GEN2 CARBON

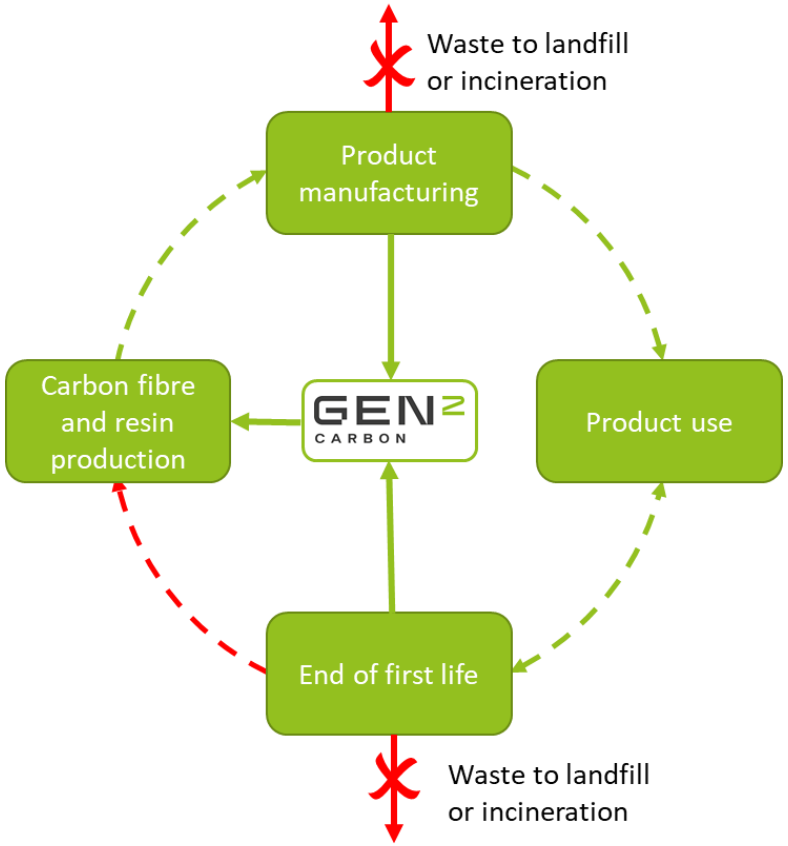
Practical Applications of Recycled Carbon Fibre

Advanced Engineering

November 2021

Our History

- 2003: Established as “Recycled Carbon Fibre”
- 2009: Establishment of first industrial scale carbon fibre recycling plant
- 2011: Acquired by ELG Haniel and becomes “ELG Carbon Fibre”
- 2015: Expansion into chopped and nonwoven carbon fibre products
- 2018: Mitsubishi Corporation acquires 25% share in “ELG Carbon Fibre”
- 2021: Short fibre business divested to Procotex
- 2021: Gen 2 Carbon created to develop next generation carbon fibre recovery systems and expansion of carbon fibre nonwoven business



Building a circular carbon fibre economy

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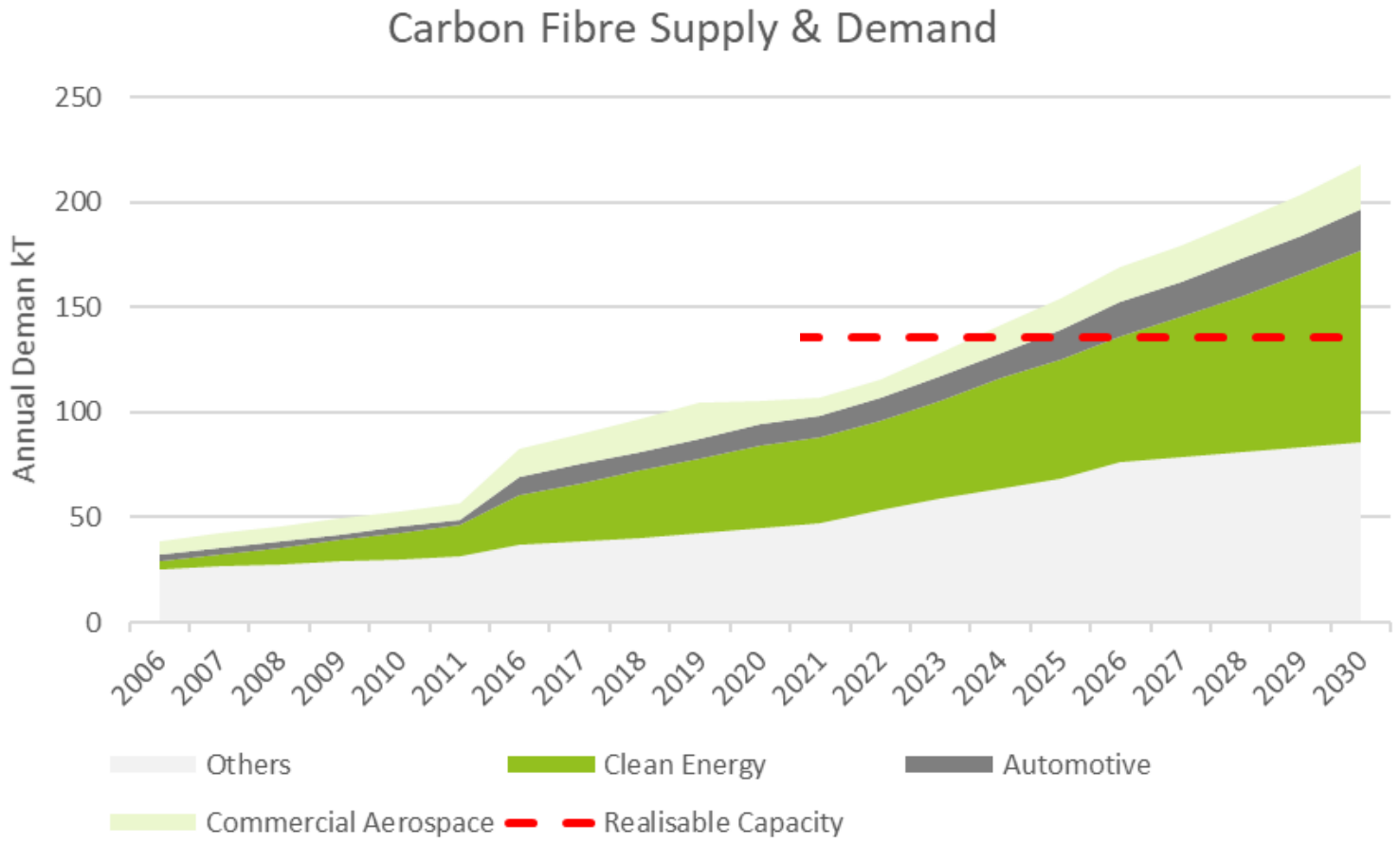
Why This Is Important



- Carbon fibre is a critical material in efforts to decarbonise the economy—pressure vessels, wind turbine blade spars, lightweight structures in transportation.
- Current forecasts for demand growth see demand exceed capacity at some point in the next 5 years.
- Even with announced capacity expansions, the supply / demand will be fragile and we have to look at how we maximise the use of this valuable resource.

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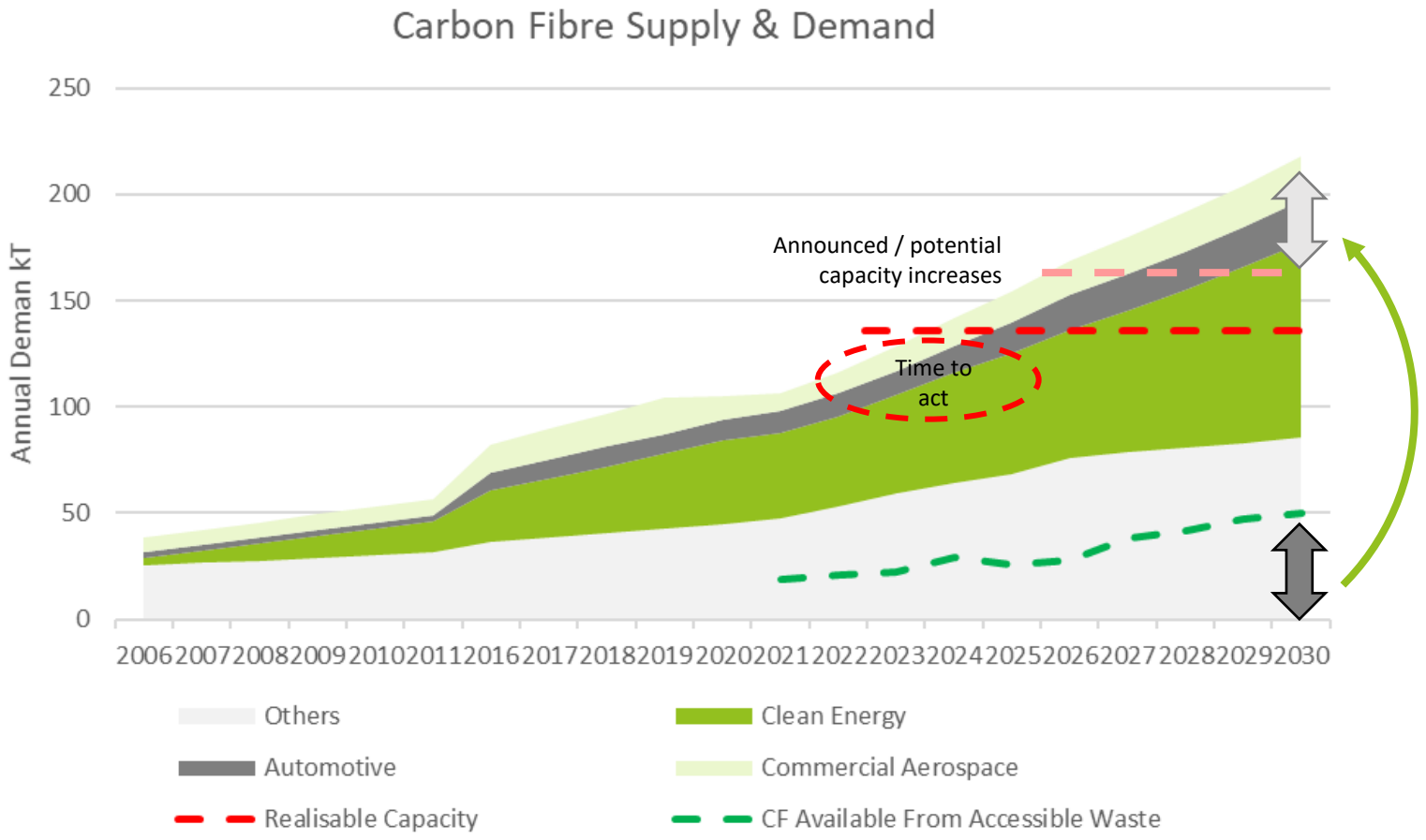
Why This Is Important



- About 90% of the carbon fibre available from accessible waste (post industrial, post consumer large / monolithic structures containing high proportions of carbon fibre) could be used in applications identified today.
- This substitution would alleviate carbon fibre supply shortages and ensure that continuous virgin fibre availability for those applications where its properties are required.
- This does require process development (intermediate materials and parts) and a rethink of how we design parts.

Recycled Carbon Fibre Materials

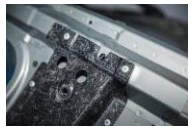
	Description	Product Forms	Process Options
G-Tex "M" 	▪ 100% recycled carbon fibre. ▪ Available in standard and intermediate modulus grades.	▪ Dry nonwoven fabrics. ▪ Prepregs (via third part processors).	▪ Vacuum infusion. ▪ Autoclave moulding (prepregs). ▪ Press moulding (prepregs, liquid compression moulding, RTM)
G-Tex "TM" 	▪ Combinations of recycled carbon and thermoplastic fibres. ▪ Typical thermoplastic fibres include MAPP, PA6, PC, PPS and PEI. ▪ Available in standard and intermediate modulus grades.	▪ Dry nonwoven fabrics. ▪ Preconsolidated sheets (via third party processes).	▪ Direct compression moulding / hot pressing. ▪ Stamp forming of heated, preconsolidated sheets. ▪ Hybrid moulding / overmoulding.

Many product / process options available to suit different types of application: size, build rate, geometry, surface finish, mechanical characteristics

Evolution of rCF in Automotive Applications

Private Medium – High Volume

Semi-structural body panels made using HP-RTM



Detailed parts made using press moulding

Growing understanding of where, how and why to use recycled carbon fibre

Many projects in development looking at higher volume applications of recycled carbon fibre

Commercial Medium Volume

Structural closures and body panels made using press moulded prepreg

Commercial Low Volume

Semi-structural closures and body panels made using autoclave moulded prepreg

Structural closures and body panels made using autoclave moulded prepreg

High Performance / Luxury Low-Medium Volume

Semi-structural closures and body panels made using press moulded prepreg and liquid compression moulding

Multifunctional parts made from stamp formed preconsolidated sheets

Enabling cost effective lightweight structures with reduced environmental footprint

2010 2020 2030

Design Considerations

- Recycled carbon fibre materials are different to virgin carbon fibre materials. This is a characteristic, not a problem!
- **Positives.**
  - Very good surface finish can be achieved, attractive “raw” aesthetic.
  - Laminates are quasi-isotropic and tend to be dimensionally stable.
  - Thickness can be built very quickly.
  - Parts can be engineered to have different thicknesses without changing the number of plies.
- **Drawbacks.**
  - The fabrics have a high bulk factor, making forming around or into corners without high pressure / matched tooling difficult.
  - Fibre volume fraction is highly dependant on consolidation pressure, and limited to about 35% for most product forms/processes. Prepregs and thermoplastic hybrids must be carefully designed to suit the intended process.
  - Nonwovens have low permeability, hence care is required in tooling and process design for liquid moulding processes.

Are rCF Materials Strong Enough?

CaFiBo Project Carbon Fibre Bogie Frame

- Tested under static and fatigue loading to BS EN 13749 at the Institute of Railway Research based in the University of Huddersfield .
- Combination of virgin and recycled carbon fibre to provide the optimum solution for weight, mechanical performance and cost.
- 6 million cycled at nominal vertical, lateral and twist loads. 2 million further cycles at 20% overload. 2 million further cycles at 40% overload.
- No visible or measured damage in any of the composite materials.

Environmental Benefits

Northern Lights Composites Ecoracer

Lower initial environmental impact, recyclable at end-of-life

- Same hull weight as an engineered glass fibre fabric structure, heavier than a carbon fibre structure.
- **Environmental Impact (all hull materials).**

	Glass Fibre	RCF	VCF
Embodied Energy (MJ)	34,639	28,333	172,200
GWP (kg CO_2)	1,759	1,567	7,378
Water Use (l)	68,536	71,333	211,190

- Higher water use is driven by higher resin use for the recycled carbon fibre hull.
- Opportunities for weight saving identified through the build of the prototype.
- Hull can be recycled at the end-of-life.

Summary

- Carbon fibre is a critical resource in many applications that support the decarbonisation of the economy.
- Carbon fibre demand is forecast to exceed supply capacity, largely driven by growth of these applications.
- The industry today is wasteful in its lack of recycling of manufacturing and end-of-life waste, and reluctance to use recycled materials.
- Effective utilisation of the carbon fibre contained in this waste is not just possible, but is a necessity if we are serious about aligning our industry with global imperatives to reduce dependance on fossil fuels and preserve critical resources.
- This is being done / has been demonstrated in applications in the wind energy, automotive, electronics, marine and aerospace market sectors, and we need to learn from these experiences to increase the number of these applications.

Thank you

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