Composites for offshore wind

Alun Roberts, 9 November 2011

BVG Associates

- Wind and marine energy only
- Formed in 2005
- Hands-on experience in the wind industry

- Market analysis
- Business development
- New technology direction
- Technical due diligence
- Wind farm development

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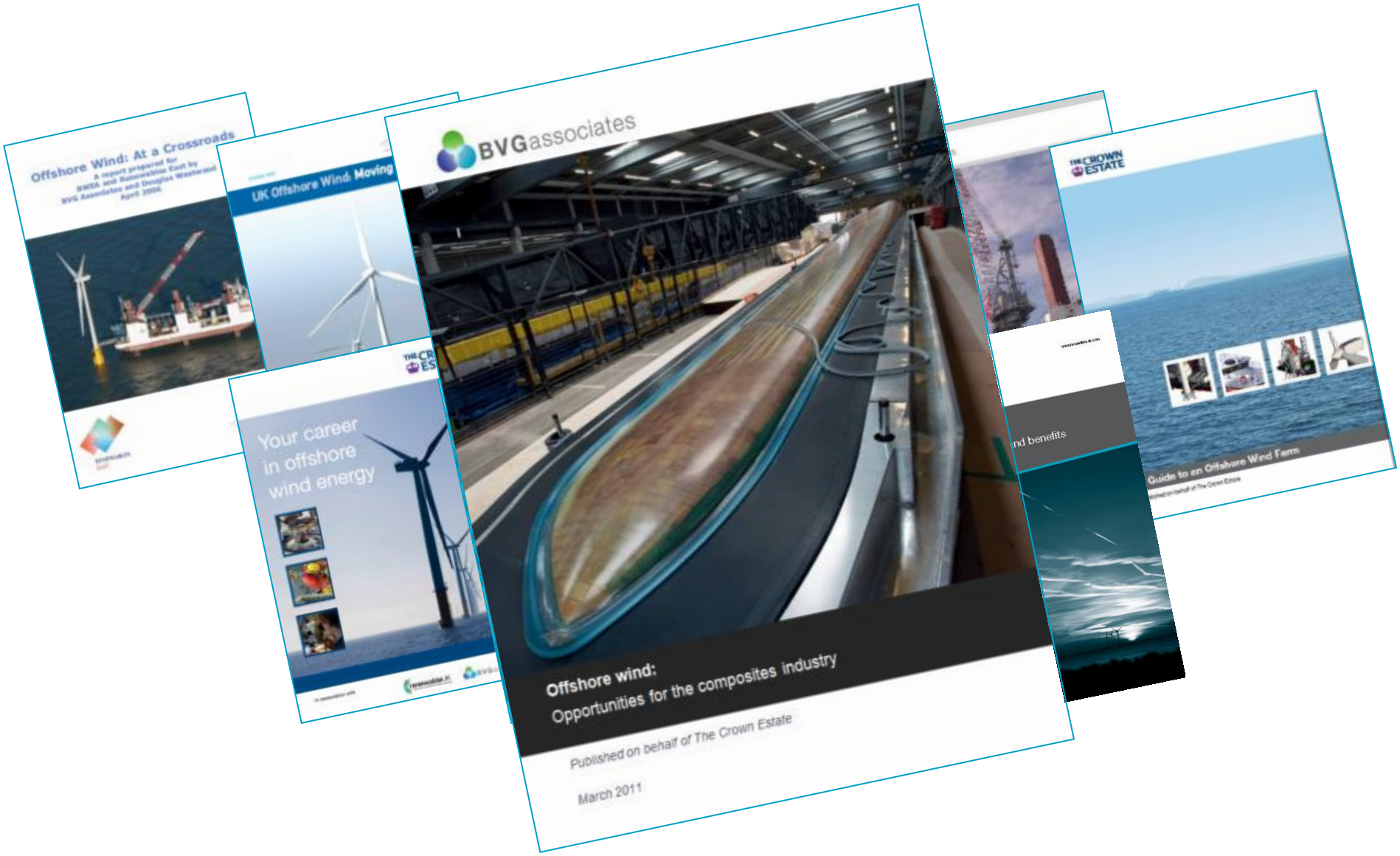


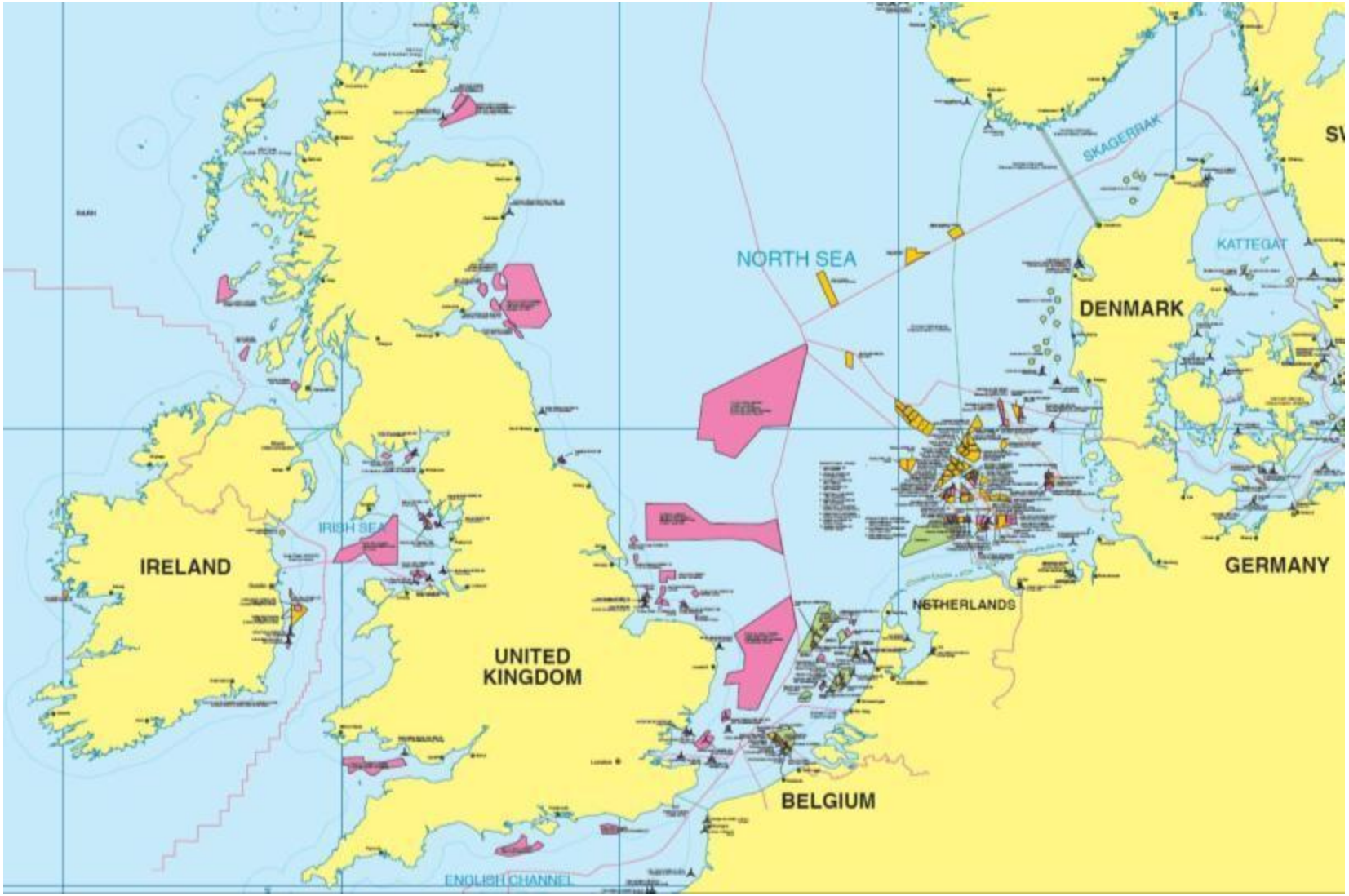
Agenda

1. Introduction
2. Offshore wind supply chain
3. Composites in an offshore wind farm
4. Blade technologies
5. Other turbine applications
6. Opportunities for the composites industry

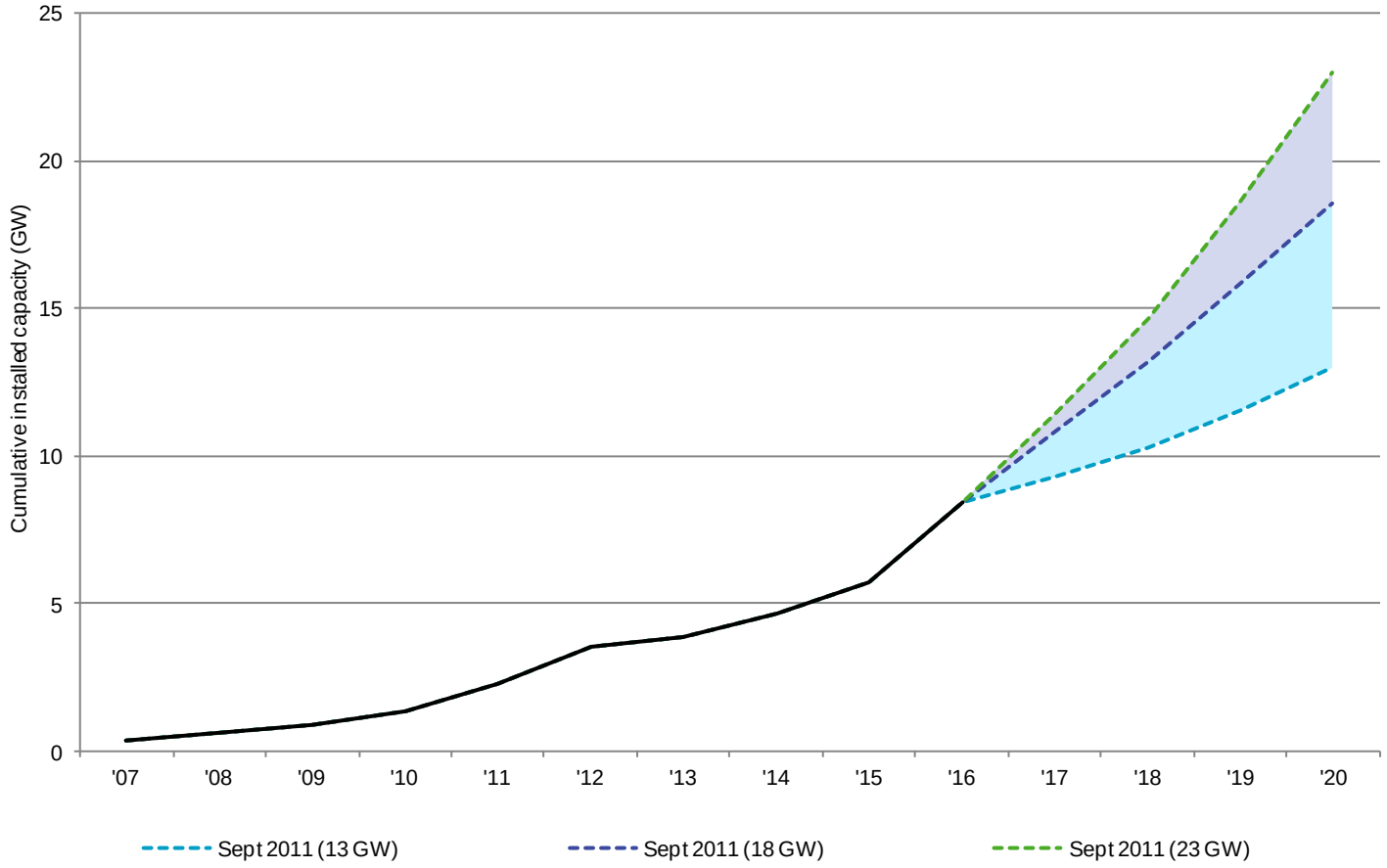
1. Introduction

- UK is the global leader in offshore wind, with over 40% of generating capacity. By the end of 2011 there will be 2.3GW, in UK waters
- UK excellence in composites in several parallel sectors, including wind

1. Introduction



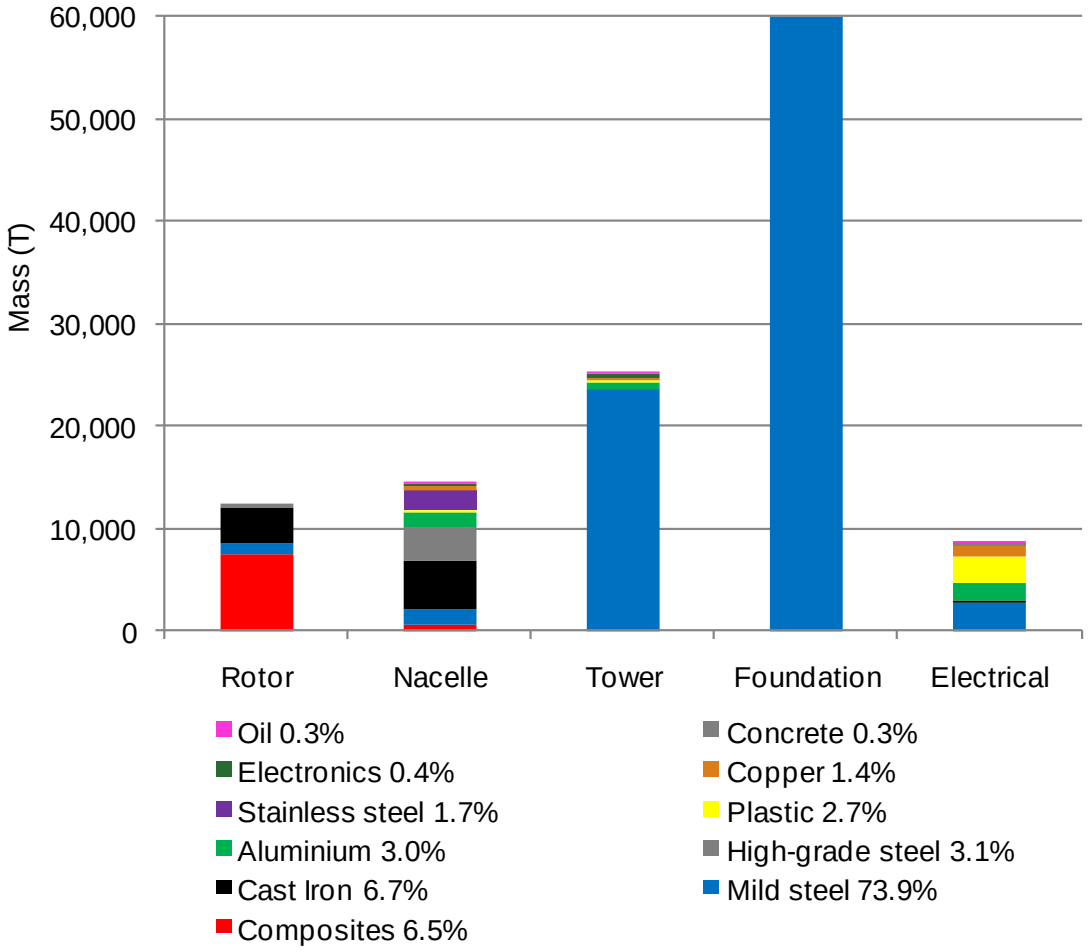
1. Introduction: market forecast



2. Offshore wind supply chain: UK supply

- For the European market, supply chains have grown up alongside their rapidly UK supply chain
- But:
  - Growth of the market
  - New offshore technology
  - UK leadership
- ... mean that there is a fresh opportunity

3. Composites in an offshore wind farm



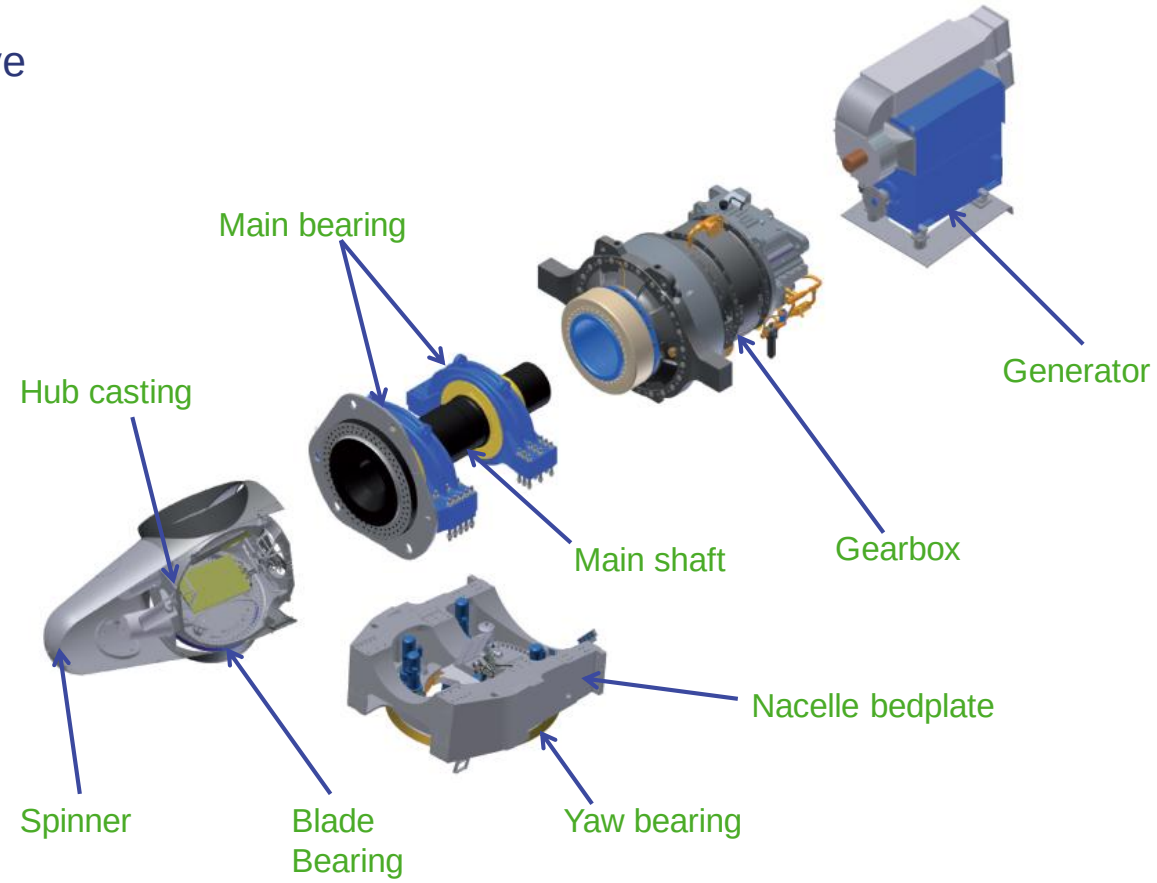
Material breakdown for a 500MW wind farm.

3. Composites in an offshore wind farm: turbine

- Blades
  - Current blade lengths 44-61m; 5m chord; 15-25t
  - Likely to average about 75m in 2020
  - Most single section
- Nacelle cover - typical dimensions of a 5MW turbine nacelle are 10-15m x 4m x 4m
- Spinner - 3-4m in diameter

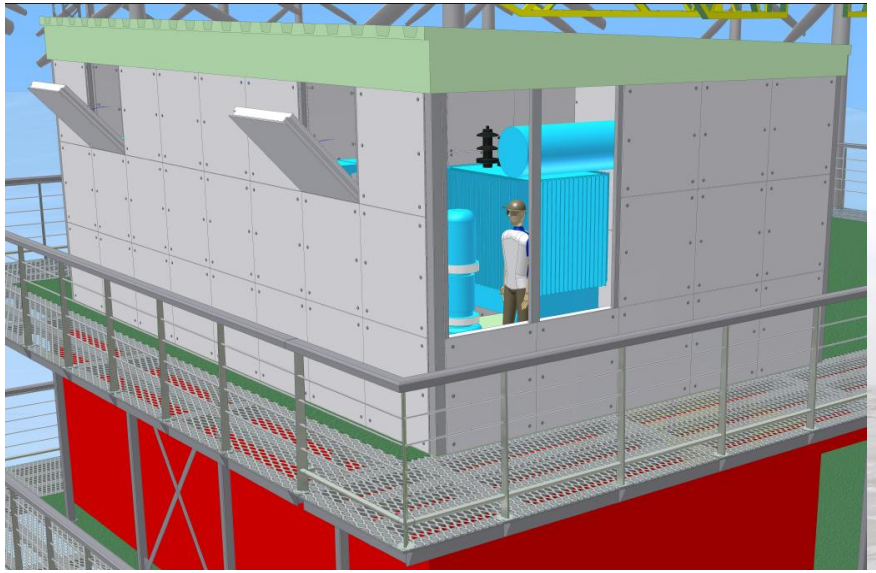
3. Composites in an offshore wind farm: other turbine components

- Cost is currently generally too high cost now to justify and unlikely to be deployed in these areas in the short term.
  - Interface with drive
  - Hub.
  - Main shaft.
  - Generator
  - Asset protection
  - Tower
  - Tower dampers
  - Bedplate



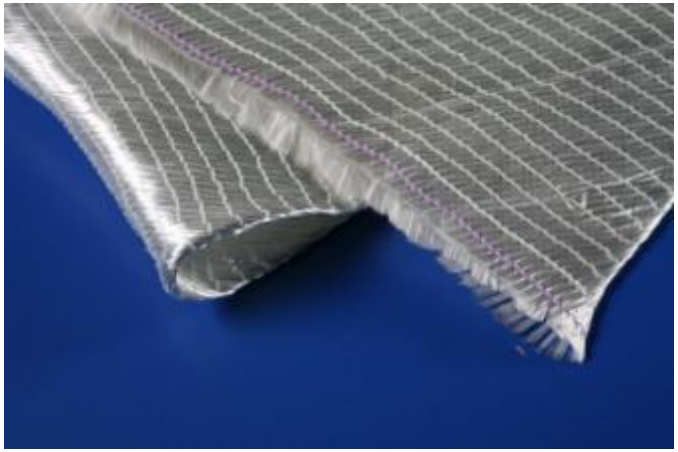
3. Composites in an offshore wind farm: other wind farm components

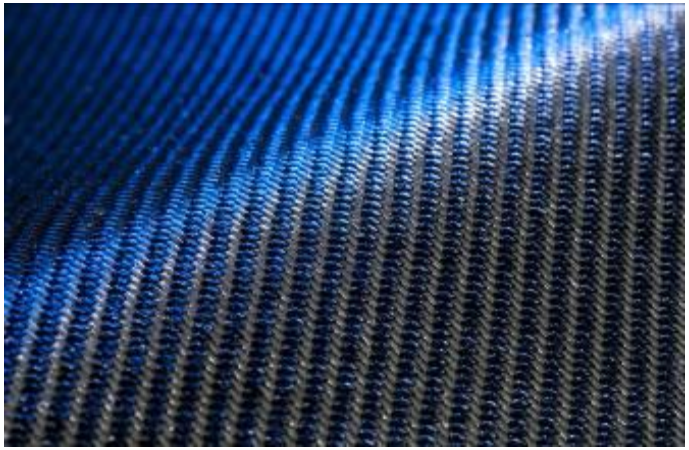
- Offshore substations
  - Blast and fire protection applications
  - Walkways and cable trays
- Vessels



4. Blade technologies: materials

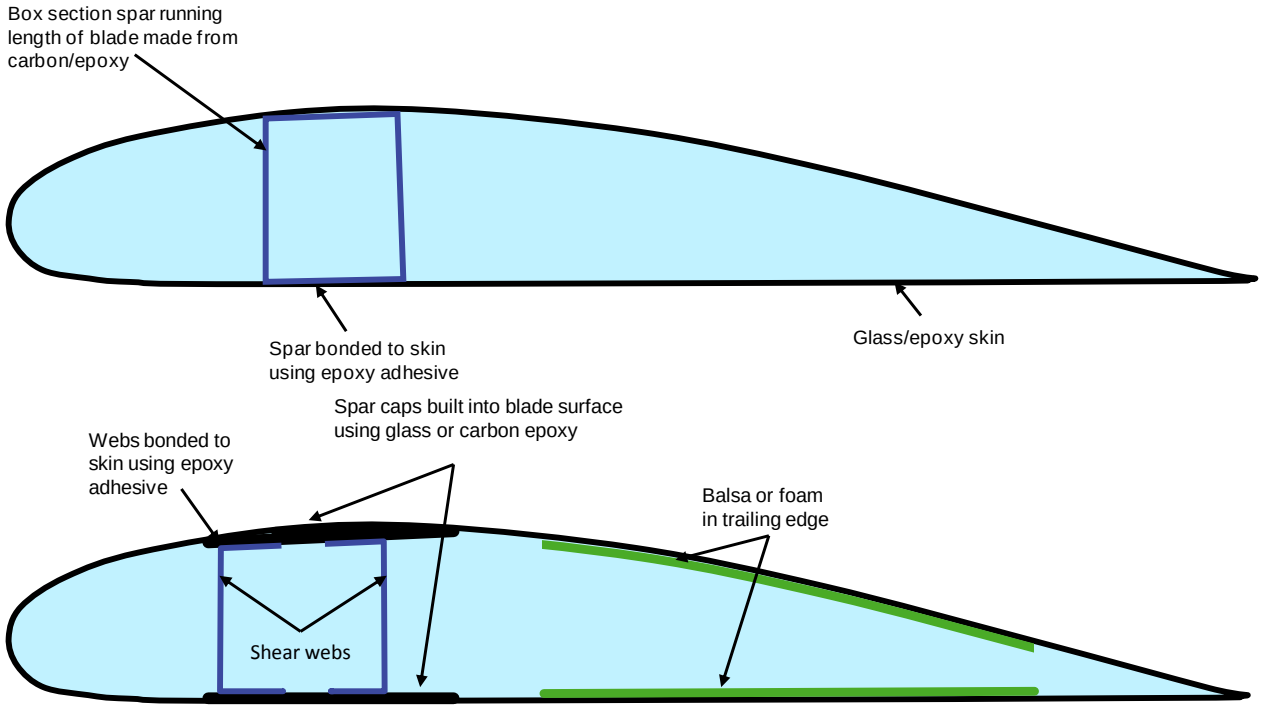
- Technology drivers: cost; fatigue and corrosion resistance; weight; strength; stiffness; consistency
- **Structural materials** – glass (E-R-S)/carbon
- **Matrix material** - typically a resin – epoxy or polyester
- **Core materials**, used for to stabilise the glass/carbon layers and carry shear loading on the structure
- **Coatings**, which are needed to protect the composite from the erosion and UV light
- **Adhesives**, used to bond together composite sub-components





4. Blade technologies: structure

- Shell. This provides the aerodynamic shape of the blade.
- Load bearing beam.
- Root end. This is part of the blade that attaches the blade to the hub.



4. Blade technologies: types of technology

Technology	Resin infusion	Prepreg	Integral blade vacuum infusion
Fibre	Glass or carbon	Glass or carbon	Glass or carbon
Resin	Polyester or epoxy	Epoxy (pre-impregnated into fibre	Epoxy
Surface finish	In mould gelcoat when polyester is used; paint when epoxy is used	Sprayed on polyurethane paint	Sprayed on polyurethane paint
Sandwich core	Balsa and polymer foam	Balsa and polymer foam	Balsa and polymer foam
Assembling of blade shells and web	Bonding with structural adhesive	Bonding with structural adhesive	No bonding zones
Company example	LM Wind Power, Euros	Vestas, Gamesa	Siemens

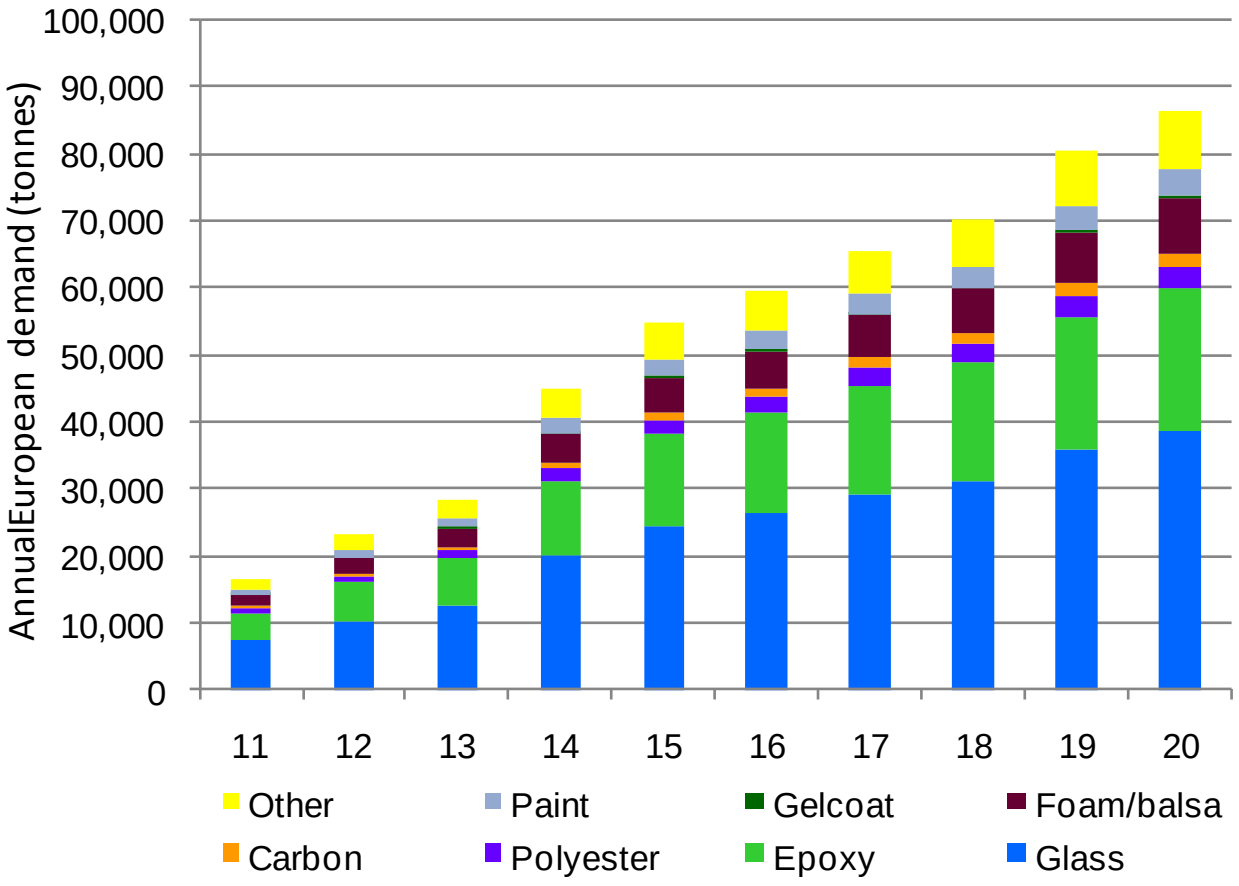
5. Other turbine applications

- For nacelle covers and nose cones - most common material used is glass and polyester with a polyester gelcoat
- Resin infusion moulding and resin transfer moulding are commonly used for these components
- Structural foam may be used in certain areas
- Made in one piece or in sections

6. Opportunities for the composites industry

- Component manufacture and supply
- Manufacturing support
- Material and sub-component supply
- Research and development of processes and materials
- Blade repair and cleaning

6. Opportunities for the composites industry: blade material and subcomponent supply



7. Opportunities for the composites industry: Component manufacture and supply

Wind turbine manufacturer	Blade supplier
Siemens	Siemens
Vestas	Vestas
Repower	PowerBlades (Repower joint venture with SGL Rotec) ; LM Wind Power
Bard	SGL Rotec
Areva	PN Rotor (wholly-owned subsidiary of Areva)
Alstom	LM Wind Power

- Limited opportunity for new players to enter the market as independent blade manufacturers as volumes are high, the market is highly competitive, there are high capital costs, and there is conservativeness around blade supply.
- EADS - Developing blade manufacturing factory using internal composite expertise

7. Opportunities for the composites industry: manufacturing support

- Tooling
  - Most blade manufacturers in offshore wind will manufacture their own moulds although specialist subcontractors do exist.
  - Infusion and mixing equipment
  - Glass cutting, fibre placement and other automation equipment
  - Blade handling and support frames
- Consumables - health and safety equipment, vacuum bags, infusion mesh
- Training - blade manufacturers will give in-house training to new recruits

7. Opportunities for the composites industry: R&D

- Technology supply chain
  - If technology developers and research organisations could license their IP to OEMs or their supply chain or form a joint venture.
  - Collaborative projects offer a strong platform for engagement between technology developers and research organisations, and OEMS and their supply chain. These allow co-development and steering from the eventual customers.
- R&D support
  - Design and testing services;
  - Provision of composite development training.

6. Research and development: challenges

- Structural design of large blades. As blade length on offshore turbines is increasing, the technical challenges on the blade are increasing as increasing demands are put on both the materials and the structure in order to maintain sufficient stiffness to prevent tower strike.
- Manufacture of large blades, eg prevention of voids curing of thick composites, handling and logistics
- Faster production cycle time, eg curing times, material lay down rates, automation
- Reliability. improved structural and fatigue models, manufacturing process improvement and condition monitoring, gel coating and paints
- Cost. Improved performance of materials, optimised manufacturing processes
- Increasing power capture. Smarter rotor challenges with fatigue flesh out
- Speed to market – rapid prototyping, improved design tools , improved material understanding optimised testing and prototyping
- Reduction of servicing needs. Self-cleaning, de-icing flesh out

6. Opportunities for the composites industry: blade repair and cleaning

- Internal and external blade inspection;
- Paint and gel coat repairs;
- Composite damage repairs;
- Blade cleaning; and
- Lightning protection systems inspection and repair.

6. Opportunities for the composites industry: challenges

- Aerospace and defence
  - Opportunities around manufacturing, design and testing and composite technology transfer
  - Aerospace industry previously favoured autoclave processing of carbon fibre epoxy prepreg, Drivers to reduce cost and production time are now leading the industry to develop out-of-autoclave processing and automated production techniques
  - Potential synergies with wind but rate of production much higher in wind and limited use of carbon
  - Motorsport – opportunities mostly in design skills and tools, and rapid prototyping

6. Opportunities for the composites industry: sector challenges

- Marine
  - Boat building and blade, nacelle cover and nose cone manufacture use very similar processes and materials
- Automotive
  - Limited experience of making composites parts in large volumes because the cost of composite parts has traditionally been prohibitive
  - Environmental considerations and the need reduce weight mean this attitude is changing and may be some scope for technology transfer between the two sectors as both explore these new manufacturing routes
- Oil and gas
  - Knowledge of environmental resistance can be transferred across to the similar environment for offshore wind

See report at

www.bvgassociates.co.uk

Thank you

Any questions?