RETROFITTING WIND TURBINES

Increase your return on investment by extending the profitability of aging equipment.
As wind turbines age, they gradually lose energy efficiency. Thousands of the 300,000 wind turbines worldwide are not performing their utmost, in large part due to blade surface and leading edge degradation. As a result, operators demand solutions for optimizing wind turbine blade performance to regain lost energy production.

THE POWER CURVE TECHNOLOGY

Power Curve solutions revolve around vortex generator technology. Vortex generators are small add-ons for wind turbine blades that improve aerodynamic performance and restore energy output lost over time.

We install our VGs along the length of the blade, both on the inner and the outer part, which allows us to offer some of the highest improvements in AEP on the market.

Our technology can provide significant improvements in AEP for both new and aging turbines. The improvement depends mainly on the turbine model, the blade type and the current surface condition of the blades.
Power Curve Benefits
OPTIMIZING WIND ENERGY PROJECTS, BLADE BY BLADE

OPTIMIZE BLADE AERODYNAMICS
No turbine can endure the elements through years of operation without some wear and tear. Our vortex generator technology reinstalls lift forces lost to blade wear.

INCREASE TURBINE AEP
Power Curve vortex generators improve the efficiency of the turbine by vitalizing the airflow across the blades. As a result, annual energy production is significantly improved.

STABILIZE AERODYNAMIC LOADS
Blade erosion leads to premature airflow separation, giving rise to increased dynamic stall loads. By controlling the airflow with vortex generators, these loads are stabilized and minimized.

REDUCE AERODYNAMIC NOISE
Premature airflow separation causes the turbine to generate aerodynamic separation noise. Our vortex generators help eliminate aerodynamic noise by stabilizing the airflow.

VALIDATED BY DTU WIND DEPARTMENT
The Power Curve technology has been thoroughly tested and validated by the Technical University of Denmark (DTU), a world-leading institute in wind energy research.

Installation methods
CHOICE OF INSTALLATION TO MATCH YOUR PROJECT

1. ROPE ACCESS
Rope access is our standard mode of installation. In most cases, it is comparatively time-efficient and cost-effective.

   Maximum flexibility and non-critical equipment.

2. AERIAL TRUCK
For wind farms in open and flat terrain. Using an aerial truck is faster in terms of per-turbine installation time.

   Fast installation in flat and open terrains.

3. SUSPENDED PLATFORM
When other blade maintenance is scheduled, a suspended platform can be an advantageous installation solution.

   Cost synergies with other scheduled maintenance.

Safe installation is the top priority regardless of installation method. We persistently ensure compliance with applicable standards, certification requirements and safety procedures.

POWER CURVE VG PANELS
Power Curve vortex generators come as panels rather than individual pairs. This allows our installation teams to perform faster and more accurate installations than most. Our clients can expect reduced turbine downtime and optimal precision.

In terms of turbine downtime, we are on par with the market average. If not even faster. This is despite the fact that we install our vortex generator panels on both the inner and the outer sections of the blade. By rope access, a typical Power Curve installation takes around 7-8 hours per rotor.
The Power Curve design process
CASE-BY-CASE OPTIMIZATION OF VG SOLUTIONS

We go through a meticulous design process when designing a new solution for a given turbine or blade model. The design process is divided into five stages, from initial site and turbine assessment, through testing and validation to site rollout.

STAGE 1
TECHNICAL ASSESSMENT AND PROPOSAL
Power Curve and the client assess the wind turbines and the wind farm site. This includes turbine type, blade condition, historical SCADA data, service history and local climate conditions.

STAGE 2
TURBINE-SPECIFIC VG DESIGN
Based on blade shape and turbine information, we complete our upgrade design process. Taking into account Leading Edge Roughness (LER) and vortex generators, we then provide a design and estimate of the expected increase in AEP.

STAGE 3
INSTALLATION AND TRIAL
Depending on the wind farm size and layout, a number of test and reference turbines are selected for the trial period. Together with the client, the most efficient installation method is chosen.

STAGE 4
BUSINESS CASE VALIDATION
To evaluate the performance, we compare SCADA measurements before and after VG installation weighted with the site-specific Weibull distribution. The client reviews their business case based on the validated AEP improvement.

STAGE 5
SITE ROLLOUT
When a rollout decision for the full wind farm is made, we cooperate closely with our local installation partner to perform safe and precise installation.

SPOTLIGHT: STAGE 2

TURBINE-SPECIFIC VORTEX GENERATOR DESIGN
Power Curve solutions draw on the latest scientific advances in aerodynamics. This is reflected in how we specify the optimal vortex generator design. The computational steps we go through to ensure the best AEP improvement for a given project are described below.

1. Blade geometry
If the geometry of the blade is not available, a 3D blade laser scan is carried out (as shown on the page opposite). We then cross-reference this with our airfoil database.

2. 2D lift and drag forces
Next, we compute the lift and drag coefficients ($C_L$ and $C_D$) for the clean airfoil using XFOIL and aerodynamic coefficients from wind tunnel measurements.

3. LER and VG modelling
We then add the effect of vortex generators and leading edge roughness (LER) in various combinations by subjecting the $C_L$ and $C_D$ of the clean airfoil to empirical engineering models.

4. 3D correction
The established 2D aerodynamic forces, $C_L$ and $C_D$, are then 3D-corrected to account for the three-dimensional flow pattern on rotating blades.

5. Blade forces
The 3D-corrected aerodynamic forces are subjected to BEM computations using HAWC Stab 2 to determine the aerodynamic forces generated by the entire blade.

6. Power curves and AEP
Finally, we compute power curves for the turbine, and together with statistical wind speed distribution we determine the expected AEP improvement for the turbine.