Sustainable repurposed products from decommissioned composite material wind turbine blades

Wind Turbine Blades:
Future Challenges
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MaREI

Science Foundation Ireland sfi For what's next

National Science Foundation

Invest Northern Ireland

Georgia Tech

Queen's University Belfast

CUNY The City University of New York

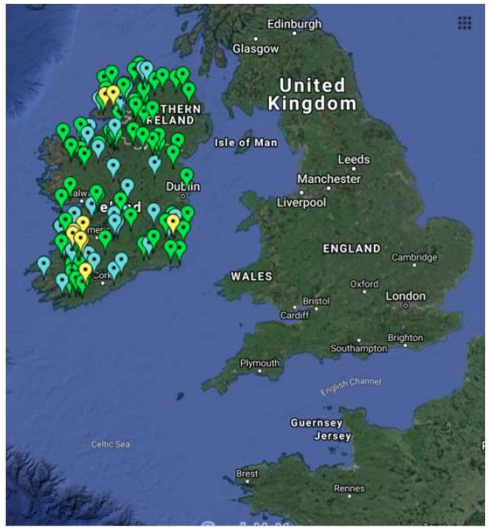
UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

End of life wind turbine blades: a circular economy challenge

- Wind turbine blades primarily composed of non-biodegradable GFRP composites
- Annual global blade waste is expected to reach 40 million tonnes by 2050
- Current solutions: incinerate, stockpile, landfill, grind for aggregates
- Can feasible repurposing options be found?

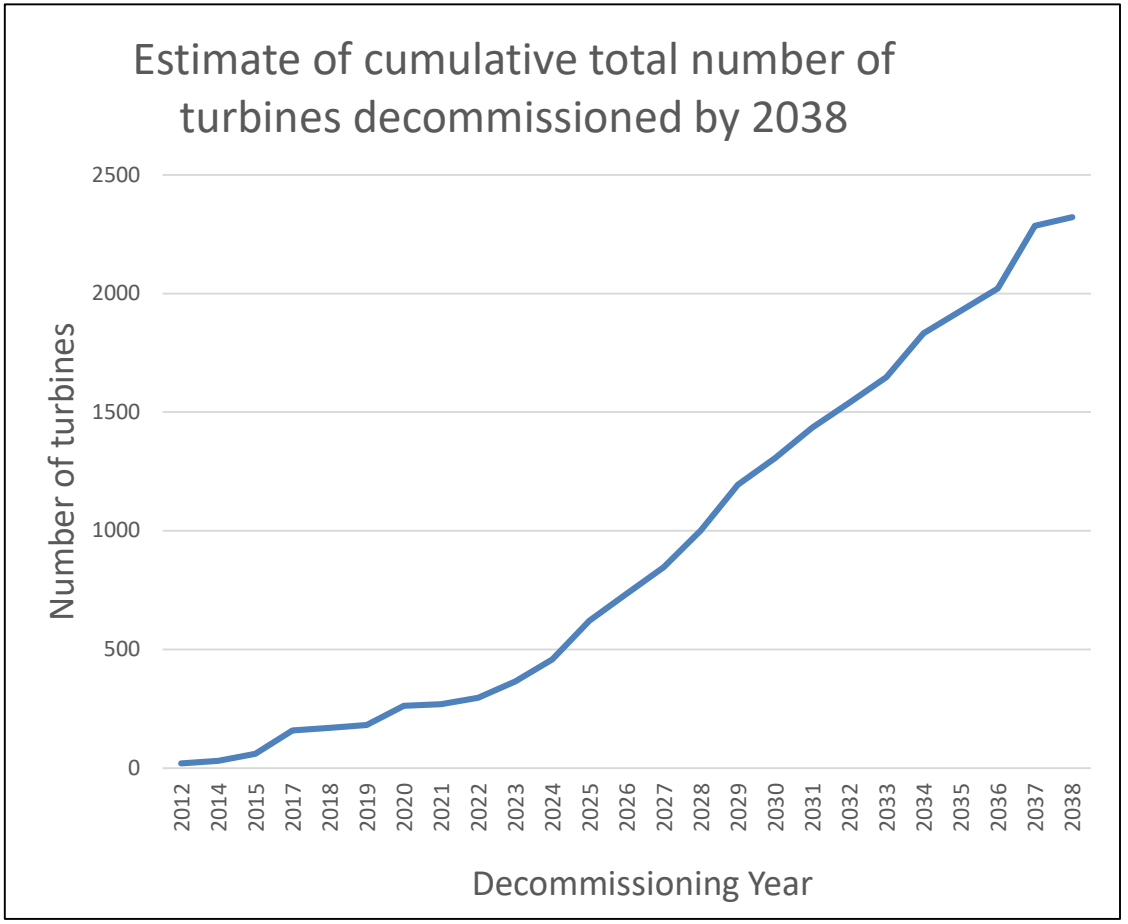
Cut GFRP composite waste
Image: BRIO project
Credit: Elhuyar Fundazioa

Turbine end-of-life & the mounting GFRP blade 'waste' issue



Approximate total number of turbines to be decommissioned in Ireland by 2038:

2323

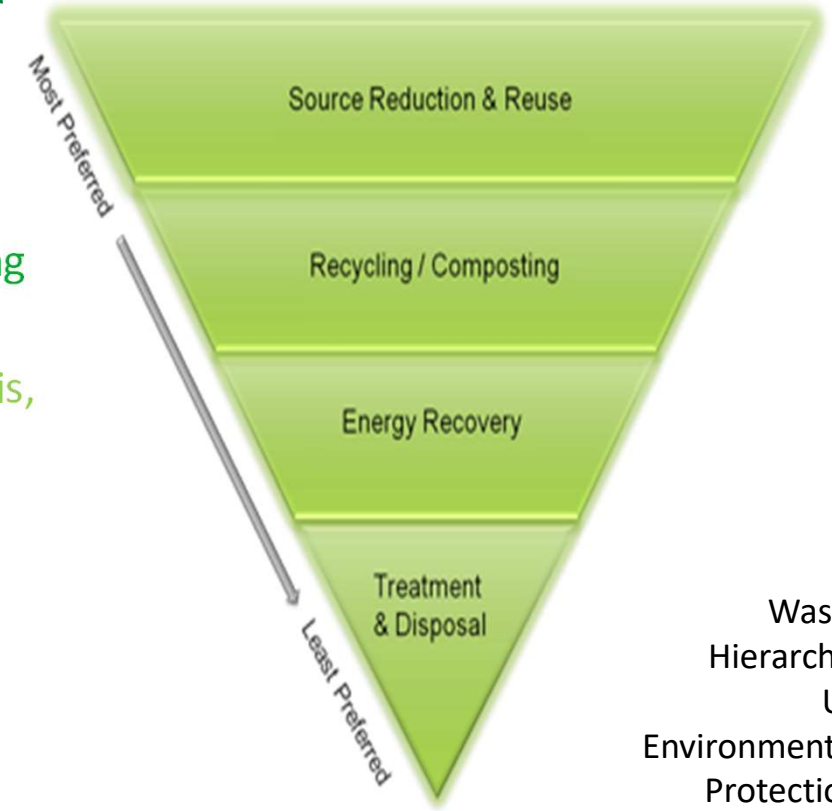


Emma Delaney, QUB

US EPA Waste Hierarchy

Repurposing lies near the top of the Waste Hierarchy

- **Prevent:** either extend project lifetime or sell blades on secondhand market
- **Repurposing**: Remanufacturing for use in new products
- **Recycling**: Shredding, grinding and milling for filler for FRP or concrete
- **Materials Recovery**: Pyrolysis, thermolysis, solvolysis to recover polymer resins or fibers or gasses for energy
- **Co-processing in cement kilns: raw material substitution**
- **Incineration** – with or without energy recovery, then landfill ash
- **Landfilling**



Waste Hierarchy: US Environmental Protection Agency

Blade Repurposing: Methodology

More than **50 blade repurposing concepts** identified initially

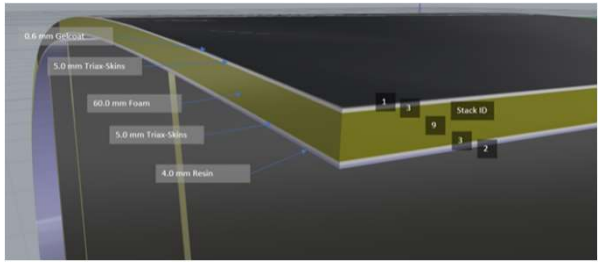
Design Office exercise (Winter 2019, Belfast) will develop and refine three concepts

The success of reuse cases depends on **technical feasibility**, **location** & **social**, **environmental** and **economic** sustainability

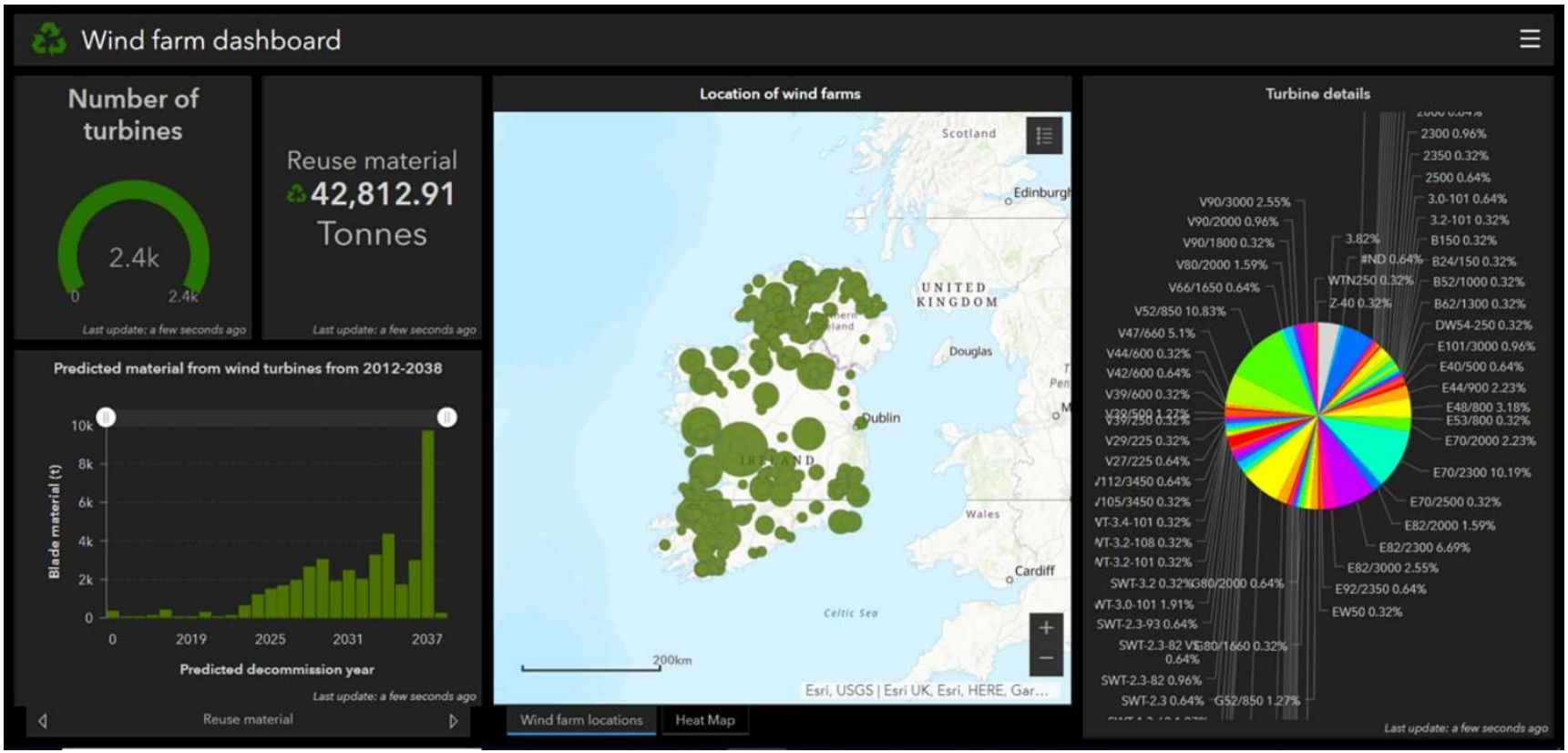
A **transdisciplinary approach** has developed tools to assess all of these:

- All-Ireland blade geodatabase
- 3-D LiDAR scanning
- Blade geometry reconstruction software
- Structural analysis & testing methods
- Community engagement methodology
- Lifecycle analysis (LCA)
- Robust set of internationally-deployable success indicators : environmental, social and economic

Disciplines: Architecture, Structural Engineering, Sociology, Energy Engineering, Business Model Discovery, Geographical Information Science



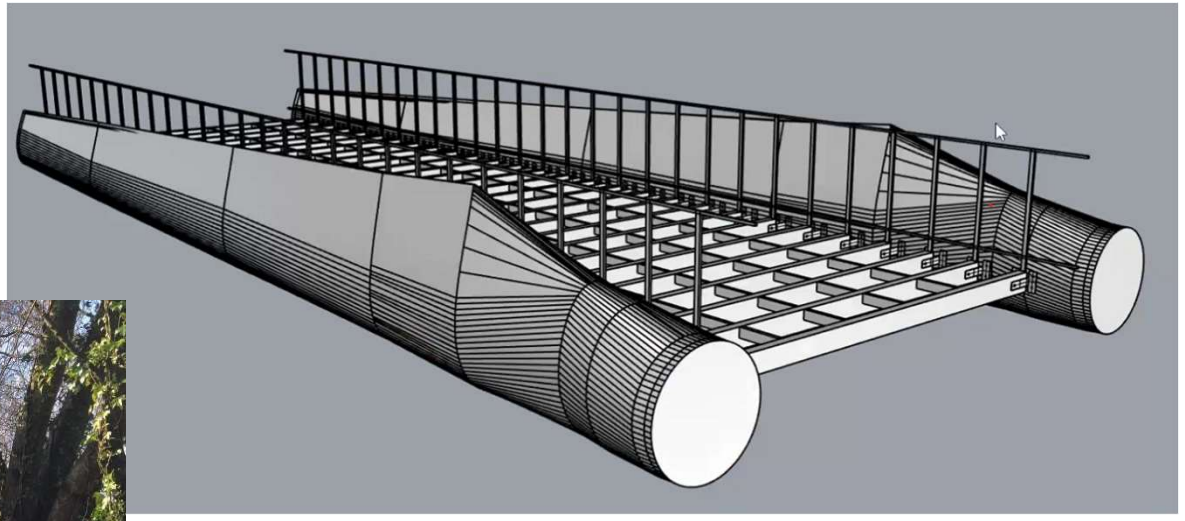
GIS Dashboard & Database



Tool allows database to be queried by: location, turbine type, blade dimensions, projected decommissioning date (Re-Wind, QUB Team)

Greenway Blade-Bridge Project

- 5.5m bridge using N27 blades
- Modelling estimates 5 x FOS
- Strength testing on 3rd blade
- Development of fasteners
- Great enthusiasm & replicable

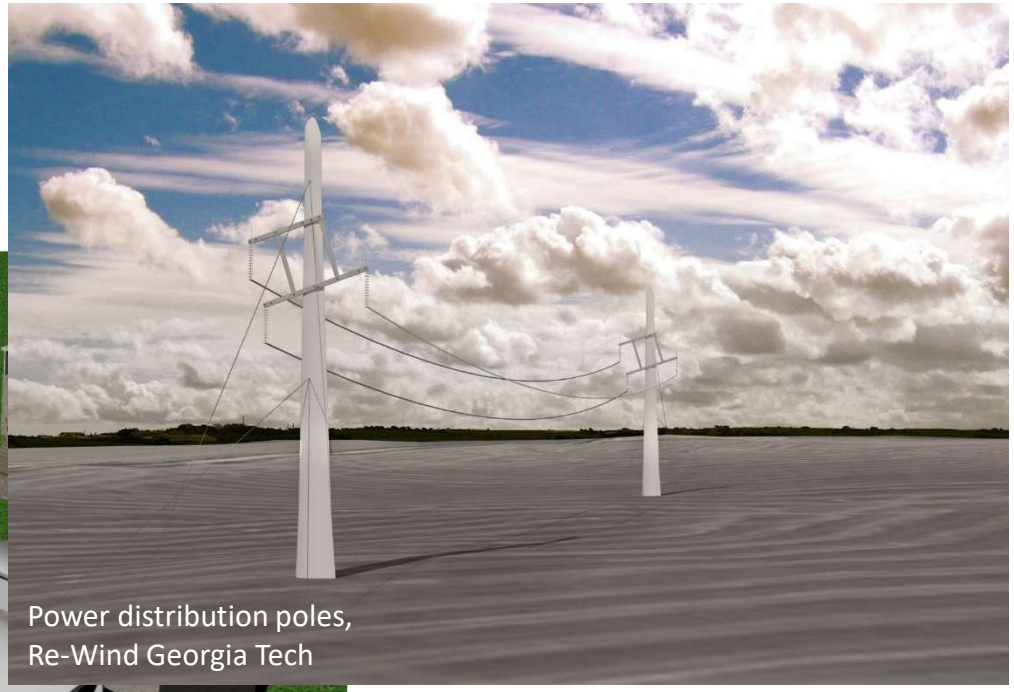


(Zoe Zhang, Re-Wind, Georgia Tech)

Angie Nagle| ReComp 25 Nov| Sustainability Assessment of a Pedestrian Bridge

Blade repurposing use cases

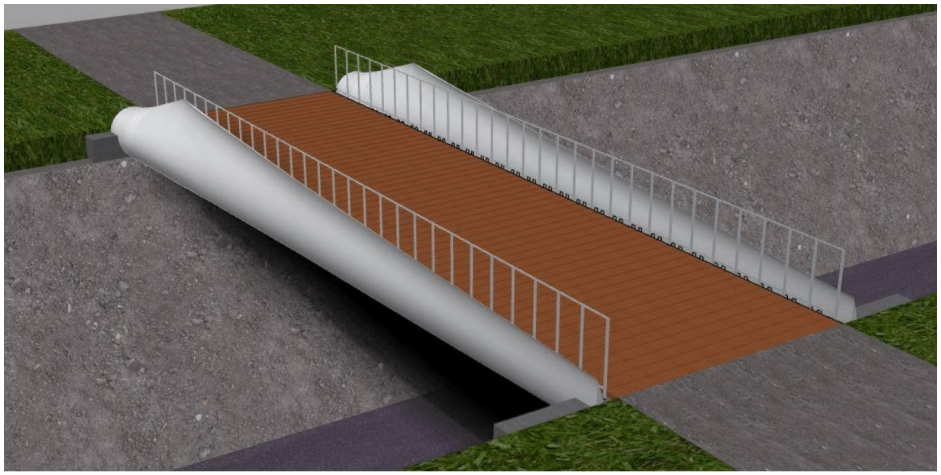
Bank et al.,
Recycling 2018



Power distribution poles,
Re-Wind Georgia Tech

Bridge Repurposing: LCA Boundary Setting & Assumptions

Functional Unit: Disposition of 4500 kg blade waste over 60 years (Cradle to Grave)

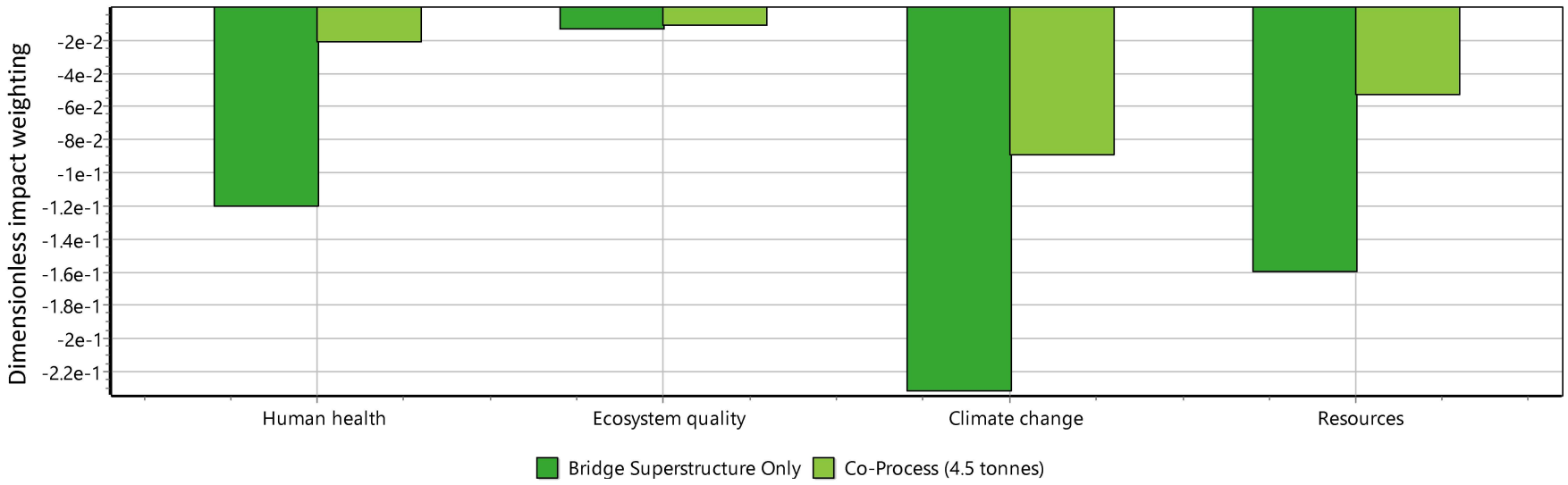


- Blades transported Belfast to Cork
- Lower 2/3 blade replaces steel girders made with partially recycled material
- Top 1/3 blade sent to landfill
- Blades coated in epoxy protective layer
- End of Life Plan: Co-processing of GFRP girders, recycling of hardware

Wooden decking material, abutments, and maintenance schedule assumed equal to bridge made with steel girders

Presented by Angie Nagle,
ReComp 25th November 2020

LCA: Comparison of Baseline to Bridge Girder Substitution



Method: IMPACT 2002+ V2.15 / IMPACT 2002+ / Normalisation
Comparing 1 p 'Bridge Superstructure Only' with 1 p 'Co-Process (4.5 tonnes)';

Blade End-of-Life:

Blade bridge is more environmentally beneficial than co-processing in cement kiln.

Blade repurposing : key results

- Technical feasibility of repurposing has been demonstrated
- Baseline scenario comparisons:
  - Co-processing environmentally superior to landfill
  - Blade bridge superior to co-processing
- Integrated environmental, social and economic assessments
  - P. Deeney, article in review" Multi-criteria Decision Analysis using the Sustainable Development Goals for end-of life choices for wind turbine blades"

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GIS: Emma Delaney, Queens University Belfast

Life Cycle Analysis: Angela Nagle, UCC

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