

End-of-Life Issues for Onshore Wind Farms

Friday 27th May 2022, Cork, Ireland

Conference Welcome



Wind Farm End-of-Life Considerations

Speaker:

Paul Leahy

School of Engineering & Architecture & MaREI Centre,
University College Cork

Re-Wind Network

University College Cork, Queens University Belfast,
Georgia Tech, Munster Technological University

Presentation at:

End-of-Life Issues for Onshore Wind Farms

Friday 27th May 2022, Cork, Ireland

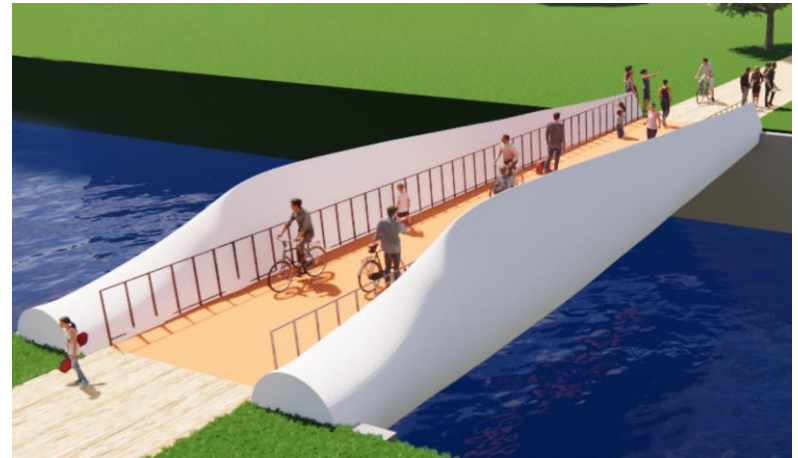


Cork, 27.05.2022



Presentation Overview

- Wind Energy in Ireland 1990-2038
- Wind Farm Life Cycle & End-of-life Decisions
- Turbine Blades
- The Re-Wind Project & Blade Repurposing
- Background to BladeBridge
- How Sustainable is Blade Repurposing?



Re-Wind Catalog Modeling and Graphics:
Asha McDonald, Chloe Kiernicki, Mehmet Bermek, Zoe Zhang, Alex Poff, Sakshi Kakkad, Emily Lau, Franco Arias, Russell Gentry.

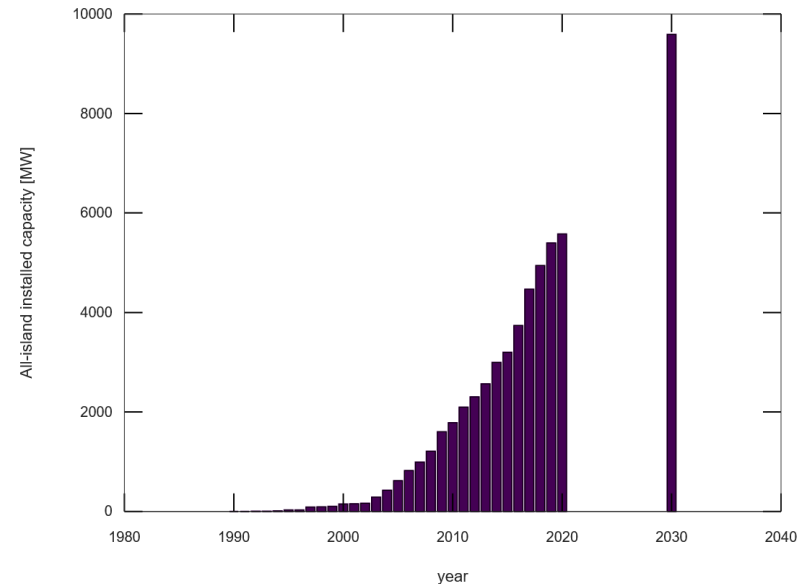
WIND ENERGY IN IRELAND 1990-2038

Wind Energy in Ireland

- Wind Energy capacity in Ireland:

- 153 MW in 2001
- 5,576 MW in 2020
- 16,000 MW by 2030

Data: Eirgrid, Climate Action Plan , SONI TES NI Scenario 3



- Wind turbine typical design life is 20-25 years
- Wind turbine decommissioning will accelerate in the next five years

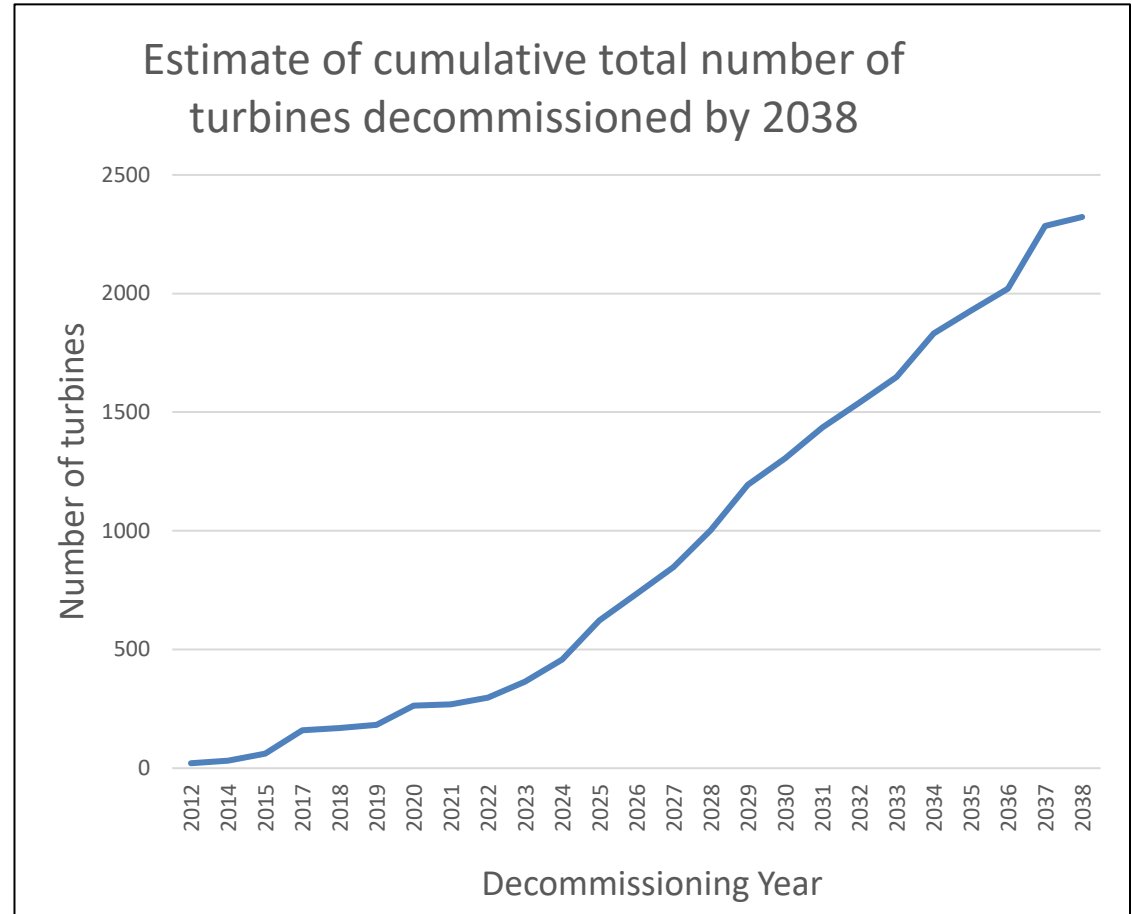


Lower image: decommissioning, energyfacts.eu

Turbine decommissioning & the mounting blade 'waste' issue

Approximately 2,323 turbines to be decommissioned in Ireland by 2038

Landfill will soon no longer be an option for end-of-life blades in Ireland



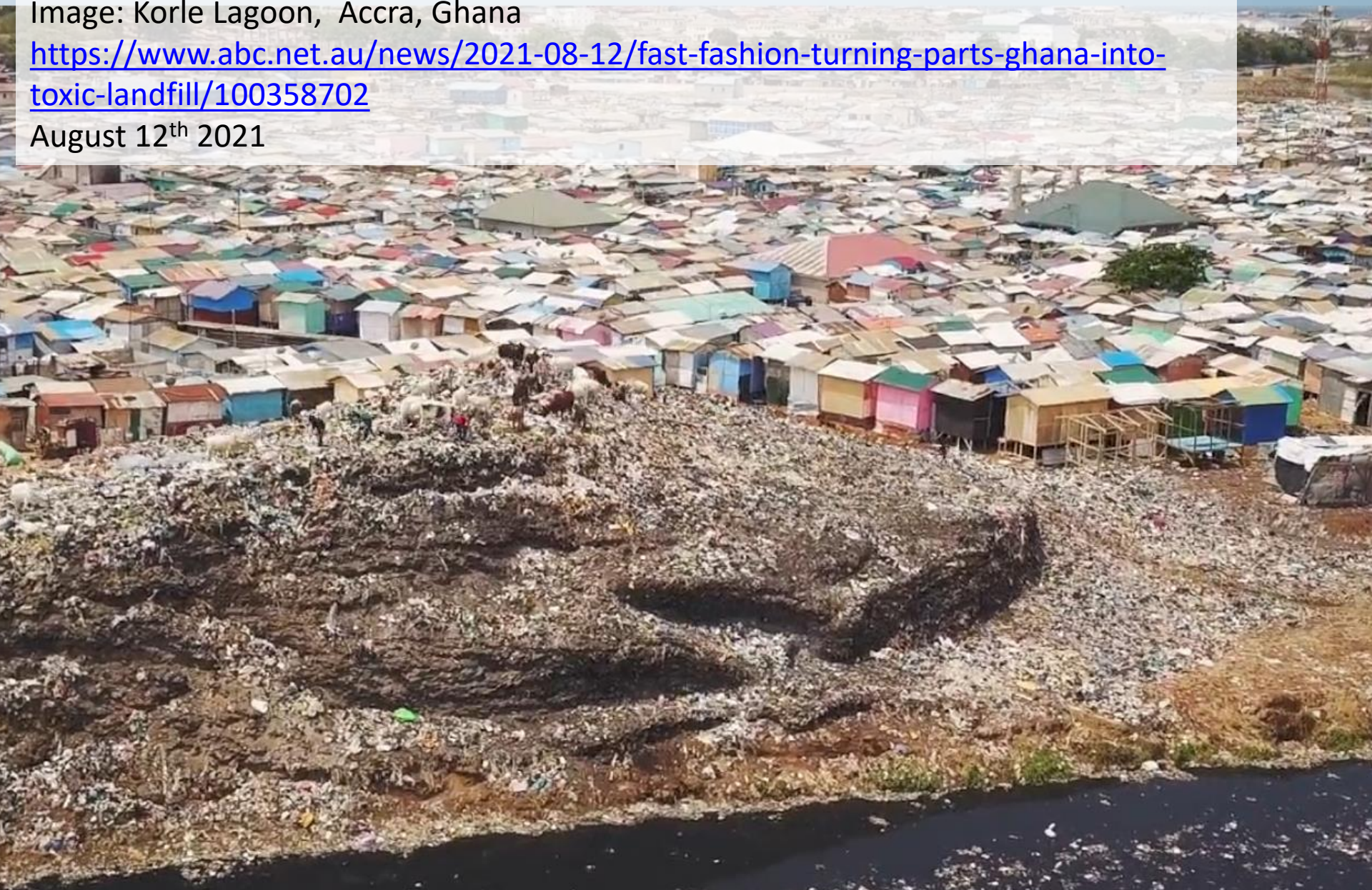
Emma Delaney, QUB

Volumes of plastic and composite waste is a global environmental problem

Image: Korle Lagoon, Accra, Ghana

<https://www.abc.net.au/news/2021-08-12/fast-fashion-turning-parts-ghana-into-toxic-landfill/100358702>

August 12th 2021



WIND FARM LIFE CYCLE & END-OF-LIFE DECISIONS

Wind farm end of life decision factors

When does a wind plant reach end of life?

- End of design life
- Expiration of planning permission
- Market reforms
- Expiration of subsidies
- Operating costs: wear, fatigue, failures, outages, repairs
- Obsolescence

What happens next?

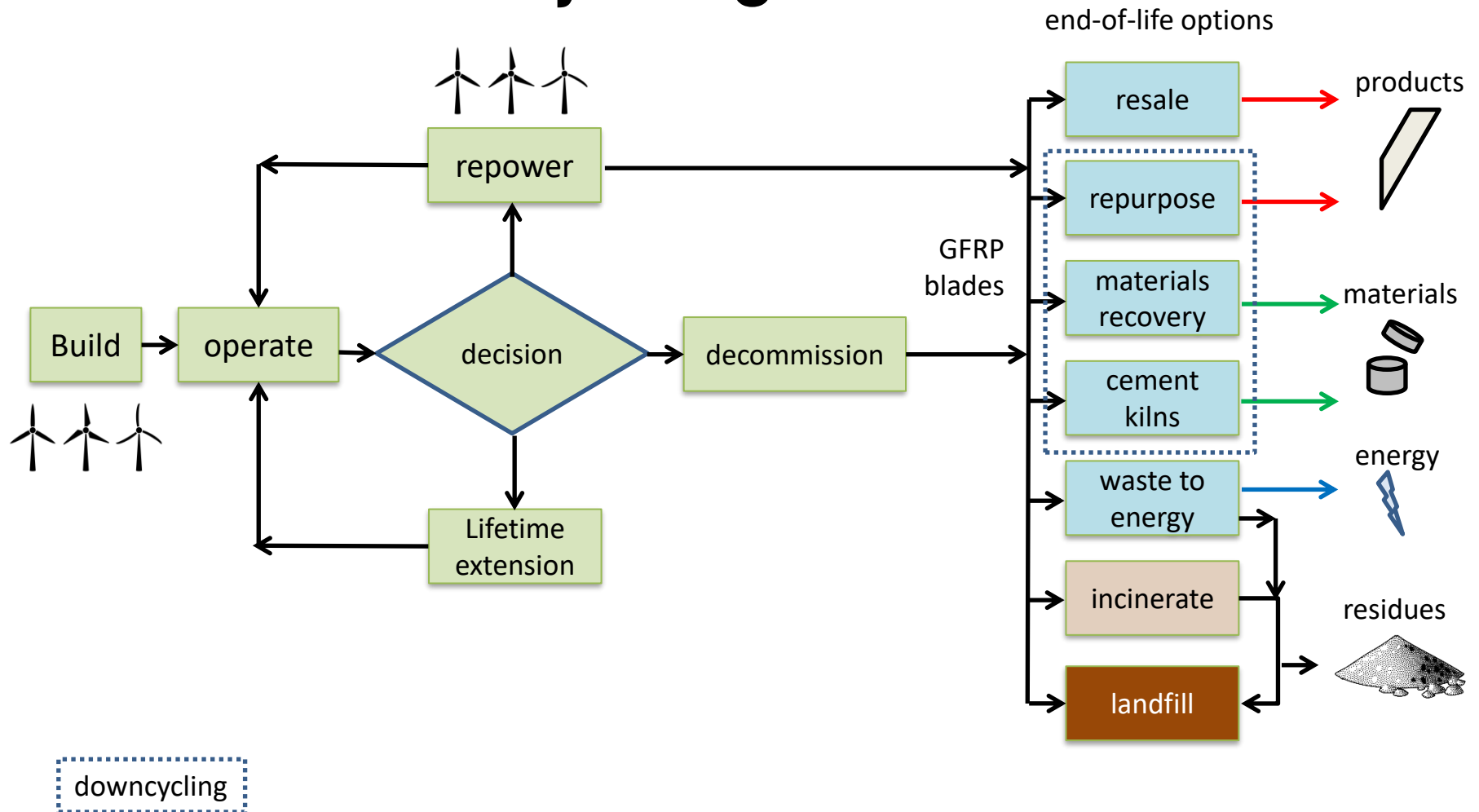
- Decommission
- Repower
- (continue operation)



Altamont Pass, USA.

Image: Noah Berger, National Geographic

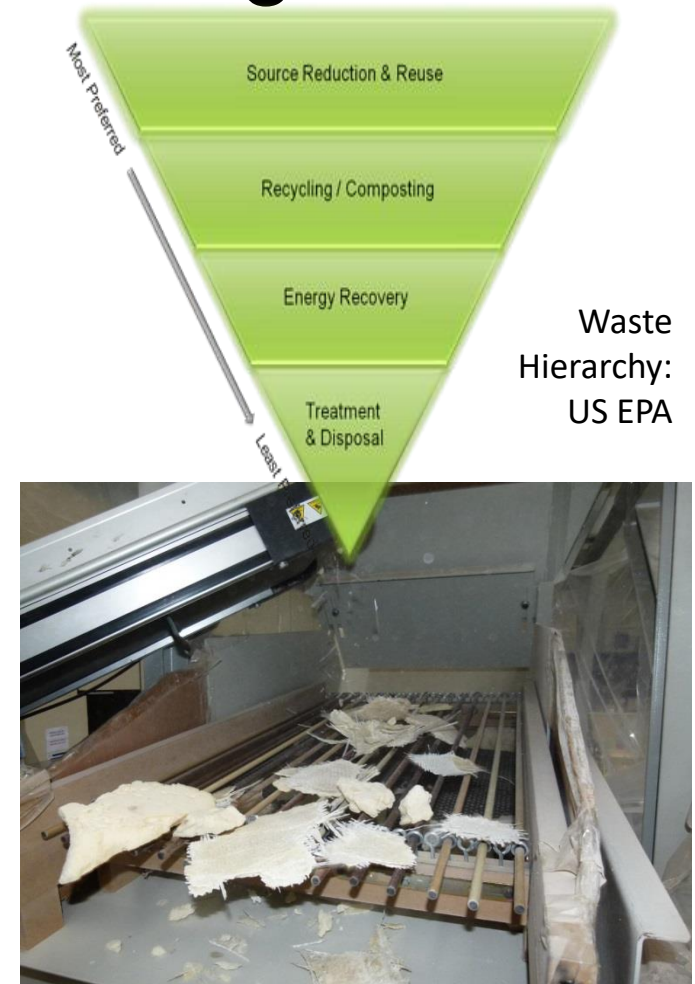
Wind farm lifecycle & blade downcycling



TURBINE BLADES

End of life wind turbine blades: a circular economy challenge

- Wind turbine blades are primarily composed of non-biodegradable GFRP composite materials
- Annual global blade waste is expected to reach 40 million tonnes by 2050
- GFRP is a highly-engineered valuable material but its components are of relatively low value!
- Can technically, economically, environmentally & socially feasible repurposing options be found?



THE RE-WIND PROJECT & BLADE REPURPOSING

Re-Wind: Driving Innovation in the Re-Use of Decommissioned Wind Turbine Blades

Supported by InvestNI/Department for the Economy (DFE), Grant USI-116; by Science Foundation Ireland, Grant 16/US/3334; and by the U.S. National Science Foundation under grants numbers 1701413 and 1701694, under the project "Re-Wind".
Re-Wind, 2020.



Wind Thrust



Mechanical Thrust



Design Thrust



Geographical Information Science (GIS) Thrust



Re-Wind Project (2017-2021) Partners: UCC, QUB, Georgia Tech, City University of New York

Re-Wind Circular Economy thrust

- The Re-Wind UCC team is focused on:
 - Environmental sustainability
 - Social acceptability
 - Sustainable business models
- for second (& third) life applications for decommissioned wind turbine blades
- Complex, multifactorial problem...



Complex challenges require transdisciplinary approaches

- Re-Wind adopts a transdisciplinary approach to determine environmentally, socially and economically sustainable repurposing options for blades
- Academic Investigators (UCC)
 - Dr. Paul Leahy, Wind Energy Engineering,
 - Dr. Niall Dunphy, Cleaner Production Promotion Unit
 - Dr. Ger Mullally, Sociology
- Disciplines: Architecture, Structural Engineering, Sociology, Energy Engineering, Business Model Discovery, Geographical Information Science

Postdocs & PhDs

Dr Peter Deeney (Finance),
Angela Nagle (Environmental),
Fergal Gough (Social/Community),
Heloisa Lemmertz (Circular Business Models)

Wind Farm End-of-Life Issues : WindValue

27.05.2022



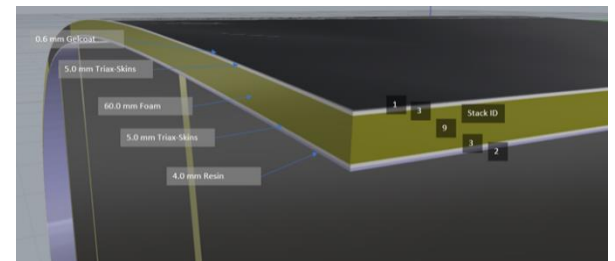
Blade Repurposing: Methodology

More than 50 blade repurposing concepts identified initially
Design Office exercise (Winter 2019, Belfast)

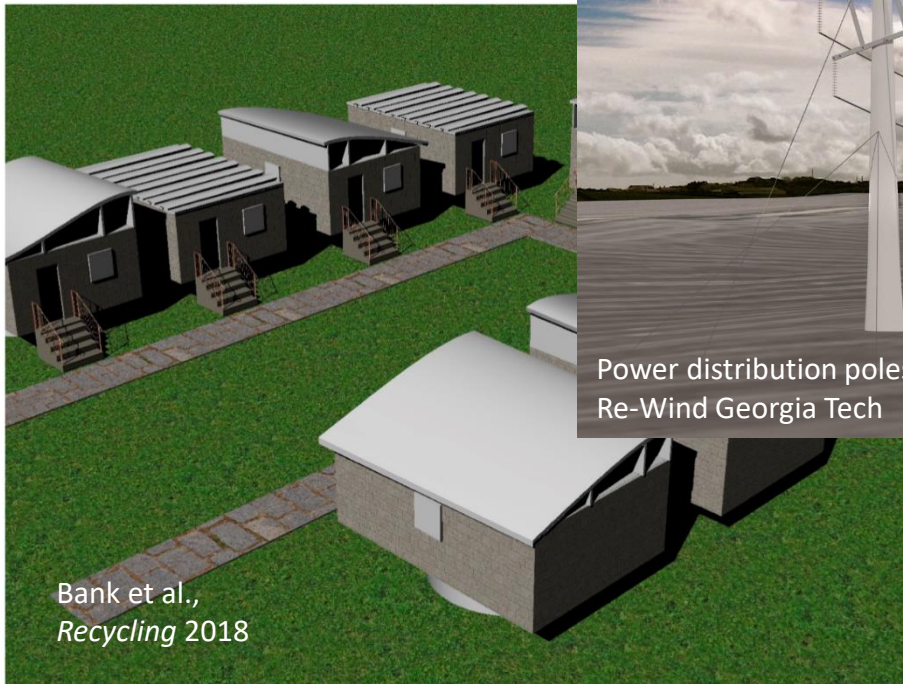
The success of reuse cases depends on technical
feasibility, location & social, environmental and economic
sustainability

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

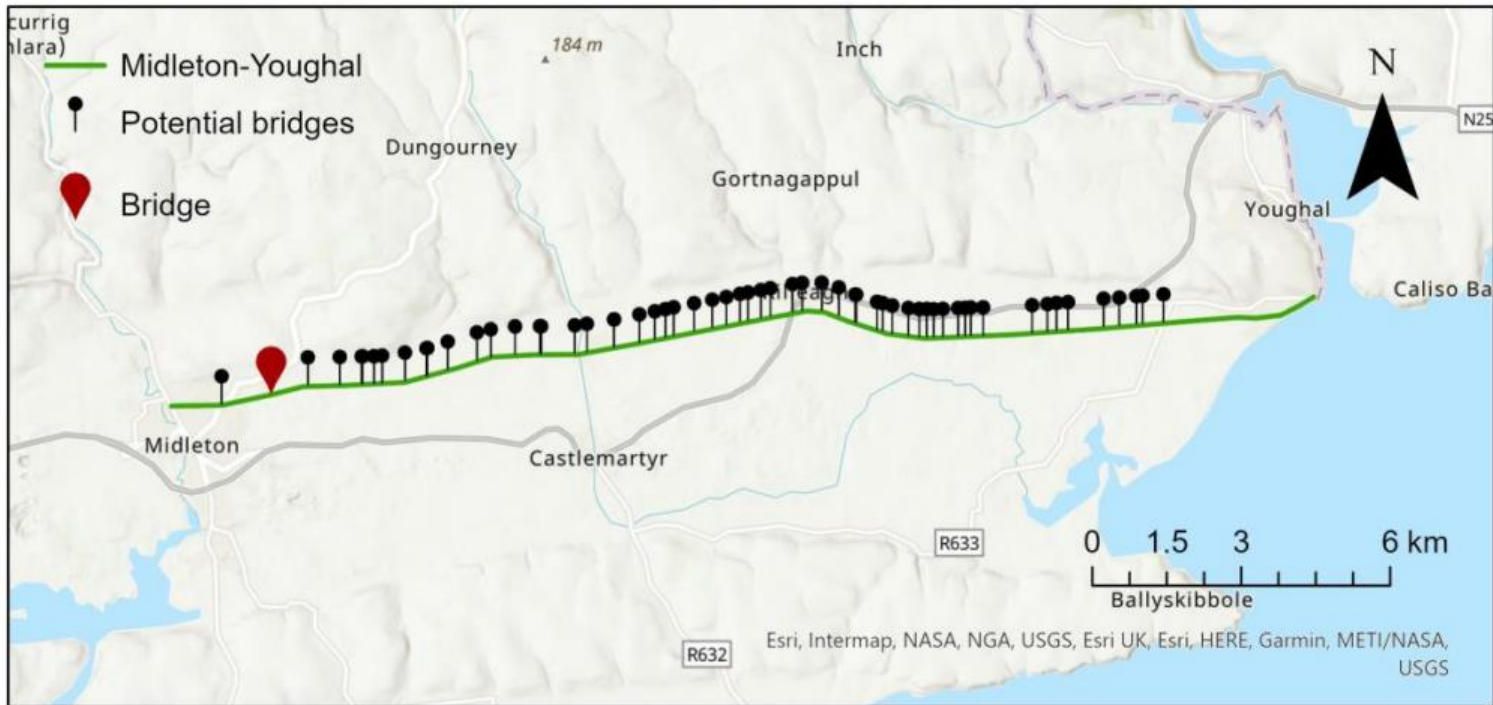


Blade repurposing use cases



BACKGROUND TO BLADEBRIDGE

Youghal-Midleton Greenway, Cork



(Emma Delaney, Re-Wind QUB)

- 23 km cycleway under development by Cork County Council
- Funded by the Project Ireland 2040 initiative.
- Expected completion 2023, sections will open earlier
- Route surveyed for potential blade bridge crossings, April 2020

QUB LiDAR scanning of Nordex N29 Blades at Everun Ltd, Belfast





HOW SUSTAINABLE IS BLADE REPURPOSING?

BladeBridge

LCA Boundary Setting & Assumptions

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

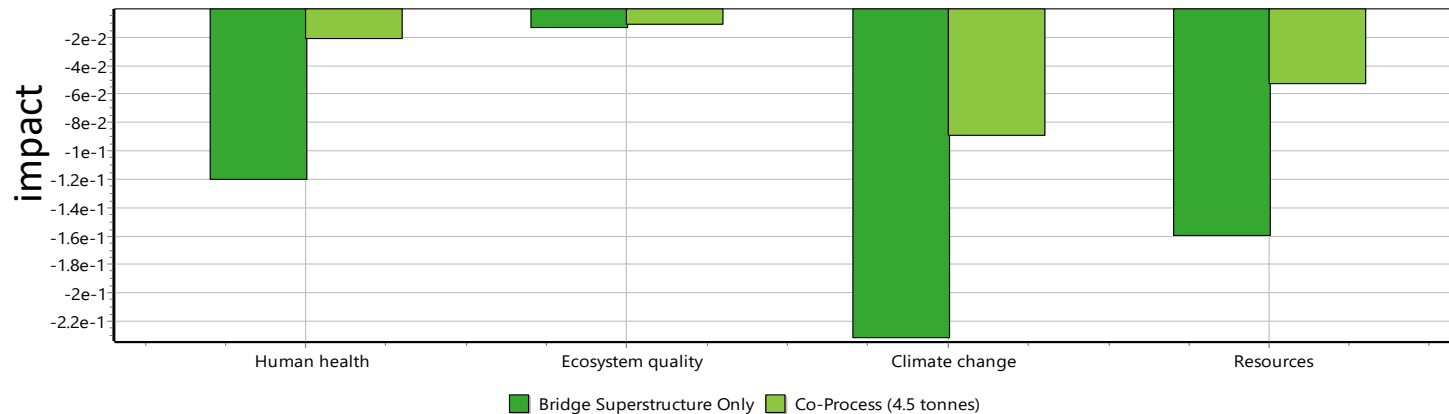
- Blades transported Belfast to Cork
- Lower 2/3 blade replaces steel bridge girders made with partially recycled material
- Top 1/3 blade sent to landfill (conservative assumption: may be repurposed)
- Blades coated in epoxy protective layer
- End of Life Plan: Co-processing of GFRP girders, recycling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

Blade bridge : initial environmental assessment

- Blade bridge **environmentally** preferable to alternative end-of-life treatments: co-processing or landfill (baseline, not shown)
- Impacts calculated using Life Cycle Analysis (LCA) by Angie Nagle



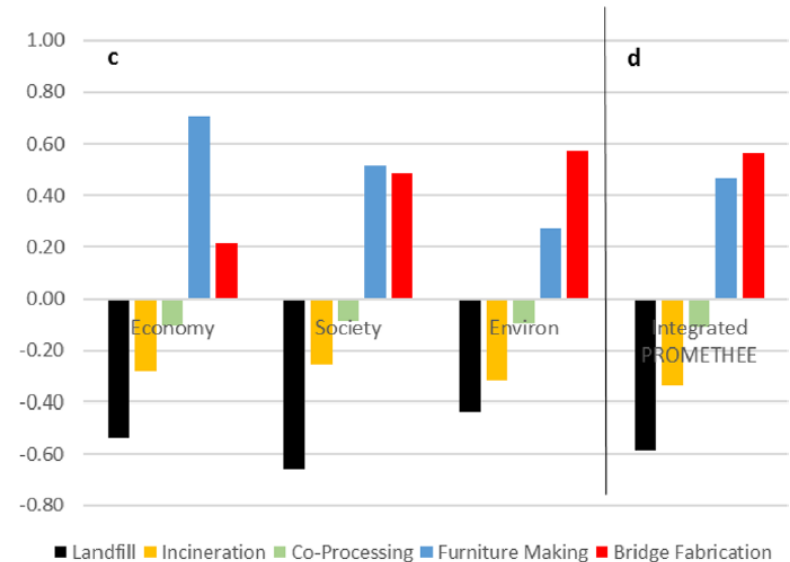
Method: IMPACT 2002+ V2.15 / IMPACT 2002+ / Normalisation
Comparing 1 p 'Bridge Superstructure Only' with 1 p 'Co-Process (4.5 tonnes)';

Value perception in Wind Farm End-of-Life



Integrated environmental, social and economic assessments

- Multicriteria decision analysis (Deeney et al., 2021) based on custom UN SDG indicators, LCA outputs, Delphi panels of experts
- Future repurposing must be sustainable in terms of social, environmental and economic aspects
- Inclusive configuration of stakeholder in which different needs and interests are reflected
- Importance of engaging communities where blades are located and likely to be reused or recycled
- There is a possible role for so-called social business models
- **Repurposing scores well on integrated metrics compared to “conventional” end-of-life disposal**

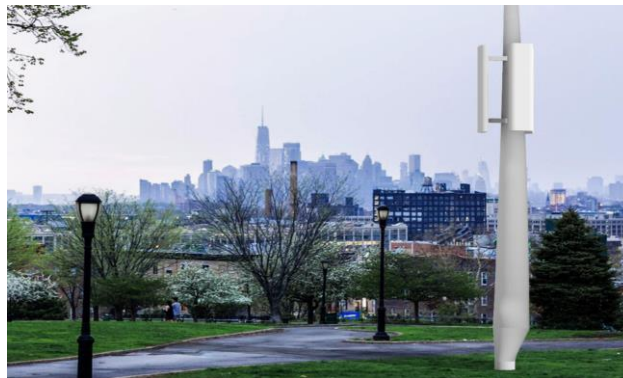


End-of-Life alternatives for wind turbine blades: Sustainability Indices based on the UN sustainable development goals

Peter Deeney^{a,b,g,*}, Angela J. Nagle^{a,b}, Fergal Gough^{a,c}, Heloisa Lemmert^{a,c}, Emma L. Delaney^d, Jennifer M. McKinley^d, Conor Graham^d, Paul G. Leahy^{a,b,g}, Niall P. Dunphy^{a,b,e,g}, Gerard Mullally^{a,c,e,f,g}

[Resources, Conservation & Recycling 171 \(2021\) 105642](#)

Repurposing Social Acceptability Poll

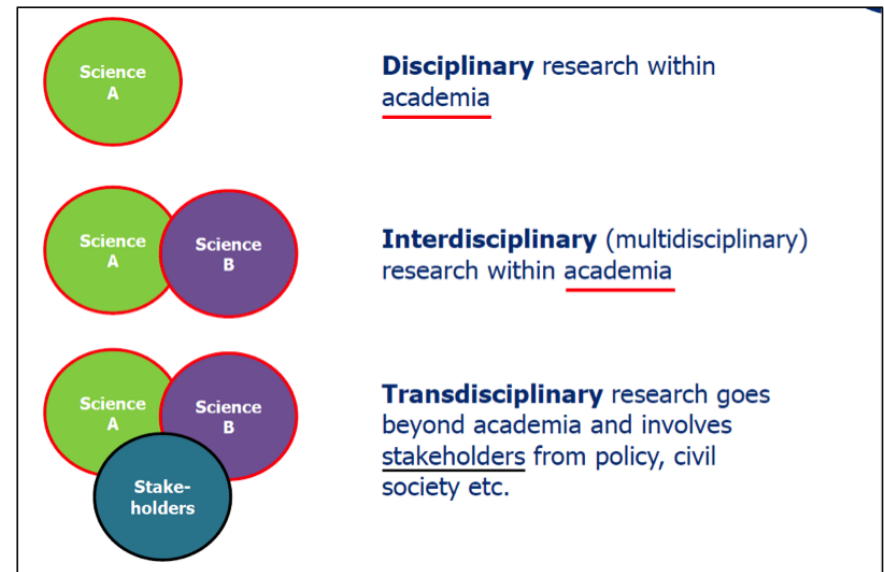


- Poll link:
<https://forms.microsoft.com/Pages/ResponsePage.aspx?id=pVz-Rm-GQk6S6e2HhiRVRQHAArlql3pOi9vvmlANsXZUMko1WlglwUVpKQU44T0pCTzJYRVVo5NFC2Ui4u>



Re-Wind : reflections and next steps

- Re-Wind integrated social, environmental and business sustainability analyses
- The blade bridge was beyond the original plan!
- The bridge was invaluable to inform the social, economic & environmental analyses
- Was the project truly transdisciplinary?



Graphic: thearcticInstitute.org

Next steps

- End-of-life decision support: allow wind farm owners, decommissioners and waste managers to make optimal decisions
- WindValue & WindLEDeRR projects
- Blade Repurposing Startup

Wind Farm End-of-Life : Conclusions

- We can address several societal challenges through greenway blade bridges: circular economy/ resource reuse, decarbonising transport, healthy lifestyles, sustainable rural development
- Technical feasibility of repurposing blades as infrastructure has been demonstrated
- Detailed life cycle analysis shows environmental benefits:
 - Repurposing blades as bridges is environmentally superior to cement kiln co-processing or landfilling the blades



Thank you!

Acknowledgements to Re-Wind research team at University College Cork, Queens University Belfast, and Georgia Tech and Kieran Ruane of Cork Institute of Technology

Funders: SFI; NSF; DfE; & Steering Group

Bridge Design: Zoe Zhang, Georgia Tech

GIS: Emma Delaney, Queens University Belfast



www.re-wind.info

paul.leahy@ucc.ie

twitter.com/ReWindUCC

Linkedin: Re-Wind Network