High-Performance Composites in Commercial Marine: Challenges and Opportunites

Thomas James
Marine Business Development Manager
E-LASS 13th September 2022

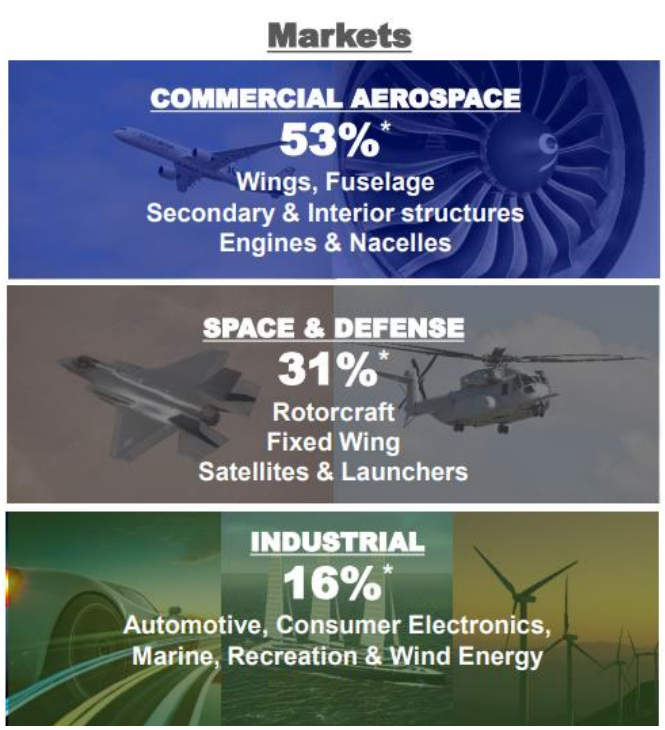
HEXCEL'S PURPOSE

To propel the future of flight, energy generation, transportation and recreation
through excellence in advanced material solutions
that create a better world for us all.

One Hexcel | Innovation | Accountability | Responsibility

HEXCEL CORPORATION : ADVANCED COMPOSITE MATERIALS

- 2021 Sales | $1.325 billion
- 23 manufacturing sites | 4,800 employees



16%

INDUSTRIAL

Automotive | Consumer Electronics | Infrastructure
Marine | Recreation | Wind Energy

- Broad range of performance applications leveraging Hexcel carbon fiber, Hexcel resin formulations & process expertise, and third-party glass fiber
- Active in 30+ different Industrial sub-markets
- Growth opportunities: marine, energy storage/electric vehicles, consumer electronics, and industrial pipes
- Wind energy comprises ~35% of Industrial

Commercial Marine is considered as an area of strategic growth within Hexcel

WE MAKE A **WIDE RANGE** OF HIGH-PERFORMANCE MATERIALS

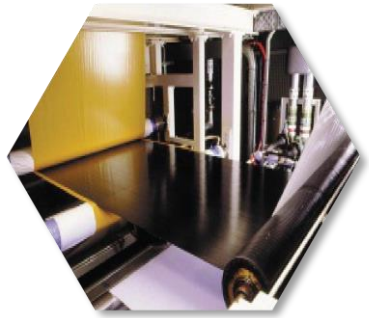
Everything from carbon fibers and reinforcement fabrics to prepregs, honeycomb core, tooling materials and more . . . from raw materials to fly away parts . . . vertical integration is a strength and a differentiator.

CARBON FIBER

Pressure Vessels
Sailing Masts
Formula 1

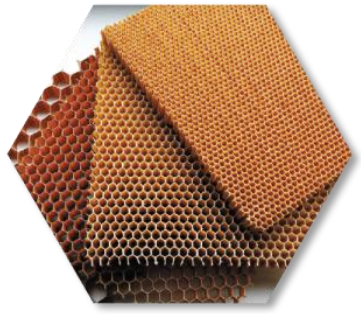
REINFORCEMENTS

BMW M-series roof
Lamborghini monocoques
Carbon wheels



CARBON PREPREGS

Metal/Composite Hybrids
Cosmetic carbon parts
Friction Discs
Skies
Yachts structure

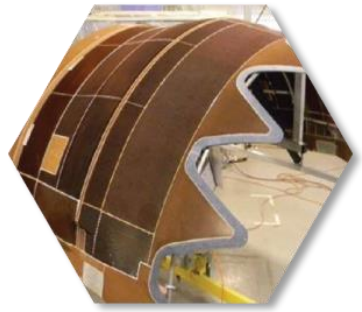


HONEYCOMB

Side impact structures

GLASS PREPREGS

Wind turbine blades
Composite Leaf Springs



ENGINEERED PRODUCTS

BMW 7 Series B-pillar stack

Examples of Industrial applications

Strong | stiff | lightweight | fatigue resistant | corrosion resistant

Our Strengths in Marine

- **Long term relationship** with key marine player
- **Innovative** Technologies / **Broad** Portfolio / **Vertical** integration
- **Class** approved marine products (DNV, BV, LR)
- **Quality excellence** at all production sites
- **Technical support** available from all locations
- Three **R&T centers** (USA, UK, Austria)
- **Aerospace experience** of long-term project management and contractualization (OTD, Buffer stock, management of specifications …)

CUSTOMER EXCELLENCE

OPERATIONAL EXCELLENCE

PEOPLE EXCELLENCE

Our experiences in other industries can benefit Marine customers

Sustainability challenges of composites

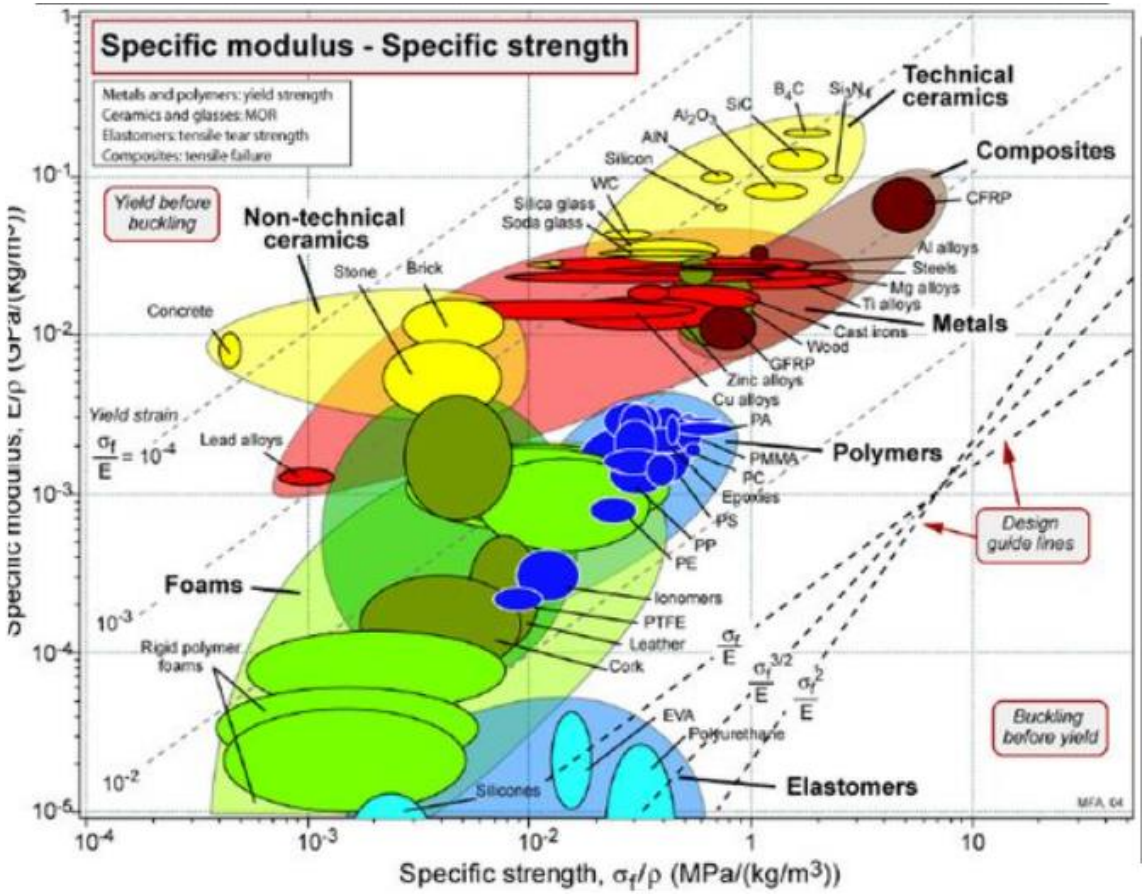
Embodied CO^2 within our materials

Energy required to process our materials

End-of-life

SUSTAINABILITY: MATERIAL SELECTION

1996



Source: Ashby & Young

SUSTAINABILITY: MATERIAL SELECTION

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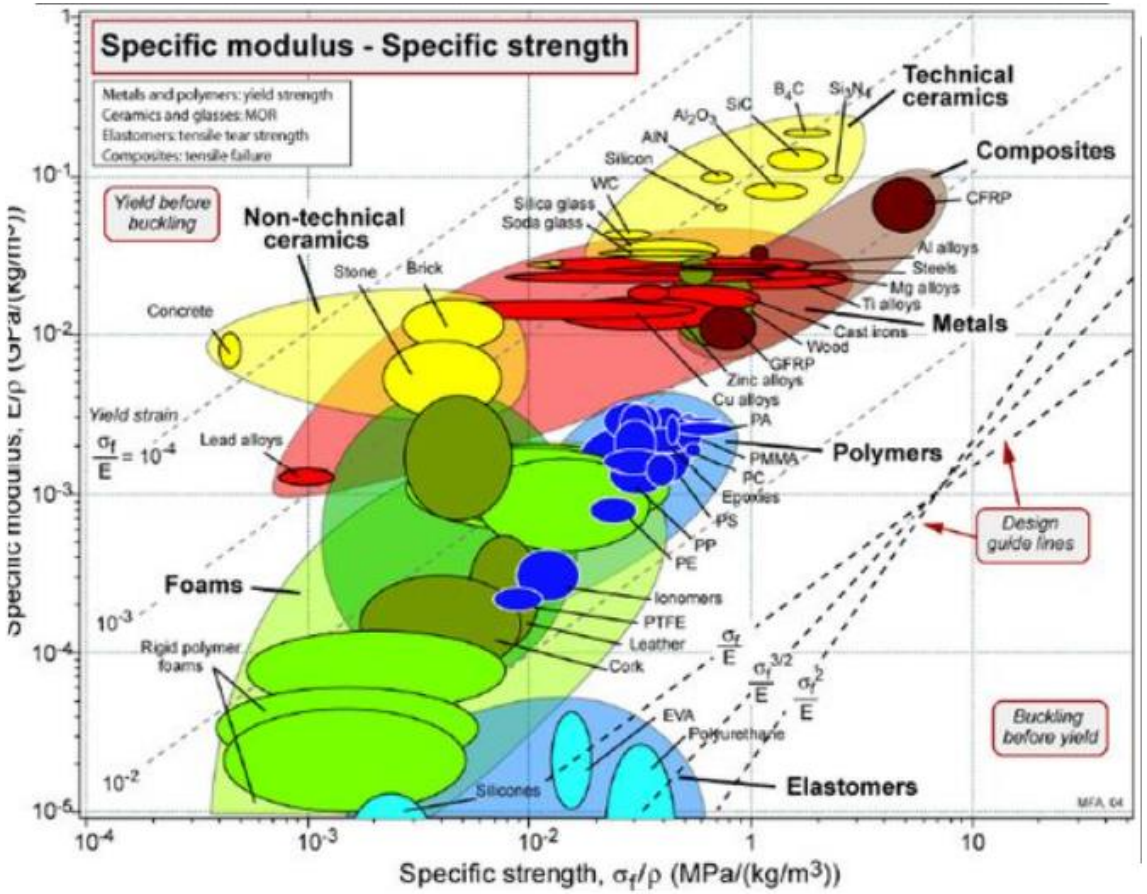
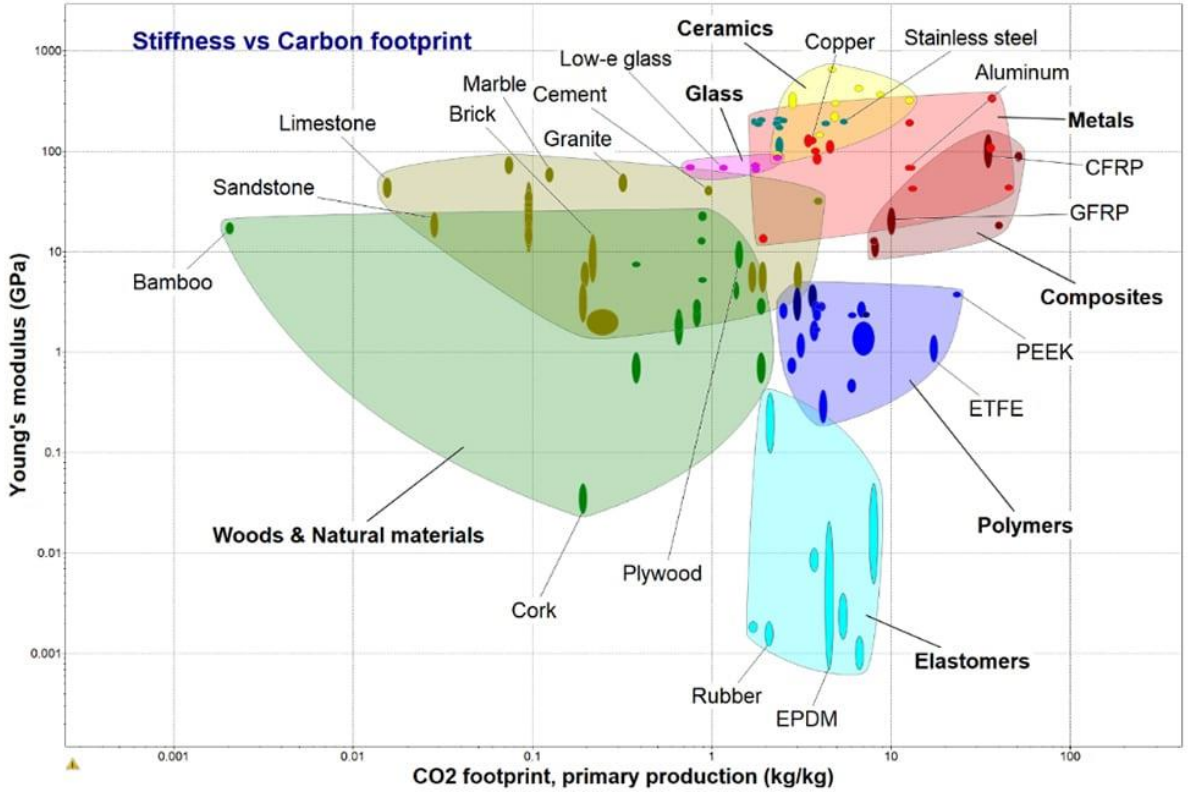


2022



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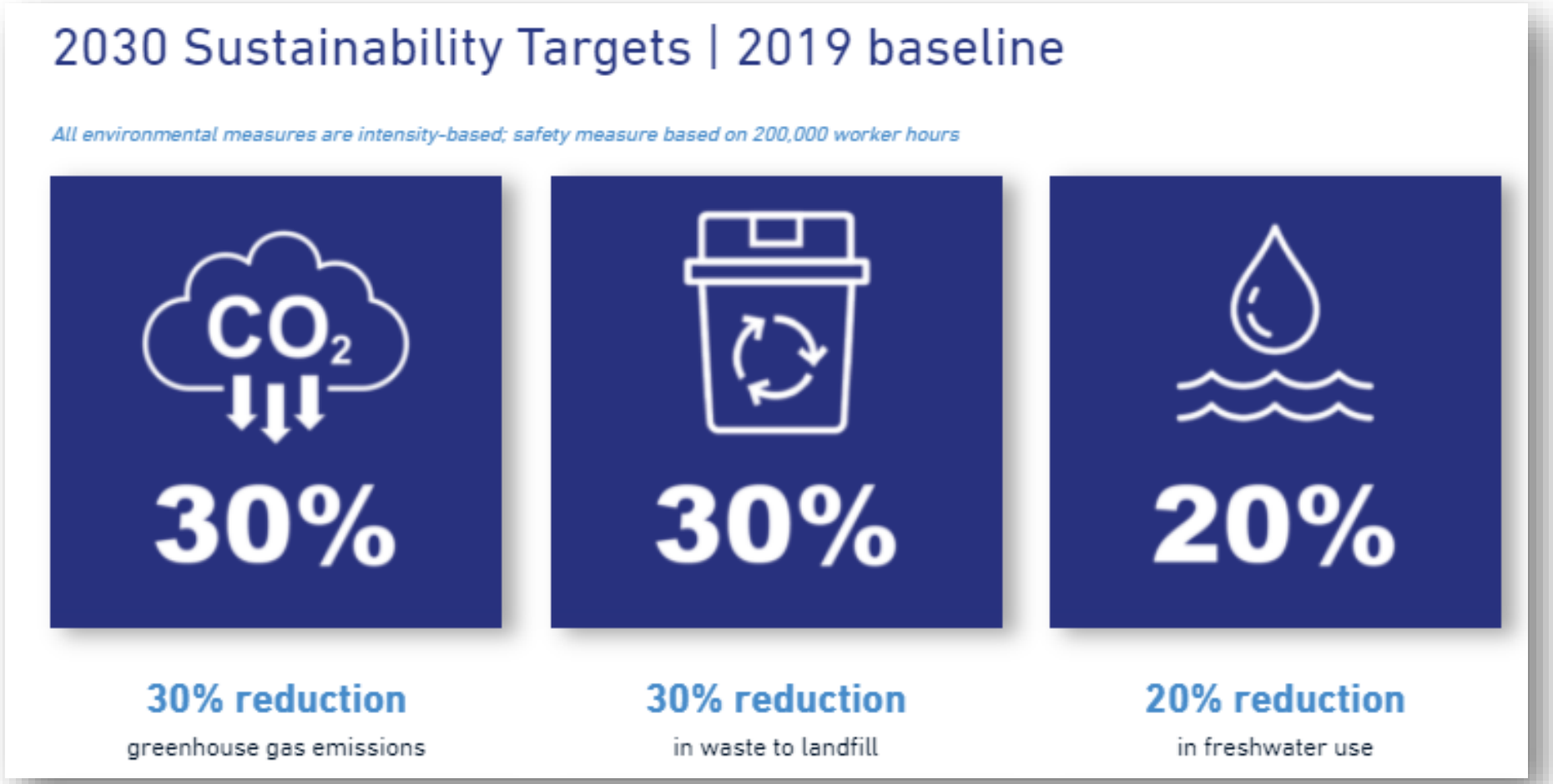
SUSTAINABILITY: HEXCEL IN TRANSITION

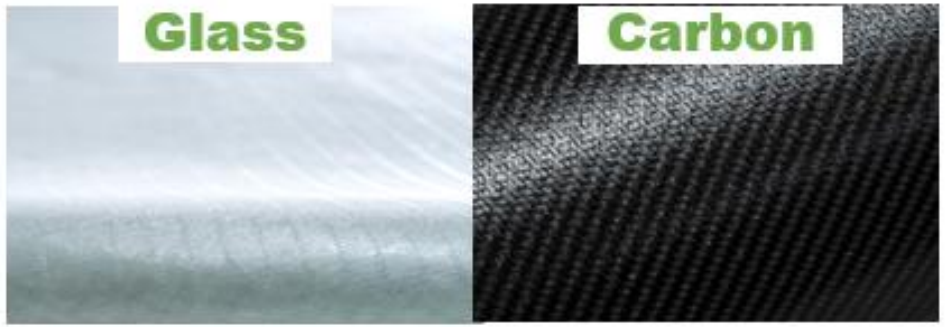


SUSTAINABILITY: HEXCEL IN TRANSITION

HexPly® Nature Range

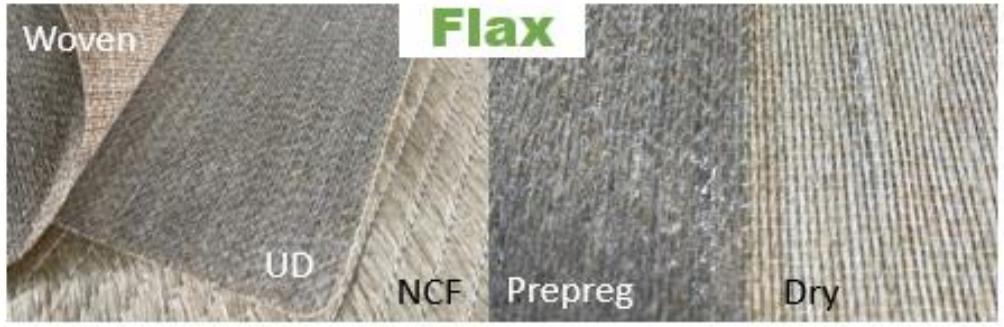
Bio-derived resin systems

- **Unchanged resin characteristics**
  - Mechanical performance
  - Processing properties
  - Storage requirements
- Products are **fully compatible** with the standard range



Optional – Flax reinforcement

- **Renewable resource**, cultivated Europe
- **Woven and NCF reinforcements**
- Flax exhibits excellent performance compared to other natural fiber types
- Potential to improve **impact resistance** and **vibration damping**

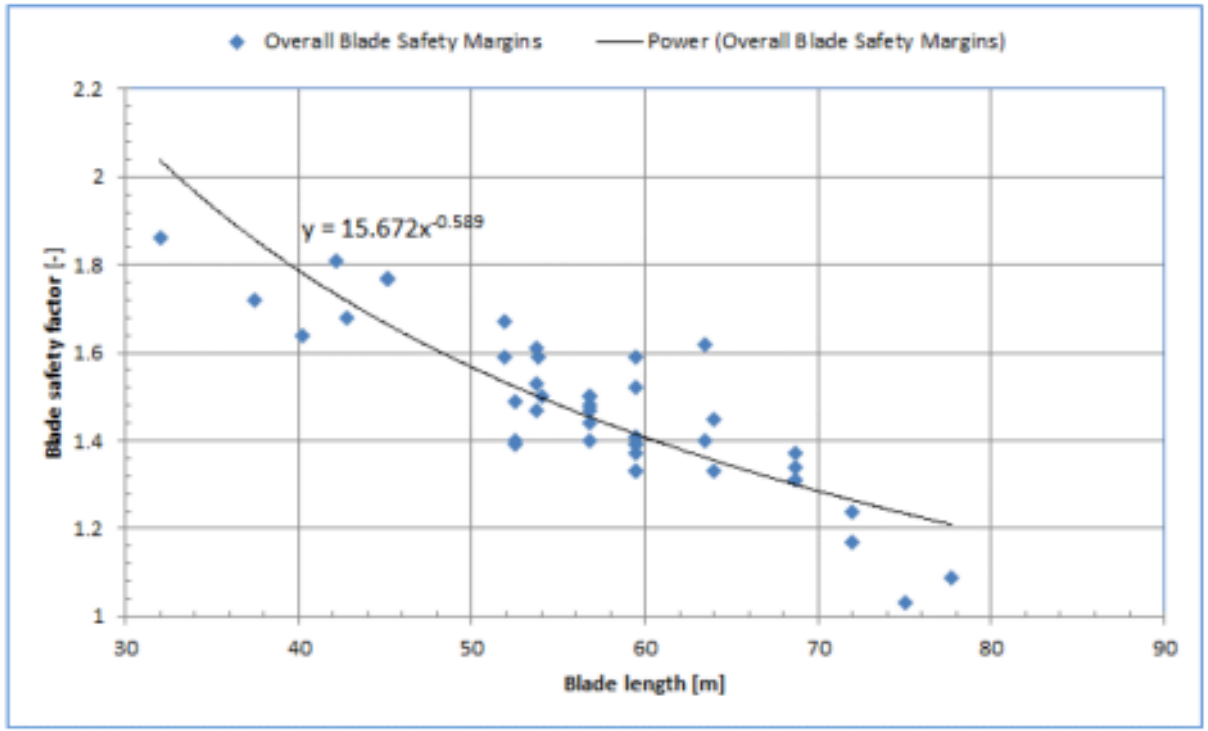


Prepregs with bio-derived resin content reinforced with glass, carbon or flax reinforcement

LEARN FROM WIND ENERGY: USE LESS MATERIAL…

Blade development trends

- **Ongoing reduction of Safety margins due to mass/cost reduction**
  - Increased responisiblity of suppliers to deliver zero defect material
  - Further improve quality control
  - In depth specification requirements
- **Ongoing reduction Time-to-market**
  - Expecting today 45-50 weeks
  - Scalable processes
  - Process robustness

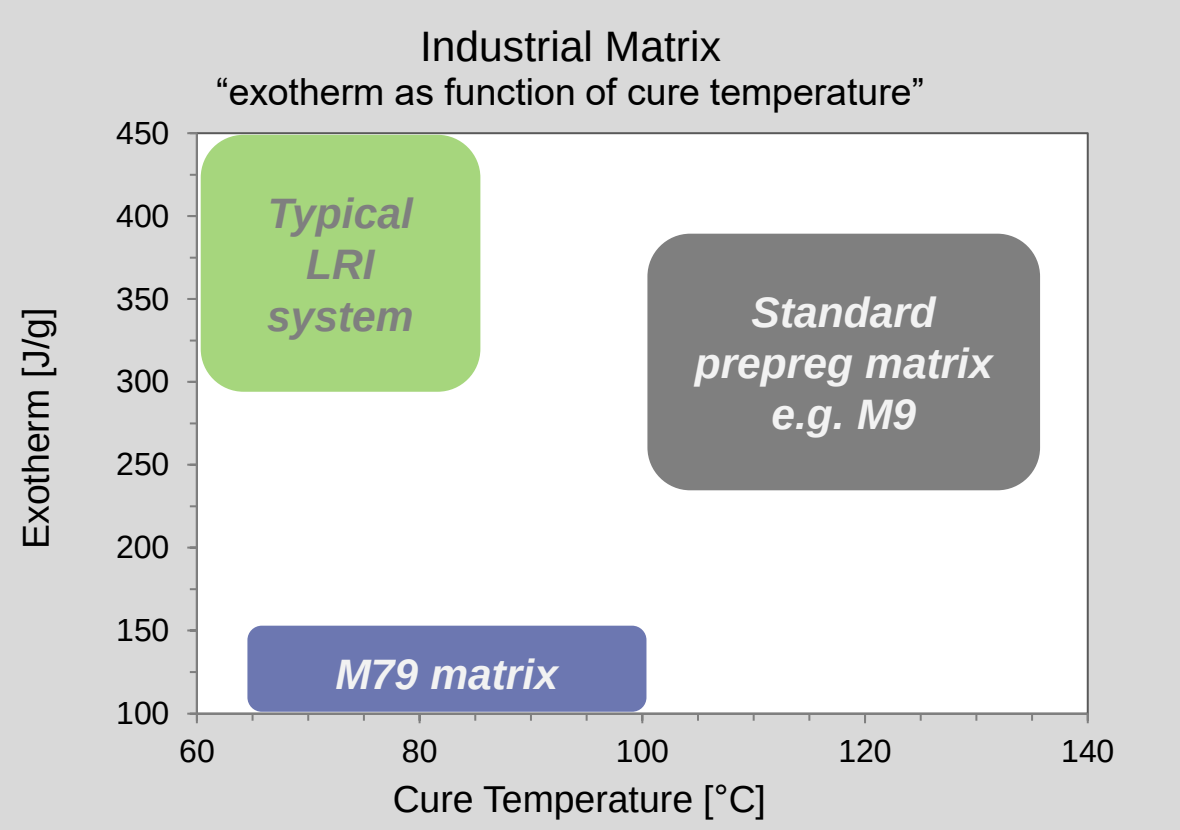


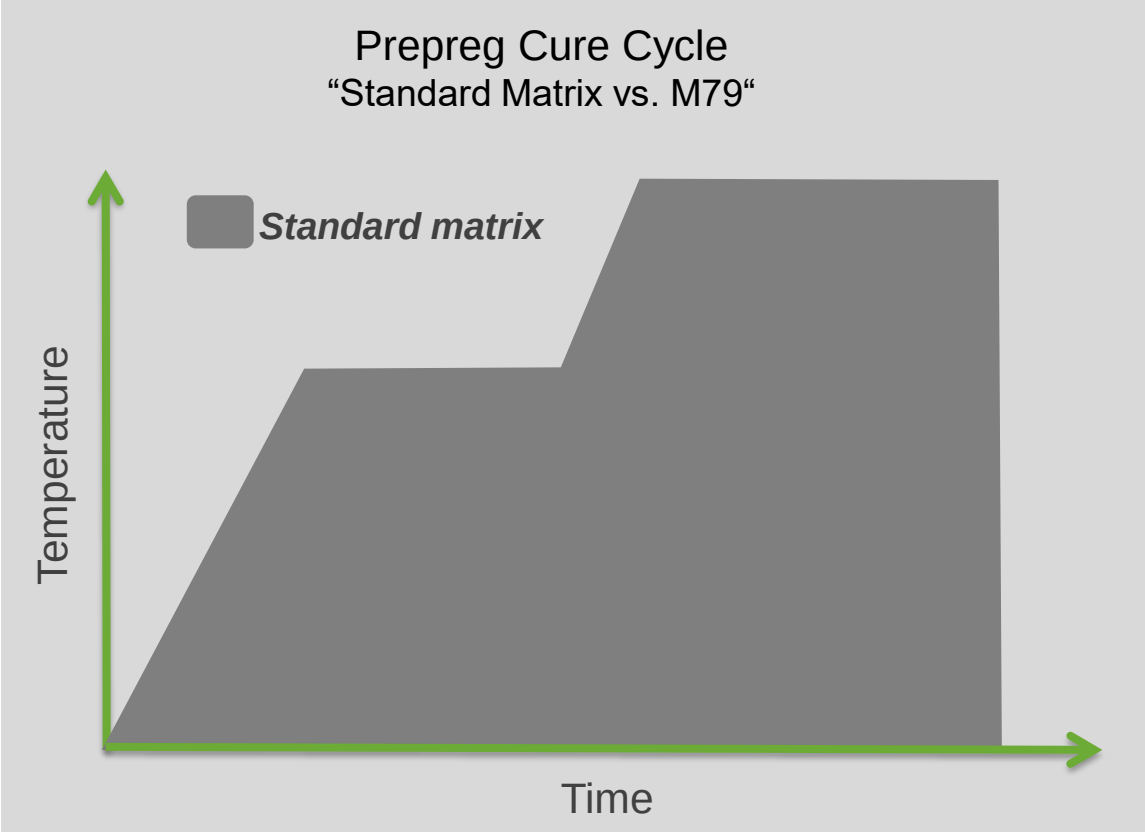
Source: LM Windpower, 2019

Optimised materials exist from >20yrs of turbine development, Marine can benefit

SUSTAINABILITY: REDUCE ENERGY REQUIRED TO PROCESS

HexPly® M79 The fastest low temperature cure out-of-autoclave prepreg on the market





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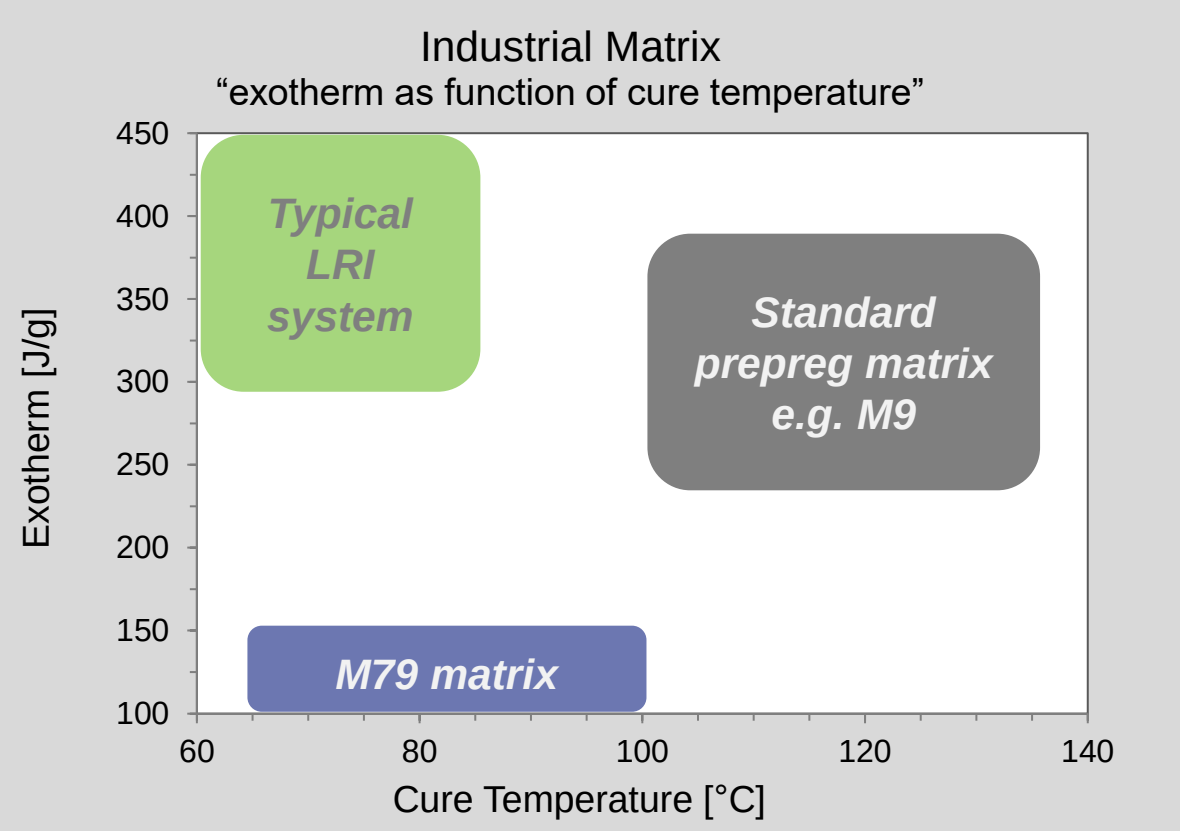
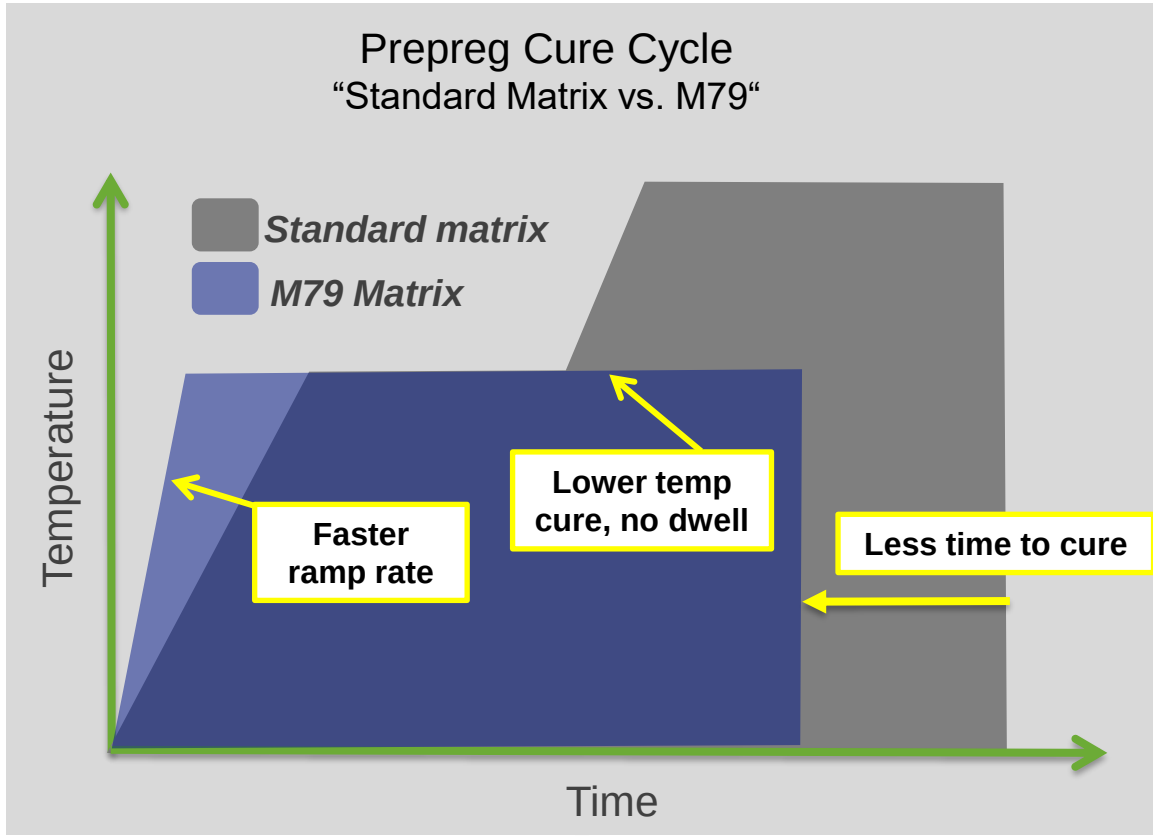




Lower exotherm energy allows short cure cycles for thick structures

HexPly® Prepregs

The right product for the right market

HexPly ® M79*

Low temp.cure System

- Cure Temp.: **70-80°C in 4-8h**
- T_g 105°C
- **Shelf life > 8 weeks @ +23 °C**

TYPE APPROVED PRODUCT DNV·GL MARITIME

HexPly ® M9.6H / M9.6GF*

Cure cycle “Allrounder“

- Cure Temp.: 85°C – 150°C
- T_g 120°C
- **Enhanced fatigue** performance
- **Shelf life > 8 weeks @ +23 °C**

HexPly® M9.6H carbon prepreg in action

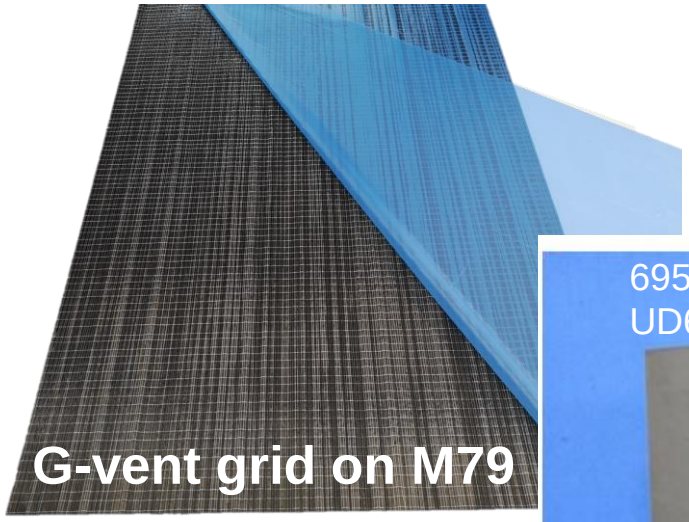
Chantiers de l’Atlantique Silenseas cruise ship concept which uses composite Solid Sail® propulsion as well as dual-fuel engines to reduce emissions and operating costs

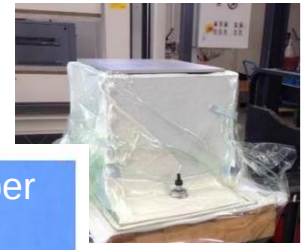
We no longer need to store prepregs in a freezer…

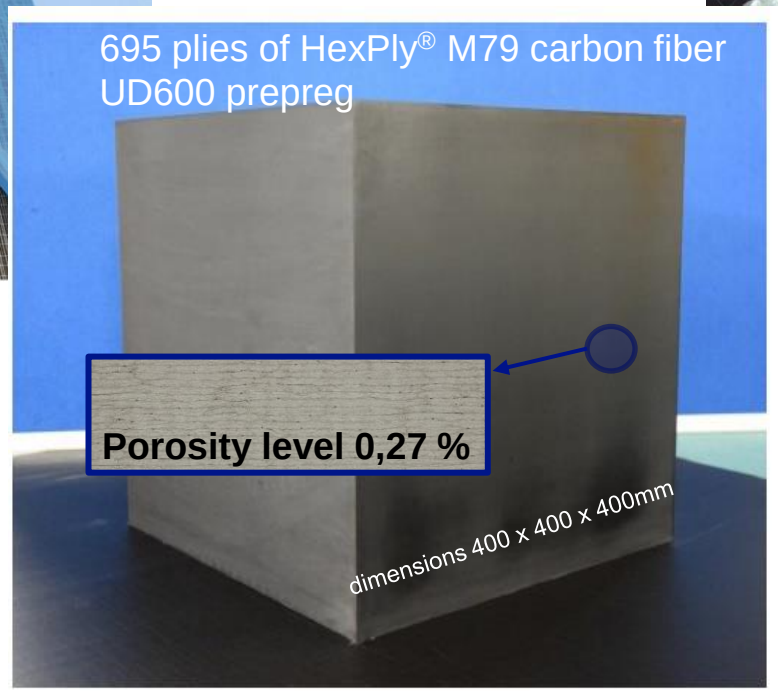
HexPly® G-vent technology for Carbon UDs

CARBON CUBE EXPERIMENT

- Can be processed **out-of-autoclave**
- Ensures super **low porosity for superior performance**
- Reduces **energy required** to process





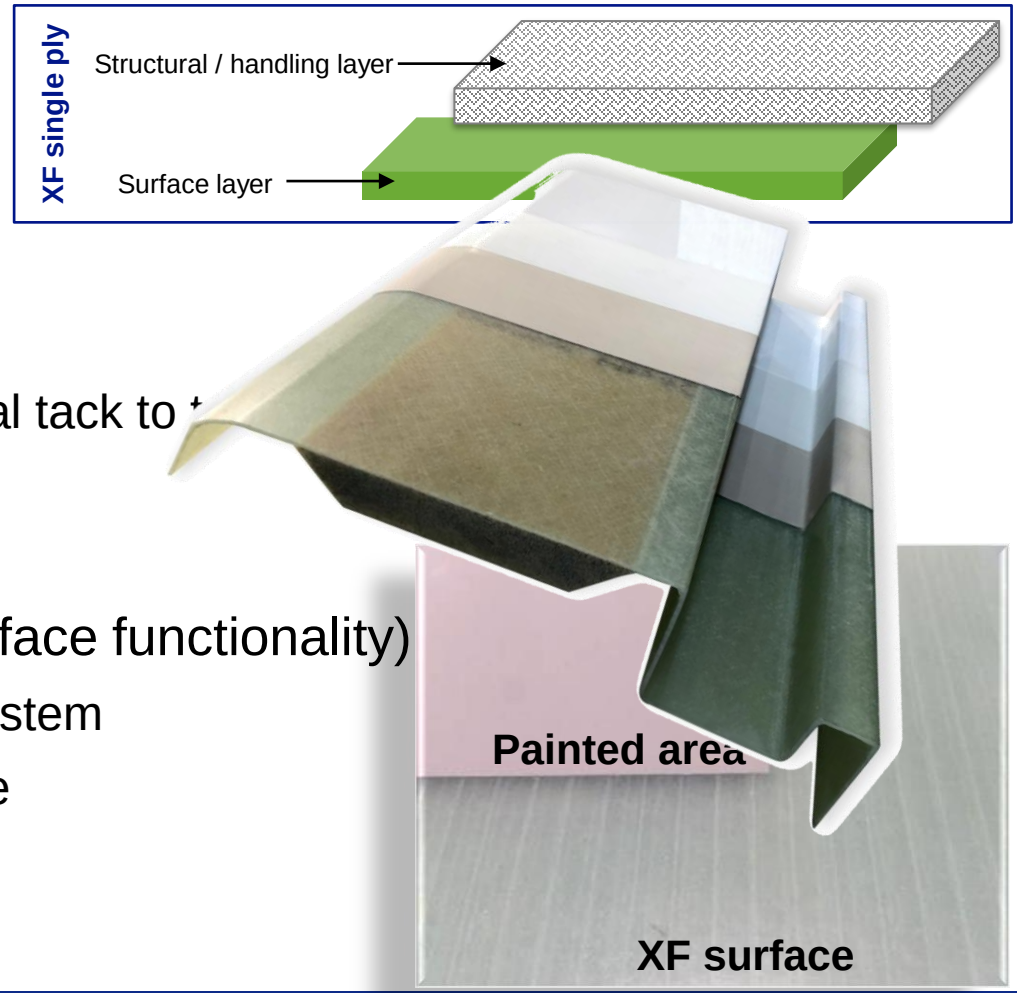


400mm cube: Cure at 80deg C for 6hrs

A technology breakthrough for low-energy processing of high-performance composites

Hexcel XF: Paint Ready Surface Finish on Demoulding

- Leverages ***M79 resin chemistry***
- ***Obviates*** need for in-mould gel coat
  - Can offer increased throughput / better mould utilisation
- Minimal surface preparation
  - No pinhole, overlap and print through defects
- ***Easy to use*** Surface Solution (good conformability and initial tack to t
  - Maintains prepreg product form factor
  - “Clean” technology compared to gel coats
- ***Single Ply*** solution (= Structural layer with integrated surface functionality)
  - Surface matrix is integral and continuous with laminating system
  - Non-parasitic – XF ply also contributes to laminate structure
  - Component weight saving
- DNV certified



HexPly® XF prepreg for enhanced manufacturing efficiency & reduced processing energy

Marine: Targeted market subsegments

Race

Luxury
(10-50m)

Motor

Sail

Commercial
(20-300m)

IN FOCUS

Appendages

Wind propulsion

Hydrofoils

Structures

Zero emission ferries

Gas carriers

Military

The decarbonisation of commercial shipping is part of our industrial growth strategy

Appendages: Market

Wind Assisted Ship Propulsion (WASP)

3% of Global CO2 comes from shipping.

Silenseas

Selected options for emission reduction	reduction potential %	when
Zero/Low carbon fuels	???	???
Speed reduction	35	2022
Wind Power	5 to 40	2023
Power system upgrade	20	2027
Hull air lubrication	15	2023
Hull coating upgrade	5	2022

2025:
30% reduction
(newbuild ships)

2030:
40% reduction
(all ships)

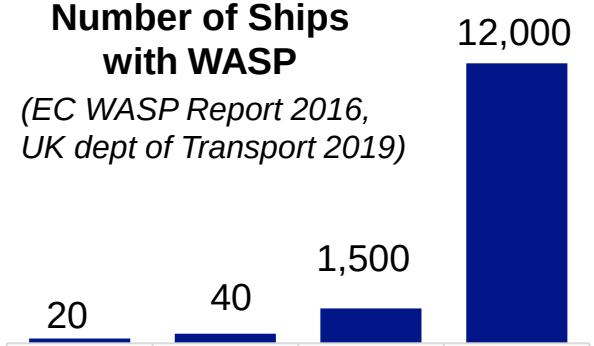
IMO INTERNATIONAL MARITIME ORGANISATION

2023 GHG Emission Regulations

2050:
70% reduction
(all ships)

Number of Ships with WASP

(EC WASP Report 2016, UK dept of Transport 2019)



Global Fleet: 93000 (>500mt)

Hydrofoils for Zero-Emission Ferries

Seachange

Hydrofoil development history

1900: First foiling craft	1970: Fast-ferries with V foils	2010: Rapid Tech Advance	2019: Adoption by E-ferries

Benefits of Foiling
Low drag at high speed (longer range)
More comfortable in waves
Less wake

Commercial Marine Appendages is a new segment; Sustainability is the key driver

Structures: Market

Ship type	Composite	Market state
General Cargo	Low performance	Commodity with barriers: FST, End-of-life
Gas Carriers	Specialised	Developing
Zero Emission Ferries	High performance	New

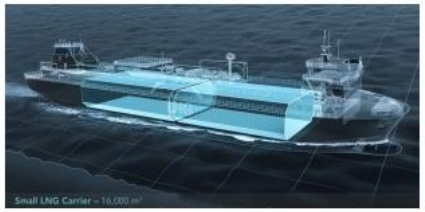
FOCUS

700 ships scrapped per year
3500t steel each= 2.5Million tonnes
90% recycled

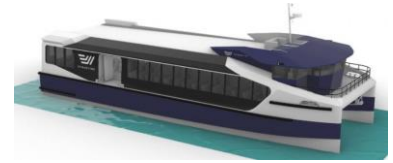
LNG Demand to double by 2040

EC Vision: 100 'Smart' cities by 2030

Tank Liners for LNG Carriers	Dimension	Primary Structures for Zero-Emission Ferries
250	Length (m)	25
30000t	Capacity	200 PAX
Under development	Products	C-NCF, Prepreg
XXX	Product requirement	Existing range



Gas carrier



Gas propulsion

High-performance composites are an enabling technology, for some applications…

Competition Sailing: Transition to sustainable materials

IMOCA60 rule 2022

Appendix G: Material limitations, construction methods, finishing products.

AG.0 DEFINITION

Alternative material: Material able to be made from a natural fibre [organic or mineral matrix], recycled material or composite materials compatible with the human body and intended to be used alone or in combination with other materials [resin] of the same kind for the design of a composite.

SailGP

SAILGP ANNOUNCES NEW ZEALAND AS THE FIRST-EVER WINNERS OF THE IMPACT LEAGUE

27 MARCH 2022 • NEWS •

The Criteria

SUSTAINABILITY // INNOVATION // ON-WATER // MERCHANDISE // WASTE & SINGLE-USE PLASTIC // TRAVEL & ACCOMMODATION // FOOD // USING YOUR VOICE // DIVERSITY & INCLUSION // COLLABORATION

Americas Cup Rule 2022

3.7 Construction of a **hull** shall meet the following criteria:

$$k_{LCA} + \sum_{i=1}^{n} a_i (k_{i,PLUG} + k_{i,MOULD}) \geq 2.5$$

where:

a_i is the proportion of the **hull surface** manufactured by a distinct tooling approach;

n is the total number of distinct tooling approaches required to build the **hull surface**;

$$k_{LCA} = \begin{cases} 1, & \text{if a life-cycle analysis is performed on the } \textbf{hull} \text{ to the satisfaction of the } \textbf{Measurement Committee} \\ 0, & \text{otherwise} \end{cases}$$

$$k_{PLUG} = \begin{cases} 2, & \text{if a plug is not required} \\ 1, & \text{if the mould plug is constructed of recyclable material (e.g. PET), with that plug being delivered to a recycling plant by 1st January 2024} \\ 1, & \text{if the mould plug is constructed of recycled material} \\ 1, & \text{if the mould plug is constructed of sustainably sourced material (e.g. timber)} \\ 0, & \text{otherwise} \end{cases}$$

3.8 The life-cycle analysis in Rule 3.7 shall;

(a) be submitted as a written report to the **Measurement Committee**;

(b) follow the guidelines defined by ISO 14040/14044; and

(c) be a cradle-to-gate life-cycle analysis with at least:

(i) the carbon footprint represented in $kgCO_2e$; and

(ii) the production of solid waste represented in kg,

Sustainability challenges of composites

Corporate energy policy
R&T
Supply chain
Operations
Marketing

Embodied CO^2 within our materials → Reduce

Energy required to process → Reduce

End-of-life → Use wisely

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