Convergence of Segmented Blades & Hybrid Materials
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Abstract
As onshore turbines push the power rating beyond 4.0 MW, we are likely to see rotor diameters upwards of 160 – 180m onshore emerge in the coming years. Transportation and logistics challenges for blades of such length have been well documented, but there is a new confluence of technologies which could accommodate design requirements for transportation, light weight, high strength, & long length simultaneously.

Objectives
In order to provide adequate strength to blades as they scale, structural reinforcement must be introduced. While hybrid material blades are not a new concept, with CFRP blades introduced in 2002, the technology can present a difficult design challenge when attempting to scale blade lengths beyond 80m. Additionally, first generation segmented blades have suffered from overdesign resulting in cost & weight increases, or else under-design resulting in joint fatigue challenges. With a second generation of segmented blades ready for market introduction, an opportunity exists for a new technical solution which avoids all previous design challenges. The combination of blade segments of differing material properties can be the best solution for overcoming these scaling challenges.

Methods
A new class of materials including metal matrix composites & structural fabrics is emerging which might overcome these scaling issues. Modular pieces of the blade could be manufactured as sub-components and assembled with overall weight and strength in mind. A segment with higher rigidity Inboard to accommodate bending loads could be joined with an outboard segment comprising lower weight, but higher stiffness material to prevent flutter.

Results
The number of companies developing segmented blade solutions continues to grow, with a total of 165 patented innovations developed, but with the majority of technical solutions for 2nd generation segmented blades still languishing atTRL 5 – 6. Additionally, numerous companies are undertaking the development of hybrid material blades with a total of 27 patented innovations developed, and some which have reached a state of maturity which indicates a pending market introduction within the next 18 months. To date, the testing of a combined solution comprising blade segments of multiple materials is still under development and testing.

Conclusions
The potential combination of multi-piece blades comprising segments of differing material properties presents a highly attractive technological combination. The light weight which is achievable by selective material use outboard coupled with a high strength, & structurally reinforced root will be a key enabler for +80m blades. 3D printing can now be used to ensure that blades with hybrid materials comprise no defects & a precise fit between structural segments is achieved.

Future Onshore Wind Energy Technologies

What is it?
What is a segmented blade?
What are the benefits?
Why is it important?
What are the challenges?
How is it done?
How does it work?
Advantages
- Ease of maintenance
- Reduced material usage
- Increased power output
- Better aerodynamic performance
- Reduced cost

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