NOVA SCOTIA ENERGY
R&D CONFERENCE 2014
ENERGY FOR CHANGE

Abstract:

R.E. Murray and K. Gracie, Dalhousie University
Research Advisor: Michael J. Pegg
Category: Marine Renewable Energy

Passively Adaptive Rotor Blades for Horizontal-Axis Tidal Turbines: Blade design and baseline performance data

Tidal energy converters (TECs) are currently challenged by large capital and maintenance costs, especially in the Bay of Fundy, which have a significant impact on the overall economic viability of the device. TECs with high capital expenditures face significant barriers to entry given that investors are required to absorb considerable financial risk, and high operating costs will require an elevated feed-in tariff by electricity corporations to attract developers. In order to become economical, these expenses must decrease by optimizing power capture and/or decreasing capital and maintenance costs.

Currently, a large percentage of turbine failures leading to unscheduled maintenance requirements are a result of blade failures and problems with variable pitch mechanisms. Also, high turbine structural loads necessitate heavy and expensive turbine support structures which currently make up a large percent of the capital cost of a turbine.

This work reports the outcomes of research into rotor blades which self-adapt to varying loads, called passively adaptive blades. Passively adaptive blades use non-homogeneous composite materials which can be tailored to couple flap-wise bending deformation with span-wise twisting (bend-twist coupling). This enables the design of blades which feather as flow speeds increase, thus decreasing loads on the blades and structure, and potentially capping the power output at high flow speeds. Decreased blade loads means longer blades can be used with an existing support structure, resulting in more power production for the same structural loads. Compared to complex, expensive and potentially high maintenance variable pitch blades, passively adaptive blades are have no moving parts, making them potentially lower maintenance.

An experimentally verified composite construction finite element model (FEM) is currently being used to inform the design of scale-model passively adaptive blades. A 0.764 m three-bladed horizontal axis turbine with rigid NREL S814 blades was tested dynamically in a tow tank to quantify baseline performance data and to identify blade root bending moments and thrust loads. These loads were used in the FEM to study the influence of difference composite layups and blade materials. The first blade design iteration will be tested statically to verify FEM predictions, and a second-iteration blade design will be compared against the dynamic performance of similarly sized rigid blades.