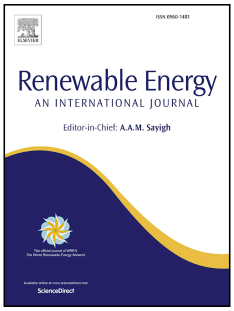

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Characteristics of the velocity profile at tidal-stream energy sites

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Abstract

Realistic oceanographic conditions are essential to consider in the design of resilient tidal-stream energy devices that can make meaningful contributions to global emissions targets. Depth-averaged or simplified velocity profiles are often used in studies of device performance, or device interaction with the environment. We improve representation of flow at tidal-stream energy regions by characterising the velocity profile. At two potential tidal-stream energy sites, the 1/7th power-law with a bed-roughness coefficient of 0.4 accurately described the observed velocity profile on average (>1 month ADCP deployments). Temporal variability in the power-law fit was found at both sites, and best characterised with Generalised Extreme Value distribution; with correlation of variability to tidal condition, wind speed and wave conditions found. The mean velocity profile was accurately simulated using a 3D hydrodynamic model (ROMS) of the Irish Sea (UK) but with temporal variability in accuracy of power-law fits. For all potential tidal sites, the spatial-mean velocity profile was also found to be similar (characterised with ~1/7th power-law and 0.4 bed-roughness value). Therefore realistic flow conditions can be characterised for tidal-energy research, but dynamically coupled wind-wave-tide models, or long-term observations, are needed to fully characterise velocity profile temporal variability.

Keywords: tidal energy; velocity profile; tidal turbine; ADCP; Irish Sea

1. INTRODUCTION

The generation of low-carbon electricity is of global importance as a strategy to mitigate the impacts of climate change and to ensure energy security in the coming century. Tidal-stream energy, the conversion of the kinetic energy that resides in tidal currents into electricity, typically through intercepting the flow via arrays of horizontal axis turbines (Batten et al. 2008), is favoured as a renewable energy resource for a number of reasons such the predictability of tidal energy to provide firm renewable electricity (e.g. Myer and Bahaj, 2010; Neill et al. 2015; Lewis et al. 2015a). For example, the UK government has set a target of 15% renewable energy generation by 2020 (Iyer et al. 2013), with marine energy projected to contribute 4GW from Welsh waters by 2025 and 27GW from UK waters by 2050 (www.gov.uk/government/collections/uk-renewable-energy-roadmap). Yet, a lack of knowledge about the range of oceanographic conditions expected at potential tidal stream sites has been identified as a limiting factor to the growth of the industry (e.g., O'Rourke et al. 2014; Lewis et al. 2015a). Hence, to meet renewable energy targets and provide the UK with a high-tech, globally exportable, industry (e.g., Charlier, 2003); realistic oceanographic conditions at potential tidal-stream energy sites need to be characterised so that resilient, and efficient, tidal-stream energy convertor devices can be designed – reducing the risks and costs of device development (see www.gov.uk/government/collections/uk-renewable-energy-roadmap).

To be economically feasible, tidal-stream energy devices are being positioned in energetic tidal flows, with first generation sites having peak spring tidal current speeds exceeding 2.5m/s and in water depths between 25m and 50m (Lewis et al. 2015a). Hence, tidal-stream energy devices, and their support structures, will be located in the region of flow that experiences friction from the seabed – often called the boundary layer (Batten et al 2008). Friction from the seabed results in