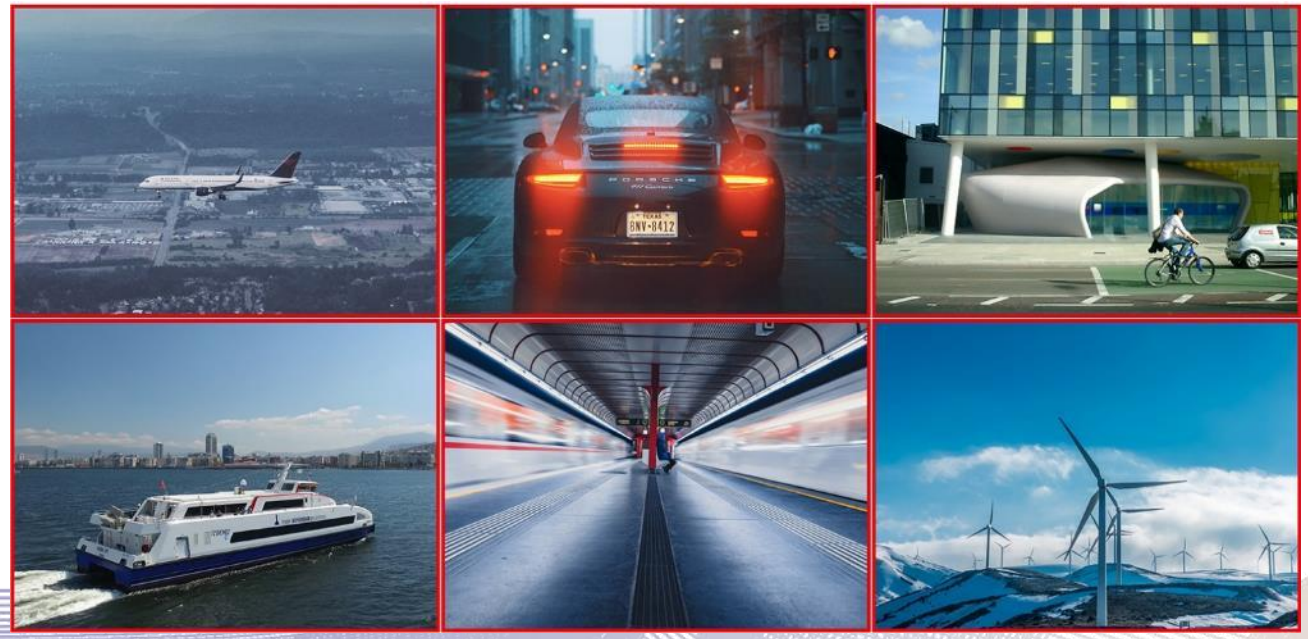
Composites UK
Trade Association

Trade Association for the UK Composites Supply Chain



KNOWLEDGE

SUPPORT

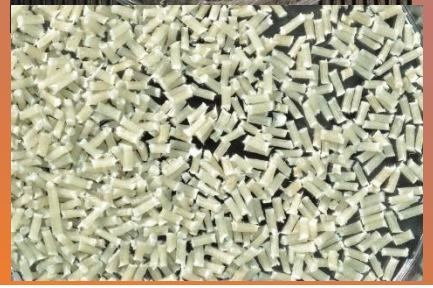
NETWORK

GROWTH

Project PRoGrESS
Dissemination Report

Innovate UK

Application number: 10014758

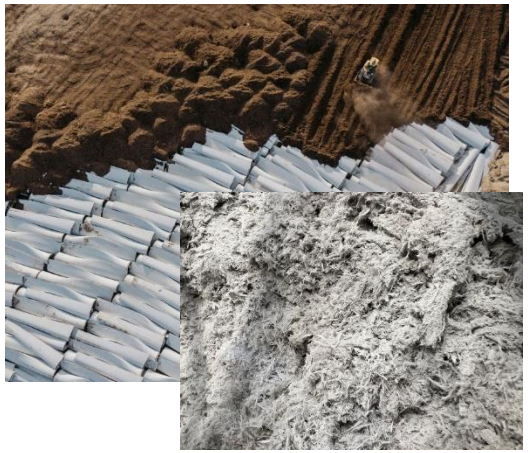


Project PRoGrESS Dissemination Report

For Public Dissemination

UKRI Innovate UK
Application number: 10014758

In Summary .....



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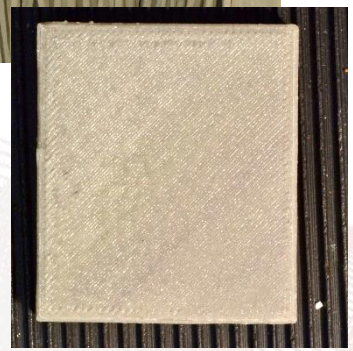

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Document Content:-

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Executive Summary

- No commercial scale, continuous, high value recycling route currently exists anywhere in the world for Glass Reinforced Polymer Composites (GRP) waste and the volume of such waste will rise rapidly in the coming years – so a viable solution is needed with increasing urgency!

- During Project PRoGrESS, we have demonstrated the following:
  - the viability & economics of the key process steps for downsizing large pieces of end-of-life GRP composite waste (such as wind turbine blades)
  - Controlled, continuous operation of the Strathclyde Fluidised Bed process, generating valid economic and environmental data to inform larger scale design and operation
  - Collection, reformatting and application of recycled glass fibre in several downstream Composites applications achieving positive customer feedback and creating confidence in downstream demand and reference pricing points for recycled fibres
  - The scale at which profitable operation of a GRP recycling plant can be achieved and at which recycled fibres show environmental benefits compared with virgin glass fibres

- As a next step, Cubis and University of Strathclyde will now collaborate further to establish an intermediate scale plant to further validate and optimise the process and recycled fibre products

PRoGrESS Consortium

PRoGrESS = Products from recycled glass fibre at economic and sustainable scale

The Project started on 1st February 2022 with a consortium of seven companies, one of whom, Aker Offshore Wind Limited (lead exploitation partner) withdrew from the project in January 2024. The lead exploitation role was taken over by existing partner, Cubis Systems Ltd. The Project end date was 31st January 2025.

Budget

- £2million over 3 years
- Innovate UK Smart grant £1.3m

Aim

- Successful operation of a pilot scale fluidized bed & fibre formatting lines
- Creation of a business plan, ahead of full-scale investment

GRP- glass fibre reinforced polymer composite
rGF – recycled glass fibre
BMC- bulk moulding compound

Scope of Project PRoGrESS

PRoGrESS will scale up and commercialise a unique, patented process developed at lab scale by University of Strathclyde (UoS) for thermal recovery and post-treatment of glass fibres from GRP[1] scrap to achieve near-virgin quality short glass fibres (vGF[2]). The project will scale up fluidised bed recovery as a continuous process, including practical add-ons such as emissions treatment, heat recovery, waste handling, processing of recycled glass fibres (rGF[3]). It will validate the process with steady-state continuous operation, trialling wastes with varying constituents from different sources

[1] GRP- glass fibre reinforced polymer composite
[2] vGF – virgin glass fibre
[3] rGF – recycled glass fibre

Scope of Project PRoGrESS

PRoGrESS will develop intermediate rGF products with lower energy input such as random and aligned mats, rGF/thermoplastic commingled mats, bulk moulding compound and thermoplastic injection moulding compounds. The focus will be on usability, creating products as close as possible to virgin, to avoid disruption to existing processes. Demonstrators will be produced in applications across several sectors.

[1] GRP- glass fibre reinforced polymer composite
[2] vGF – virgin glass fibre
[3] rGF – recycled glass fibre

Drivers/ Why did we do it?

- No commercial scale, high value recycling route currently exists anywhere in the world for Glass Reinforced Polymer Composites (GRP) waste.

- Currently, most of the GRP scrap generated in the UK goes to landfill or energy from waste (~80 kt/yr thermoset GRP in UK and around 530 kt/yr in Europe) – these current, non-circular treatment options are wasteful and not sustainable in the long-term

- The volume of End of Life (EOL) and manufacturing GRP waste is rising rapidly

- With the significant projected increase in wind turbine deployment in the UK, this waste problem will get significantly bigger (~20,000 tonnes/pa waste wind turbine blades in the UK by 2030, based on estimated developed by European Composites Industry Association and Composites UK)

- An economically and environmentally viable solution for recycling of GRP waste is therefore needed with increasing urgency as the scale of the problem grows

Key Achievements

- Designed, built, and commissioned a pilot scale composite recycling system with validated safety and operational performance.
- Produced samples of recycled glass fibre for BMC trials and for customer testing
- Developed efficient fibre separation components for continuous operation considering the peculiar characteristics of the recycled fibre.
- Replaced 100% virgin glass fibre with recycled glass fibre in bulk moulding compound trials with expected performance retention rate
- Replaced 100% virgin glass fibre in injection moulding compound with a significant potential for further improvement.
- Replaced 100% virgin glass fibre with recycled glass fibre in glass/polypropylene mat compression moulding.
- Replaced 100% virgin filler/fibre with recycled feedstock in 3D printing filament.
- Commercial exploitation agreement is in place between UoS and Cubis

Work Packages

1. Technology baselining
Definition of market landscape, waste types, intermediate products, first economic and environmental models, pilot location search

2. Process Optimisation (lab)
Process definition, waste characterisation, cost process analysis, optimisation

3. Material validation & process optimisation
Make end market intermediate products, test & characterise, 2nd stage process optimisation for final configuration parameters and specifications

4. Feasibility study dynamic hybrid pyrolysis
Initial impact, formal feasibility study, confirm potential for commercial unit

5.Define confirmation & Pilot approval
Procurement selection, funding approval, secure all permissions/licences

6. Construction /Commission Pilot
intermediate products, first economic and environmental models, pilot location search

7. Pilot Plant Operation & Optimisation
EOL collection Pre-treatment, optimise GRP waste recycling process

8. User Validation
Customer testing of BMC[3], injection moulding and aligned/ non- aligned mats

9. Business/ environmental case
Revenue, cost, environmental assessments, business model options

10. Project Management
Stakeholder & project management from start to end including liaison with Innovate UK, project dissemination & final reporting

[3]BMC = Bulk Moulding Compound

PRoGrESS Summary timeline (plan /actual)

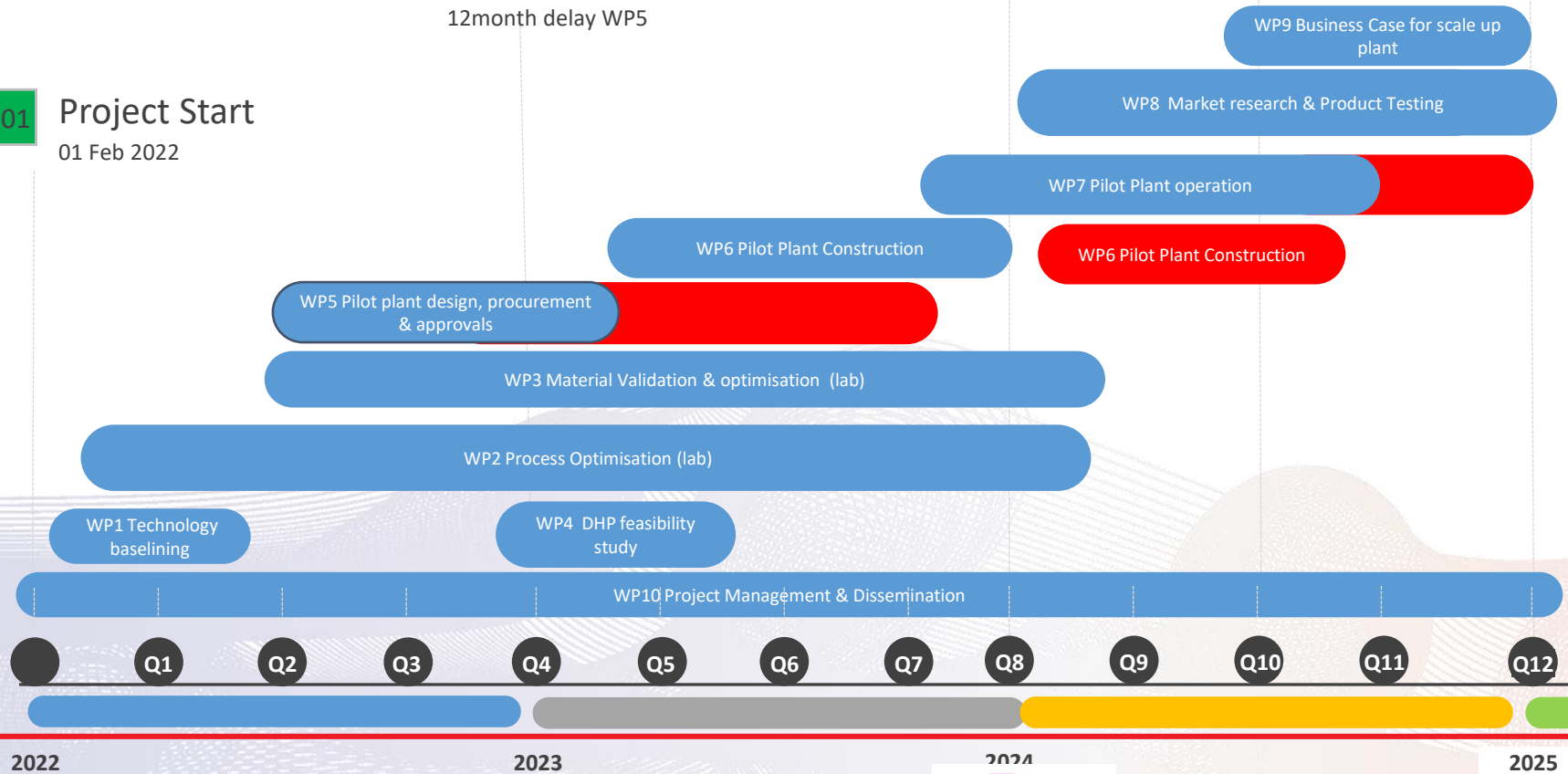
01 Project Start
01 Feb 2022

02 Procurement
Issues & cost increases
12month delay WP5

03 Cubis lead
Aker exited
Jan 2024

04 Market Test
Earlier engagement
Prioritised

Project end
Q12 31 Jan 2025



Key risks managed during PRoGrESS

Context:

- Post-covid supply issues and Ukraine invasion caused significant rise in raw material costs & some supply chain challenges
- Original lead commercial partner withdrew from project half-way through

Risk: CAPEX Cost escalation prevents completion of Pilot system build

- System scaled back and (following partner exit) build site changed to bring costs back within project budget.

Risk: Loss of Key Personnel/Partners means unable to complete scope

- Original lead commercial partner withdrew part way through project. Another existing partner, Cubis Systems Ltd, stepped up and took on this role, but some delays to programme were incurred as a result of the restructure

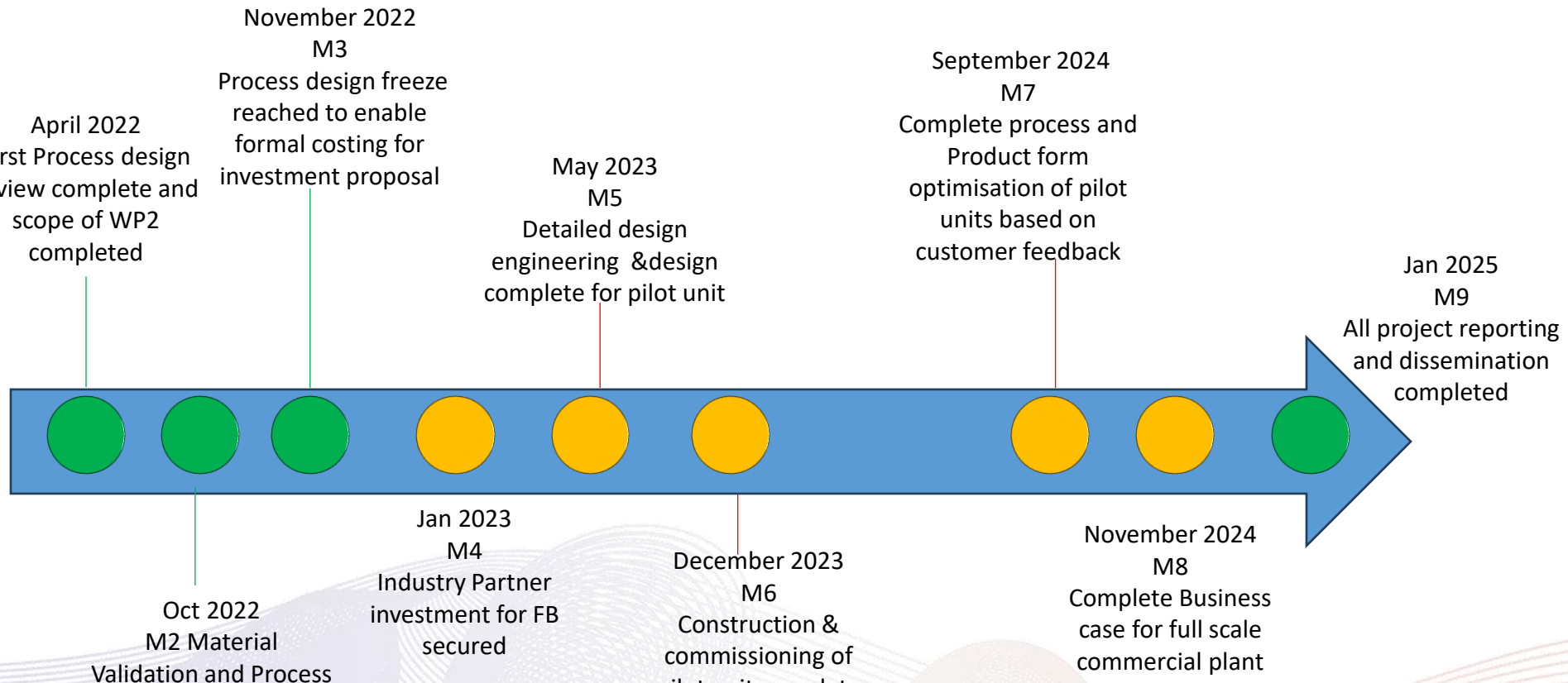
Risk: Supply chain challenges/delivery overruns lead to delays in completion of Pilot system build

- Some equipment delivery timescales proved unacceptable, mitigated by design changes

Risk: Failure to secure permits to operate at target site

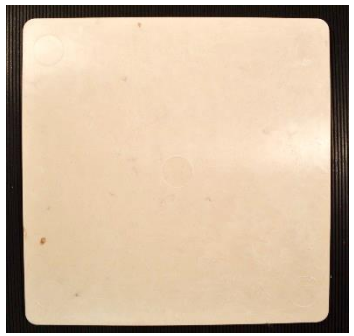
- Early engagement with SEPA secured a favourable “Enforcement Position” allowing pilot plant to operate.

Project Milestones



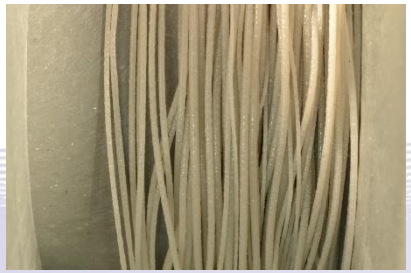
M4 to M8 were all delayed due to procurement delays and project restructuring but were all satisfactorily completed before the end of the 3-year project period

Recyclate produced



Bulk moulding compound (BMC) (100% rGF)

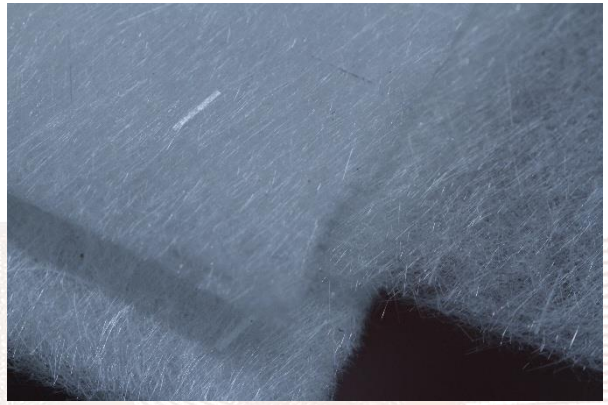
Pelletised rGF filled PP composites for injection moulding process (100% rGF)



3D printing filament (100% rGF)

Aligned mats made with 50% and 100% rGF

Non-Aligned mat made with 50% and 100% rGF



rGF = recycled glass fibre

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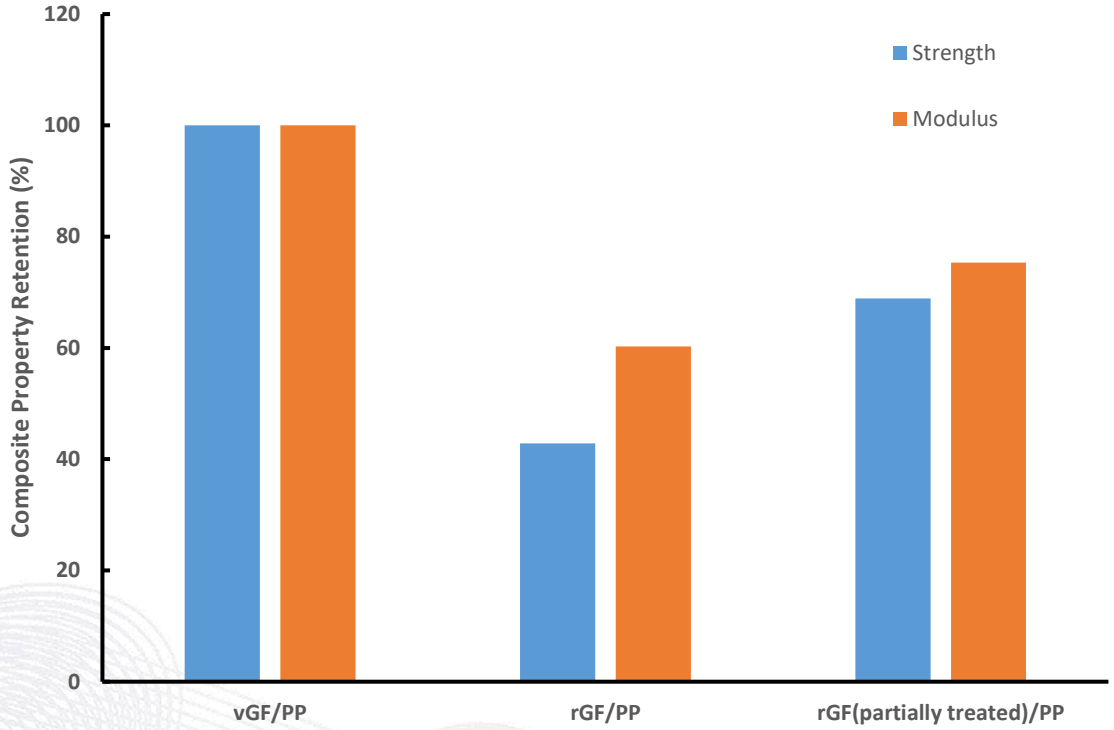
Recycled glass fibre in Injection Moulded products

- A new approach developed to compound “fluffy” recycled glass fibre with thermoplastic polymers (e.g. polypropylene) for the injection moulding process.

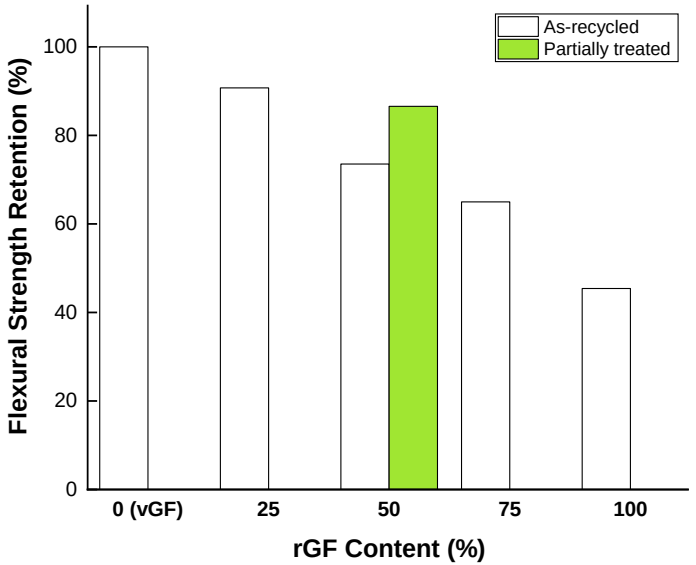
- Initial results – see graphs – show that replacing virgin glass fibre with the recycled fibres can lead to a significant performance drop, but this can be mitigated with a partial (not yet fully optimised) further treatment.

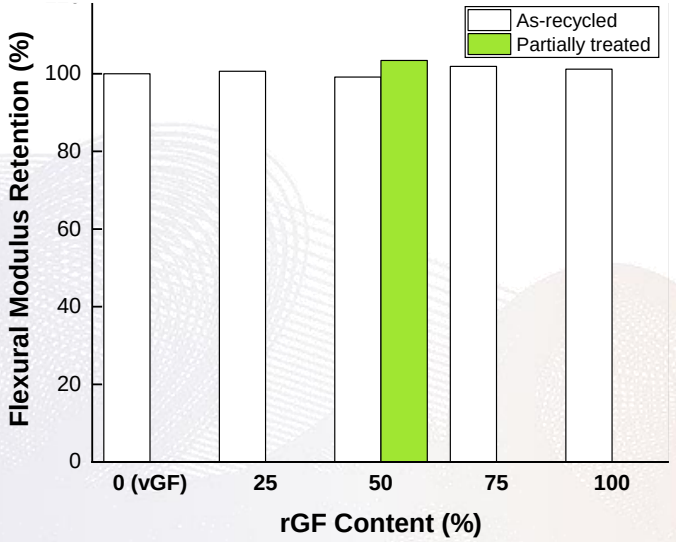


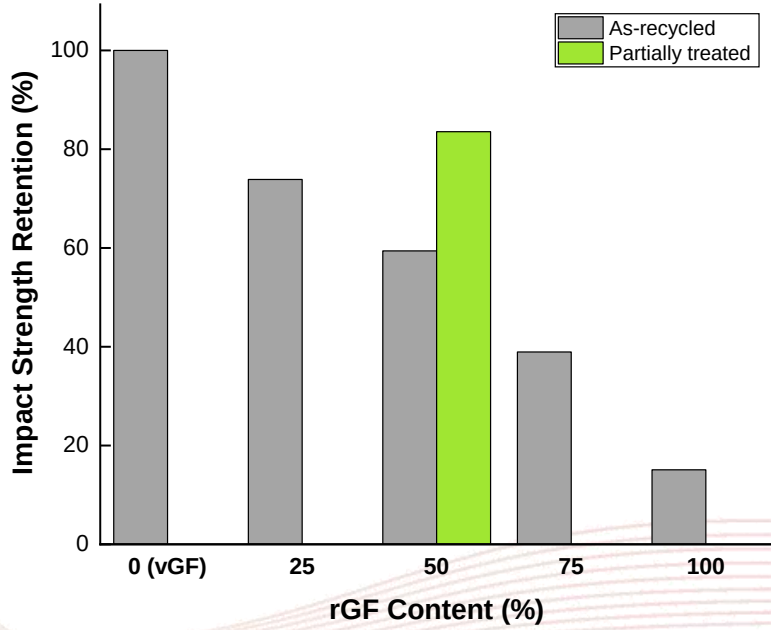
Recycled glass fibre in BMC products

- Bulk moulding compound mixing processes are well suited for the incorporation of “fluffy” recycled glass fibre with minimal post-processing and no special equipment needed

- Initial results – see graphs – show that mixes with up to 50% recycled fibre can achieve acceptable material properties with additional improvement feasible through further treatment (see “partial treatment” results in green bars)







rGF = recycled glass fibre

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Market Test Feedback on mat products

- Samples of random non-woven mats made by the Lightweight Manufacturing Centre and aligned mats made by the University of Nottingham were provided to 5 GRP fabricators for process testing in both open and closed mould processes

- 4 of the 5 were able to use the mats in their industrial processes and 2 of the 5 requested further rolls of the mats for further, more detailed testing

- The closed mould testing generated a good, void-free laminate when combined with virgin, bi-axial mats

- Market interest in a glass mat product made with recycled fibres was strong with clear desire to purchase such products when commercially available at similar price points to mats made with virgin glass fibre

Dissemination during the Project

3 core elements:

1. 14 Proactive presentations/ abstract submissions by partners at trade shows, conferences etc

2. 26 expressions of interest received by partners

3. 20 key company discussions around market testing with industry (GRPS lead) which led to active market tests of recycled fibre mats with 5 companies

When	Year	What	Location	Partner
May	2022	Team Kick off Meetings PR	Glasgow	CUK
Oct	2022	ACP Offshore Wind conference Presentation	Providence, USA	Aker
Nov	2022	Recomp conference	Sheffield	CUK, ACG
July	2023	23rd International Conference on Composite Materials	Belfast	LMC
July	2023	Internal Energy Transition workshop	Stockton	Aker
Sept	2023	Floating offshore wind Presentation	Aberdeen	Aker
Sept	2023	7th International Seminar on ORC Power Systems	Seville Spain	ACG
Nov	2023	Recomp conference	Sheffield	CUK, ACG
March	2024	BBC article feature	UK	CUK
July	2024	21st European Conference Composite Materials Abstract	Nantes, France	ACG
Sept	2024	International Composites Summit	Milton Keynes	CUK
Sept	2024	Linked in Post on Shredding update	Online	Suez
October	2024	Advanced Engineering Show	Birmingham	CUK
Nov	2024	Recomp	Warwick	CUK, ACG

Technical Achievements

- Designed, built, and commissioned a pilot scale continuous processing composite recycling system with validated safety and operational performance.
- Characterised different GRP waste streams (e.g. wind blades, infrastructure and utility, roofing panels, building components etc.)
- Understood the effective process optimisation parameters for the recycling process.
- Developed a detailed thermo-chemical model of the process using the pilot data for understanding risk and performance of an upscaled commercial recycling system.
- Developed efficient fibre separation components for continuous operation considering the peculiar characteristics of the recycled fibre.
- Replaced 100% virgin glass fibre with recycled glass fibre in bulk moulding compound (BMC) trials with expected performance retention rate.
- BMC products with properties acceptable for commercial implementation can be achieved with significant replacement of virgin fibre.
- Replaced 100% virgin glass fibre in injection moulding compound with a significant potential for further improvement.
- Replaced 100% virgin glass fibre with recycled glass fibre in glass/polypropylene mat compression moulding.
- Replaced 100% virgin filler/fibre with recycled feedstock in 3D printing filament.

Environmental Statistics

Projection for a 5kT/yr plant processing Wind Turbine Blades

Energy input
Equivalent total primary energy [MJ / kg rGF] = ~46 % of vGF

Emissions
Scotland [kg CO2 eq. /kg rGF] = 78% of vGF. (more renewables in Scottish electricity mix)
UK [kg CO2 eq. /kg rGF] = 83% of vGF.

Costs
Minimum price (£/kg rGF) to break even = 70% of vGF.

Water usage
11.1 litres/kg vGF (averaged value for dry and wet chopped fibres)
Near zero /kg rGF (dry no post treatment included)

vGF – virgin glass fibre
rGF – recycled glass fibre

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Key Project learnings – Waste Processing & Fluidised Bed

- The characteristics (e.g. size, shape, and composition) of waste feedstock significantly affects the preparation cost, recycling efficiency, safety, and recyclate reuse.
- It is possible to produce a 5-10mm feedstock from a wind turbine blade using a three-stage downsizing process consisting of first cut to 10 metre sections, first shred to 250-300mm and then a final shred utilising a hammer mill to 5-10mm particle size
- To maximise efficiency of the downsizing process, prior knowledge of composition is very important but due to the innovative nature of wind turbine blade design, and GRP products more broadly, knowledge sharing on composition is currently challenging
- The shredded GRP has a high tendency for bridging and does not move easily on inclined surfaces, and therefore fibre blockage will be a key challenge when increasing fluidised bed capacity, if the fibre handling unit is not designed properly.
- The reactor capacity and feed rate are the determining factors on the cost and emissions of the recycling operation.
- Discontinuous recycled glass fibre has a low bulk density which presents a challenge for post-processing and reuse.
- Bulk moulding compound mixing processes are well suited for the incorporation of recycled glass fibres with minimal post-processing.
- The primary challenge to compounding is intermediary fibre reprocessing and extrusion compounding processes may require fibre post-treatment and chopping to deliver a drop-in product for injection moulding applications
- Random, non-woven mats and aligned mats of the required quality and performance for industrial applications can be made from recycled fibres, opening up a range of added value potential applications for recycled fibres

Key Project learnings – Applications, Market & Project Mgmt

- Bulk moulding compound mixing processes are well suited for the incorporation of recycled glass fibres with minimal post-processing.
- The primary challenge to compounding is intermediary fibre reprocessing and extrusion compounding processes may require fibre post-treatment and chopping to deliver a drop-in product for injection moulding applications
- Random, non-woven mats and aligned mats of the required quality and performance for industrial applications can be made from recycled fibres, opening up a range of added value potential applications for recycled fibres
- Market interest in using recycled glass fibres with lower carbon footprint is significant, with users happy to trial and expecting prices around virgin levels
- BMC applications and surface mat applications may be the early adopters
- During a 3-year consortium project of this kind, strong project management capability and experience is key for ensuring delivery of all project work packages in a cost effective and timely manner
- Within a 3-year timeframe, most, if not all, of the potential risks do materialise and therefore proactive risk identification and mitigation activity is vital
- Continuity of people in key project & work package leadership roles helps with crisis navigation and efficient project team working

Project Successes and Next Steps

Project successes

- Process TRL has increased from 3 to 6
- Demonstrated a viable continuous process of recycling glass fibre
- A commercial exploitation agreement is in place between UoS and Cubis
- Real collaborative working between industry and academic research

Next Steps

- Final Project Progress Innovate UK reporting February 2025
- Dissemination PR via CUK website March 2025
- 3-year Knowledge Transfer Partnership (KTP) Cubis/ UoS starting Q1 2025
- 1-year Impact Acceleration Account Project at UoS starting Q2 2025
- Further refinement of exploitation model/options by Cubis in Spring/Summer 2025

Meanwhile, the need for composites recycling continues to grow …. !

For further information please email

info@compositesuk.co.uk