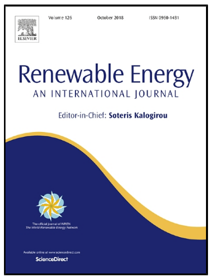

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Active Control of Wind Turbines Through Varying Blade Tip Sweep

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ABSTRACT

In this research work an introduction to the concept of an actively controlled horizontal axis wind turbine through varying blade tip sweep, is presented. The concept refers to variable tip swept rotor blades, that have the ability to pivot collectively aft, about an axis located at the blade tips. Quantities to be controlled are power production and blade loads. The investigation is carried out with a modified Blade Element Momentum (BEM) model that takes into account variable tip swept rotor blades and the modifications are based on results from a lifting line theory based model. The simulations refer to the 5MW NREL reference wind turbine that incorporates a suitable controller and preliminary results show beneficial behaviour in all of the investigated areas.

Keywords – Active Control, Swept Blades, Unsteady Lifting Line Theory, Blade Element Momentum Theory

Abbreviations:

AEP: Annual Energy Production
AOA: Angle Of Attack
BEM: Blade Element Momentum (Theory)
CFD: Computational Fluid Dynamics
CUDA: Compute Unified Device Architecture
DEL: Damage Equivalent Load
DU_SWAMP: Delft University Smart Wind turbine Aeroelastic Modular Processing (model)
ECN: Energy research Centre of the Netherlands
EOG: Extreme Operating Gust
IEC: International Electrotechnical Commission
MW: Megawatt
NREL: National Renewable Energy Laboratory
STAR: Swept Twist Adaptive Rotor
TE: Trailing Edge
TurbSim: Turbulence Simulator
ULL: Unsteady Lifting Line (Theory)

List of Symbols:

A: cross section area – rotor swept area
$\mathbf{A_{mp(x)s}}$: amplitude of a wind turbine parameter due to the harmonic sweeping motion of the blade tip
aif: axial induction factor
$\mathbf{C_L}$: Lift coefficient
$\mathbf{C_{LSW}}$: Lift coefficient of a swept wing
$\mathbf{C_P}$: power coefficient
$\mathbf{Circ_{diff}}$: bound circulation difference between adjacent blade elements