



Sustainable Energy Authority of Ireland

National Energy Research,
Development & Demonstration
Funding Programme

FINAL REPORT TEMPLATE

SECTION 1: PROJECT DETAILS – FOR PUBLICATION

Project Title	REBLADE: Re-blading of Irish wind turbines using novel technologies
Lead Grantee (Organisation)	ÉireComposites Teo
Lead Grantee (Name)	Dr Tomas Flanagan
Final Report Prepared By	Pamela Byrne
Report Submission Date	14/01/2025

	Name	Organisation
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Project Summary (max 500 words)

As the world moves towards a more sustainable way of life, Ireland must invest significantly in creating a carbon-free energy system. Currently, the largest source of renewable energy globally is from wind and Ireland has an installed capacity of wind energy of 4,137MW, where 17% of wind turbines will reach their end-of-life by 2030. If solutions to extend turbine life are not found, 700MW of capacity will be decommissioned. To this end, the REBLADE project aimed to develop advanced technologies to retrofit aging turbines through re-blading with new highly efficient and resilient blades. Hence, it will extend the working life of the turbines, while reducing their weight and increasing their efficiency and power production. To achieve this, the project designed, manufactured, and mechanically tested a new wind blade, which is suitable for installation in Irish

wind farms to extend the life of the turbine. The extensive research programme demonstrated the performance of the novel wind blade technology developed, which was performed by a collaboration between blade manufacturer, ÉireComposites, and design/testing facility, University of Galway. The overall environmental impact of re-blading is the displacement of up to 8,260 million tonnes of CO₂ by 2030 by extending the life of existing turbines, which aligns well with the aims of the Climate Action Plan 2019. During the REBLADE project, the novel solution was promoted to Irish and international wind energy developers and project findings were disseminated to key project stakeholders to maximise the impact of the technology developed.

Keywords (min 3 and max 10)

Re-blading; Low carbon emissions; Manufacturing; Advanced materials; Retrofitting; Wind blades; Wind energy.

NB – Both Section 1 and Section 2 of this Final Report will be made publicly available in a Final Technical Report uploaded online to the National Energy Research Database.

In the following Section, please provide a clear overview of your project, including details of the key findings, outcomes and recommendations. The section headings below are provided as a guide, please update or add to these as best suits your project.

By submitting this project report to SEAI, you confirm you are happy for Section 1 and Section 2 of this report to be made publicly available. If you wish to request edits to this section in advance of publication, please contact SEAI at EnergyResearch@seai.ie.

SECTION 2: FINAL TECHNICAL REPORT – FOR PUBLICATION

(max 10 pages)

2.1 Executive Summary

As the world moves towards a more sustainable way of life, Ireland must invest significantly in creating a carbon-free energy system. Currently, the largest source of renewable energy globally is from wind and Ireland has an installed capacity of wind energy of 4,137MW, where 17% of wind turbines will reach their end-of-life by 2030. If solutions to extend turbine life are not found, 700MW of capacity will be decommissioned.

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In future developments, a sample may be demonstrated with a relocated leading-edge bond line to protect it against accelerated bond line leading edge erosion.

2.2 Introduction to Project

The REBLADE project is a pioneering initiative aimed at addressing the challenge of aging wind turbines in Ireland, specifically focusing on the Vestas V27 model. With a significant portion of Ireland's wind turbine fleet approaching the end of its operational life, the project seeks to extend their lifespan by retrofitting them with newly designed, highly efficient, and resilient blades. This retrofit solution will not only improve turbine performance and reduce maintenance costs but also contribute to Ireland's renewable energy targets by preserving and enhancing existing wind energy capacity. The project combines advanced blade design, cutting-edge manufacturing techniques, and sustainable materials to offer a cost-effective and environmentally friendly solution, ensuring the continued growth of Ireland's wind energy sector and its alignment with national climate goals.

2.3 Project Objectives

The main aim of the REBLADE project is **to develop an innovative solution for efficiently retrofitting existing Irish wind farms** by producing highly efficient and resilient wind turbine blades for re-blading. In achieving this aim, the life of wind turbines at Irish wind farms can be extended in a cost-effective manner, while also boosting the power performance of the wind farms by installing newly designed, more efficient blades in place of outdated, less efficient blades. The REBLADE project focuses on proving this technologies and promoting its widespread adoption within the Island of Ireland and

internationally. The type of wind turbine being targeted in this project is the Vestas V27. In order to achieve the project's aims, a number of strategic objectives were established:

- **To design a highly efficient and resilient wind turbine blade**, suitable for re-blading Irish turbines, using the BladeComp software (developed by University of Galway)
- **To de-risk the design** through structural testing of full-scale wind turbine blades
- **To develop high volume production manufacture processes** for these new wind turbine blades
- To explore commercial opportunities and **new markets within Ireland and Europe** to expand EireComposites' customer base

These objectives have been expanded to work package specific objectives, with associated deliverables, and a summary of these are show in Table 2.1 below.

Table 2.1 – Summary of Project Objectives

No:	Objective Description:
1.	WP1-O1: To effectively manage and coordinate the project
2.	WP1-O2: To identify, manage and reduce risks throughout the project
3.	WP2-O1: To develop a new highly efficient wind turbine blade design
4.	WP2-O2: To perform validation of the new design using demonstrator tests
5.	WP3-O1: To manufacture a heated mould tooling for volume production of wind turbine blades
6.	WP3-O2: To produce a new highly efficient wind turbine blade
7.	WP4-O1: To de-risk the new wind turbine blade design through structural testing of a full-scale blade
8.	WP5-O1: To disseminate and communicate project findings and progress

2.4 Summary of Key Findings/Outcomes

Describe how your project has furthered the current state-of-the-art, current knowledge or current practice. Clearly highlight the degree of novelty and innovation demonstrated by your project. Address each innovation in a bullet point below. Add as many bullet points as you need:

The REBLADE project, running from February 2022 to January 2025, advanced wind blade technology by designing, manufacturing, and testing a highly efficient 13m blade. Key achievements included the release of the BladeComp software, as shown in Figure 1, The successful development of moulds and use of recyclable resin Elium in manufacturing the final 13m blade (Figure 2), and rigorous structural testing that confirmed the blade's durability and performance (WP4). The project achieved significant milestones, culminating in a final seminar and peer-reviewed publications. The project contributed valuable knowledge to wind blade design, manufacturing processes, and material innovation.

- Innovation 1: Manufacturing

A leading-edge reverse flange has been designed as a leading-edge erosion prevention method. The designs practical implementation was successfully demonstrated with novel manufacturing techniques in the creation of the full scale 13 m wind blade prototype, which has a reverse flange to improve bond line area and strength.

- Innovation 2: Blade optimisation & performance

The optimised wind blade developed using UG's proprietary software, BladeComp, achieved both weight reduction and an increase in performance. However, due to a manufacturing error, the actual wind blade prototype was heavier than expected. The results from structural testing completed showed that despite the blade being heavier than expected, the wind blade was significantly stronger, which shows significant room for improvement in blade mass and future optimisation.

The wind blade was manufactured with an innovative, recyclable resin, called Elium, which has similar properties to epoxy. This has significant environmental benefits such as avoiding land fill and enabling a more sustainable circular economy for end-of-life wind blades.

- Innovation 3: Reduced LCoE for retrofitted turbine.

The redesigned wind blades are expected to increase annual power production of the turbine by 4.22%, more than the original blades and will hence reduce LCoE. This was based on the redesign wind blade having less material as a result of the weight reduction achieved in the design phase. A weight reduction would also reduce wear and tear on turbine bearings and generator components; thus, helping to reduce maintenance costs and further reduce LCoE of retrofitted turbines.

- Innovation 4: Life extension of turbines

The new, highly efficient wind turbine blade underwent 500k fatigue cycles with negligible damage observed and also withstood 170% of the design load post-fatigue testing. This implies the blade was de-risked to survive in extreme working conditions, successfully demonstrating its suitability to replace end-of-life wind turbine blades and extend the life of existing turbines with improved performance.

The innovations described above have been demonstrated at full-scale in a relative environment and thus, has reached technology readiness level (TRL) 6.

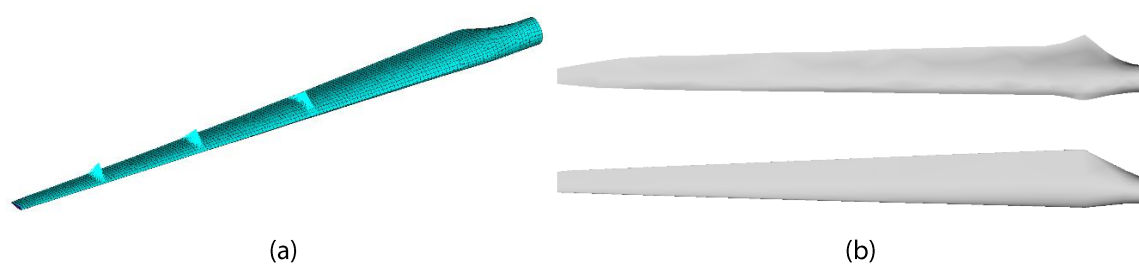


Figure 1: a) Finite element model and (b) comparison of newly designed blade above the original wind blade geometry.



Figure 2: Completed 13 m wind blade (left) with T-bolts installed (right)

2.5 Project Impact

Clearly position the impact of your project with reference to the needs of the Irish Energy Sector, national and international policy objectives, and SEAI's remit.

Discuss the key impacts of your project: societal, economic, technological or otherwise. Clearly identify and highlight the value of your project in the wider context.

The REBLADE project has proven the ability to extend the life of existing wind energy sites in Ireland. It has eliminated the need to alter the infrastructure by re-blading end-of-life wind turbines with new, highly efficient blades. As a result, the 17% of Irish wind turbines which are approaching the end-of-life have a means to be retained. Moreover, the electricity production of 700 MW previously generated by these turbines, could be exceeded. The project demonstrated this by retrofitting the turbines with higher performing wind blades, as shown by Blade 4 in the wind blade design optimisation graph in Figure 1, below. Wind farm operators will see an increase in revenue from their existing farms, while it is estimated that the revenue generated by companies providing blades for retrofitting is on average €150,000 per MW, or a total of €105 million. It is evident that REBLADE will have significant economic benefit, while having very little negative social or environmental impact, that yields a very efficient use of the existing infrastructure and a highly environmentally friendly approach to electricity generation.

The wind blades used in the project are made from sustainable, recyclable composite materials using Elium resin. This has enabled the recycling of end-of-life wind blades, reducing the need for environmentally damaging disposal methods such as landfilling or incineration. This sustainable approach contributes to the broader environmental goal of minimizing environmental harm while enhancing the overall performance of Ireland's wind energy sector.

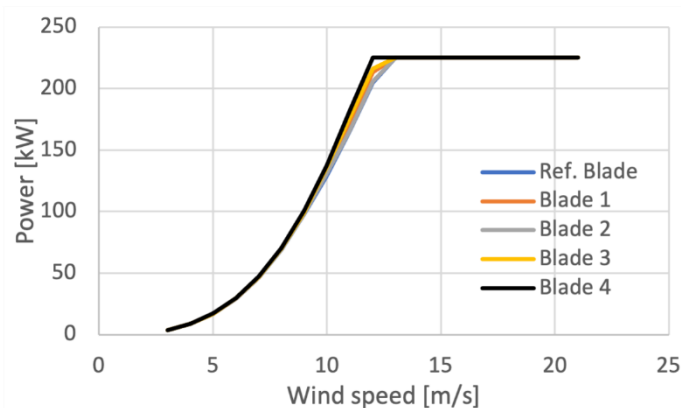


Figure 1: Wind blade design optimisation.

2.6 Recommendations

Please highlight any implications/opportunities/recommendations for Ireland (e.g., for policy makers, for the research community, for industry) based on the work carried out in the project.

The findings of this research highlight the potential for significant improvements in the performance and sustainability of wind turbines, specifically for the V27-225 kW model. The new rotor blade designed by BladeComp Software achieved a 4.22% increase in annual power production and a 12% reduction in material usage, while improving blade stiffness by 15%. These results suggest that the methodology and software developed applied in this project could be used to retrofit existing wind turbines, enhancing their efficiency and reducing operational costs.

For Ireland, this offers several implications and opportunities. Policymakers could support the adoption of such innovative retrofitting technologies as part of the country's ongoing efforts to meet renewable

energy targets, contributing to a more sustainable energy mix. The research community can build upon these findings to explore further optimization techniques and validation studies for different turbine models using BladeComp, advancing the state of knowledge in wind energy technology. Additionally, industry stakeholders—particularly those involved in wind turbine manufacturing and operation—could leverage these developments to improve the performance of existing wind farms, reducing the need for costly new infrastructure while extending the life of current assets. This could lead to enhanced economic returns for operators and manufacturers, with broader benefits for Ireland’s energy security and sustainability goals.

Moreover, the use of Elium resin in the new blade design presents an opportunity for further environmental and economic benefits. Elium resin enables the blades to be recyclable at the end of their life, addressing a significant issue in wind energy sustainability. Policymakers and industry leaders could consider incentivizing the use of recyclable materials in wind turbine components to promote a circular economy, reducing waste and supporting Ireland's environmental goals.

2.7 Conclusions and Next Steps

The REBLADE project has successfully demonstrated the potential of retrofitting aging wind turbines with highly efficient and resilient blades, providing a cost-effective solution to extend the life of Ireland’s wind energy infrastructure. The innovative design and manufacturing processes, coupled with the use of recyclable materials like Elium resin, not only improve turbine performance and reduce environmental impact but also contribute to Ireland’s broader sustainability goals. Overall, REBLADE’s successful outcomes highlight its ability to make a substantial contribution to both Ireland’s clean energy future and its growing green economy.

Building on the success of the REBLADE project, the next steps involve:

- **Follow-on Project:** Obtain SEAI funding for a follow-on project to further validate the design and manufacturing of the highly efficient, recyclable wind turbine blade prototype and bring it to market.
- **Refine Manufacturing Processes:** Optimize production methods to support accurate, high-volume manufacturing of the new, efficient wind turbine blades.
- **Design Improvements:** Develop a demonstrator sample with a relocated leading-edge bond line to protect it against accelerated bond line leading edge erosion.
- **Scale-up Implementation:** Expand the deployment of the newly developed blade technology to broader range of wind turbines in Ireland and internationally.
- **Further Testing and Validation:** Conduct additional performance and durability testing under various real-world conditions to ensure the reliability and effectiveness of the retrofit solution.
- **Expand Commercial Opportunities:** Collaborate with industry partners to roll out retrofitting solutions and explore new market opportunities globally.