CREATING CIRCULAR STREAMS FROM COMPOSITE WASTE

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Recycling of GRFP (Glass Fiber Reinforced Polymers), ongoing projects 2019-2021

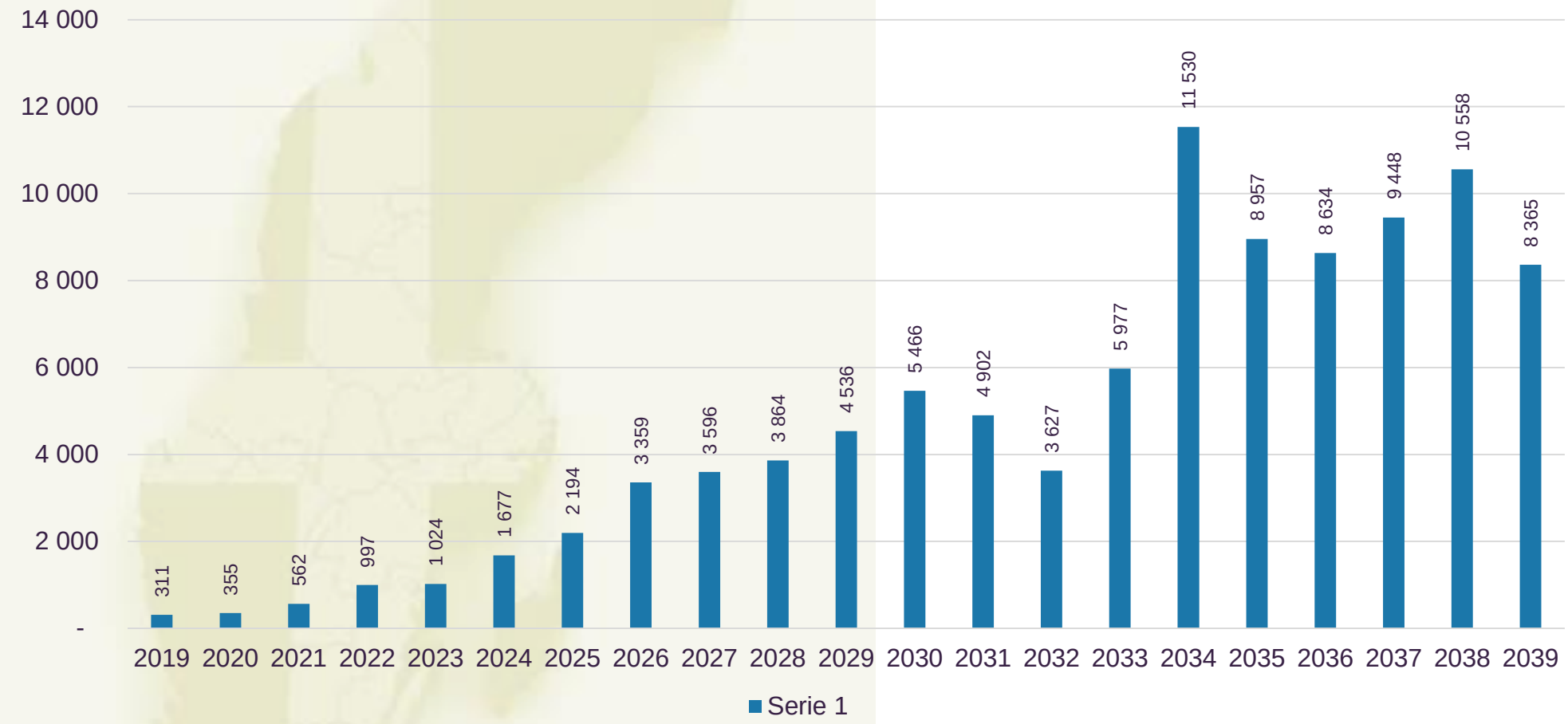
Rekovind

Chemical recycling of (GFRPs) from wind turbine blades

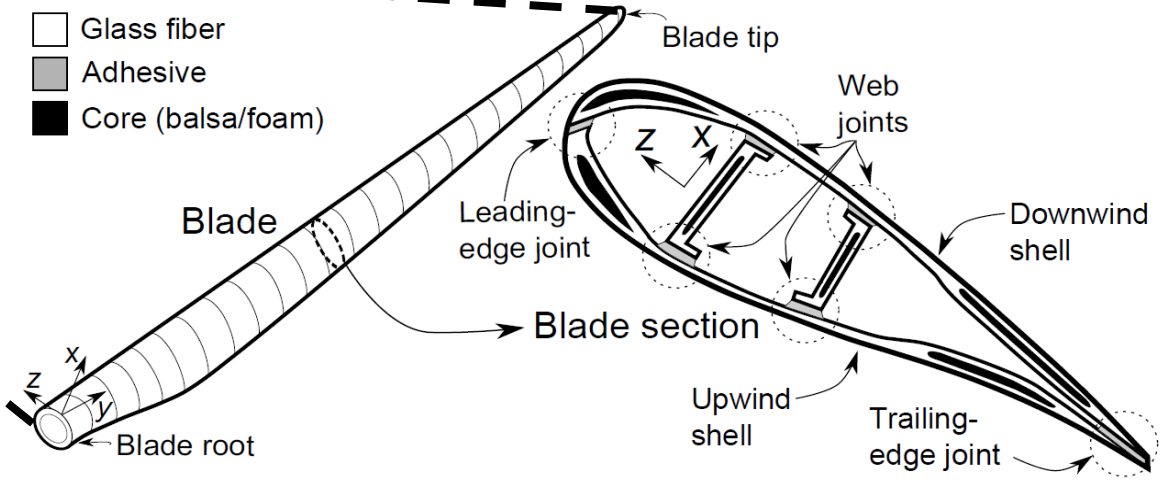
ReComp

Circular streams from GFRPs - wind turbine blades, boats and vehicles

Predicted decommission of wind turbine blades from Swedish windmills



Wind turbine blades are made of a variety of materials, major part is made of glass fiber reinf polymers (GFRP)



The GRFP usually contains 2/3 glass fiber and 1/3 thermoset, such as:

- Epoxy
- Polyester
- Vinyl ester

The rest of the blade is made of material such as balsa wood, PVC, polystyrene and polyuretane foam in addition to other thermoplastics

Why is it so difficult to recycle thermoset composites?

Thermosets are not thermoplastics = they are not possible to melt

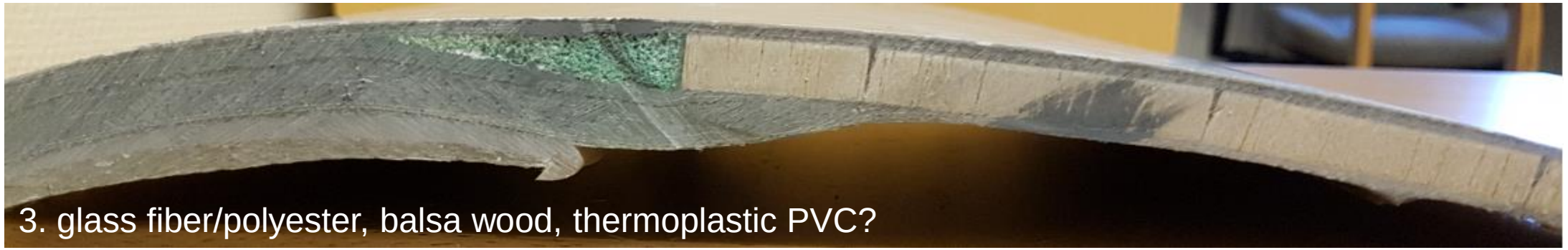
3D-network made of cured thermosets makes it impossible to dissolve by organic solvents.

The glass fiber length and quality is affected from shredding and milling.

No public recipe from producers - wind turbine blades contain a complex mixture of materials

1. Glass fiber epoxy, laminate polystyren foam, balsa wood and more?

2. glass fiber/polyester laminate, balsa wood, black rubber?, grey laminate?



3. glass fiber/polyester, balsa wood, thermoplastic PVC?

Current end of life scenarios for GFRP from wind turbine blades

- Landfill
- Incineration
- Crushed and burned in cement kilns, reducing need for fossil fuel
- Shredding, milling, use as fillers in new composite materials of lower strenght

How recycle wind turbine blades?

- Dissasembly and transport, separation and shredding
- Separation of glass fibres from plastics by chemcial recycling - Solvolysis (HTL), pyrolysis or gasification
- Recovery and purification of plastics and glass fibers
- Use of plastic fraction for new composites or as feedstock for refinery
- Use of recycled glass fiber for insulation, cement, composites, glass

HTL (hydrothermal liquefaction)

Solvent/reactants:

- Water (374 ºC, 221 bar)
- Alcohols (Ethanol 241 ºC, 63 bar)
- Catalysts (ZrO_2, KOH, K2CO3, acetic acid, H2O2, air/oxygen)

Subcritic depolymerization (200-350 ºC, <22 MPa):

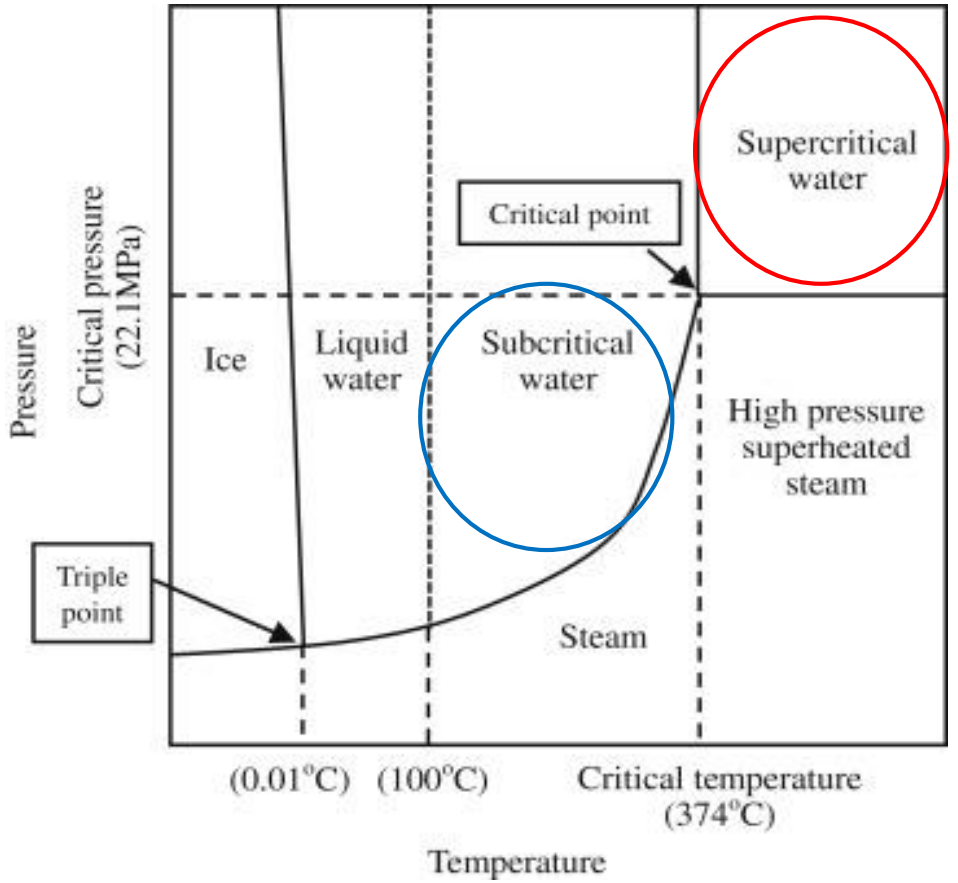
- Hydrolysis, liquid products (200-350 C, <22 MPa)

Supercritic depolymerization (>374 ºC, >22 MPa):

- Radical reactions, gas-phase and liquid products

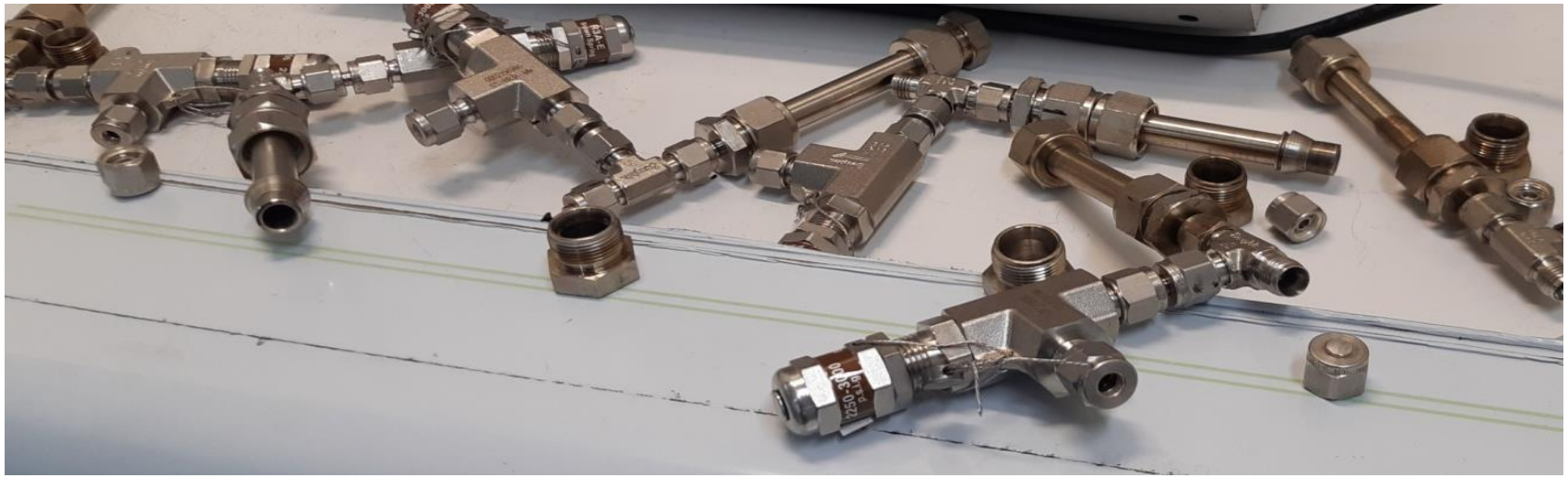
Products

- Depolymerization: gas, monomers and polymers
- Repolymerization: polymers and char
- Radical reaction products



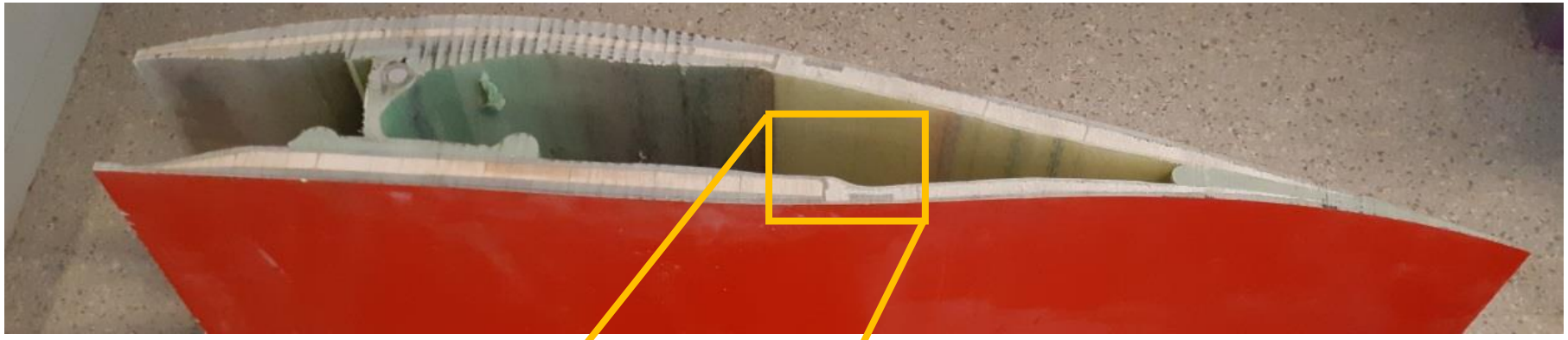
Reactors for HTL

- Reactors of stainless steel with release valves that keeps a maximum pressure of 170-190 bar.
- External heating in furnace, 200-400 C
- Subcritical water replaces organic solvents to some extent
- Addition o alcohols, acids, bases, organic solvents, catalysts and more



Sections of wind turbine blades sent to RISE are cut, separated by material, and grinded into samples

Cutting and milling followed by HTL results in oil and glass fiber fractions



Chemical evaluation

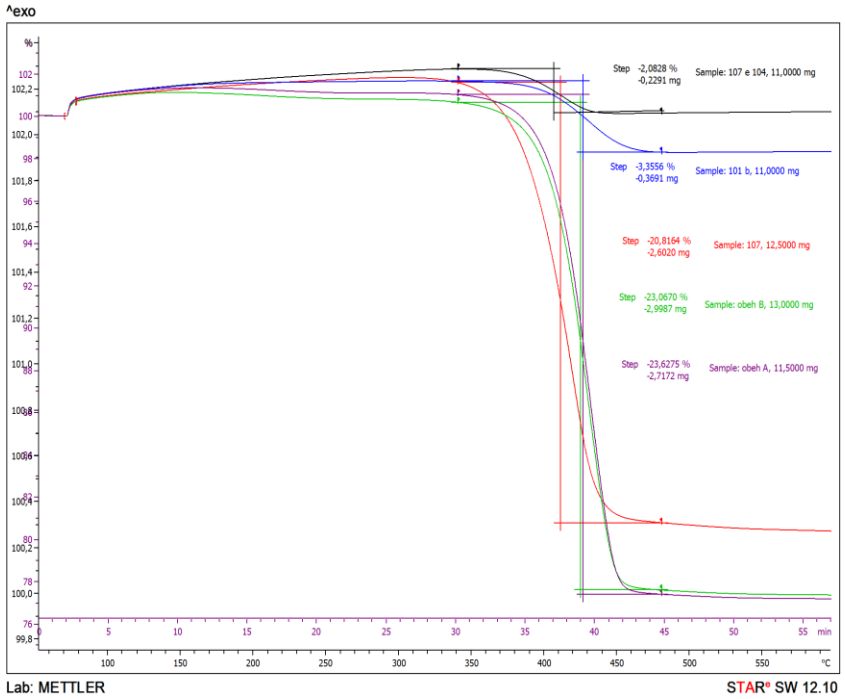
TGA (Thermogravimetric analysis) – possible to analyze yield of HTL reaction on small samples

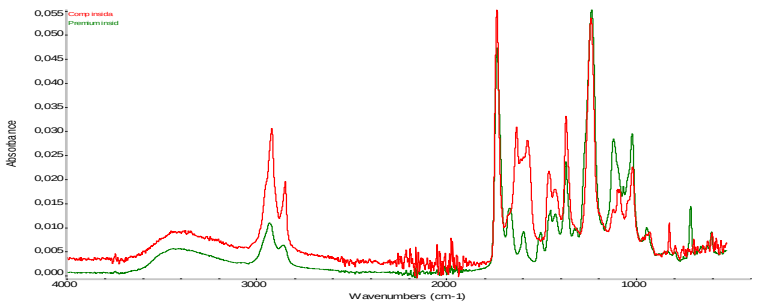
CHN – Gives yield of remaining carbon and nitrogen content in GFRP after HTL

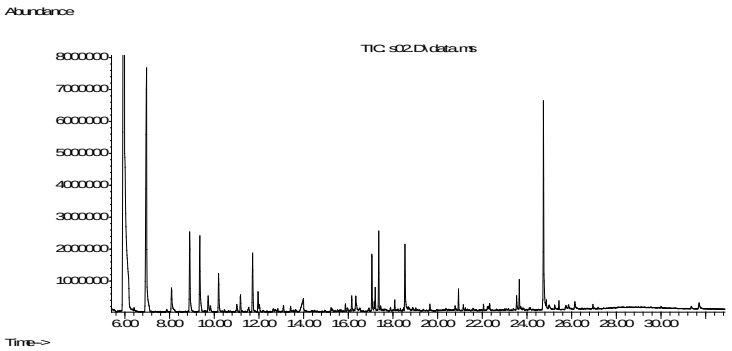
GC-MS (Gas Chromatography-Mass Spectrometry) - identity and concentration of volatiles < 350 C

FTIR (Infrared Spectroscopy) – identifies polymers or functional groups such as amines, esters or aclohols

$$\text{Yield} = \frac{mg\ organic\ material\ after\ HTL}{mg\ organic\ material\ at\ start}$$







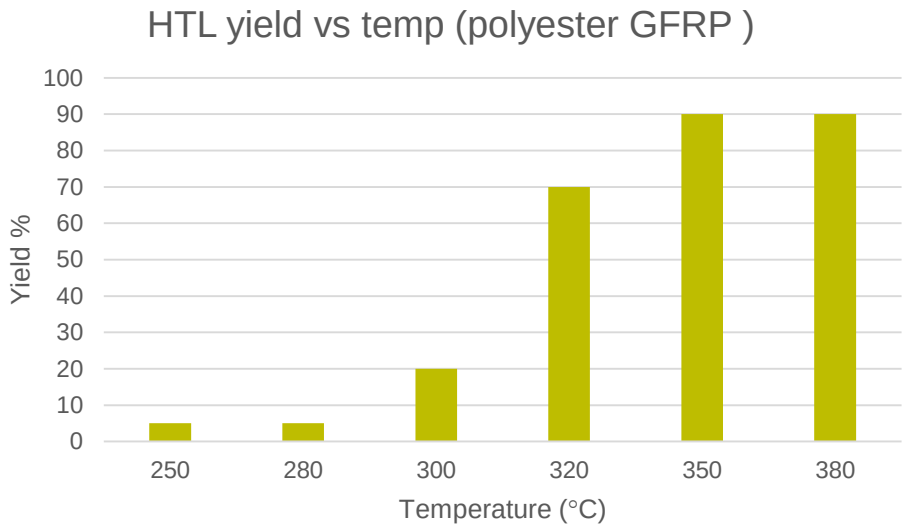
Test results so far

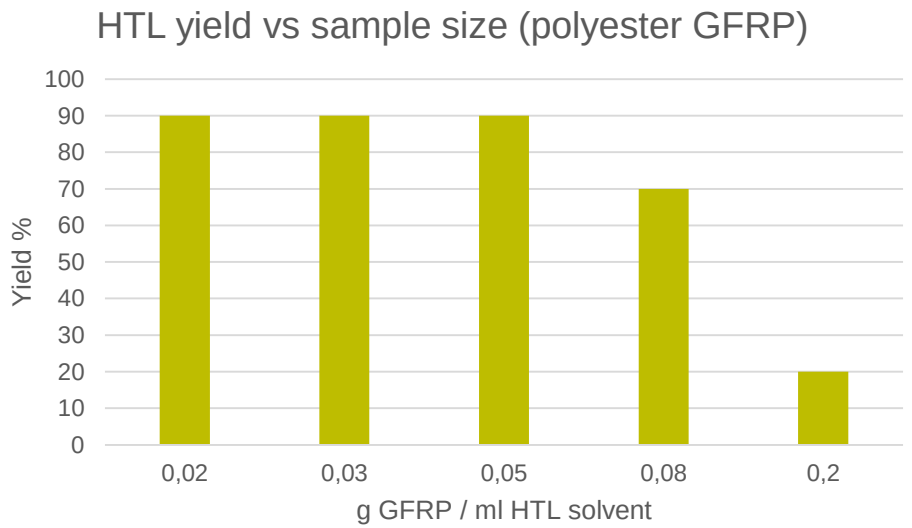
Preliminary results indicate that the HTL works well for GFRP samples, but chemicals are needed in addition to water

Polyester based GFRP gives good yields after 4 hours treatment with a mixture of water, hydrogen peroxide, base and alcohol

Epoxy GFRP requires a two-step process; 1. Short HTL treatment with hydrogen peroxide, water and alcohol, followed by 2. water, NaOH and alcohol.

Critical parameters are so far temperatures > 320 °C, reaction time > 4 h, propanol content > 20% (for epoxy)





Lookout for improvements

Will the HTL process be able to compete with other recycling methods and new innovations in terms of energy consumption, environmental impact and economy?

Is there a need for alternative materials?

Connora Technologies

Recyclamine hardener - enables epoxy resins to be recycled as thermoplastics

Second Life for GFRP in building/infrastructure projects

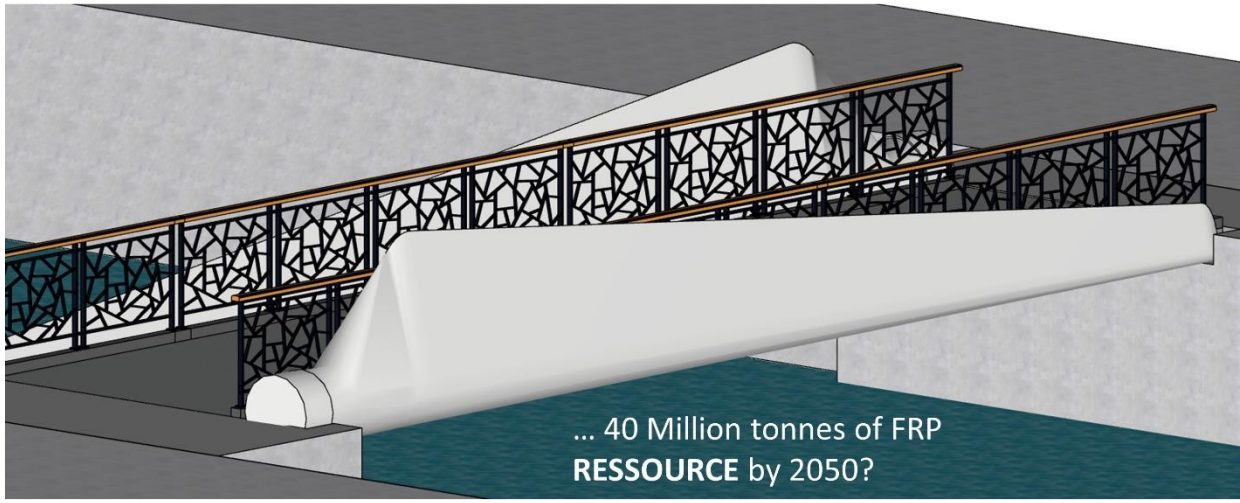
- Resource efficient use of wind turbine blades
- Re-use of materials that would go to waste by incineration or landfill
- GFRP structures with >50 years durability
- Replaces concrete building materials that contribute to CO2 emissions

Materials for Wind Turbine Blades: An Overview
Mishnaevsky et. al. materials 2017
Bank et. al. Concepts for Reusing Composite Materials from DecommissionedWind Turbine Blades in Affordable Housing 2018
https://www.windpowerengineering.com/mechanical/blades/recycling-wind-turbine-blades/

Blade 2 Bridge

”Initiera och intressera svenska företag för att i samverkan utveckla cirkulära lösningar för tex cykelbroar och fasadelement byggda av uttjänta vindkraftsblad som idag går till förbränning och deponi”

- **Undersök olika brokoncept** där vindkraftsblad är den viktigaste lastbärande strukturen
- **System och cirkulär ekonomi perspektiv**
- **Samarbete RISE och Chalmers**



We are looking for project partners.
Do you want to be one of them?

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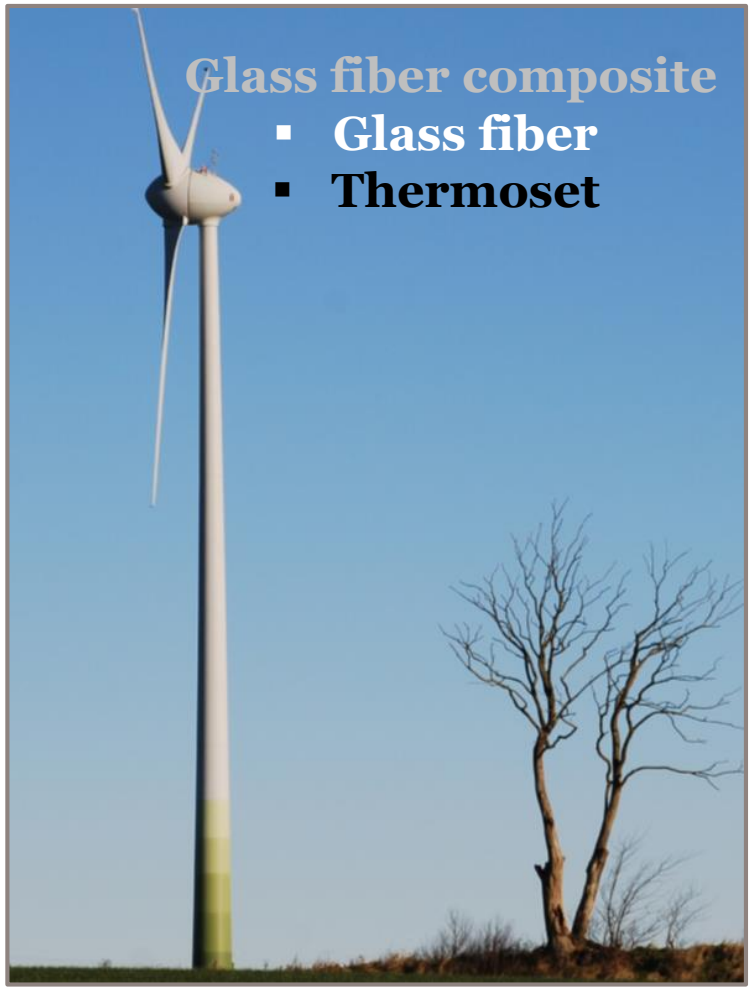
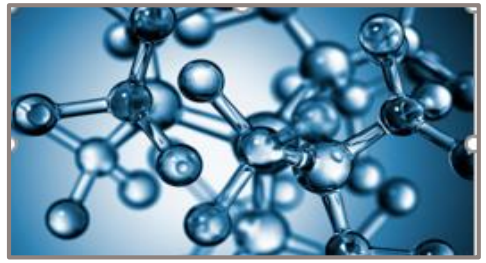
Our solution: Feedstock recycling of GFRP from wind turbine blades



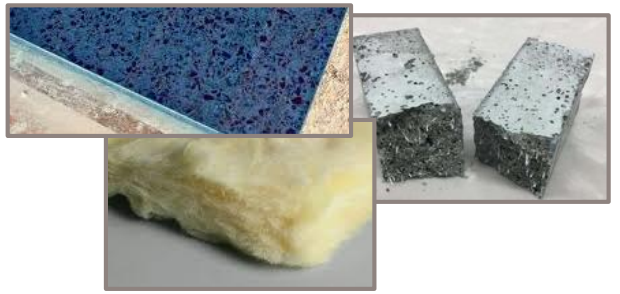
HTL

Recycled materials

Glass fiber



Plastic building blocks



Concrete, Insulation, Composites, glass

New products

Thermosets, thermoplastics, refinery feed, fuels