Title: **Stability analysis of parked wind turbine blades**

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Track: **Scientific**

Topic: **……**

Summary:

Wind turbine blades in parked position can experience extremely high flow angles of attack in the region of ±90$_o$, depending on the direction of the incoming wind. Under such conditions the flow is massively separated over the entire bladespan and might significantly contribute to the design loads. The present paper focuses on the stability problem. The linear stability tool of CRES and NTUA is employed with the aim to investigate the aeroelastic stability of isolated parked blades for winds coming from all possible directions with respect to the rotor plane and wind speeds ranging from the cut in up to the survival speed. Results are presented for a reference blade (around 40m) designed in the framework of the EU project UPWIND, under the Work Package 1B1 led by GAMESA.

Description:

The blades of a parked wind turbine might be eventually exposed to local flow angles of attack in the vicinity of 90deg. At such extreme angles of attack massive flow separation takes place over the whole blade span which might generate load variations that can substantially contribute to the fatigue of the machine. Also, in conjunction with extreme winds of 50 years recurrence, they can be considered for situations that drive design loads.

The greatest uncertainty in the aeroelastic modelling of a standing still wind turbine is the prediction of the aerodynamic loads of the fully separated flow over the blades. All existing engineering dynamic stall models provide aerodynamic loads in deep stall conditions for angles of attack lying in the neighbourhood of the C_{lmax} angle. However, none of them is properly tuned or validated in cases where the local flow incidence reaches 90^{degs}.

In the context of the Work Package 1B1 of the EU funded project UPWIND, the stability of a parked wind turbine rotor is considered. The analysis is performed for a 40m blade designed in this Work Package, for a 2MW variable pitch, variable speed wind turbine. The baseline stability tool is formulated by coupling a beam structural model of all the flexible components with a BEM model for the rotor aerodynamics. The Extended ONERA model is used to account for dynamic stall. By implementing an “aeroelastic” finite element and proper linearization about a reference-periodic state the aeroelastic equations become amenable to linear stability analysis. Results of this kind are subjected to uncertainties mainly generated by the aerodynamic modelling in massively separated conditions. In order to moderate these uncertainties a free-wake aerodynamic model is employed. It is based on vortex particle approximations which are released along the trailing edge and tip. In cases of massive separation, the release of vortex particles is extended along the leading edge resulting in a “double wake” [1]. The two vortex sheets interact with each other and through their role up they form a separation bubble that extends over the suction side of the blade. Simulations using this kind of modelling are performed in the time domain and stability analysis is carried out on the resulting time series.

[1] Riziotis and Voutsinas. Dynamic stall on wind turbine rotors: comparative evaluation study of different models. EWEC97, Dublin