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Eco-Boat building guide

Nauta Morgau ecoboats

SEA TEACH

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Welcome

WELCOME TO ECO-BOATS!

This comprehensive tool is designed to assist you in establishing your eco-boat building company or transforming your traditional boat building practices into eco-friendly ones. The guide is structured around five main areas:

1. Definition of Eco: We begin by explaining what 'eco' means in the context of boat building.
2. Skills Needed for Your Working Staff: Identifying the essential skills required for your team.
3. Eco Methods: Exploring the methods used by partners to enable the usage of more sustainable resources.
4. Eco Materials: Highlighting the materials that contribute to sustainable boat building.
5. Economic and Environmental Considerations: SWOT Analysis, LCA and Sustainable Development Goals.

The Eco-Boats Guide is an integral part of the Eco-Boat Skills Project, funded by Erasmus+ and supported by four esteemed partners: Nauta Morgau, Sea Teach, Innovation Yachts, and Greenboats.

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1. What does ECO mean to us?

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What does ECO mean to us?

For the Eco Boat Skills partners, eco represents a holistic approach aimed at balancing ecological impact, social well-being, and economic growth. This approach ensures that the needs of the present are met without compromising the ability of future generations to fulfill their own needs. Achieving this balance involves adhering to various principles and practices, including:

1 ECOLOGICAL IMPACT

Ecological impact involves prioritizing local production and consumption, known as KM0 (Zero Kilometer), to reduce transportation emissions and support local economies. It also encompasses the 3R approach—Reduce, Reuse, Recycle—which aims to minimize waste by cutting down on consumption, reusing products, and recycling materials to extend their lifecycle. Furthermore, using renewable materials that can be naturally replenished is essential to reduce dependence on finite resources.

2 SOCIAL WELL-BEING

Social well-being involves ensuring generational fairness by making resources and opportunities equitably available across all age groups, thereby promoting fairness and equity. Additionally, it includes holding producers accountable for the environmental and social impacts of their products throughout their lifecycle, from production to disposal.

3 ECONOMIC GROWTH

Economic growth can be fostered by designing durable, long-lasting products that reduce the need for frequent replacement and by creating items that are easily repairable, thus promoting a circular economy and reducing waste.

4 END OF LIFE AND LCA

End of life and life cycle assessment involves evaluating the environmental impacts of a product throughout its entire lifecycle — from raw material extraction to disposal. Additionally, it includes implementing end-of-life management strategies for the responsible disposal or recycling of products, thereby minimizing their environmental impact.

5 ALIGNMENT WITH THE 17 UN SUSTAINABLE DEVELOPMENT GOALS (SDGS)

Alignment with the 17 UN Sustainable Development Goals (SDGs) involves an integrated approach to sustainability that supports goals such as poverty eradication, quality education, clean water, affordable and clean energy, and climate action.

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2. SKILLS NEEDED FOR YOUR WORKING STAFF

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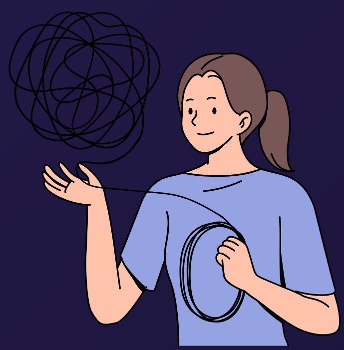
In this section, you will identify the essential skills required for your staff to operate as an "Eco" boat building company.

A series of definitions will be provided, outlining the knowledge, skills, transversal skills, and green skills pertinent to the following professional roles:

- Boat Builder
- Engineer
- Marketing
- Managing Director
- Purchase
- Research and Development (R&D)
- Working Student



The skills for each role are split into four groups, as shown on the next page.

Please note that these positions are specific to the participating boat building companies. Other companies may employ additional or different roles.

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Definitions

01

Knowledge

"refers to familiarity with factual information"

02

Hard Skills

"refer to the ability to apply knowledge to specific situations"

03

Transversal Skills

"personal attributes that enable someone to interact effectively"

04

Eco Skills

"refer to technical knowledge, expertise and abilities that enable the effective use of green technologies and processes in professional settings"

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BOAT BUILDER

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BOAT BUILDER

Knowledge

- Materials
  - Fibers
  - Resins
  - Core materials
  - Their properties and characteristics
  - Their handling: temperature, humidity...
  - Latest bio / eco / sustainable trends
  - Evaluation / identification / comparison of quality and properties
- Construction techniques
  - Hand layup lamination
  - Resin infusion/ vacuum infusion
  - Resin Transfer Moulding
  - Vacuum bagging
  - 3D printing
  - Prepreg
  - Strip-planking
  - Press
- Prototype construction
- Mould construction
- Load flow and load application
- Safety aspects and risk assessment in handling fiber, resin and composites
- Understands the company's sustainable construction system and its added values compared to usual production systems
- Companies work process
- Waste management
  - 3R (reduce, recycle, reuse)
  - Waste sorting
  - Awareness of hazards

Hard skills

- Can read plans
- Can act according to his experience
- Can apply eco methods and products
- Can apply less pollutant oils and varnishes
- Can apply less pollutant paints
- Can assemble parts with different methods
- Can assess the safety aspects
- Can carry out any assigned duty related to boat building
- Can cut / format parts
- Can modify and adjust materials
- Can optimize the use of materials, reuse material left overs
- Can perform handcraft work
- Can prepare materials
- Can drape fiber
- Can handle tissues and fibers
- Can mix resin safely and correctly
- Can evaluate components after visual inspection
- Can produce fiber composites using various techniques:
  - Hand laminate, Vacuum infusion, 3d printers, Press
- Can repair
- Can rework surfaces
- Can sand and fair
- Can ensure vessel compliance with ISO regulations

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BOAT BUILDER

Transversal Skills

- Adaptation of work methods
- Attention to detail
- Can roughly visualize forces
- Communication skills
- Concentration
- Conscientious
- Curious
- Defend own material
- Enthusiastic about technology
- Fascination for natural fibers
- Good humor
- Have a good eye
- Imagination
- Improvise
- Involved with the company and its values
- Open-minded, think outside the box
- Order, cleanliness and organization
- Passion for handcraft
- Patience
- Positive thinking
- Problem solving
- Research skills
- Rigorous
- Safety-conscious
- Teamwork
- Thinks logically
- Time control
- Try and error approach

Eco Skills

- 3R (reduce, recycle, reuse)
    - Waste avoidance
    - Use of left-overs
    - Less loss of material as possible - economic use
- Assess the sustainability of materials - before, during and after production
- Can maintain a boat with sustainable materials
- Change of mindset
- Circularity
- Environmentally positive thinking
- General sense of sustainability in everyday life
- Km0 awareness (local sourcing)
- Knowledge of wood of controlled origin
- Open mind to learn new sustainable techniques

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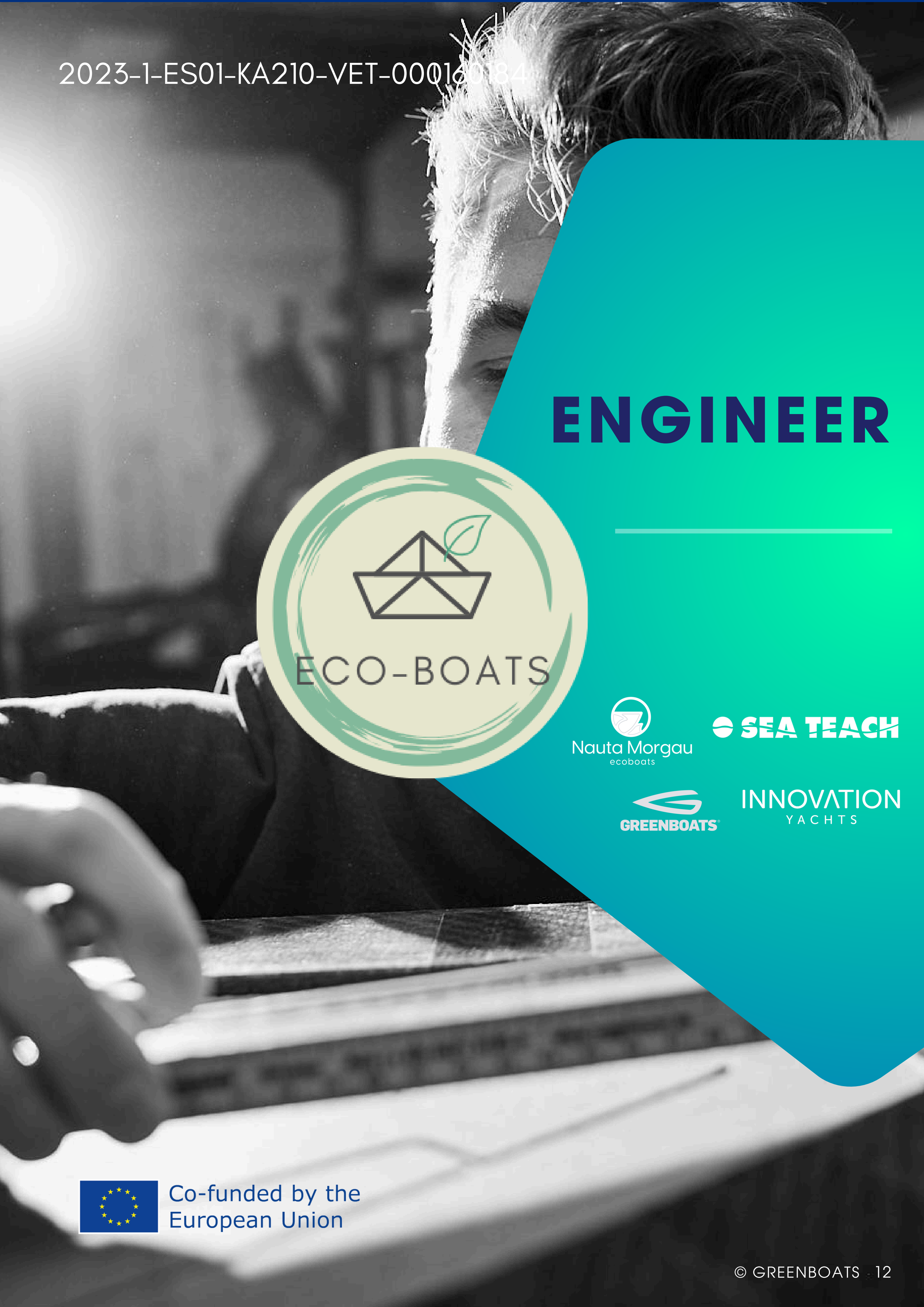

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ENGINEER

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ENGINEER

Knowledge

- Knowledge of design / calculation / construction / building methods
  - Process comparisons
  - Hull and deck, structure
  - Appendixes (keel, rudder, dagger board, foil...)
  - Sail
  - Rig
  - Systems and equipment
- Calculation and design of composite
- Finite element method, structural optimization
- Mechanical test procedures
- Computer fluid dynamics
- Hydrodynamic optimization
- Technical documentation
- CE Certification
- Combining process and engineering, reasonable tolerances
- Quality Control and safety standards
- Research & Development & Innovation: products, techniques and sustainable solutions
- Supply chain
- Knowledge of materials and their application
  - Fiber
  - Resin
  - Core materials
  - Theory of fiber composite materials
  - Bio / eco materials
  - Identification and research of more ecological and potentially recyclable products
  - Contaminating effects
- Maintenance service and winter storage

Hard skills

- Can understand and interpret technical data
- Can analyse and interpret "sustainable" materials
- Can use boat design programs
- Can use various computer programs to calculate metrics, weights and materials
- Can apply computer fluid dynamics
- Can calculate the behaviour of the product
- Can lay out laminates
- Can lay out molds
- Can make technical drawings
- Can develop measurement methods
- Can analyse and interpret the results of experiments carried out in the workshop with new materials
- Can compare processes, has an understanding of resource and energy requirements
- Can assess the health impact of different materials and processes
- Can write risk assessments
- Can carry out workshop construction tasks:
  - Laminating, sanding and shaping
  - Can hand laminate
  - Can vacuum infusion
  - Can use prepregs
  - Can vacuum press
  - Can work with autoclaves
  - Can CNC mill
  - Can work with wood
  - Can produce prototypes / models
  - Can build moulds and knows what to look out for

ENGINEER

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Transversal Skills

- Attention to detail
- Analytical approach
- Complete tasks in a timely manner
- Concentration
- Critical thinking
- Enthusiastic about technology
- Future-orientated way of thinking (especially with regard to processes and materials)
- Sens of design, art
- Imaginative
- Innovative
- Interdisciplinary, mediating
- Knows how and who to ask
- Numerical and logical ability
- Patient
- Pedagogical capacity
- Practically able
- Problem solving and realistic
- Process information, ideas and concepts
- Search capability
- Teamwork
- Techniques and sustainable solutions
- Technical approach
- Think / design innovatively
- Willingness to learn

Eco Skills

- Sustainable boat model design
- Environmental consciousness - importance of sustainability
- Build better quality to get a long-lasting product
- 3R (reduce, recycle, reuse) - waste management
- Bio composites
- Life cycle assessment
- Innovation and new technologies
- Km0 awareness (local sourcing)
- Knowledge of contaminating effects of products
- Laboratory testing, scientific based
- Love for the marine ecosystem
- Passion for sailing
- Production efficiency (sustainable and economic)
- Stay up to date with the latest developments in sustainable boat construction
- Understanding the company's sustainable construction system and its added values compared to usual production systems

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MARKETING

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MARKETING

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Knowledge

- Cost management
- Craftsmanship
- Data analysis (statistics)
- Economics
- Life Cycle Assesemnt
- Life time operational costs
- Marketing
- Polluting effects of fiberglass
- Programs to promote the use of sustainable materials
- Qualitative Approach
- Resource knowledge
- Sustainable products and materials (biocomposites, bio-epoxys...)
- Techniques and the construction process
- transparency
- Types of boats and wood
- Understanding costs
- Values, traditions and maritime culture of the territory.

Hard skills

- Can apply the life cycle as a whole concept
- Can assign value function to the product
- Can carry out catalogs about the boats
- Can create advertising campaigns and promotions
- Can create social media and website content
- Can do cost accounting and management
- Can do event management
- Can engage in business conversations
- Can handle administrative tasks
- Can make company presentations for contests, commercial events, fairs, and institutional events
- Can make financial proposals
- Can search for collaborators and sponsors
- Can write press articles and contact the media
- Holds bachelor's in economics
- Human resources
- Knows how to prepare reports and analyze data
- Knows how to use design tools such as Photoshop, Illustrator, Canva...
- Knows that linear is not the way
- Knows the mission, vision, and values of the company
- Searches for reports on sustainable materials and techniques

MARKETING

Transversal Skills

- Adaptability
- Commitment
- Communication skills
- Creativity and imagination
- Critical thinking
- Empathy
- Enthusiasm
- Involvement with the company and its values
- Management skills
- Motivation
- Open-mindedness
- Patience
- Problem-solving skills
- Responsibility
- Teamwork
- Time management
- Willingness to learn
- Writing skills

Eco Skills

- Circularity
- Innovative
- Non linear thinking
- Open minded
- Respect for the sea and nature
- Sensitivity to the environment

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MANAGING DIRECTOR

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MANAGING DIRECTOR

Knowledge

- 3R: Reduce, Reuse, Recycle
- Different boat types
- Electronics design
- Experience with different materials
- Experimental methods
- fiber composites as high-end materials (glass fiber and carbon fiber)
- Hydraulic systems and their design
- Impact on the boat during use
- Laminate plans and layering
- Market trends
- Master boat builder
- Metal knowledge
- Production and processing of fiber composites
- Reuse of leftovers and materials
- Sandwich effect
- Skilled boat builder for modern boat building
- Strakes and rake curve
- Structure of materials
- Sustainable materials
- Technical drawing
- History of different solutions: why/how
- Use of recyclable materials
- Use of recycled materials
- Wood and its processing

Hard skills

- Can assess resins effectively
- Can build kayaks and modern wooden boats
- Can build moulds
- Can CE certification
- Can design electronics
- Can do bookkeeping (halfway)
- Can plan work processes
- Can process moulding wood
- Can produce fiber composites using the hand layup method
- Can prototype
- Can restore boats
- Can sail
- Can show the importance of ecology and transmit this
- Can simplify procedures
- Can test non-quantifiable (suitability assessment)
- Can train the team
- Can understand and apply rules and regulations
- Can use all manual skills involved
- Can use balsa
- Can use prepregs
- Can use shape bonding and veneer (quasi preliminary stage of fiber composite)
- Can use vacuum infusion
- Has a feeling for dimensions
- Holds a bachelor's in economics

MANAGING DIRECTOR

Transversal Skills

- Attention to detail
- Creativity
- Good handling of machines and tools
- Has a "good eye"
- Has a feeling for shapes
- Has an overview of processes
- Imaginative
- Improvisation skills
- Knows how to use hands and tools effectively
- Motivator
- Organized
- Positive thinker
- Problem-solving skills
- Quick decision-making
- Responsibility for equipment
- Talented craftsman
- Ability to think holistically and complexly

Eco Skills

- Circularity
- Innovative
- Non linear thinking
- Open minded
- Respect for the sea and nature
- Sensitivity to the environment

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ECO-BOATS

PURCHASE

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PURCHASE

Knowledge

- 3R (Reduce, Reuse, Recycle)
- Boat construction
- Composites design
- Biobased materials
- Textiles
- Extensive compsite industry knowledge
- Industry mediation
- Textile manufacturing processes
- Resin expertise
- Theoretical knowledge about sizing

Hard skills

- Can assess suppliers for quality and reliability
- Can critically scrutinize processes and information
- Can differentiate between manufacturing processes
- Can give presentations at trade fairs
- Can identify greenwashing
- Can laminate (including by hand)
- Can make application decisions
- Can evaluate resources to determine suitability
- Can simplify, summarize, and track purchasing processes
- Knows about fabrics and can consider selection criteria to save resin
- Knows about manufacturing techniques and can provide suggestions

PURCHASE

Transversal Skills

- Adaptable, but secure in structures
- Applies knowledge effectively for the benefit of the company
- Communicates in multiple languages
- Creativity focused on processes
- Curiosity
- Open-mindedness
- Problem-solving skills
- Resilience
- Stamina

Eco Skills

- Carbon footprint impact
- Circularity
- Lifespan: residual pieces, degradation, and reuse
- Promoting a corporate attitude
- Short distribution channels (km0)
- Emphasis on sustainability aspects
- Understanding resource usage
- Waste management
- Collaborating with committed partners and suppliers

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RESEARCH & DEVELOPMENT

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RESEARCH & DEVELOPMENT

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Knowledge

- Computer Fluid Dynamics
- Consider the design and construction for the utilisation phase of the life cycle.
- Conventional materials
- Definition of sustainablility
- Estimating loads on components
- Experimental methods
- Finite Element Methode
- How to use less resins
- Identification of eco-products
- Non Destructive Testing
- Plastics knowledge for a shipbuilder, material composition, molecular structure, manufacturing processes
- Research on eco materials, methods or procedures
- Resource consumption
- Shipbuilding construction, interative design processes
- Sustainable materials (applications lightweight construction - fiber composites, bio-based fiber composites, if no lightweight construction then use of fast-growing woods)

Hard skills

- Can analyse team building
- Can and knows where to look for information, e.g. at suppliers
- Can apply solution finding methods
- Can break down and visualise processes
- Can carry out computer fluid dynamics simulations
- Can carry out experimental tests, can carry out long-term application tests, can carry out mechanical measurement methods, can analyse experimental results
- Can design fiber composites
- Can detect greenwashing
- Can draw conclusions about the loads acting on the object from CFD simulations
- Can impart knowledge (present resource requirements clearly)
- Can observe, and analyse processes, and investigate resin consumption
- Can do finite element method (static & dynamic)
- Can perform life cycle analyses, can find and validate data
- Can research on eco materials, methods or procedures
- Can work with motion sensors
- Can use the visual inspection of a component to assess the quality of the surface
- Knows best practices, quality control quality gates and can apply them

RESEARCH & DEVELOPMENT

Transversal Skills

- Attention to detail
- Can take on responsibility
- Confidence in methods
- Enthusiasm
- Likes to teach
- New try and error
- Project management
- Questioning things, values
- Role finding
- Seeing the skills of others and transferring them to yourself
- Solution-orientated
- Step out and let others do it
- Take personal responsibility
- Team player

Eco Skills

- Be aware of energy consumption in the process
- Bio-based not oil-based
- Breaking out of old patterns in terms of sustainability
- Carbon footprint impact, takes part in life
- Circularity
- Energy consumption
- Environmentally positive thinking
- Eutropication
- Future-orientated
- How to solve things
- Interest in teaching
- Km0 awareness
- Laboratoy testing scientific based
- Lifespan of products, long, not necessarily circular
- Toxicity
- Water consumption

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WORKING STUDENT

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WORKING STUDENT

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Knowledge

- Biomimetic optimasiation approaches for lightweight construction
- Biomimetics
- CAD
- Computer Fluid Dynamics
- Conventional materials
- Corrosion and corrosion protection
- Design and construction as important phases within the life cycle of a product
- Design methodology product development
- Experimental methods
- Extended Products
- fiber reinforced plastics mechanics
- Finite Element Methode
- Identification of eco-products
- Life cycle assesments
- Non Destructive Testing
- Plastic knowledge
- Production of fibers
- Prodution of fiber reinforced plastics
- Research on eco materials, methods or procedures

Hard skills

- Can do Hand Layup (material testing scale)
- Can analyse experimental results
- Can carry out experimental tests
- Can carry out mechanical measurement methods
- Can do Vacuum infusion (scientific approach, including determination of fiber volume content, (material testing scale))
- Can research on eco materials, methods or procedures
- Can write risk assessments

WORKING STUDENT

Transversal Skills

- Critical thinking
- Curious
- eager to learn new stuff
- interdisciplinary
- Practically able
- Project managment
- Team player
- Tolerance of frustration

Eco Skills

- Is aware of energy consumption in the process
- Carbon footprint impact
- Energy consumption
- Environmentally positive thinking
- Eutropication
- km0 awareness
- Waste management
- Water consumption

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3. ECO METHODS & PRACTICES

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METHODS
INTRODUCTION

In this section, we present methods and practices currently employed by the project partners. While these approaches reflect common processes in the manufacturing of fiber-reinforced composites, they are not listed step by step. Instead, we provide an overview of the key advantages and disadvantages identified by the partners. It is important to note that these insights are shared as observations and considerations, not as definitive recommendations or sustainability benchmarks.

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Additionally, we aim to provide specific know-how about natural fibers, which are among the materials discussed in this guide. Natural fibers, unlike glass or carbon fibers, have unique characteristics that must be carefully considered during processing. For instance, they are hydrophilic, meaning they can absorb resin and swell. To ensure high laminate quality, natural fibers should ideally be processed in a closed system, such as vacuum infusion, to control resin uptake and achieve optimal structural performance.

By highlighting these practices, we hope to offer practical insights while encouraging readers to evaluate and adapt these methods to suit their specific needs and sustainability goals.

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For natural fibers, use a closed process (e.g., vacuum infusion) to prevent swelling because of resin absorption and ensure laminate quality.

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METHODS
VACUUM INFUSION

Description of the method

Vacuum infusion is widely used in boatbuilding for its ability to improve laminate quality and material efficiency. When applied correctly, it offers sustainability benefits, particularly in reducing material waste and improving working conditions. However, some environmental challenges remain, mainly related to single-use materials and energy consumption.

Advantages and Disvantages of the process

--> Advantages

- More **efficient** resin distribution: Reduces resin waste and material consumption.
- **Higher part quality:** Fewer voids, improved mechanical properties compared to hand-lamination, particularly beneficial for natural fiber composites.
- Reduced worker exposure to VOCs: The closed process minimises direct contact with resin fumes. However, VOCs are still emitted via the vacuum pump, so filtration or ventilation systems are advisable.

--> Disadvantages

- High consumption of disposable materials: Vacuum bags, sealant tapes, and flow media generate waste. Alternative: Reusable silicone membranes.
- Process complexity & training requirements: Proper preparation is essential to prevent leaks and resin flow issues.

Vacuum infusion is a alternative to hand lay-up, offering better material efficiency, improved laminate quality, and reduced worker exposure to VOCs. However, its environmental impact depends on minimising single-use materials. By integrating bio-based resins and reusable tooling, boatbuilders can further enhance the sustainability of this process.

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METHODS
HAND LAMINATION

Description of the method

The method uses a rigid base structure coated for adhesion, natural fibers like flax or hemp, and bio-based resin. Resin is applied to the structure, fibers are placed and saturated with resin using rollers, and air bubbles are removed. Layers are added until the desired thickness and strength are achieved, with reinforcements in critical areas for durability.

Advantages and Disadvantages of the process

--> Advantages

- **Sustainability:** reduced disposable materials compared to vacuum infusion.
- **Customization:** Allows for unique shapes to be created directly on the base structure.
- **Lightweight:** Natural fibers are lightweight and, when combined with resins, produce strong components.

--> Disadvantages

- **Laminate Quality:** Hand lamination does not bring out the best quality in a laminate. This is mainly due to the lack of pressure. The fiber volume ratio is relatively low with this method compared to vacuum infusion or RTM processes. An improvement can be achieved if, for example, a vacuum is subsequently drawn over the laminate. This can help to reduce pores in the laminate.

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METHODS
TRADITIONAL BOATBUILDING

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The traditional boatbuilding varies according to the region, the natural resources available, the navigation needs and the culture of each area. Broadly speaking, we could differentiate them according to:

- Materials used: wood, reeds, bamboo, skins stretched over bone frames, hollow logs or planks sewn with vegetable fiber.
- Boatbuilding techniques: clinker, carvel, sewn planks, monoxile canoes.
- Design and shape: drakkars, reeds, dhows, cattails, Egyptian boats...

© Keops solar boat.
Olaf Tausch / CC BY 3.0

© Totora reed fishing boats on the beach at Huanchaco, Peru
Roy & Danielle

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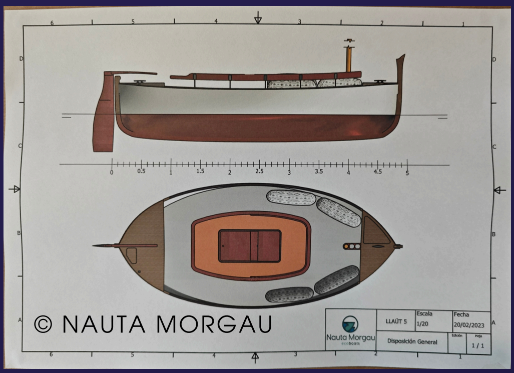
METHODS
TRADITIONAL BOATBUILDING

However, they all have in common the use of local materials, techniques handed down from generation to generation, adaptation to sailing conditions and the use of traditional hand tools.



To transform traditional boatbuilding into "eco-boatbuilding", artisanal techniques and ancestral knowledge must be maintained while incorporating ecological principles that reduce environmental impact.

Among the strategies to be applied are:

- **Use of sustainable and renewable materials:** certified or reforestation woods, vegetable alternatives, use of waste, ecological adhesives and paints....
- **Low-impact construction methods:** traditional techniques with less mechanization, heavy metal-free joints, design optimization, etc.
- **Recovery of ancestral knowledge with ecological innovation:** revitalizing traditional methods, training and transmission of knowledge, use of clean technologies...

Traditional Eco-Boatbuilding not only preserves the history and art of traditional shipbuilding, but also adapts it to today's environmental needs, guaranteeing sustainable vessels for the future.

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4. ECO MATERIALS

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MATERIALS
INTRODUCTION

In this section, we provide an overview of the materials used by the project partners, along with their typical applications in boatbuilding. While these materials offer interesting possibilities, it is important to note that their use does not inherently guarantee improved sustainability. **Selecting the right material requires careful consideration of its properties, application, and lifecycle.**

We encourage you to engage with these materials - don't hesitate to ask questions, request samples, or experiment with them in your projects. Understanding how a material behaves in practice is a crucial step toward integrating it into your work effectively.

As always, material selection should be guided by thoughtful evaluation. One of the most effective tools for this is a Life Cycle Assessment (LCA). By analysing the environmental impact of a material across its entire lifecycle, from production to disposal, you can make more informed decisions. For example, while a bio-based fiber might seem like a sustainable choice, certain scenarios could make another fiber more suitable depending on your goals.

The materials presented in this section reflect a range of possibilities for modern boatbuilding, but it is important to note that not every material will be suitable for every boat or builder. The choice of materials depends heavily on the type of boat being built, the builder's approach, and the intended application.

Key Considerations

To help you navigate this diversity, here are some points to keep in mind:

- **Material Suitability**: Consider whether the material fits your boat type and purpose (e.g., traditional vs. modern designs).
- **Application Area**: Structural vs. non-structural use - materials like natural fibers might work better in interiors than in load-bearing components especially if the processing process is not yet fully developed.
- **Sustainability Goals**: Assess how the material aligns with your environmental priorities.
- **Experimentation**: Don't hesitate to test new materials - request samples and try them in smaller projects before scaling up.

Tip: Use a Life Cycle Assessment (LCA) to evaluate materials comprehensively. This tool helps balance environmental impact and application needs.

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FIBERS
MINERAL - VOLCANIC

Description

When magma reaches the earth's surface, it cools down and the newly formed rock contains tiny minerals. Several minerals get selected according to a recipe, melted and then pulled into mineral fibers.

Volcanic fibers are different volcanic rocks, ground, mixed according to a recipe, melted and then pulled into fibers.

Both fiber types can be customized in terms of mechanical properties to suit the project demands.

Material Properties

- As the fiber is made out of rocks, it resists perfectly our environment – the sunlight (UV) and rain, water and even acids.
- It doesn't absorb water (hydrophobic) so together with the correct resin there is no problem like osmosis.
- It's a nice and safe material to work with as it's smooth in the hand (not spikey, skin neutral) and the particles are big enough not to go into the lungs.
- At the same time rocks have a hard surface, ironically, they are very well shock absorbing which is great in case of collisions.
- It has a high tensile and compressive strength.

- It has the same density as glass but takes more loads so can be lighter dimensioned.
- Further it is an excellent heat protection, as it's resistant up to 850 °C. The melting temperature is around 1520 °C.
- Finally, the fiber is fully recyclable, as it can be melted again and a new fiber might be made out of it at the same quality level.

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FIBERS
MINERAL - VOLCANIC

Material Properties

Fully recyclable - Skin neutral - Hydrophobic - Acid resistant - UV resistant - Hard surface - High tensile - and compressive strength - Temperature resistant up to 850 °C

Sustainability:
Mineral fiber is a natural product, available in huge quantities, harmless to health and fully recyclable.

In summary there is also a significantly lower carbon footprint compared to synthetic alternatives such as glass or carbon fibers.

Processing

Available Forms
Mineral / Volcanic fibers are available as woven fabrics, non-crimp fabrics, fire-barrier prepregs, needlefelt, chopped strands, meshes etc. and this in many different areal weights.

Resin Systems
Mineral / Volcanic fibers are best used with bio-based epoxy resin for an optimized strength performance, osmosis resistance and the lowest environmental impact.
Whereas, according to the sizing, they are also compatible with common resin systems such as:

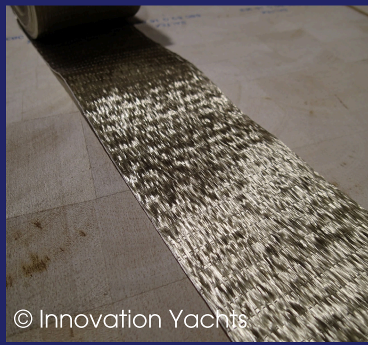
- Polyester
- Vinyl ester
- Epoxy

Processing Techniques
Mineral / Volcanic fibers can be processed using established fiber composite methods, including:

- Hand layup lamination
- Vacuum infusion
- Prepreg techniques

As the fiber is a “rock”, its hard surface makes it necessary to use high quality tools, because of it’s highly abrasive and blunting caracter.

Volcanic fiber UD tape



Lamination IY LBV35

IY Open60AAL Innovation Yachts

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FIBERS
FLAX

Bast fibers from the Flax Plant *Linum usitatissimum*

Description

Flax fibers, also known as linen fibers, are gaining increasing significance in boatbuilding as a sustainable alternative to conventional fiber-reinforced composites. These natural fibers combine solid mechanical properties with ecological benefits, making them particularly attractive for innovative boatbuilders. However, they differ in many aspects from commonly used glass fibers, which should be taken into account during processing and application.
For more detailed information, refer to (1).

Material Properties

Raw Material Origin:
Flax fibers are derived from the stems of the flax plant (*Linum usitatissimum*), which is primarily cultivated in temperate climates, such as France. The plants require approximately four to six months to reach harvest.
fiber extraction involves several steps:

1. Retting: The stems are exposed to weather conditions, allowing microorganisms and moisture to break down the plant tissue and release the fibers. This process takes several weeks.
2. fiber Extraction: After retting, the bast fibers are separated from the stem.
3. Further Processing: The fibers are bundled and then spun into rovings, usually with a slight twist for added stability. Finally, the rovings can then be woven.

Sustainability:
Flax fibers are a renewable resource with a significantly lower carbon footprint compared to synthetic alternatives such as glass or carbon fibers.

Mechanical Properties:
The mechanical properties of flax fiber bundles, processed rovings, or fabrics can vary depending on the manufacturer and growing conditions. It is advisable to consult suppliers for specific material properties or collaborate with research institutions to test the desired characteristics in composite applications.
Flax fibers are not yet comprehensively listed in material databases. Alternatively, scientific publications provide a good source of information on mechanical parameters.

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FIBERS
FLAX

Damping Properties:
Due to their internal structure, flax fibers possess excellent damping properties. The fibers contain lumens (hollow spaces within the fiber cells) that effectively absorb vibrations and oscillations.

Moisture Sensitivity:
Flax fibers are hygroscopic, meaning they absorb moisture from the environment. This water uptake leads to fiber swelling, which can negatively affect mechanical properties and fiber-matrix adhesion in composites.

Processing

Available Forms:
Flax fibers are available as fabrics, non-crimp fabrics, and prepregs in various areal weights. Their price can fluctuate due to cultivation cycles and fashion trends (e.g., linen textiles in the clothing industry) affecting availability.

Resin Systems:
Flax fibers are compatible with common resin systems such as:

- Polyester
- Vinyl ester
- Epoxy

Processing Techniques:
Flax fibers can be processed using established fiber composite methods, including:

- Vacuum infusion
- Prepreg techniques
- Compression moulding

For high-quality results, closed-mould processes are preferred.

FLAX27

GREENLANDER SHERPA

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FIBERS
FLAX

Specific Challenges in Processing

- **Resin Absorption & Swelling**: Flax fibers tend to absorb large amounts of resin and swell in the process. Without sufficient pressure during processing, this can lead to a low fiber volume fraction and increased porosity in the laminate, negatively impacting mechanical performance.
- **fiber Lengths**: Flax rovings do not consist of continuous fibers but rather fiber bundles with a maximum length of approximately 1 metre. This becomes evident when pulling apart a roving, as it will separate.
- **Moisture Absorption**: Since flax fibers absorb moisture, they should be dried before processing. Drying at around 60 °C for afew hours is ideal. Alternatively, applying vacuum for an extended period before resin infusion can help.

In conclusion, don't be discouraged by the challenges — Flax fibers are an exceptional resource that can be handled with confidence. As demonstrated by Greenboats' Flax27 and MB9, as well as the pressed flax fiber panels used in the Sherpa, this material offers impressive structural integrity and can achieve the desired stiffness when used correctly. With the right approach, flax fiber is not only a viable alternative to conventional materials but also a highly practical and sustainable choice for modern boatbuilding.

Further reading: [2]

MB9

FIBERS
BAMBOO

Introduction

Bamboo fiber is gaining attention as a sustainable alternative for boat construction due to its high strength-to-weight ratio, flexibility, and low environmental impact.

Structural Reinforcements (Hulls)

The use of bamboo fibers for fiber composites has recently been discussed. There are already initial attempts to use the fibers for fiber composites in the hull (14).

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However, the initial tests are limited to a few examples. Advantages that have been recognized in the fibers are high stiffness compared to the mass, good resistance to media and UV as well as the possibility of further processing textiles made of bamboo fibers into fiber composites using conventional processing methods. However, it should be noted that textiles made from bamboo fibers are the exception rather than the standard and are therefore still in the development phase.

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WOOD
BIRCH

Description

Birch is a hardwood with high density, originating from trees of the Betula family. It is known for its strength and durability. It has a fine and uniform grain, perfect for smooth and elegant finishes.

Sustainability Aspects

- **Origin**: From temperate and boreal regions, mainly in Europe, North America, and Asia.
- **Environmental Benefits**:
  - It is a fast-growing species, making it more sustainable compared to slow-growing tropical woods.
  - Birch is typically abundant and easier to replenish if sourced from sustainably managed forests.

- **Disposal/Recycling**: It is biodegradable.

Technical Properties

- The **density** of birch is relatively consistent, ranging from 640 to 710 kg/m^3, making it lighter than high-density hardwoods like oak or teak. This characteristic makes it easier to work with and suitable for interior or decorative applications.

- Birch has low natural durability against fungi, termites, and insects, limiting its use in outdoor or humid environments without treatment. However, its **high treatability** allows it to be protected with chemical products, making it more suitable for specific applications where additional durability is required.

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WOOD
ASH TREE

Description

Ash wood comes from trees of the *Fraxinus genus*. European ash is renowned for its high quality, elasticity, and uniform grain, making it especially valuable for nautical and carpentry application.

Sustainability Aspects

- **Origin**: From Western, Central, and Eastern Europe. The countries with the highest production include France, Germany, Poland, Ukraine, and the Baltic States.
- **Environmental Benefits**:
  - Local origin: Its availability in many parts of the world helps minimize carbon footprints by sourcing locally, especially for shipyards in Europe and North America.
  - Long lifespan: When properly treated, ash can last for decades in nautical environments, reducing the need for frequent replacements.
- **Disposal/Recycling**: It is biodegradable.

Technical Properties

- Strength and Hardness: High mechanical strength, comparable to oak but more elastic, ideal for structural and wear-prone nautical components.
- Elasticity: Highly flexible, suitable for stress-absorbing applications like oars, curved beams, and hull parts.
- Workability: It is easy to cut, shape, and sand, making it suitable for detailed designs or custom pieces.

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WOOD
CANADIAN CEDAR

Description

Canadian cedar, also known as Pacific red cedar (*Thuja plicata*), is one of the most widely used woods in naval construction due to its physical, mechanical, and natural properties that make it suitable for marine environments.

Sustainability Aspects

- **Origin**: Pacific red cedar is native to the western coast of North America, particularly in British Columbia (Canada) and the northwestern United States.
- **Environmental Benefits**:
  - Processing: Its ease of workability reduces energy consumption during processing, contributing to a lower ecological footprint.
  - Canadian cedar has high resistance to decay, insects, and moisture, reducing the need for additional chemical treatments.
- **Disposal/Recycling**: It is biodegradable.

Technical Properties

- Lightweight: Low density, improving vessel maneuverability and buoyancy.
- Durable: High natural resistance to external agents and salinity, ideal for marine environments.
- Customizable: Easy to work with for intricate designs.
- Long-lasting: Extends vessel lifespan, reducing maintenance and replacements.

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CORES
BALSA

Description

Balsa wood is a natural, very pressure-resistant wood with a low density which, due to its properties, is often used as a core material in sandwich constructions in boat building.

Material Properties

Raw Material Origin:

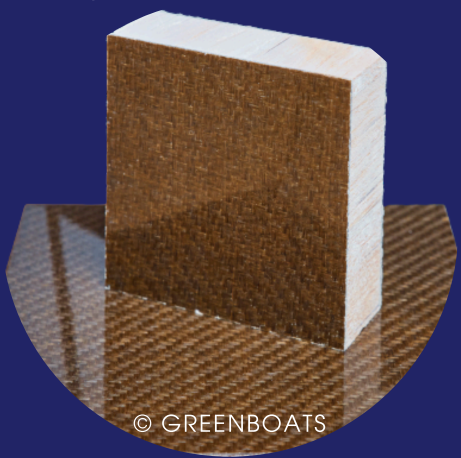
Balsa wood is mainly obtained from the balsa tree (*Ochraoma pyramidale*), which is native to South America. This tree is known for its extremely rapid growth and can reach a height of up to 30 metres and a diameter of around 45 cm in just five to seven years (3).

Sustainability Aspects

The harvesting of balsa wood is not without controversy. Although balsa wood is considered a fast-growing and renewable material, there are concerns about the ecological impact of large-scale cultivation and harvesting. In some cases, it is reported that rainforest areas are cleared for the cultivation of balsa wood, which leads to a loss of biodiversity. In addition, intensive cultivation can lead to soil degradation and other ecological problems.

Transport routes:
Balsa wood is mainly grown in South America, particularly in Ecuador, and often has to be transported over long distances to reach global markets. This transport route contributes to CO_2 emissions and reduces the environmental benefits of the material. Transport is usually by ship, which is more efficient than air transport, but still leaves a significant environmental footprint (4).

Possible certifications:
To ensure the sustainability of balsa wood extraction, there are various certifications that ensure the wood comes from responsibly managed forests.



The most important certifications include:

- FSC (Forest Stewardship Council): Guarantees that the wood comes from sustainably managed forests and that social and ecological standards are met.

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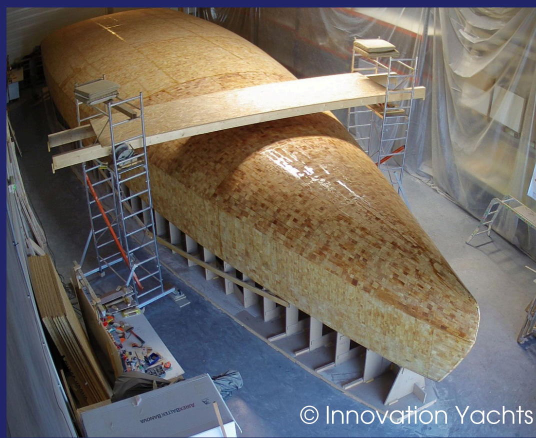
- PEFC (Programme for the Endorsement of Forest Certification): Similar to FSC, it ensures that the wood comes from sustainably managed sources and that the forests are preserved in the long term.

Mechanical properties:

- Density: Typically ranges from 40 to 340 kg/m^3
- Strength-to-weight ratio: Exceptionally high, making it ideal for lightweight yet sturdy constructions
- Compressive strength: Outstanding, particularly when cut in end-grain orientation

Moisture Behavior:

Balsa wood is susceptible to moisture absorption. Inadequate sealing can lead to water absorption and associated damage, which can compromise structural integrity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Processing of Balsa in Boat Building

Available Forms:

Balsa wood is available in sheets from 3 to 50 millimetres thick or in cube form, with the latter being bound by a mesh backin.

Advantages and Disadvantages

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Advantages:

- Low mass with high compressive strength
- Good insulation and damping properties
- Renewable raw material
- Easy to process

Disadvantages

- Susceptibility to moisture damage
- Need for careful sealing
- Possible restrictions in extreme weather conditions

Balsa wood is a versatile and sustainable core material for sandwich constructions in boat building. Its unique properties make it an attractive option for many applications, especially where lightness and strength are required. However, the use of balsa wood requires careful processing and protection from moisture to fully utilise its benefits. When used correctly, balsa wood can be an excellent choice for modern, high-performance and environmentally friendly boat designs.

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CORES
CORK

Description

Cork is a versatile material derived from the bark of cork oak trees, increasingly used as a decking material in boat construction. Its unique properties make it an attractive alternative to traditional materials, offering a blend of functionality, comfort, and eco-friendliness.

Material Properties

Raw Material Origin:

Cork is harvested from the bark of cork oak trees (*Quercus suber*), primarily grown in the Western Mediterranean region. The bark is carefully removed every 9 years without harming the tree, allowing for multiple harvests throughout the tree's lifetime (5).

Sustainability:

Cork is considered sustainable due to its renewable nature. A single cork oak tree can provide 10 to 12 harvests over its lifespan, absorbing significant amounts of CO_2 in the process. This makes cork an excellent choice for environmentally conscious boat builders and owners (5).Another advantage is the relatively short transportation route, thanks to cultivation in the EU

Moisture Behavior:

Cork is naturally hydrophobic with low wettability towards polar liquids like water (5). This characteristic makes it resistant to water absorption and rot, crucial for marine applications (3). however, different additives and plastics/glue are usually added for the final use, so that the original properties of the cork may differ.

CORES
CORK

Processing of Cork in Boat Building

Available Forms:

Cork is available in various forms for boat decking:

1. Cork agglomerates: Compressed cork granules formed into sheets or panels.
2. Spray-on cork: A specialized form that can be applied to hulls and other surfaces.
3. Pre-cut cork decking kits: Tailored for specific boat models or custom applications.

Advantages and Disadvantages

Advantages:

- Non-slip surface: Cork provides excellent traction, even when wet, enhancing safety on deck
- Thermal regulation: Cork remains cool in hot weather and provides insulation in cold conditions.
- Durability: Resistant to UV exposure, saltwater, and harsh marine environments.
- Low maintenance: Requires minimal upkeep compared to traditional materials like teak.
- Lightweight: Cork's has a relatively low density.

Disadvantages

- Cost: Cork can be expensive, comparable to exotic woods used in boat building.
- Aesthetic considerations: Some may perceive cork as less noble or traditional compared to wood decking.
- Limited long-term data: While durable, there's less historical data on very long-term performance in marine environments compared to conventional materials

In conclusion, cork offers a compelling combination of performance, comfort, and sustainability for boat decking. Its unique properties address many challenges in marine environments, making it an increasingly popular choice among boat builders and owners seeking eco-friendly and functional alternatives to traditional decking materials.

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CORES
RECYCLED PET

Description

Recycled polyethylene terephthalate (rPET) is derived from post-consumer PET products, such as plastic bottles. In boat construction, rPET is utilised as a sandwich core material, providing a lightweight alternative to traditional core materials like balsa wood and PVC foam. Its use in boat building offers specific advantages, including environmental benefits, cost-effectiveness, and desirable mechanical properties.

Material Properties

Raw Material Origin:

Recycled PET is mainly obtained from used PET bottles and other packaging materials. This waste is collected, cleaned and converted into new PET products through mechanical or chemical recycling (6).

Sustainability:

Recycled PET is a circular product. Depending on how it is processed, there is no need to use fossil raw materials, which reduces the need for new fossil raw materials.

Mechanical properties:

rPET foams are available in many different configurations. Their density can vary from 65 to 200 kg/m³. As a result, the compressive strength and flexural modulus also differ (7).

Moisture Behavior:

rPET has low water absorption rates, which helps prevent moisture-related issues such as rot and degradation (8).

CORES
RECYCLED PET

Processing of Agave Wood in Boat Building

Available Forms:

rPET is available in various forms, including sheets, blocks, and structural foams. These forms can be easily integrated into composite structures, providing flexibility in design and construction.

Processing Techniques:

Recycled PET can be integrated into sandwich structures using various common techniques such as vacuum infusion and hand lamination. These techniques allow the material to be precisely customised to the desired structural shape.

Advantages and Disadvantages

Advantages:

- Mass Efficiency: When optimised, rPET can provide a good strength-to-weight ratio
- Versatility: rPET can be used in various parts of the boat structure, including hulls and bulkheads
- Recyclability: Unlike conventional composites, rPET is fully recyclable, allowing for better end-of-life options for boats.This is possible in theorie. In the sandwich composite, however, the adhesive and cover layers must first be removed to enable separation by type.
- Mechanical Properties: rPET offers high resistance to process temperatures, exceptional chemical resistance and good mechanical properties

Disadvantages

- Shear Strength: Current rPET foams may have lower shear strength compared to traditional PVC cores, sometimes necessitating higher densities or hybrid solutions with PVC for structural applications.

In conclusion, recycled PET as a sandwich core material in boat building offers a promising balance between sustainability and performance. While it presents some challenges in terms of shear strength and potential weight increases, its environmental benefits and good mechanical properties make it an attractive option for boat builders looking to reduce their ecological footprint. As the technology continues to evolve, we can expect further improvements in rPET's performance, potentially leading to its wider adoption in the marine industry.

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CORES
AGAVE CACTUS

Description

The material commonly referred to as agave wood in boatbuilding and surfboard construction is not wood in the botanical sense. Most Agave plants are monocotyledons and lack a vascular cambium, meaning they do not produce secondary xylem—the defining tissue of true wood.

Instead, the core material is derived from the flowering stalk (inflorescence stem) of the agave plant, a robust, fibrous structure that supports the reproductive part of the plant. This stalk exhibits wood-like properties such as low density and significant strength, making it an attractive candidate for lightweight core applications in marine composites.

Thanks to its structural behavior and ecological benefits, this plant-based material is gaining traction as a sustainable alternative to conventional foam and balsa cores.

Material Properties

Raw Material Origin:

Agave wood is sourced from the agave plant, which thrives in arid environments, particularly in regions like Mexico, the southwestern United States and parts of Africa. The flowering stalk used for core material is a by-product of fiber production, typically harvested once the plant matures (after 7–12 years) and begins its single, dramatic bloom. Grow Blanks Ltd sources its agave from one of the world's largest sisal fiber-producing farms in Kenya. (9, 10)

Sustainability:

The plant requires minimal water and thrives in poor soil conditions, making it ideal for arid regions. Agave farming promotes biodiversity, conserves water, and sequesters carbon, contributing to ecological balance (9, 10).

Grow Blanks Ltd emphasises the use of organic waste from large-scale sisal farms to create eco-friendly products, supporting local communities and reducing environmental impact. Eco Surf Supply highlights that agave blanks are made from the flowering stem of the agave plant, which is a by-product of fiber production, ensuring zero waste (11).

Mechanical properties:

Agave stalk material exhibits high strength and low density, making it suitable for lightweight applications. While comprehensive data for marine use is limited, studies on agave leaf fibers suggest promising properties such as high tenacity and specific stiffness (12).

Moisture Behavior:

Agave is hygroscopic, meaning it absorbs and releases moisture based on environmental conditions. Proper sealing and treatment are essential to prevent moisture-related issues such as swelling or rot.

Processing of Agave Wood in Boat Building

Available Forms:

Agave stalk can be processed into various forms, including planks, strips, and veneers, suitable for different construction techniques (9, 10). Grow Blanks Ltd produces agave blanks for surfboards, which could be adapted for boat building (9). Eco Surf Supply offers agave blanks in various sizes, from small kiteboards to large SUP boards (11).

Processing Techniques:

Agave stalk can be integrated into sandwich structures using methods like vacuum infusion or hand lamination. Eco Surf Supply notes that agave blanks can be CNC-milled or hand-planed, and should be sealed before laminating to prevent resin absorption (10).

Advantages and Disadvantages

Advantages:

- Lightweight and Strong: Ideal for enhancing boat performance.
- Sustainable: Environmentally friendly and promotes biodiversity.
- Good Insulation and Damping: Reduces noise and vibrations.

Disadvantages

- Moisture Sensitivity: Requires proper sealing to prevent swelling and rot.
- Limited Data: Less established in the industry, with limited performance metrics.

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MATRIX
BIO-EPOXY

Introduction

Bio-based resin systems are emerging as promising matrix materials for fiber-reinforced composites in boatbuilding, offering a more sustainable alternative to conventional petrochemical-based resins. These systems are derived from renewable resources and provide ecological benefits while maintaining comparable mechanical properties to traditional resins.

Material Properties of Bio-Based Resin Systems

Raw Material Origin:

Bio-based resins are primarily derived from renewable plant-based sources. For example, epoxidized linseed oil, serve as precursors for bio-based epoxy resins. These materials represent a shift from fossil fuel-based precursors toward renewable resources.

Sustainability:

The use of bio-based resins offers ecological benefits:

- Reduced carbon footprint: Bio-based resins can contain up to 51 % bio-based carbon content (resin only), potentially lowering CO_2 emissions compared to petrochemical alternatives (13).
- Renewable resources: The raw materials are derived from plants, which are renewable.

However, it's crucial to assess the entire value chain critically. The cultivation of crops for bio-based resins may compete with food production or lead to land-use changes. Additionally, the processing and transportation of these materials still contribute to environmental impact.

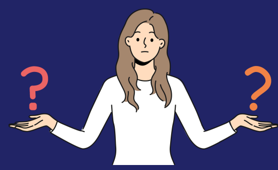
MATRIX
BIO-EPOXY

Processing of Bio-Based Resin Systems in Boatbuilding

Processing Techniques:
Bio-based resins can be processed using common composite manufacturing methods:

- **Vacuum infusion**: Particularly suitable due to low viscosity and good wetting properties
- **Hand lay-up**: Feasible but may require adjustments in working time
- **Resin Transfer Molding (RTM)**: Possible with proper viscosity control

Differences and Similarities with Conventional Resin Systems



Differences:

- Origin of raw materials
- Potentially lower environmental impact
- In some cases, slightly lower glass transition temperatures

Similarities:

- Mechanical properties (strength, stiffness)
- Processing characteristics (viscosity, cure times)
- Chemical resistance

Conclusion

Bio-based resin systems represent a promising development in sustainable boatbuilding materials. They offer comparable mechanical properties to conventional petrochemical-based resins while providing ecological benefits through their renewable resource base and potential for reduced carbon footprint. However, the overall ecological impact must consider the entire life cycle, including crop cultivation and processing. Economically, bio-based resins can be more expensive than conventional alternatives, which may limit their adoption in large-scale manufacturing. As production scales up and technology advances, this cost differential is expected to decrease. Performance-wise, many bio-based resin systems have demonstrated properties comparable to conventional systems in terms of strength, stiffness, and processing characteristics.

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THERMOPLASTICS
INTRODUCTION
TYPES & USES

Thermoplastics are a group of plastics that are widely used in boat interiors. Innovations in this area are thermoplastics that are not based on fossil resources like conventional plastics, but on polymers obtained from renewable resources. Generally, thermoplastics can offer advantages over traditional materials thanks to their recyclability and reprocessability. These materials can reduce & minimize waste and optimize the use of resources, thus contributing to the development of more environmentally friendly boats aligned with the principles of circular economy and sustainability.

SOME EXAMPLES


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Polylactic Acid (PLA)

Biodegradable and bio-based thermoplastic polymer delivered from renewable resources such as corn starch, sugarcane, or cassava.

✅ ADVANTAGES

- Biodegradable
- Renewable origin
- Lightweight
- Versatile
- Safe for food contact
- Additive manufacturing

❌ DISADVANTAGES

- Requires industrial composting facilities for proper degradation.
- Lower heat resistance compared to other plastics.
- More expensive than conventional petroleum-based plastics.

🌊 Use in Sustainable Boat Building

- Non-structural elements
- Interiors
- Lightweight equipment

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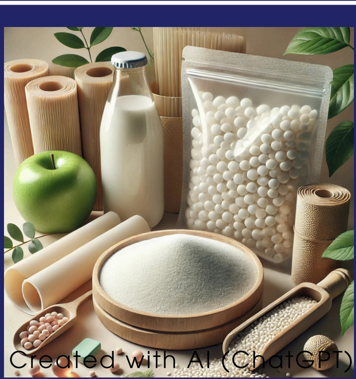
THERMOPLASTICS
INTRODUCTION
TYPES & USES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Polyhydroxyalkanoates (PHA)

Biodegradable polymer produced by bacteria through fermentation of organic waste

ADVANTAGES

✅ Fully biodegradable under natural conditions.
✅ Leaves no toxic residues
✅ Bio-based
✅ High biocompatibility

DISADVANTAGES

❌ High production cost
❌ Limited availability
❌ Lower mechanical strength compared to synthetic plastics

Use in Sustainable Boat Building

- Medical applications
- Disposable interior products


Created with AI (ChatGPT)

Recycled High-Density Polyethylene (rHDPE)

Recycled material from industrial and consumer waste, highly resistant and durable.

ADVANTAGES

✅ 100% recyclable
✅ Durable, chemical-resistant, lightweight, strong
✅ UV radiation-resistant, suitable for corrosive enviroments

DISADVANTAGES

❌ Non-biodegradable
❌ Requires adequate recycling infrastructure
❌ Quality degradation after multiple recyclings

Use in Sustainable Boat Building

- Structural components
- Piping systems, tanks...
- Marine buoys

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THERMOPLASTICS
INTRODUCTION
TYPES & USES

ECO-BOATS

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Recycled Polypropylene (rPP)

Recycled polymer obtained from industrial or consumer waste, known for its strength and versatility.

ADVANTAGES

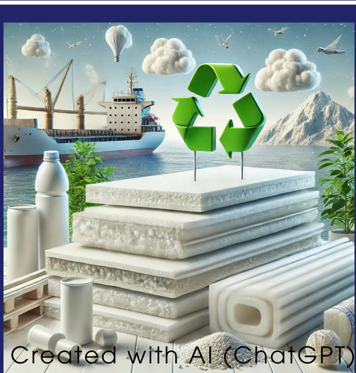
✅ 100% recyclable
✅ High strength-to-weight ratio
✅ Moisture and chemical-resistant
✅ Energy-efficient

DISADVANTAGES

❌Non-biodegradable
❌ Potential loss of mechanical properties after repeated recycling
❌ Limited availability

Use in Sustainable Boat Building

- Lightweight interior and exterior components



Created with AI (ChatGPT)

Recycled PET Foam (rPET Foam)

Lightweight, resistant material made from recycled PET, used in lightweight composite structures.

ADVANTAGES

✅ Made from recyclable PET.
✅ High mechanical strength, thermal and acoustic insulation.
✅ Moisture-resistant.

DISADVANTAGES

❌ Non-biodegradable
❌ More expensive than conventional foams.
❌ Requires advanced production technologies

Use in Sustainable Boat Building

- Structural insulation panels, hulls, decks, bulkheads.

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SOURCES

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5. OTHER CONSIDERATIONS

ECO-BOATS

Nauta Morgau ecoboats

SEA TEACH

GREENBOATS

INNOVATION YACHTS

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OTHER CONSIDERATION

Balancing financial and environmental impacts in eco-boat construction

Introduction

The sustainable boatbuilding industry faces the challenge of balancing environmental impact and economic viability.

Companies like **Greenboats**, **Innovation Yachts**, and **Nauta Morgau** share a commitment to eco-friendly materials but struggle with high costs, limited scalability, and competition from traditional shipyards adopting "green" technologies, sometimes as mere marketing strategies.

Each company has a unique approach: Innovation Yachts pioneers volcanic fiber composites, Greenboats extends its innovations to other industries, and Nauta Morgau embraces an artisanal and collaborative model.

These companies are working in niches which is a challenge and opportunity at the same time. Further it's important to push development and sustainability.

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OTHER CONSIDERATION
SWOT

A SWOT analysis is a strategic planning tool used to identify and assess a project's or organization's **Strengths**, **Weaknesses**, **Opportunities**, and **Threats**. It helps clarify internal capabilities and external challenges, supporting better-informed decisions and long-term strategies. The following SWOT-based analysis explores their strategies and the potential of green skills to transform the sector amid growing demand and a lack of clear regulations.

This analysis explores the shared challenges and opportunities in sustainable boatbuilding, connecting each company's unique approach to broader market trends. Despite differing strategies, they face common issues like scalability, competition, and unclear regulations, highlighting the need for industry-wide collaboration and innovation. The next section examines their key connections.

Key Connections Across the Three Companies

S

- **Commitment to sustainability** – All three companies focus on sustainable boatbuilding using eco-friendly materials such as flax fibers, bio-resins, and volcanic rock fiber.

W

- **Challenges with large-scale production** – Each company struggles with scalability due to the high costs of sustainable materials and limited production capacity.

O

- **Opportunities in market expansion** – The growing awareness of eco-friendly boats and demand for sustainable composites across industries presents growth potential for all companies.

T

- **Threats from industry competition** – The three companies face challenges from large conventional shipyards adopting "green" technologies, whether genuinely or as a greenwashing strategy.
- **Need for regulation and standardization** – The absence of universal sustainability standards makes it harder to define what truly qualifies as an eco-friendly boat.

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OTHER CONSIDERATION
SWOT

To advance sustainable boatbuilding, industry-wide strategies are needed to tackle scalability, market positioning, and regulatory gaps. While each company has its own solutions, collaboration, innovation, and policy support are key to building a more competitive and resilient sector. The following strategies outline this path forward.

Key Strategies for Advancing Sustainable Shipbuilding

- **Foster strategic alliances** among sustainable shipyards to share resources and expertise.
- **Develop clearer branding strategies** to enhance differentiation and market positioning.
- **Invest in specialized training** to ensure a skilled workforce in sustainable shipbuilding.
- **Promote industry certifications** to establish standards for eco-friendly materials, such as natural fiber composites.
- **Optimize production costs** by exploring innovative materials and more affordable alternatives.
- **Conduct Life Cycle Assessments (LCA)** to measure environmental impact and enhance transparency.
- **Focus on high-performance, low-impact vessels** to stand out in competitive sectors like racing and adventure yachting.
- **Leverage partnerships and R&D** to drive innovation, cost reductions, and broader adoption of sustainable technologies.
- **Expand production capacity** to compete effectively with larger composite manufacturers.
- **Advocate for policy support** to encourage sustainable practices and financial incentives for eco-friendly shipbuilding.

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OTHER CONSIDERATION
SWOT

Conclusion

Sustainable boatbuilding faces **challenges** such as high costs and unfair competition but also presents significant growth opportunities.

To move forward, it is essential to strengthen strategic alliances, invest in specialized training, and promote certifications that establish clear standards.

Optimizing costs, conducting **Life Cycle Assessments (LCA)**, and expanding production will enhance competitiveness and transparency.

Through innovation and collaboration with regulators and industries, the sector can establish itself as a viable and sustainable alternative for the future of maritime navigation.

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Life Cycle Assessment in Naval Construction
LCA

Life Cycle Assessment (LCA)

Is a methodology that evaluates the environmental impacts of a vessel throughout all stages of its lifecycle: from raw material extraction for construction, design, and manufacturing, to its use, maintenance, and final disposal. In naval construction, LCA enables shipyards to identify more sustainable materials and processes, optimize resource use, and reduce emissions, promoting environmentally friendly vessels throughout their use phase. This tool is essential for driving innovation and aligning with environmental regulations and market expectations toward a greener economy.

1. Benefits for Shipyards

✅ Identify areas for improvement in processes and materials.
✅ Reduce costs through more efficient resource use.
✅ Enhance the sustainability perception of products among customers and regulators.
✅Prove sustainability; fight greenwashing

2. Key Steps to Conduct an LCA

📌 **Life Cycle Inventory:**

- Compile a lifecycle inventory by documenting all inputs (materials, energy, water) and outputs (emissions, waste) at every stage, from design to end-of-life disposal.
- Use established standards and databases, such as MarineShift360, to streamline data collection and ensure consistency. Leveraging existing resources helps simplify what can otherwise be an overwhelming process.

📌 **Environmental Impact Assessment:**

- Analyze the environmental impact of inputs and outputs in key categories e. g. CO_2 emissions and water use. This can be done manually or with the support of dedicated software tools. Using platforms like OpenLCA or other established LCA software can simplify calculations and provide more accurate assessments.

📌 **Results Interpretation:**

- Identify critical points and suggest changes to reduce impact. Consider modeling two or more scenarios to better understand hotspots and evaluate potential improvements.

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Life Cycle Assessment in Naval Construction
LCA

3. Sustainability Criteria for Materials

Selection of Sustainable Materials:

- Prioritize materials of non-fossil origin, such as natural fibers and biocomposites, while evaluating their environmental impact through databases and comparative analyses. Consider factors such as lifecycle impact and safety margins to make informed, sustainable choices.
- Evaluate the feasibility of replacing synthetic fibers with renewable alternatives like hemp, flax, or volcanic fibers.

Origin and Traceability:

- Encourage selecting suppliers with environmental certifications and local materials to reduce transport emissions.

End-of-Life:

- Prioritize materials that can be recycled or biodegrade, reducing waste at the end of the boat's lifecycle.

Cooperation with local farmers for the cultivation of raw materials

4. Efficient Construction Processes

Waste Minimization

Include strategies to reduce material waste during the construction process, such as using 3D printing technology or optimization software.

Use of Renewable Energy

Promote the use of renewable energy in shipyards during manufacturing.

Maintenance & Repair

- Design boats with modular components to facilitate repairs and extend their lifespan.
- Track the consumption of virgin materials and water.
- Calculate the percentage of materials that can be recovered at the end of the lifecycle.

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5. Examples of LCA Tools for Shipyards

Marine Shift 360

A specific tool for the marine industry that helps evaluate the environmental impacts of materials and processes.

Generic Tools:

- SimaPro
- GaBi
- OpenLCA for more detailed assessments

6. Key Indicators for Shipyards

© Freepik

Carbon Emissions

Measure the carbon footprint of the vessel at each stage of its lifecycle.

© Freepik

Resource Use

Track the consumption of virgin materials and water.

© Freepik

Recyclability Rate

Calculate the percentage of materials that can be recovered at the end of the lifecycle.

3Rs
REDUCE, REUSE & RECYCLE

The 3Rs of waste management is an initiative that was developed in the early 2000s as a method that helps all of us to reduce the amount of waste we send to landfill or incineration, and to reduce the amount of items being produced unnecessarily.
The 3Rs stand for Reduce, Reuse, Recycle. These three small words are pivotal to managing waste and helping to combat climate change.

REDUCE

It consists of reducing the amount of waste we generate and the consumption of resources such as water, energy and materials.

- Reduce the use of fossil fuels by using solar energy and electric batteries.
- Reduces the emission of polluting gases and noise pollution in the oceans.
- Optimizes the design of vessels to make them more efficient and consume less energy.

REUSE

Giving products a second life before discarding them, using them for another purpose or repairing them.

- The reuse of sustainable materials in boat construction is encouraged.
- Parts and components can be reused in the maintenance and repair of the boats.
- Promotes the use of long-lasting boats to avoid unnecessary manufacturing of new boats.

RECYCLE

Transforming waste into new products to reduce pollution and the use of raw materials.

- Recycled materials are used in the manufacture of boats, such as plastics recovered from the sea.
- Recycling of components at the end of the boat's use phase is incentivized.

SUSTAINABLE DEVELOPMENT GOALS

EcoBoat Building is a sustainable alternative in the naval industry that aims to reduce environmental impact through the use of recyclable materials, renewable energy, and efficient designs. This approach aligns with several Sustainable Development Goals (SDGs), promoting innovation (SDG 9), responsible consumption (SDG 12), climate action (SDG 13), and the protection of marine ecosystems (SDG 14).

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Sustainable shipyard promotes responsible production, using innovative technologies for efficient resource management and waste reduction, driving maritime industry towards sustainable growth.

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Sustainable shipyard adopts responsible production practices, optimizing resource efficiency and waste management through innovative technologies and eco-friendly processes.

Responsible consumption and production foster efficient resource use, minimize environmental impact, and encourage the maritime industry toward sustainable growth, innovation, and circular economy solutions.

13 CLIMATE ACTION

Sustainable shipyard implements innovative technologies in the eco-boats, using sustainable materials and low-emission propulsion systems.

The development of sustainable infrastructures drives the transition to a greener economy, fosters technological research and generates new opportunities in the maritime industry.

14 LIFE BELOW WATER

Sustainable boat building prevents ocean pollution by eliminating the use of fossil fuels, reducing oil spills and CO_2 emissions into the water.

Protecting marine ecosystems is essential to conserving biodiversity and ensuring the health of the oceans, benefiting both aquatic species and the communities that depend on them.

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The Eco-Boats Directory

ECO-BOATS

Nauta Morgau ecoboats

SEA TEACH

GREENBOATS

INNOVATION YACHTS

We have created a directory, which includes companies that are trying and testing sustainable approaches. It includes:
a) who is engaged in Eco-boat building,
b) which methods and/ or materials are used.

Have a look at our outputs! CLICK HERE!

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ECO-BOATS DIRECTORY

ALVEUS BOOTSBAU ✉️ info@alveus-bootsbau.de 📍 *Germany*	Sailboats Motorboats 🪵 *Wood*	• **Repair** • **Refit** • **Paint work** • **Collision damage**
AMER YACHTS ✉️ info@gruppopermare.it 📍 *Italy*	Yachts Custom-built vessels 🪵 *Wood*	• **Handcraft** • **Built** • **Repair** • **Refit**
BALTIC YACHTS ✉️ info@balticyachts.es ✉️ info@balticyachts.fi 📍 *Finland*	Yachts Catamarans Sailboats 🪵 *Cork* 🪵 *Balsa wood* 🪵 *Cork-oak* 🪵 *Marinedeck-cork* 🌿 *Flax Fiber* 🌿 *Biobased Epoxy Resin*	• **Built** • **Refit** • **Custom**
BLUE TREE BOAT BUILDERS ✉️ hello@bluetreeboatbuilders.com 📍 *UK*	Yachts Motorboats 🪵 *Wood* 🌿 *Biobased Epoxy Resin*	• **Handcraft** • **Custom**
BOOTSBAU LIEBNER ✉️ info@liebner-bootsbau.de 📍 *Germany*	Sailboats Motorboats 🪵 *Wood*	• **Built** • **Repair** • **Refit** • **Paint work**

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ECO-BOATS DIRECTORY

BOOTSBAU WELKISCH mail@bootsbau-welkisch.de *Germany*	Sailboats Motorboats *Wood*	• **Repair** • **Built** • **Custom**
BOOTSBAUHANDWERK TUTZING post@bootsbauhandwerk.de *Germany*	Sailboats Custom-built vessels *Wood*	• **Repair** • **Built** • **Custom**
COCKWELLS info@cockwells.co.uk *UK*	Motorboats *Wood*	• **Built** • **Custom**
DELPHIA YACHTS delphiayachts@delphiayachts.eu *Germany*	Sailboats Custom-built vessels Motorboats *Wood*	• **Built** • **Repair** • **Refit** • **Custom**
GREENBOATS hi@green-boats.com *Germany*	Sailboats Motorboats *Cork* *Balsa wood* *Marinedeck-cork* *Flax Fiber* *Biobased Epoxy Resin* *Agarve*	• **Built**

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ECO-BOATS DIRECTORY

ECO-BOATS

INNOVATION YACHTS ✉️ info@innovation-yachts.com 📍 *France*	Custom-built vessels Yachts Catamarans Sailboats Motorboats Small Series 🪵 *Balsa wood* 🌿 *Biobased Epoxy Resin* 🌋 *Volcanic fiber* ♻️ *Recycled PET*	• **Built** • **Handcraft** • **Development**
KAISER BOATS ✉️info@kaiserboote.de 📍 *Germany*	Motorboats 🪵 *Wood*	• **Parts construction** • **Built**
KNIERIM YACHTBAU GmbH ✉️ info@knierim-yachtbau.de 📍 *Germany*	*Sailboats* *Catamarans* *Custom-built vessels* *Motorboats* 🪵 *Wood*	• **Built** • **Repair** • **Refit** • **Paint work**
NAUTILUS HAUSBOOTE ✉️ anfrage@nautilus-hausboote.de 📍 *Germany*	House boats 🪵 *Wood*	• **Built** • **Charter**
ROBBE & BERKING ✉️ classics@robbeberking.de 📍 *Germany*	Sailboats Motorboats 🪵 *Wood*	• **Built** • **Refit** • **Repair**

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ECO-BOATS DIRECTORY

RM YACHTS 📍 *Germany*	Sailboats 🪵 *Wood*	• **Built** • **Semi-custom**
SPIRIT YACHTS ✉️ enquiries@spirityachts.com 📍 *UK*	Custom-built vessels Yachts Sailboats Motorboats 🪵 *Wood* 🌿 *Biobased Epoxy Resin*	• **Handcraft** • **Built** • **Custom**
SUNREEF ✉️ info@sunreef-yachts.com 📍 *Poland*	Catamarans *Sailboats* *Motorboats* 🪵 *Cork* 🌿 *Flax fiber* 🌋 *Basalt fiber*	• **Built**
VALKAMA BOATS ✉️ contact@valkama.com 📍 *Finland*	*Motorboats* 🪨 *Aluminum*	• **Built**
WINDELO ✉️ contact@windelo-catamaran.com 📍 *France*	Catamarans 🪵 *Wood* 🌋 *Volcanic fiber* ♻️ *Recycled PET*	• **Built**
IDBMARINE ✉️ info@idbmarine.fr 📍 *France*	Sailboats Small Series 🌿 *Flax fiber*	• **Built** • **Handcraft** • **Refit**

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ECO-BOATS
DIRECTORY

NORTHERM LIGHT COMPOSITES Italy	Custom-built vessels Sailboats *Thermoplastic resin*	• **Built** • **Development**

Do you know of other Eco-boats builders not listed here?
Send us a message and help us to keep it updated.

Thanks!

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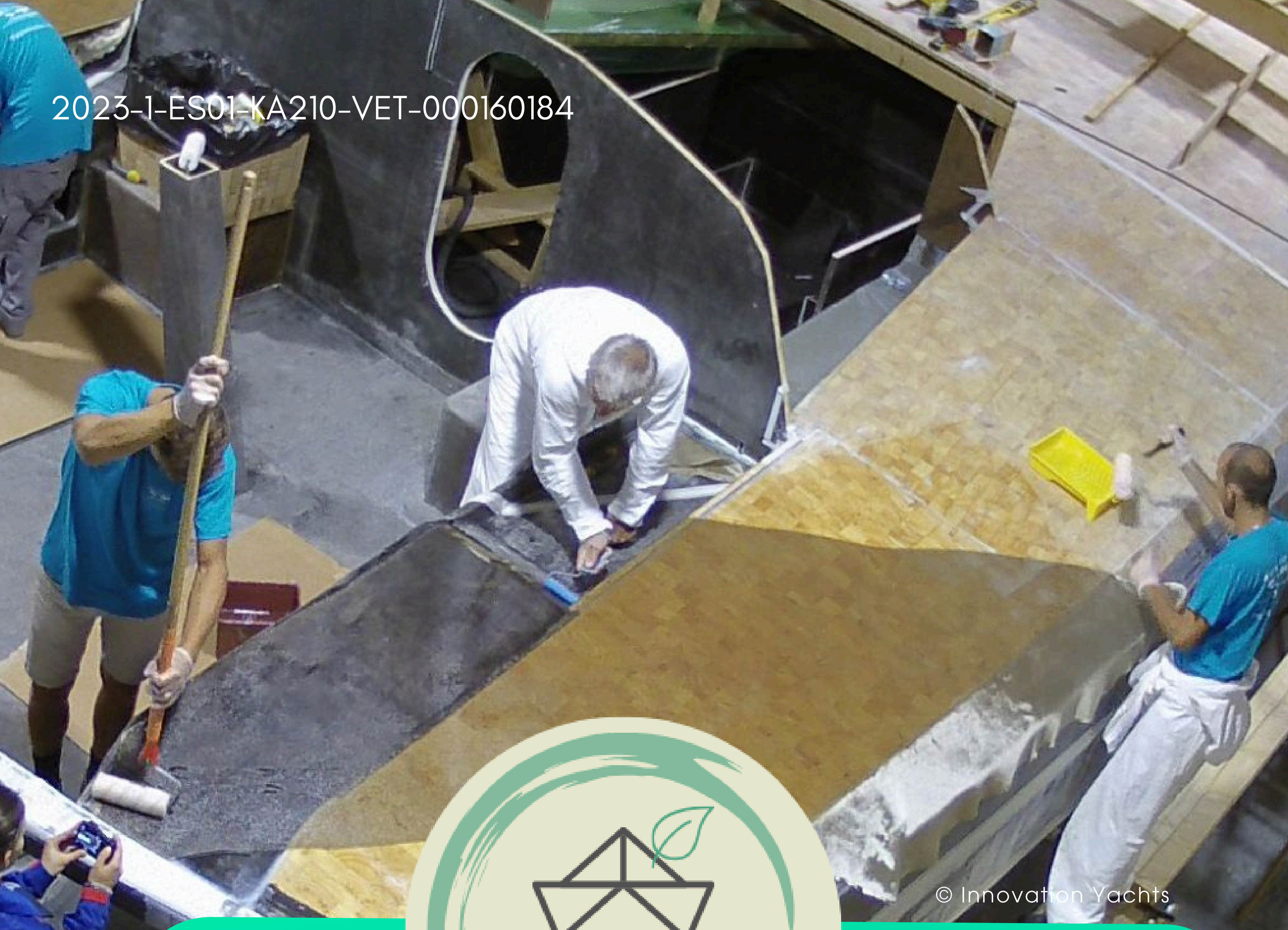

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