Introduction

The technology used in the wind industry has to comply with the rapid growth in demand for wind energy related services. Even if new designs and prototypes performed by manufacturers and validated by certification bodies offer safer and more reliable wind turbines (with simulations performed more frequently and accurately, mechanical loads of prototypes measured thoroughly, calculations and measurements checked meticulously), their development and related improvement are based on the experience with turbines smaller than those currently being erected according to the relevant standards and recommendations (e.g. load assumptions).

Therefore the technology is still coming up against its limitations. With these limitations occur two direct consequences and one indirect:

- Firstly, damage to gearboxes, bearings or rotor blades and related losses of production.
- Secondly, damage to the relationship with insurance companies who are complaining about high rates of damages and consequently are introducing stronger clauses in their contracts.
- Unfavourable indirect consequences for the image and the acceptation of the wind energy each time an accident occurs on a wind turbine. Although limited, these accidents are most of the time impressive and the press and media find information with dramatic reports and pictures. Who has never seen one of these dramatic pictures produced after fire damage on a nacelle, rotor blades collapsed or wind turbines knocked down and pulled out of the ground?

What can be done to limit as far as possible the negative effects that affect not only the wind farm owners but also have an impact on the whole wind energy industry?

Wind Turbine Inspection, a Strategic Service?

An industrial logic

Wind energy follows an industrial process to generate electrical energy for consumer use. All industrial processes evolve according to a well known life cycle which consists of indispensable steps among which is the commissioning phase followed by an operating period as long as possible or at least as long as expected. An industrial process, as a wind turbine in operation, has to be maintained in optimal condition by means of maintenance and inspection programs. To maintain a valuable industrial facility (the wind turbine),
constant efforts have to be made and pursued at least during the certification period of wind turbines, resulting in 20 years of good and reliable operation!

In spite of the contractual warranty period and related services with the manufacturer, maintenance, inspections and repair actions have to be performed on the turbines. As there are unavoidable steps when realising a wind farm project like the development phase, financing process and construction phase, the operation period requires necessary maintenance and inspection actions to ensure a safe and efficient operation of each wind turbine of the wind farm.

Special care has to be given 6 or 12 months prior to contract completion in order to address the manufacturer with remaining issues before the end of the warranty period. An inspection program properly scheduled is a powerful means to prepare the commercial talks. Results of the various ranges of inspection performed allow substantiating the requests and the needs with technical and practical arguments, before signing the next warranty period with the manufacturer or any maintenance service provider.

Further to this observation, wind farm owners may choose between developing a strong internal technical department with an important investment in manpower as well as in specific equipment, or to mandate an independent company to perform wind turbine inspection and specific inspections for each critical component (e.g. gearbox, rotor blades and generator).

Beyond the economic interest, wind turbine inspections carried out by an independent third party company provides a confidence capital. The owner holds in his hands an important advantage in order to comply with the expectations of lenders, banks and insurance companies.

Conclusions and related recommendations of the expertise made by an independent third party have to be notified, as thoroughly as possible, in a well documented inspection report. This inspection report can be used to reassure and to comfort the lenders, banks and insurance companies on the technical integrity and efficiency of the production goods by enabling them to anticipate outgoings; to assess the need to fund or to adapt the financing package in order to comply with the technical and operational reality.

**Economic facts and current trend**

Despite a worldwide recession of industrial activities, the wind industry continues to gather momentum. The experts of the Global Wind Energy Council (GWEC) forecast a constant growth in wind energy resulting in an increase in worldwide capacity to 460,000 MW in 2015.

The European market is really dynamic and Europe remains a leading wind power market. The European growth is borne by mature onshore markets and newer growth areas in Eastern Europe as well as by the offshore market.

According to the Syndicat des Energies Renouvelables and France Energie Eolienne [1], several leading countries have announced important development and investment plans. Shown below are some of these plans:

- United Kingdom with 100 billion pounds until 2020 among which a large part is destined for wind energy resulting in an increase to 28,000 MW in 2020.
- France where it is planned that 10% of the national electrical consumption be produced by wind energy
in 2020. On 31st December 2010 the global capacity installed in France was 5,660 MW with 3,720 turbines. The objective defined by the government is to increase this to 25,000 MW (among which 19,000 MW will be onshore and 6,000 MW offshore). This represents 8,000 wind turbines thus 4,280 additional wind turbines will have to be commissioned between 2011 and 2020. To meet this challenge, at least 500 wind turbines per year have to be installed in France until 2020.

- Germany plans 23,903 MW.
- Spain plans 16,740 MW.
- Norway plans to create between 5,000 and 8,000 MW.
- Denmark plans 3,180 MW.

Wind energy in France: current events and trend of the regulation

The official publication of the decree concerning the classification named ICPE (installations classified for the environmental protection) was postponed from the middle of July until the beginning of August 2011. This decree concerns facilities producing electricity using the mechanical energy of the wind within an installation subject to declaration in compliance with section 2980 of the legislation regarding the installations classified for environmental protection. Following the last update of the order preparing this decree, article 2 specifies the provisions of appendixes I and II which
would be applicable the day after the official publication of the order. According to section 3.6 of appendix I periodic inspections of the facilities are mandatory. The owner will have to perform an inspection of the wind generator comprising the following points:

- Flanges of connection
- Flanges of mast
- Flanges of the rotor blades
- Visual inspection of the mast/tower
- Safety systems

The results of these checks shall be stated in an inspection report which must be handed over on demand to the Classified Installations Inspectorate.

Besides, according to section 8.4 of appendix I the sound emission (acoustic impact) shall be monitored by the owner according to the terms of the French standard NF 31-114.

### Wind turbine failures and weaknesses of the critical components

A wind turbine is a complex machine functioning in a complex environment. Wind turbines are built by the integration of various technologies and elements coming from aeronautics, mechanical engineering, hydraulics, electrical and electronic engineering, automation, informatics as well as civil works for the foundations. Fig. 2, [3] shows a quick review on the cause of failures occurred on a wind turbine.

As for any integrated system, some of the components are more important than others, so, for a wind turbine, neuralgic components hence identified as critical are the gearbox, generator and rotor blades.

These critical components have to be carefully controlled by means of a maintenance program and regular inspections. If a fault is occurring on one of these main components, it may lead to an unsafe situation for the wind turbine itself and for others but inescapably lead to a financial risk with a loss of production.

Therefore, a wind turbine has to be efficiently controlled by frequent inspections in order to protect the goods and preserve the continuity of production or, at least, to minimise as far as possible the shut down period when performing maintenance work, repair or exchanging a component.

To briefly sum up the situation, on the one hand, there is the demand for wind energy which is rapidly expanding and on the other hand, the heart of the industrial process that converts wind energy into electrical energy, consists of a complex machine made of critical and neuralgic components that may lead to important production losses and repair costs. Now that we have drawn a parallel between these observations, does wind turbine inspection seem to be a strategic service?

### What is this about?

The periodic inspections of the wind turbine and the main components are carried out by an independent technical expert who shall have access to the relevant technical documentation [5].

On the basis of these documents, a specific checklist with the evaluation criteria is prepared in order to perform the inspection. The assessment and results have to be based on the Guideline for the Certification of Wind Turbines of Germanischer Lloyd [5] and the IEC standards [6][7] in their latest editions.

The inspection plan includes all critical components related to the power production, the protection system and the protective measures for safety of the staff.

The inspection report is written and signed by the technical expert. At least, this report has to contain the following information:

- Manufacturer, type and serial number of the wind turbine and the tower
- Location of the owner and the operator of the wind turbine
- Operating hours and total energy produced
- Date and weather condition on the day of inspection
- Persons present at the inspection
- Detailed description of the scope of inspection
- Remarks, defects and deviations found. A timeframe shall be prescribed for repairs and recommended corrective actions.
- Result of the inspection

The owner has to file the inspection reports for the operating life of the wind turbine.

### Which are the Weakest Links of Critical Components?

#### Gearbox

It is generally accepted that gearboxes are the main problem for wind turbines with asynchronous generators because of their complexity and multiple moving parts which are possible weaknesses (e.g. bearings). Gearboxes generate a lot of failures and hence they require more maintenance as well as careful inspections [4].

The reasons for these failures are varied and can be attributed to manufacturing quality lapses when controlling the material supply and production activities, inappropriate design decisions or extreme weather situations on a given site. Several times per year, maintenance teams have to take care of the gearbox. Frequent and complex maintenances request an appropriate program and actions as well as frequent inspections to assess the technical condition and so to define the consistent corrective measures. Statistically, in a wind turbine the gearbox is replaced every 5 to 7 years [4].

Even in a year when a turbine gearbox has not failed, gearboxes represent single-handedly a financial risk because of their environmental impact through their acoustic emission which may lead to possible recourse action or financial resources to be implemented for maintenance work.

### Why do acoustic problems arise on a gearbox?

The noise emission of a gearbox depends both on the disturbances (gear meshing, bearing operation, etc) and on the insulating capabilities between the gearbox housing and the bed frame of the nacelle. Noise created by a gearbox comes from the tooth meshing of the gear wheels. The noise created by the tooth mesh is propagated by the roller bearings toward the frame of the gearbox and the bedplate of the nacelle. Finally the noise is communicated to the external environment of the wind turbine through the tower sections assembled with the bed frame of the nacelle.

A gearbox has got a known acoustic signature and the wind turbine where it is integrated has been certified for a given and known emission noise level. When rollers, bearings or teeth of gear wheels are deteriorated, this also affects the acoustic signature of the deteriorated gearbox.
Generator

Two main categories of failures are known regarding the generators:

1. Winding failure which may result from defective insulation systems or poor winding design
2. Mechanical failure because of early bearing fatigue which may result from poor lubrication

The quality of the insulation is affected over the years because of functional stress. This stress reduces the electrical resistivity of insulations which creates an increase of the leakage currents and then can lead to incidents which may affect the safety of goods and persons as well as causing production losses due to shut down periods (see Fig. 3).

Root causes of defective insulation (See Fig. 4):

1. Electrical origin: Mainly due to phenomena of over- and undervoltages.
2. Mechanical origin: Mainly due to sequences of starting and stopping phases especially when they are frequent, misalignment of the rotating machines (gearbox/coupling part/generator front bearing) and all direct shocks on cables.
3. Chemical origin: Mainly due to the proximity of chemical products like oil, corrosive vapours as well as dust, which impact the performance of insulation materials.
4. Fluctuation of temperature: Mechanical loads from the starting and stopping phases of the equipment lead to fluctuation of temperatures. These fluctuations involve dilation and contraction phases that impact properties of the insulating materials. Furthermore, operating phases with extreme high temperature significantly increase the ageing process.

5. Pollution of the environment: Moisture, particles, deposits in hot and wet areas lead to a deterioration of the insulation properties.

The various root causes add up mutually. By a lack of regular inspections and therefore appropriate corrective measures, the sum of these root causes may lead to incidents and thus loss of production. In order to ensure a safe operation and to avoid incidents with losses of production, it is strongly recommended to perform periodic insulation tests on the generator (windings stator and rotor). These tests allow detecting early defects or premature ageing regarding the insulation properties of the generator’s windings.

Rotor blades

The rotor blades of a wind turbine catch the energy of the wind. This energy is transformed into mechanical energy through the rotor that turns the main shaft of the wind turbine and then the generator to produce electrical energy. The blades are permanently stressed by environmental conditions like rain, moisture, temperature change, ice, UV radiation and of course lightning.

Rotor blades are manufactured with glass-reinforced plastic (GRP), also known as glass fiber-reinforced plastic (GFRP) and epoxy resin with an exterior gel coat. The blade interior structure consists mainly of a spar reinforced with rigid polyurethane foam encased in glass-reinforced plastic (GRP) as well as additional interior strength via “sandwich sheets” in built-up layers.

There are several types of damages according to the localisation of the deviations:

- Inside the blade: cracks at the bonding resin, missing adhesive, discontinuities on the sandwich, delaminations within the glass fiber reinforced plastics (GFRP) or
the sandwich, crack on web, excess of bonding resin, problems in the bonding, waves, air inclusions, etc.

Outside, on the surface: erosion impact on the blade - surface, deviations to observing laminate (spalling, flaking and cavities), deficient bond at the bonding surfaces, cracks and of course lightning strikes.

Critical areas of a blade are beam and webs, bonding (web, leading edge and trailing edge) and the sandwich at the maximum profile depth (see Tab. 1).

It is obvious that rotor blades are a highly stressed part of a wind turbine because of the constant wind contact. They need regular inspection to evaluate their structural safety by experienced experts.

Failures, damages and debris on the rotor blades can reduce the overall productivity of a turbine which can result in expensive repairs and important losses of production. Regarding the economical facts and costs to exchange a blade, it makes sense to be sure that the blades are in a good condition and that they will last a long time.

To face this operational reality, it is strongly recommended to take care of the blades by performing yearly blade inspections as well as making sure that repairs and cleaning are part of the preventative maintenance program implemented by the manufacturer or other maintenance service company mandated by the owner or its operator.

What could be highlighted by a blade inspection?
For example, an abnormal moisture presence. It is necessary to prevent the accumulation of moisture in the glass-reinforced plastic (GRP). Such accumulation of moisture in the GRP leads to mechanical forces in the material which finally explodes. Then severe damages can occur on the rotor blade:

- When moisture penetrates different areas of the blade interior, it may cause imbalances within the blade structure.
- When moisture penetrates the blade structure via previous structural cracks or as a result of surface damage caused from previous lightning strikes.
- Blade repairs that result in surface porosity may lead to future water access.

The worst case is a combination of lightning impact on a blade and residual internal moisture. The high temperatures generated by lightning can lead to the accumulated moisture instantaneously changing into steam by a thermal expansion effect inside the blade. After such a phenomenon, damages observed are: de-lamination, burst bonding, trailing edge cracking, detached blade pieces, de-bonding; longitudinal cracks, spar separation, fires due to presence of hydraulic fluids/lubricants and partial or complete blade destruction.

The aim of regular blade inspections is to reduce the risk by highlighting issues and taking appropriate action immediately. Beyond these facts and observations, the combination of valuable blade inspection programs and appropriated preventive maintenance works may help your relationship with your insurance company.

Wind Turbine Inspection to Ensure a Safe and Efficient Operation

DEWI offers an independent WTI (Wind Turbine Inspection) service:
- At appropriate times
- For periodic technical inspections during life time of the wind farm and of the wind turbine
- With specific inspections on main components

<table>
<thead>
<tr>
<th>Possible damages found on blade</th>
<th>Recommended time for correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor superficial defects found inside and outside (erosion, dirt, spallings, flakings, small cavities)</td>
<td>24 months</td>
</tr>
<tr>
<td>First signs of damage in the structure, several surface defects and thin cracks at the bonding</td>
<td>12 - 24 months</td>
</tr>
<tr>
<td>Damage in the structure, cracks in the shell and in the bonding, several surface defects</td>
<td>3 - 12 months</td>
</tr>
<tr>
<td>Major defects in the main structure and important cracks that decrease the aerodynamic structure</td>
<td>0 -3 months with possible reduction of power</td>
</tr>
<tr>
<td>Damage that cannot comply with a safe operation</td>
<td>Stop of the production for safety reason</td>
</tr>
</tbody>
</table>

Tab. 1: Possible damages found on blade and recommended time for correction

Why performing wind turbine inspections?
- Safety reasons first....
  To verify that the wind turbine under test displays the predicted behaviour in the design and that provisions relating to staff safety are properly implemented.
- ... Economical reasons
  To address issues occurred before the end of the warranty period in order to combine technical safety with a reliable and profitable management within the long term operation of the wind turbine.
Our goal is to bring you the keys in order to maintain your wind turbines in optimal condition by means of an assessment of the current technical state, clarification of technical issues and initial damages summed up with accurate recommendations in a well documented report.

**Fitted inspections at appropriate times**
- At the workshop as soon as nacelles and blades have successfully passed the manufacturing quality control process.
- at the site during the delivery of the components from unloading until the definitive storage condition.
- at certain stages during assembly/construction of the wind turbine or wind farm.

**Periodic inspections**
The complete turbine shall be examined closely by visual inspection on individual components as well as rotor blades [5]. The structural integrity of the wind turbine, including machinery, functioning of the safety and braking systems, shall be checked at the period stated below:
- Just after the commissioning performed by the manufacturer to inspect the work done and to establish a snag list before signing the official take-over certificate of each wind turbine.
- 6 months prior to the contract completion (turbine sale contract or operation and maintenance contract) in order to address to the manufacturer the remaining issues before the end of the warranty period.
- Whenever during the life time of wind farms and wind turbines, recommended every 2 or 4 years.

**Specific Inspections on Main Components**

**Gearbox inspection**
In order to perform a general assessment of the gearbox’s condition, our investigations are aided by a visual and by a video-endoscopic inspection inside the gearbox to detect wear and deviations on bearings and gears.

A gearbox inspection according to the DEWI scope of work includes these following issues:
- Oil sample and analysis: upon request of the owner, the oil analysis including spectrometry, ferrometry and counting the optical particles with a conclusion. **Comments:** If there is an oil analysis report produced within the last three months this report can be used and oil analysis during the inspection is not necessary.
- Gearbox condition: cleanliness, painting, oil level glass, litters added, gear stay, bushings and torque arms condition.
- Oil condition: foam presence, coloured black or not, smells burned or not, sour or rotten odour, increase of oil viscosity.
- Oil tightness: main shaft seal, seal of rotary connector, seal of output shaft, sealing surfaces of covers, split line flanges, gearbox oil lines.
- Gearbox’s cooling system and oil lines cooling systems.
- Inspection of the gearbox via a flexible video-endoscope on all visible bearings, cogs, pinions and sprockets.

**Generator inspection**
A generator inspection according to the scope of work at DEWI consists of these following investigations:
- Verification high speed shaft coupling,
- Verification of the high speed shaft alignment and calculation of the compensations to re-align the coupling train,
- Check if abnormal noise is heard from the bearings (if requested a video-endoscopy and/or grease analysis of the front and rear bearings can be done),
- Generator’s cooling system,
- Insulation test of the generator (stator and rotor).

**Periodic vibration diagnosis**
Since the operation of a wind turbine is certified for a 20-year service life, the following questions arise: when will inevitable maintenance problems occur? How can wind farm owners limit the related costs of this maintenance such as the use of a crane and losses of production knowing that spare parts for wind turbines are expensive and that their delivery on site at the appropriate time can be difficult? Condition monitoring on the drive train is usually associated with both periodic inspection and video-endoscopy of the
gearbox. On the one hand this inspection program allows to verify the technical condition of the complete machine which provides good information for the vibration investigations such as cracks in rotor blades and foundations, problems on components around and inside the gearbox or any excessive wear of components of the wind turbine. On the other hand a vibration diagnosis because an accurate knowledge of the kinematic chain condition allows avoiding the preventive replacement of main and expensive components sometimes required by insurance companies [10]. Therefore this important information allows to answer the problem how best to determine and deploy the most suitable maintenance actions.

With a condition monitoring strategy on the drive train, maintenance intervals can be improved through better day-to-day maintenance routines and hence risky, costly maintenance activities can be reduced. Two strategies exist to perform a good condition monitoring on the drive train:

- **Continuous condition monitoring** based on fixed data acquisition and analysis system, software and wireless communication with suitable sensors which collect data and issues an alarm as soon as the component characteristics start to change.
- **Periodic vibration diagnosis** based on a «check up » strategy. A mobile data-acquisition and analysis system with its measuring instruments is implemented along the kinematic chain from the main bearing to the generator rear bearing for a temporary troubleshooting activity. With this method possible installation and material faults can be detected already during the first diagnosis by comparing the characteristic frequency lines of the measured spectra.

The vibration diagnosis provides early fault detection and allows prevention by means of evidence of initial and potential damages of the rotor bearings, generator or gearbox as well as incipient failures and damages on the gear wheels. For example, these following conspicuous defects can be detected with a periodic vibration diagnosis:

- Problems on rotor blade: unbalanced propeller blades, blade vibrations, small misalignments of a blade angle, first blade wears like delamination...
- Problems with the drive train: misalignment, shaft deflections, mechanical looseness, bearing condition, gear damage, generator rotor/stator problems.
- Problems of lubrication, electrical problems, resonance problems and abnormal tower vibrations.

**When is a periodic vibration diagnosis recommended?**

Most of the requests for a periodic vibration diagnosis are regarding these followings periods and needs:

- When the end of warranty period is approaching, at least 6 months prior to current contract completion.
- Need of an assessment of the kinematic chain after several years of operation, need of an investigation due to abnormal phenomenon which may cause damages (e.g. after operating period with frozen rotor blades), need of a confirmation further an observation made during a periodic or a video-endoscopic inspection (e.g. abnormal noise, possible damages further a presence of particles notified on an oil or grease analysis report).

The diagnosis report shows advices for correcting existing or impending conditions to improve machine reliability, availability and performance.

**Blades Inspection**

Both interior and exterior sides of each blade and its root region are checked for air inclusions, cracks, lightning damages, erosion wears, delamination, defective bonds and other quality problems. The condition of the joint seals, lightning protection systems and additional aerodynamic parts are checked as well as existing rain deflectors or possible repaired areas. The lightning protection system can be verified with a measurement of the ohmic resistance.

**Technical Expertises - Technical Risk Evaluation**

**Financial impact of insurance policies on operation and maintenance budget**

Cost of the insurance policies in application for the wind industry has a significant impact on the budget of operation and maintenance (see Fig. 5 and Fig. 6). The economical issue is to find a fair balance between:

- the requirement of the operational stability and the safety that leads to limited damages and,
The profits generated by low production costs and low running costs with the maximum performance.

The insurance companies apply the same logic to every industrial facility, whether it is a chocolate factory or a wind farm, their problems remain the same.

The best client for an insurance company is the one who shows the lowest risk. The main effort and main difficulties are met within the design of fitted and efficient organisation and solutions to reach the valuable lowest risk situation of the production equipment. Once it is done, the implementation of this organisation year after year allows the owner to forecast heavy maintenance actions and appropriate inspections. By taking care of the expectations requested by insurance companies, the benefit to owners is doubled. On the one hand the financial insurance fees' weight of O&M costs decreases and the maintenance actions and the legal verifications are under control.

Take up the challenge!

To put the production equipment in this profitable situation (lowest risk), the owner has to comply with the expectations of insurance companies and then manage to maintain the benefit of this valuable situation for the duration of the operating period.

DEWI offers an independent technical advice service named Technical Risk Evaluation for wind farm owners as well as for lenders or banks in order to perform a general risk assessment of wind farms.

A full diagnosis focuses on a wind farm or a wind farm portfolio. The objectives are stated below:

• Identify technical strengths and weaknesses of the production goods.
• Identify administrative strengths and weaknesses related to filing and the data and documentation traceability process of the operation and maintenance.

• Determine appropriated actions that may be done to comply with the assessment sheets of insurance companies (performing regular turbine inspections, specialised investigations, improving filing methods or transmission of operation and maintenance documentation, etc.).

• Setting up or follow up of internal program to solve weak points identified through a reasonable period defined by the owner.

• Get well prepared to talk about insurance fees (broken machinery and business interruption) with your current insurance company and/or other ones.

• Reverse the current situation and put the insurance companies in a competitive situation by showing the risk prevention initiatives and corrective actions you have already made as well as your internal organisation set up to reduce the risk level in the wind farm (production equipment).

• Apply this valuable strategy to your other wind farms.

Our independent technical evaluation is performed in close cooperation with the owners. Practically the Technical Risk Evaluation is based on mutual confidence, on analysed documentation, on an active participation of the owner and on visits of wind turbines and sub-stations of which a wind farm is composed (at least 1/3 of the wind turbines per wind farm should have a representative assessment).

The Technical Risk Evaluation consists of three steps:

1. Phase 1: After the visit to the wind turbines and the sub-station and an analysis of the documentation, DEWI elaborates a preliminary report that shows initial conclusions including all possible improvements with accurate recommendations.

THE INDEPENDENT EXPERT HIGHLY RECOMMENDED BY INSURERS

“In some cases, insurers have insisted on regular inspections of wind turbines or even laid down guidelines for the replacement of parts. Risks of premature component failure caused by insufficient quality standards or poor quality of assembly can, say industry experts, be reduced significantly when a greater authority is given to the work and reports of inspectors.

These independent experts, among others, carry out commissioning and end-of-warranty inspections, and are usually in a good position to offer a balanced judgement on the condition of given turbines and specific turbine types.” [10]
2. Phase 2: Upon reception of the preliminary report, the priorities stated allow the owner to define a reasonable period to observe and to perform the recommendations and the appropriated corrective measures.

3. Phase 3: DEWI elaborates the final report that states the corrections and shows the development since the diagnosis provided in the preliminary report. The final report sums up and validates practical facts that demonstrate the commitment of the owner to properly maintain and manage his production facility as well as to guarantee the integrity of the wind farm. The implementation of appropriated means (regular turbine inspection and specialised investigations, maintenance programs, legal verifications…) shows the ability of the owner to handle the risk in order to reduce risks regarding broken machinery and losses of production.

Technical Expertises - Damage Analyses

In case of damage on or caused by wind turbines, DEWI, as an independent expert, can clarify the nature of the damage and determine the root cause at any stage of the defect occurrence, from the component delivery to any time during the operating period. DEWI can be mandated to conduct investigations into the circumstances of the damage and to render a technical opinion (See Fig. 7).

For further information please contact c.hilario@dewi-france.fr

A longer and a French version of this article can be found on www.dewi.de under Publications/DEWI Magazin (issue 39).

References / Literatur:


