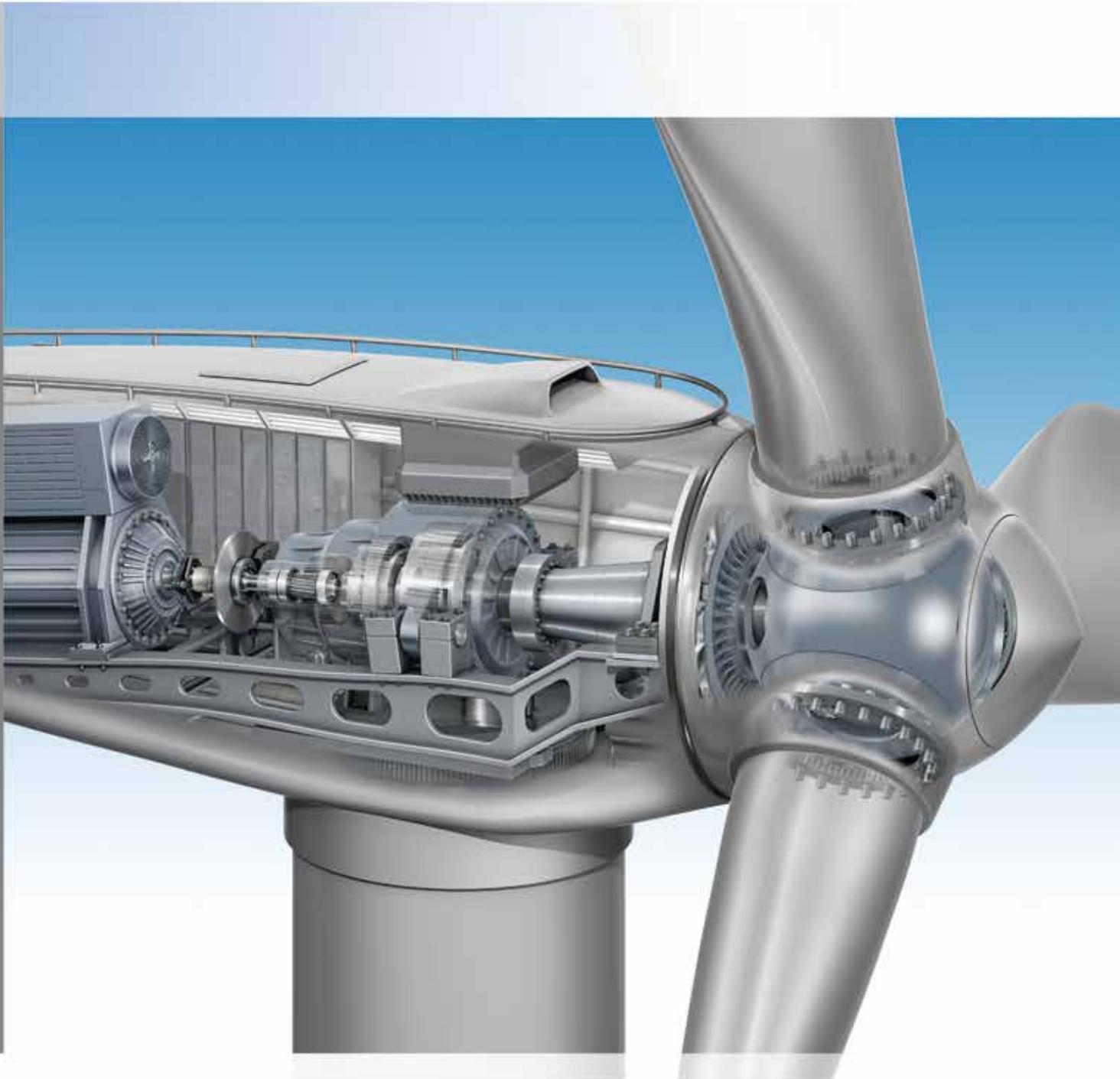
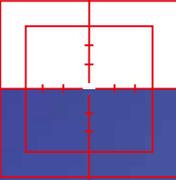


# Keep the blades turning

Condition Monitoring of wind turbines



# PRUFTECHNIK - Your Independent Solution Provider



## Single source for reliability systems and services

Condition-based maintenance of wind turbines consists of inspection, measurement, evaluation and maintenance of the machinery, and monitoring service.

Condition Monitoring, a tool for condition-based maintenance, is one element of the long-term service packages offered by some wind turbine manufacturers and is essential when operating offshore wind farms.

PRUFTECHNIK solutions increase the efficiency of wind turbines by minimizing the risk of downtime.

## Our solutions



Monitoring Center – DNV.GL certified



Condition Monitoring and Vibration Analysis



Drive Train Laser Alignment

# Monitoring wind turbines pays off

Profitability of a wind turbine is measured by the following indicators:

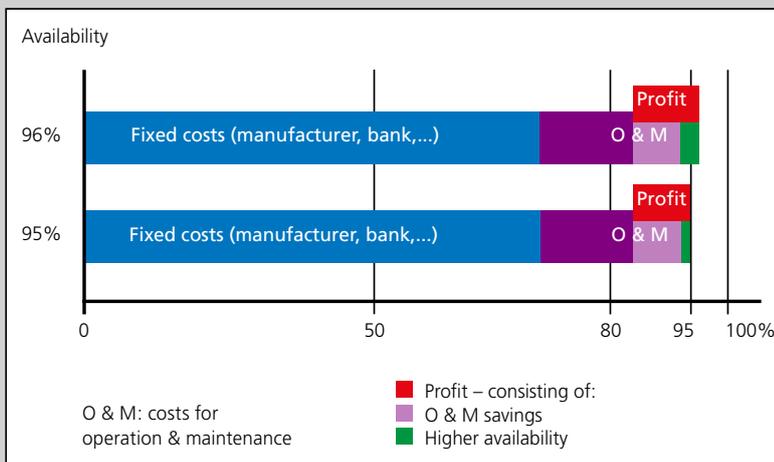
- ▶ Mean wind speed
- ▶ Price per kWh / hp h
- ▶ Plant availability
- ▶ Operating and maintenance costs

While you have no influence on the first two indicators, plant availability and operating costs can be positively influenced by the right maintenance strategy.

This is where PRUFTECHNIK comes into play: Online Condition Monitoring Systems (CMS) detect mechanical and electrical faults during operation at an early stage and make it possible to plan and prepare repair and service before major damage can occur.

## Efficiency has top priority

- ▶ Longer service life
- ▶ Lower maintenance costs
- ▶ Lower insurance rates
- ▶ Lower lifecycle costs
- ▶ Higher availability
- ▶ Optimal performance
- ▶ Improved safety



## A source of potential savings

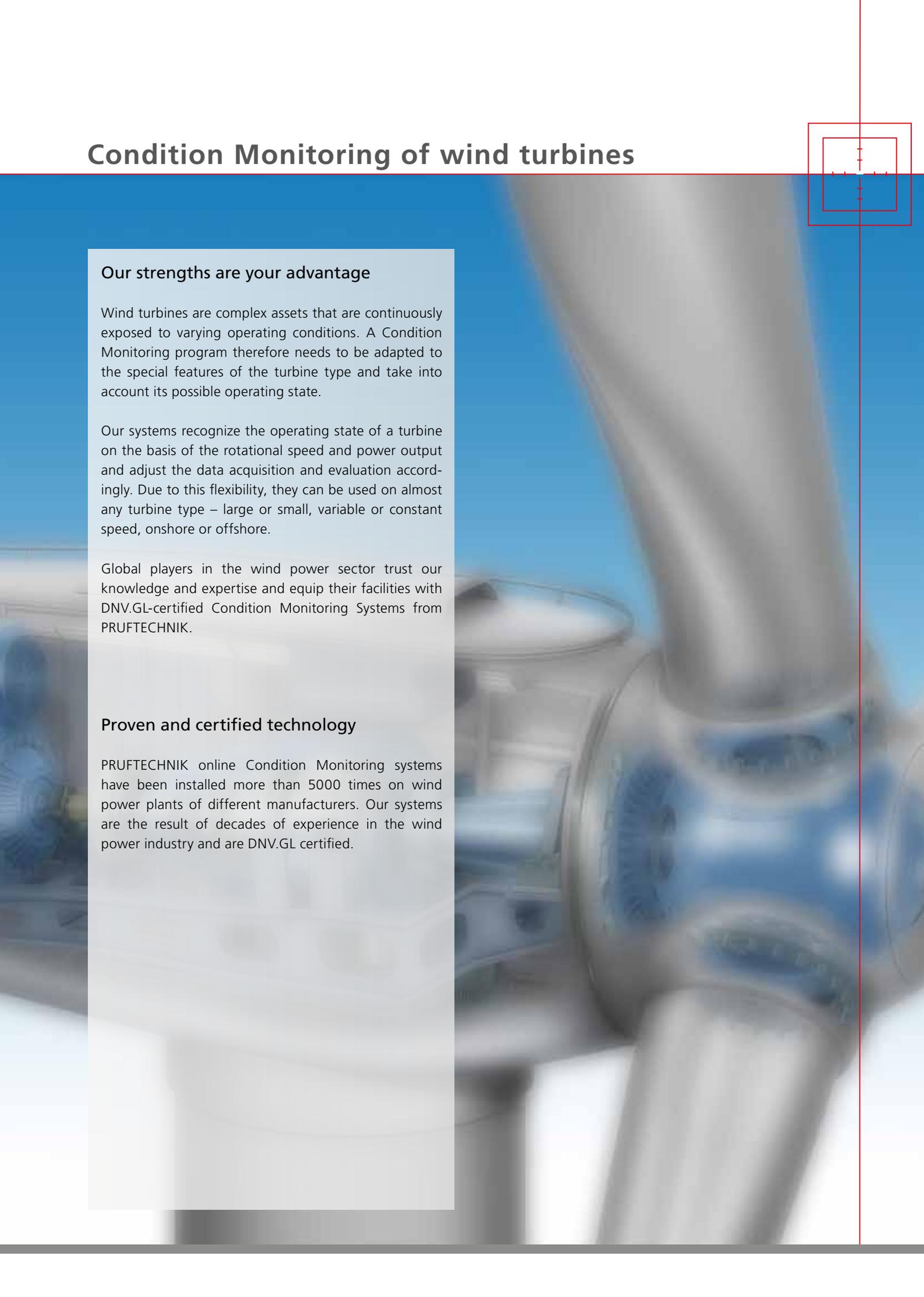
Condition Monitoring can reduce operating and maintenance costs by up to 60%. Asset availability, on the other hand, has only a limited impact on potential savings as it is usually already at a fairly high level.



## PRUFTECHNIK systems and Monitoring Center are certified

Your wind turbines are monitored by measuring systems and methods that are regularly certified by DNV.GL.

# Condition Monitoring of wind turbines



## Our strengths are your advantage

Wind turbines are complex assets that are continuously exposed to varying operating conditions. A Condition Monitoring program therefore needs to be adapted to the special features of the turbine type and take into account its possible operating state.

Our systems recognize the operating state of a turbine on the basis of the rotational speed and power output and adjust the data acquisition and evaluation accordingly. Due to this flexibility, they can be used on almost any turbine type – large or small, variable or constant speed, onshore or offshore.

Global players in the wind power sector trust our knowledge and expertise and equip their facilities with DNV.GL-certified Condition Monitoring Systems from PRUFTECHNIK.

## Proven and certified technology

PRUFTECHNIK online Condition Monitoring systems have been installed more than 5000 times on wind power plants of different manufacturers. Our systems are the result of decades of experience in the wind power industry and are DNV.GL certified.

# PRUFTECHNIK product range

## VIBXPERT® II

- ▶ Data collector, analyzer and field balancer
- ▶ Two simultaneous measuring channels for voltage, current, ICP signal, current line drive signal
- ▶ Broad- and narrowband overall values in the time domain and frequency domain
- ▶ Analysis functions: envelope, order spectrum, cepstrum, orbit
- ▶ Ideal tool for Onsite Blade Balancing

## VIBGUARD® XP



The ideal solution for high-end monitoring of offshore and onshore turbines

- ▶ 20 channels for continuous and parallel data acquisition and processing
- ▶ Stand-alone system: no PC required for signal processing and data storage
- ▶ Condition monitoring on the basis of broadband and/or frequency-selective characteristic values
- ▶ Real-time data analysis based on the various operating states
- ▶ Analysis functions: envelope, order spectrum, cepstrum
- ▶ Easy to install, sturdy components suitable for harsh environments
- ▶ Communication: TCP/IP, Modbus TCP



## WEARSCANNER®

Early wear detection with WEARSCANNER® particle counter. To increase quality of diagnosis in low speed roller bearings and planetary stages, we monitor the particle size distribution in the lubricating oil of force-lubricated gearboxes.

## ROTALIGN® touch

Using the patented sensALIGN® technology, our measurement systems ensure safe measurement conditions during the shaft rotation.

- ▶ Alignment of generator to gearbox
- ▶ Measurement during shaft rotation in idling state
- ▶ Special brackets enable shaft rotation of up to 360°
- ▶ High-quality repeatable results with patented IntelliSWEEP® measurement mode



## Live Trend

- ▶ Measurement of machine movements in operating conditions
- ▶ Definition of alignment targets for optimal alignment in operation
- ▶ Available on ROTALIGN® touch and ROTALIGN® Ultra iS

Live Trend measures machine displacements in operation and delivers clear data on the misalignment to be considered in cold condition. This enables to achieve the best possible alignment of the entire drive train in operating conditions to ensure optimum power transmission and wind turbine efficiency.

# Your assets kept under close watch

## Intelligent data management

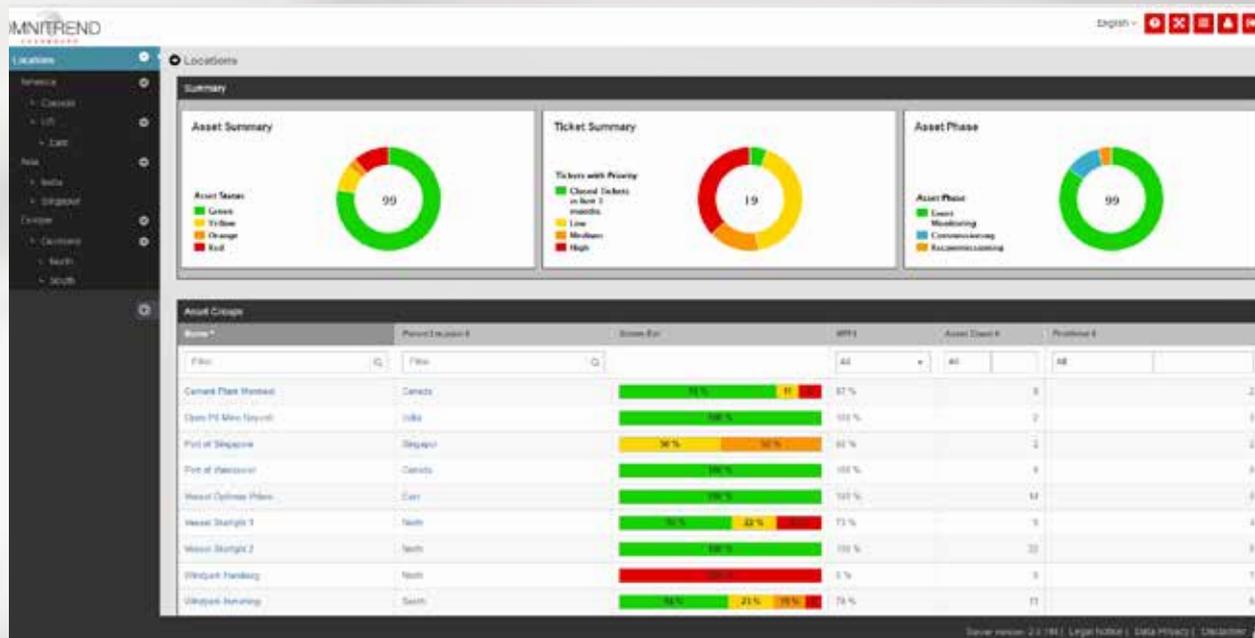
Our online CMS come with an automated process that independently handles the evaluation of measurement data during routine operation. It informs the operator about the asset condition at regular intervals on the basis of the determined characteristic values. Diagnosis experts, who can then perform an in-depth analysis, are directly notified of critical conditions. Transmission and distribution of daily measurement data to the applicable databases are fully automated. The system monitors data traffic and alerts the operator if a turbine ceases to deliver data.

## Document turbine condition, identify problems

Regular reports give the operator an overview of the general turbine condition. The status report displays the current condition of the turbine on a traffic light display. Detailed problem reports contain data relating to the cause of increased vibrations and specific, prioritized recommendations for action.

## Online visualization

OMNITREND® Dashboard is our service portal that provides you with an overview of all the data we collect to help you quickly understand the condition of your assets. Complex measurement methods and large amount of data are represented in a user-friendly graphical web interface. The cloud-based OMNITREND® Dashboard is available worldwide through an Internet connection. All our servers are secure and based in Germany.



OMNITREND® Dashboard service portal showing overall asset condition with drill-down functionality.

# PRUFTECHNIK Monitoring Center

Certified diagnosis quality

## Certified since 2007

The PRUFTECHNIK Monitoring Center has been contracted to monitor several hundred wind turbines around the world to provide comprehensive Condition Monitoring services. Highly qualified diagnosis specialists examine measurement data obtained via e-mail for significant changes in condition (TeleMonitoring, Level 1), identify their causes (TeleDiagnosis, Level 2), evaluate machine conditions and make recommendations for improving plant reliability (Level 3).

On the basis of the latest FMEA methods, our specialists recognize vulnerabilities in a wind farm and individually adjust the monitoring routines. Several thousand wind turbines can potentially be monitored in this way with reasonable effort.



## Monitoring Center

- ▶ System configuration and setup
- ▶ Data collection and archiving
- ▶ Evaluation and telediagnosis
- ▶ Creation of reports on turbine conditions
- ▶ Alarm handling
- ▶ Development of efficient monitoring concepts on the basis of FMEA
- ▶ Statistical analysis

## FMEA method

- ▶ FMEA stands for failure mode and effects analysis
- ▶ A method employed to analyze potential vulnerabilities and find ways to eliminate them
- ▶ Globally recognized and proven method of fault analysis and quality optimization with the goal of reducing failure costs

## Data management

- ▶ Automatic acquisition, preparation and evaluation of measurement data in the CMS
- ▶ Time and event-controlled data archiving on a server
- ▶ Monitoring of data transmission
- ▶ Automatic data import into databases
- ▶ Automatic alert via e-mail or SMS when thresholds are exceeded
- ▶ Remote access to CMS via a secure Internet connection
- ▶ Provision of customized reports on a secure Internet server
- ▶ End-to-end solution: data management and analysis available around the clock

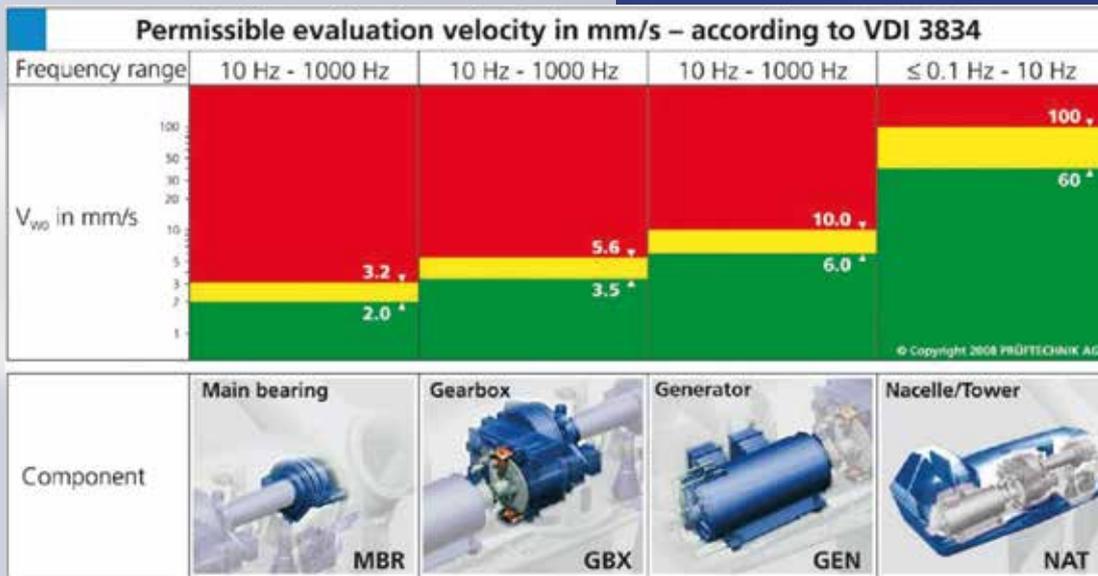
## Typical services

- ▶ Design of a monitoring concept
- ▶ Telediagnosis by experienced experts
- ▶ Consultation on challenging vibration diagnoses
- ▶ Support setting up an individualized Monitoring Center

# PRUFTECHNIK sets new standards

PRUFTECHNIK applies DIN ISO 10816-21/VDI 3834 when monitoring the general vibration condition. This standard defines component-specific frequency bands and makes recommendations for warning and alarm thresholds. Our diagnosis specialists contributed to the development of this standard and apply the vibration characteristic values it defines in their telemonitoring work.

Experience has shown that rotational vibrations are the cause of most threshold violations. They are often due to a mass imbalance on a rotor or a misaligned drive train component.



DIN ISO 10816-21/VDI 3834 is used to evaluate the vibration condition of individual drive train components

# Alignment and balancing

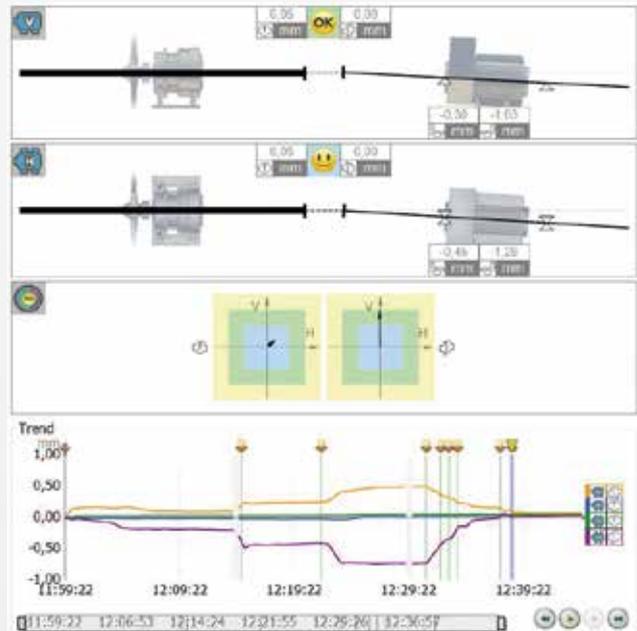
## Reduce vibration with optimal alignment

Fluctuating wind conditions change the alignment of machine components in the nacelle during operation. Misalignment causes strong vibrations and leads to premature bearing wear and gearbox failures. To minimize the reaction forces in bearings, alignment targets are needed.

The temporarily installed Live Trend monitoring system is used to record alignment changes mainly due to the wind speed. Measurement data is used to define target values for an optimal alignment in the nominal operating conditions.

Our laser shaft alignment systems – e.g. ROTALIGN® touch – are used to align drive train components safely during shaft rotation.

The ARC 4.0® alignment software enables alignment data analysis and trending.

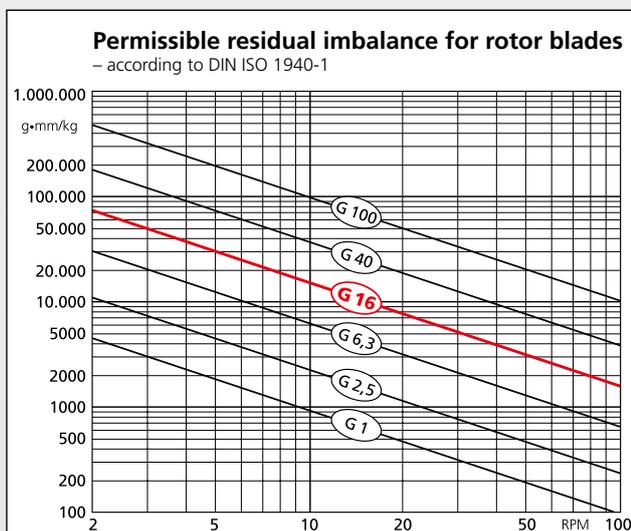


Screen in the alignment software showing the recording of the machine movements in time (bottom) and the corresponding coupling values (top).

## Balancing of rotor blades to grade G16\*

Rotor blade imbalance causes strong, low frequency vibrations. Our specialists use the portable VIBXPERT®II and specially developed accelerometers to balance very low speed machines.

VIBXPERT®II and VIBGUARD® feature efficient balancing functions and enables long measuring times – as demanded by VDI 3834.



\* to grade G16\*, In lattice mast towers according to grade G 6.3

## Balancing FAQ

### What causes a mass imbalance in the rotor blade?

- ▶ Repairs after a lightning strike, moisture in the blade, destruction of protective coating, are common causes.

### How does balancing benefit me, the operator/ manufacturer?

- ▶ Reduction of wear in roller bearings and gearbox, higher availability of turbines
- ▶ Constraint of rotational vibrations to within acceptable values (DIN ISO 10816-21/VDI 3834)

### Which methods can be used?

- ▶ Field balancing with VIBXPERT®II:
  - 1) Attach test weight
  - 2) Measure influence of test weight
  - 3) Attach balancing weight
  - 4) Perform verification measurement
- ▶ Balancing grade G16 as target

### What is the necessary time and effort?

- ▶ One day
- ▶ Balancing specialist + field balancer

## On-site service, around the clock

Manufacturers, operators and mechanics can benefit from a number of valuable services from PRUFTECHNIK. Our experienced technicians are there when you need them.

- ▶ When erecting a new turbine
- ▶ When installing replacement components
- ▶ During operation
- ▶ During servicing and maintenance

If rapid on-site action is needed, PRUFTECHNIK is ready to respond with an around-the-clock service team. Countless missions have shown that immediate and accurate action is critical in quickly returning a turbine to the power grid.



# Installation with precision

## Prototype monitoring with VIBGUARD® portable

- ▶ 20 synchronous channels
- ▶ Supports torque measurement, noise, vibration, deflection measurements, etc.
- ▶ Transient capture module with pre and post-trigger
- ▶ Cepstrum, orbit
- ▶ Hybrid triaxial sensor for dynamic acceleration and inclination in 3 dimensions
- ▶ Data is processed in the system – optionally available with embedded PC



## Our services at a glance:

- ▶ Mobile diagnosis measurements for the localization of fault causes (vibration condition, sound measurement, etc.)
- ▶ Laser-optical alignment of drive trains
- ▶ Measurement of foundation and flange flatness during the erection phase
- ▶ Monitoring of alignment conditions during operation to determine alignment targets
- ▶ Torque measurements with overload monitoring and the detection of load collectives
- ▶ Temporary teliagnosis for localizing transient events
- ▶ Remote monitoring of the turbine and regular vibration diagnosis service. Provision of the results in a report or via the Internet
- ▶ Dynamic balancing of rotor blades
- ▶ Condition Assessment: survey, inspection, documentation of turbine conditions
- ▶ Condition Monitoring Partner Concept (CPC): "You measure – We analyze."

## Securing claims with Condition Assessment

Prior to warranty expiration, both operators and manufacturers are interested in identifying any existing component issues. The turbine condition can be measured and documented by conducting diagnosis measurements, alignment checks and oil analyses.

## Condition Monitoring Partner Concept (CPC)

"You measure – we analyze" is the motto under which we support you with on-site mobile drive train testing. We offer product training to enable you to perform the required vibration measurements yourselves several times a year. The collected data is evaluated by experienced specialists at the PRUFTECHNIK Monitoring Center and made available to you in our online service portal.



Measurement of flange flatness using LEVALIGN® expert.

# PRUFTECHNIK

## Your Independent Solution Provider

### Expertise through experience

**20** Years of experience in the wind sector have provided PRUFTECHNIK with a high level of expertise

**1000** Laser shaft alignment systems are used by service providers worldwide to align turbine drive train components

**1500** Wind turbines around the world are monitored by the PRUFTECHNIK Monitoring Center

**5000** Wind turbines worldwide are equipped with PRUFTECHNIK systems



### Global presence

Sales partners and distributors for PRUFTECHNIK products and services are active in over 70 countries – 18 of which are home to PRUFTECHNIK subsidiaries.

Visit our website to find our office nearest to you.

**PRUFTECHNIK**  
delivers  
maintenance  
solutions  
worldwide



Alignment Systems



Condition Monitoring



Nondestructive Testing



Service & Support



Approval of  
Air Carrier  
Security Programs

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