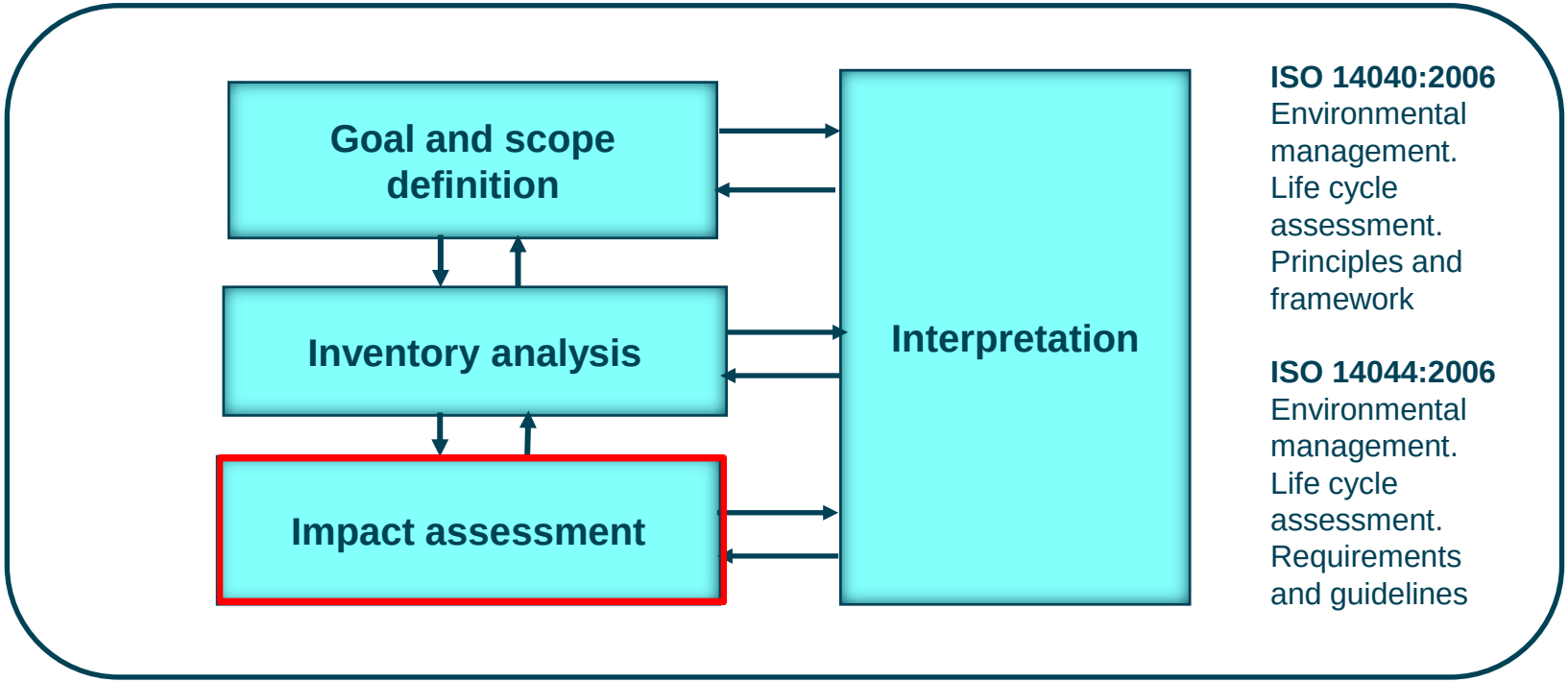
ISO 14044:2006
Environmental management. Life cycle assessment. Requirements and guidelines

Inventory Analysis



Life Cycle Assessment framework



ISO 14040:2006
Environmental management. Life cycle assessment. Principles and framework

ISO 14044:2006
Environmental management. Life cycle assessment. Requirements and guidelines

Impact Assessment - Softwares and Methods

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GaBi Database Content

One Click LCA

umberto® know the flow.

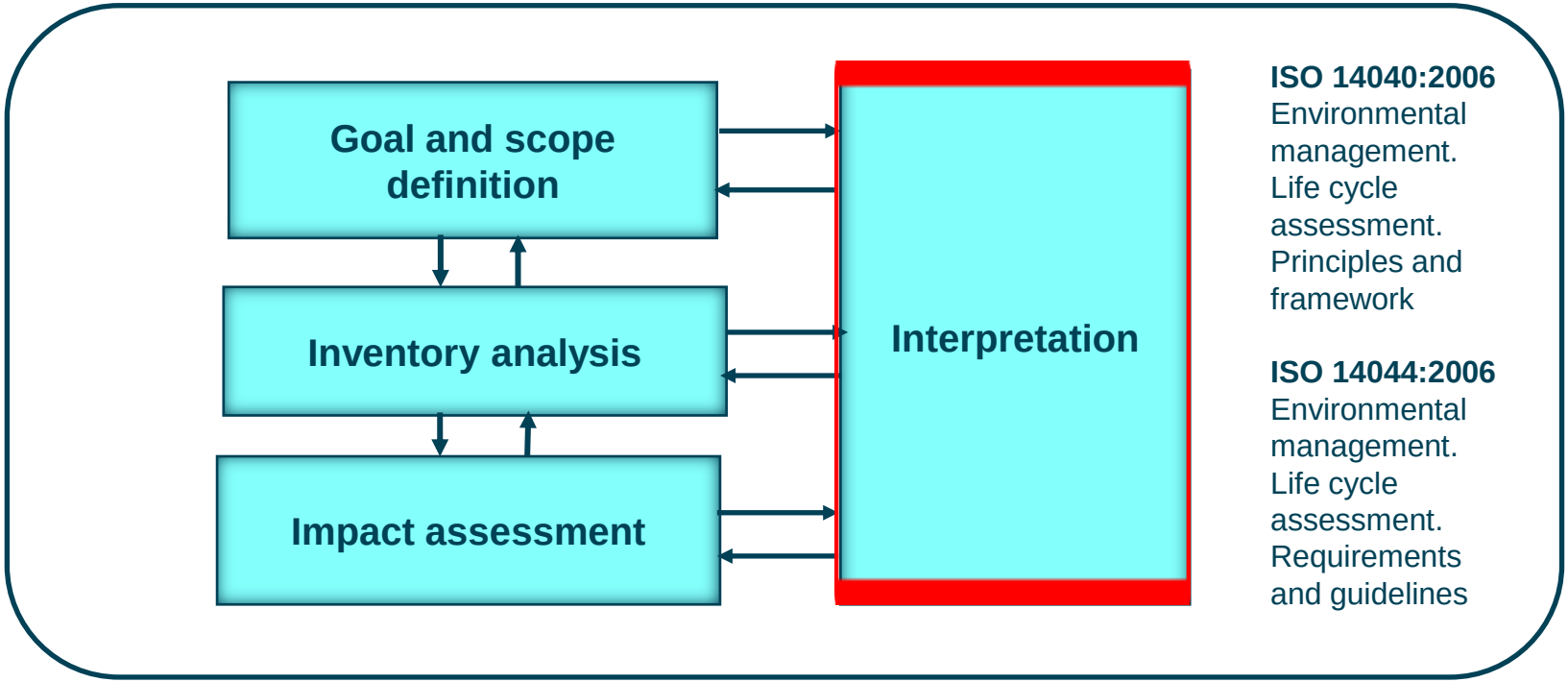
SimaPro

OPENLCA

LCA manager

Single Issue	Global	European
• IPCC 2021 • Cumulative Energy Demand	• IMPACT World + • ReCiPe 2016	• CML • EPD • Ecological Scarity

Life Cycle Assessment framework



ISO 14040:2006
Environmental management. Life cycle assessment. Principles and framework

ISO 14044:2006
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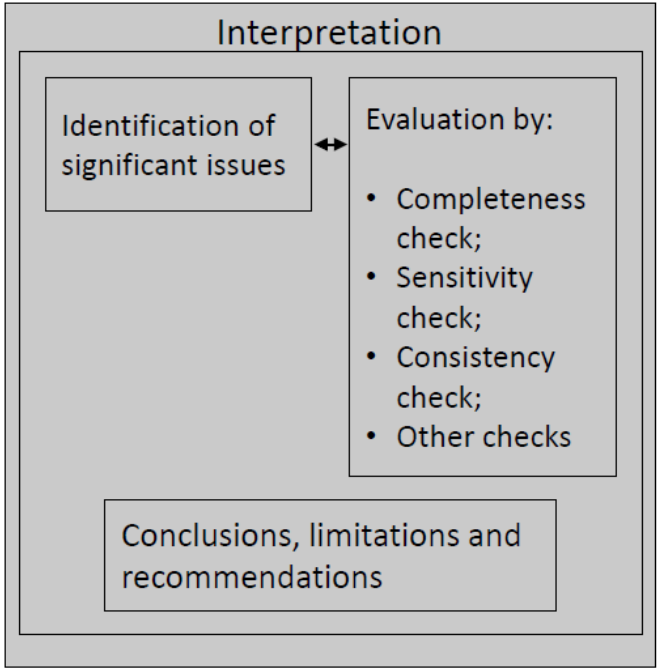
Life Cycle Assessment - Interpretation

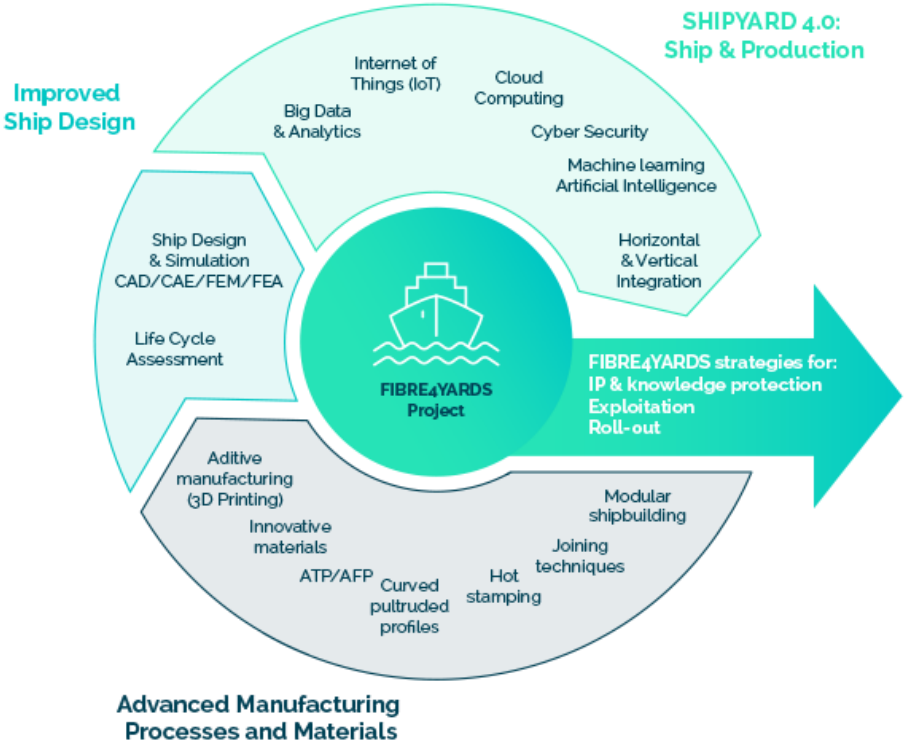
What is the study telling us?

- **Evaluation – Are our results significant?**
  - Completeness – is all relevant information complete? Anything missing?
  - Sensitivity – how are results affected by data & methodological choices
  - Consistency – are assumptions, methods & data consistent with goal and scope?
- **Identification – Which issues are important?**
- **Conclusions, limitations & recommendations**



Fibre4Yards Concept

The main objective of FIBRE4YARDS is to maintain European global leadership in ship building and ship maintenance, through implementation of the Shipyard 4.0 concept in which advanced and innovative FRP manufacturing technologies are successfully introduced.



The main benefits of applying FRP in shipbuilding industry

Benefits for shipowners due to the overall weight reduction

Bunkering Consumption Reduction, increased cargo/passenger capacity, reduction of powering needs

Benefits for shipowners derived from the reduction of maintenance costs

FRP are corrosion immune and offer superior fatigue resistance which results in a life-cycle costs reduction

Environmental benefits during operation thanks to FRP application

Substantial reduction of greenhouse gas emissions due to lower power needs, better underwater acoustic signature, reduction of noise pollution at ship accommodation spaces

Project objectives

Objectives

- To perform LCA analysis of **advanced and innovative Fibre-Reinforced Polymers** (FRP) manufacturing technologies developed in the project to assess the environmental impact over the entire life cycle of FRP ships.
- To provide recommendations for optimal solutions of the environmentally friendly FRP production technology for the shipbuilding industry.

Out of die UV curved pultrusion

IRURENA

Hot stamping

INEGI

ATP

3D printing

10XL

Adaptive moulds

CURVE WORKS

NAVAL GROUP

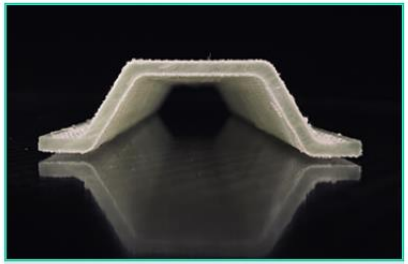
Vacuum infusion

Demosntrator assembling

FRP manufacturing technologies

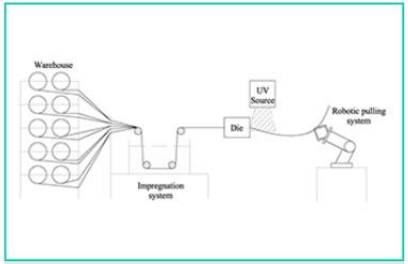
The targeted technologies

❑ Out of die UV cured pultrusion for manufacturing curved profiles



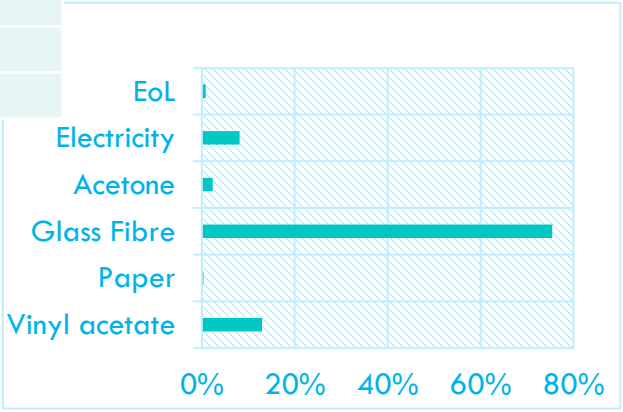
Transversal section ©INDUSTRIAS QUIMICAS IRURENA

Vessel profile ©INDUSTRIAS QUIMICAS IRURENA



Free shape diagram ©INDUSTRIAS QUIMICAS IRURENA

	%
Vinyl acetate	12,96%
Paper	0,31%
Glass Fibre	75,46%
Acetone	2,33%
Electricity	8,13%
EoL	0,82%

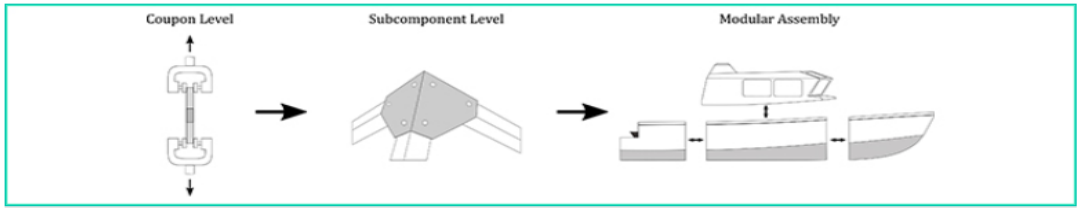


The targeted technologies

- **Hot stamping of thermoplastic materials and Connection techniques**

Hot stamping ©INEGI

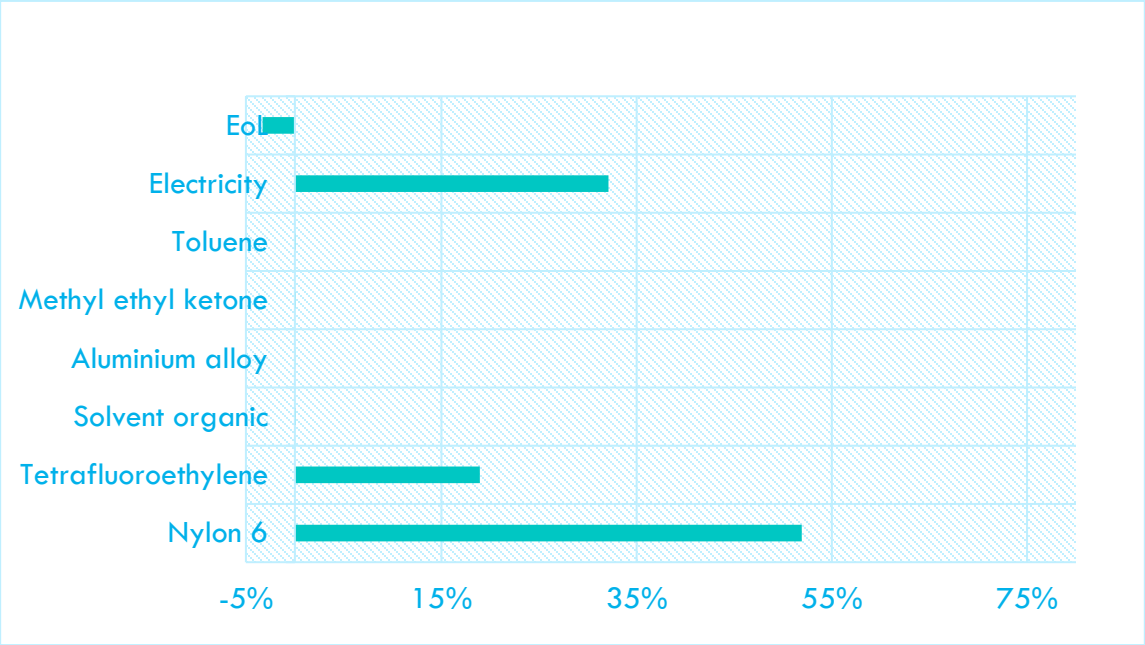
Hot stamped and over-injected part ©INEGI



Modular assembly ©INEGI

The targeted technologies

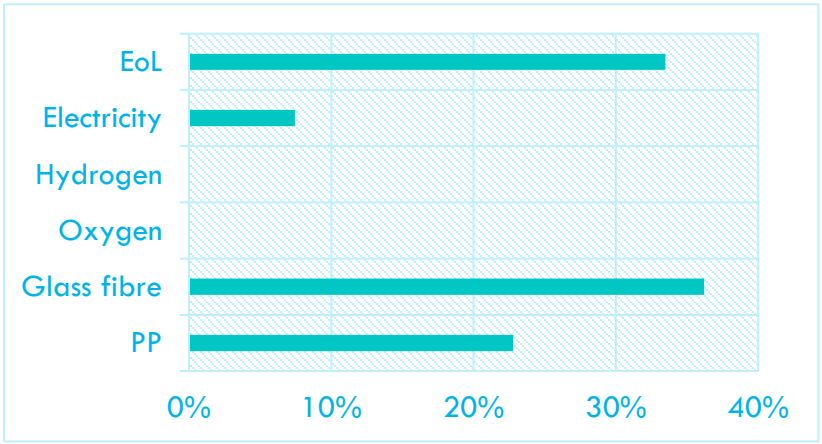
Hot Stamping Technology (INEGI)



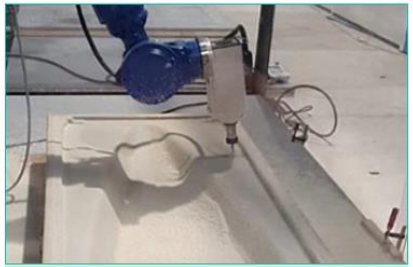
	%
Nylon 6	51,92%
Tetrafluoroethylene	18,96%
Solvent organic	0,099%
Aluminium alloy	0,002%
Methyl ethyl ketone	0,103%
Toluene	0,107%
Electricity	32,13%
EoL	-3,31%

The targeted technologies

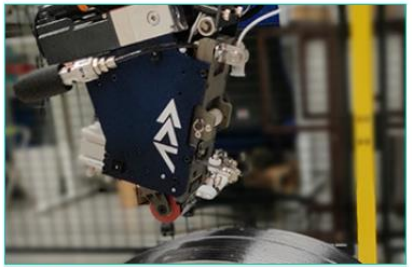
- **Automatic Tape Placement (ATP) and Automatic Fibre Placement (AFP) and Additive manufacturing: 3D printing**



Robotic 3D printing ©10XL



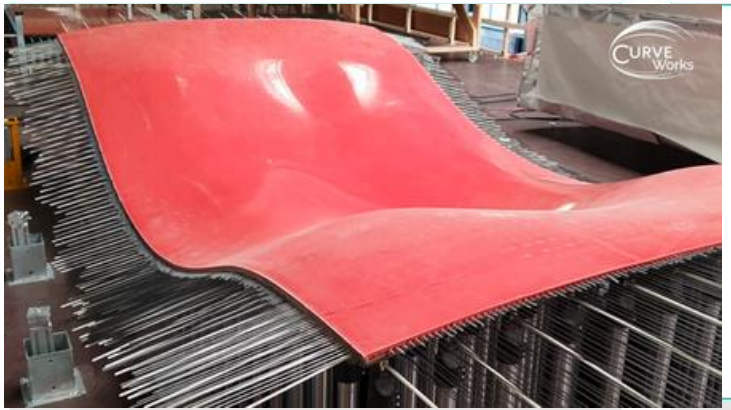
Robotic CNC routing ©10XL



Robotic automatic tape placement ©10XL

The targeted technologies

- **Adaptive moulds for composite panel assemblies**

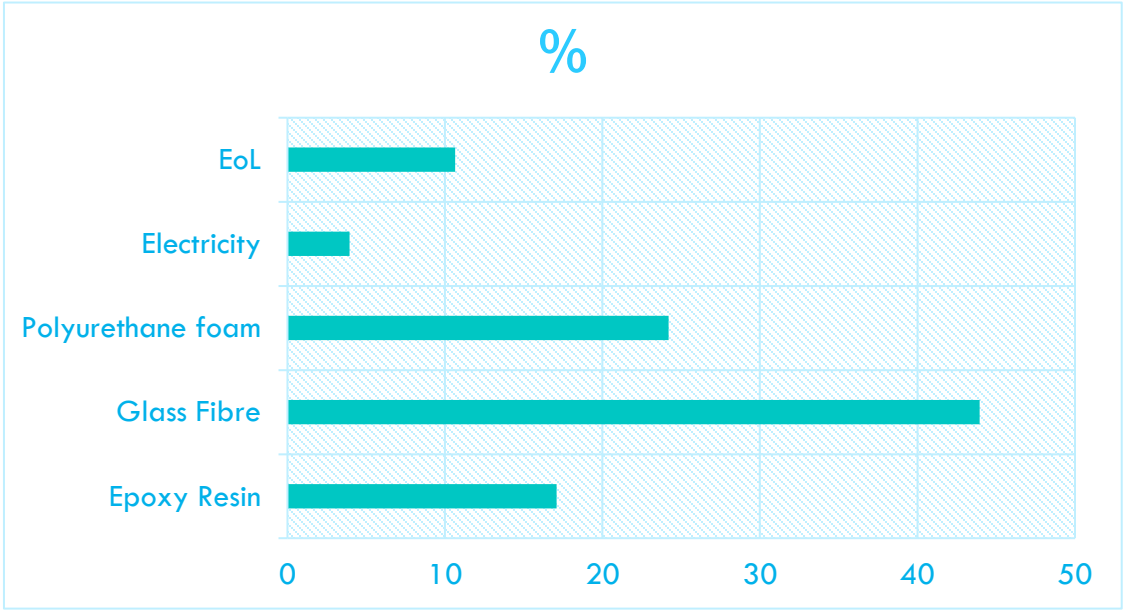


Curve Works adaptive mould "Bee" is 2.5 x 1.3 m, used for higher curvature parts. ©CURVE WORKS

Curve Works adaptive mould "Ant" is 3.8 x 1.8 m, used for large parts. ©CURVE WORKS

The targeted technologies

GWP100 for Adaptive Mould Technology (Curve Works)



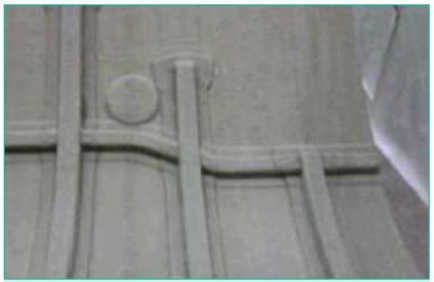
	%
Epoxy Resin	17,09
Glass Fibre	43,94
Polyurethane foam	24,20
Electricity	3,94
EoL	10,65

The targeted technologies

❑ Manufacturing and testing of demonstrators

Demonstrator - topside ©NAVAL GROUP

Demonstrator - deck ©NAVAL GROUP

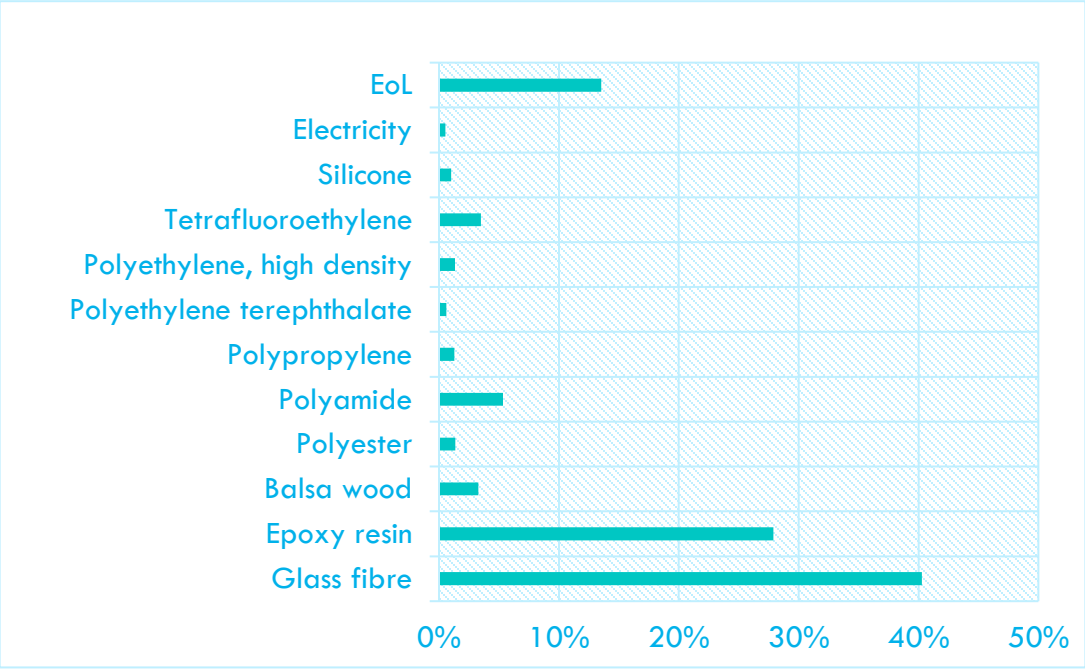


Demonstrator - deck ©NAVAL GROUP

Superstructure Frigate La Fayette (1980 – 1990)

The targeted technologies

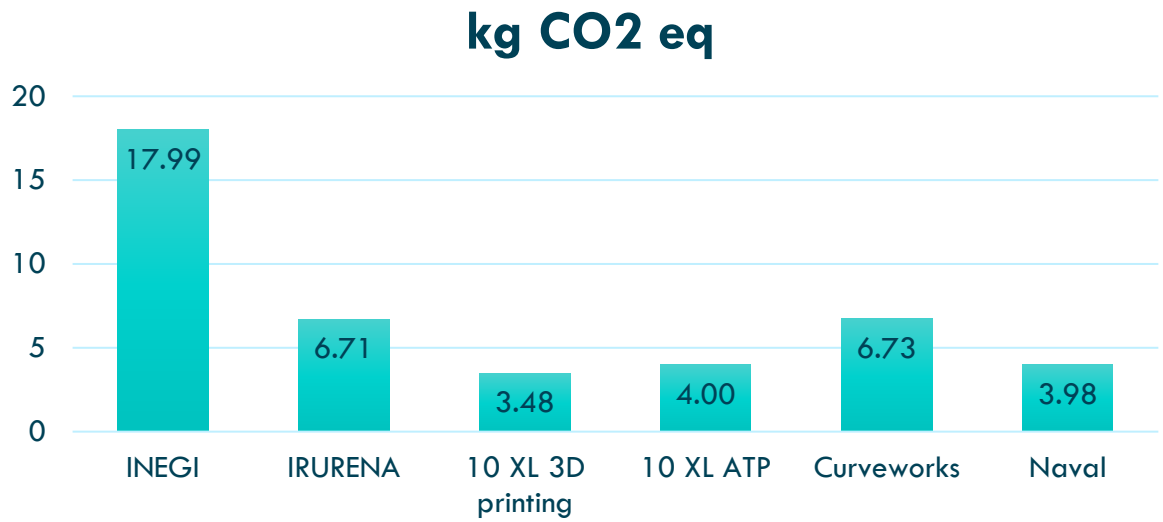
GWP100 for Vacuum Infusion (NAVAL Group)



	%
Glass fibre	40,27
Epoxy resin	27,90
Balsa wood	3,29
Polyester	1,36
Polyamide	5,34
Polypropylene	1,28
Polyethylene terephthalate	0,62
Polyethylene, high density	1,33
Tetrafluoroethylene	3,51
Silicone	1,03
Electricity	0,54
EoL	13,53

Results

Comparison of environmental loads produced by each FIBRE4YARDS technology in CO2 emission, kg eq, EoL included



kg CO2 eq.	
INEGI	17,99
IRURENA	6,71
10 XL 3D printing	3,48
10 XL ATP	4,00
Curveworks	6,73
Naval	3,98

Conclusions

- The work proposed by FIBRE4YARDS project aims **to redefine shipbuilding for small and medium shipyards.**
- With FIBRE4YARDS approach FRP ship construction **will become modular** and will increase its efficiency and quality.
- All technologies developed will be implemented in a new shipyard 4.0, which will be digitally interconnected with all suppliers and technology providers.

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Thank you for your attention!

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