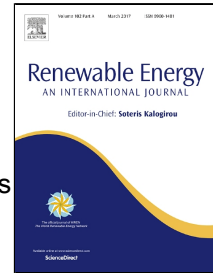


Accepted Manuscript

The influence of turbulence model and two and three-dimensional domain selection on the simulated performance characteristics of vertical axis tidal turbines



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PII: S0960-1481(16)31047-3
DOI: 10.1016/j.renene.2016.11.063
Reference: RENE 8337
To appear in: *Renewable Energy*
Received Date: 06 May 2015
Revised Date: 28 November 2016
Accepted Date: 30 November 2016

Please cite this article as: Philip Marsh, Dev Ranmuthugala, Irene Penesis, Giles Thomas, The influence of turbulence model and two and three-dimensional domain selection on the simulated performance characteristics of vertical axis tidal turbines, *Renewable Energy* (2016), doi: 10.1016/j.renene.2016.11.063

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1 **THE INFLUENCE OF TURBULENCE MODEL AND TWO AND THREE-DIMENSIONAL DOMAIN**
2 **SELECTION ON THE SIMULATED PERFORMANCE CHARACTERISTICS OF VERTICAL AXIS**
3 **TIDAL TURBINES**

4
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15
16 **ABSTRACT:** The influence of Computational Fluid Dynamics (CFD) modeling techniques on
17 the accuracy of fixed pitch vertical axis turbine power output predictions was investigated. Using
18 Two-Dimensional (2D) and Three-Dimensional (3D) models, as well as the Baseline-Reynolds
19 Stress Models (BSL-RSM) model and the $k-\omega$ Shear Stress Transport ($k-\omega$ SST) model in its fully
20 turbulent and laminar-to-turbulent formulation, differences in power output modeling accuracy were
21 evaluated against experimental results from literature. The highest correlation was found using a 3D
22 domain model that fully resolved the boundary layer combined with the $k-\omega$ SST laminar-to-
23 turbulent model. The turbulent 3D fully resolved boundary layer $k-\omega$ SST model also accurately
24 predicted power output for most rotational rates, at a significantly reduced computational cost when
25 compared to its laminar-to-turbulent formulation. The 3D fully resolved BSL-RSM model and 3D
26 wall function boundary layer $k-\omega$ SST model were found to poorly simulate power output. Poor
27 output predictions were also obtained using 2D domain $k-\omega$ SST models, as they were unable to
28 account for blade tip and strut effects. The authors suggest that 3D domain fully turbulent $k-\omega$ SST
29 models with fully resolved boundary layer meshes are used for predicting turbine power output
30 given their accuracy and computational efficiency.

31 **Keywords:** Vertical Axis Turbine, Computational Fluid Dynamics, Turbulence Model,
32 Computational Domain, Laminar-to-Turbulent Transition

33 **Highlights:**

- 34
- 35 • 2D CFD models cannot capture blade tip and strut effects resulting in poor power
36 output simulation accuracy
 - 37 • 3D CFD models can now accurately capture turbine power output without excessive
38 computation requirements
 - 39 • The $k-\omega$ SST turbulence models provide the closest agreement with experimental
40 results
 - 41 • Transition flow modeling is computationally demanding and only increases simulation
42 accuracy at high rotational rates when compared to fully turbulent models
 - 43 • BSL-RSM and $k-\omega$ SST Wall Function models poorly simulate power output

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