NREL Developing a Numerical Simulation Tool to Study Hydrokinetic Energy Conversion Devices and Arrays

New capability will help accelerate design improvements by providing a high-fidelity simulation tool to study power performance, structural loading, and the interactions between devices in arrays.

To efficiently develop robust marine hydrokinetic (MHK) technologies that are cost competitive, powerful numerical simulation tools are needed to reliably predict device and array performance and reliability. Traditionally, simplified analytical and potential flow methods have been used; however, the deployment failures of several prototypes designed using these simplified analysis methods have demonstrated the need for higher-fidelity simulation tools. These tools capture the effects of complex environmental conditions and nonlinear fluid-structure interactions, such as turbulence, vortex shedding, wave slamming, and device array interactions.

To address this need, a modeling team at the National Renewable Energy Laboratory (NREL) is developing an open-source computational fluid dynamics (CFD) code that uses the large-eddy simulation (LES) method coupled to a hydroelastic model to simulate wave energy converters and water current turbines. The code has the ability to model multiple devices and capture important nonlinear physical interactions between the device and the marine environment. To date, an alpha version of a code that is capable of modeling current turbine arrays in realistic bathymetric settings with turbulence has been completed. This code has been utilized to simulate a tidal current turbine array to better understand the effects of turbine array design on wake propagation and power production. The results characterize the loads that the turbines must be designed to withstand and suggest array configurations that maximize power production. In the future, further augmentation and use of the combined LES-hydroelastic code will help accelerate the development of effective, efficient, and reliable hydrokinetic energy conversion technologies, thus helping to lower the cost of electricity produced using MHK devices and arrays.

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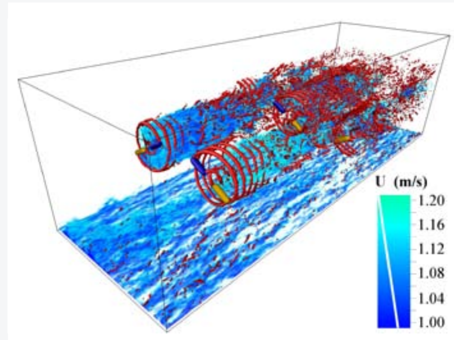
Reference: Churchfield, M.; Li, Y.; Moriarty, P. (2012). "A Large-Eddy Simulation Study of Wake Propagation and Power Production in an Array of Tidal-Current Turbines." Accepted by *Proceedings of the Royal Society A: Mathematical Physical and Engineering Sciences.*



Current turbine array simulation using LES model. Illustration by Mathew Churchfield, NREL

Key Research Results

Achievement

NREL researchers are refining a high-fidelity LES model that can predict the performance and loading of water current turbines and wave energy converters in arrays.

Key Result

This model will enable more accurate device design iteration along with more optimal array design and site selection and planning.

Potential Impact

As it enables a better understanding of MHK farm performance, this tool will contribute to increased annual energy production and reliability, therefore reducing the cost of electricity.

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