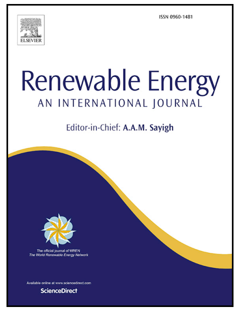
Accepted Manuscript



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PII: S0960-1481(18)31005-X

DOI: 10.1016/j.renene.2018.08.055

Reference: RENE 10482

To appear in: *Renewable Energy*

Received Date: 19 September 2017

Revised Date: 9 August 2018

Accepted Date: 14 August 2018

Please cite this article as: Ahmadi MHB, Influence of upstream turbulence on the wake characteristics of a tidal stream turbine, *Renewable Energy* (2018), doi: 10.1016/j.renene.2018.08.055.

Influence of upstream turbulence on the wake characteristics of a tidal stream turbine

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Abstract

The influence of the upstream turbulence intensity on the flow characteristics downstream of a laboratory-scale horizontal axis tidal stream turbine is investigated in this study. Three test cases with the same mean velocity and different turbulence intensities are simulated numerically using the hybrid large eddy simulation/actuator line modelling technique. The mean velocity components, mean turbulent fluctuations, velocity deficit and wake extension are compared along the streamwise direction to examine the upstream turbulence effects. The inflow conditions are generated by the mapping method using the mean velocity and turbulent profiles experimentally obtained for a turbulent open channel flow. Comparing results for the mean velocity and turbulent fluctuations shows that the upstream turbulence level strongly affects the flow characteristics downstream of the turbine by influencing the tip vortices breakdown process and in turn wake recovery. The comparison also reveals that the ambient turbulence level strongly influences the velocity deficit but it does not significantly affect the streamwise velocity and the radial location of tip vortices in the flow.

Keywords: Tidal turbines, ALM, LES, Turbulence, Wake recovery, Wake extension

1. Introduction

The upstream turbulence intensity (UTI) plays a key role in the behaviour of horizontal axis Tidal Stream Turbines (TST). The turbulent flow approaching the turbines induces continuous changes on their blade loading and power extraction and deeply influences wake characteristics by affecting the mixing between the wake and the surrounding flow. It may affect various aspects of the wake including wake recovery and tip vortex generation and breakdown. In tidal turbine arrays, the flow approaching downstream turbines will be determined by the far wake of turbines positioned upstream and thus the wake of an upstream turbine may inevitably influence the power performance of another downstream turbine. This implies that for more accurate predictions of array performance and optimisation of tidal arrays, a thorough understanding of the upstream turbulence effects on the turbine wake is a crucial issue.

The influence of UTI on the flow characteristics downstream of tidal turbines have been investigated numerically and experimentally. Myers *et al.* [1] showed the close proximity of the water surface has a

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