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Modelling Tidal Flow Turbulence Characteristics and Tidal Power Plants using Large Eddy Simulations (LES) and Actuator Line Method (ALM)

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The sustainable development goals of the UN include an increase of the renewable energy share in the global energy mix. Electric power generation from current and tidal energy is one component for sustainable energy production. The Deep Green, a tidal power plant developed by Minesto, is now undergoing full scale tests in realistic conditions. It uses a unique technology with a flying “kite” sweeping the tidal flow approximately perpendicular to its main direction several times the tidal flow velocity. This operation enables it to utilize lower flow velocities compared to many other tidal power plants. These power plants will eventually form arrays and it is then necessary to know how the individual power plants interact with each other and the environment as such. It is also important to assess how the turbulence in tidal flows affects the design and operation of tidal plants, e.g., through control system and dynamic loads.

The present work uses Large Eddy Simulations (LES) to study first the undisturbed tidal flow and then the flow with a power plant in operation. It is for example shown that the turbulence characteristics in the undisturbed flow differ between the acceleration and deceleration phase of the tidal cycle. The undisturbed flow simulations are used to evaluate the control system and to estimate the increasing dynamic loads on the tidal plant with respect to, e.g., fatigue. The Deep Green tidal power plant is modelled using a novel adaption of the Actuator Line Method (ALM). It takes the arbitrary trajectories (unique operation for this power plant technology) of the power plant wing into account. The results show how the power plants affect the environment, available power downstream, and turbulence characteristics affecting other power plants. The present study shows that the wake is several times longer than the power plant trajectory width.