PowerCone® from Biome Renewables

The Root of the Problem

The blades of modern wind turbines have poor aerodynamic properties at the blade root, due to their geometry and operational limitations. The required length of modern blades requires a structurally circular blade root, with aerodynamically sub-optimal chord sections extending to the widest chord length. As such, turbines almost universally sacrifice energy capture at the center of the rotor disc. Further, this lack of performance is driven by a pressure imbalance between outer efficient blade sections, which display high upwind pressure, and central inboard sections nearest the root, which display low pressure. When the turbine is operating, this creates a suction effect towards the center of the rotor disk, and the phenomena of Rotor-Root-Suction (RRS), creating additional performance loss. Incoming flow separates off these un-optimized blade sections along their surface and creates turbulences and associated vibrations that drive increased loads and higher fatigue on critical turbine components.

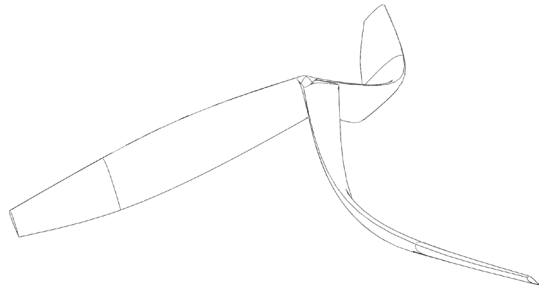


Illustration of a PowerCone® equipped turbine

This lost potential energy has been easy to justify in the industry on account of ever-expanding blade lengths, which drive higher capacity. However, when the turbine is operating properly, RRS accounts for the largest performance loss of the turbine - up to 5% net-loss (negative Cp) is seen in industry. As turbines get larger, the problem area gets larger. As such, there is always the potential for aerodynamic improvement of their performance.

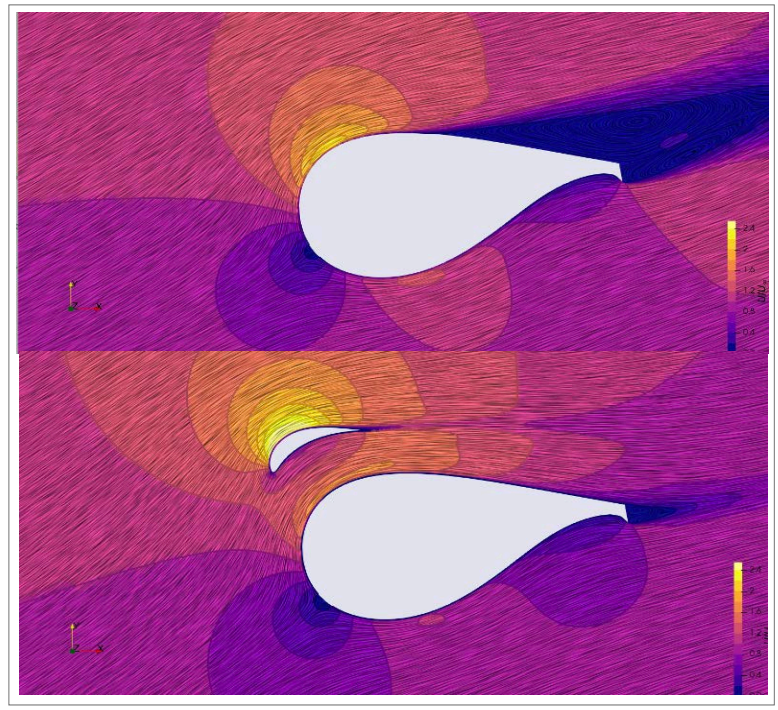
Most turbine retrofits only play at the margins. The PowerCone cuts to the heart of the issue in every way, redistributing wind to maximize performance.

The result is not just more power, but power from a place where no longer blade or smarter software can find it.

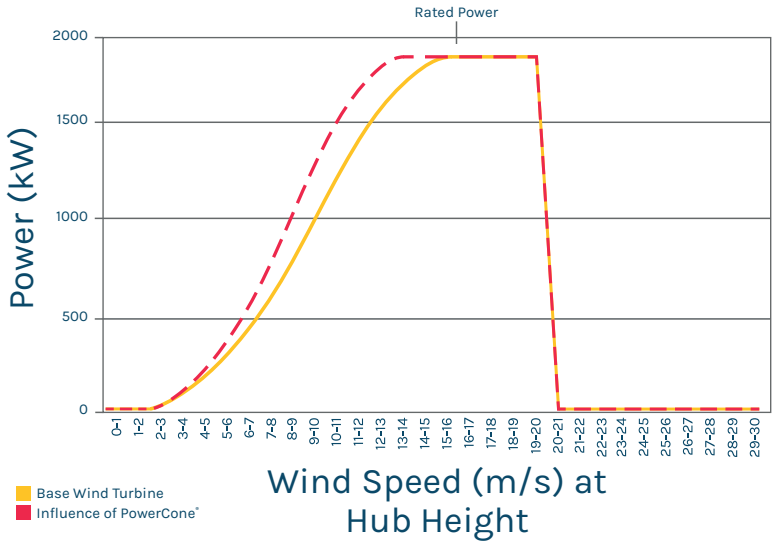
Your Aerodynamic Advantage

The PowerCone is a turbine enhancement that unlocks wind power's true potential.

By addressing the aerodynamic problem of RRS using a novel twin-hybrid aerodynamic mechanism, the PowerCone channels wind away from the central region of the rotor, creating torque in the process, before directing this flow onto the leading edge and suction side of the rotor blade, promoting laminar flow. Through its refined geometry, inspired by the flow path of a falling maple seed, the PowerCone equalizes the pressure distribution across the entire rotor disk and reduces the impact of gusts, boosting performance for the whole turbine while reducing loads on the rotor.



PowerCone® CFD Simulations on DTU 10MW wind turbine blade



The baseline power curve seen here comes from a Vestas V100 turbine located in an IEC Class IIa wind regime.

More Power

You can't create wind, but with the PowerCone, you can make the most of what's blowing.

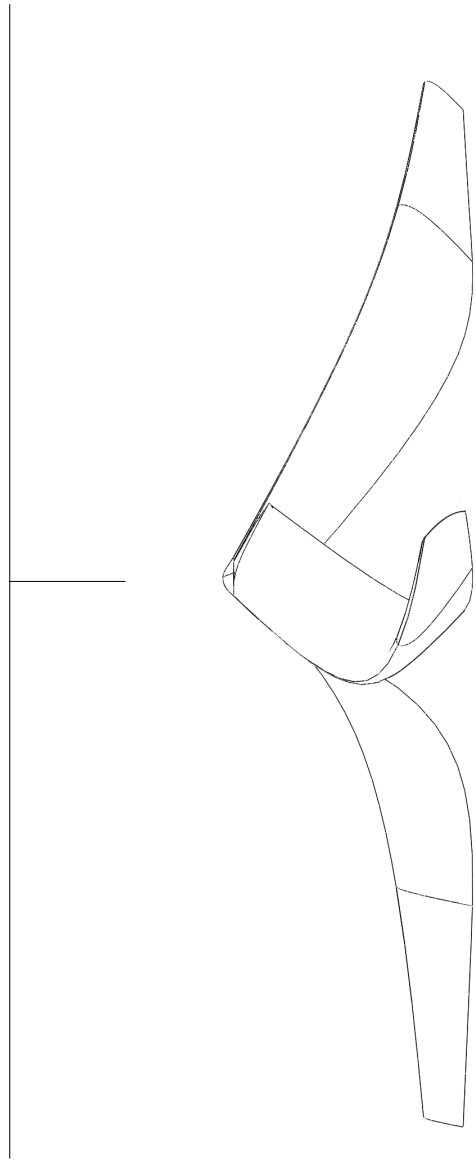
Through our novel aerodynamic approach, flow at inner radial locations is moved radially outward upwind of the rotor, causing a slight increase in the effective wind speed. This allows the turbine to capture more of the free-stream air across the entire rotor disc and put it to better use, increasing torque in the process. The effect is increased yield beyond the immediate location of the product and annual energy production potential of more than 6%, and this is before our upcoming wind farm tests to prove additional yield through multi-turbine impact and controller adjustments. This elevated performance greatly reduces the levelized cost of wind energy (LCOE) and improves wind farm economics.

Minimized Load Impact

The modular PowerCone is designed so its center of mass is in-line with the rotor, with its span occupying approximately 20-25% of the rotor diameter of the turbine, regardless of MW class. Working with DNV Turbine Engineering, the additional mass was determined to be negligible, while extreme loads on the rotor and tower from DLC 6.4 were modeled to be significantly reduced. Through our patented aerodynamic design, flow separation on the rotor is greatly reduced, with full-scale pilot fatigue load reductions seen in tower top and bottom normal bending moments and on tower top normal bending moments.

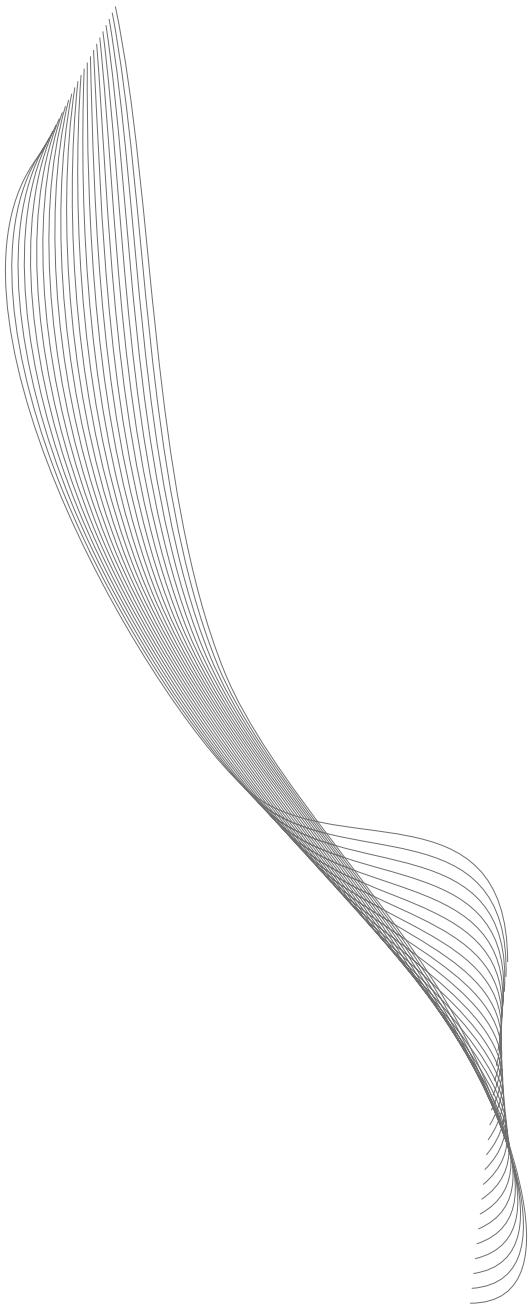
The position of the PowerCone is optimized based on the turbine type to create a slot between the device's trailing edge, and the turbine blade's leading edge. Flow coming off the device is directed to this slot, and passes through at accelerated velocities to the suction side of the blade, keeping the flow attached and turbulence to a minimum through a wide variety of pitch positions.

The length of the PowerCone blades is designed to locate this secondary flow effect at rotor locations where separation is most problematic, to yield the most benefit. As a result, this energized boundary layer of air reduces vibrations that would have been directed to the drive-train of the turbine.



Bat Curtailment

Operating wind turbines in areas of bat populations can lead to lost production due to curtailment. With the PowerCone, you can help make up these losses by producing more power in the ramp-up portion of the power curve, from your curtailed cut-in speed to rated power.

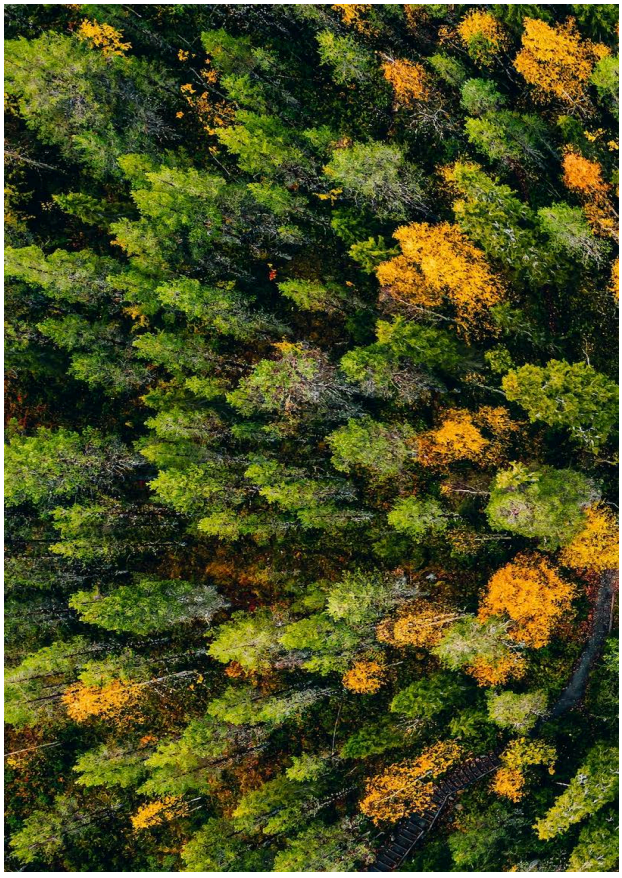


Icing

Operating wind turbines in cold climates can lead to lost production due to curtailment. With the PowerCone, you can help make up those losses by producing more power in the ramp-up portion of the power curve. The PowerCone does not lead to increased risk of rotor icing, and does not carry the same risk of icing as the outer portion of the blade. Even so, the PowerCone follows the principles for the IEC 61400-1 standard to withstand the loads due to ice accumulation.

Seamless Integration

The PowerCone has been specifically designed as an enhancement device that can be fitted to 98% of installed turbines globally, both onshore and offshore. Manufactured from glass fiber composite, it is designed to follow the principles of IEC specifications and is manufactured to ISO 9001:2015 standards to be OEM agnostic, with varying blade lengths to ensure you are getting the most of what's available. Installation is complete in a few days with custom easily-installed brackets and steel hard-points that mount onto the static pitch bearing in a secure, effective location. With extra tie-off points for turbine technicians, there is improved safety to your established maintenance regime.



Valuable Partnerships

The PowerCone has more than 50,000 person-hours behind its development. Wind tunnel, real-world and computational studies have given us a confident platform to make assertions about PowerCone performance. Working with leading technical partners such as DNV, NREL, and leading research institutes and OEMs around the world, data and information gathered to date can be overlaid onto power curves from real wind farms.

Through the PowerCone, you unlock the power of Evolved Design.