Re-Wind: Driving Innovation to Explore Sustainable Re-Use of Decommissioned Wind Turbine Blades

Recomp: Reuse and Recycling of FRP Composites by Composites UK 24 November 2020

PARTNERS

AVK Industrievereinigung Verstärkte Kunststoffe

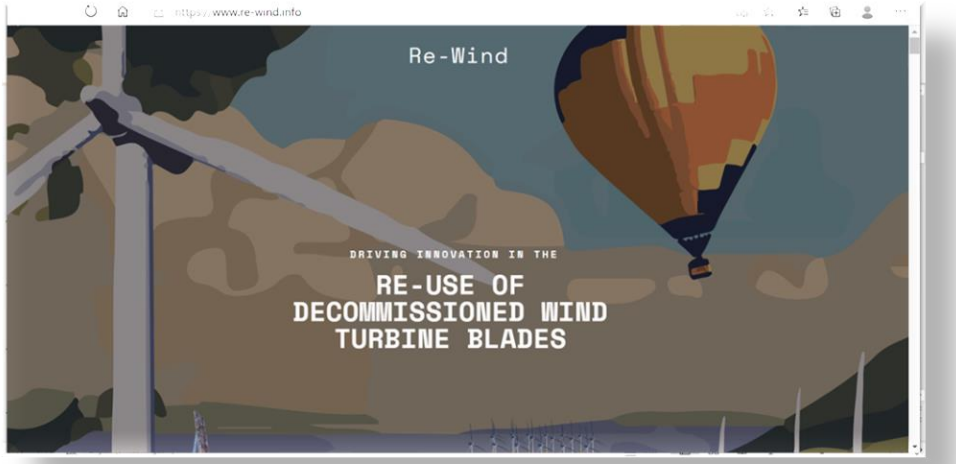
CATAPULT High Value Manufacturing ReDisCoveR project

ELG Carbon Fibre Ltd. Recycled Carbon Fibre

EuCIA European Composites Industry Association

WARWICK

www.re-wind.info/



Jennifer McKinley, Emma Delaney and Conor Graham

Geography, Centre for GIS and Geomatics, School of Natural and Built Environment,

Queen's University Belfast, UK

Re-Wind project

www.re-wind.info/

This work is 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. Re-Wind: Driving Innovation in the Re-Use of Decommissioned Wind Turbine Blades [WWW Document]. URL https://www.re-wind.info/

- Exploring sustainable repurposing strategies for wind turbine blades
- Collaborative US-Ireland research team from QUB, UCC, CUNY and Georgia Tech
- Engaging with a multidisciplinary team from engineering, architecture, geography, political and social science and Local Development Experts
- Moving towards a circular economy

Team in Georgia Tech, Atlanta, February 2019

Waste or Resource?

Bloomberg Green

ıdfill in Wyoming.

https://www.bloomberg.com/

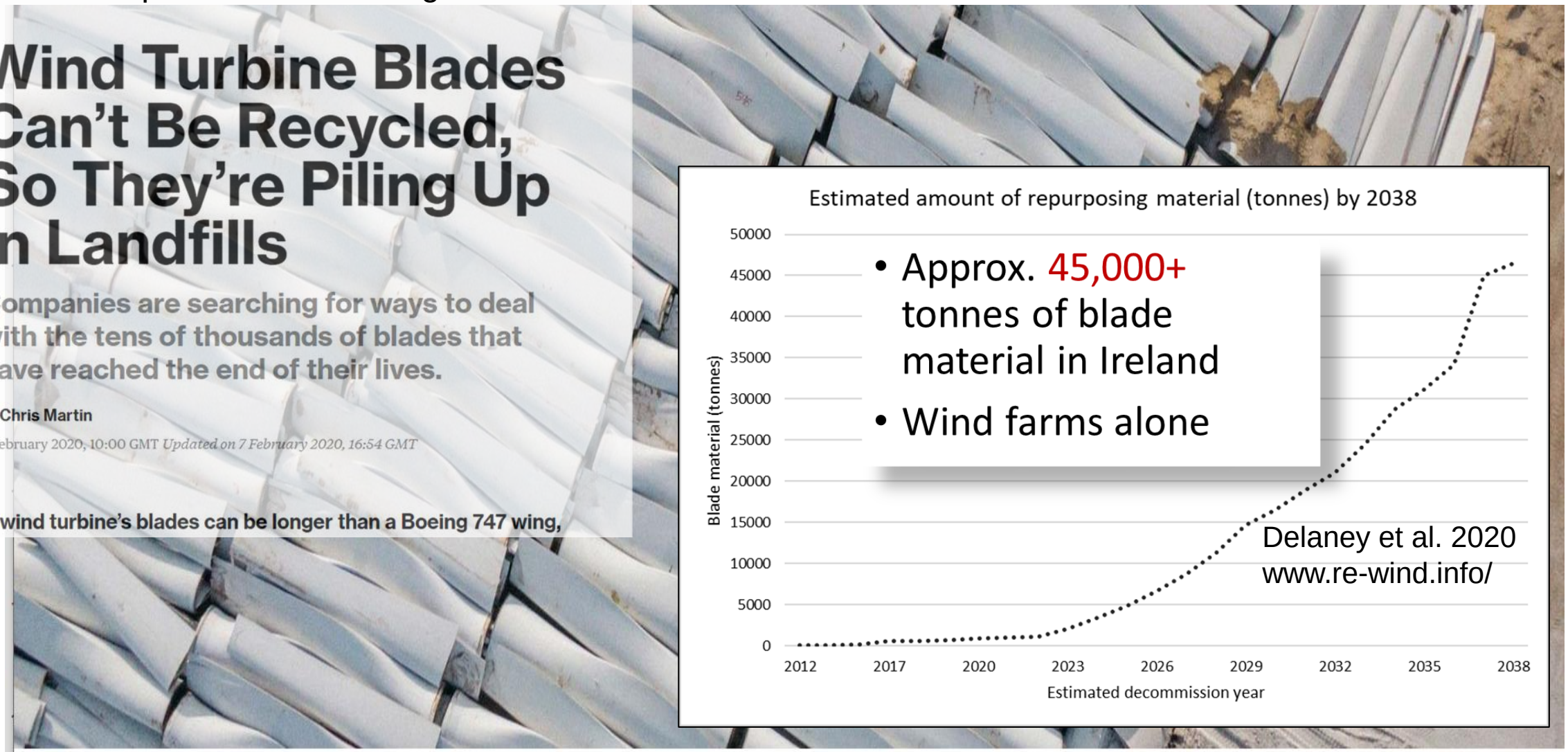
Wind Turbine Blades Can't Be Recycled, So They're Piling Up in Landfills

Companies are searching for ways to deal with the tens of thousands of blades that have reached the end of their lives.

By **Chris Martin**

5 February 2020, 10:00 GMT *Updated on 7 February 2020, 16:54 GMT*

A wind turbine's blades can be longer than a Boeing 747 wing,



Fragments of wind turbine blades await burial at the Casper Regional Landfill in Wyoming.

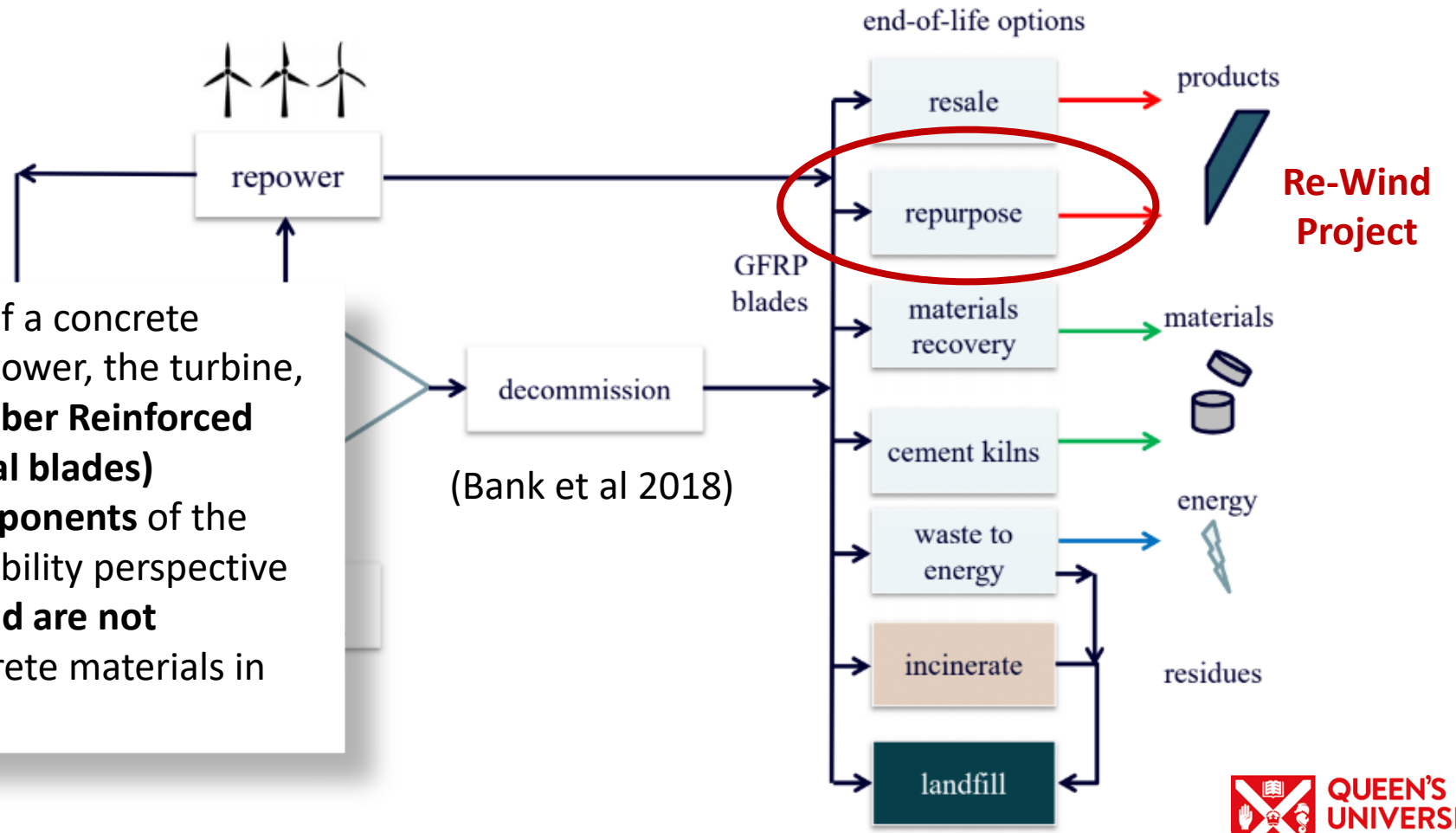
Photographer: Benjamin Rasmussen for Bloomberg Green

QUEEN'S UNIVERSITY BELFAST

Wind Farm Lifecycle

Vestas FRP turbine blade

Vestas shown 40.5 m long



(Bank et al 2018)

- A modern wind turbine consists of a concrete foundation, a steel (or concrete) tower, the turbine, and the rotor (a hub with three **Fiber Reinforced Polymer (FRP) composite material blades)**
- **FRP is the most problematic components** of the turbine from a material's sustainability perspective since they **non–biodegradable and are not recyclable** like the steel and concrete materials in the turbine.

Re-Wind is based on the concepts of cradle–to–cradle product design.

The circular economy philosophy emphasizes the need to make products that can be always be remade and reused.

Wind Thrust

Mechanical Thrust

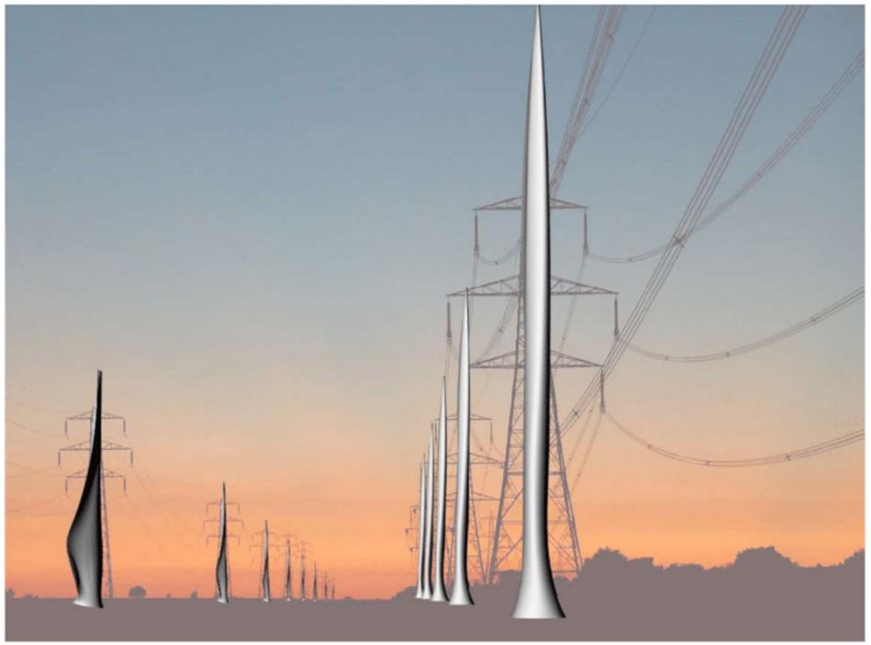
Design Thrust

Geographical Information Science (GIS) Thrust

Georgia Tech · Queen's University Belfast · CUNY The City University of New York · UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

Repurposing Options: Affordable / emergency housing

Bank et al. (2018)



©US-Ireland Tripartite Research Grants 1701413 (NSF), 1701694 (NSF), 16/US/3334 (SFI), USI-116 (DfE) (2017-2021)

recycling

MDPI

Article

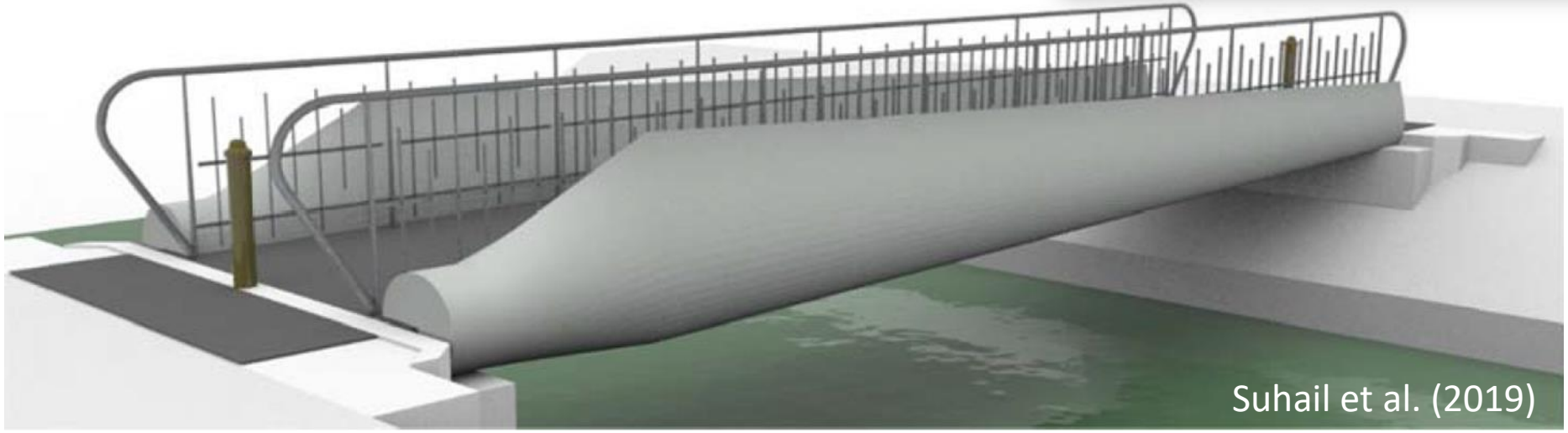
Concepts for Reusing Composite Materials from Decommissioned Wind Turbine Blades in Affordable Housing

Lawrence C. Bank [1,*], Franco R. Arias [1], Ardavan Yazdanbakhsh [1], T. Russell Gentry [2], Tristan Al-Haddad [2], Jian-Fei Chen [3] and Ruth Morrow [3]

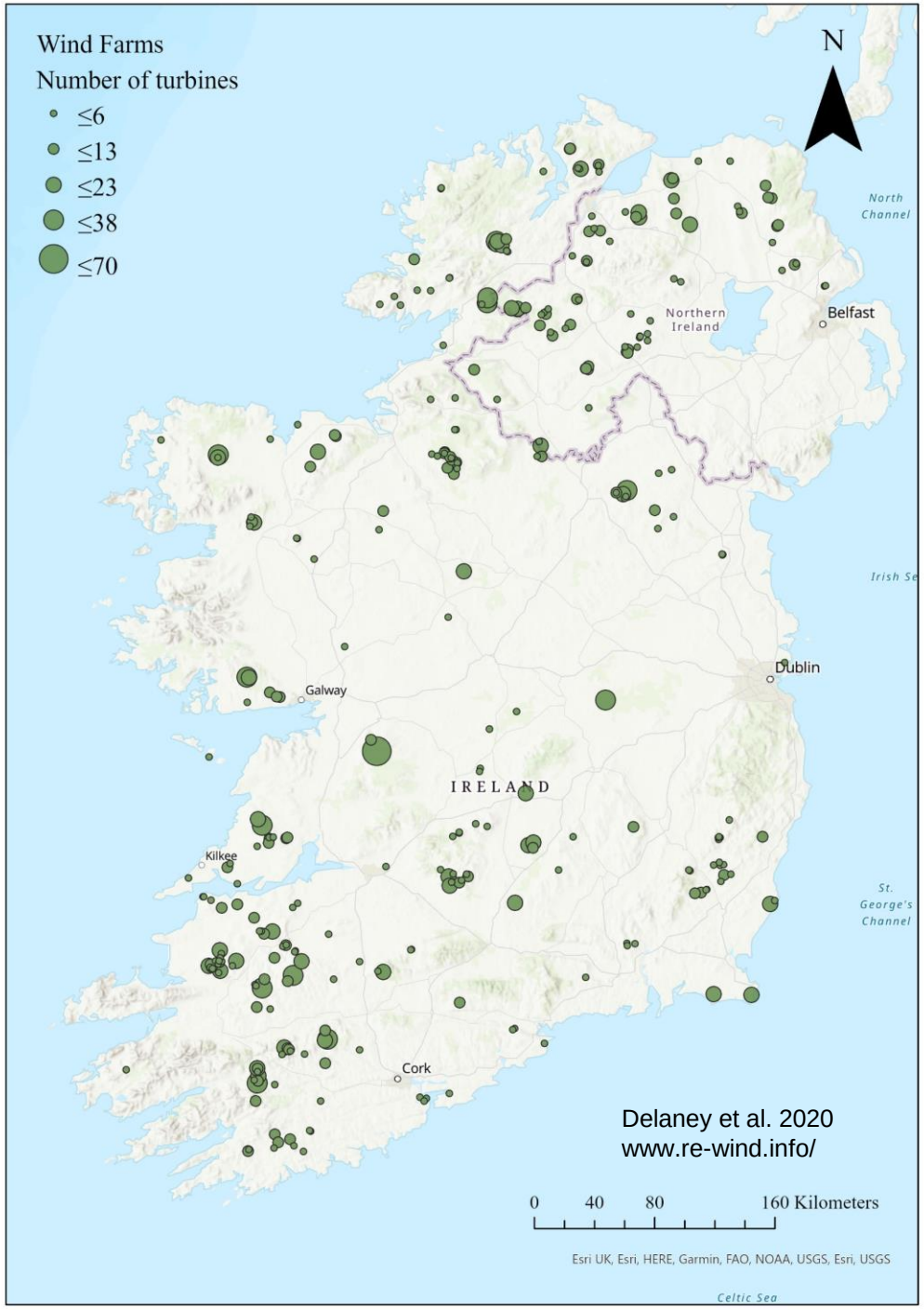
Pedestrian Bridge

- A29 Blades (14.3m)
- 8.5 m footbridge

Re-Wind, 2020. https://www.re-wind.info/



Suhail et al. (2019)



Driving Innovation through Geographical Information Science (GIS)

A GIS-based decision framework to provide wind energy stakeholders with a methodology to evaluate and compare sustainable repurposing strategies for FRP composite material wind turbine blades

QUEEN'S UNIVERSITY BELFAST

Driving Innovation in Re-Wind through GIS

To develop **a wind farm inventory and GIS database** by assimilating all relevant **wind farm information and locations and transport networks** for the Island of Ireland.

To **analyze wind farm characteristics** and calculate the **estimated waste quantities** associated with **the decommissioning stage** of wind farms in Ireland

To develop and customize geospatial analytical tools to aid **decision-making** for **a cycle-recycle** wind turbine strategy.

To provide **a novel geospatial approach** for integrating **a wide variety of stakeholder opinions** into an analytical framework **for decision making.**

To **develop integrated geospatial methodologies** to create a customised **GIS-based network analysis decision framework** for FRP composite material wind turbine blades.

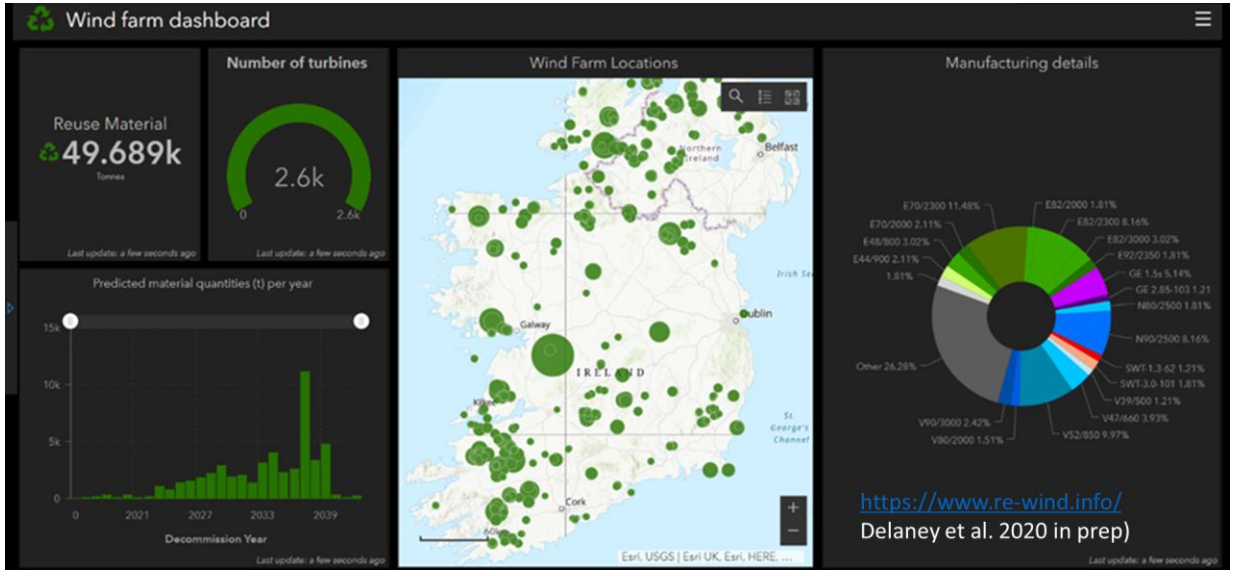
To **create a geospatial protocol for updating, verifying and integrating data** and **a methodology for performing database inquiries** to extract relevant data for **decisions, network analysis and cost/benefit analyses**.

QUEEN'S UNIVERSITY BELFAST

Re-wind GIS Dashboard

- The Re-Wind database provides information on wind farm locations represented as point data with attribute data including manufacturing details, developers and commission dates.
- The dataset is an updated and supplemented version of a database, obtained from TheWindPower (TheWindPower, 2018).
- These data were cross-referenced, corrected, where necessary, and updated using other available databases (IWEA, 2020; RenewableUK, n.d.; SEAI, 2020; Wood Mackenzie, 2019).
- This has resulted in a comprehensive and most up-to-date database for onshore wind in Ireland (Re-Wind, 2020) which enables the prediction of decommission dates and waste material quantities

The Dashboard offers an interactive way for the Re-Wind team to access the wind farm database



Delaney et al. 2020

www.re-wind.info/

https://www.re-wind.info/
Delaney et al. 2020 in prep)

Georgia Tech · Queen's University Belfast · CUNY The City University of New York · UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

GIS Decision-making process

GIS analysis to assist in finding the most sustainable re-use strategies for wind turbine blades

Conceptual Model | Analysis Model | Outputs

1 Define Query → 2 Identify Criteria → 3 Derive Data → 4 Combine Layers → 5 Analysis → 6 Present and feedback

Step 1 Defining the Query:

Identify the goal

Establish how to evaluate the goal through a set of Criteria

Step 2 Identify criteria:

Decommissioning windfarms in the next 10 years or farms with more waste or bigger blades

Appropriate blades for reuse purpose (such as pedestrian bridge)

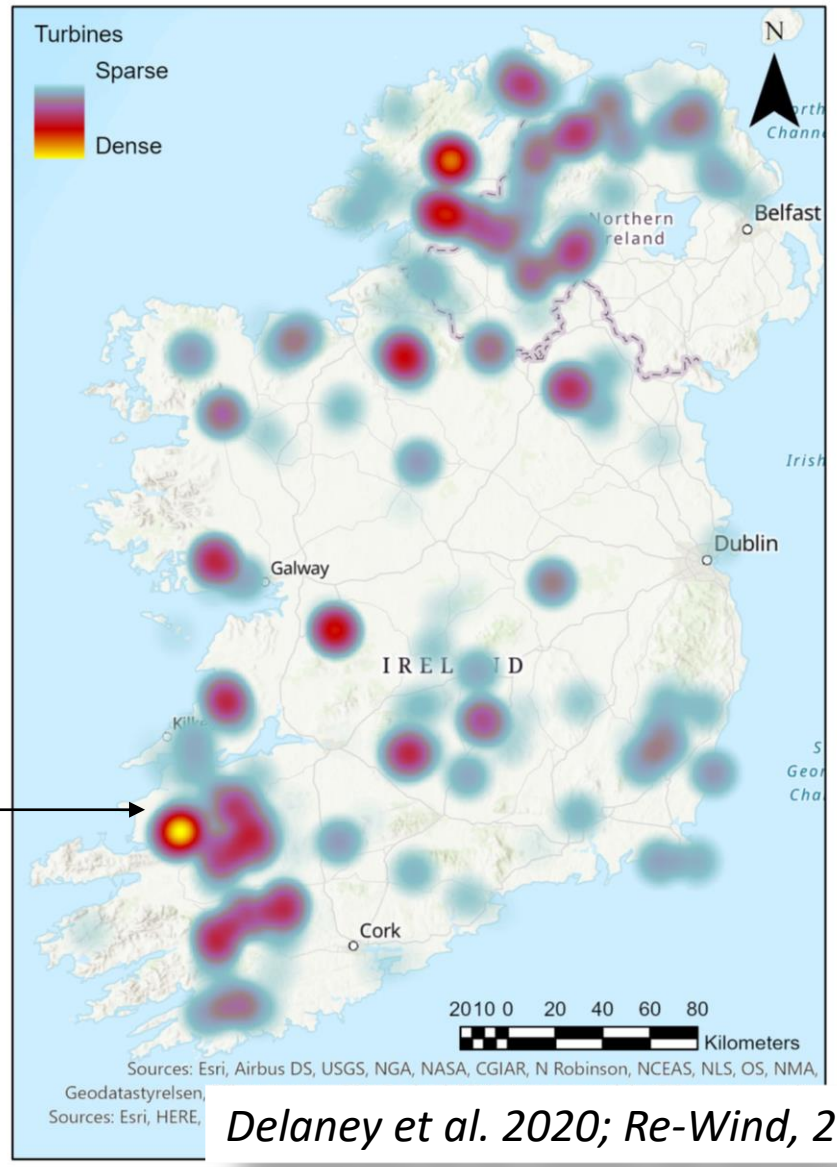
Step 3 Deriving data:

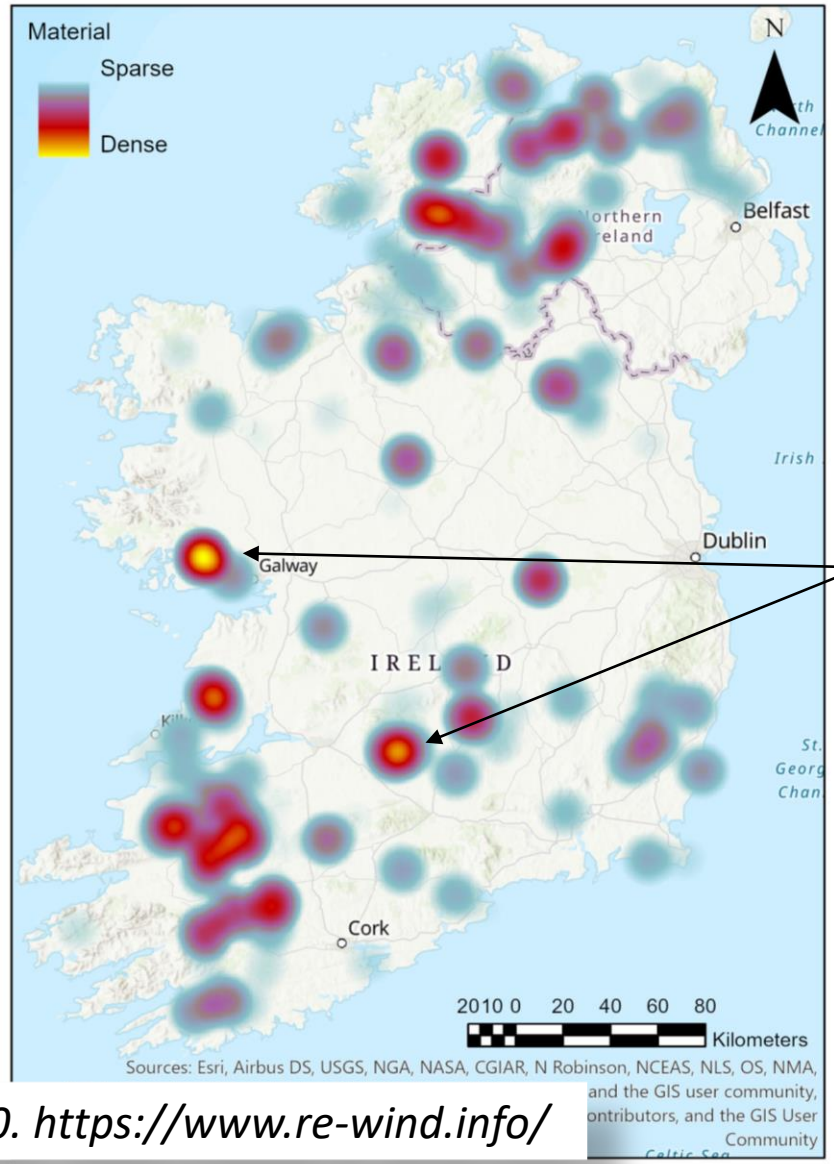
Identify data relevant the query or research question

QUEEN'S UNIVERSITY BELFAST

Delaney et al. 2020
www.re-wind.info/

Material Locations





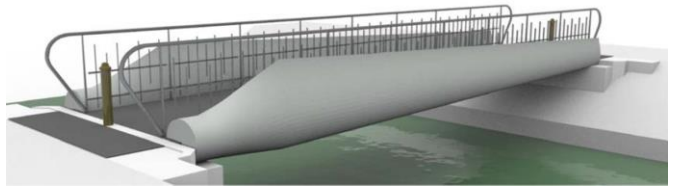
Highest density of turbines

Highest density of repurposing material

Delaney et al. 2020; Re-Wind, 2020. https://www.re-wind.info/

QUEEN'S UNIVERSITY BELFAST

Greenways



Demand for pedestrian bridges: Greenway scenario

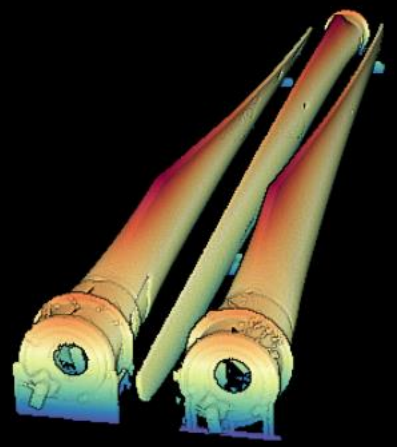
Re-Wind, 2020. https://www.re-wind.info/

QUEEN'S UNIVERSITY BELFAST

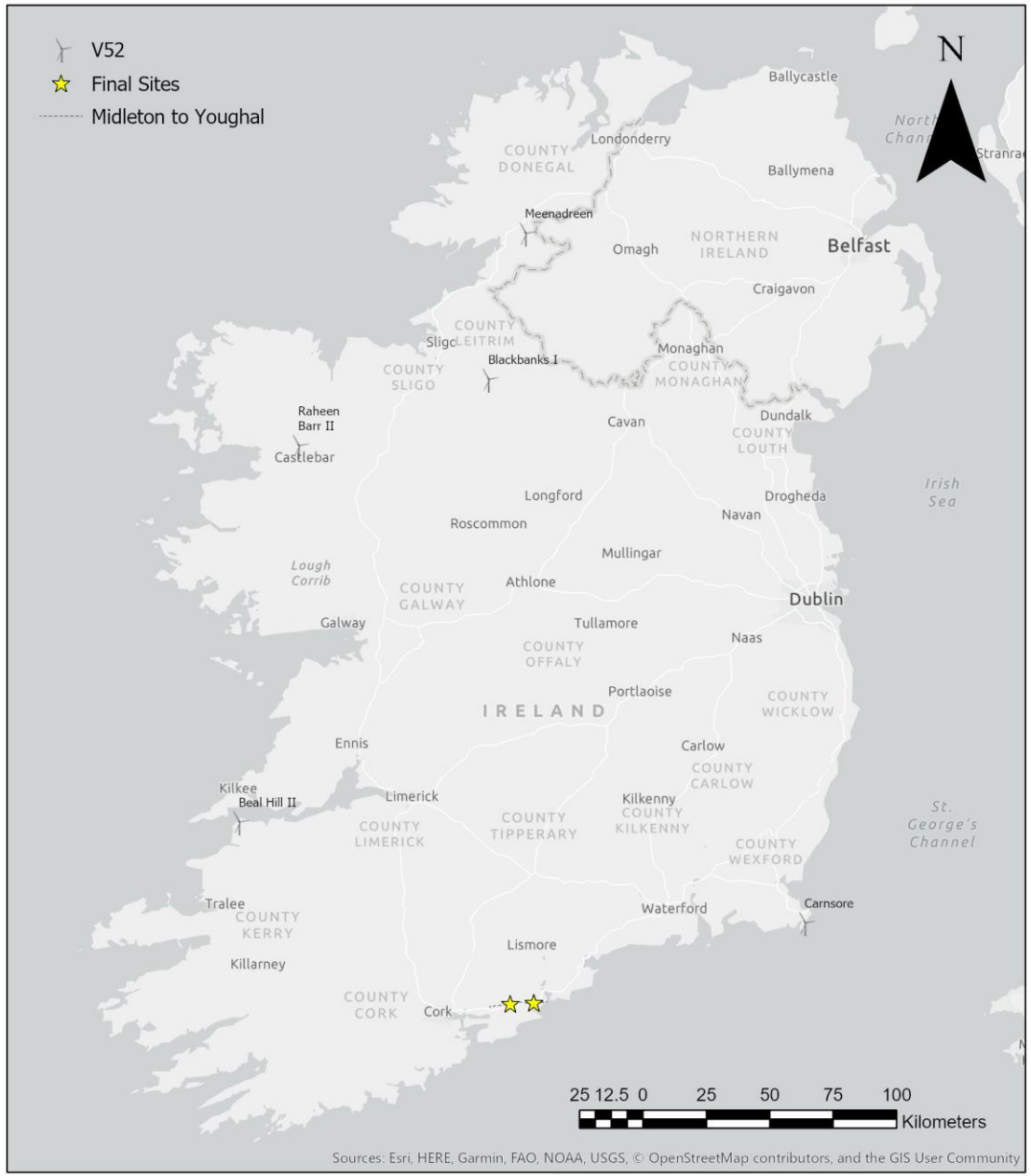
Georgia Tech | QUEEN'S UNIVERSITY BELFAST | CUNY THE CITY UNIVERSITY OF NEW YORK | UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

LiDAR scans of Vestas V52
(using Leica ScanStation P30/P40)

Scanner has a range accuracy of 1.2mm and xyz of 3mm up to 50m to target

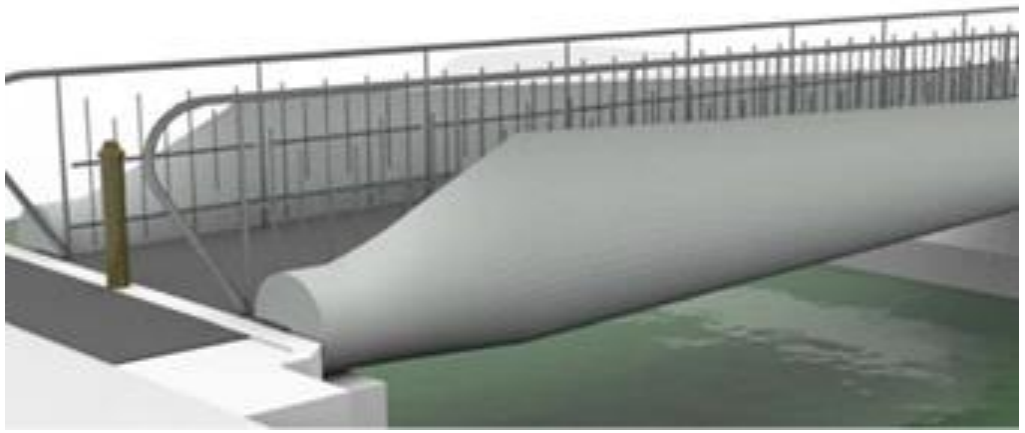


QUEEN'S UNIVERSITY BELFAST

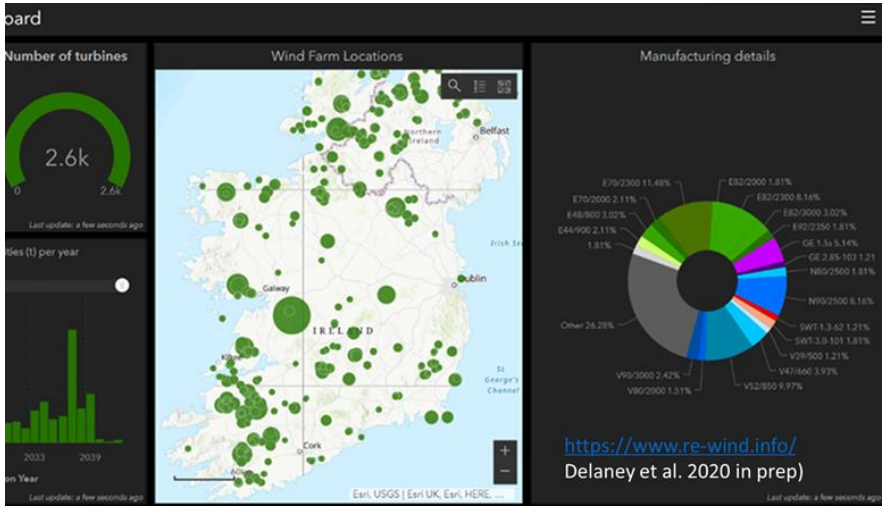


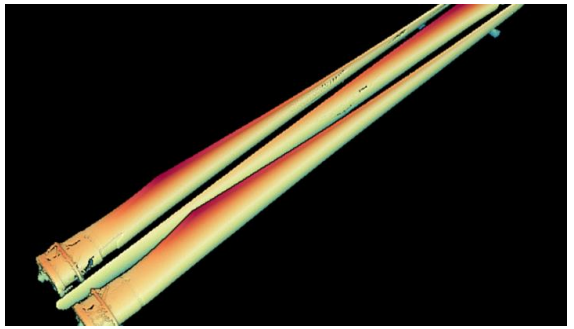
QUEEN'S UNIVERSITY BELFAST

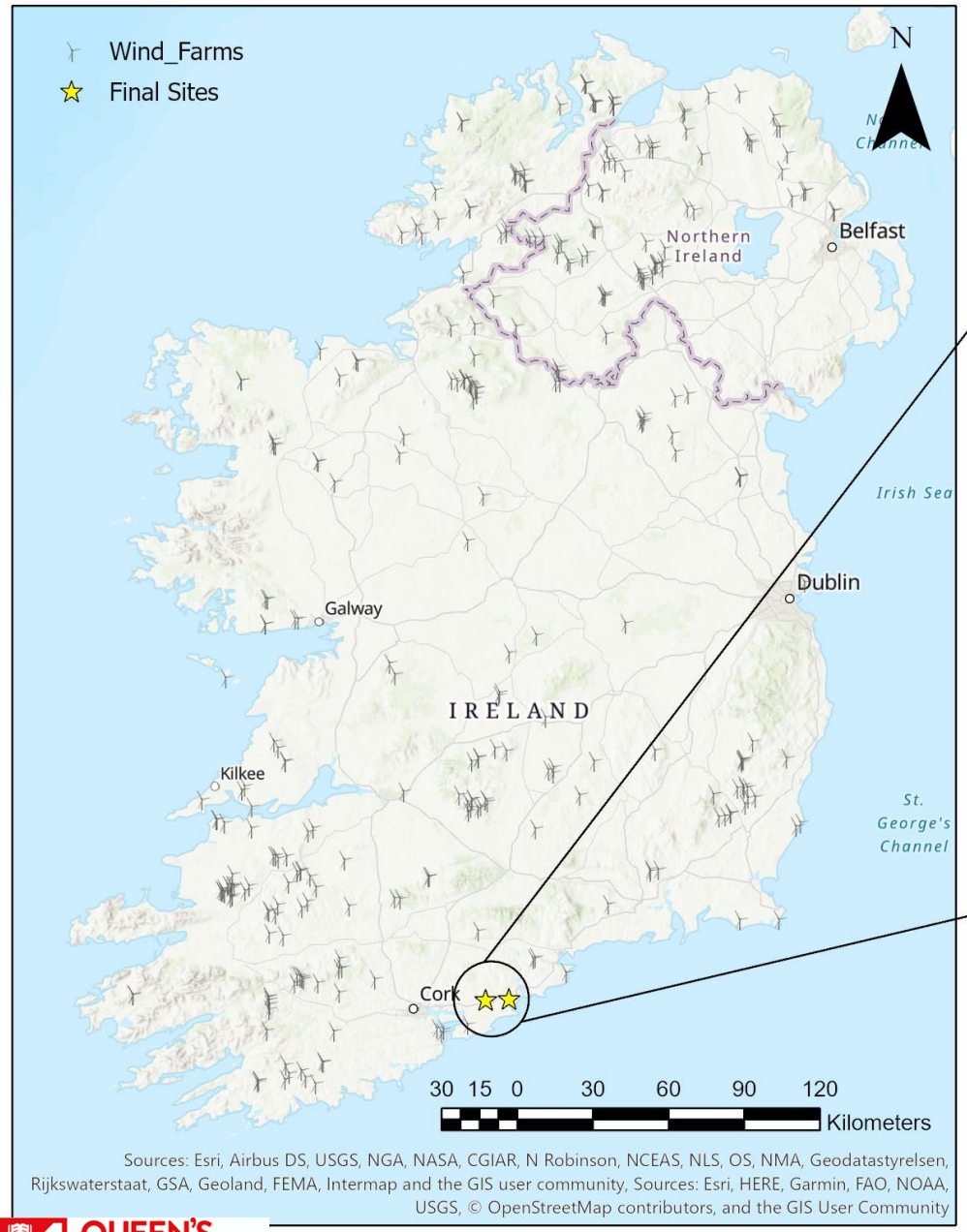
Delaney et al. 2020; Re-Wind, 2020. https://www.re-wind.info/

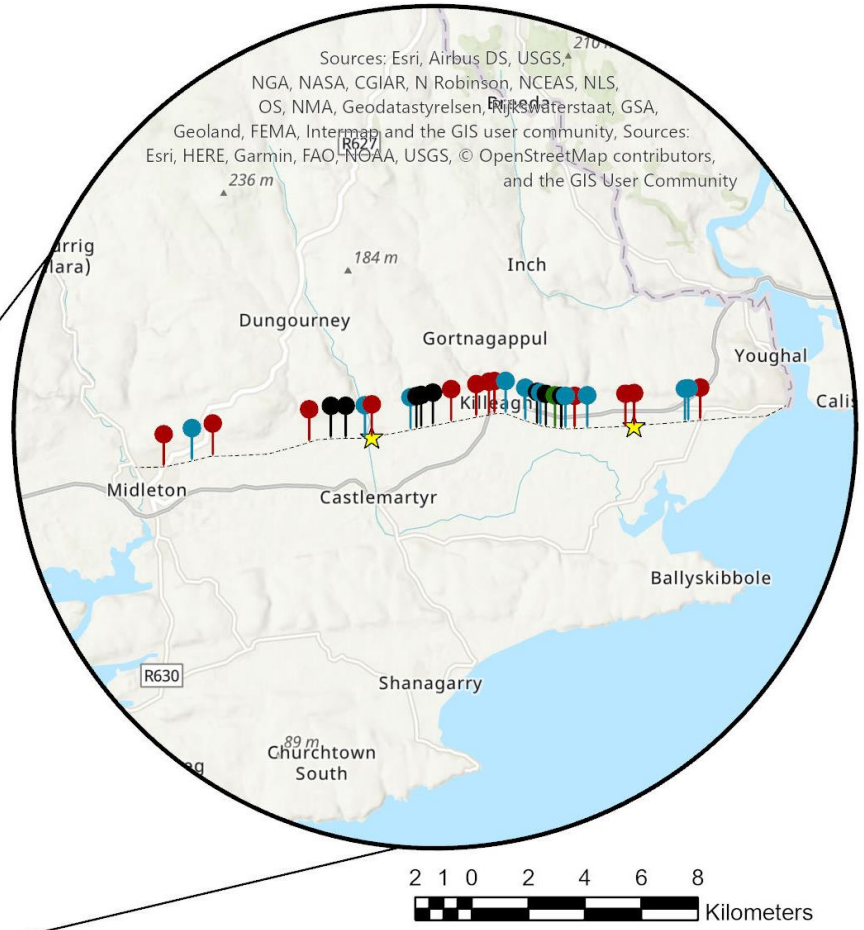


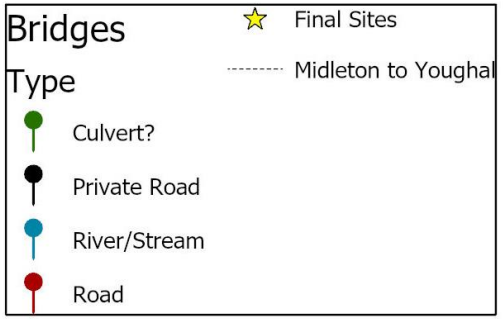

Belfast
Irish Sea
Dublin
Galway
IRELAND
Kilkee
St. George's Channel
Cork

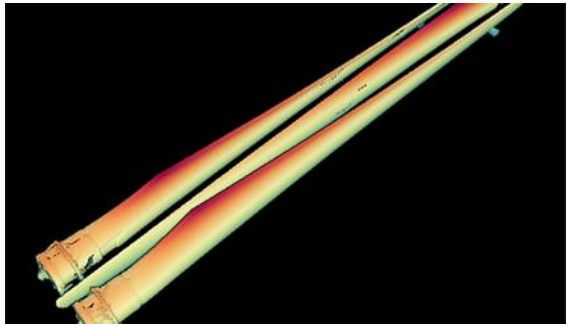

Number of turbines
2.6k
Wind Farm Locations
Manufacturing details
https://www.re-wind.info/
Delaney et al. 2020 in prep)

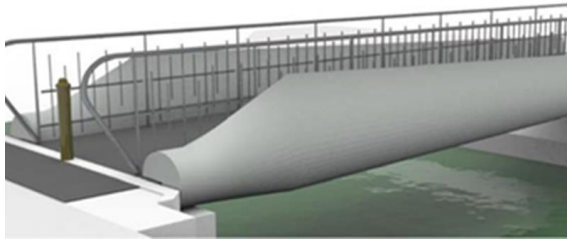












QUEEN'S UNIVERSITY BELFAST

Delaney et al. 2020; Re-Wind, 2020. https://www.re-wind.info/

Final thoughts

Re-Wind, 2020. https://www.re-wind.info/

- With the rapid development of wind energy technology in the past 15 years comes a new conundrum: how to dispose of the non-biodegradable blades in current wind turbines in a sustainable way.
- Reuse and recycling strategies must be found that will prevent environmentally and socially unpalatable and unsustainable landfilling and incineration of composite material wind blades.
- RE-WIND explores “the potential reuse of the blades across architecture and engineering. Developing such methods can have a positive effect on air quality and water quality by decreasing a major source of non-biodegradeable waste”— Lawrence C. Bank, Georgia Institute of Technology
- The GIS Thrust aims to show the benefits of a spatial database and GI Science for wind blade reuse and recycling, containing embedded reuse design options and their environmental, economic and social impacts for subsequent network analysis.

Background References for Re-Wind database

Re-Wind, 2020. Re-Wind: Driving Innovation in the Re-Use of Decommissioned Wind Turbine Blades [WWW Document]. URL https://www.re-wind.info/

RenewableUK, n.d. Wind Energy Projects [WWW Document]. RenewableUK. URL https://www.renewableuk.com/page/UKWEDSearch (accessed 8.20.20).

SEAI, 2020. Wind Mapping System [WWW Document]. Sustainable Energy Authority of Ireland. URL https://gis.seai.ie/wind/ (accessed 8.20.20).

TheWindPower, 2018. TheWindPower: Wind Energy Markey intelligence [WWW Document]. URL https://www.thewindpower.net/ (accessed 8.20.20).

Wood Mackenzie, 2019. Global wind power asset ownership report and database 2019 [WWW Document]. URL https://www.woodmac.com/reports/power-markets-global-wind-power-asset-ownership-report-and-database-2019-355658/ (accessed 8.20.20).

QUEEN'S UNIVERSITY BELFAST

Acknowledgements and References

This work is 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. Re-Wind: Driving Innovation in the Re-Use of Decommissioned Wind Turbine Blades [WWW Document]. URL https://www.re-wind.info/

Raj Suhail, Jian-Fei Chen, Russell Gentry, Benjamin Taristro-Hart, Yicong Xue and Lawrence C. Bank, "Analysis and Design of a Pedestrian Bridge with Decommissioned FRP Windblades and Concrete" proceedings of FRPRCS14, Belfast, UK, June 4-7, 2019, paper no. 176.

Bank, Lawrence, Arias, F., Yazdanbakhsh, A., Gentry, T., Al-Haddad, T., Chen, J.-F., Morrow, R., 2018. Concepts for Reusing Composite Materials from Decommissioned Wind Turbine Blades in Affordable Housing. Recycling 3, 3. https://doi.org/10.3390/recycling3010003

Delaney E., Bank L., Gentry R., Graham C., Leahy P., McKinley J.M., Megarry W. (in prep 2020) An Integrated GIS Approach for Repurposing of FRP Wind Blades.

Bank, L., Chen, J.-F., Gentry, R., Leahy, P., Nagle, A., Tasistro-Hart, B., Graham, C., Delaney, E., Gough, F., Arias, F., Mullally, G., Lemmertz, H., Mckinley, J., Nicholl, M., Dunphy, N., Suhail, R., Morrow, R., Al-Haddad, T., 2018. RE-Wind Design Atlas.

Nagle, A.J., Delaney, E.L., Bank, L.C., Leahy, P.G., 2020. A Comparative Life Cycle Assessment between landfilling and Co-Processing of waste from decommissioned Irish wind turbine blades. Journal of Cleaner Production 277, 123321. https://doi.org/10.1016/j.jclepro.2020.123321

QUEEN'S UNIVERSITY BELFAST

Thank you

Prof Jennifer McKinley j.mckinley@qub.ac.uk

Director: Environmental Change and Resilience

Director: Centre for GIS and Geomatics,

Geography, School of Natural and Built Environment,

Queen's University Belfast, UK

www.re-wind.info/