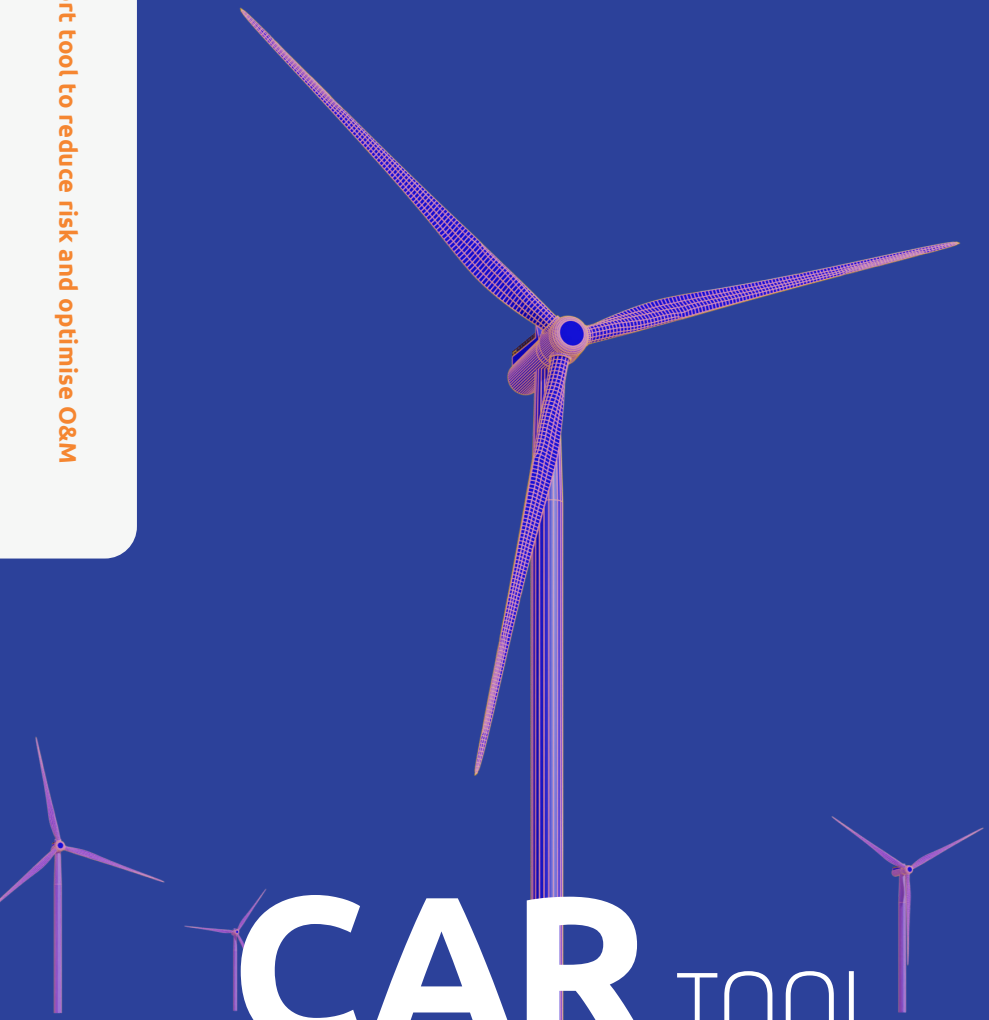
A decision support tool to reduce risk and optimise O&M



CAR TOOL

by Bladena

BLADE ENABLER

This is the CAR tool

The CAR Tool helps Wind Turbine Owners in the decision making during the Operation and Maintenance (O&M) lifetime of a wind turbine. It performs assessment on maintenance strategies based on an internal model that analyses the expected risk and cost of each of the strategies that you as a user create.

The foundation of the CAR Tool is based on a damage propagation model, that estimates the future size growth of a given damage. The output is expressed in terms of cost, risk, and financial indexes, aiming to give a deeper insight about different O&M strategies. A group of tables, plots and figures help you understand these results in a visual and simple way.

The CAR Tool aims to give a solution to the current pains of WTOs during the O&M of wind turbine blades. Increased OpEx costs, prolonged downtime periods and unexpected damages are some of the problems that the CAR Tool addresses. Eventually, you can utilize it in combination with other analyses, to improve the performance of your assets.

How the tool works

Thanks to the cooperation between partners, the CAR Tool has been mainly developed based on two models: an advanced numerical model i.e., fracture mechanics, and a reliability model.

The fracture mechanics model refers to the study of the over-time propagation of structural damages like transverse cracks. Having this type of information, key questions for the O&M decision making can be answered. For instance, when should you make an inspection, when a repair shall be considered, how to inspect the blade etc.

On the other hand, the reliability model, combined with advanced uncertainty analysis, can eventually lead to risk evaluation of the various simulated maintenance scenarios.

1 **Give your input**

The first step is to customize the strategies that you desire to simulate and compare. In order to represent the reality as much as possible, a wide list of variables is offered with its corresponding different options e.g., number of strategies to compare, level of accepted risk, inspection interval...

2 **Upload your data**

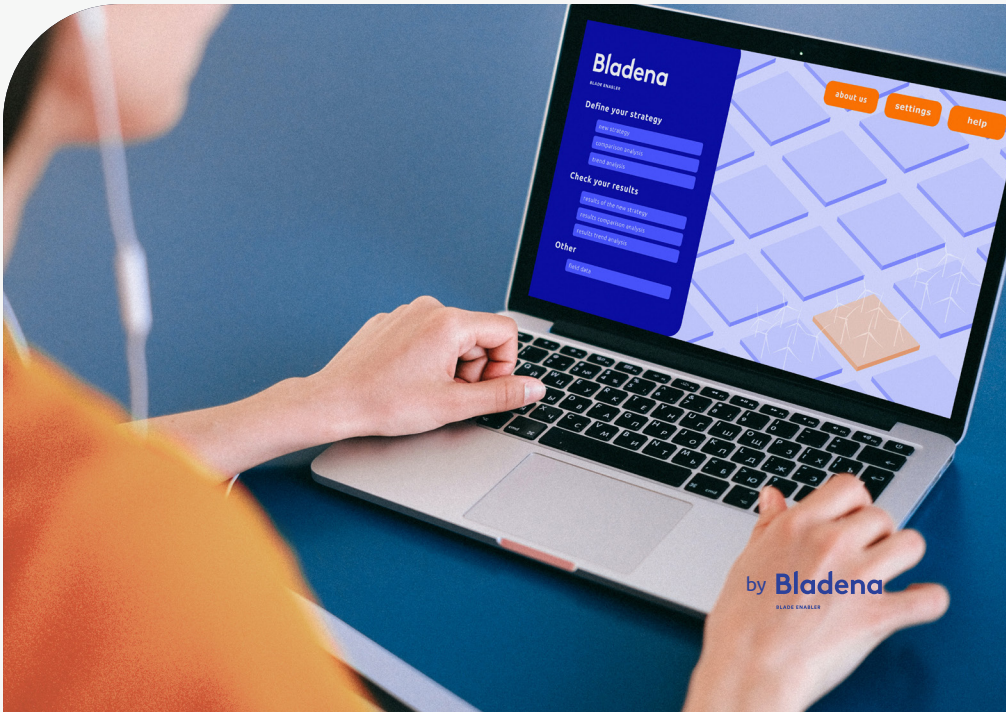
Field data is understood as available measurements from previous inspections. Each location and wind turbine have their own particularities, so by having information for the historical progression of damages, the output of the CAR Tool can be improved. The more filed data, the more accurate the results will be.

3 Run the CAR Tool

Once the selection of variables has been finalized, and field data has been introduced (if available), the CAR Tool will simply start generating the different sets of results.

4 Compare strategies

These results will provide a comparative analysis of the maintenance strategies that have been simulated.
You will be able to detect what the impact will be, from an economical and risk perspective, of your preselected decisions.



Decrease hidden risk

One of the biggest issues that decision makers face during the lifetime of the wind turbine blades is the unplanned repairs, and in general any kind of unexpected OpEx cost that can compromise the initial budget allocation.

Risk is understood as the probability of an event to happen, multiplied by the consequence of that event. The CAR Tool will allow to have an estimation of this risk, which will give the ability to develop more sophisticated O&M decisions and plan the maintenance strategy considering additional factors, such as the reliability of the structure and the expected future costs.

Decision making through digitalization

Digitalization is everywhere nowadays. The more data is introduced in the CAR Tool, the more field measurements are provided by WTOs, and in general, the more functionalities are added to the tool, the closer you will be to have a program that represents the reality that you face when planning your O&M activities. The current version of the CAR Tool represents the first step towards a holistic O&M tool.

The values of the CAR tool

KPI and economic analysis

The economic analysis provided by the CAR Tool is currently focused on risk identification and on some specific indexes like Net Present Value, Internal Rate of Return and Payback Time. However, a deep evaluation of the results can also be turned into valuable knowledge regarding some Key Performance Indicators like: downtime due to repair of failures, downtime due to external factors, hours spend due to reoccurring of similar failures, or medium time to return after a failure and inspection.

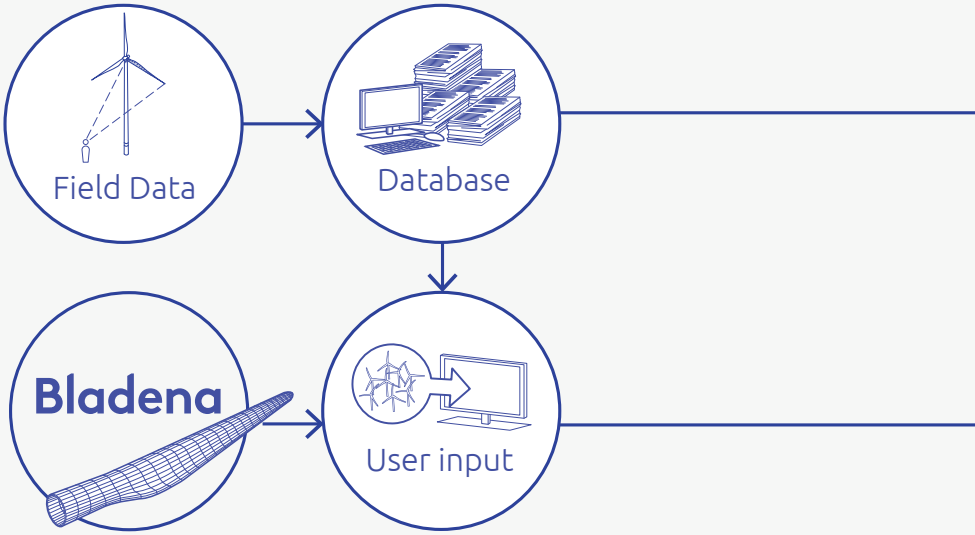
Alternative techniques and strategies

During the inspection and repair campaigns, testing new methods and strategies can be an expensive activity to evaluate. The CAR Tool allows you to check the consequences and advantages of some inspection techniques over others.
In addition, you can “play” with the numerous variables, tailoring the tool to simulate your exact decision making process.
The strategies created might be different from WTO to WTO. So, you will get key information about where specifically, your focus should be on.

Improvement of O&M planning

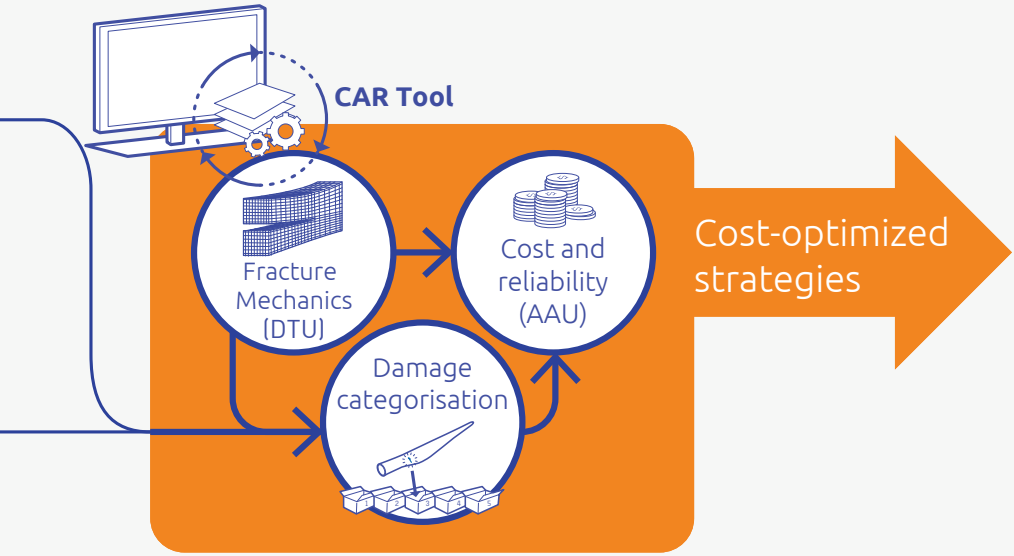
An efficient management of O&M activities is a complex task, as it involves a vast amount of planned and unplanned factors that eventually may impact the annual returns. Therefore, identifying which of these factors, and how much each of them influences the calculated risk, it is considered as an essential and first step to optimize O&M.

Data flow



The CAR Tool is the result of the combination of several areas of research. Partners have cooperated providing feedback, sharing ideas, and establishing as a group the framework of further analysis, creating a flow of data and consequent progress.

This is the case for instance, for the fracture mechanics approach by DTU, for which a group of partners have been in continuous communication designing an appropriate set of testing, as well as a complex global numerical Finite Element Model. The result from this has led to understand how cracks are generated and propagated in blades, which has been the basis for the CAR Tool's solver development.

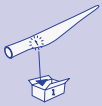


This is at the same time combined with advanced uncertainty analysis provided by AAU, as well as with a big set of considerations covering damage categorization, characteristics of the different inspection methods, most common inspection intervals and other inputs that have been considered for a complete O&M analysis.

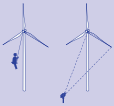
The result: an optimized cost and risk assessment of maintenance strategies.

CAR TOOL - today

simple investment calculations

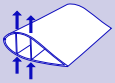


no repair type evaluation



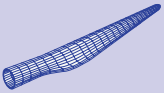
two inspection methods

limited to one blade

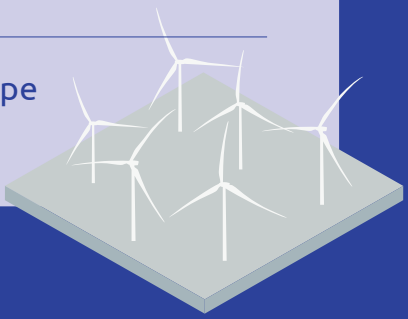


simplified load case

one failure mode



one blade type

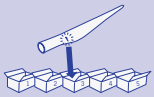


Roadmap

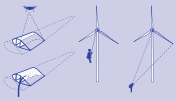
A Minimum Viable Product (MVP) has been developed. What has been obtained so far in the tool covers enough content to provide you with a first valid assessment, but it is still in need for some considerations to represent the reality that you find every day during your O&M activities.

CAR TOOL - future vision

advanced investment calculations



repair type evaluation

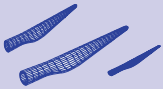


additional inspection methods

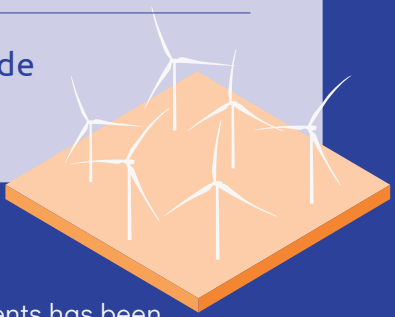
wind farm level

load improvements

additional failure modes



additional blade types



Because of this, a roadmap of further developments has been designed and is already in an initiation phase. The limitations will be studied, tested, and converted into additional functionalities to create a holistic and complete version of the CAR Tool.

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Partners

CORTIR Project

Cost and Risk Tool for Interim and Preventive Repair – includes the development of a sophisticated, yet user friendly, numerical tool (CAR Tool) to optimize the management of turbine blade maintenance in terms of risks and costs, with the main focus to reduce the Levelized Cost of Energy and secure alignment towards maintenance throughout the full value chain.

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