The ReCoVeR Project

Regenerating the strength and value of glass fibres thermally recycled from end-of-life GRP composites

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AMRL
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EPSRC
Engineering and Physical Sciences Research Council

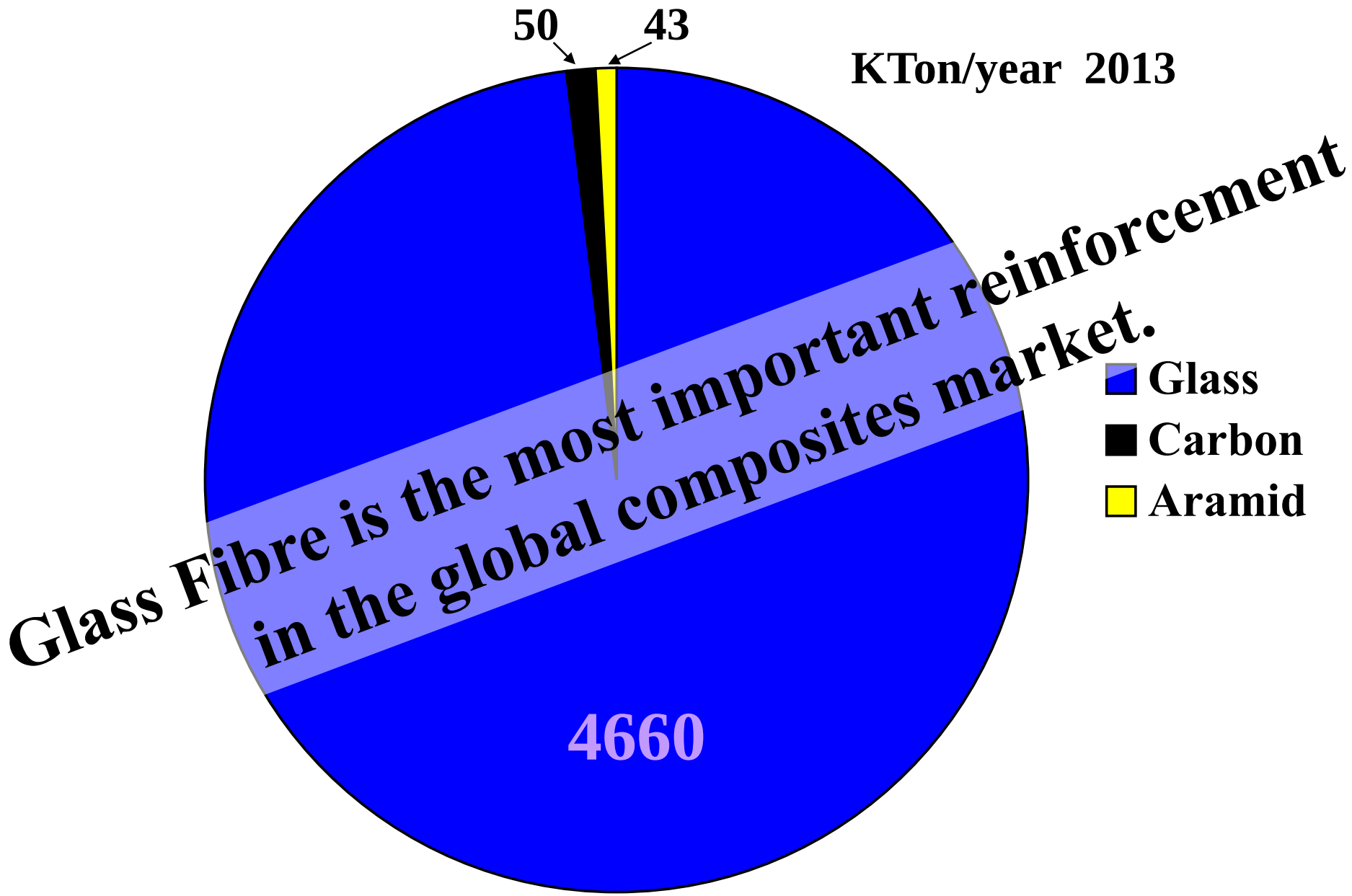
University of Strathclyde Engineering

ReCoVeR

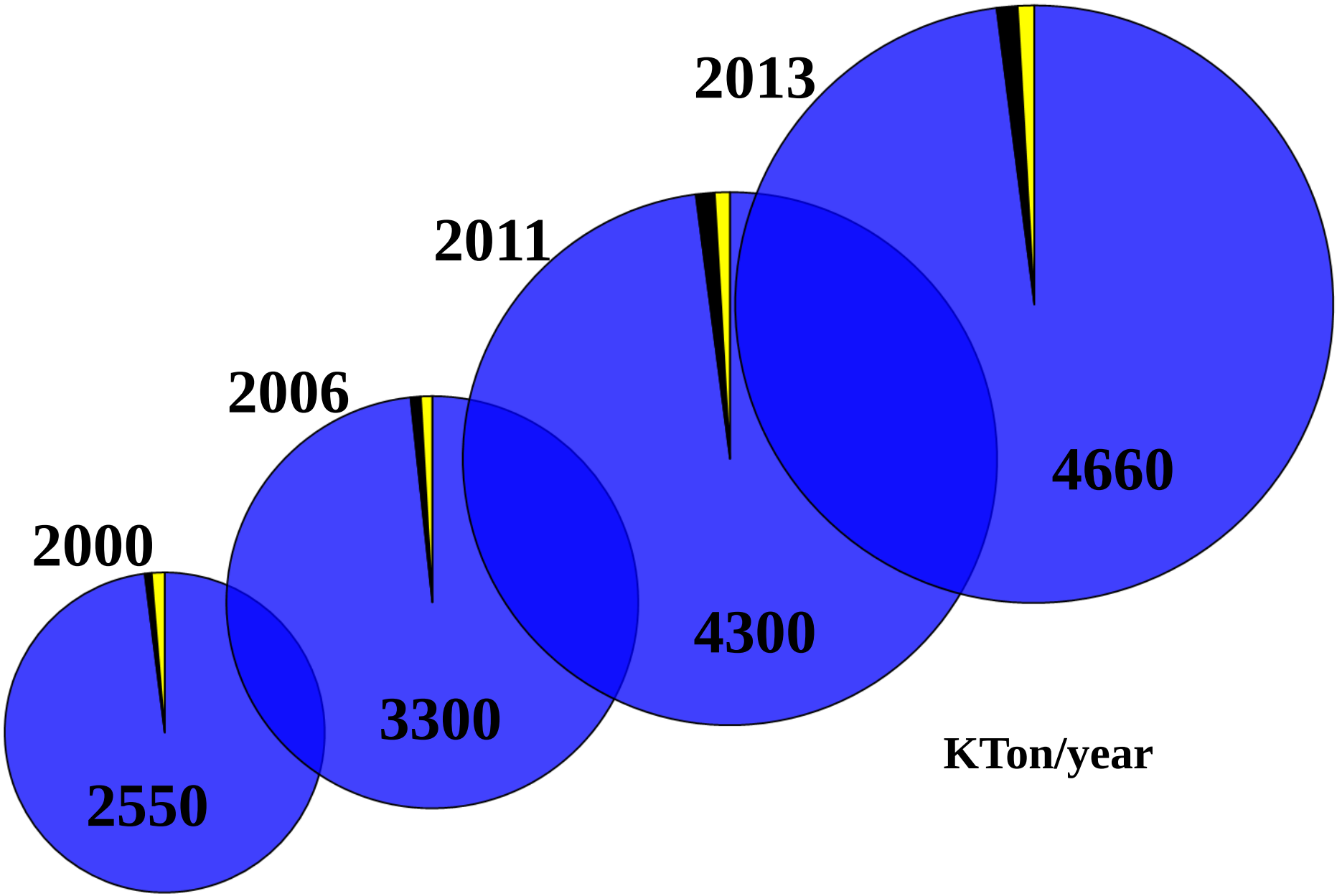
University of Strathclyde Engineering

- Introduction
- Some Results
  - Performance ReCoVeRed Glass Fibres
  - Composite Performance
  - *(Fundamentals of Glass Fibre Strength Loss)*
- Some Conclusions
- Future Developments?

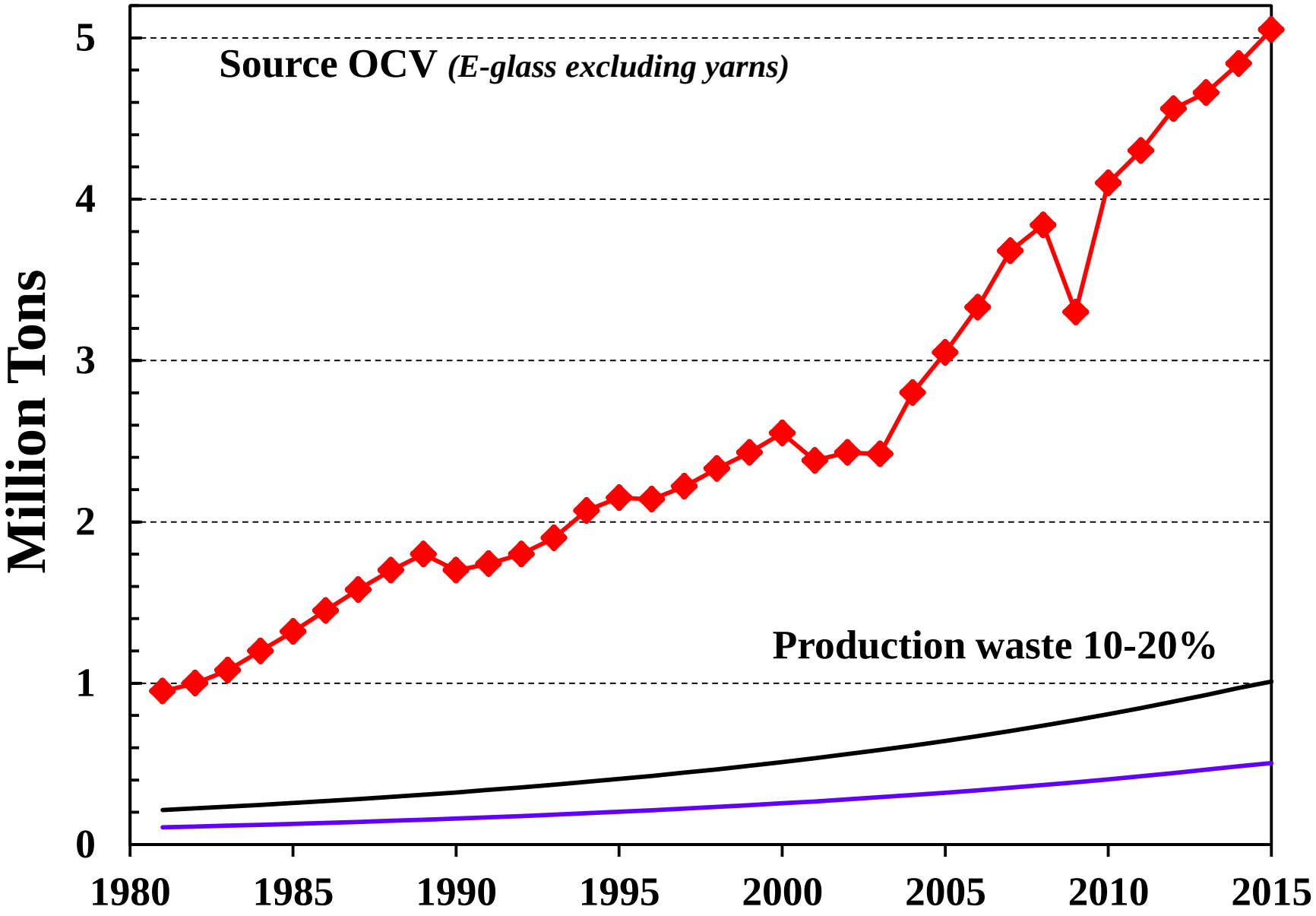
Global Reinforcement Fibre Usage



Global Reinforcement Fibre Usage



Global Glass Fibre Demand



Composites in Automotive

BMW photo as shown in Modern Plastics Magazine

GF in End-of-Life Wind Turbine Blades

Assuming 20 year Blade Life

>10 year Exponential Increase

EU Landfill Directive 99/31/EC ?

Global GF in EoL Blades (kT/a)

1,000

100

10

1

2010

2015

2020

2025

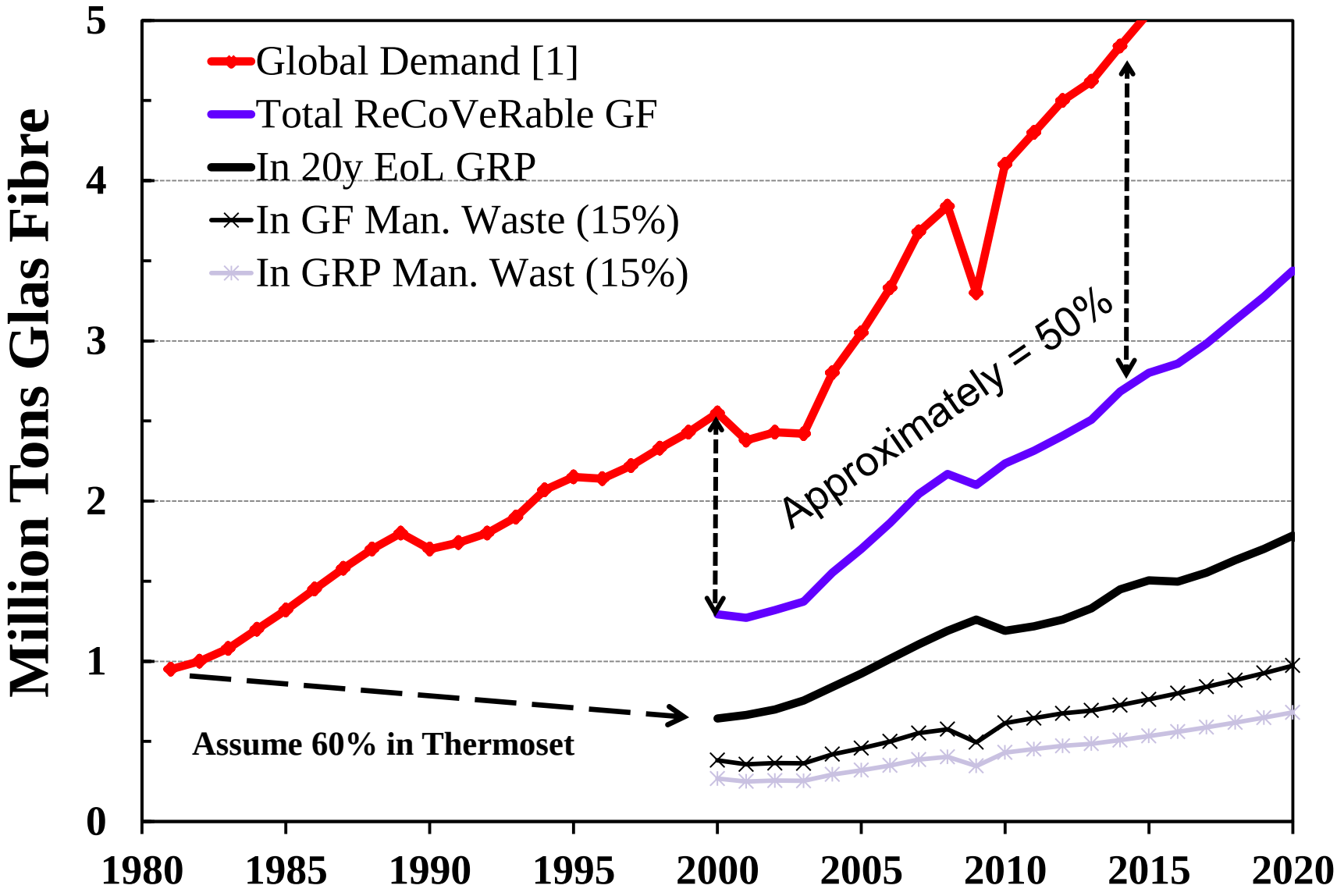
2030

2035

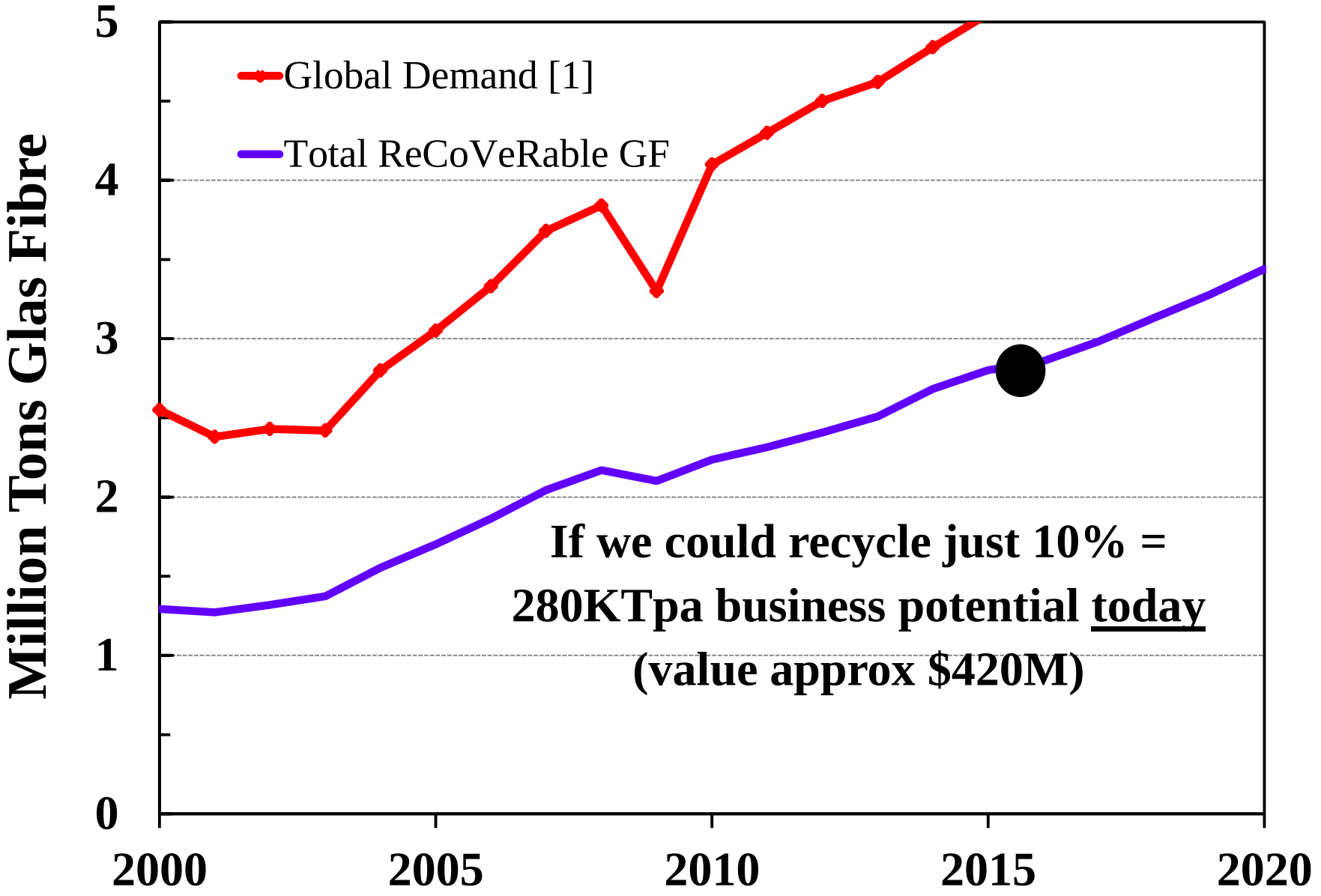
Year

Source - Composites Technology, June 2008, GWEC 2013

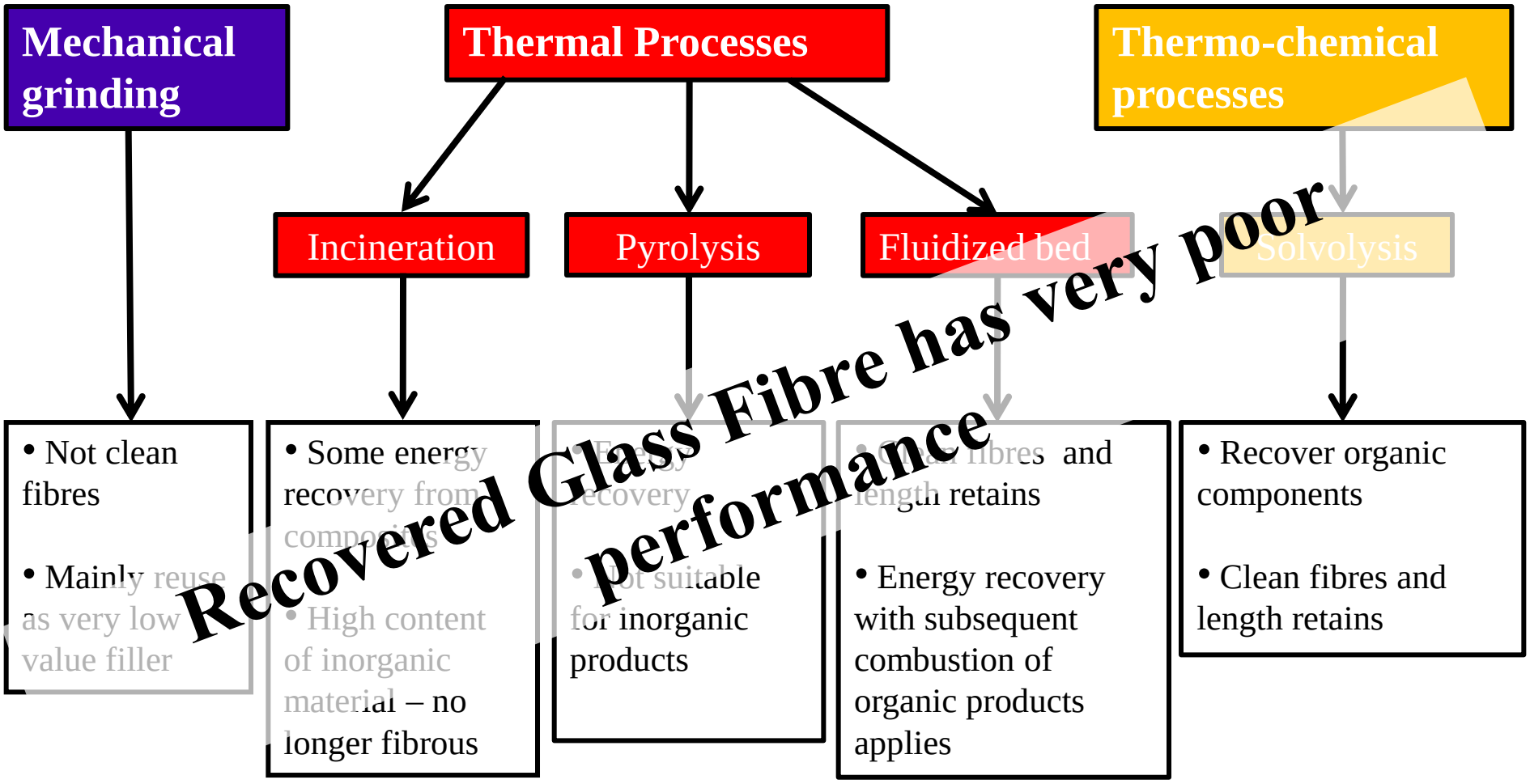
Global Glass Fibre Numbers



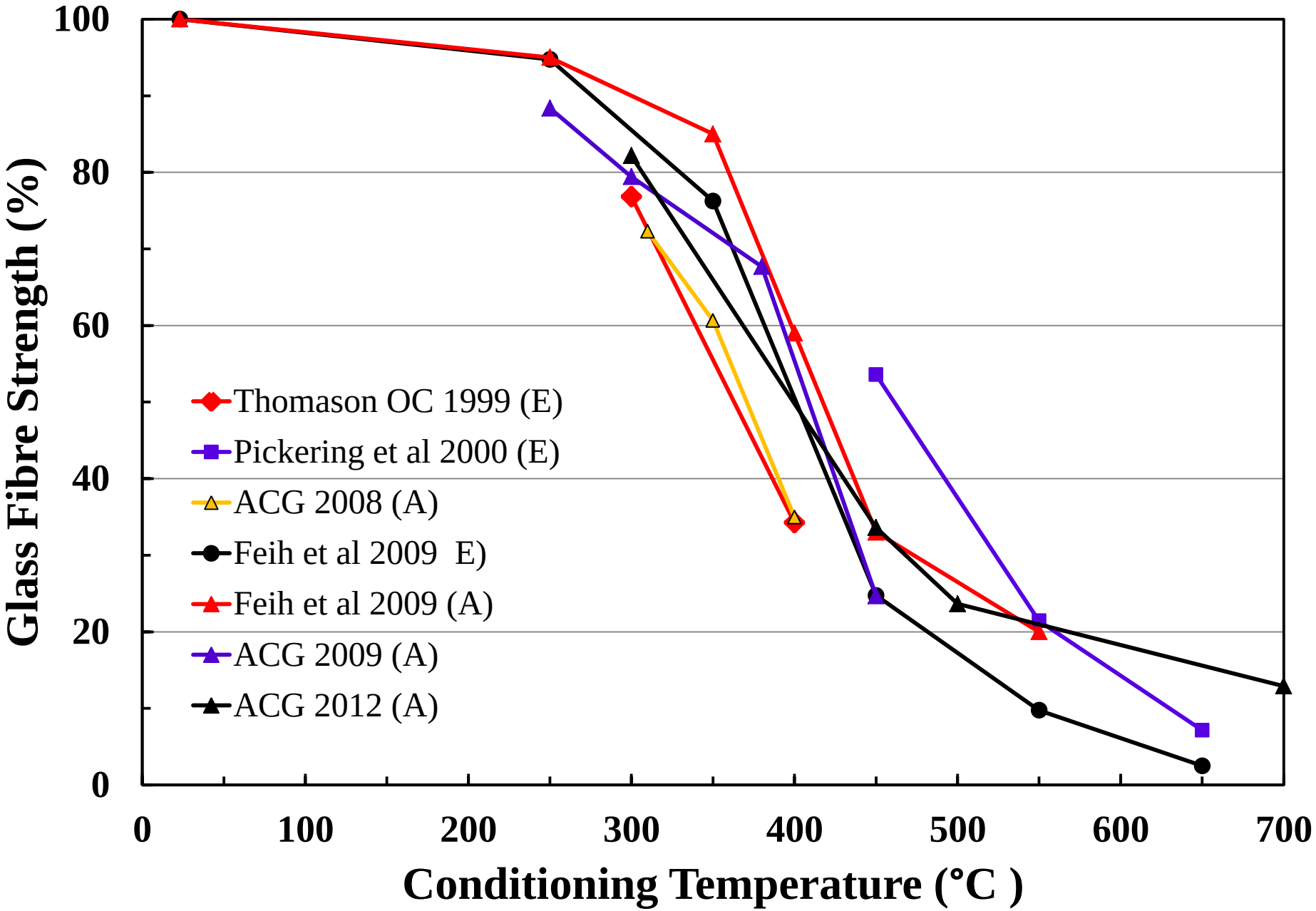
Global Glass Fibre Numbers



GRP Recycling Techniques



GF Strength (*Value*) after Thermal Recycling



The ReCoVeR Project

EPSRC
Engineering and Physical Sciences Research Council

Regenerated Composite Value Reinforcement

The ReCoVeR Mission

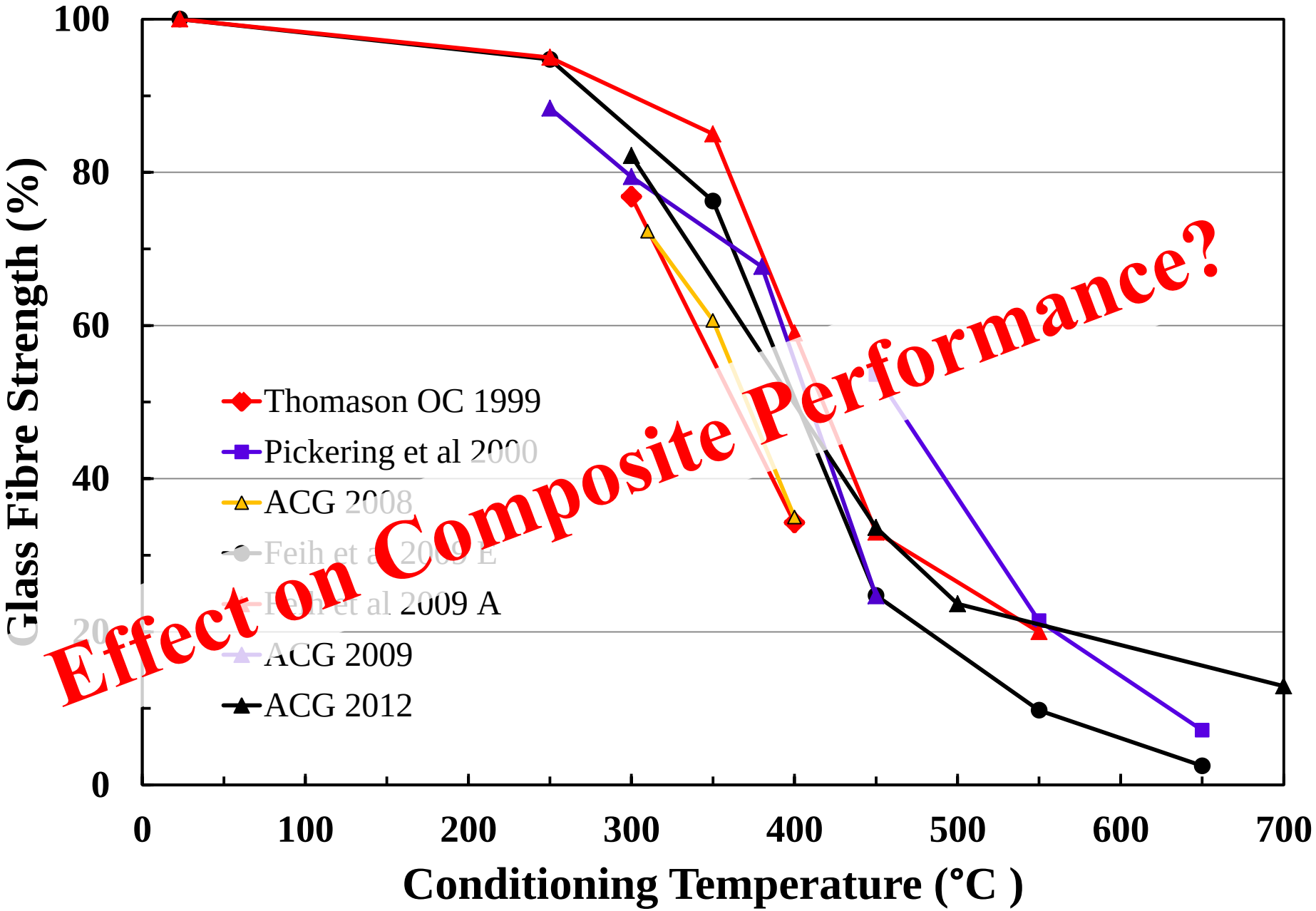
Enable the development of cost-effective, *drop-in*, glass fibre and composite products based on recycled glass fibres with regenerated mechanical performance

The Research Goals

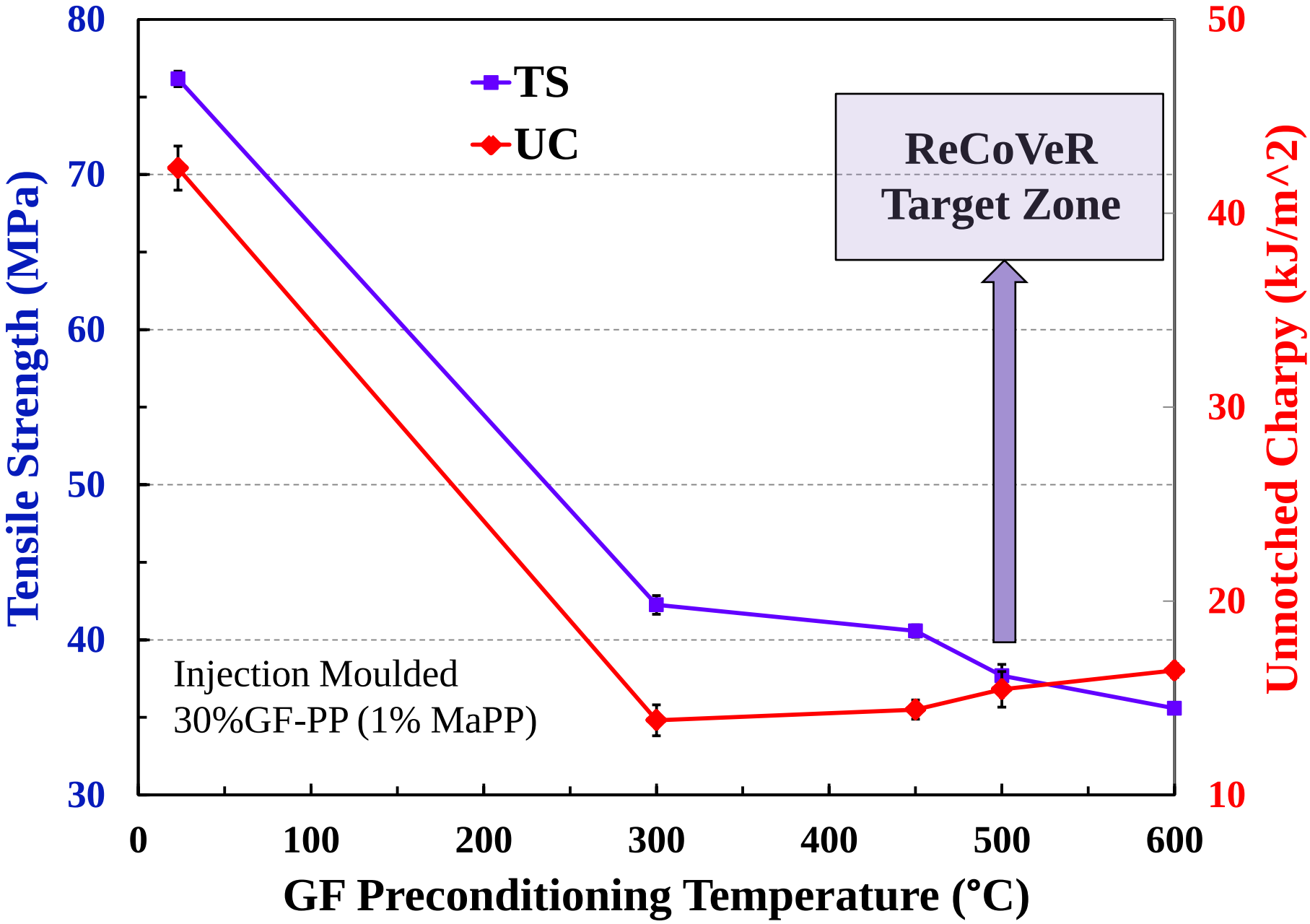
- ***Research fundamentals of (300-600°C)RGF property changes***
- ***Cost effective treatments to regenerate RGF performance ?***
- ***Produce examples of GF or composite products using RRGF***

2012-16, £1M EPSRC funding, 8 Researchers in ACG team

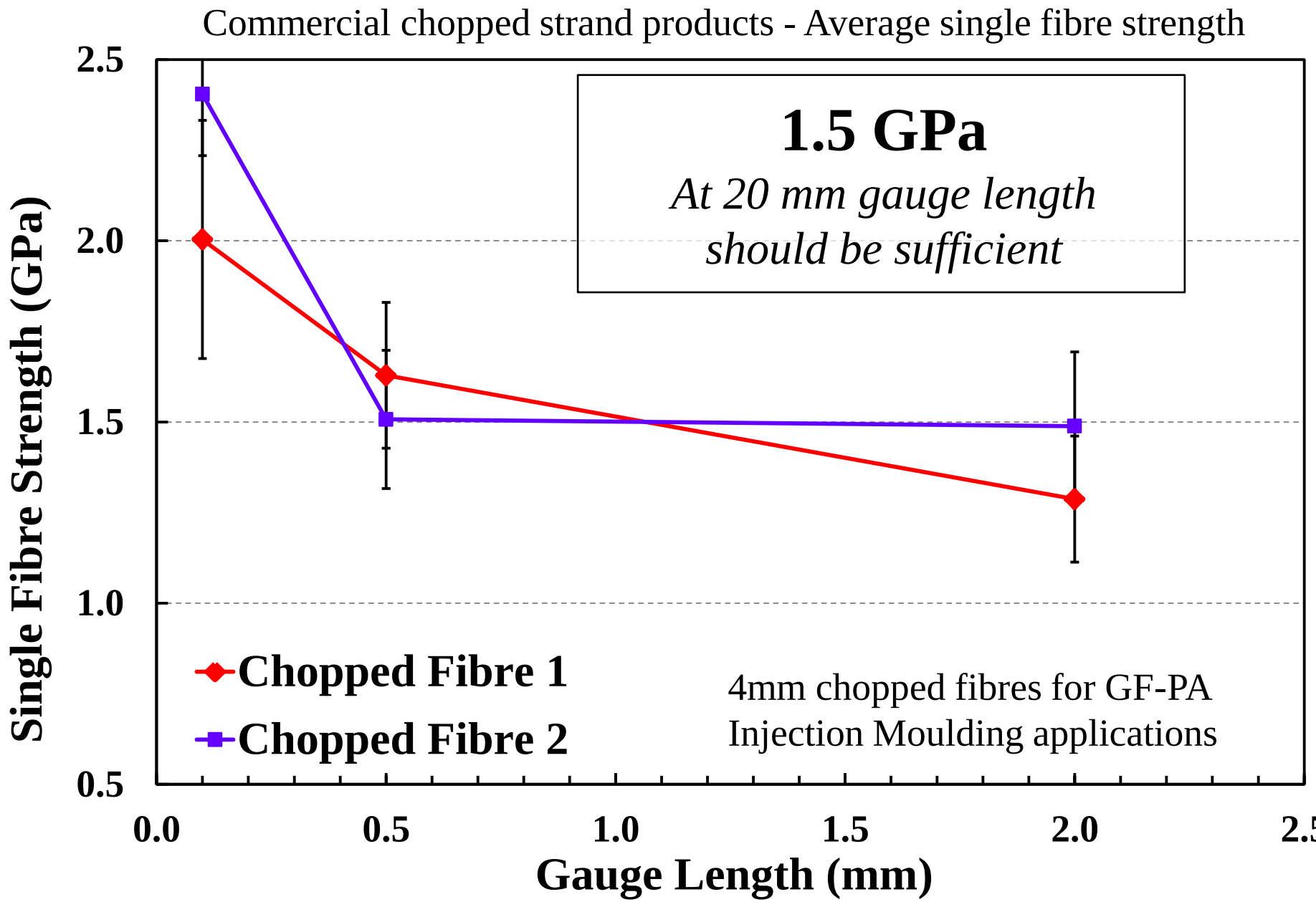
Strength after Thermo-Mechanical Treatment



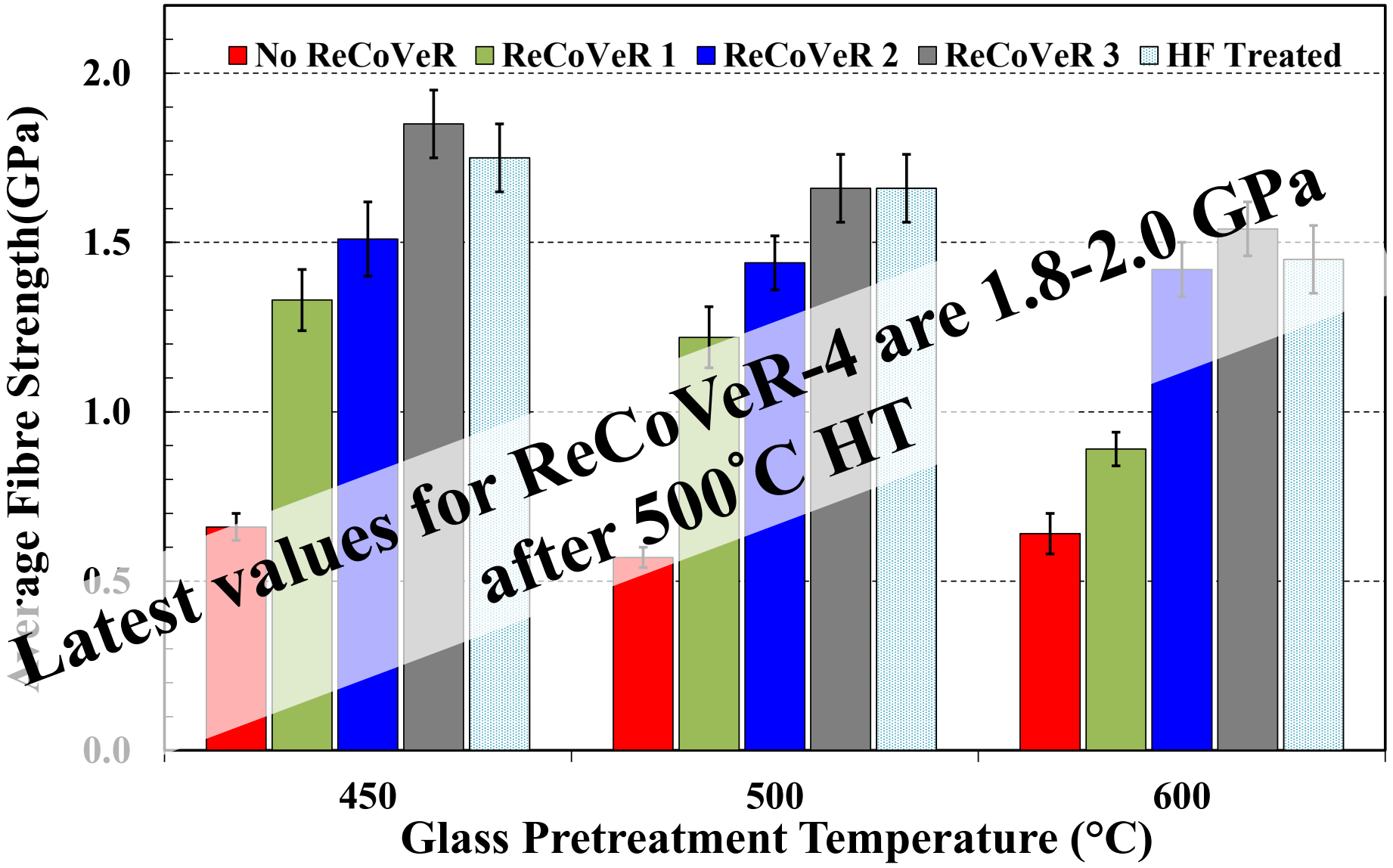
GF Heat Treatment & Composite Performance



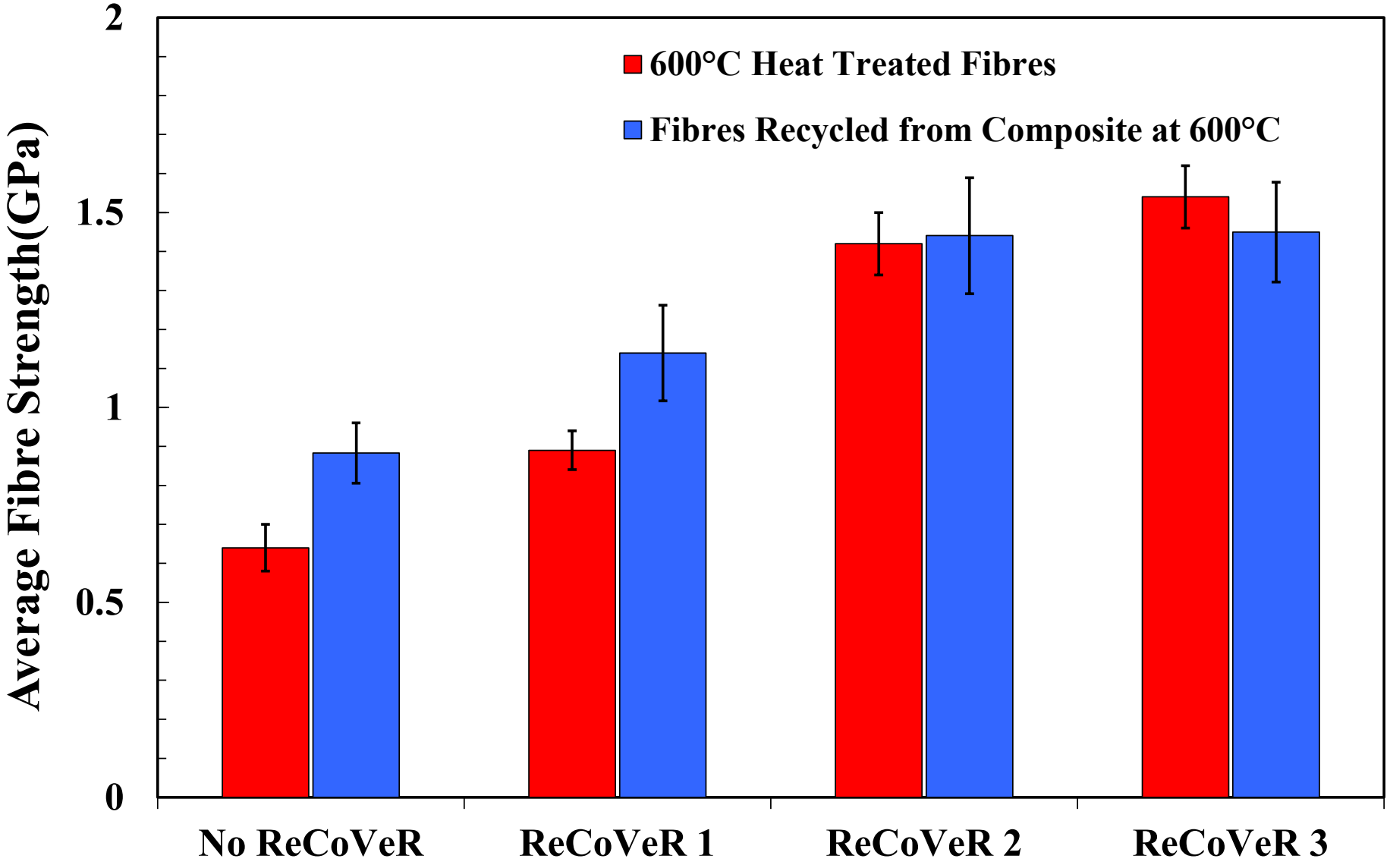
Target Strength for ReCoVeRed Fibre ?



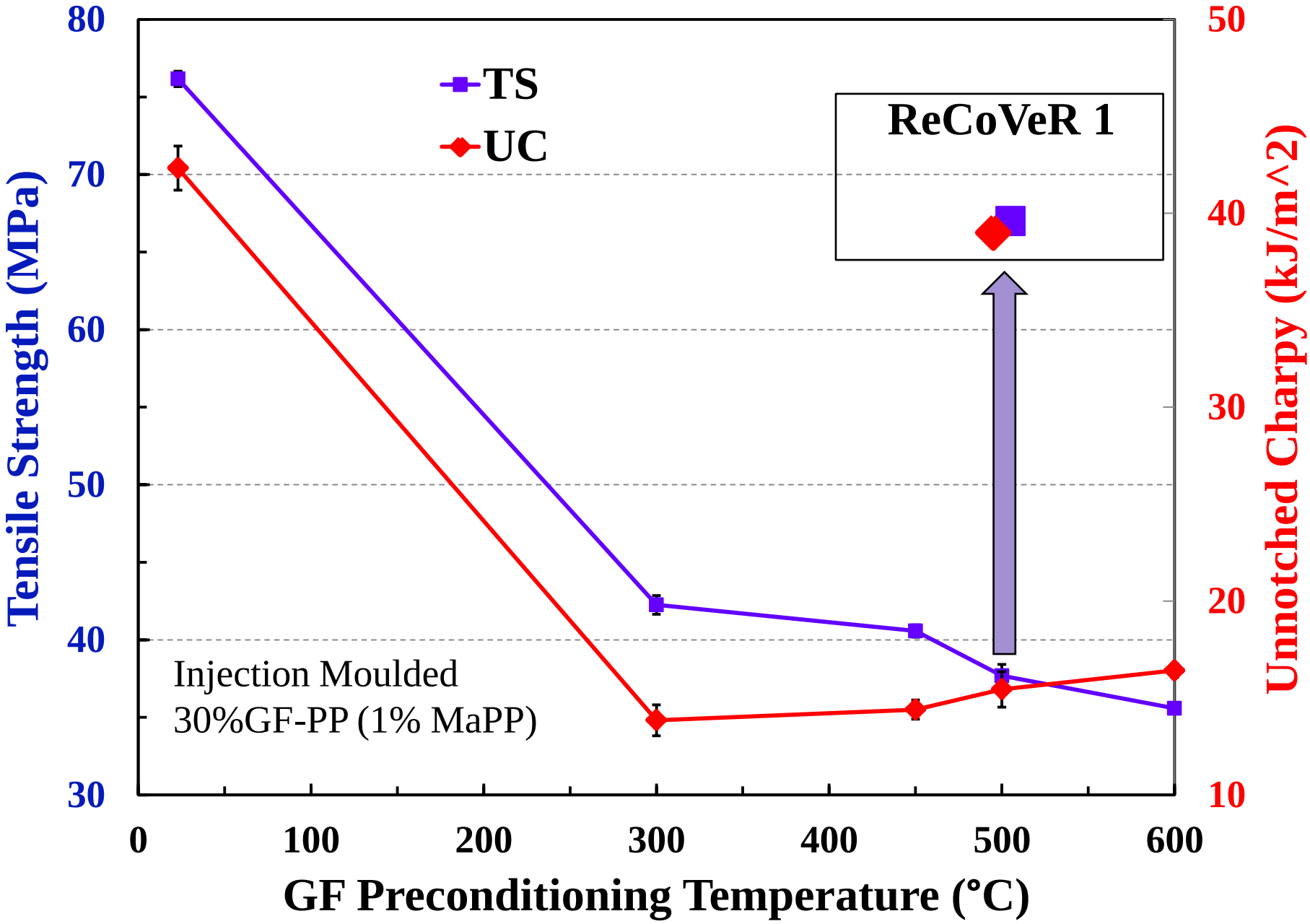
Glass Fibre Strength ReCoVeRy



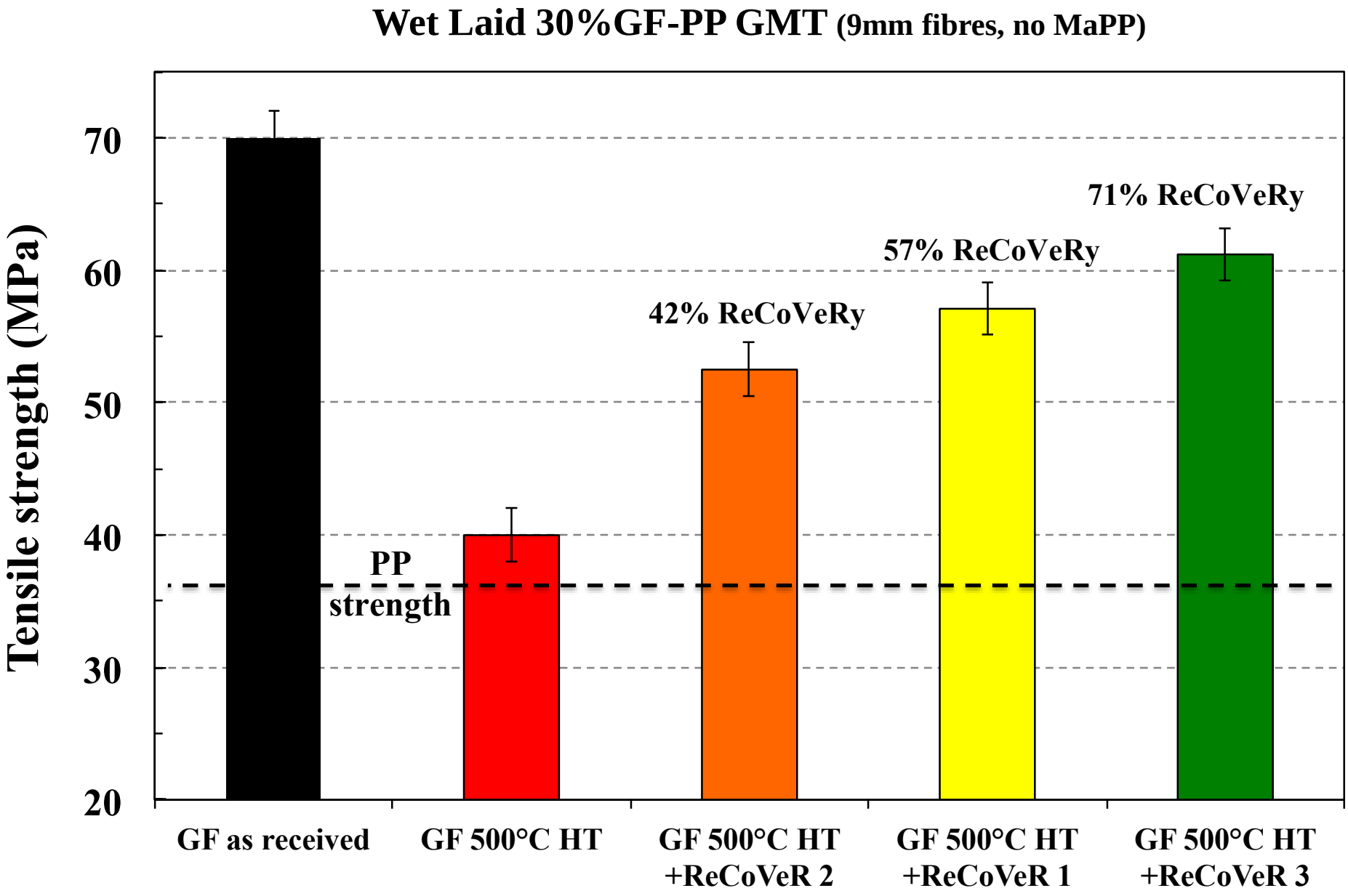
Glass Fibre Strength ReCoVeRy



ReCoVeR Composite Performance



ReCoVeR Composite Performance



Initial Results on ReCoVeR Glass Fibres in PP Composites

72% ReCoVeRy of Composite Tensile Strength

87% ReCoVeRy of Unnotched Charpy Impact

- Non-optimized sizing on ReCoVeR fibres
- Higher potential ReCoVeRy performance to come
- Patent Application submitted

Strength Loss Mechanisms Investigation

- **TMA for single fibre modulus and dimension changes during conditioning**
- **TGA of silane film degradation**
- **AFM/SEM analysis of surface morphology changes**
- ***Fibre strength after heating (or composite recycling)***
- ***TVA of water evolution and dehydroxylisation***
- **IR analysis of silane NH_2 group on fibre**
- **XPS surface analysis of %N on fibre**
- **XRD for crystal growth (devitrification)**

Current State of Strength Loss Mechanisms Investigation

Strength loss probably involves

- ***sizing degradation***
- ***surface flaws (number/severity increase)***
- ***change/relaxation in glass structure***
- ***removal of water/dehydroxylization***

More work required for full understanding

Conclusions

- **The development of a cost-effective technology to regenerate the properties of thermally recycled glass fibres will have major environmental benefits**
- **Glass fibres lose most of their strength after a short heat treatment above 400°C**
- **Mechanism of strength loss involves both sizing degradation and changes in glass fibre structure**
- **Thermal conditioning of fibres also drastically reduces end-use composite performance**
- **The ACG is developing cost-effective treatments to ReCoVeR the strength of thermally recycled glass fibres**

Future Development ?

- **Continue fundamental research of GF strength loss and new options for regeneration**
- **Integration of ReCoVeR technology into full recycling/regeneration/reuse process – requires**
  - **Formation and funding of consortium of vested interests**
  - **Identification of input material stream, end-of-life GRP, production waste (GRP or GF)?**
  - **Identification of recycling process for fibre input to ReCoVeR**
  - **Identification of target end-use application (GF-PP in Automotive?)**
- **We are seeking partners to move this technology forward**