Press Release

Presentation at IFAT, May 4–7, 2026, Messe München

Repairable Rotor Blades for Wind Turbines: Making Climate Protection Sustainable, Not an Environmental Burden

Wind turbines are typically designed for about 20 years of service, with a maximum of 30 years before replacement. Since the early 2000s, Europe has accumulated several tens of thousands of tons of composite wind turbine waste yearly. Decommissioned glass fiber – reinforced rotor blades are especially problematic: current disposal options like thermal recovery or minor reuse in cement are unsustainable, and EU regulations rightfully prohibit landfilling. Thus, end-of-life management is a key challenge for a circular economy in wind energy. For future wind turbines, Fraunhofer IWU, together with partners in the EU-funded RECREATE project, is demonstrating new approaches to material selection, joining technologies, and design. The goal is to enable wear-prone components to be replaced and to manufacture them from recyclable materials.

Current Rotor Blade Design and Manufacturing

Today's wind turbine rotor blades are almost exclusively produced using a two-shell construction. Two separate half-shells are manufactured first and later bonded together to form the closed blade structure. This design enables very large blade lengths of well over 80 meters and is well-suited to fiber-reinforced composite materials.

Manufacturing begins in very large, heated female molds, each representing one half-shell. Layers of glass fiber fabrics and, in some cases, carbon fiber fabrics are placed into the molds – mostly by hand. The core material of the sandwich structure is also positioned manually before additional fiber layers are applied. The dry fiber layup is then infiltrated with epoxy or polyester resin under vacuum, cured, and removed from the mold. After extensive post-processing, shear webs or spars are installed in one of the shells, the two half-shells are precisely aligned, and bonded together over large areas.

This process is highly labor-intensive, particularly during fiber placement, core positioning, and final finishing. Due to the extreme component size and complex geometry, full automation is still only possible to a limited extent. As a result, production is predominantly located in countries with low labor costs.

Detachable Adhesive Joints Enable Timely Replacement of Worn Components

A key factor influencing rotor blade service life is the leading edge. It is exposed to wind, dust, and rain, and is typically the first part to wear, depending on site conditions. If the leading edge cannot be replaced as a module, the entire rotor blade becomes unusable.

This is where Justus von Freeden from Fraunhofer IWU Wolfsburg and his partners come in. The research rotor blade has a modular design: all components are bonded around a continuous load-bearing spar, and the leading edge – made of thermoplastics reinforced with natural fibers – is replaceable thanks to a detachable adhesive joint.

Replacing the Leading Edge Restores New-Blade Efficiency

As leading-edge wear increases, aerodynamic performance deteriorates and efficiency declines. Timely replacement, therefore, makes it possible to maintain efficiency – and thus the economic performance of the turbine – over a long operating period.

Pultruded Continuous Spar: Enabling Automated Manufacturing

The design-for-manufacturing concept of the demonstrator presented at IFAT pursues an additional ambitious goal: enabling rotor blades – and thus key components of wind turbines – to be produced economically in Europe again through a high degree of automation.

A major contribution comes from a process that has been known for many years: pultrusion. In this process, continuous fibers are pulled through a resin bath, cured in a heated die, and formed into profiles. For example, the spar could be produced as a continuous profile and cut to the required length. For the leading edge, organo sheets – fiber-reinforced composite semi-finished products made of continuous fibers embedded in a thermoplastic matrix – could be heated and formed in a highly automated process.

Natural Fiber–Reinforced Thermoplastics Are Better Suited for R-Strategies than Glass Fiber Systems

Natural fiber–reinforced thermoplastics (NFRTPs) are better suited for R-strategies (Reuse, Repair, Refurbish, Remanufacture, Recycle) than glass fiber–reinforced thermoplastics because they behave more robustly over multiple use, repair, and recycling cycles and exhibit fewer critical damage mechanisms.

As a result, NFRTPs enable much better integration into design-for-circularity concepts and practical circular economy strategies – particularly for mechanical recycling. In this process, end-of-life components are shredded, remelted, and processed into new compounds or semi-finished products. Compared with glass fiber–reinforced thermoplastics, NFRTPs better tolerate the unavoidable fiber shortening involved, as natural fibers gradually lose their reinforcing effect rather than abruptly degrading from “reinforcement” to a purely detrimental contaminant.

In the EU project RECREATE, around 20 partners from research and industry, coordinated by Politecnico di Milano (Italy), are working on recycling technologies for circular fiber-reinforced composites. In addition to Fraunhofer IWU and Fraunhofer WKI, INVENT GmbH, RES-T, and RESCOLL Applus were involved in the design and manufacturing of the demonstrator for reusable composite structures of a wind turbine rotor blade.

RECREATE has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement No. 101058756.

Further RECREATE project partners include: Tampere University (Finland), ICAM Ouest (France), University of Patras (Greece), Fundación Gaiker (Spain), CNRS (France), INVENT GmbH (Germany), Iris Technology Solutions (Spain), Cobat Compositi (Italy), Rescoll (France), N. Benasedo S.p.A. (Italy), Carbon Cleanup GmbH (Austria), EDAG Engineering Group AG (Switzerland), HEAD Sport GmbH (Austria), Geven S.p.A. (Italy), APRA Europe (Belgium), AVK – Federation of Reinforced Plastics (Germany), Grifo Multimedia Srl (Italy), and Giacomelli Media Management (Slovenia).

Fig. 1 IFAT exhibit: Segment of a rotor blade, designed in the RECREATE project. It demonstrates options for a more circular design, including material selection and manufacturing processes. In particular, a replaceable and recyclable leading edge (shown in the trade fair exhibit) can contribute to longer service lives and consistently high efficiency of wind turbines. © Fraunhofer IWU

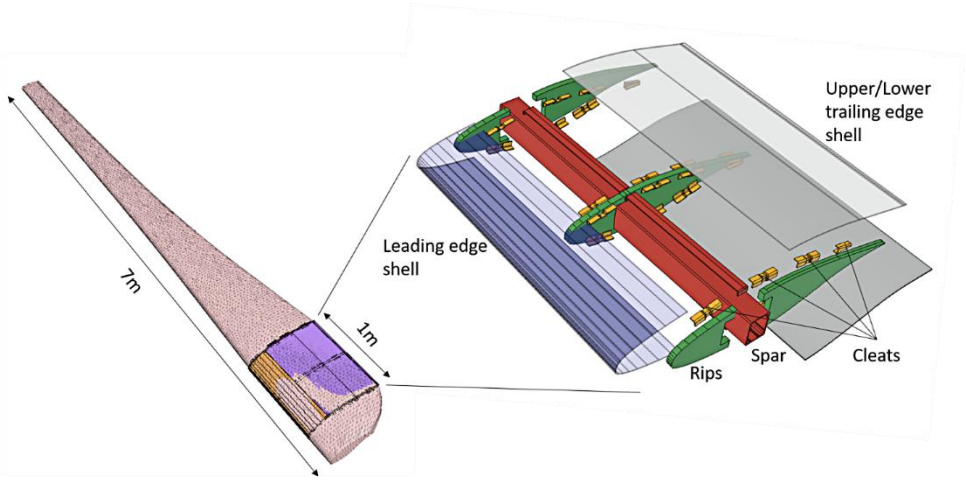

Fig. 2 Structure of the research rotor blade: pultruded spar; the ribs are made from material cut from a decommissioned rotor blade, illustrating the potential for partial reuse of end-of-life material. © RES-T

Fig. 3 A scenario to be avoided: partially shredded end-of-life rotor blades ending up in landfills. © Fraunhofer IWU (AI-generated)

The **Fraunhofer Institute for Machine Tools and Forming Technology IWU** is an innovation-driven partner for research and development in production engineering. Over 600 highly qualified employees work at our locations in Chemnitz, Cottbus, Dresden, Leipzig, Wolfsburg, and Zittau. We unlock potential for competitive manufacturing, across industries like automotive, aerospace, electrical engineering, and precision engineering. Our research and contract research encompass the entire manufacturing ecosystem, from individual components to processes, methods, complex machine systems and human interaction. As one of the leading institutes for resource-efficient manufacturing, we bank on highly flexible, scalable cognitive production systems using nature as an example. We take a holistic approach to the entire process chain, aligning with circular economy principles. We develop technologies and intelligent production plants and optimize forming, cutting, and joining manufacturing steps. Our services include innovative lightweight structures and technologies for processing new materials, functional transfer to assembly groups, and the latest technologies of additive manufacturing (3D printing). We provide solutions for climate-neutral factory operations and large-scale production of hydrogen systems, thus paving the way for the transition to renewable energies.

Contact

Andreas Hemmerle
Fraunhofer Institute for Machine Tools and Forming Technology IWU
Spokesperson
Phone +49 371 5397 1372
andreas.hemmerle@iwu.fraunhofer.de
www.iwu.fraunhofer.de