



Report 2023

Task 45

Photo: DTU Wind and Energy Systems.

Recycling Wind Turbine Blades

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The issues related to recycling wind turbine blades are broad and range from technical challenges to legislative disparities, as well as lack of information on the materials to be recycled.

To address these issues, Task 45 brings together key stakeholders to identify barriers and mitigation strategies for the implementation of large-scale wind turbine blade recycling solutions. The participating industries include wind turbine blade manufacturers, wind farm owners and recycling industries. Universities and wind energy associations from

several countries are also involved. The objectives of the Task are to identify gaps and barriers, identify research needs and recommend best practices for the recycling of wind turbine blades.

In 2023, the IEA Wind Task 45 held several events online and in-person. One general meeting was held online

in June and one general assembly was held in-person in November at the National Composite Centre in the UK. These meetings were intended for all members involved and provided information about ongoing activities. These meetings also promoted networking in breakout rooms when meeting online and through workshops and discussions when meeting in-person.

In 2023, two deliverables were published in the IEA Wind Task 45: one reviewing the current state of blade design and novel materials research for improved recyclability of wind turbine blades. The second reviewed wind turbine blade end-of-life treatments.

Introduction

Research on wind turbine blade recycling has been ongoing for more than a decade. However, recycling solutions are still rare, and the few existing solutions are not implemented

to a large extent. As a result, recycling solutions for wind turbine blades are not available in many countries. The technical difficulty of recycling glass fibre reinforced thermoset composites, the low cost of landfill, and the assessment of waste volume are some of the challenges preventing the implementation of recycling solutions.

To tackle these challenges, the expertise of several disciplines and a unified approach across countries is needed. That is why Task 45 brings key stakeholders together to identify the barriers and provide mitigation strategies for the implementation of large-scale recycling solutions. The main objectives are to map the state-of-the-art in wind turbine blade recycling, identify data and policy gaps and research needs, and recommend best practices for the successful recycling of wind turbine blades.

The expected outcomes at high technology readiness level (TRL) are best practices to set up a solid recycling

value chain. Additionally, to create guidelines for end-of-life which consider cost, environmental and social impacts, including legislative recommendations. At low TRL, the expected outcomes include a description of the current state of wind turbine blade recycling, an identification and prioritisation of new recycling technologies, as well as the identification and prioritisation of research within new materials and blade structure design for improved recyclability.

Industry participation, universities and associations involved in the Task are presented in Table 1.

Progress and Achievements

The Work Packages in Task 45 are divided among the following three recurring themes, which challenge the ability to recycle wind turbine blades:

- WP 2: Technical aspects of recycling.

Table 1. Countries Participating in Task 45.

COUNTRY/SPONSOR	INSTITUTION(S)
Denmark	Aarhus University; DTU Wind & Energy Systems; Erhvervshus Nord; HJ Hansen; Port of Aalborg; Siemens Gamesa Renewable Energy; SDU; Vestas
United States	EPRI; Georgia Tech; NREL
United Kingdom	National Composite Centre (NCC); ORE Catapult; University of Leeds; University of Sheffield; University of Western England
Ireland	Munster Technological University; University College Cork (UCC); SEI; Wind Energy Ireland
Germany	Fraunhofer IWES; Fraunhofer ICT; DNV; DLR; NEOWA; TPI Composites; VDMA; Windnovation
The Netherlands	ECHT Community; IX Wind; TNO; TU Delft; Windesheim University
Sweden	Chalmers University; RWE; RISE research center; Vattenfall
The Netherlands	Windpoint; TU Delft; Whiffle; KNMI
Norway	NVE
France	EDF Renouvelable; Arkema; IRT Jules Vernes; Engie Laborelec
WindEurope	



Figure 1: Workshop at the National Composite Centre in Bristol, November 2023.

- WP 3: Analysis of the recycling value chain.
- WP 4: Standards and legislation framing the end-of-life of blades and recycling activities.

In WP 2, a report reviewing the current state of blade design and novel materials research for improved recyclability of wind turbine blades was published (Deliverable 2.1). This deliverable was coordinated by Fraunhofer IWES (DE) together with TU Delft (NL), RISE Sweden (SE), and TPI Composites (DE). The full document provides an overview of existing, upcoming and future materials used in the manufacturing of blades and is currently available for all members of the Task. A shorter version is available to the public on the [Task 45 website](#). Future publication on a similar topic includes Deliverable 2.3, which includes guidelines to design wind turbine blades for recycling and answers questions such as: what elements of design (material and structure) could ease the repurposing or recycling process. Fraunhofer IWES (DE) and TU Delft (NL) organised a workshop on this topic during the in-person general assembly meeting in November.

In 2023, WP 2 produced another publication known as Deliverable 2.2, which reviews wind turbine blade end-of-life treatments. Deliverable 2.2 was coordinated by the University College of Cork (IE) with the support of many other members, see Highlights. The deliverable reviews available recycling methods for existing blades as well as the applications for recycled materials. The categories used to describe the recycling methods are: technical considerations, environmental impacts, circularity potential, economic indicators, social acceptance, and impacts. The full version of this deliverable is currently available for Task members and a summary is available to the general public on the [Task 45 website](#).

The University College of Cork, UCC (IE) collaborated with the University of Leeds (UK) to organise a workshop dedicated to upscaling challenges of recycling solutions for wind turbine blades. The outcome of the workshop provided the basis for a future publication.

Finally, in 2023, the University of Leeds took over the coordination of WP 4 and is currently prepar-

ing guidelines for policymakers to promote recycling of wind turbine blades. These include options for legislative provisions and for development of tender requirements. The aim is to facilitate dialogue with stakeholders on (i) the option's appeal from a regulatory and commercial perspective; (ii) its strengths and weaknesses; and (iii) how the option could be revised to aid its commercial viability.

Highlight(s)

- In June and November 2023, Task 45 held general assembly meetings with over 30 participants including members of WindEurope, from nine different countries. In November, the general assembly was held in-person and involved workshops dedicated to Deliverable 2.3 (design for recycling) and Deliverable 3.1 (recycling value chains). Figure 1 provides an insight into the in-person meeting with participants taking part in a workshop.
- Deliverable 2.1 reviewed the current state of blade design and novel materials for improved re-

cyclability of wind turbine blades. It was coordinated by Fraunhofer IWES (DE) and prepared together with TU Delft (NL), RISE Sweden (SE), and TPI Composites (DE). It required the expertise of several disciplines, material scientists, recycling experts and blade designers to discuss the technologies reviewed.

- Deliverable 2.2, reviewing wind turbine blade end-of-life treatments, was coordinated by the University College of Cork (IE) and gathered a large group of members. The participating members included the Georgia Institute of Technology (USA), TNO (NL), DTU (DK), University of Leeds (UK), the National Composites Centre (UK), the Research Institute of Sweden (SE), Windesheim University of Applied Sciences (NL), Delft University of Technology (NL), Chalmers University (SE), and Munster Technological University (IE). This deliverable proposes

a new structured overview to compare end-of-life solutions, see Figure 2.

Outcomes and Significance

The goals of IEA Wind Task 45 are to review the state-of-the-art in wind turbine blade recycling, identify data gaps and research needs, and formulate policy recommendations. Currently, there are no international standards for decommissioning or recycling wind turbine blades, which is why Task 45 provides recommended and best practices for wind turbine blade recycling for the industry. Each deliverable in Task 45 contributes to the preparation of such recommended practices. The recommended practices should be relevant to public authorities interested in implementing recycling solutions for wind turbine blades on a regional or national level, as well as industrial stakeholders interested in developing a recycling business from wind turbine blades, and researchers developing

new blade designs, new composite materials, and new recycling processes. Based on the analysis of the recycling value chain and its related impacts (economic, environmental and social), the outcome of the Task should also provide the framework to support modifications or the development of new standards, preferably on an international level.

Next Steps

The Task 45 members are seeking to extend the work of the Task for another four-year period. In 2023, the participants of Task 45 initiated the preparation of a proposal for a follow up IEA Wind Task. Four workshops were held between September 2023 and April 2024. During these workshops a list of topics of interest was agreed upon, objectives were defined, and work packages coordinators were identified. The proposal for the extension was presented at the ExCo 92 meeting in Hannover, Germany, where it received initial

Material description	Full blades	Large blade sections	Small blade sections	Composite pieces	Shredded / coarse granulate	Grinded / fine granulate	Milled / Powder
Length scale	> 10m	> 2 m	0,5 to 2 m	10 to 50 cm	From 40 to 100 mm	< 40 mm	< 100 µm
Continued operation, Reuse	Green	Grey	Grey	Grey	Grey	Grey	Grey
Stockpiling	Green	Amber	Amber	Amber	Amber	Amber	Amber
Repurpose	Green	Green	Green	Amber	Grey	Grey	Grey
Material recovery (pyrolysis, etc)	Grey	Grey	Amber	Green	Green	Green	Amber
(Mechanical recycling application?)	Grey	Grey	Grey	Grey	Green	Green	Green
Co-processing	Grey	Grey	Grey	Grey	Grey	Green	Grey
Incineration / Energy recovery	Grey	Grey	Grey	Grey	Green	Amber	Amber
Landfill	Amber	Amber	Green	Green	Green	Amber	Amber

Figure 2: Table published in Deliverable 2.2 giving an overview of blade end-of-life treatments categorised by blade section size. Green cells indicate the optimal blade section size for each treatment with present-day technology. Amber cells indicate potentially possible but non-optimal sizes for each treatment.

approval. The final proposal was submitted and approved in May 2024 at the ExCo 94 meeting in Bari, Italy.

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<https://iea-wind.org/task45/>