



condition.monitoring

SMART DATA SOLUTIONS: KNOWLEDGE-BASED MAINTENANCE



bachmann.





EFFICIENT POWER PLANTS

Minimize downtime and failures with
condition monitoring systems.

1,200,000

TREND VALUES PER DAY

3,000

ROBUST EARLY WARNING
INDICATORS PER DAY

FAILURE RATE AFTER TWO
YEARS **6%** LOWER

> € 3 MILLION
SAVINGS PER ANNUM

STATISTICAL AND ESTIMATED NUMBERS FROM 1000 EXISTING WTG

A close-up photograph of a white industrial robotic arm with blue cables, positioned over a green conveyor belt in a factory. The background shows other industrial equipment and a bright, clean environment.

INTEROPERABILITY

As a designer of control systems, Bachmann fully appreciates the importance of interoperability. We have a pedigree in combining automation and control technology with innovative measurement and data processing technologies, both directly and via networking.

INFORMATION TRANSPARENCY

Our systems support full data transparency through network connectivity, without compromising industry best practice in data security. We aggregate data streams from a variety of control and measurement sources to provide a single data flow from your equipment, which can then integrate seamlessly with process models.

TECHNICAL ASSISTANCE

Our visualization solutions are fully customizable to your application, to provide the data your operators need in an intuitive format, combining all your automation systems into a single decision engine.

DECENTRALIZED DECISION MAKING

Our controller modules offer every automation possibility you may need to minimize the need for operator intervention, and to optimize the process in line with your company goals.



INDUSTRY 4.0

Design principles for automation with Industry 4.0

A lot of people talk about Industry 4.0, but what is it and how can it help you? Industry 4.0 is about being able to use the latest digital developments to provide real value to your industrial processes. There are four basic design principles:

- Interoperability
- Information transparency
- Technical assistance
- Decentralized decisions

The next step for automation: We now take for granted the automation of machinery to carry out complex tasks to a high level of quality. At Bachmann we are proud of our track record in enabling this through our control system technologies.

It is now time to take the next step, integrating further innovative measurement and data processing technologies to deliver knowledgebased optimization, reducing your throughlife costs and increasing the efficiency of your maintenance and operations.

Bachmann brings control integrated measurement technology into the world of automation, using innovative robust algorithms to deliver condition monitoring as an integrated part of your Industry 4.0 Strategy.

HOLISTIC APPROACH

Condition monitoring

Condition monitoring with Bachmann Monitoring means more than just measuring vibration: advanced hardware solutions; an innovative web-based analysis software; onsite installation and measurement support; and certified remote monitoring services combine to form a holistic, knowledge-based health monitoring package to support predictive maintenance.

Our modular approach allows you to select the appropriate measurement technologies for your needs, and couple this with the right software solutions and plug-ins for the characteristics of your machines.





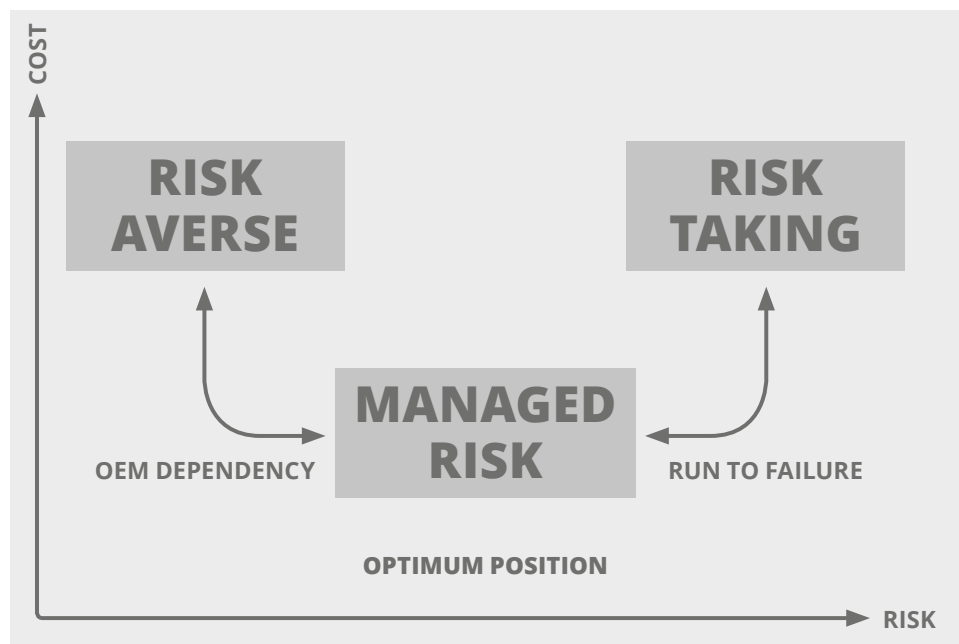
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WHY CONDITION MONITORING?

Focus on efficiency and cost saving

In continuously striving to drive down costs, it is imperative that you can understand what is going on in your machine. By tracking the health of your machine you protect not only your investment, but also optimize your maintenance practices, so that you intervene before consequential damage, but avoid unnecessary measures.

▼ Condition monitoring helps to manage plant operational risks and thus reduce costs.



This knowledge also helps you to plan your maintenance to avoid times of high machine demand and to identify small measures which may improve your output. Monitoring can also shed light on the underlying cause of your problems – is your rotor correctly balanced? Are your grid connections stable? Is your structure experiencing damaging loads? Bachmann can help you to answer all of these questions and drive your maintenance practice to the point of lowest cost without introducing excessive risk.

Condition Monitoring is the use of data to obtain information about the state of a machine. Thanks to the advent of »Big Data«, we have ever more data from which to obtain information, but how do you choose what to measure, how to analyze it and what to do with the results. The ultimate aim of Condition Monitoring is to keep you informed about the status of your machines, thus reducing costs associated with unnecessary repairs or consequential damage and minimizing your risk of unplanned downtime. Simply acquiring data will not help you; the data must be processed into information through the correct analysis, then presented and organized to create knowledge upon which you can act to maintain your equipment. This is where Bachmann's experience can help you. Our hardware systems are designed to give all the right information, and our software and services provide knowledge sharing systems that you can use to optimize your maintenance planning.

Maintenance Strategy

There are three approaches to maintenance of equipment. Maintenance can either be preventative (also known as time based), predictive (condition based) or reactive (run to failure). The regime chosen will depend upon the criticality of the item, the implications of an untimely failure, and the replacement cost for the item.

In reality a combination of all three types is required to produce an optimal maintenance strategy. The correct selection of strategies will

- Reduce planned and unplanned downtime
- Reduce spare parts inventories
- Minimize risk to the plant
- Improve planning through early warnings

These together contribute to significant reductions in O&M costs in both the short and long term.

To underpin the choice of strategy the operator needs to identify the likely failure modes and know what the symptoms of a developing fault will look like. With experience of over 80 turbine types from 30 manufacturers, across over 9000 turbines, we are well placed to support you with this analysis.

Why Vibration ?

Vibration has long been recognized as an excellent parameter for condition monitoring. This is because the different frequencies contained within the signal provide a wide range of diagnostic possibilities, including unbalance, misalignment, bearing and gear defects. In addition, it is easy to measure, and provides a repeatable signal level, given similar operating conditions. In most cases the lead time between fault and failure provides ample time for planning and carrying out the maintenance activities recommended. Bachmann's system of characteristic values and operating classes accelerates the learning process and diagnostics, providing you with early warning of any impending failure. In addition, our newly developed plug-ins can deliver further information relating to tower fatigue and rotor unbalance, thus allowing lifelimiting conditions to be corrected before any critical point is passed.

Experience you can rely on

- Worldwide monitoring of several thousand wind turbines including over 80 different types from a range of manufacturers utilizing both direct drive and geared technologies
- Power range: 600 kW onshore to 8 MW offshore
- Supply and installation of condition monitoring solutions for wind energy, maritime and industrial engineering applications
- DNV-GL certified CMS services: Hardware and software, remote monitoring, reporting, service and training
- Certified CMS – PLC-integrated or stand-alone; easily expandable and flexible; standardized and open communication interfaces; suitable for any turbine type
- Provision of condition monitoring solutions specifically configured for wind power, machine construction and maritime applications

BENEFIT FROM OUR EXPERIENCE IN CONDITION MONITORING

Complete service

A one-stop shop for your condition monitoring needs. Whether it is hardware or software, analysis or consulting – every Bachmann Monitoring solution is based on more than 20 years of experience with thousands of installations monitored worldwide by our DNV-GL certified monitoring systems and services.



What are the advantages of Centralized Remote Monitoring?

Bachmann's Remote Monitoring Team provides a large pool of expertise and knowledge. All staff are trained and accredited, and we ensure knowledge is regularly updated to maintain this. Experience of so many turbines has taught us to recognize a wide range of fault types and severities. Our extended team acts to cover each other in case of sickness or holiday absence, so you don't have to worry about faults that occur whilst your specialist is not available. This also provides the possibility for peer review and second opinions in unusual cases. Furthermore, as independent experts we have no conflict of interests relating to eventual repair costs or liabilities.

Bachmann Monitoring

- An established leader in the field of wind turbine condition monitoring
- Provides the entire chain of hardware, software and service to support condition monitoring
- Continuously develops and updates the CM portfolio on all levels
- Offers modular system solutions, individually configured for any turbine or machine type
- Extensive monitoring experience
- Uses economies of scale to provide highly efficient condition monitoring processes
- DNV-GL certified, and supported by accredited quality systems

BACHMANN REMOTE MONITORING SERVICES

CMS specialists at your side

With sites in Europe, North America and Asia, Bachmann Monitoring offers a worldwide monitoring service that can be used from anywhere.

Our remote center reviews every alarm from your monitoring systems, screening for the most important anomalies and providing expert analysis and recommendations based on our experience. Your team then receive a specific targeted message identifying the fault, its severity, and the prognosis and implications for operation over the next period. Messages are delivered via the internet using WebLog Tickets, from which our customers can see not only the data related to that ticket, but also access any other data from the turbine, or others on their sites for comparison. The system also allows the customer to load the results back into WebLog, including photos and stripdown reports. This means that in future you can compare a new fault with a previous similar event – a true knowledge capture system.

Our remote vibration monitoring service looks after thousands of turbines, including more than 80 machine types from almost 30 different manufacturers, ranging in size from 0.6 to 8 MW. We deliver remote vibration monitoring using our WebLog Expert software, and customers can view the results online through our WebLog package.

With over 20 years' experience in delivering this service, we currently cover more than 10 GW

of offshore and onshore wind assets. All the alarm messages from every CMS are reviewed daily. Our alarms are based on trends of characteristic values which are generated from specific features which indicate the health of the turbine. Where a system has flagged an alarm, the vibration data and trends are reviewed and analyzed in detail. We will also perform a review at the request of a customer, if there is concern over something noted on site. Detailed vibration analysis and diagnostics are performed by an accredited technician. Our technicians undergo training to ISO 18436-2, and are accredited to category 2, 3 or 4, depending on skills and experience. The resulting messages to site, based on this diagnostic information, provide initial root cause suggestions and recommended actions. Reporting of severity and/or urgency is ranked using a simple traffic light scheme.

Our service includes:

- Initial and ongoing system configuration and alarm management
- Regular remote vibration monitoring and diagnostics
- Ad hoc support
- Periodic reporting (at an interval of the customer's choosing)
- Regular service review meetings

Remote vibration monitoring service

Why do we do it? To:

- Provide early warning of developing faults
- Improve maintenance planning
- Inform negotiations with the OEM
- Avoid unplanned availability
- Understand failure mechanisms
- Save our customers money

Case report

One of the gearbox types we monitor is susceptible to a major failure mode. Our monitoring team worked with the customer to identify a frequency band which would reliably inform us of changing conditions on these types of gearboxes. Based on this parameter, an alert was sent to the customer in late August.



The customer inspected, but could see no obvious problems, and attributed the change to standstill marks; however we were not convinced.

The trend continued, and further alarm levels were exceeded. On our advice, and with support from the manufacturer, the customer made the decision to prioritize the exchange of this gearbox.

Benefits

Our service monitors the health of your wind turbine allowing you to concentrate on optimizing your procedures. This leads to:

Increased Availability

- Early detection of faults allows timely intervention before failure occurs
- Accurate diagnoses based on our extensive experience and knowledge bank

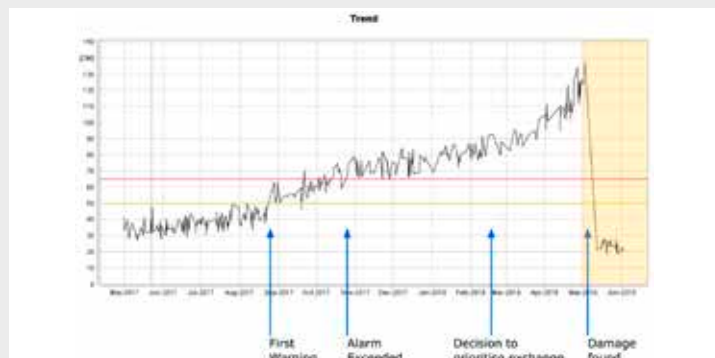
Cost Reduction

- Condition based maintenance and maintenance optimization leads to reductions in maintenance cost

Risk Management

Our experience delivers in-depth knowledge of your wind turbines, which allows you to:

- Understand the status of your wind park
- Confidently challenge the manufacturer or service provider from an informed position
- Improve risk analysis when considering how long to run with minor faults



On exchange it was found that the ring gear had indeed begun to suffer from the damage mechanism, which starts beneath the tooth surface, so is not always apparent via endoscopy, sometimes until it is too late.

Before we found this particular indicator, gearboxes were known to fail catastrophically, destroying the tooth surfaces and bearings. In this case only the pictured gear had suffered any damage, thus saving significant refurbishment costs.

YOUR TURBINES, YOUR DATA

Transparent monitoring, secure communication

At Bachmann, we believe in transparent monitoring while keeping data security in mind. With complete access to all CMS data, customers gain complete visibility into the status of their fleet and are able to make informed maintenance decisions, resulting in greatly decreased O&M spending.



▲ The Remote Monitoring Service centers are a key part of the Bachmann CM portfolio. Specialist teams monitor the connected wind turbines and are available round the clock from centers in Europe, North America and Asia. Data analytics is used to develop informed action recommendations.

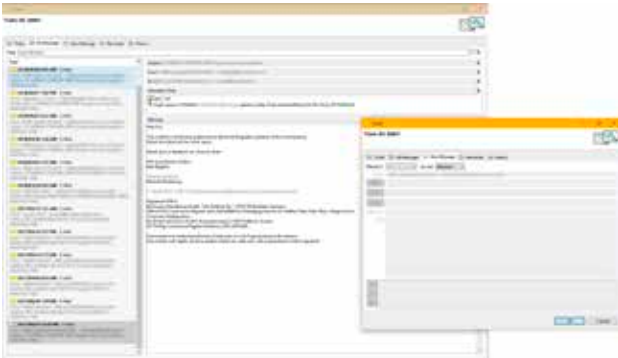
Our remote monitoring services provide customers with dedicated analysts tasked with ensuring all diagnostic information is not only relayed to your team but also understood. Remote centers located in North America, Europe, and Asia staffed with the industry's leading analysts provide increased peace of mind to our customers knowing that further support is always just a phone call away.

At Bachmann, secure data transmission and the confidentiality of the recorded data have top priority. In order to ensure absolutely secure CMS communication, we offer different possibilities to protect outgoing and incoming connections all round: For example, through different firewall options as well as VPN accesses to the plant network. We work with your IT infrastruc-

ture providers to ensure top security standards are met, whilst providing the connectivity needed to allow us to advise you on the condition of your plant and enable you to see all the results.

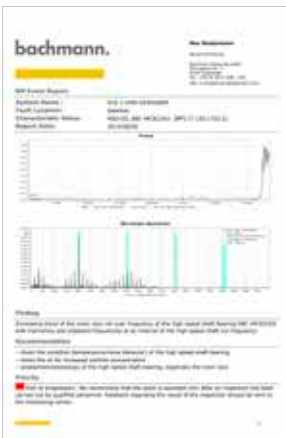
Intuitive reporting

Custom diagnostic reports at the turbine level or fleet level, ensure that your team is provided with the exact information they need, when they need it most. All turbine faults and maintenance activities are logged within WebLog, creating a comprehensive maintenance record for each turbine. Within each diagnostic report, customers are provided with a summary of our expert analysts' diagnostic findings, as well as recommended maintenance actions to follow and all relevant supporting information and CMS data.



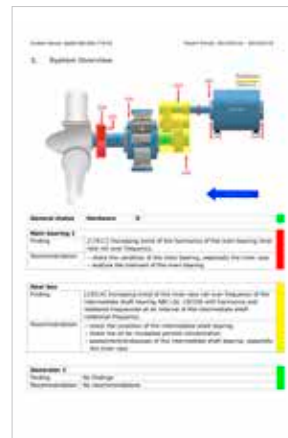
Ticket system

Bachmann's incident-triggered ticket system ensures that no fault goes unseen by your team. Alarms, triggered by machine faults or increases in vibration levels, are sent to maintenance teams via a ticket system that tracks all communication related to outstanding alarms/maintenance actions required. There is easy access to any tickets and related communication between analysts and maintenance teams to track progress. As well as e-mail texts, the ticket system contains all reports generated and sent to our customers in a searchable format.



Event report

These one page reports are generated to provide an overview of a new finding. The data contained is a simple summary of what we have observed and what we suggest you should do. We include our assessment of the severity and urgency of the event.



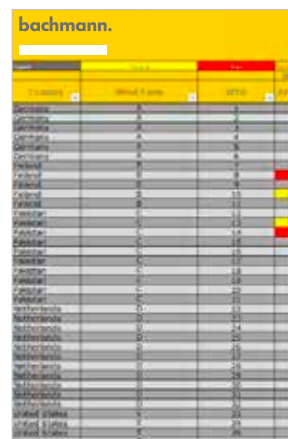
Diagnostic report

The diagnostic report is generated to provide more detail about a specific turbine, and is used to report progression of faults, more detailed information about the effect on the turbine as a whole, and to confirm the current status of a developing fault.



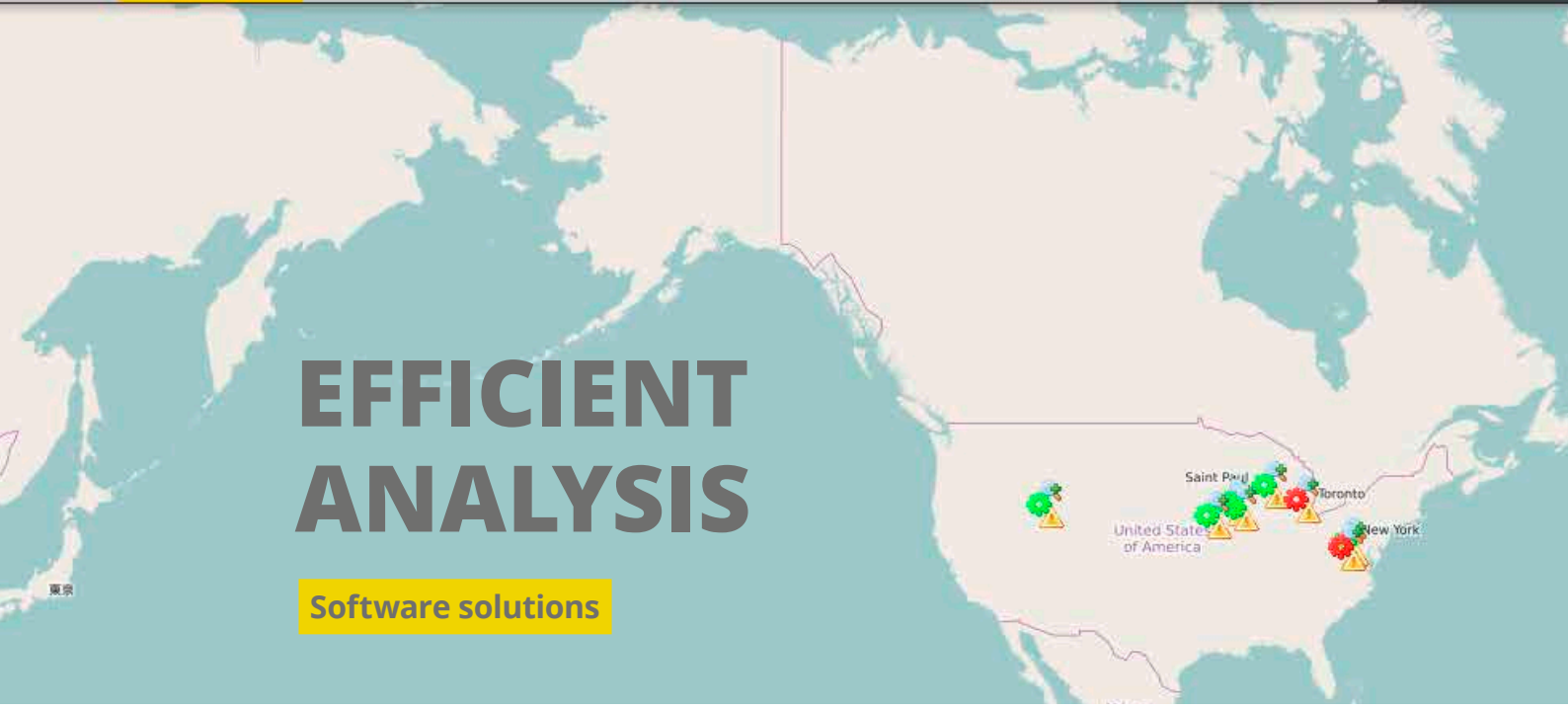
Status report

A status report is generated on a regular basis for every turbine, in line with customer requests, typically quarterly or half yearly. This gives a snapshot of the current status of the wind turbine, including details of any open tickets.



Fleet reporting

To facilitate efficient fleet management, we provide a prioritized status table showing all the turbines in your fleet. The coding is based on standing warnings and alarms. Links from each cell open the tickets containing the details. Using Excel format allows you to filter by country, wind farm or turbine, to simplify the dialog with the relevant fleet managers.



EFFICIENT ANALYSIS

Software solutions

Your CMS hardware alone will not detect or prevent failure. This can only be achieved with the appropriate software to enable expert analysis of the results.

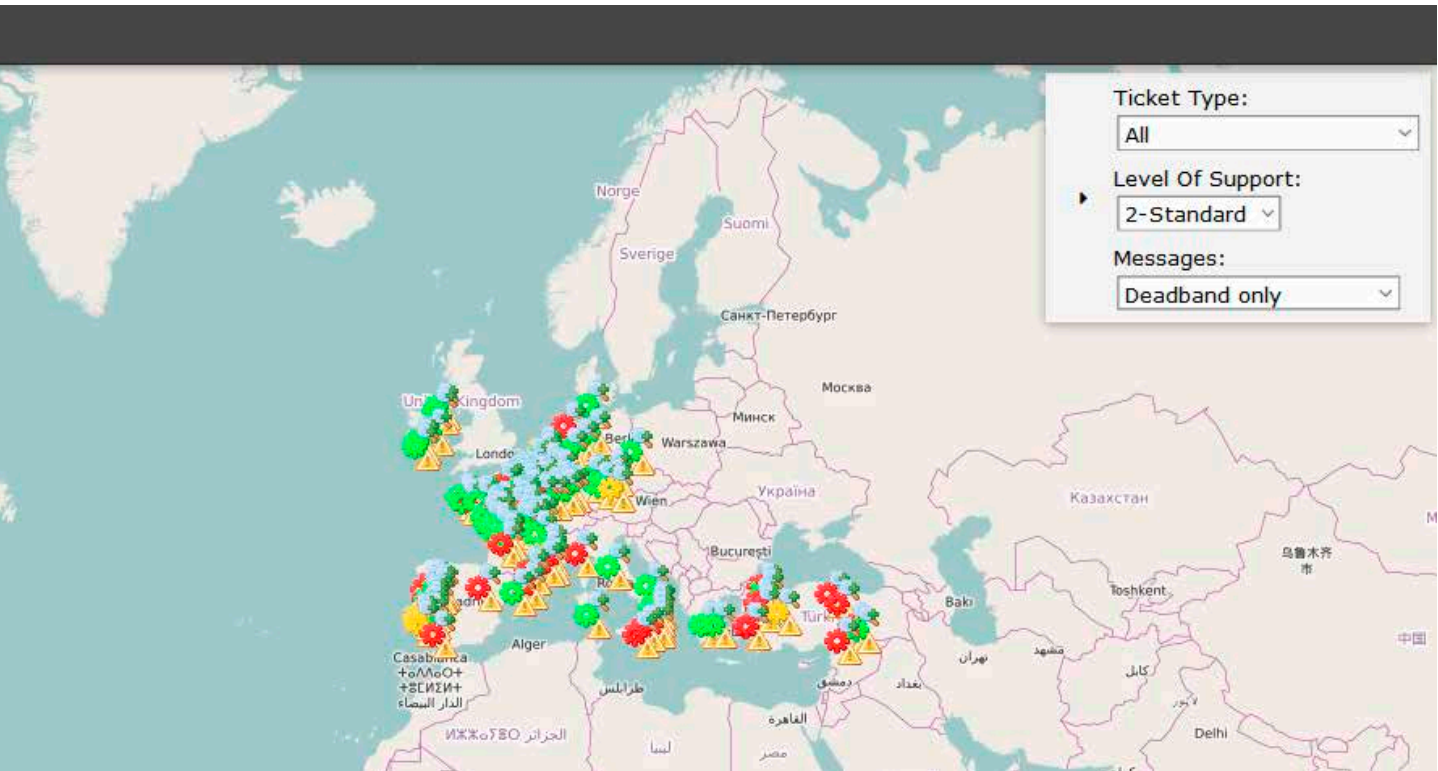
One aspect is the software that runs within the system itself to carry out the advanced signal processing and generate the appropriate characteristic values; another part is the display options, which deliver the information to the customer to drive the appropriate maintenance actions.

As well as providing the hardware for the CM systems, Bachmann have also developed the software to support the systems and the packages for data analysis, which allow our own teams to provide you with expert advice.



CMSSTD

CMSSTD is our controller software which runs on your hardware system. CMSSTD supports the system installation and commissioning, through a web-based interface used by the installers on site, and also carries out the advanced signal processing using our own order tracking algorithms to enhance the accuracy and repeatability of our results. We offer a range of add-ons to CMSSTD which will provide enhanced monitoring capabilities, through which the Bachmann CMS becomes a truly holistic system. The CMSSTD software also enables the transfer of data offsite to our WebLog databases, from which we provide you with full access to your data.

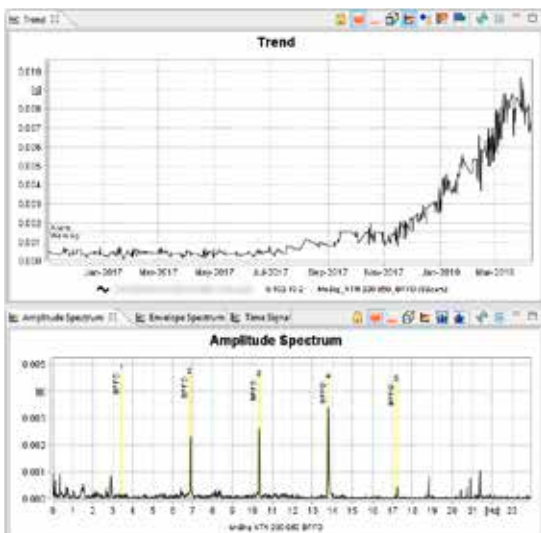


▲ WebLog Alarm Map



WebLog

WebLog is provided to customers of our condition monitoring service. It provides a simple interface to the latest results and tickets generated from the monitoring service. Access can be customized to the specific turbines of interest to a user, which may be a fleet view or a site view, or maybe even a turbine view. The user interface shows a map-based list of current alarms or tickets, with a traffic-light based system, which users can use to choose the turbine of most interest. WebLog is intended to deliver the information needed to drive the maintenance through its ticket system. It is not intended as the platform for expert analysis of individual spectra, although it does include some graphical capabilities. Customers looking to carry out their own analyses should use WebLog Expert.



WebLog Expert

WebLog Expert is a client based software tool, which allows much more detailed analysis of the data and gives access to the configuration of the system parameters. As a client software it must be installed on the user's PC. This is the same software package that our remote monitoring team use for their work, including commissioning and investigations as well as routine monitoring. The database server(s) used are the same as those which drive WebLog, so customers who wish to have greater access to diagnostics need not host data themselves, although Bachmann will support anyone who wishes to do so.

The software also provides comprehensive graphical and trending capabilities as well as full access to the ticket system, into which graphics can be directly copied. It also supports automated report generation onto user specified templates. WebLog Expert therefore delivers all the capabilities expected of a modern condition monitoring system and more. With a highly integrated display layout the system is designed to support our mature monitoring processes, and can also help you to optimist your own.

PREVENTION IS BETTER THAN CURE

Total machine health monitoring



At Bachmann we recognize there is more to condition monitoring than vibration. The ultimate aim of condition monitoring is to prevent failure through the early detection of faults. However, we go one step further and also aim to reduce their occurrence.

Faults occur as part of the wear out process. Loads on a machine will vary continuously as the duty changes, and these repeated load cycles will eventually lead to fatigue failure of the components, such as bearing surfaces, gear teeth, and ultimately nacelle and tower structural components.

But what if we can reduce the loads on the machine parts? First, we have to detect what they are and consider the impact they may be having. Then, by correlating the damaging loads with prevailing operating conditions, we can help you to operate your machine in a way which will prolong its life.

We already have powerful and early fault detection through vibration analysis, but what can we do to take the technology further?

Health monitoring plug-ins

Bachmann are introducing a range of plug-ins to the CMS software and new sensors to go along with these, aimed at monitoring the life usage of the machine rather than just the onset of faults. The first of these plug-ins looks at main rotor unbalance through measurements of tower sway.

Using results from an FEM model, the results are calculated in terms of kgm, so you know exactly how much unbalance is affecting your main rotor, without the need for a costly balance survey. Mass unbalance of main rotors is relatively common and is believed to contribute to main bearing failures and increased tower fatigue.*

Blade Unbalance Calculator

The Blade Unbalance Calculator for Bachmann Monitoring's CMSSTD software, provides calculated mass unbalance results for your rotor. This allows you to identify those turbines which

require mechanical balancing, rather than requiring you to assess the entire farm individually.

The mechanical balance is calculated by a model-based algorithm using basic build data. The model is built once and is valid for all the similar turbines on your farm. Using real-time information from a 2D MEMS sensor in the center of the nacelle, the output from the module is a measure of mechanical unbalance (in kgm). With the addition of an extra position sensor on the main shaft the module will also identify the angular location of the required correction mass.

You can also confirm whether a rotor 1/rev is caused by aerodynamic or mechanical effects, thus allowing you to plan the appropriate corrective action for a time that suits you. There is also full visibility of whether turbine balance is degrading.

We also have a Structural Health monitoring plug-in, which allows rainflow counting of the fatigue cycles of the tower. This information not only monitors the consumption of material life, but, by combining with process data, also allows the most damaging events to be identified, and potentially avoided.

Developments in data analytics give further insight into the health of the whole machine. Often mechanical failure arises from subtle changes in the control of the machines, due to unexpected consequences of normal wear and aging processes. Data analytics allows such changes to be detected earlier, and mitigating actions to be taken, thus removing the sources of damage, rather than waiting for the faults to appear.

*Reference: Dr. Christoph Heilmann, Anke Grunwald, Michael Melsheimer, BerlinWind GmbH: "Auswuchten von WEA-Rotoren: Wirtschaftliche Vorteile und technische Umsetzung", WID-Whitepaper 03/15, Internet portal "Windindustrie in Deutschland" des Bundesverband Windenergie e.V., März 2015)

FLEXIBLE HARDWARE SOLUTIONS

Modular system configuration

Through Ω -Guard[®], the world's first PLC-integrated condition monitoring system to be certified by Germanischer Lloyd, Bachmann offers a variety of options for retrofitting wind turbines or other industrial applications.

Condition monitoring systems are increasingly being fitted to support predictive maintenance. They enable incipient damage to be detected early and thus help improve the planning of remedial actions. Bachmann has a range of configurations to meet the increasing demand. Our PLC-integrated system solution enables the logging, analysis and evaluation of the plant condition in parallel with the PLC program, giving obvious benefits for integration with wider SCADA based data analytics. Alternatively CM systems can be retrofitted to wind turbines: The CMS module here runs independently of the controller environment, either as a complete stand-alone solution or as a TopBox variant in an existing control cabinet.

Complete offering based on experience

Our ongoing hardware and software developments are based on our own significant experience in vibration analysis and condition monitoring, as well as taking into account improvements suggested by our customers. The latest revisions to the hardware allow periods of continuous measurement to be taken, and enable event driven data capture, both utilizing a ring buffer arrangement

within the system. Up to three continuous measurement values per channel can be fed back to the controller, which can be configured in accordance with the ISO Standards for machinery vibration.

Vibration channels can be configured with a variety of filter and sampling channels up to 51.2kHz for the high speed section and down to 100Hz for the low speed sections.

Our system software can also interface with any variable within the control system, either directly in the case of an integrated system, or via a range of standard interfaces such as Modbus, Profinet or CANbus. This means we can provide the full data analytics package beyond just vibration; and use our significant experience to your advantage.

In addition to the monitoring hardware our product range includes the sensors, cables and other accessories. We also offer a portable system that can be deployed as required, such as for investigations or end of warranty surveys on machines with no CMS.

Ω -Guard[®] Portable 18

Built from the same modules that power Bachmann's proven Ω -Guard[®] CMS, OGP18 provides 18 channels of IEPE vibration monitoring for those jobs where using a hand-held system is just not tenable. This may be the case, for example, when wind farm owners restrict access to the nacelle during operation, or when your visit takes place on a calm day. Ω -Guard[®] Portable 18 provides enough channels for a comprehensive survey of your turbine (or other equipment) and can be left to collect data for a period that will ensure you have seen a range of operating conditions. Specific firmware runs

so that you can use your PC's browser to check that you have set up the system correctly, then set the recording going and leave it for the required period. Data is collected whenever the machine is within the defined speed range. Once the data has been collected, the browser software shows whether the recording was successful. Data can be downloaded to your PC then uploaded to a WebLog server for analysis using our WebLog software (also compatible with WebLog Expert). For longer campaigns the network port can be used to connect the device to the internet to allow periodic remote access.



Stand-alone CM solution

A stand-alone control cabinet contains the CPU as well as the measuring module and the relevant power supply units. It is also possible to retrofit a communication unit (e.g. router) to the configuration, as well as to integrate all the relevant components for the sensors.

»Ω-Guard®« Condition Monitoring System

- Online monitoring
- A II-in-one package (sensors, wiring, measuring, evaluation, reporting)
- Stand-alone CMS, TopBox CMS or fully-integrated CMS
- Over 9,000 wind turbines equipped with Bachmann CMS



TopBox solution

PLC-independent installation in the existing control cabinet: fewer hardware and installation requirements.



PLC-integrated solution

Integration in an existing Bachmann controller environment as well as in the existing control panel: fewer hardware and installation requirements.



Ω-Guard® Portable 18

The mobile / transportable solution, giving 18 channels for vibration monitoring and 3 analog inputs for temporary machinery surveys.

Features and benefits of offline use of the Bachmann system

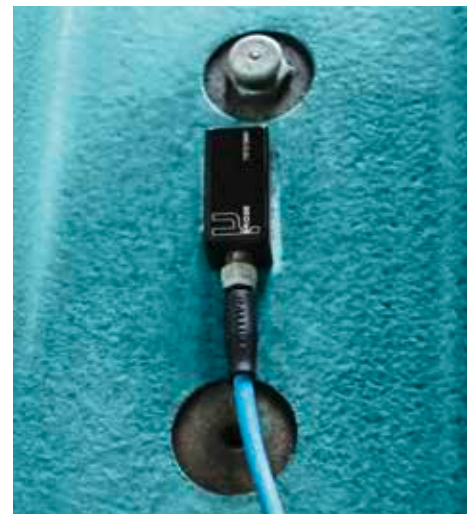
- Mobile system for temporary vibration tests on wind turbines
- Convenient, menu-driven configuration
- Safe storage of measuring results, for long periods
- Data transfer for analyses via WebLog
- Optional: Remote access via the Internet

INSTALLATION AND SUPPORT

Consistent quality guarantee

Effective condition monitoring depends on correct installation. Every Bachmann condition monitoring system is adapted to the turbine make/model, with installation supported using extensive documentation and mobile apps, to ensure stringent quality metrics are met along each step of the way.

► Bachmann specifies the position and type of sensors to be installed beforehand for each machine type. The relevant mounting kits ensure efficient, quick and safe fitting.



Application flexibility

Bachmann offers solutions for every element of the measurement chain

- Design of the measurement requirements
- Configuration of the measuring equipment
- Choice and installation of the sensors
- Installation and cabling
- Data transfer
- Data analysis
- Reporting
- Recommendations

These automated installation tools streamline each installation, document the in-situ work of each project, and provide customers with reports for their records.

Our quality process requires that the installers photograph every part of the installation, allowing us to confirm the quality remotely. Our color coded cabling system assists us by giving a clear picture of where the sensors should be located, and then providing a confirmation that the correct positions and wiring have been completed. We use either our own installers, contractors or customer staff directly trained by our own installers, to

complete the installation. This is followed by remote commissioning of the system using our extensive experience of appropriate characteristic values and thresholds to apply to each section of your machine.

Once sufficient data has been collected, our Remote Monitoring team compiles an end of commissioning report to highlight any issues which may remain, and to confirm the validity of the thresholds chosen.

Onsite Support

Bachmann can offer a range of onsite support for installation and measurements.

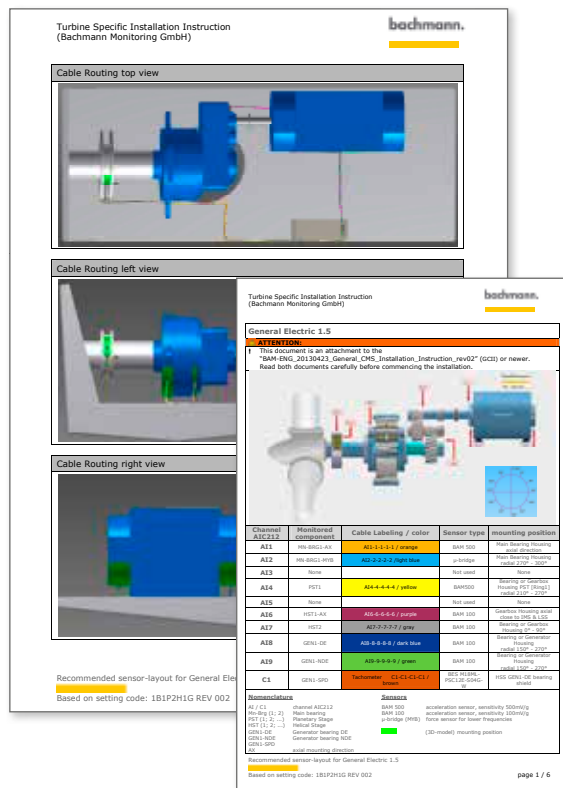
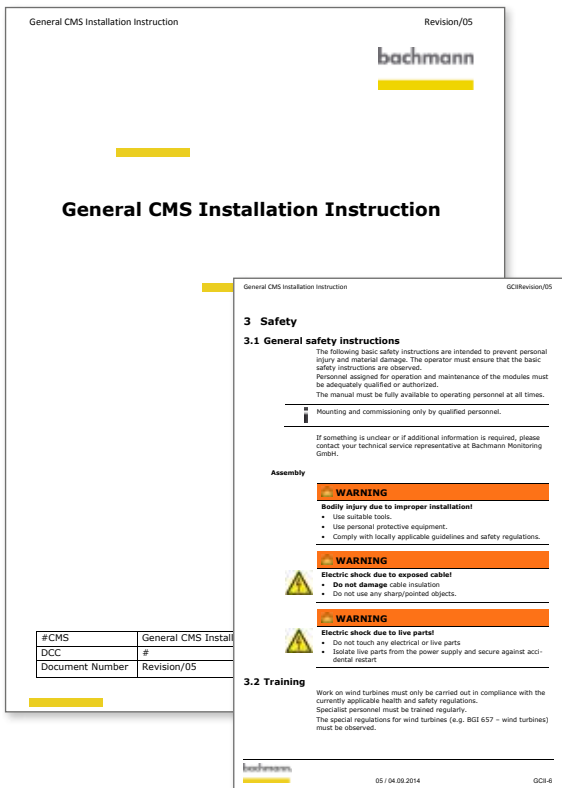
Our installation team can provide the full service themselves, or alternatively can come to the site to train your technicians to ensure accurate installation. We can also help as required with troubleshooting for sensors, set-ups, interfacing and communications.

In addition, we can support one-off measurement campaigns using the Ω -Guard® Portable. We can either visit the site ourselves to set up the equipment or ship the equipment to you to make the measurements. Data can be transferred to us via PC card, USB stick or the Internet. The system can then be moved from place to place around your site until you have collected all the data required.

Our approach is flexible. We can offer any part of the measurement chain:

- Design of the measurement requirements
- Configuration of the measurements
- Choice and installation of the sensors
- Installation and cabling
- Data transfer
- Data analysis
- Reporting
- Recommendations

Temporary measurements cannot replace the security of a permanent monitoring system, but can provide an excellent solution for specific short-term measurement requirements, such as end of warranty surveys – perhaps for comparison with a CMS results provided by the manufacturer – or general troubleshooting and investigation of an unreliable machine.



General CMS installation instructions

- Health and safety equipment required
- General installation rules and tools

Turbine specific installation instructions

- Drivetrain specific sensor installation
- Wiring specifications

VERSATILE SOLUTIONS

Applications & uses

Condition monitoring is a long established technique across all industrial sectors. In particular, vibration analysis is widely used to assess the condition of rotating plants. Bachmann's solutions are equally applicable to all sectors, and our ability to integrate with the automation system enhances the opportunities for data driven analytics and Industry 4.0 methods, relating the condition indicators to the operating conditions.



Our sectors

In addition to wind energy, Bachmann condition monitoring solutions are used in all sectors where Bachmann controllers are also found:

- Maritime applications
- Industry & machine building
- Non wind renewable energy

Our focus

No matter how varied the application the focus always stays the same: we identify the failure modes that can be detected on the various different plant components, such as bearings, gears and rotors, then apply the measurements which will provide information about the condition of the plant. Alongside casing and/or shaft vibration we also record physical measured values such as:

- Plant output
- Temperatures
- Pressure
- Lubricant consistency
- Particles in the oil
- Plus any other relevant parameters, such as wind speed and direction for wind turbines

With our fully integrated system, your condition monitoring data flows seamlessly through your control system, and the operational state of your plant helps inform the condition assessment. Such an integrated approach reduces the costs of installation and improves the accuracy of the outcomes.

Supporting maintenance optimization

Maintenance optimization is not simply applying condition monitoring to everything. Although CM is proven to be the most cost-effective form of maintenance, it is not a cure all. There will still be the need for life cycle counting, regular maintenance activities, and replacement of disposables. Our team will help you to bring together the information you need to inform and optimize your maintenance strategy by:

FMEA analysis, accompanied by identification of detection probability, to consider what is suitable for maintaining on condition.

Data analysis to help you identify the correct basis for scheduled maintenance. Time based, duty based, number of starts or some combination of operating conditions. All these possibilities can be calculated within the controller to give you a real time display of how far towards your next maintenance cycle each preventive maintenance item is. Indicators to help optimize the maintenance visit when the disposables will have reached end of life, or will do before the next scheduled visit (e.g. filter condition, brush condition, oil changes).

Your plant has a wealth of data. Bachmann systems convert this to information, and our teams convert this to knowledge to inform your teams, who combine this with their own knowledge to carry out optimal actions.

TECHNICAL SPECIFICATIONS

Hardware product portfolio

Ω -Guard[®] system variants: The DNV-GL tested and certified Ω -Guard[®] condition monitoring system provides you with an intelligent monitoring system without any mechanical moving parts (hard drives, fans) for use in harsh environmental conditions. The CMS module is available as a 4 channel or 12 channel variant, based on the same underlying design:



Vibration Sensor Input Module AIC214

The AIC214 module offers a vibration monitoring solution that can be fully integrated with the control system. The AIC214 can provide up to 12 channels of IEPE enabled vibration inputs for high resolution, simultaneous monitoring. Up to 3 of these channels may be utilized as general analog input modules for voltages between ± 10 V. Two counter channels are available for speed inputs, or alternatively as a single differential encoder, giving speed, position, direction of rotation and phase within a single measurement.



Vibration Sensor Input Module AIC206

The AIC206 module offers a vibration monitoring solution that can be fully integrated with the control system. The AIC206 can provide up to 4 channels of IEPE enabled vibration inputs for high resolution, simultaneous monitoring. Two counter channels are provided for speed inputs, or alternatively as a single differential encoder, giving speed, position, direction of rotation and phase within a single measurement.



Ω-Guard® Portable 18 (OGP18) **18 channels of IEPE vibration monitoring**

»Ω-Guard® Portable« is our portable solution for temporary capture of vibration measurements, e.g. for an investigation or an end of warranty survey.

For the OGP18, an accessory set comprising cables, connectors and a speed signal is available, customized to the requirements of your survey.



BAM100 / BAM500 Acceleration Sensors

The tried and tested acceleration sensors are provided with an extremely robust housing, a hermetic sealing and an insulated housing, and are thus proven even for demanding ambient conditions. Their minimally invasive mounting on the object as well as compact dimensions make them suitable for difficult to access measuring points.



μ-Bridge Sensor

We developed the »μ-bridge« sensor to capture sound waves and flexural vibrations in machines and plants (e.g. on components, solid bodies, etc.). The structure-borne sound waves emitted by machine parts are characteristic for the wear status of a part.

Our system overview offers you a clearly organized introduction to all Bachmann products, solutions, and services: <https://www.bachmann.info/en/service/download-area/catalog-system-overview/>

Internationally recognized approvals



▲ All the system components used for condition monitoring including the online remote monitoring center are certified in accordance with the regulations of Germanischer Lloyd. The Bachmann automation components are furthermore provided with several internationally recognized approvals for use in all Bachmann automation sectors.

TRUST THROUGH EXPERTISE

Applications for the wind sector

Many of the leading global manufacturers and operators of wind energy plants rely on us. Together with them, we are setting new benchmarks and achieving new success.



ABO WIND

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»I'M CAPTURING NEW MARKETS AND INCLUDING... MY CMS«

How the long-standing customer relationship helps

ABO Wind with internationalization

ABO Wind was one of Bachmann's first customers to consistently pursue the implementation of condition monitoring systems. Both companies are today working together on the internationalization of ABO Wind and are developing strategies for a CMS that is standard worldwide.

ABO Wind demonstrates very well how the wind power sector has matured. The customer relationship developed from the very start, when both companies worked together on making further improvements to the first CMS at ABO in service operations. »Today, this is an established company, making successful steps towards internationalization. Any entry into global markets naturally requires good planning. I have the greatest respect for what they have achieved,« says Holger Fritsch, CEO of Bachmann Monitoring. The journey towards this includes CMS and

Bachmann expertise already integrated in the package. »This is a clear demonstration of trust by ABO Wind. We will make sure that it pays off for them,« says Fritsch. Future issues are discussed and CMS projects are developed in joint workshops. Particularly in countries where operators still have little experience with local logistical challenges, good early detection can save a lot of money and even more annoyance. A standard CMS also makes it easier for the company to set up its own service business in the target markets.



» If you are new to a country, it helps to know the CMS already. A reliable early fault detection system saves money and even more annoyance with overseas logistics. «

Matthias Bockholt
Chairman at ABO Wind

ABO WIND

ABO Wind is an international project developer and wind farm manager from Wiesbaden. Wind power has been the company's core business since 1996, and it already has 600 wind turbines connected to the grid. ABO Wind provides the long term operational management of wind farms, and offers service and maintenance as well as expert technical reports.

www.abo-wind.com

CMS PARTNERSHIP FOR THE DIGITAL BUSINESS MODEL

Revolutionizing the service business with plant data

As part of its predictive maintenance strategy, BKW Group in Germany tested the condition monitoring system from Bachmann Monitoring. The test was so successful that the wind farm operator decided to form a strategic partnership with Bachmann Monitoring! The future aim of the two companies is to roll out a comprehensive health monitoring system for the wind turbine fleet. Status information for imbalance, rotor blade, gears and tower is kept secure in the ownership of BKW and revolutionizes its service business at its plants.



Headquartered in Bern, the Swiss capital, the BKW Group constructs and operates energy production and supply infrastructures and offers digital business models for renewable energy. BKW currently operates ten wind farms in Germany. It invests heavily in wind power and is positioned as a medium-sized power station operator in Europe.

www.bkw.de

Sustainable management and above-average wind yield are BKW's highest priorities. The company achieves this by implementing efficient operational control and a predictive maintenance strategy. During the construction and operation of the wind turbines, the company only carries out those tasks itself by which it can provide added value on account of its own expertise. In the other areas, BKW collaborates with partners with whom it seeks to establish long-term contractual relations. Bachmann Monitoring is its partner for condition monitoring. Together with BKW it is developing a comprehensive, state-of-the-art health monitoring system, which predicts any maintenance needs and can thus optimize the costs for maintenance and logistics.

»In order to standardize our service business, we also need digital standards for the condition monitoring technology, in other words: We definitely want a CMS with some »sense and intelligence«,« says Martina Dabo, head of asset management and development. Holger Fritsch, CEO at Bachmann Monitoring adds: »The partnership is driving progress since it offers us several formal freedoms. We can concentrate

completely on evaluating which plants would benefit from balance monitoring, a rotor blade CMS, gear or tower monitoring. We then draw up the separate individual projects on the basis of the evaluation and implement them.« BKW is pioneering the digitization of the energy system and is using its own data to provide added value to the customer with additional service options. The data is kept securely on the customer's servers so that they have the rights to their own information at all times.

BKW spent a long time thoroughly considering whether to invest in a CMS system. »For them, it was important to examine Bachmann's know-how and solutions before forming a strategic partnership. The human factor was also naturally a key factor here. Both companies have a high level of quality awareness. That's why the partnership works so well,« says Holger Fritsch. The system was initially installed at the Bockelwitz wind farm in Saxony. A task for which Bachmann won the respect of the customer. This resulted in a considerable number of orders for other parks such as those for the Dubener Platte, Bippen, Holleben and Sendenhorst.



PROFITABLE CONDITION MONITORING

Wind turbines in a challenging environment



A fully functional condition monitoring system considerably increases the profitability of wind turbines. CSR Wind Power recognized this fact very early on and now has its own CMS department which equips its wind turbines with suitable systems. The Bachmann M1 automation system has been used for several years as the controller for the CSR Wind Power's 2 MW turbine. Bachmann's tried and tested condition monitoring solution is now also being used in their plants.

CSR Wind Power has ten years' experience in the development and construction of wind turbines. More than 100 wind turbines are currently being delivered to the Huarun Power Group in Hubei province (China) and commissioned. Initially 28 of these systems are being fitted with the Bachmann CMS.

Challenging environmental conditions

CSR Wind Power has been involved in the condition monitoring of wind turbines for many years, and now has its own specially created department for this area. In recent years they have used systems from a wide range of different manufacturers. »We have thus acquired a comprehensive knowledge of CMS,« Xiangyan Ruan, head of CMS at CSR Wind Power, explains. The diverse geography of China is a particular challenge. »The intertidal zone with saline-alkali soil in Liaoning province, Inner Mongolia with its very low temperatures and the high altitudes of the provinces of Gansu, Yunnan and Guizhou – our wind turbines and CMS systems must be able to withstand all these environmental conditions,« Xiangyan Ruan explains the difficulties involved.

Profitable cooperation

The controller system for the 2 MW turbines has been implemented with Bachmann for several years. »We know and appreciate the benefits of the Bachmann automation solution – the high level of reliability speaks for itself,« Xiangyan Ruan says. »On the basis of this experience

we are sure that Bachmann's CMS will function just as well.« The idea behind the project is simple. »We know our wind turbines and the environmental conditions in China like no other – and Bachmann has extensive experience in the field of condition monitoring,« Xiangyan Ruan explains. »Together we now have the opportunity to develop an advanced, practical and comprehensive CMS solution for wind turbines in China.«

Step by step to greater success

The next steps for CSR Wind Power are already planned. The Bachmann CMS will thus be temporarily installed as a stand-alone solution. »We want to be able to understand the system and also examine it,« Xiangyan Ruan explains the idea behind it. A continuous and close exchange with Bachmann is also planned for this. The subsequent step will focus on the testing of the integrated CMS. »Bachmann correlates measured values with other operating parameters, considerably increasing the diagnostic reliability of the condition monitoring,« explains Xiangyan Ruan. »The possibilities resulting from this are very exciting,« Precise statements on the condition of different plant sections can thus be made, the lifespan of already damaged parts extended, and maintenance dates scheduled precisely. CSR Wind Power is excited about the results of the test in all cases: »This approach will soon provide us with a reliable CMS perfectly tailored to the requirements of our wind turbines and the Chinese market,« Xiangyan Ruan sums up.



CSR Zhuzhou Institute CO., Ltd. or CSR Wind Power for short, was founded in August 2006 as a subsidiary of CSR Corporation Ltd. The company develops, builds and sells wind turbines and is one of the top ten in the Chinese wind power market. CSR Wind Power has over 50 years of experience in the construction of locomotives and other components for the Chinese railway. The company is renowned for its wind turbines, which demonstrate a proven track record in terms of reliability, even under varying environmental conditions.

www.wind.csrzic.com



FLEET REPORT OPTIMIZES SERVICE CALLOUTS

Locating error sources and gaining
an overview at lightning speed

So-called Fleet Reports are not so common in the wind sector. These provide a rapid overview of the status of the turbine fleet.

Wind turbine manufacturer Nordex is breaking new ground with Bachmann. The 22 employees in Bachmann Monitoring's CMS center evaluate the data of the plants, assess their status and save the results in the customer's database.

Nordex uses the WebLog Expert, a client-based software, to access the error messages at the click of a mouse, quickly obtain an overview and optimize its service organization.



Plant manufacturer Nordex, headquartered in Hamburg, has successfully grown in recent years. The specialist in onshore wind turbines also grew considerably in the service area. The company invests heavily in technology and in lowering its electricity production costs.

www.nordex-online.com

BACHMANN TRAINING OFFERINGS

Benefit from our expertise

Bachmann Monitoring offer a range of training courses, tailored to your needs. Our expertise in vibration analysis can be shared with you either as basic training to help you understand what the Condition Monitoring reports are telling you, or advanced vibration analysis so that you are able to begin to carry out monitoring yourself. Training for monitoring setup and design explains the details of maintenance strategy, parameter selection and failure mode analysis.

Benefits of engineering training

- Program adaption to individual requirements thanks to the modular concept
- Intensive knowledge transfer through hands-on training
- Training seminars held on site at Bachmann, at a venue of your choice or as webinar
- Access to the in-depth knowledge of Bachmann engineers

We offer specific training based on our software packages – WebLog or WebLog Expert. Another important aspect is training for installers on the correct procedures to follow when fitting a system within a turbine, and how to use our support tools to ensure quality.

Bachmann also offers comprehensive training on the automation system and all its

related technologies, which may be necessary for customers wishing to incorporate vibration monitoring results more closely into SCADA.

We also have experience of establishing condition monitoring centers and can act as consultants to customers wishing to set up their own center.



Basic Vibration Training and WebLog

This training session provides a basic explanation of the principles of vibration, and how these can be used to detect machinery faults. The course then gives an overview of the WebLog tool, explaining how to use its different features, and taking you through the ticket

system and its possibilities. At the end of the course you should have an improved understanding of the messages you are receiving, and be confident in feeding back relevant information to your partners in the Bachman Monitoring team.

Advanced Vibration Training and WebLog Expert

This session is based on the WebLog Expert software, and as such goes into much greater depth on the subject of vibration analysis. As well as the basics of vibration, we cover specific signal processing techniques used to enhance the signals, and provide numerous case studies to support

this information. In addition, the training includes explanations of what you need to do to configure the system in the optimum way for monitoring your machines, both from a theoretical standpoint, and through practical demonstrations of how to achieve this in WebLog Expert.

Condition Monitoring and Maintenance Optimization

Our Experts can also take you through the principles of maintenance optimization, providing examples from their own experience of how different maintenance strategies work, and the pros and cons of each. The course covers the different strategies available, the pro-

cess of FMEA and technique selection, and the expected returns on investment from each. We also discuss the use of Data Analytics to support maintenance decisions and optimization.

Installation Training

Our experienced technicians talk you through the full process of an installation, explaining the software tools, the precautions required on site and the tools and materials you will need for a successful install.

They then hand over to a member from our RM team who will guide you through the process of commissioning, describing the data requirements and the philosophy behind threshold setting and evaluation.

Control System Training

Bachmann offers a variety of levels of training for the M1 products to support the development of automation systems. Even though the training needed for engineering is kept to a minimum thanks to the standard development environment, updating and deepening

one's knowledge of individual engineering areas at regular intervals is worthwhile. The combination of the user's sound knowledge with first-class products is ultimately the key to perfect automation.



BIG DATA PORTAL

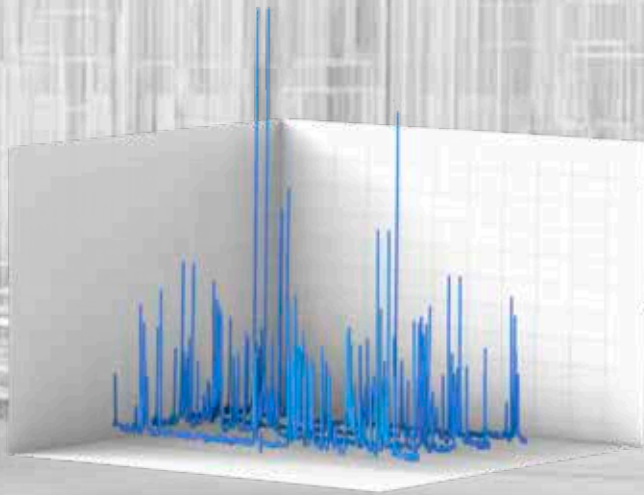
- Data acquisition
- Data analysis
- Data correlation

SMART TURBINE AUTOMATION

- IEC 61400-25 structure
- Integrated safety and CMS
- Grid measurement/protection

SMART GRID AUTOMATION

- Communication
- Substation – park control unit
- Energy protocol



CONDITION MONITORING

- CMS analysis
- Monitoring
- Reporting



WIND POWER SCADA

- Online data
- Historical data, park overview
- RMS values according to ISO 10816-21

AND IN THE FUTURE ALSO AI FOR ENERGY TECHNOLOGY?

»We are making great progress in implementing our AI strategy. Of course, our enormous experience in the wind industry also helps us here. We can base our work on a huge database that has emerged over the last 20 years. We know all the various drive concepts of wind turbines with their sometimes complex fault patterns. At the same time, this gives us a decisive advantage over big data companies. Our customers know this and therefore turn to us with confidence. This confirms our capabilities.«

Holger Fritsch
Bachmann Monitoring, Rudolstadt

