An integral maintenance optimization using a Gravitational Search Algorithm (GSA). An application to onshore wind farm

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In Spain, the actual wind power capacity nearly reaches 20000 MW, what corresponds to a 16 % of the total capacity available to supply the electricity demand [1]. The amount of wind energy produced in the Spanish electric market has increased due to the construction of wind farms and to the improvement in their availability [2]. This improvement, is obtained by the analysis and continuous improvement of the reliability, availability and maintainability (RAM) of wind turbines.
The availability of wind turbines depends on weather conditions, in particular, wind velocity and on preventive and corrective maintenance necessary to guarantee the correct operating state.

The energy produced by a wind turbine is therefore directly proportional to wind turbine availability and wind farm benefits can increase with an appropriate management of preventive and corrective maintenance [3]. The overall availability of wind turbines is increased by maximizing the time interval between repairs and overhauls. Furthermore, suitable maintenance intervals, spare parts and associated man-hours are planned ahead, adding up to greater turbine availability. A key element of such management is an optimal planning of the material resources required to undertake such maintenance. Management of wind turbine spare parts must take into consideration two restrictions: the cost of a spare part not in use, as an example the gearbox cost is over 400.000 €, and the dimensions of such components. So, it is of great important to determine the optimal number of wind turbine components to guarantee a high level of availability considering: the cost of such components, the warehouse dimensions and the wind regimes over a year. To consider the effect of materials resources is necessary to extend the existing analytical models including in these models, the number of available spare parts.

The extended model introduces more restrictions and decision variables; therefore, to search the optimal maintenance planning is a complex task that requires the use of advanced optimization methods.
In this context, the objective of this work is focused on the optimization of the maintenance strategies under unavailability and cost criteria taking into account the maintenance interval and the material resources as decision variables and considering the stochastic behavior of wind to obtain the objective function [4].
An application case is also provided that focuses on maintenance optimization of a wind farm. A meta-heuristic algorithm, such as Gravitational Search Algorithm (GSA)

[5], has been implemented for performing the optimization. This is a heuristic algorithm based on the laws of gravity and the interaction between masses. This algorithm works with a multi-dimensional coordinate system in the space defined by the problem, each point of the space is a possible solution of it.

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