Co-creation in Wind works

JEC Paris 2014

Luuk Groenewoud, DSM
Luc Peters, 3B-the fibreglass company

DSM
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DSM Mission

Our purpose is to create brighter lives for people today and generations to come.

We connect our unique competences in Life Sciences and Materials Sciences to create solutions that nourish, protect and improve performance.

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DSM Global Presence

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DSM Composites Means Innovation for Sustainability

Cobalt Free	Zero Styrene	Renewable	GMP
Increased health and safety through substitution of soon-to-be listed Ingredients by greener alternatives	Performance and sustainability by reduction and elimination of styrene emission and smell	Long term supply security, Reduced environmental impact through replacement of raw materials by renewable alternatives	End user product safety through Good Manufacturing Practice (GMP) for Composite components in contact with Food and Drinking water

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3B-the fibreglass company

A reference in fibreglass for quality and innovation

Major and dynamic actor in composite reinforcement solutions

- A large product range of reinforcements for thermoplastic, thermoset and specialty glass fibers for numerous applications with a special focus on specific market segments: thermoplastics, wind energy, performance composites
- Three manufacturing plants: Birkeland (Norway), Battice (Belgium) and Goa (India)
- R&D center in Belgium
- Dedicated marketing, commercial and technical organizations
- 950 employees building upon a long heritage of expertise

unique glassfibre solutions

high performance and eco-responsible

Innovating and setting new standards within the fibreglass industry

Chopped Strands

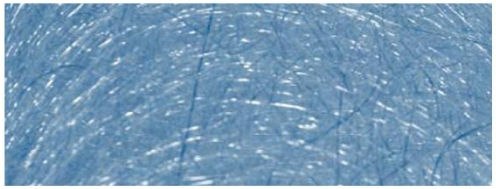
Applications

Automotive, Electrical & Electronics, Consumer, Transportation, Construction

Direct Rovings

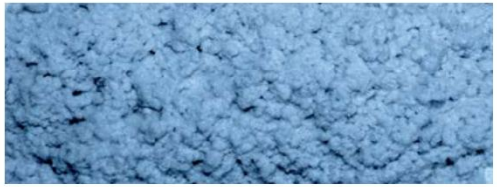
Wind, Infrastructure, Transportation, Electrical & Electronics, Pipes & Tanks

Continuous Flament Mat



Automotive, Infrastructure, Construction, Electrical & Electronics

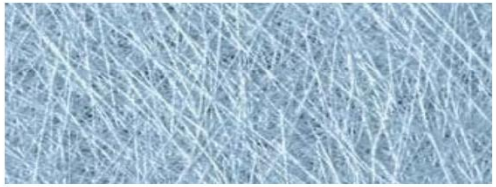
Textured Yarns Milled Fibres



Applications

Construction, Electronics, Automotive

Chopped Strand Mat



Electrical & Electronics, Transportation, Pipes & Tanks

Assembled Roving

Automotive, Transportation

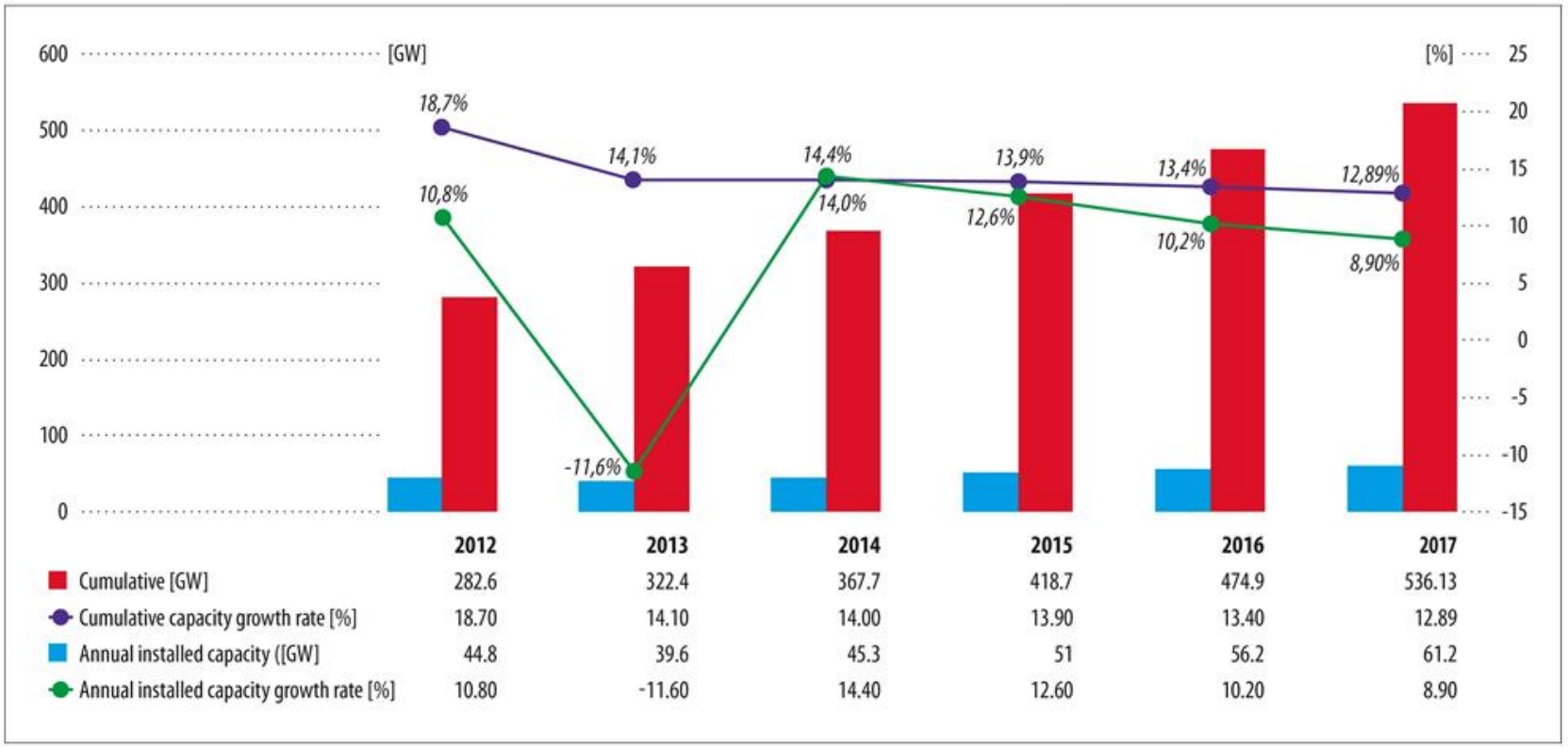
partnering with customers

to develop today's innovation and tomorrow's products

- 3B's values of proximity and reliability, our high level of service and responsiveness, as well as our ability to innovate, are of great benefit for our customers

- Providing partners with a value proposition beyond the product itself such as innovative tailor-made solutions for a specific customized sizing, packaging and logistics for example

Wind Energy Markets are Anticipated to Grow



	2012	2013	2014	2015	2016	2017
Cumulative [GW]	282.6	322.4	367.7	418.7	474.9	536.13
Cumulative capacity growth rate [%]	18.70	14.10	14.00	13.90	13.40	12.89
Annual installed capacity ([GW]	44.8	39.6	45.3	51	56.2	61.2
Annual installed capacity growth rate [%]	10.80	-11.60	14.40	12.60	10.20	8.90

Source: GWEC

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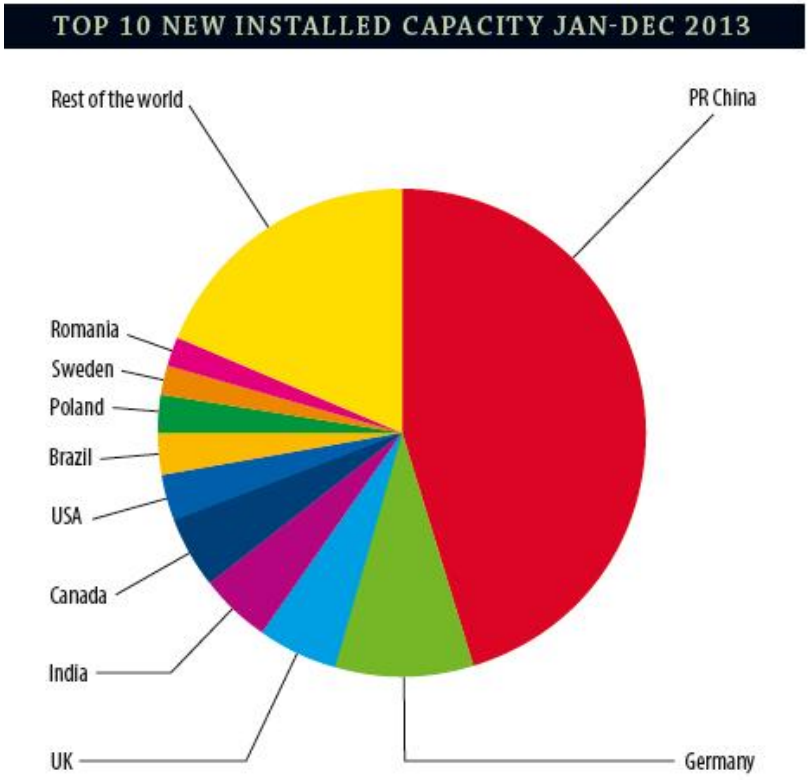
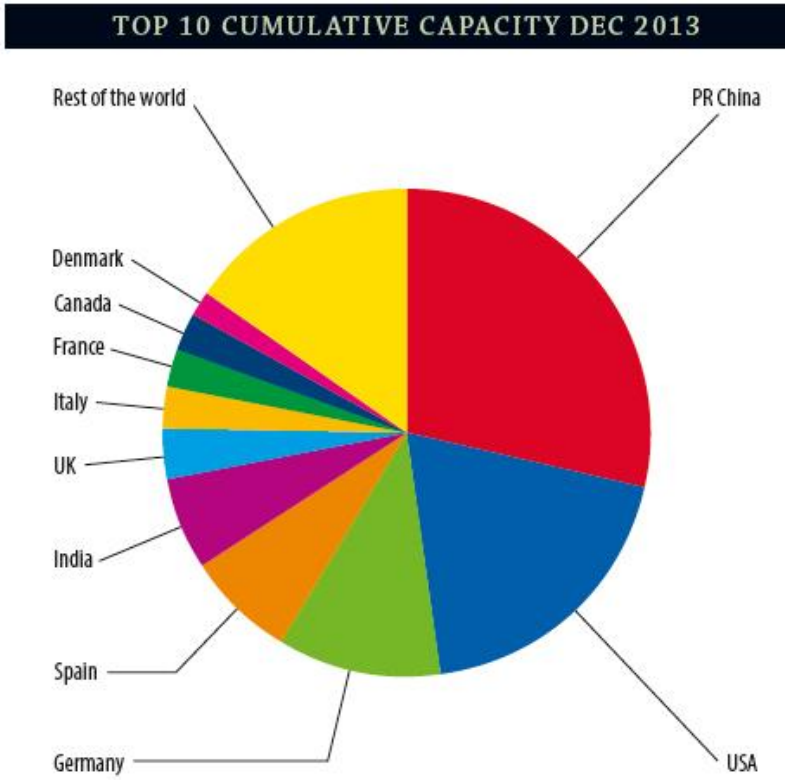
Significant Portion Installed in China





Source: GWEC

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Tough Requirements Wind Energy

- Reliable wind turbine operation
- Generate energy without interruption
- Low investment cost
- Minimal maintenance
- Long and efficient working life

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Current Material Systems for Wind Turbine Blades Have Limitations

- Mostly based on epoxy resins
  - Bring resistance to fatigue
  - Yet sensitive to process variations
  - Require a time-consuming post-cure for reaching optimum physical properties
- Blades based on polyester resins have important share of market
  - Resins are easier to process
  - But laminates feature less fatigue resistance
  - Typically based on styrene-containing resins, requiring appropriate emission control systems in blade production

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Composites Industry is Dealing with Several Challenges at the Same Time

- Desire for higher performance material systems
  - Excellent mechanical properties
  - Large production series capability
  - Improved process consistency and quality (e.g. less repairs)

- Desire to have alternatives to styrene
  - Styrene is most commonly used reactive diluent
  - Strong smell, need for emission control
  - Flammability

- Replacement of traditional Cobalt catalysts used for curing
  - Cobalt Octoate already classified as CMR2
  - Future classification yet unclear

- Reduce dependence on fossil-based raw materials
  - Eventual depletion fossil resources
  - Price volatility

Breakthrough Beyone™ 201-A-01 Resin from DSM

- Can be employed in high end applications and compete with epoxy resins on performance
- Reactive diluent derived from renewable feedstock
- Works perfectly with a new, Cobalt-free catalytic system based on BluCure™ Technology

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Properties of Beyone™ 201-A-01 Resin Can Compete with those of Epoxy Resin

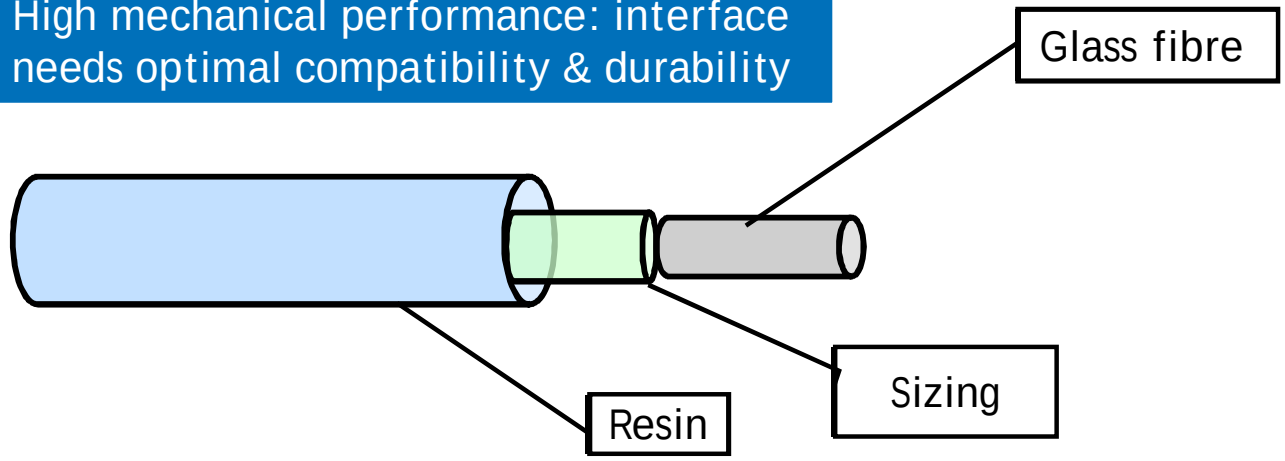
Casting formulation	K_1C (MPa√m)	Tensile strength (MPa)	Tensile modulus (GPa)	Elongation at break (%)	Flexural Strength (MPa)	Flexural Modulus (GPa)	Tg (°C)	Density (g/cm³)
Beyone™ 201-A-01	1.48	77	3.4	6.3	124	3.7	111	1.12
Epoxy reference	1.02	78	3.1	4.7	123	3.4	89	1.18-1.20
UPR reference	0.66	60-90	3-4	2-10	90-120	3-4	60-150	1.15

Benefits of Beyone™ 201-A-01 Resin

- Excellent mechanical performance, incl. fatigue resistance
- With all the benefits of UPR processing
  - Low viscosity – quick infusion
  - Fast and adjustable hardening at room temperature
  - No or limited post-cure (dependent on process set up)
- Close to 40% derived from renewable sources
- Close-to-zero emissions as resin is 100% styrene-free
- Has low labeling, marginal smell before and no smell after curing
- The resin utilizes sustainable, Cobalt free curing technology (based on BluCure™ Technology)

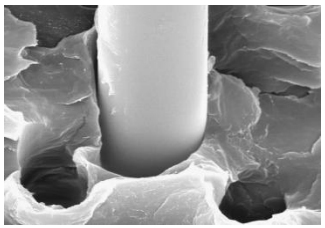
Composite Properties Rely on Interface of Fibre and Matrix

High mechanical performance: interface needs optimal compatibility & durability

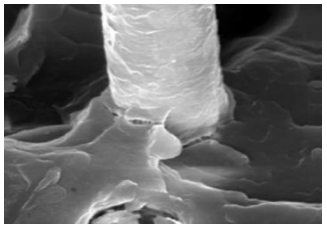


Optimum fibre/matrix interface properties required

- Wetting ability
- Adhesion performance



Poor adhesion
Fiber debonding



Good adhesion
Cohesive failure

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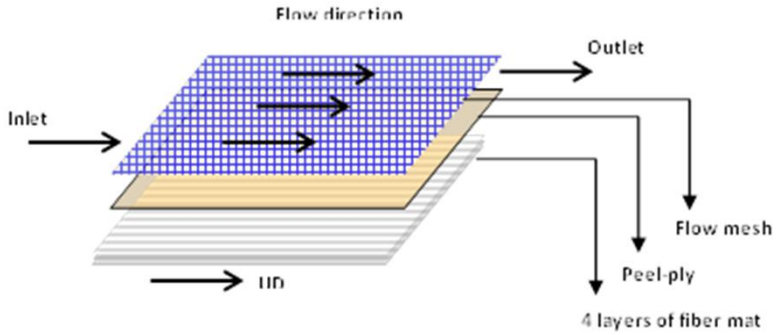
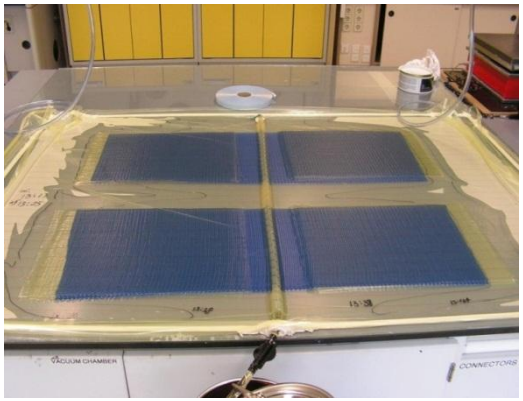
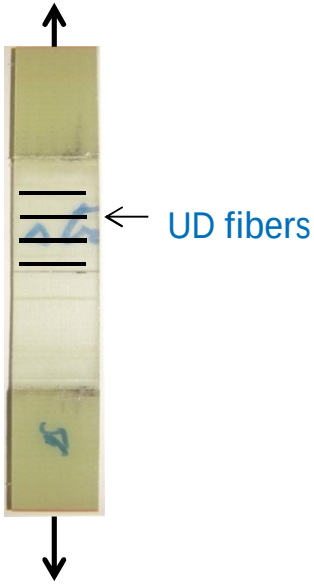
Breakthrough SE 3030 Glass Fibre Rovings from 3B

- Novel sizing enables excellent wetting of fibres and laminate quality
- Great adhesion between fibre and matrix
- Enhanced fatigue performance
  - Increase more than 10 times vs. traditional sizings
- Meeting Epoxy system benchmark for the Wind Energy market
- Improved inter-fibre properties and Inter-Laminar Shear Strength

Transverse Tensile Strength UD Laminates is Good Indication for Resilience







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Adhesion to the Fibre Crucial for Laminate Performance

Laminate based on	Post-cure conditions	ILSS (MPa)	Transverse Tensile Strength (MPa)	Transverse Flexural Strength (MPa)
Beyone™ 201-A-01 (Pure UD Filament Wound)	4h @ 40 °C	65	49	52
Epoxy reference (Pure UD Filament Wound)	4h @ 90 °C	62	49	49

Comparable properties at reduced post-cure

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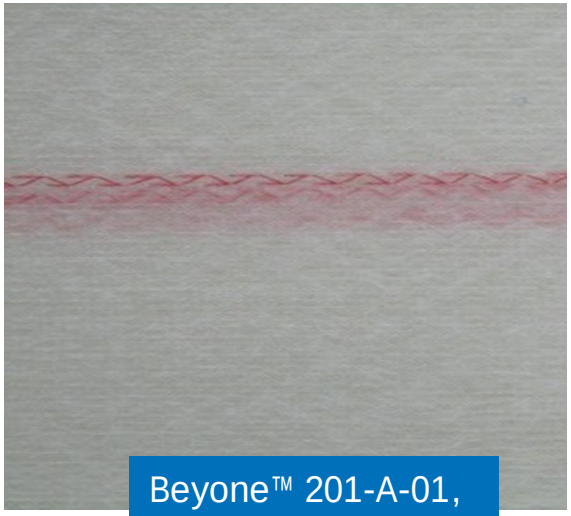
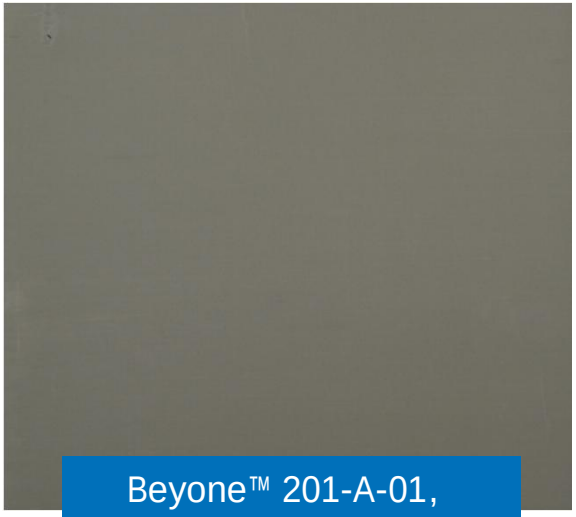
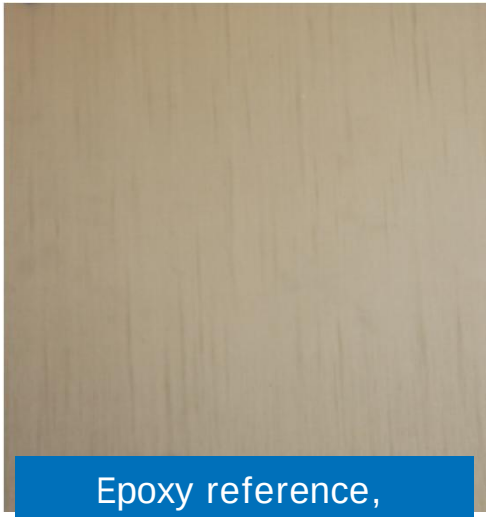
Excellent Laminate Appearance



Beyone™ 201-A-01,
Glass fabrics



Beyone™ 201-A-01,
Pure UD Filament Wound



Epoxy reference,
Pure UD Filament Wound

Good impregnation, no dry spots, low fiber visibility

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Co-creation in Wind works

Winner 2014 JEC Innovation Award

DSM, Siemens Wind Power,
3B, DTU Wind Energy

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Sustainable Material Solutions for Wind Turbine Blades

- Reliable wind turbine operation through stronger blades
- Increased blade production output
  - Easy impregnation through low viscosity
  - Minimal repair and dry spots
  - Minimal post-cure resulting in reduced mould occupation time
- Reduction in blade manufacturing cost
  - Lower exotherm resulting in longer mould life
- Healthier environment during material processing
- Styrene-free, Cobalt-free (BluCure™ Product), 40 % bio-based
  - No costly emission and air control systems
  - Healthier and more enjoyable working environment

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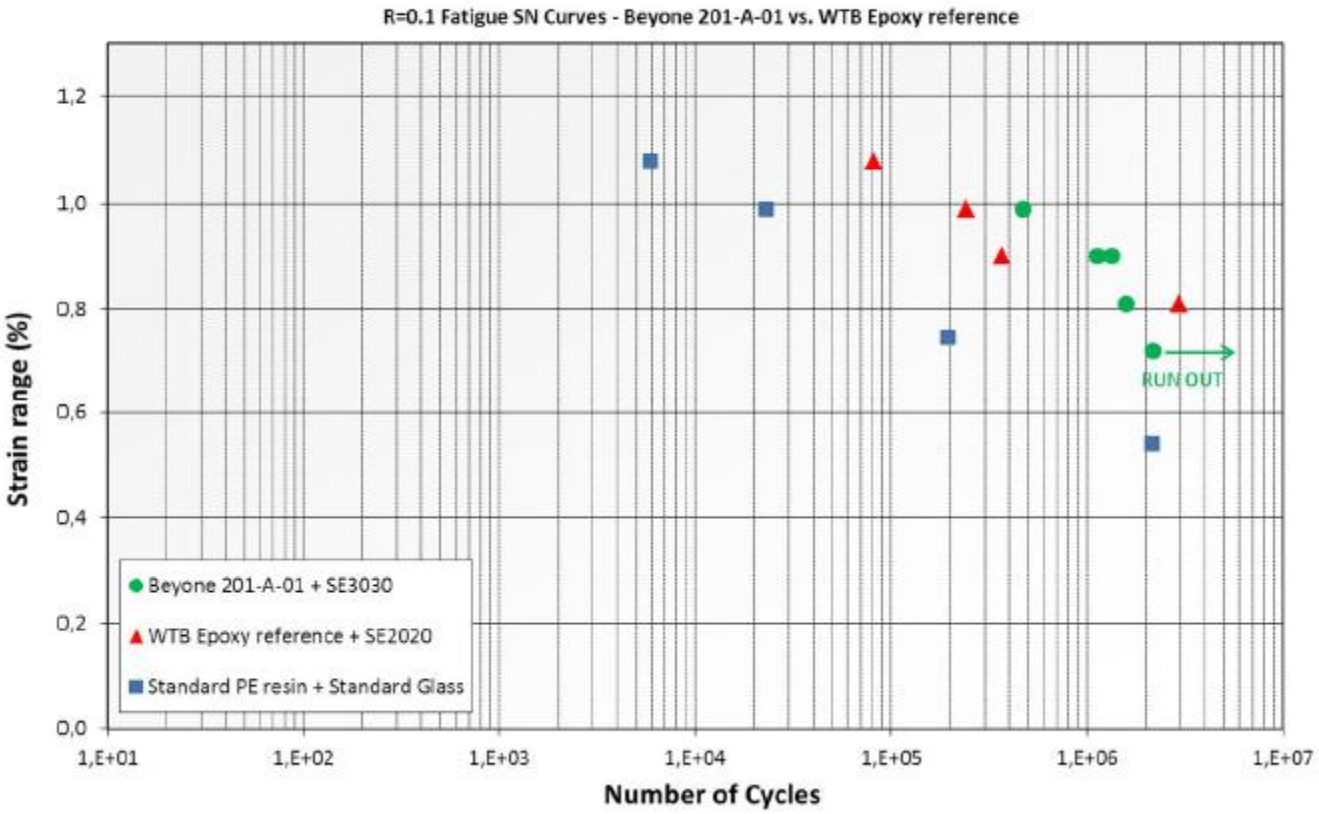
Excellent Resistance to Fatigue for Long-life Blade Performance



Note:
Pure UD filament wound laminates (based on Advantex® glass)

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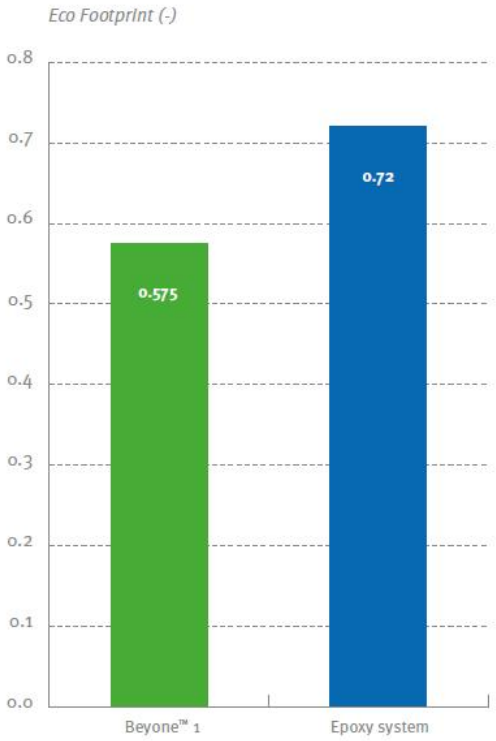
Beyone™ 201-A-01 resin has Reduced Eco-Footprint



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Outstanding Value and Sustainability through Co-Creation

- Channel partners taking on the challenge together
- Complementary expertise to create robust composite system for blade manufacturing
- Peace-of-mind on sustainable turbine operation and on sustainable materials used
- Increasing competitiveness of Wind Energy

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