'When the turbines stop: strategies, opportunities and challenges for the management of end of life of wind infrastructure'
Summary Report, Workshop 10/09/2024
Frenchay Campus, UWE

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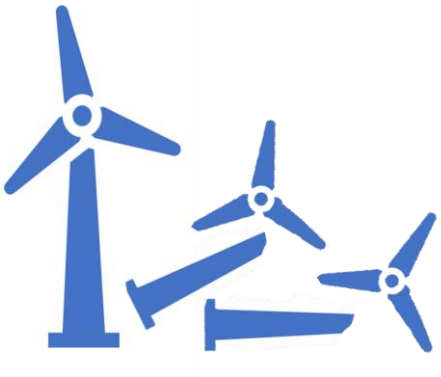
Date: September 2024



Acknowledgement:

This workshop was supported by a Vice Chancellor's Early Career Researcher (VC ECR) Development Award. The author would like to express their sincere gratitude to the University of the West of England for providing the funding for this research.

The workshop, and the insights discussed in this report, would have not been possible without the time offered and the expertise of the participants, I am extremely grateful for their time and support.

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Introduction

Ageing onshore wind infrastructures are an emerging environmental sustainability issue globally, with international significance in relation to the solutions for existing infrastructure in the UK and beyond.

In the UK, according to the Renewable Energy Planning Database, a total of 261 MW of onshore wind installed capacity (about 542 wind turbines) has been in operation pre-1998. A further 1149 MW has been in operation between 1999-2005 (about 923 turbines). While this capacity could be decommissioned by 2025, there are expectations that this will be roughly four times higher by 2032.

As wind farms reaching their end of technical, or consent life, increase, managing the end of life of onshore wind assets represents many cross-sectoral challenges. In addressing these, we require the sharing of best practices and active engagement from the main players from the wind industry and beyond. The workshop held on the 10th of September 2024 brought together a cross-disciplinary network of planners, academics, waste management organisations, wind developers and asset owners, SMEs and circular economy specialists. This report summaries the discussion that took place during the event.

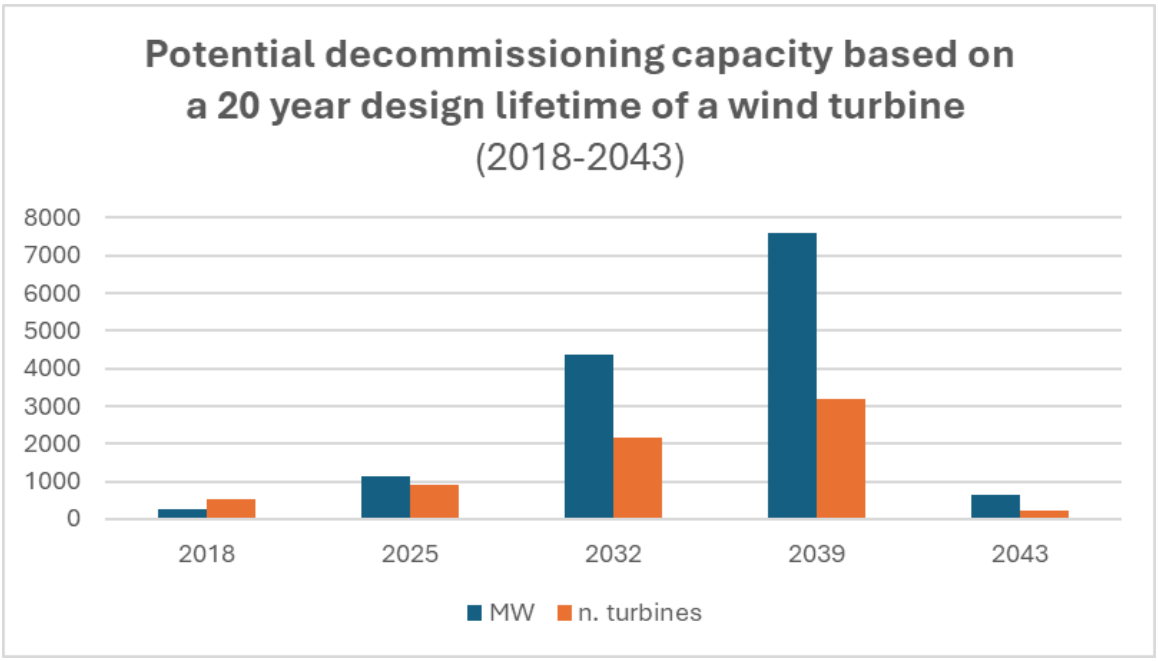


Fig. 1 Potential decommissioning capacity (REPD, 2024)

Workshop's aim and objectives

This workshop is part of a funded research project at the University of West of England which is designed to explore waste management opportunities and challenges from end of life of on-shore wind infrastructure in the UK. The aim of the workshop was to *engage explicitly with questions concerning the need to reconcile the demands of ageing infrastructure alongside environmental sustainability issues and, particularly, what to do with existing turbines*.

The event provided a platform to discuss and explore the emerging best practices and practical challenges associated with the management of end of life of wind turbines.

Fig. 2 Workshop participants

The workshop was set up specifically to investigate the extent to which the current knowledge and information on end of life of wind infrastructure is adequate to address the emerging waste challenge as wind turbines approach their end of life (Figure 3).

This event set out to address the following questions:

- What are the current and emerging best practices for the management of end of life of wind infrastructure?
- What are the emerging environmental issues associated with the end of life of wind turbines?
- What roles do government, and regulatory actors play in shaping and addressing the end-of-life challenges of wind turbines?
- What current and future technologies and opportunities are emerging to address the waste management challenges of end of life of wind turbines?
- What successful collaborative platforms can support the development of sustainable waste management practices for end of life of wind turbines?

Participants were also asked to contribute the questions they wanted addressed during the event. These are reported in figure 4.

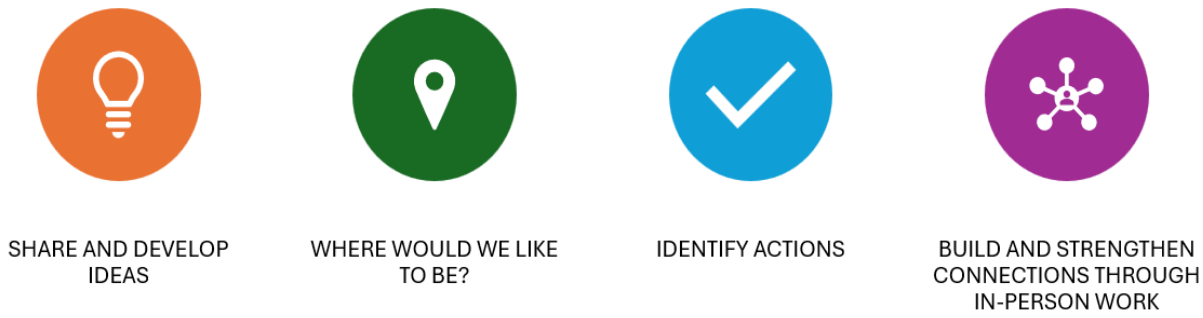


Fig. 3 Workshop's aim and objectives

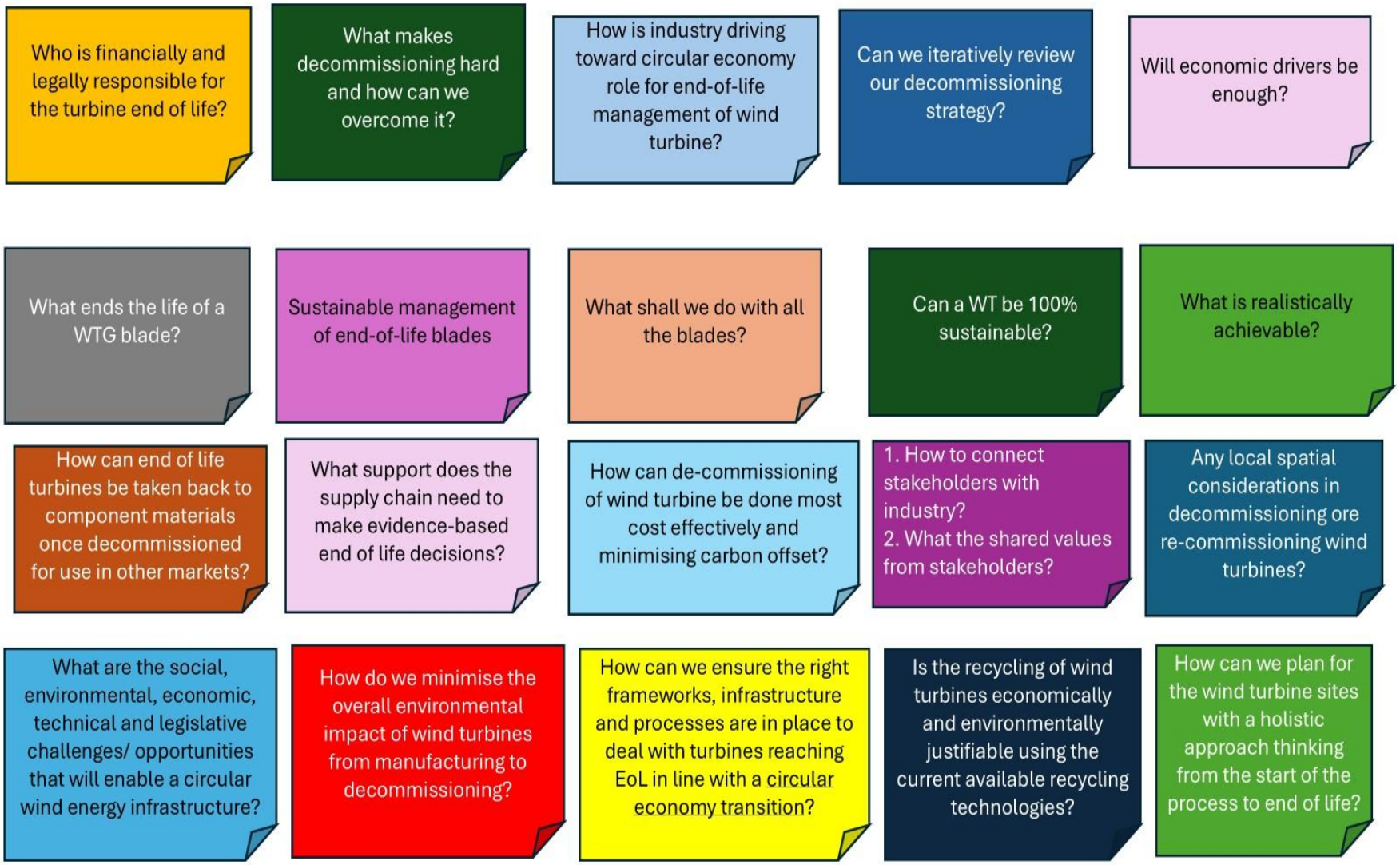


Fig.4 What is the big question you want to have answered?

When the turbines stop Workshop

The workshop was organised around three round tables, consisting of a number of connected tasks each:

- *Roundtable 1: Exploring the themes around the management of end of life of wind infrastructure challenge (s)*
  - Task 1 Write examples of challenges and cluster them into themes
  - Task 2 Everyone to walk around and look at what challenges have been identified and what themes are emerging
  - Task 3 Selection of most pressing challenges
- *Roundtable 2: What would a successful sustainable end of life and waste management for wind infrastructure would look like?*
  - Task 1 How might we address our 'selected' challenges- ideal, real and cynical exercise
  - Task 2 sharing examples of ideal solutions
- *Roundtable 3: What are the drivers/ actions/ barriers and actors that can support a successful sustainable end of life and waste management for wind infrastructure?*
  - Task 1 each group to work on a solution identified
  - Task 2 what are the drivers, barriers, actors and actions to take?

This report summarises the results of each roundtable in turn. The agenda and attendance list can be found in appendix.

Fig. 5 Workshop's activities

Roundtable 1: Exploring the themes around the management of end of life of wind infrastructure challenge (s)

As a way of setting the discussion, participants were asked to write down and cluster around themes the pressing challenges for end of life of wind infrastructure.

Each group answers have been collated in the table provided in the appendix. A number of challenges were identified and each group, via a nominated rapporteur, introduced and explained the relevance of these challenges for the management of end of life and waste management of wind infrastructure.

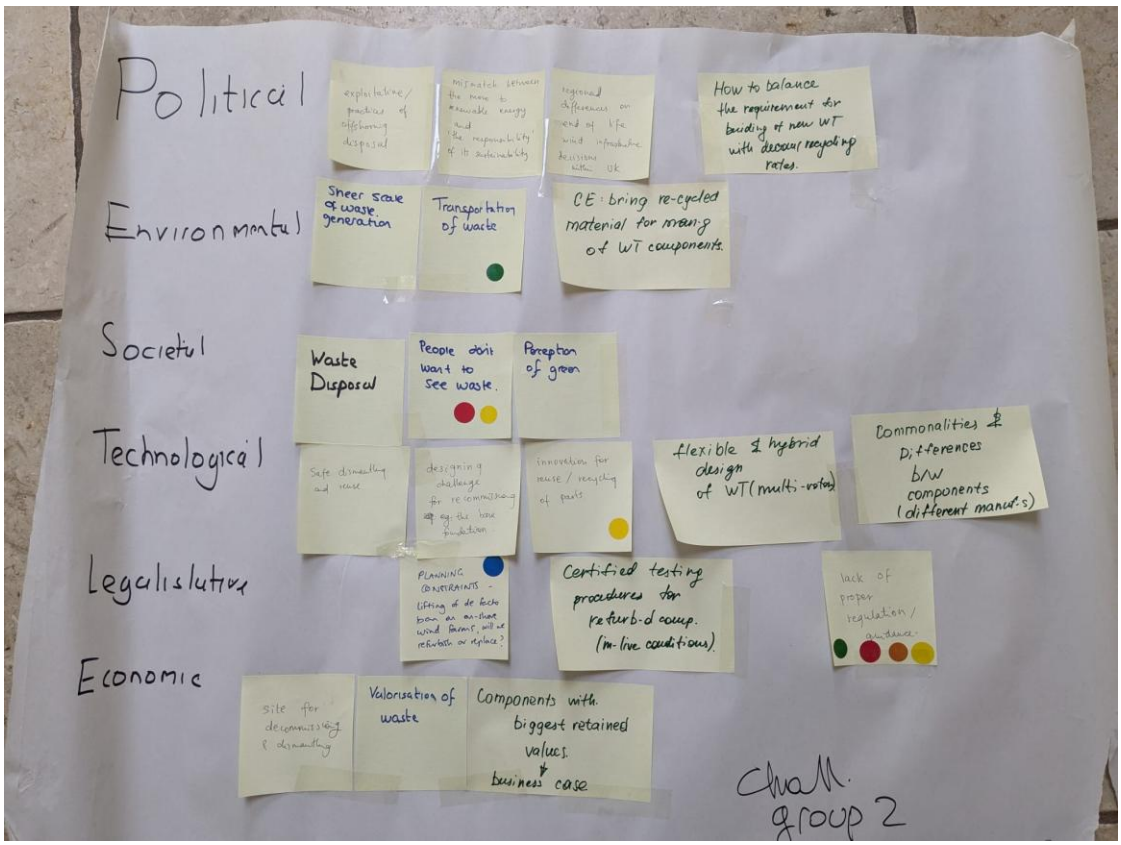


Fig. 6 Challenges identified by group 2

Examples of challenges and themes identified

Among the *political challenges* identified, participants suggested that the urgency of building new capacity often dominates the political narrative and there is less of an appreciation of how the decommissioning of wind assets might align with sustainability goals. There was agreement that more could be done, at the political level, to balance the requirement for building of new wind infrastructure with decommissioning/ recycling rates.

> ‘mismatch between the move to renewable energy and 'the responsibility' of its sustainability’

Environmental challenges identified refer primarily to the critical issues of the recycling and decommissioning of wind turbine components. Yet, there are some unintended consequences that might need to be taken into consideration: e.g. the energy intensity of current end of life solutions for fibre-glass, the different waste streams emerging from the recycling process and the challenges related to the transportation of waste.

> ‘potential environmental harm on 'recycling' everything (concrete bases; cables)’

And while landfilling turbine blades might represent a significant *social challenge* for the wind energy industry, there is a need to raise awareness of the lifecycle impacts of various solutions to better understand different waste management practices and promote informed decision-making. This pose the question of ‘what is it that we are trying to reduce/ mitigate?’

> ‘public education: what seems to be a green solution (waste to energy) could be worse than landfilling/ storing’

The *technical challenges* identified were multifaceted. Some challenges related to the dismantling and re-use of wind turbine components such as the complexity of waste material generated and the current and future innovation for recycling and material re-use. Others were associated with the techno-economic feasibility of decommissioning, including estimate of waste volume and the logistics associated with it and the net costs of decommissioning which requires accurate forecast for the associated financial implications, including bonds and asset depreciation.

'Complexity of waste & low value of material (e.g. glass is cheap new)'

'is there even enough waste to justify blade recycling?- international logistics'

'decommissioning will be net cost, have bonds etc been accurately forecasted? Asset depreciation'

Legislative and regulatory constraints will also have an impact on end of life and waste management practices. While current planning reform is underway to speed up implementation of wind energy, this raises the issue of how planning consent might influence decisions on the future of wind sites. This is relevant to shed light on how much waste will be generated in the future and the range of possible options for a handling system for end-of-life materials to enable a circular economy. Complexity of waste classification, the lack of waste codes and certifications for refurbished components show that current regulatory frameworks are inadequate to facilitate sustainable end of life solutions.

'Planning constraints- lifting the de-facto ban on on-shore wind farms will we refurbish or replace?'

'lack of regulations forcing waste generators/ owners to 'do the right thing''

It might not come as a surprise that the most comments were recorded around the *economic challenges* of end of life. These range from the lack of experience in decommissioning of sites, immature markets for reused and recycled components and lack of certainty for business case.

‘components with biggest retained values- business case’

‘amount of turbines that can be recycled currently’

‘lack of projects and lack of certainty for business case’

‘challenge to create a market for repurposed turbines for export’

‘supply chain not ready; significant volume coming (e.g. technicians, cranes etc.)’

‘required demand for the recycled material’

‘business case for recycling is tough- inherent low value of products’

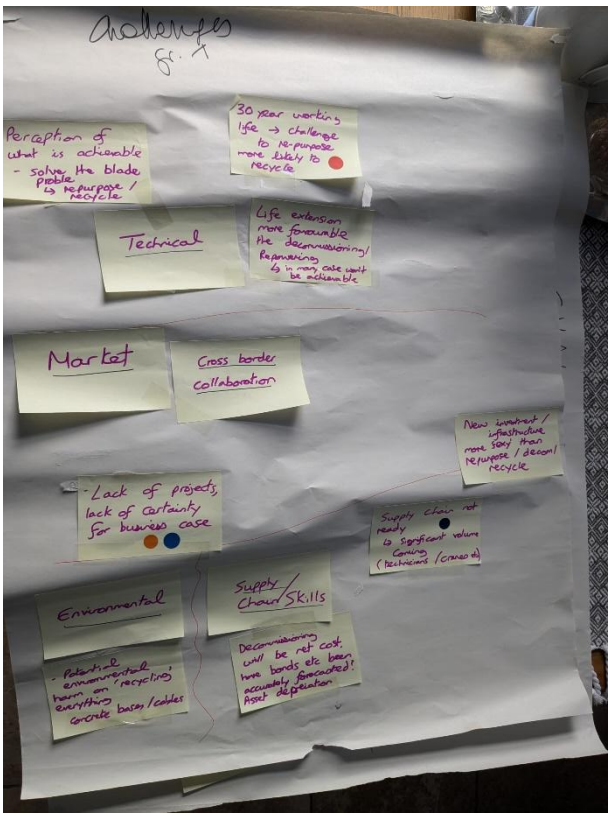


Fig. 7 Challenges identified by group 1

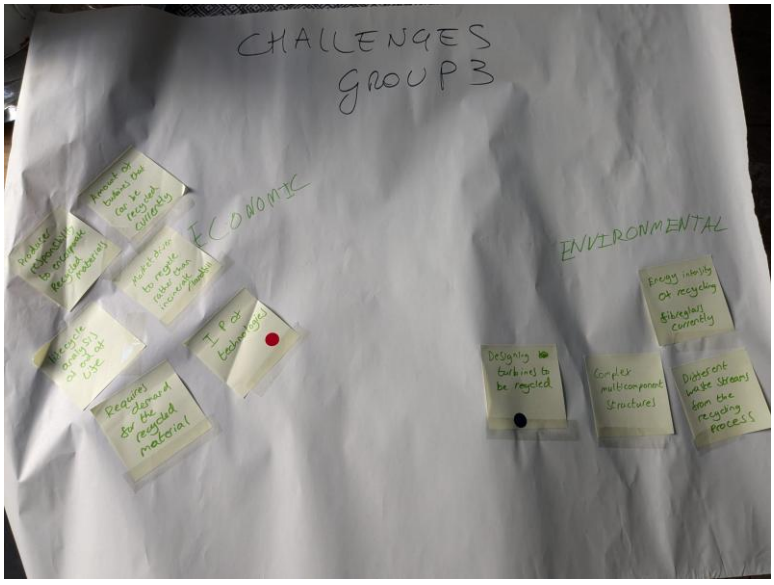
Participants were offered the opportunity to vote on the most pressing challenges to take forward to the next exercise. There were four that had more than 3 votes and three were taken forward.

What are the most pressing challenges? As voted by participants

Business case for recycling is tough- inherent low value of products?

Challenge to create a market for repurposed turbines for export

Historically decommissioning has been an 'after thought'



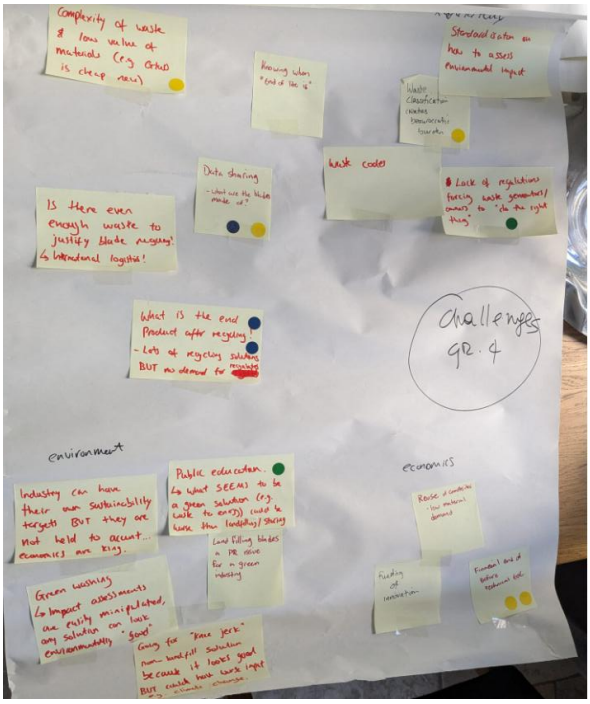


Fig. 8 Challenges identified by group 3 and 4

Roundtable 2: how might we address our challenge(s)

The selected most pressing challenges were used in this second roundtable. To structure the discussion, the ideal, real and cynical exercise was used. The purpose of this exercise was to generate as many ideas as possible to address the challenges selected.

The ideal, real and cynical exercise was selected as an example of *idea stretcher tool* to support participants in moving beyond safe ideas, helping participants to take the obvious and stretch it out.

Each selected challenge and some examples of ideas generated are discussed in what follows.

Ideal	***Real***	***Cynical***
If there were no barriers to implementing a solution to your challenge…	**But, of course, it's not really like this. There are lots of barriers that you have to 'work around'**	**And there are always people who want to look like they're solving the problem and keep doing business as usual**
What ideal solutions are possible?	So what real solutions are possible	What would cynical solutions to your challenge look like?

How might we …..
'Historically, decommissioning has been an 'after thought'

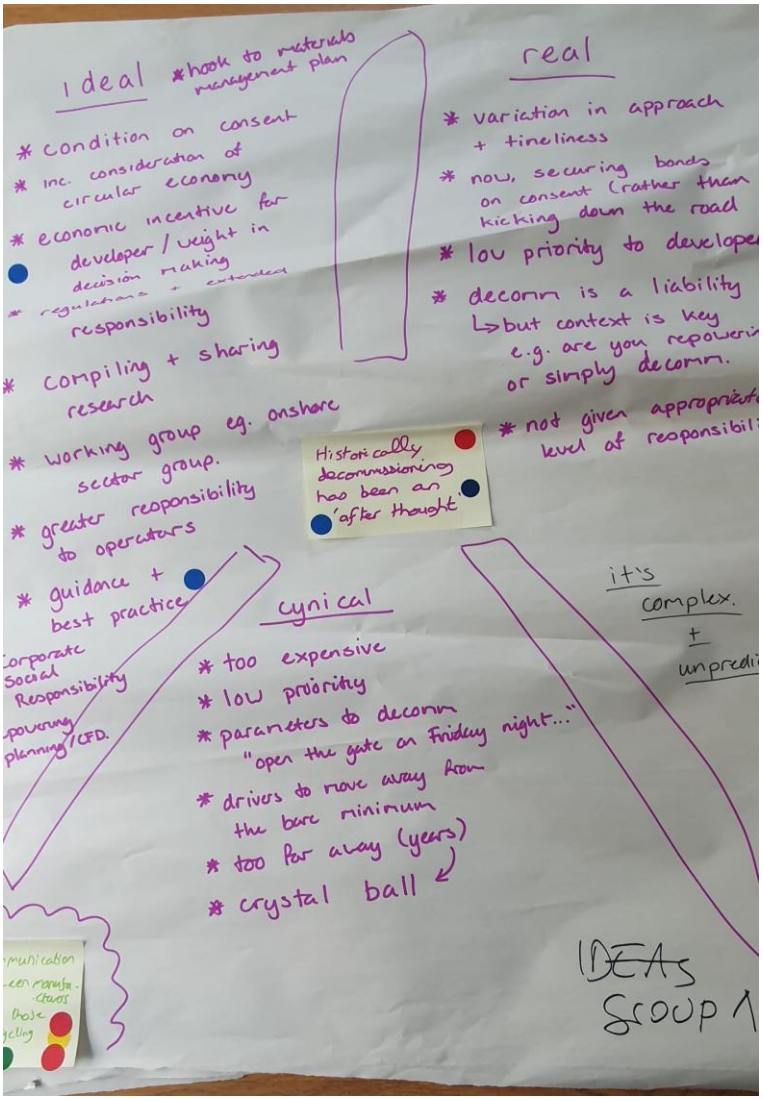


Fig. 9 Ideal, Real and Cynical: Group 1

In order to address the issue that decommissioning is often considered an afterthought, participants suggested a number of *ideal* ideas. Among these, participants proposed that decommissioning should be a condition on a planning consent decision. Securing bonds on consent is a proposed action that could be achieved now (a *real* idea). Yet, what might happen is that parameters to decommissioning could be left unregulated e.g. 'open the gate on Friday night' (a *cynical* idea).

How might we …..
'Business case for recycling is tough! Inherent low value products'

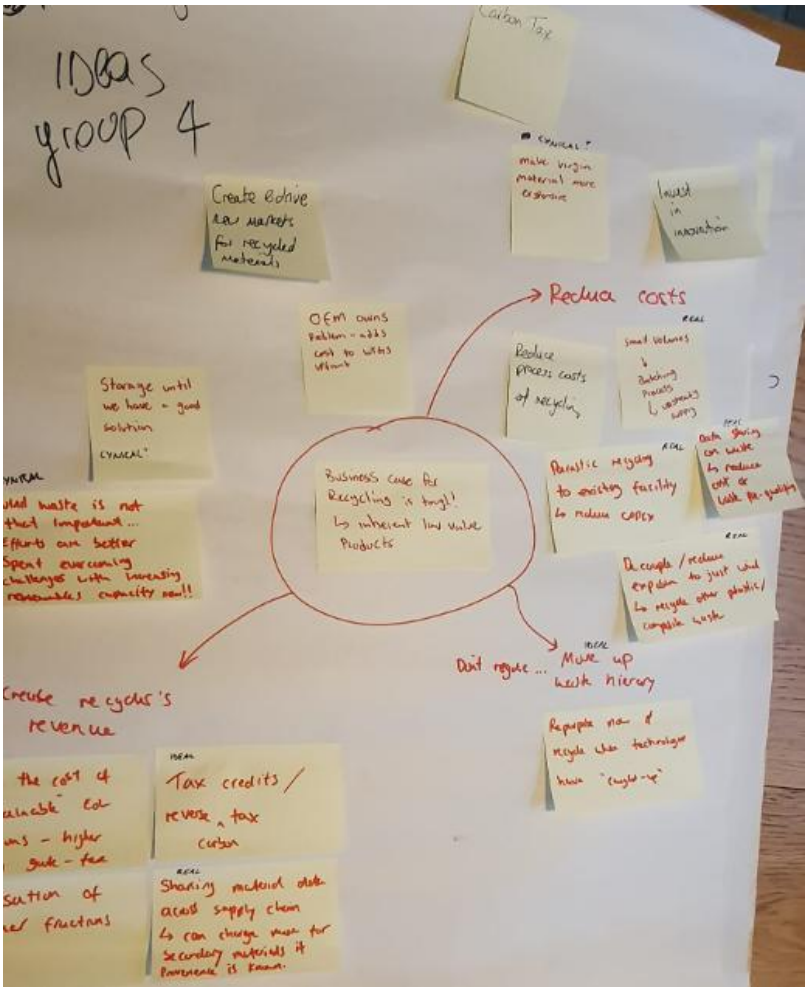


Fig. 10 Ideal, Real and Cynical: Group 4

Participants discussed the challenge of addressing the difficulties of identifying a business case for recycling. Among the *ideal* ideas identified, participants suggested to re-purpose now and recycle when technologies have 'caught up'. The use of tax credits/ reverse carbon tax were also discussed to create financial incentives for secondary material and re-furbished parts. *Real* ideas suggested included data sharing on waste and the reduction of the cost of pre-qualification of waste material. A *cynical* idea suggested OEMs take on more responsibility for recycling by adding to the cost of wind turbine generators upfront.

How might we …..
'Business case for recycling is tough! Inherent low value products'

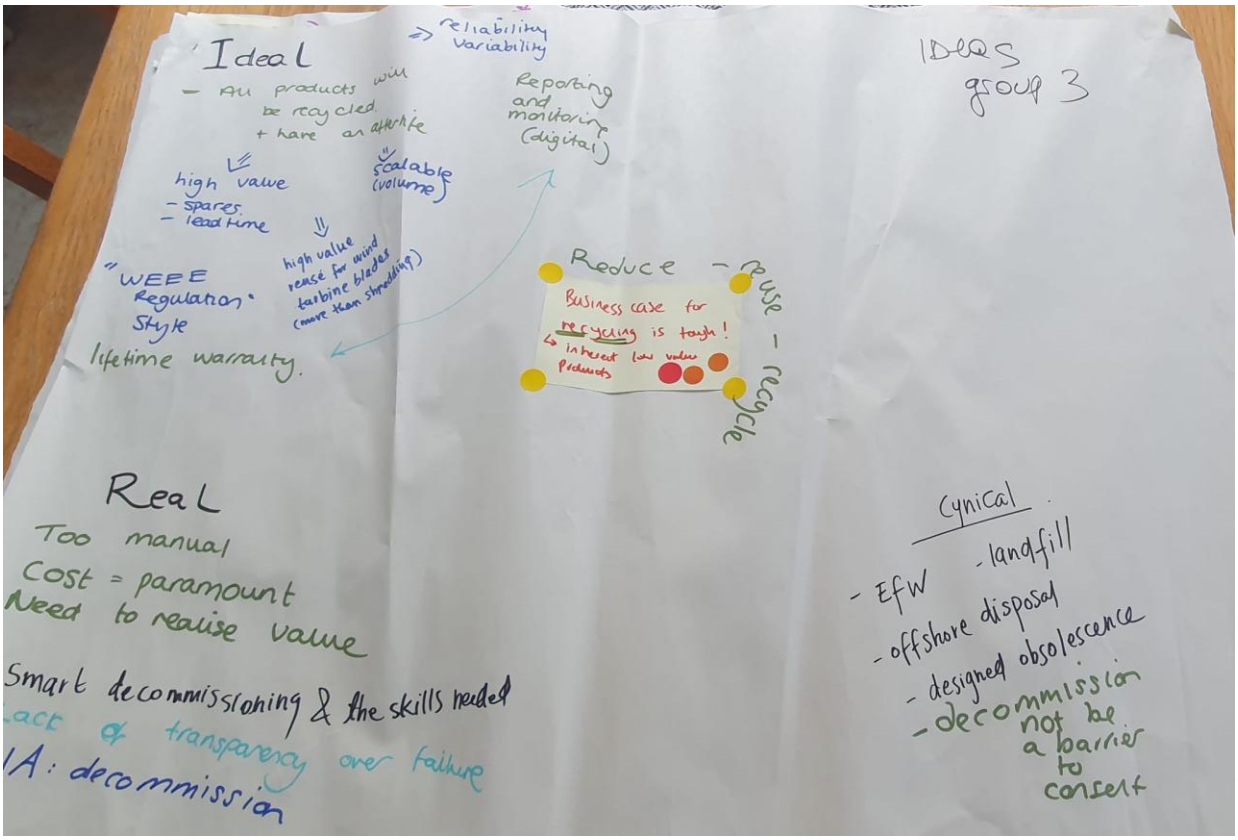


Fig. 11 Ideal, Real and Cynical: Group 3

Ideas generated from a different group on how to address the business case (or lack of) for recycling, suggested that high value reuse for wind turbine blades could be emphasised and the introduction of a digitalised reporting and monitoring system could aide reduce-reuse and recycle (*ideal* ideas). A *real* idea to facilitate the business case for recycling would be to include decommissioning as part of EIA reporting which take the reduce-reuse and recycle into account. *Cynical* ideas include both energy from waste and landfilling of components and materials.

How might we …..
'Challenge to create a market for re-purposed turbines for export'

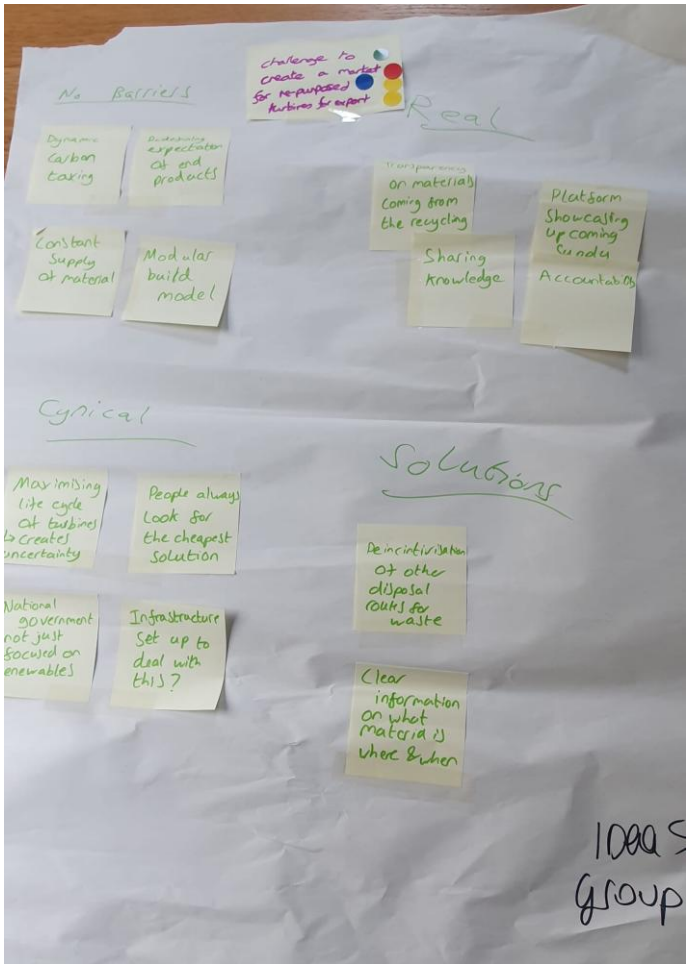


Fig. 12 Ideal, Real and Cynical: Group 2

The final group explored the challenge on how to create market for re-purposed turbines for export. An *ideal* idea suggested referred to the use of modular build model and modular design to facilitate among others the replacements of parts. A *real* idea would be to develop a digital platform to provide date and information on upcoming supply. *Cynical* ideas were based around the challenges that maximising life cycle of turbines might create uncertainty for the development of re-purposed turbine markets and there is a need to de-incentivise alternative disposal routes for waste to increase numbers and availability.

Roundtable 3: What are the drivers/ actions/ barriers and actors that can support a successful sustainable end of life and waste management for wind infrastructure?

Once identified some ideas to address the chosen challenges, participant were asked to work on an idea per group to identify drivers/ actions/ barriers and actors that could shape the future development of solutions to some of the challenges of end of life and waste management of wind infrastructure.

Each group was asked to report back with feedback from the table in order to address the following question: What can we do to make it happen?

The report presents these in turn.

Fig. 13 Roundtables' discussion

Actors, drivers, actions and barriers…..
'Economic incentives for developers and weight in decision making process'

The first idea taken forward related to the opportunity to explore economic incentives to shape developers' decision-making. Such incentives could take the form of i. CfDs incentives, enabling repowering and life-extension proposals to be eligible to apply for CfDs in future rounds; ii. policy support through simplification of planning requirements for repowering/life extension of sites and iii. the introduction of grid reforms that can also address specific grid bottlenecks and a preferential grid queuing system for repowered sites. Key actors to be involved include developers, determining bodies (e.g. local planning authorities) and the Department for Energy Security and Net Zero. Drivers for such change comprise agreed principles such as net-zero targets. The latter could also become a barrier, if the focus becomes to increase operational efficiency and asset yield ('sweating the assets'). The lack of a proof of concept and/or pathfinder projects can affect the learnings for future projects to inform the detailed design of the regulatory framework and its benefit.

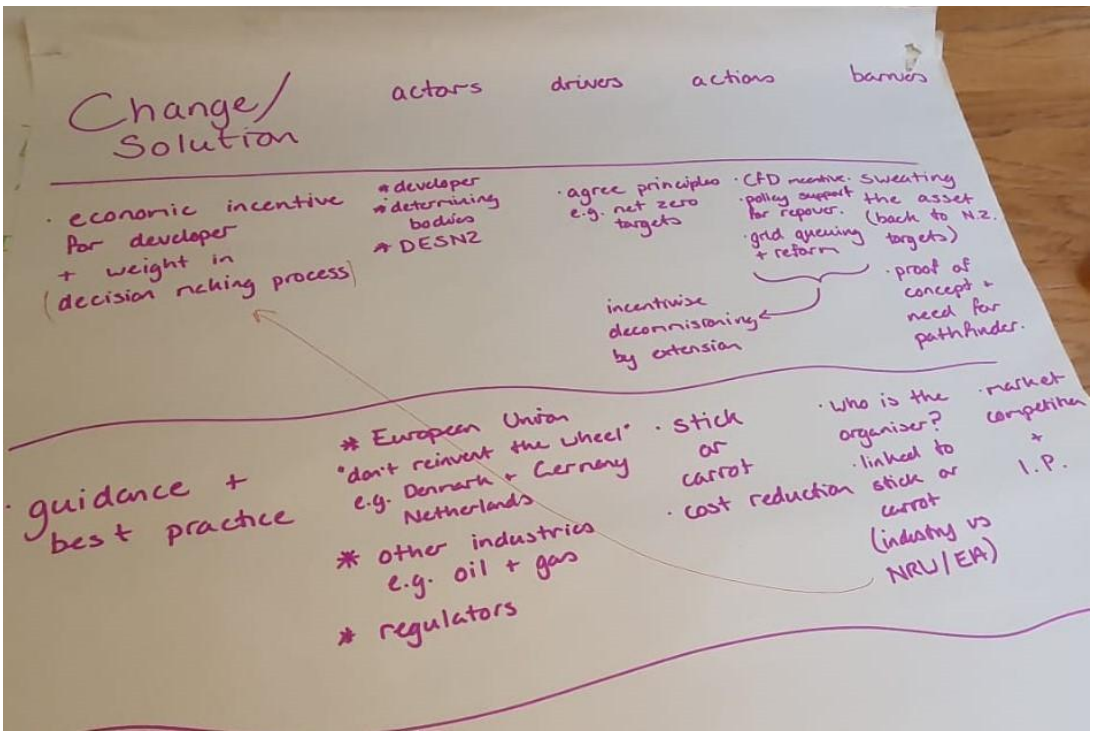


Fig. 14 Actors, Drivers, Actions and Barriers: Group 1*

* The image shows two suggested solutions; yet only the first one was covered in detail during the discussion.

Actors, drivers, actions and barriers…..
'WEEERegualtion style'

Group two explored the possibility of developing a WEEERegualtion style similar to the regulation introduced for electrical and electronic equipment aimed at reducing the amount of waste incinerated or landfilled. Such reduction can be achieved through various measures which encourage the recovery, reuse and recycling of wind turbine components. The group highlighted in detail the actors that need to be involved, ranging from operators and OEMs to recyclers and governments. Such change would be determined by a number of drivers. Among the suggested are the opportunity to provide clarity on volume of waste and its viability (e.g. composition and material) and the role of the demand side to encourage recovery, reuse and recycling of components. These could improve visibility of decommissioning of wind turbines and the identification of users. Specific barriers included the cost of compliance and the added responsibility for the actors involved. The group also highlighted the problems associated with the lack of material passport, accurate line maintenance records and the lack of confidence in second-hand use of parts.

Fig. 15 Actors, Drivers, Actions and Barriers: Group 2*

* The image shows two suggested solutions; yet only the first one was covered in detail during the discussion.

Actors, drivers, actions and barriers…..
'Implementation of a Digital Material Passport'

Material passports that could provide a digital record of materials and components of a wind turbine are seen as key to address some of the challenges of waste management of the end of life of wind infrastructure. Yet their implementation requires a concerted effort among national government, developers and assets owners, OEMs, players in wind farm decommissioning and recyclers, as suggested by group three. Among the barriers for implementation, the group identified data security, legacy materials, quality assurance and lack of legislation to ensure consistency.
Tax incentives as well as standardisation and regulation could drive the implementation of digital material passports, with suggestions to look at

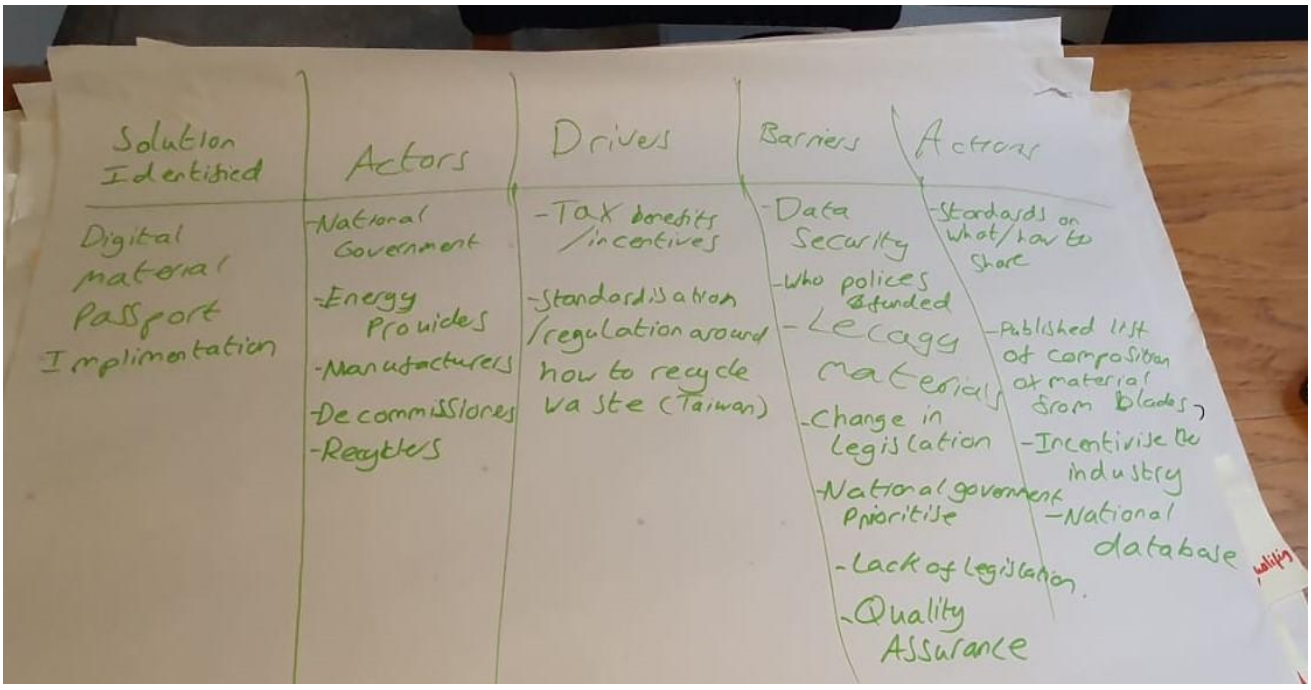


Fig. 16 Actors, Drivers, Actions and Barriers: Group 3

Actors, drivers, actions and barriers…..
'Mandated recycled content in wind (to encourage a circular economy)'

Fig. 17 Actors, Drivers, Actions and Barriers: Group 4

Conclusion and next steps

Once identified some ideas to address the chosen challenges, participant were asked to work on an idea per group to identify drivers/ actions/ barriers and actors that could shape the future development of solutions to some of the challenges of end of life and waste management of wind infrastructure.

Each group was asked to report back with feedback from the table in order to address the following question: What can we do to make it happen?

The report presents these in turn.

Appendix 1: List of Attendees

Carla De Laurentis	Senior Lecturer (organiser and facilitator)	University of the West of England
Benita Benny	Circular Economy Facilitator	SevernNet
Bob Carnell	Director	Distributed Generation Limited
Charlotte Stamper	Strategic Partnerships Manager	European Metal Recycling Ltd
Chris Jenkins	Head of Research & Innovation	Uplift360
Costa Athanatos	Business Account and Project Delivery Manager	WRAP
David Butler	MTC Professor in Sustainable Manufacturing	University of Birmingham
Evgenia Yakushina	Principal knowledge exchange fellow	National Manufacturing Institute Scotland & Coalition for Wind Industry Circularity
Harry Miller	UK director	Uplift360
Hui Li	Research Fellow	University of Leeds
Jack Pugsley	Associate Director	RTPI/ Savills
Jacob Hall	Local Energy Engagement Project Manager	Centre for Sustainable Energy (CSE)
Katy Karampour	Senior Lecturer in Urban Planning	UWE, Bristol
Keri Vaughan	Research Business Development Manager	Offshore Renewable Energy Catapult
Kevin Lind	CTO	Perceptual Robotics
Kyle Pender	Advanced Research Engineer	National Composite Centre
Laura White	Senior Development Manager	Ecotricity
Max Goodliffe	Circular Economy Senior Consultant	Resource Futures
Merav Shub	Research Officer	RTPI
Robert Kerr-Bonner	Senior Property Manager	RWE Renewables
Simon Morgan	Development Director	Trydan Gwyrdd Cymru
Swati Sood	PhD. Researcher	UWE

Appendix 2: Agenda

9:30	**Registration and coffee**
10.00	**Welcome and introductions** **event introduction and rules of engagement**
10.45	**Roundtable 1: Exploring the themes around the management of end of life of wind infrastructure challenge (s)**
11.30	**Comfort break**
11.45	**Roundtable 2: What would a successful sustainable end of life and waste management for wind infrastructure would look like?**
12.30	**Roundtable 3: What are the drivers/ actions/ barriers and actors that can support a successful sustainable end of life and waste management for wind infrastructure**
13.15	**Lunch**
13.45	**Closing and next steps**