Offshore wind:
Opportunities for the composites industry

Zoe Barnes, 5th May 2011

BVG Associates

- **Technical wind and marine energy consultants**
- **Formed in 2005.**
- **Hands-on experience in the wind industry**

Specialists in:

- **Market analysis**
- **Business development**
- **New technology steering**
- **Technical due diligence**
- **Wind farm development support**

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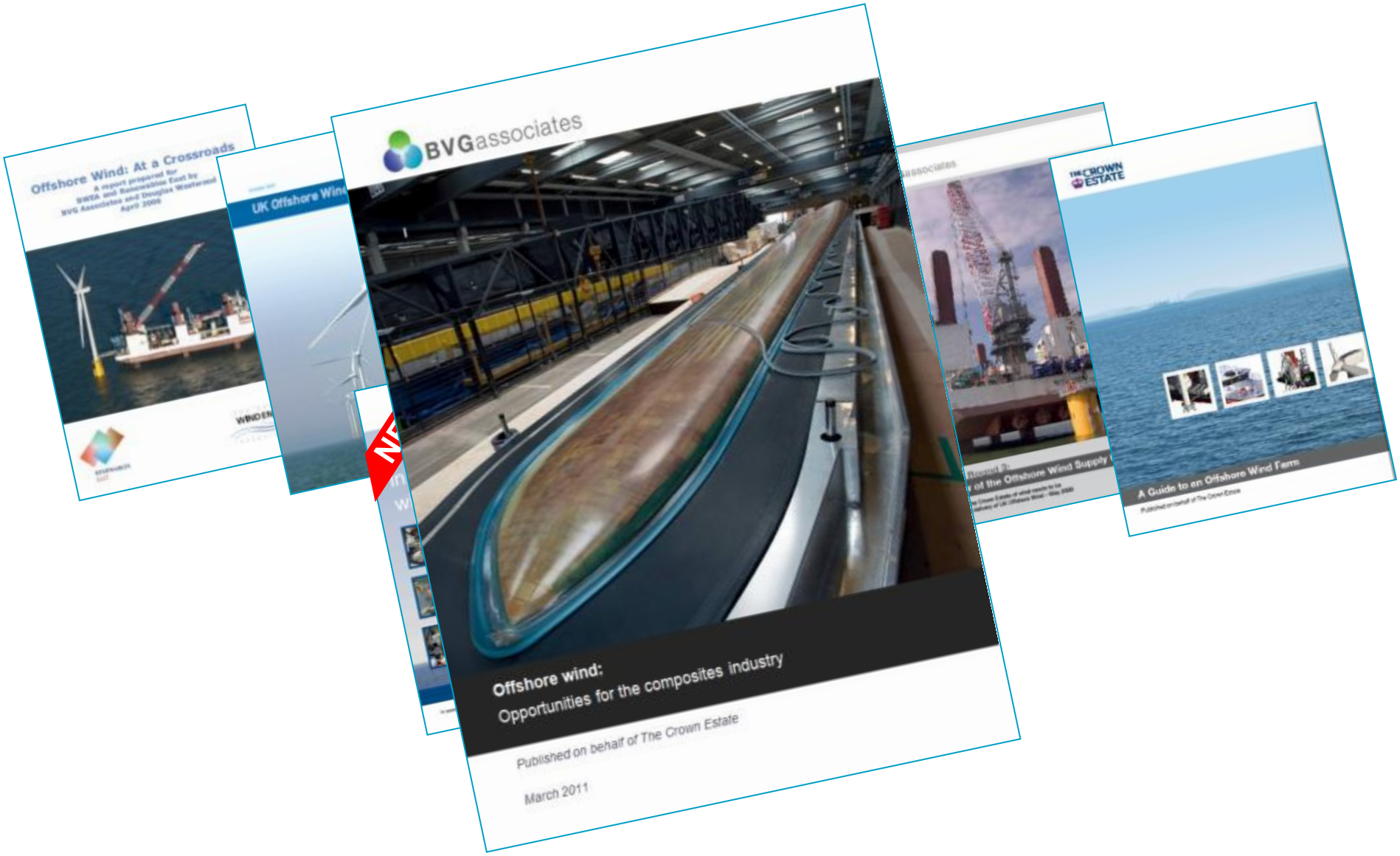
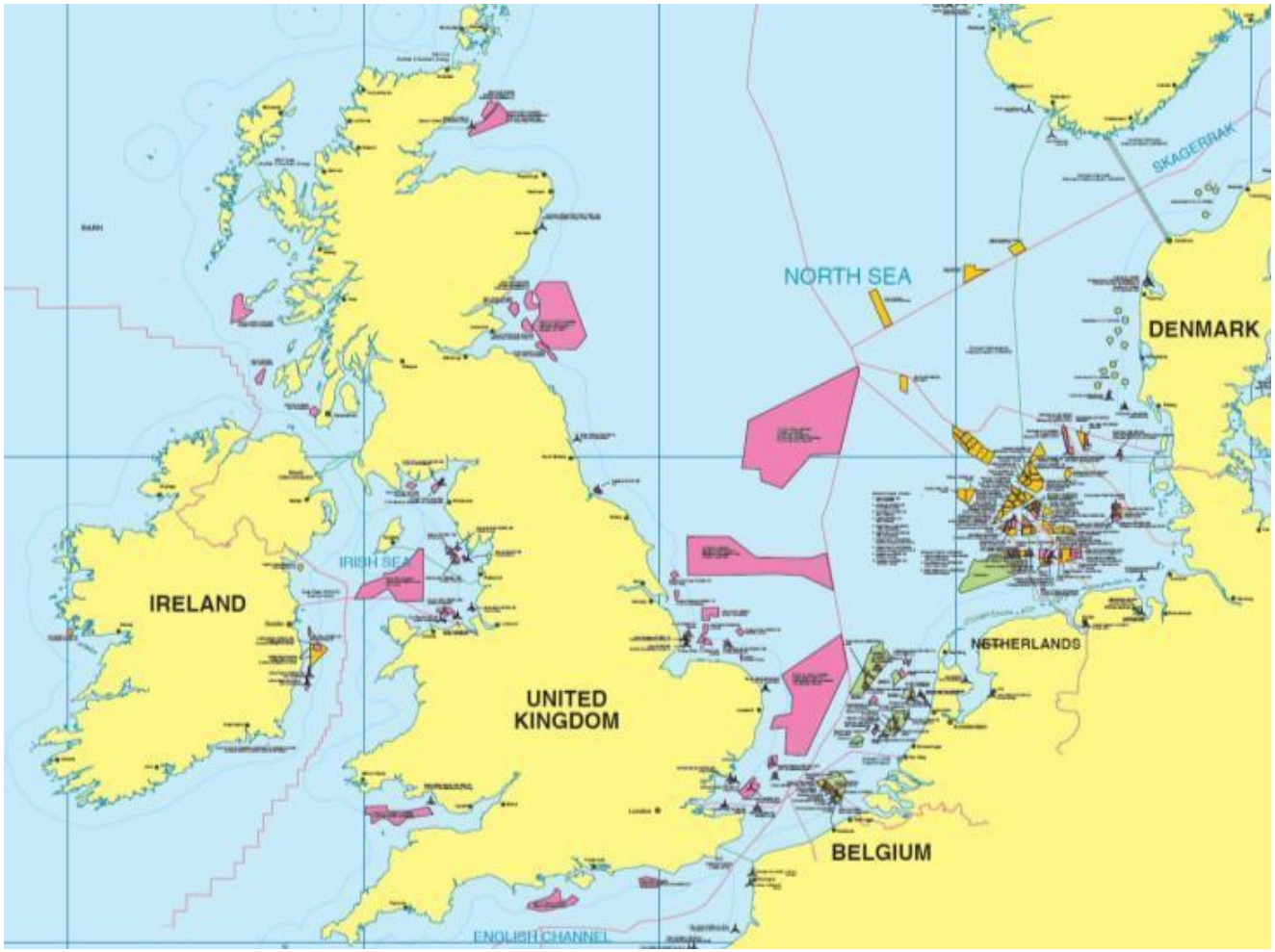


Agenda

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

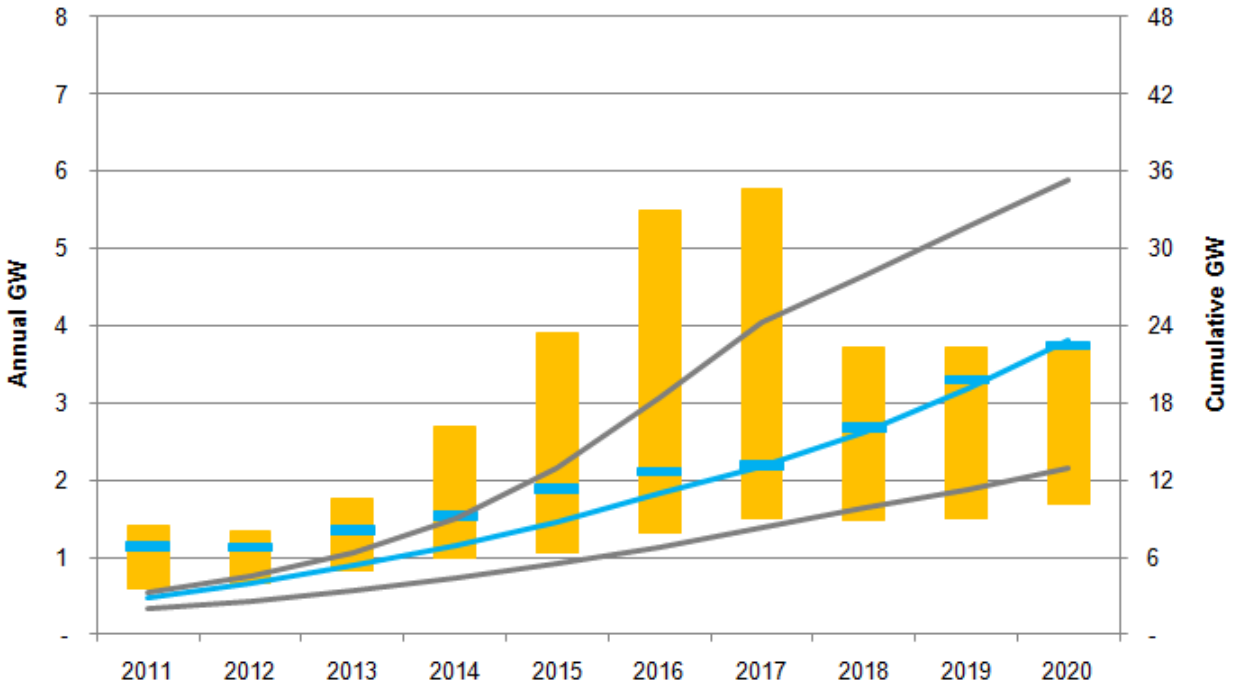
1. Introduction

1. Introduction: Offshore wind in the UK



The Crown Estate has leased seabed for the development a total of 48GW of offshore wind energy

1. Introduction: Strong predicted market for offshore wind to 2020



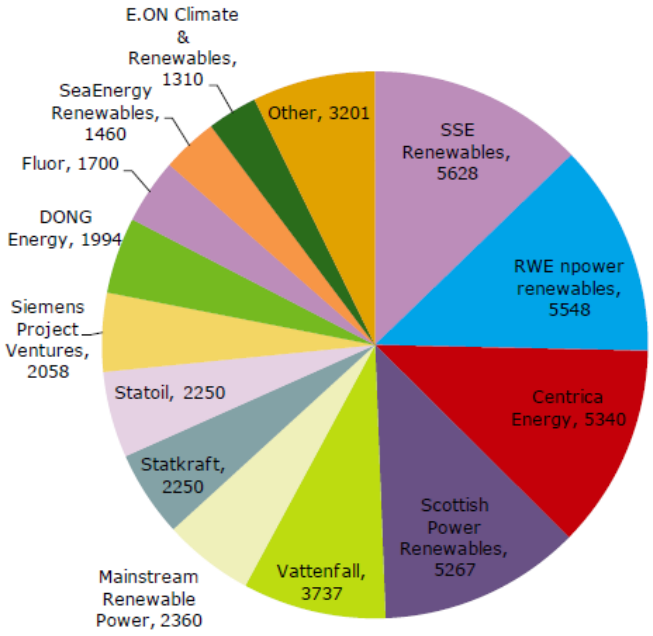
Predictions for wind farm installation to 2020

The rate of installation of turbines is expected keep increasing exponentially to beyond 2020

Estimations of installed capacity by 2020 vary from around 13GW to around 36GW.

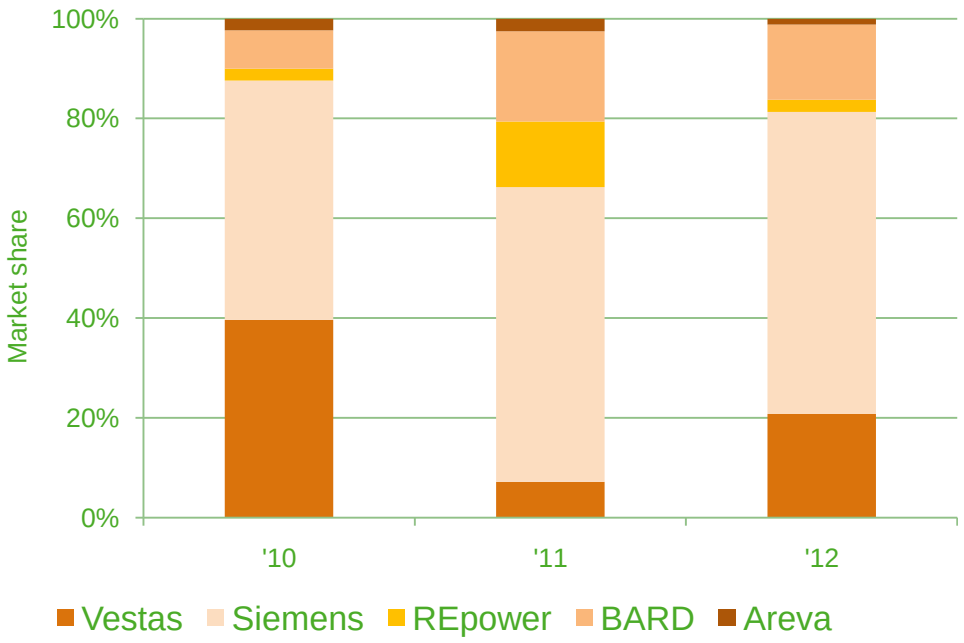
2. Offshore wind supply chain: Dominated by a large turbine manufacturers and developers

- Offshore wind farm development is increasingly dominated by large utilities from across Europe, such as Centrica, DONG, RWE, E.ON and Vattenfall.



Developer share of UK offshore wind farms in planning (MW)

- Most of the top-10 manufacturers of large onshore wind turbines are developing products for the offshore wind market



Manufacturer share of European offshore wind farms in planning

2. Offshore wind supply chain: Trends in offshore turbines

- Costs must come down
- Increasingly, turbines are being designed specifically for offshore deployment.
- Fewer market constraints: such as noise and visual impact
- Increase in turbine capacity: Average today 3.2MW expected to be 6MW in 2020 with some 10MW (or 15MW machines entering the market.
- Increase in turbine size: Current market standard around 110m rotor with 164m and 190m rotors entering the market.

2. Offshore wind supply chain: Opportunities for UK supply

- Supply chains for the onshore wind turbines are well established and have grown alongside the growth in the market.

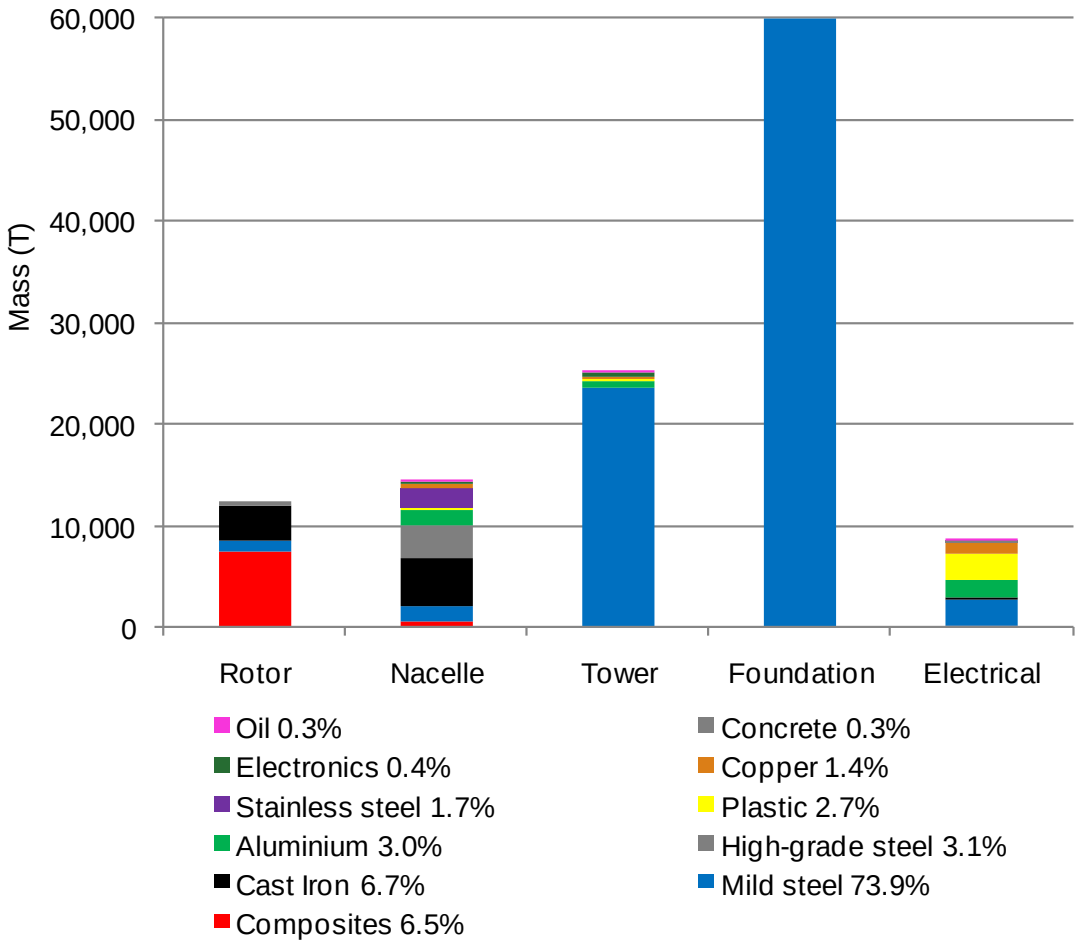
- However:
  - Growth of the offshore market
  - New offshore technology
  - UK leadership in offshore wind market

.....this means that there is a fresh opportunity

3. Composites in an offshore wind farm: Significant amounts of composites are used in a wind farm

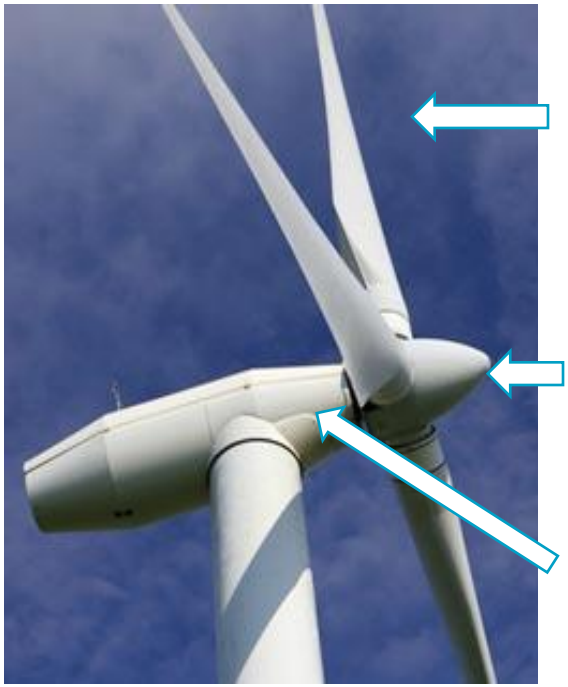
Approximately 6.5% of an offshore wind farm is made of composites

There are over 8000 tonnes of composites in a 500MW wind farm



Material breakdown for a 500MW wind farm.

3. Composites in an offshore wind farm: Key composite turbine components are the blade, nacelle cover and nose cone



	Primary Function	Size	Weight
Blade	Capture the energy from the wind	Approx. 60-80m, 5m chord (expected to grow to around 75m by 2020	15-30 tonnes
Nose cone	Protect hub casting	3-4m in diameter	0.5 tonnes (includes steel components)
Nacelle Cover	Protect internal nacelle components	10-15m x 4m x 4m	20 tonnes

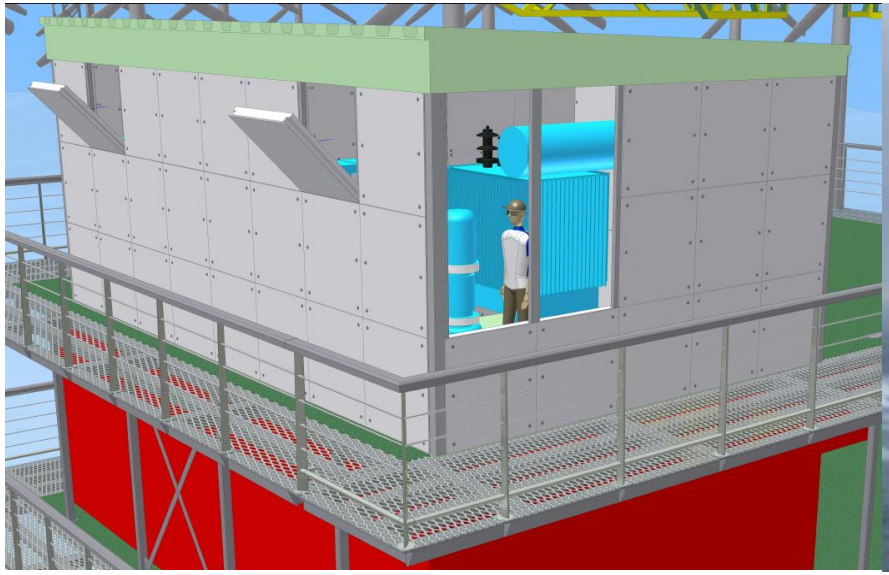
3. Composites in an offshore wind farm: Other turbine components could potentially be made of composites.

- There are a number of other components that could be manufactured from composites.
  - Hub.
  - Main shaft.
  - Generator components.
  - Asset protection
  - Tower
  - Tower dampers
  - Bedplate

However, the cost is currently generally too high cost now to justify and unlikely to be deployed in these areas in the short term

3. Composites in an offshore wind farm: There are a number of uses for composites on a wind farm

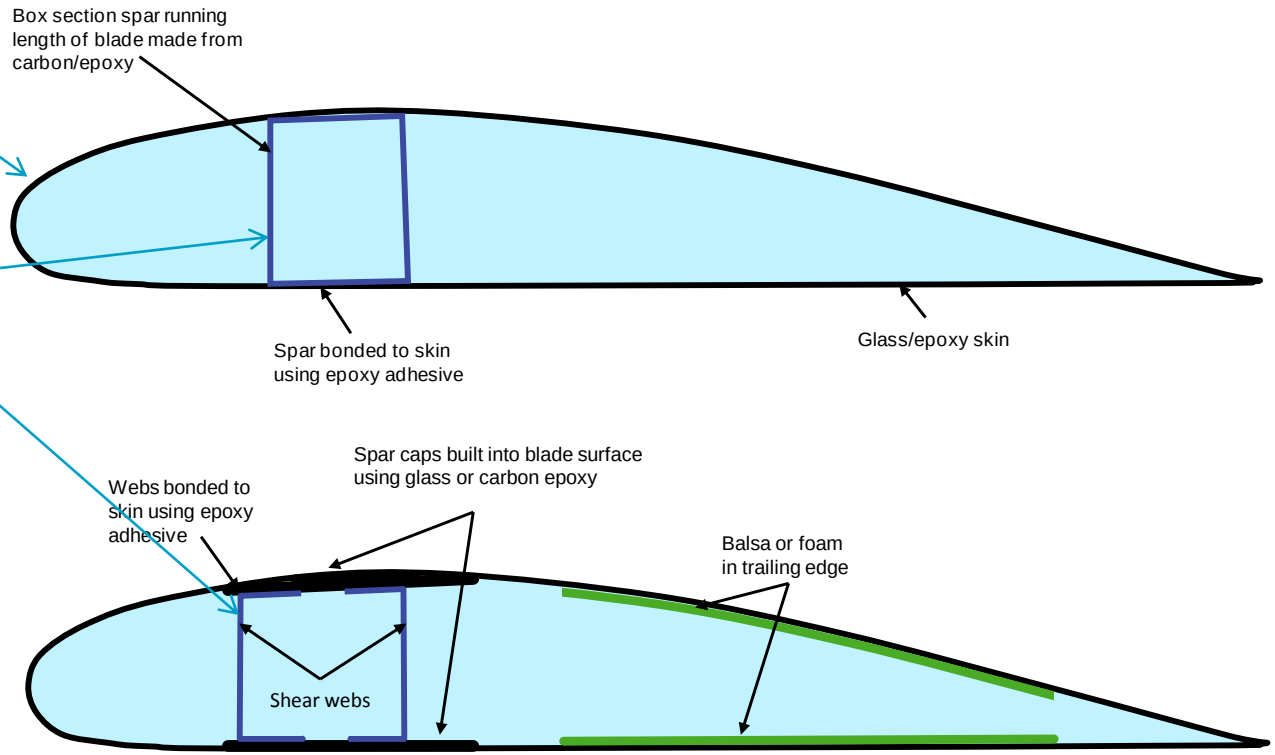
- Offshore substations
  - Blast and fire protection applications
  - Walkways
- Vessels/ access pods



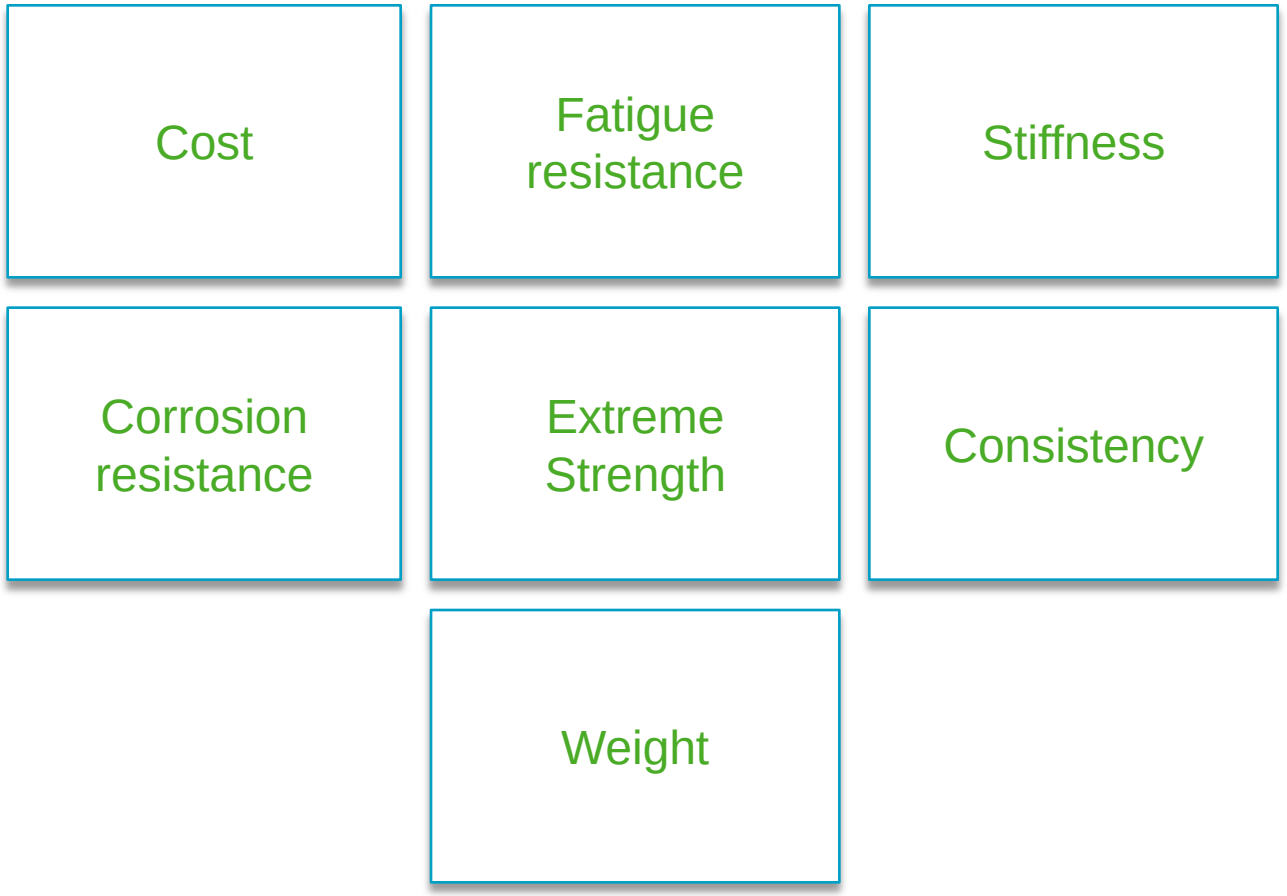
4. Blade technologies: Most blades have are similar structure.

Blade technologies vary between manufacturers but most have the following features:

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



4. Blade technologies: Key material property drivers are well suited to composites



4. Blade technologies: 3 different manufacturing process are used by the industry

Blades are currently manufactured in one of 3 ways:

- Resin infusion
- Pre-preg
- Integral infusion

The most commonly used manufacturing technique is currently resin infusion resin (approximately of blades are 2/3 resin infused)

4. Blade technologies: A range of materials are used in the different technologies

Technology	Resin infusion	Prepreg	Integral blade vacuum infusion
Fibre	Glass (E-R-S) or carbon (found in approx.1/3 of blades world-wide)		
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	
Sandwich core	Balsa and polymer foam		
Assembling of blade shells and web	Bonding with structural adhesive		No bonding zones

5. Other major wind turbine components: Nacelle covers and nose cones

- Material – The most common materials used are:
  - Fibre - Glass
  - Matrix - Polyester resin
  - Coating - Polyester gel coat.
  - Core - Structural foam may be used in certain areas.
- Typically made in one piece or in sections using resin infusion moulding and resin transfer moulding.

6. Opportunities for the composites industry

There are 5 key areas of opportunity for the composite industry to enter the offshore wind market:

- Component manufacture and supply;
- Material supply;
- Manufacturing support;
- Blade repair and condition monitoring
- Research and development of processes and materials;

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

Blades:

- Limited opportunity for new players to enter the market as independent blade manufacturers because:
  - Highly competitive
  - High capital costs
  - General conservativeness around blade 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)

However with more manufacturers emerging there may be opportunity for a limited number of new entrants.

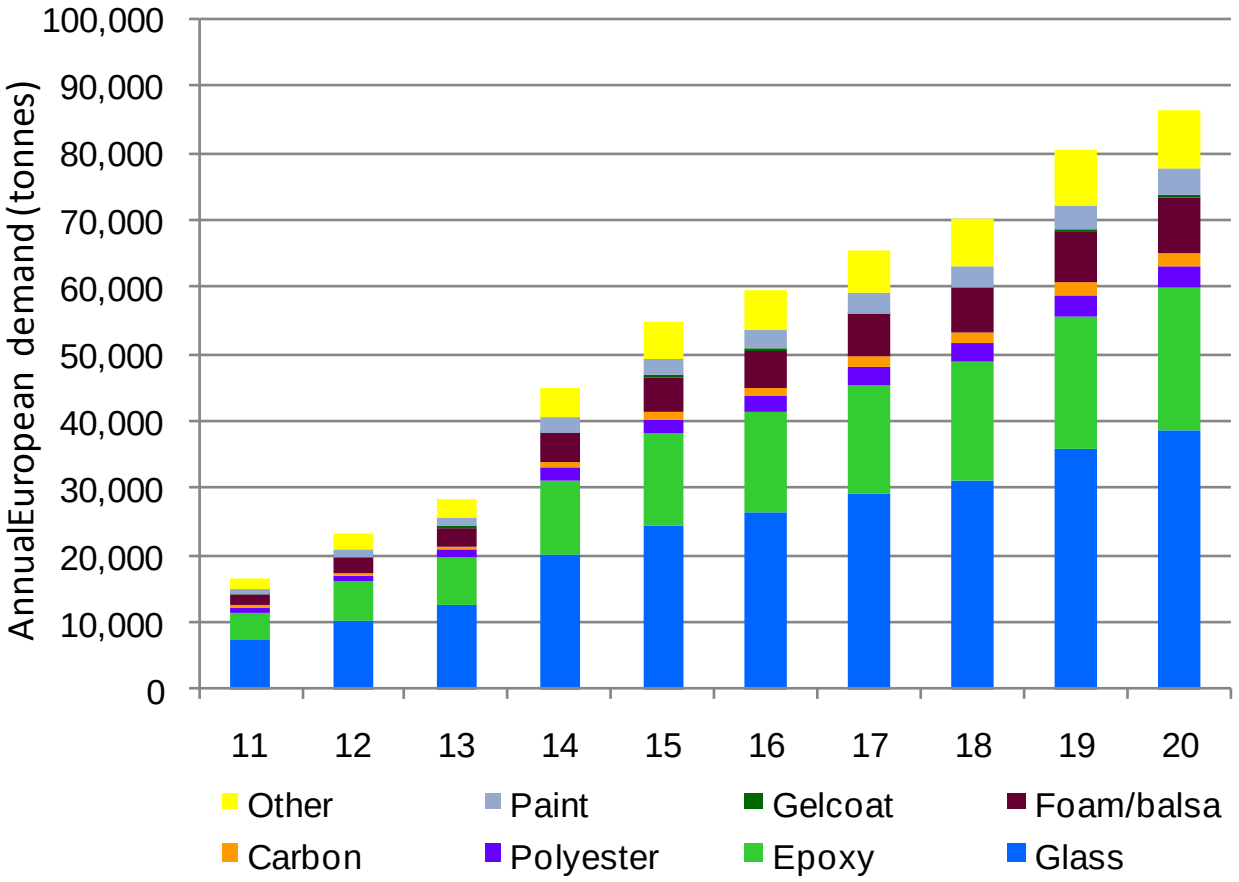
6. Opportunities for the composites industry: Component manufacture and supply

Nacelle and nose cone:

- Opportunities are better for nacelle cover and nose cone supply because:
  - Most manufacturers subcontract these components
  - IP associated with nacelle covers and nose cones is less contentious,
  - Tooling costs are lower than for blades.

Image Courtesy of Eikboom.

8. Opportunities for the composites industry: Material and subcomponent supply



Forecast composite material demand in Europe from offshore wind blades to 2020.

6. Opportunities for the composites industry: Manufacturing support

Blade, nacelle cover and nose cone factories require supporting functions such as:

- Development and supply of Tooling
  - Moulds- Most blade manufacturers in offshore wind will manufacture their own moulds but there are some opportunities for specialist subcontractors.
  - Infusion and mixing equipment
  - Glass cutting, fibre placement and other automation equipment
- Supply of consumables – e.g. health and safety equipment, vacuum bags, infusion mesh
- Provision of Training – Often internal but some opportunities for external training providers.

. Blade manufacturing training. Courtesy of Consuta Training.

6. Opportunities for the composites industry: Blade repair and condition monitoring

Specialist, rope access teams are needed for:

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

The need to reduce O&M costs means that there is also a growing demand for condition monitoring of turbine blades.

6. Research and development: Challenges and opportunities

Structural design of blades	Manufacture of large blades	Faster production time	Increasing Power capture
Increased blade length leads to challenges with self-weight and stiffness.	Prevention of voids, curing of thick composites, handling and logistics	Curing times, materials lay down rates, automation	Active rotor

Reliability	Cost	Speed to market	Reduction of servicing needs
improved structural and fatigue models, manufacturing process improvement and condition monitoring, gel coating and paints	Improved performance of materials, optimised manufacturing processes	rapid prototyping, improved design tools , improved material understanding optimised testing and prototyping	Reliable condition monitoring Erosion resistance

6. Opportunities for the composites industry: Significant opportunities for technology and skills transfer from parallel sectors.

There are shared opportunities and challenges with an number of sectors including:

- **Aerospace** (Technology transfer, material/component supply, skills and knowledge transfer, manufacturing technologies)
- **Automotive and motorsport** (Technology transfer
- **Oil and gas** (Offshore experience)
- **Marine** (Offshore experience)

6. Opportunities for the composites industry: Cross sectorial barriers to entry

Some significant features of the wind industry could act as barriers to transfer to some sectors (particularly aerospace).

These include:

- Almost exclusive use of out of autoclave processes.
- High rate of production of very large components (typically 600 blades per year per factory).
- Low profit margins and continual cost down culture in wind industry.
- Limited use of carbon

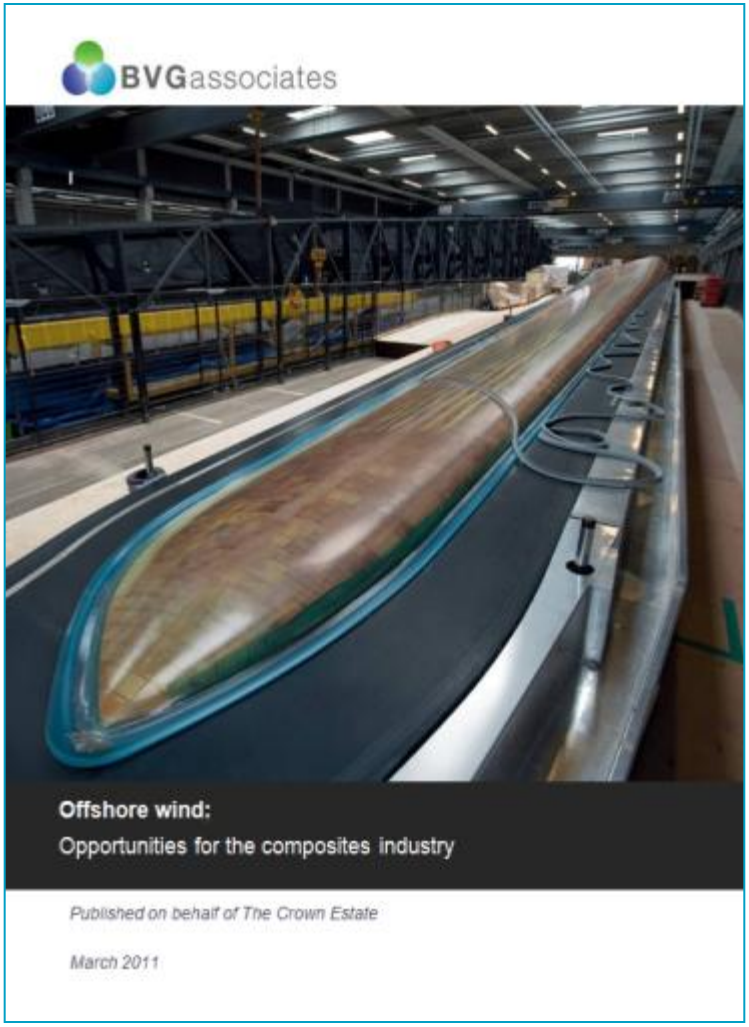
6.Opportunities for the composites industry: Conclusions

There could be around 2400 50m+ wind turbine blade[illegible] annually in the UK by 2020

- There are significant opportunities [illegible] in:
  - Nacelle and nose [illegible]
  - Material [illegible]

Opportunities for UK companies will significantly when blade and nacelle manufacturing facilities are announced in the UK

There are real opportunities for transfer of skills, knowledge and technology from aerospace, automotive, oil and gas and marine sectors



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Thank you