Smart turbine control
to increase AEP
Avoids detrimental loads, helps optimize blade design, and enables turbine lifetime extension.

Identifies different types of degradation and damage based on analytical and empirical tools.

FEATURES

SOLUTION

OVERLY CONSERVATIVE DESIGNS
POOR ENERGY-TO-LOAD RATIO
UNKNOWN LIFETIME LOADS
STRUCTURAL DAMAGE
SLOW DEGRADATION
MAINTENANCE WORK

YIELD LOSS DUE TO STANDSTILL
MANUAL INSPECTION / RESTART
PREVALENT SAFETY RISK

SITUATION

EFFICIENT OPERATION
Stopping as late as necessary and restarting as early as possible increases the energy yield.

AUTOMATIC STOP/START
Automatic restart without visual inspection even in low wind significantly increases yield.

RELIABLE DETECTION
Reliable and certified detection of ice mass on the rotor increases safety to people, assets and property.

Rotor Ice Control

Turbine Load Control

Turbine Integrity Control

RIC

TLC

TIC

LIMITED LOAD CONTROL

KNOWLEDGE OF LOADS
Using a load control system allows lighter and cheaper blades, as safety reserves can be optimized.

ACTIVE LOAD REDUCTION
Active load reduction and avoidance of overloads allows the use of longer blades.

LIFETIME EXTENSION
Knowledge of cumulative loads can determine the virtual age and form the basis for lifetime extension.

DAMAGE DETECTION
The impact of sudden damage can be quantified, trigger fail-safe operation and avoid costly fatal accidents.

DEGRADATION MONITORING
Turbine wear is tracked over time and alert levels are set for early damage detection and to avoid fatal loss.

OPTIMIZED MAINTENANCE
Improved predictive maintenance and repair planning increases turbine uptime and annual energy production.

IMPACT

4% AEP
12,000 EUR
per year for a 3 MW turbine – assuming a price of 5 cents/kWh.

8% AEP
24,000 EUR

10,000 EUR/Case
through less production downtime and less costly replacement.

Early detection of fatal damage can save at least

12,000 EUR
24,000 EUR

24,000 EUR
4% AEP
8% AEP

TLC

TIC

RIC
Improves sector curtailment and power curve over the entire range of wind speeds and terrains.

Manages noise curtailment to increase overall energy output or even enable a specific site at all.

Supports the optimization of the entire wind park, for example by balancing wake effects.

**IMPACT**

**FEATURES**

**SOLUTION**

**TURBINE UNDERPERFORMANCE**

- Complex wind fields
- Sector curtailment

**LIMITED SITE SELECTION**

- Increased product cost
- Noise curtailment

**POWER LOSS DUE TO WAKES**

- Turbine fatigue
- Power output instability

**SITUATION**

**TEC**

Turbine Efficiency Control

Improves sector curtailment and power curve over the entire range of wind speeds and terrains.

**BNC**

Blade Noise Control

Manages noise curtailment to increase overall energy output or even enable a specific site at all.

**WFC**

Wind Farm Control

Supports the optimization of the entire wind park, for example by balancing wake effects.

**OPTIMAL OPERATION**

Sensor data helps to optimize the energy yield for high turbulence, wind shear, and non-horizontal inflow.

**IMBALANCE CORRECTION**

Correcting yaw-misalignment, pitch error, aerodynamic rotor imbalance, and anemometer calibration errors.

**SECTOR MANAGEMENT**

With empirical knowledge of flow conditions and loads, operating restrictions are reduced and yield increased.

**PASSIVE NOISE REDUCTION**

Identifying the sources of noise leads to better wind turbine and blade designs.

**ACTIVE NOISE REDUCTION**

Dynamically maximized energy-to-noise ratio optimizes the possible energy yield.

**CUSTOM CONTROL STRATEGIES**

Sectorial wake-steering or power-dereating control strategies reduce the wake effects within the wind farm.

**POWER SYSTEM INTEGRATION**

Dynamic wind farm control algorithms assist in the power system and energy market integration of wind farms.

**CURTAILMENT MANAGEMENT**

With actual and ongoing noise measurements, operating restrictions can be reduced and yield increased.

**PARK-WIDE INSIGHTS**

Turbine sensor data provides valuable insights on design, operation and planning of wind farms.

- **2% AEP**
  - 6,000 EUR per year for a 3 MW turbine – assuming a price of 5 cents/kWh.

- **3% AEP**
  - 9,000 EUR per year for a 3 MW turbine – assuming a price of 5 cents/kWh.

- **4% AEP**
  - 12,000 EUR per year for a 3 MW turbine – assuming a price of 5 cents/kWh.
Under the umbrella brand “X4edge” we bundle our portfolio of digital products for the optimization of wind turbine performance. Some of these products are based on our modular sensor platform “fos4Blade”.

At the core of the fos4X rotor blade sensor platform fos4Blade is our unique and reliable fiber-optic measurement technology, which is immune to lightning and electromagnetic interference. fos4Blade can be individually and cost-efficiency adapted to your requirements due to its modular design, consisting of a configurable set of strain and vibration sensors and a central measuring device.

The software solutions (or apps) based on the sensor platform close the gap between the fundamental measurement of blade properties and real customer value. With our industry expertise and cutting edge model-based analytics, machine-learning and AI techniques, we convert sensor data from the edge into relevant, actionable insights that you can access from wherever you are.

Founded in Munich in 2010, fos4X GmbH specializes in innovative fiber optic measurement technology and sensor technology – primarily in rotor blades for wind turbines – and develops intelligent solutions for the optimization of wind energy.

The fiber optic sensors and solutions are also used in the fields of electric mobility and railways, thereby supporting the efficiency and further development of these industries focused on renewable energies.

CONTACT
fos4X GmbH
Thalkirchner Straße 210 | 81371 Munich | Germany
T: +49 89 999 542-00 | F: +49 89 999 542-01 | info@fos4x.de
www.fos4x.de | www.x4edge.com