Scalability of floating Vertical Axis Wind Turbines

Elin Andersen, University of Stavanger, elin.andersen@uis.no
Arnfinn Nergaard, University of Stavanger

Universitetet i Stavanger

Background

Wind energy is moving offshore and floating wind turbines might be the next step. In floating applications, vertical axis wind turbines (VAWTs) has some advantages:

- they offer a lower center of gravity,
- they does not need a yawing mechanism,
- sensitive equipment can be located at sea level in a protected engine room
- they offer simpler operation and maintenance (O&M) activity
- they offer suppressed roll/pitch due to gyro-effects

There is a variety of rotor configurations, rotor sizes, blade profiles, blade materials etc., and it is not clear which is the most effective wind turbine rotor type. What is the optimum size and the best material choice for blade manufacturing?

Objective

To investigate the possibility of upscaling floating vertical axis wind turbines (FVAWTs) *to a size where it can produce energy at a competitive levelized cost of energy.*

Examples

Figur 1 Examples of VAWTs: a) Gwind [1] b) Seatwirl [2] c) Deepwind [3]

Methodology

When VAWTs are scaled up to a commerzial size, i.e 5MW, there will be new challenges in the structural design. For a Darreius-type rotors, see figure 1 a-c, with two or three blades, the loads will vary with 2P or 3P, and the wake effects might be considerable.

The wind loads will be determined utilizing the aeroelastic tool HAWC2 [4], and its newer module for VAWTs. Hydrodynamic effects will be included as rotations and translations from global maotion analysis.

The newer developments on isogeometric analysis in finite element methods gives new opportunities for analyzing structures that has a smooth geometry [5]. New finite element types are developed to be capable of modeling the highly anisotropic properties of composite material layups [6].

Fluid-Structure Interaction is a useful tool to evaluate how the rapid change in angle of attack leads to high frequency and high-amplitude variations in aerodynamic torque acting on the rotor [7].

Expected results

Full-scale finite element analysis will be performed to structurally evaluate to what extent floating Vertical Axis Wind Turbines can be scaled up to MW power range.

References:
[1] http://www.gwind.no [2] http://seatwirl.com [3] http://www.deepwind.eu [4] http://www.hawc2.dk
[5] M-C. Hsu, Y. Bazilevs. Fluid–structure interaction modeling of wind turbines: simulating the full machine. (Journal of Computational Mechanics), (Vol. 50, Issue 6), 2012.
[6] J. Kiendl, Y.Bazilevs, M.-C. Hsu, R. Wüchner, K.-U. Bletzinger. The bending strip method for isogeometric analysis of Kirchhoff–Love shell structures comprised of multiple patches. (Journal of Computer Methods in Applied Mechanics and Engineering), (Vol. 199, issue 37-40), 2010.
[7] Y. Bazilevs, A. Korobenko, X. Deng, J. Yan, M.Kinzel, J. O. Dabiri. Fluid-Structure Interaction Modeling of Vertical-Axis Wind Turbines. (Journal of Applied Mechanics), (Vol. 81, issue 8), 2014.