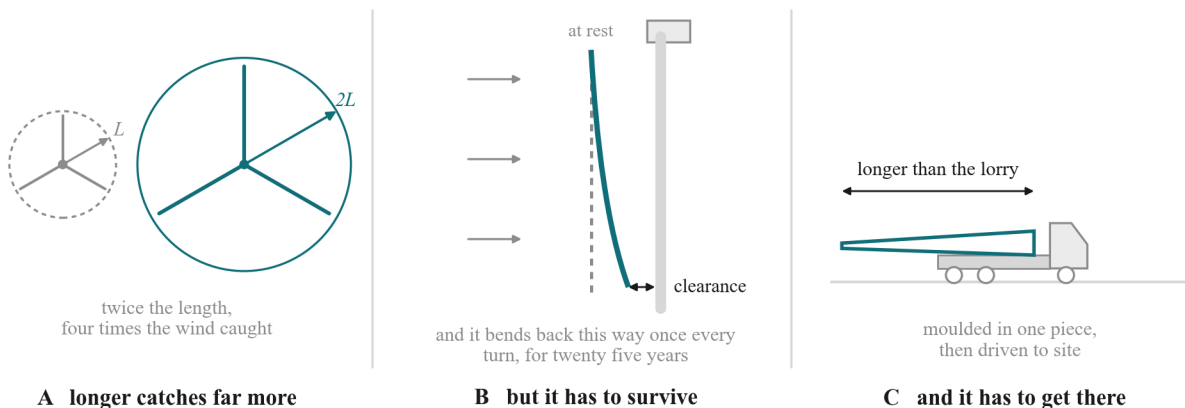


Wind Turbine Blade Design Competition

Intuitive Understanding

A turbine blade is a wing and a beam at the same time. Make it twice as long and it sweeps four times the area, so it catches roughly four times the wind. The same blade then has to bend without striking the tower, survive that bend once every revolution for twenty five years, be moulded in one piece, and still fit on a lorry. The design is the argument between those two pressures.



Every gain in length has to be paid for in structure, manufacture and transport.

Project Scope

Blade design sets the ceiling on what a wind turbine can deliver. Rotors have now grown to the point where the binding constraints are as much structural and logistical as aerodynamic – a blade that captures more energy but cannot be moulded, moved along a road, or survive twenty-five years of fatigue loading is not a blade that ever gets built.

The aim is to Design a Wind Turbine Blade and Take it from Aerodynamic Concept Through to Physical Test – covering aerofoil and planform selection, CFD, structural layup, loads and fatigue, manufacture, and validation against experimental data. This is the combination of two tasks that should be completed by sub-teams working closely together.

The following sections will break down the requirements and expectations of each task. However, it is important to remember that although these are outlined as separate tasks, they

have significant reliance on information from each other – the structural and test work in Subtask 2 can only be carried out against the geometry and load cases that Subtask 1 produces, and should feed back into how that geometry is then refined.

Subtask 1 – Aerodynamic Design and Computational Fluid Dynamics

1.1.1 This task is to develop the aerodynamic design of a blade against a stated turbine specification – rated power, rotor diameter, hub height, and a named wind resource. Teams should fix these early and justify them, and are encouraged to use the measured wind distribution of a real site rather than a generic Weibull fit.

1.1.2 Teams must select the aerofoil family and its radial distribution, and define the planform: chord, twist, and thickness distribution, along with any root or tip treatment. Blade element momentum theory should be used to establish a baseline, and any departure from the BEM optimum should be justified rather than tuned into existence.

1.1.3 CFD is mandatory and is expected at two levels: two-dimensional aerofoil analysis verified against published wind tunnel data, and three-dimensional rotor analysis (RANS is acceptable, higher fidelity is encouraged). Mesh definition, turbulence model choice, convergence, and a mesh independence study must all be reported – a contour plot on its own is not evidence.

1.1.4 Off-design performance is a required output, not an optional extra. Teams must report the power curve across the full operating range including start-up, rated, and cut-out, the control strategy (pitch and torque) used to hold it, and the resulting annual energy production against the chosen site's wind distribution.

1.1.5 Aeroacoustic performance should be assessed at least at the level of trailing edge and tip noise, since noise limits are frequently what caps tip speed and therefore what caps the achievable power coefficient. Teams should state the noise constraint they are designing to and show what it costs them in energy capture.

1.1.6 We would like to see evidence of verification of the aerodynamic model against published data (e.g. the NREL 5 MW or DTU 10 MW reference turbines, or published wind tunnel and field measurements).

1.1.7 The primary figure of merit is annual energy production per unit of installed cost at the chosen site. However, there is also significant weighting on other things such as:

a) Modelling approach taken – the thoroughness, quality, and compliance with good coding



practice such as PEP8.

- b) Project management and process – planning, recording of information, communication, risk capture etc.
- c) The consideration and justification of the level of modelling fidelity used. What assumptions have been used and how have they been captured? This is a powerful skill.
- d) Key points of learning during the task and how this is recorded. We want to see what you discover, how you explore options, what you learnt and how you then applied this.
- e) Novelty of the aerodynamic concept or the design methodology.
- f) First phase presentation.
- g) Final presentation and summary report.
- h) Cross-functionality working and integration between teams.
- i) Depth of research.
- j) Realism of the underlying site, loads, and cost assumptions.

1.1.8 The scope outlined isn't expected to be completed by the first deadline – this is for the finals. Progress up to the first phase is what will be assessed in the initial project down-selection. Students should utilise their relevant skills and interests to complete tasks they think will be useful and interesting, even if not explicitly listed here.

Subtask 2 – Structural Design, Manufacture and Experimental Validation

2.1.1 A blade is a structure before it is an aerofoil. This task takes the geometry from Subtask 1 and establishes whether it can actually be built and whether it survives, working closely with the Subtask 1 team so that the structural result feeds back into the aerodynamic design rather than arriving after it is frozen.

2.1.2 The mandatory core of this task is the structural design of the blade: spar cap and shear web layout, skin layup and ply schedule, material selection (glass, carbon, or hybrid) with real material data, and the resin and core system. Teams should cost the laminate as well as size it.

2.1.3 Load cases must be derived rather than assumed. Teams should work from the IEC 61400-1 design load cases and assess ultimate strength, tip deflection against tower clearance, buckling of the panels and spar caps, and fatigue over a twenty-five year life using a damage accumulation method they justify.

2.1.4 A specific and mandatory sub-topic is aeroelastic coupling: how the structural deflection



under load changes the aerodynamic performance calculated in Subtask 1, and whether the blade is free of flutter and edgewise instability across the whole operating range. Teams should report the aeroelastically corrected power curve against the rigid one.

2.1.5 Manufacture and transport must be addressed explicitly – mouldability and layup access, cure and cycle time, defect and tolerance sensitivity, and, if the blade exceeds a transportable length, the segmentation or joint concept and what it costs in mass, stiffness, and money.

2.1.6 Experimental testing is mandatory and is what closes the loop on this project. Teams must design and, where facilities allow, execute a physical test programme – for example static and fatigue coupon tests on the chosen laminate, a scaled rotor in a wind tunnel, or a structural test on a representative section. Where a facility is genuinely unavailable, the test must still be specified in enough detail that it could be run: rig, instrumentation, load path, sampling, uncertainty, and acceptance criteria.

2.1.7 The measured results must be reconciled against the predictions, with disagreement explained rather than smoothed over. Where the model and the test disagree, we want to see which one was wrong and how the team found out.

2.1.8 The main scoring criteria for this subtask is the quality of the closure between prediction and measurement. A modest test that is well designed, well instrumented, and honestly reported is scored more highly than an ambitious one that produces data nobody can interpret. However, the other criteria listed for Subtask 1 are also of importance.

Timeline

This competition has two phases: the first ends at the beginning of January, wherein each team presents their design to judges online; from here, 2 teams' designs are selected from each university for the in-person finals. Members from teams which did not get selected can apply to join the two selected teams for the remainder of the competition.

In January a mid-project review will be held, and for this the only deliverable is a presentation outlining the progress made thus far.

The in-person finals consist of a 30 minute presentation, as well as the submission of a report; this has a limit of 8 pages (title, contents, and reference pages not included, appendix not included but will not be included in the scoring) and should cover the concept, the method of development, evidence of initial V&V, and key lessons learned. This should be delivered 2



weeks before the final presentation. We recommend including short snippets of code in the appendix for sections of interest. The report should cover both tasks.

6 October 2026	Applications Open
25 October 2026	Applications Close
20 October 2026	Teams formed
24-28 November 2026	Mentor Check-In (Feedback given)
12-16 Jan 2027	Phase 1 Presentations (Feedback given)
9-13 February 2027	Mentor Check-In (Feedback given)
20 March 2027	Finals