0300 Summary

1. Summary

Unit 3 tries to simplify the types of maintenance that exist to avoid the most common incidents in a wind turbine, and also to exemplify some documents with procedures for maintenance tasks.

Wind turbines are very complex engines subject to a number of adverse conditions. The wind velocity, the weather, vibration, and dust are examples of conditions that can contribute to incidents that, if not detected at the right time and not duly fixed, can lead to serious failure.

Vibrations, the continuous movement suffered by the wind turbine during operations, is one of the main factors that can result in failures. It can loosen bolts and connections, it can also produce undesired clearances and displacements in different parts of the wind turbine, and it can result in cracks in the blades, etc. Another common problem that can lead to a possible failure in the wind turbine is dust. Dust (in the form of pollen, fluffs, seeds, insects, etc.) obstructs air flow and reduces cooling – thereby increasing the temperature of different components such as electric cabinets, generators, multipliers, etc.

To eliminate these incidents and minimize the effects of the ones that cannot be avoided, it is important to perform a correct preventive maintenance. Every wind turbine manufacturer has its own preventive maintenance manual. The annual preventive maintenance procedures include a number of tasks, check-ups, and operations in the different systems of a wind turbine. Preventive maintenance is important given the fact that it will enable the improvement of the wind turbine results, through for instance lubrication of mobile parts and adjustments that, if not executed, can cause serious consequences for short-term operations.

Apart from preventive maintenance, there is predictive maintenance also. Its objectives are the same – to improve reliability by reducing possible failures. However, it has some peculiarities. It is based on the analysis of certain components for the early detection of changes in the operation conditions. When this kind of maintenance is performed some data is collected. This data is registered and will be analysed and compared with the previous existing data, allowing maintenance personnel to make estimations that will permit the scheduling of corrective procedures, resulting in minimal impact on the wind engine and to a minimal cost.

Another kind of maintenance, performed in wind turbines, is proactive maintenance. Proactive maintenance consists of an analysis into the origin of existing failure. It focuses on identifying and correcting the causes of failures in industrial equipment components and installations. There are different ways to prevent this kind of failures. Modifications to the design, improvement of maintenance procedures,

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and improvements of training and the involvement of maintenance personnel, are the main objectives of proactive maintenance.

The first task to be done when arriving at the wind farm is to check the condition of each and every wind turbine. If a wind turbine is stopped due to failure, corrective maintenance is needed. Corrective maintenance in a wind turbine is the performance of maintenance work with the objective of repairing possible failures, replacing components, or correcting some anomalous situation detected during any kind of previously performed maintenance. Corrective maintenance can be of varying complexity depending on the type of failure.

A structured scheduling of maintenance is needed to optimize wind farm production. Scheduling estimation is subject to delays for reasons like corrective maintenance, the weather, etc.

Another important topic of unit 3 is information data analysis. Wind turbines produce varying information about their condition and different variables like wind directions and speed, generated output, and others.

The number of hours a wind turbine operates, the production capacity, the mean time between failures, and the mean time until repair is crucial information to know about the wind farm.

In connection with document management in wind farms, there are different types of documents, depending on the related area. Almost all technical documents in wind farms are maintenance manuals that include a list of preventive maintenance tasks to be performed. It also includes documents and procedures defining how to manage quality, occupational hazard prevention, waste management, staff working hours, etc.

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0301 Most common incidents in a wind turbine

1. Summary

Wind turbines are complex engines subject to a number of adverse conditions and to different factor that contribute to the appearance of minor incidents that, if undetected and not duly fixed, can result in more serious failures.

One of the main factors is vibrations. The continuous movement suffered by the wind turbine during operation produces vibrations in all its components. These vibrations can loose bolts and connections, producing failures in electrical connections, hardware breakage in different joints, leakage in the hydraulic system, leakage in cooling circuits, and leakage in lubrications systems, etc.

Vibrations can also produce undesired clearances and displacements in different parts of the wind turbine. One of the systems particularly sensitive to these misfits is the yaw control. The yaw control needs to be strong enough to cope with the stress received by the nacelle and transmit it to the tower, as well as to keep the nacelle facing the wind. The yaw control also has to permit the nacelle to turn 360º when required, what makes necessary a correct fit to allow the nacelle to slide over the tower, minimizing the friction and stress required for do it so.

When there are misfits in the yaw control, there is an increase of frictions and loads, causing premature wear and even breakage of elements such as wheel teeth and yaw pinions, break pads and skids, both axial and radial.

2. Cracks in the Blades

Another undesired effect of vibrations is the cracks in blades. The thrust the blades are subject to due to the wind is not constant, it has up and downs of variable length that cause the blade to move forward and backwards.

Also, especially with moderate and strong winds, when blades rotate, they suffer small accelerations and decelerations, and so the blades suffer variable strains that can cause defects along the time.

Cracks in blades usually start on the surface and, as time goes by and the blade keeps working, those cracks grow both in length and depth, affecting to the inner layers of the blade and putting at risks their integrity. Therefore, it is important to check the blades regularly and, in the case of detecting any crack, to repair it as soon as possible or at least to make a follow up to see its evolution.

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Figure 3.1. *Example of a blade inspection*

Figure 3.2. *Example of a cracked blade incident*

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3. Other Incidents

Other incidents, also caused by vibrations, are the friction of wires and hoses rubbing against different parts of the wind turbine. That friction produces wear in cables and hoses that, in the long run, can cause their breakage producing electric failure or leakages, generally oil or water leakages.

Another factor that causes failure in wind turbines is dampness and water above all. Wind turbines are designed to prevent water from getting inside them, but they are no watertight. In days with rain, snow or fog, the humidity in the inside is high and condensations occur in different elements of the wind turbines. These condensations can create rusting in metal parts and even short circuits in the electrical cabinets.

To avoid short circuits in the electrical cabinets prone to this problem, a heating wire controlled by a thermostat is installed inside the cabinets.

If lager amount of water gets into the blade and freeze could cause misbalance of wind turbine rotor and often cracks occur on the blades. In this case rotating of the rotor get very hard.

Dust in another element wind turbines are exposed to. Dust, pollen, fluffs, seeds, insects, etc., settle on the different filters and radiators of wind turbines, obstructing air flow and reducing cooling, that way producing an increase of the temperature of different components such as electric cabinets, generators, multipliers, etc.

To eliminate part of these incidents and minimize the effects of the ones that cannot be avoided, it is very important to perform a correct preventive maintenance.

Apart from all these incidents, there is another type of them due to faults in the component design, manufacturing faults, assembly faults and also maintenance faults. When a component, a process or an assembly does not comply with the specifications, a Non-Conformance Report should be issued.

Non-Conformances generate corrective actions to solve the detected problems.

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0302 Preventive maintenance

1. Summary

Preventive maintenance consists of a series of regular checking and operations of the different systems of a wind turbine, scheduled along its life span, aiming at preventing and detecting possible failures in time that, sooner or later, could cause a failure in the wind turbine, that way improving its reliability.

Every wind turbine manufacturer has its own preventive maintenance manual, which defines exactly the wind turbine systems to be checked and the frequency to do so.

Some of the systems are: yaw control, multiplier, generator, blades, hydraulic system, electric cabinets, etc. The first preventive maintenance is usually performed before the first year of operation of the wind turbine, usually at 3 or 6 months.

This is an initial preventive maintenance, to check that the wind turbine has not failures that could have occur during its assembly, setup or commissioning.

This initial preventive maintenance is quite thorough, due to the fact that loose bolts, incorrect wiring or inadequate adjustments in stages previous to normal operation can cause serious consequences in the short term of operation, and that is why it is important to detect those failures and correct them as soon as possible.

After this initial preventive maintenance, the rest of preventive services are performed, usually each 6 and 12 months. Six-monthly maintenance tasks usually include lubrication of mobile parts such as bearings and yaw control, and more or less simple checking that do not require long outages for the wind turbines.

However, annual preventive maintenance tasks, apart from including regular six-monthly preventive ones, consist of a higher number or checkings and somehow more costly operations that force the wind engine to a longer outage.

Usually, as annual preventive tasks require the wind engine to stop for a longer period, they are performed in the times of the year with the less wind, generally in spring-summer time.

Here, there is a chart with examples of different preventive maintenance tasks in wind turbines.

SUMMARIZED EXAMPLES OF PREVENTIVE MAINTENANCE	First preventive in 3 months time	Frequency of preventive (in months)
GENERAL		
Check tightness of bolts and screws	-	6
Check metal structures for cracks	X	24
Re-tighten all bolts and screws	X	12
GEARBOX		
Check gearbox oil level	X	6
Check condition of the gearbox gears	X	6
Check the gearbox for abnormal noises or vibrations	X	6
Check for oil leaks along the cooling circuit	X	12
Take some oil samples from the gearbox to analyse	-	12
Replace oil in gearbox	-	36
Replace filters in the gearbox cooling circuit	X	12
SUMMARIZED EXAMPLES OF PREVENTIVE MAINTENANCE	**First preventive in 3 months time**	**Frequency of preventive (months)**
BLADES		
Check blades for cracking	X	12
Check that blades are clean	X	12

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YAW CONTROL		
Check that yaw control works smoothly	X	6
Check that there are no clearances in the yaw control	X	6
Lubricate yaw control pitch-wheel and pinions	X	6
Lubricate yaw control roller track	X	6
HYDRAULIC CIRCUIT		
Check hydraulic oil level	X	12
Check tare weight of main storage battery of hydraulic circuit	X	12
Check that hydraulic circuit filter is clean	X	12
Check for oil leaks along the hydraulic circuit	X	12
Check adjustment of main pressure switch of hydraulic circuit	X	12
Take some oil samples from the hydraulic circuit to analyse	-	12
GENERATOR – ELECTRIC		
Check the generator for abnormal noises or vibrations	X	6
Check that terminals in the generator are correctly connected	X	12
Check that the generator does not leak grease	X	6
Check nacelle sensors	X	12
Check condition of electrical wiring	X	6
Check condition of lightning conductor system	X	12
Lubricate generator bearings	X	6

POWER CABINETS		
Check condition of relays and contactors	X	12
Check for signs of burns or overheating	X	6
Clean cabinets and their filters	-	12
Re-tighten terminals, connection and power bolts and screws	X	6
Check operation of engines magnetothermics	X	12
Check operation of general differential	X	12

This is a very summarized chart. The manufacturer's manual will probably contain more complete charts as well as descriptions of every task to be performed, specifying everything relative to preventive maintenance tasks to perform, including plans, references for materials, adjustments values, etc.

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0303 Predictive maintenance

1. Summary

Predictive maintenance goes a step further than preventive maintenance, therefore, its objective is the same, to improve reliability reducing possible failures, but it has some peculiarities.

This type of maintenance is based in the analysis of certain components for an early detection of changes in the operation conditions.

This maintenance is also performed regularly, collecting some data that we register and gives us the possibility to analyse and compare it with previous existing data, reaching important conclusions about the evolution of the analysed components and enabling us to make an estimation of the remaining life span. That estimation permits us to schedule corrective works with the minimum impact on wind engine outages and production.

That is, with predictive maintenance we act before the failure. It allows performing a corrective work in a controlled and scheduled way, reducing times and costs.

The main predictive maintenance tasks performed on wind turbines are the taking of vibrations and analysis of grease and oils from different mechanical elements as well as thermographies in electrical systems.

2. Vibrations and Analysis of Grease and Oils

The taking of vibrations is performed by special equipment that registers the different frequencies generated by mechanical elements when rotating, mainly bearings. Those equipments collect plenty of information that afterwards has to be understood and analysed. To do so, specific training is required.

The most common place to do vibration taking is in multipliers bearings. Ideally, this should be done twice a year to analyse the evolution of multipliers bearings. That will give us valuable information about the condition and evolution of the bearings, detecting possible premature wear or other problems and being able to schedule the replacement of the relevant part before hand.

Another predictive tool used to study the evolution of multipliers and other bearings is the analysis of grease in the case of generator bearings and others, and oil analysis for multipliers.

Samples of grease and oil are taken regularly and forwarded for analysis. In those analyses the condition of the lubricant itself is checked as well as rests of materials produced as a result of the wear of lubricated elements.

If different indicators show that there is a minimum degradation of grease or oil, and that it is within the correct parameters, it is not necessary to replace it, therefore, with this system of analysis we can make the most of the product and minimize waste, which becomes an advantage compared to preventive maintenance based on scheduled replacements according only to hours of operation.

Grease and oil analysis also give information about the type and amount of metal particles contained, helping us to detect possible failures in early stages.

3. Thermographies

Another predictive method is thermographies. The images taken with thermographic cameras allow us to detect hot spots indicating lubrication problems in case of mechanics, and other sort of problems in electric systems.

In wind turbines, thermographies are more commonly used in electric systems, particularly in power and high voltage.

A hot spot indicates that there might be a losse or incorrect connection, cooling failure, deficient contacts, insufficient wire cross sections, etc.

This information is important to detect this type of problems that if undetected and corrected in time, get worse and can cause an earth leakage or shortcircuits that can even cause a fire.

Another difference between preventive maintenance and predictive maintenance is that the latter does not require to stop the wind turbine, even more, the wind turbine must be in operation for vibration taking and thermographies and, if possible, at rated power so the collected are more valid.

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0304 Proactive maintanance

1. Summary

Proactive maintenance is a continuous improvement technique focused in identifying and correcting the causes of failures in industrial equipment, components and installations. Therefore, it consists in analysing the origin of failure followed by the relevant change in design or in the item's original condition to prevent failure.

This maintenance involves a general management of equipment, because it focuses in technical management, in used procedures and in the people who puts them into practice. There are different ways to prevent failure in equipments: modifications in their design, improvement of maintenance procedures and improvement of training and involvement of the people who use those procedures.

These are two types of design modification:

- Retrofitting, that is modifications performed on items that do not comply with the required design specifications, so these specifications can be met
- Improvements, that are those design modifications performed on an item - that does meet requirements - in order to optimize performance.

The improvement of procedures consists in revising all written maintenance procedures, to carry them out, to evaluate how maintenance staff follows them and to use all that information to improve the said procedures.

Finally, another very important factor to improve results is the correct training of maintenance technicians and their active participation in continuous improvement process. So, s/he will have to think about issues like:

- What should I do?
- How should I do it?
- Why should I do it?
- What is the benefit?
- Can it be improved?

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0305 Corrective maintance

1. Summary

Corrective maintenance tasks are the works performed to repair the different failures that occur in wind turbines, or to replace any component or correct an anomalous situation detected during preventive or predictive maintenance.

A simple rule to recognize whether maintenance is corrective or not is to consider corrective maintenance any work performed on a wind turbine that is not defined or scheduled in the wind turbine preventive works manual.

For instance, a wind turbine stops working because a hydraulic hose has burst and there is a leakage of hydraulic oil, so the said hose has to be replaced. This is a clear example of corrective maintenance, but it can be the case that during a preventive maintenance, a swollen hydraulic hose is detected, and so the hose is replaced before the failure takes place, in this case we also perform a corrective maintenance.

Corrective maintenance can be isolated, that is to say that it only affects to one wind turbine, or it can be general, affecting all wind turbines.

Usually, when the same failure affects to all wind turbines in a wind farm, it is due to a fault in the design of the affected component, and in that case that generates a Non-Conformance, and a corrective action is established, usually consisting of a serial replacement of modification in all the wind farm wind turbines.

Using the same example of the hose, if the failure occurs in one wind turbine, it is an isolated failure, but if it happens in several wind turbines and in the same hose, it is probably because the hose does no resist the existing pressure and it will have to be replaced by a more resistant one.

This replacement will be done in the whole of the wind farm and will affect all wind turbines, even those where the hose does not show any problem yet.

Corrective maintenance can be more or less complex depending on the type of failure. There are corrective tasks that a couple of people can solve in less than one hour, with simple tools (hose replacement), but there are also another type of failures that require a higher number of technicians as well as the use of many tons cranes (multiplier replacement) and last for several days.

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0306 Work instructions

1. Summary

Work instructions are specific documents that establish the procedures to be followed to perform a specific task. The header of the work instructions contains the title of the instruction, the instruction number, the date of drafting and the names of the people who draft and checked that instruction.

Those documents usually have a very similar structure and contain the following sections:

- **Purpose:**

In this section, the objective of the work instruction in question is set out. It gives us information of the reason for the task.

- **Scope:**

The scope gives us information of the limits of application of the works to perform, i.e., which wind farms, which wind turbine model is affected, which version, which system, etc.

- **Reference documents:**

It makes reference to existing documents related to the work of the instruction.

- **Responsibilities:**

It establishes different responsibilities in this instruction and whose responsibilities are.

- **Varied considerations:**

Previous or additional information to take into account when performing the works.

- **Required equipment:**

It includes tools, equipments, personal protection equipment, materials, external services and human resources required to perform the work. They are generally lists.

- **Process:**

Description of the actions to perform, explaining one by one all the steps to follow to perform the task. In need be, some explanatory pictures of the relevant step might be included.

This section describes the tasks to perform and also the precautions to be taken when performing the job to prevent hazards that might cause any accident.

It is a matter of performing the task as safely and effectively as possible with the required quality.

- **Appendixes**

Appendixes are different annexed elements related to the task to be performed. They can be plans, charts, schemes, control check lists, other work instructions, etc

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0307 Maintanence scheduling

1. Summary

The first thing to explain about maintenance scheduling is that it has to be considered that this scheduling is an estimation subject to delays for different reasons, so the tasks have to be re-scheduled along the year.

One of the reasons for changes in maintenance schedules is the possible failures that occur to wind turbines at night time.

The first thing to be done when arriving to the wind farm in the early morning is to check the wind farm condition and every wind turbine. If everything is in good condition, the schedule can be followed, but if there is any stopped wind turbine due to a failure, that usually takes priority over scheduled works, being the first thing to be cared of.

The repair works can last a short time or be extended along several days, which will have a delaying effect on scheduled works.

The number of technicians working permanently in the wind farm is another factor to be considered, as well as if any of them is on holidays. That is taken into account when scheduling annual maintenance, but it has an influence when it comes to repair unexpected breakdown and, therefore, it is a cause for delay in performing scheduled works.

Another important factor that carries a lot of weight to perform scheduled works is the weather.

Wind, rain, snow, cold and heat, they all have an influence on performing wind farms maintenance works, particularly in wind farms located in high areas.

These weather conditions are usually taken into account when scheduling annual maintenance works, but sometimes it is a bit of an imaginative approach, and it is normal to get more or less diverted from the original plan.

2. Weather conditions

Wind is the weather element with the highest influence in maintenance work delays. When the wind is strong, there are is double reason for not performing scheduled works, firstly for safety reason, because some of the tasks cannot be performed up from a given wind speed, and secondly for production, because when those winds the wind turbine works at its rated power and scheduled works are intended -whenever possible- with soft winds or in calm to minimise losses.

This has to be considered when scheduling annual works. Usually, there are times of the year with less wind than others and also, the weather tends to be more

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favourable, therefore a great amount of works are scheduled to be performed during those periods trying to have a minimum impact on the wind farm output. This generally happens in summer time, with the added advantage of more hours of natural light that allows performing outdoors works during all day.

Snow also affects, particularly in wind farms built at certain height, because sometimes it is very difficult or even impossible to drive in the wind farm due to the fallen snow, totally stopping maintenance works.

Both strong heat and very low temperatures have an effect on maintenance works because, for safety reasons, a person should not be exposed to such conditions for many hours having to stop working several times along the day. In extreme cases it would not be possible to work at all.

3. Further information

In short, an annual maintenance work schedule in a wind farm tries to take into consideration all those possible hindrances, but it is normal to find deviations that force a re-schedule and give priority to maintenance works.

As for the management of resources, maintenance works schedule changes depending on the type of wind turbine in the wind farm. It is not the same a wind farm where wind turbines have a lift as one with no lifts.

In wind farms with lifts it is possible to schedule short lasting tasks in many wind turbines along one working day.

On the contrary, not having lifts becomes a handicap that limits the number of wind turbines that can be climbed up in a day and the strategy in those cases is to make a schedule concentrating a number of task for the whole day in one or two wind turbines, thus minimising the number of wind turbines to be climbed in a day.

Tools or special equipment and contracted services are other resources to be considered when work scheduling.

There might be special equipments for specific tasks that, due to their high cost, are hired or shared with other wind farms. In those cases the equipments are used in times of the year when both weather conditions and human resources in the wind farm allow making the most of them.

This might be the case of thermographic cameras, vibration analysers, etc.

The same applies in the case of contracting cranes or companies with specialized personnel and tools, annual scheduling should make the most of these services.

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0308 Information data analysis

1. Summary

Information is constantly generated in wind farms. At all moment, each wind turbine is producing varied information about its condition and different variables. It gives information about wind direction and speed, generated output, diverse temperatures, blades angles, rotational speed, etc.

If we multiply those figures by the number of wind turbines in the wind farm and during 24 hours a day, the amount of generated data must be processed by powerful software that allows seeing all that information in an ordered and filtered way.

With those programs we can see the wind turbine condition and data in real time as well as the historical records of that very same wind turbine, that way we can know the alarms that particular wind turbine has had during a determined period, and to analyse and see the evolution of a particular variable.

This information is crucial to know the wind farm general state in every moment and be able to schedule the work and set priorities.

Apart from the information constantly generated by wind turbines, there is also a lot of daily information related to the works performed in the wind farm. A database is required to entry all works carried out on the wind turbines, so the number of hours and materials used can be noted, and also to know the pending tasks to be performed on each wind turbine.

When scheduling daily work, this database will serve to see the pending works and give them priority according to the situation. This database will also serve to analyse the works already performed in wind turbines in order to detect possible deviations related to consumption or working hours.

2. Indicators details

As for the indicators more commonly used in wind farm maintenance, these are the most widely spread:

- **Availability:**

It is the number of hours of operation of a wind turbine, expressed as a percentage.

Annual availability = (Hours of wind turbine operation per year / Hours in a year) * 100

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For example, the monthly availability of a wind turbine that stopped for 18 hours due to a breakdown in April would be 97.5%. A wind turbine is operative when it is generating energy or when it is waiting for good wind conditions to start generating energy. A wind farm annual availability is the arithmetic mean of annual availabilities of all the wind turbines in the wind farm. Generally, annual average availability is one of the conditions established in a maintenance contract for a wind farm. A good wind farm annual availability stays around 98%.

- **Equivalent hours:**

It is the equivalence in hours of a wind turbine or a wind farm output, or what is the same, the number of hours the wind turbine or the wind farm have been operating at rated power to generate their output.

Equivalent hours = Output / Rated power

For example, if an 800 kW wind turbine has generated 36,000 kWh in total, its equivalent hours is 45.

- **Capacity factor:**

It is the percentage of equivalent hours in relation to the total hours during a determined length of time.

Capacity factor = (Nº of equivalent hours for a given period / Nº of total hours for that given period) * 100

For instance, capacity factor in the former example during April would be 6.25%.

- **MTBF: Mean Time Between Failures:**

It is the average (mean) time between two failures in the wind turbine.

MTBF = Total length of a given period / Nº of failures during period

For instance, the MTBF of a wind turbine that stopped 3 times in April due to failures 240.

- **MTTF: Mean Time To Failure:**

It is mean time a wind turbine remains operative without interruptions along a given period. It gives us an idea of the wind turbine reliability.

MTTF = Operating time in a given period / Nº of failures during period

For instance, the MTTF of a wind turbine with availability 97.5% and that stopped 3 times in April due to failures is 234.

- **MTTR: Mean Time To Repair (Maintenance):**

It is mean time a wind turbine remains stopped due to failure in a given period; this is to say the average time that passes from the moment when the wind turbine stops until it works again. It gives us an idea of the maintenance effectiveness.

MTTR = Time stopped due to failures during a given period / N° of failures during period

For instance, the MTTR of a wind turbine with availability 97.5% and that stopped 3 times in April due to failures is 6, that means that the average time to repair in April was 6 hours.

MTBF = MTTF + MTTR

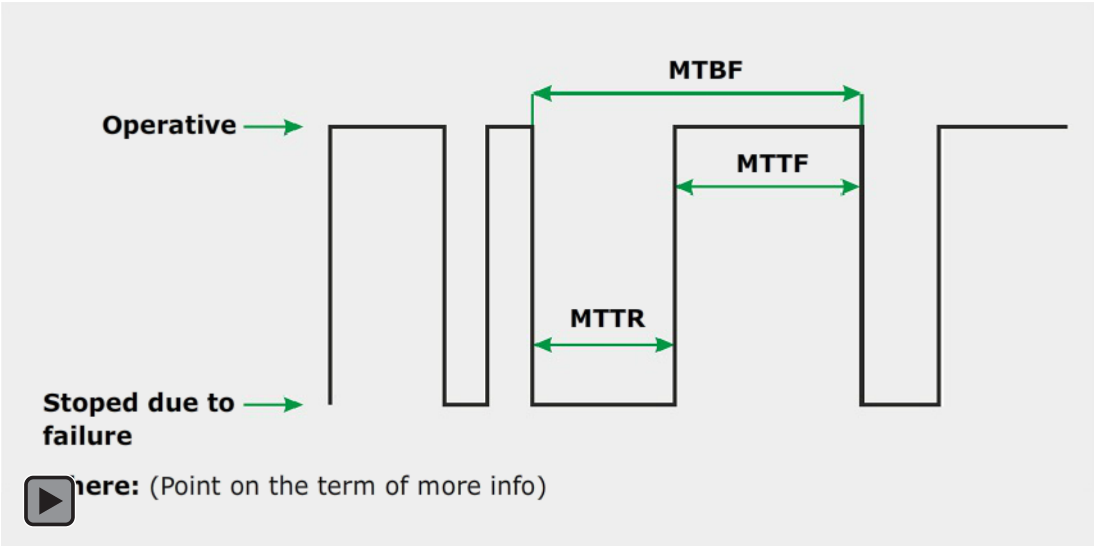

Figure 3.3. *Graphical representation of MTTR, MTTF and MTBF*

3. Further information

The most important maintenance reports are monthly reports, that contain the monthly output and the maintenance indicators described before related to the said month and also related to the annual mean for the year being.

Other data included in the monthly reports are the performed works, both preventive and corrective, along with a study of the main failures occurred during that month.

Apart from monthly reports that inform on the wind farm state and evolution along the year, there are also more specific reports for concrete breakdowns.

When long lasting, costly or exceptional failures take place, detailed reports are drawn to register the failure analysis.

The report indicates the failure cause, the performed corrective works and the preventive measures adopted to prevent that failure from happening again.

It also includes an estimation of the failure cost in terms of hours of work (staff), materials, services and production losses.

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0309 Document information

1. Summary

In relation to document management in wind farms, there are different types of documents depending on the related area. All documents are codified, registered and listed to facilitate search.

And above all wind farm technical documents are maintenance manuals, that include a list of preventive maintenance works to be performed, the wind turbines operating instructions, all kind of wind turbines and wind farm plans, different work instructions, information on chemicals, etcetera.

Both QA and Occupational Hazard Prevention are part of wind farms maintenance; therefore they are included in the technical documents and work instructions.

But there are also documents of procedures to define how to manage Quality, Occupational Hazard Prevention, Waste Management, staff working hours, etcetera.

2. Quality, Occupational Hazard Prevention and Waste

Following there is a brief exposition of the main existing documents for QA, Occupational Hazard Prevention and Waste Management:

In the case of Quality, there are procedures that establish which work equipments should be regularly checked or calibrated, as well as the frequency and way of doing it. These equipment calibrations/checkings generate documents that should be filed and regularly renewed and where you can find the condition and operativeness of the wind farm existing equipment.

The management of Non-Conformances is also included in Quality. A Non-Conformance is a deviation or a failure to comply with specified requirements. Most Non-Conformances in wind farms refer to wind turbines components, but they can also refer to processes.

There are different formats to manage Occupational Hazard Prevention in order to register the training received by workers and personal protection equipment that they are given. There are also documents to complete in the case of work accidents, and proposals of solutions to prevent the accident from happening again.

Another document used in Occupational Hazard Prevention is the Hazard Statement. That document describes potential hazards detected in wind farm maintenance works. The document serves as a basis to study and set the required measures to prevent that hazard.

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There is usually a register in wind farms to record the entrance of staff from outside the wind farm. This book has entries for the date and hour from entrance and exit, the incoming personal details, the company s/he works for and the reason for the visit.

In relation to Waste Management and its documents, the most important document is the Waste Production Register. That book keeps an account of the waste generated in the wind farm. There is a control of the type of waste generated, as well as the amount and the dates when the waste is collected by an authorized waste management company.

Another documents used in wind farms are work control sheets, that have to be completed by the maintenance workers at the end of every working day indicating the tasks performed and to which wind turbines, the number of hours spent in the works and the materials used.

These work sheets are used to update the databases where all works performed on wind turbines are filed, and those databases are also used for daily control of all replacement material inputs and outputs.

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