Optimal Design of Very Large Tidal Stream Farms: for Shallow Estuarine Applications

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28/11/2013

Overview

Objectives

- Obtimization of tidal stream farms for maximum power and minimum flood risk.
- Quantities to be optimised are:
  - Location of devices
  - load factors of individual devices

Work Packages

WP1

CFD and Analytical modelling

- Performance and flow analysis
- Wake interactions investigations

WP2

Estuary modelling

- Flood risk analysis

WP3

Optimization

- Maximization of the power output from tidal stream farms

WP4

Experiments

- Performance, flow, and wake interaction analaysis

Partnership

Aquascientific Ltd

- Design and development of tidal turbine

University of Exeter

- CFD and analytical modelling
- Flood risk assessment for the deployment of hundreds of devices
- Optimisation of the location of devices for a tidal stream farm

University of Edinburgh

- Experimental works on a single and clusters of tidal turbines

Target application

Facts:

- Named as Momentum-Reversal-Lift (MRL) turbine with a length of 0.3 m and overall diameter of 0.2 m
- Suitable for operating in shallow waters near the free surface
- Could reach its efficiency upto 50% due to the contribution of both drag and lift to the rotation of the main shaft
- In early stage of development and testing

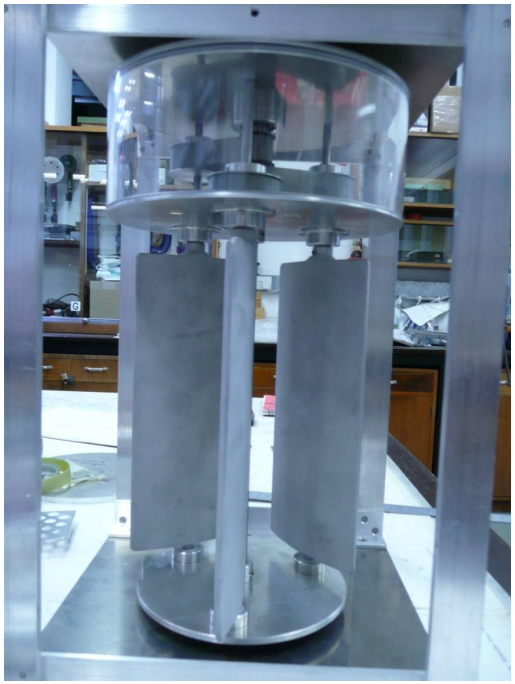


Figure : MRL turbine

CFD Modelling

Detailed CFD model

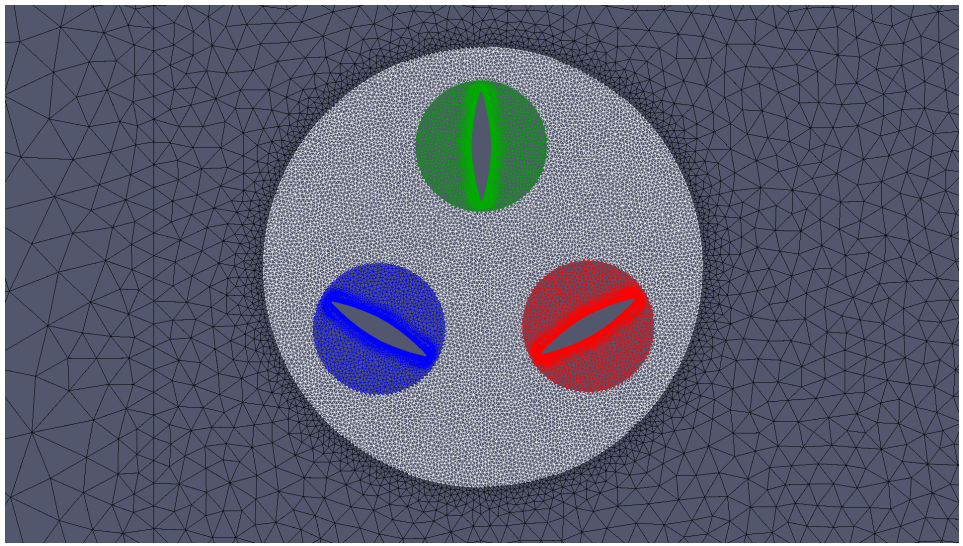


Figure : Schematic representation of Dynamic meshing (Berry M.,2013)

Simplified CFD model

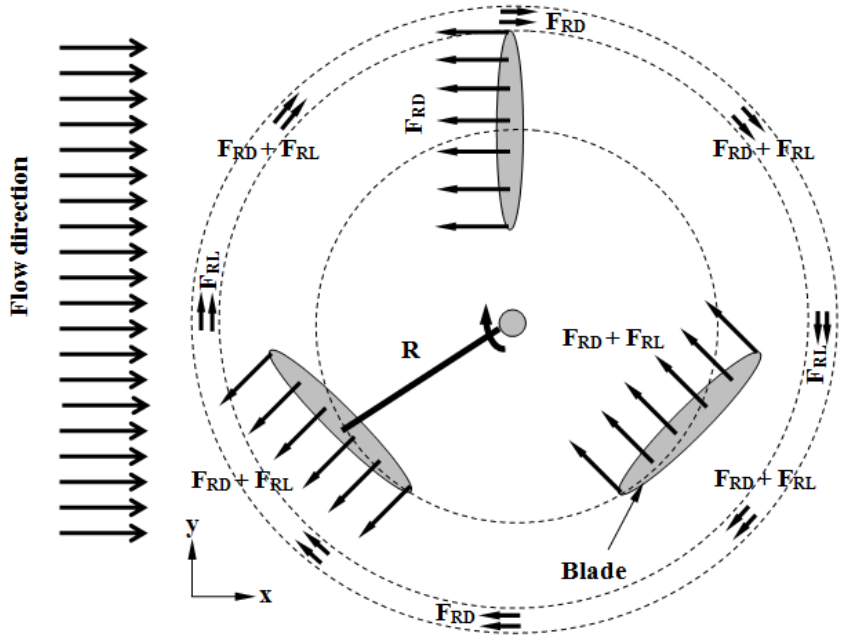


Figure : Schematic representation of IBF model

Estuary Modelling

Case study: Solway Firth site

- Uses Mike21 software
- Predicts the flooding risk because of the tidal stream farm by analysing the surface elevation of the flow

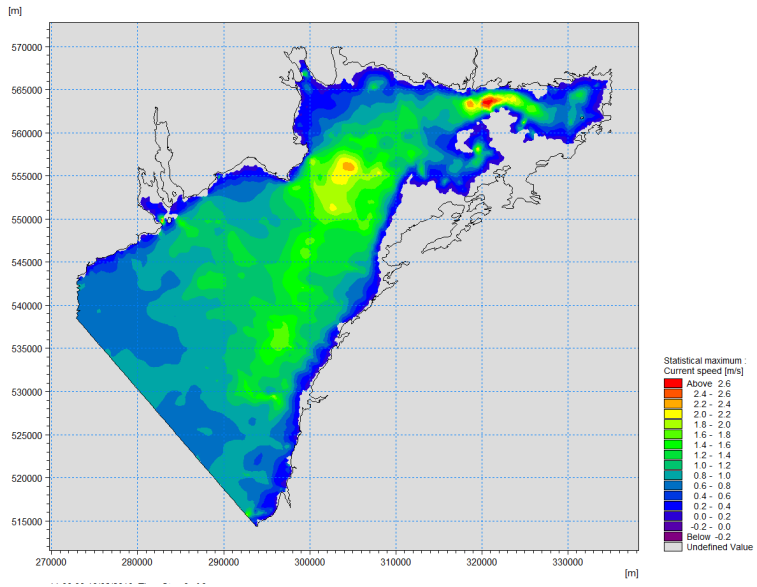


Figure : Current speed (Miriam, 2013)

Optimization

Several options are currently under consideration and some of them includes:

1. Cellular Automata
   - Model complex physical systems with reduced computational load
   - Discrete space / Simple transition rules
2. Genetic Programming
   - Evolutionary algorithm
   - Find computer programs that execute a task

Two MRL turbine prototypes

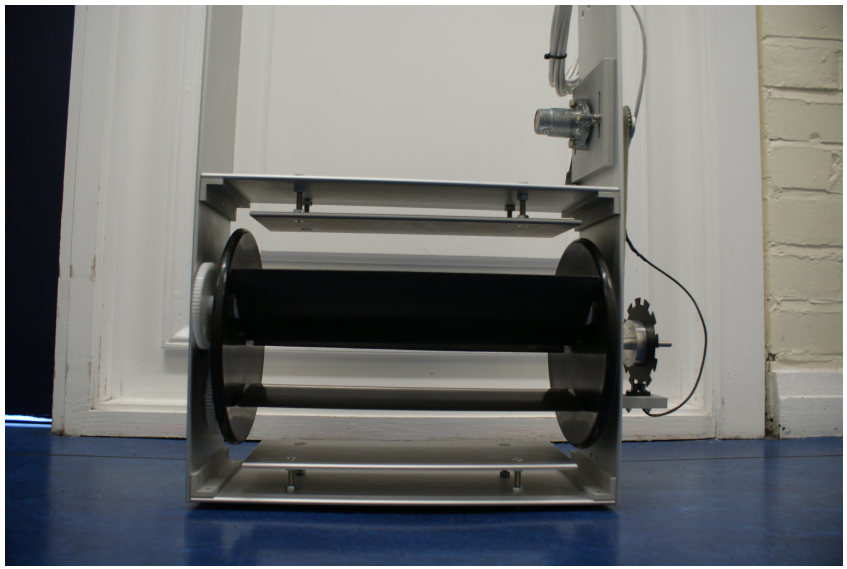


Figure : O.3 meter blades

Figure : 1.5 meter blades

Single Turbine Flow Analysis

Results from the Detailed CFD model

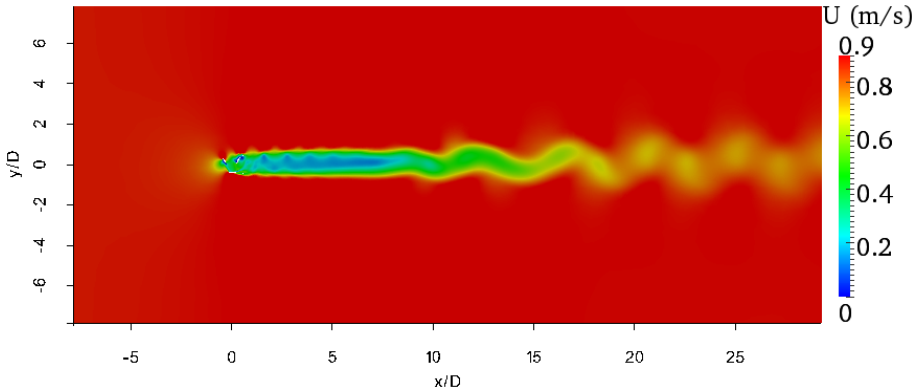


Figure : Velocity contour (Berry M, 2013)

Results from the simplified CFD model

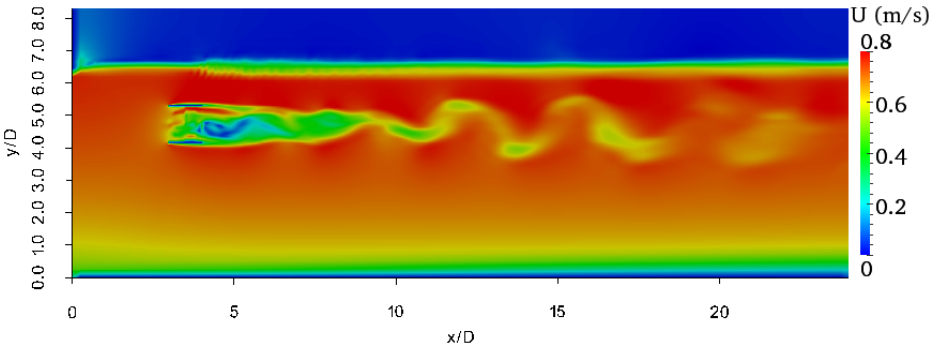


Figure : Velocity contour

Single Turbine Power Analysis

Detailed CFD and Experiment

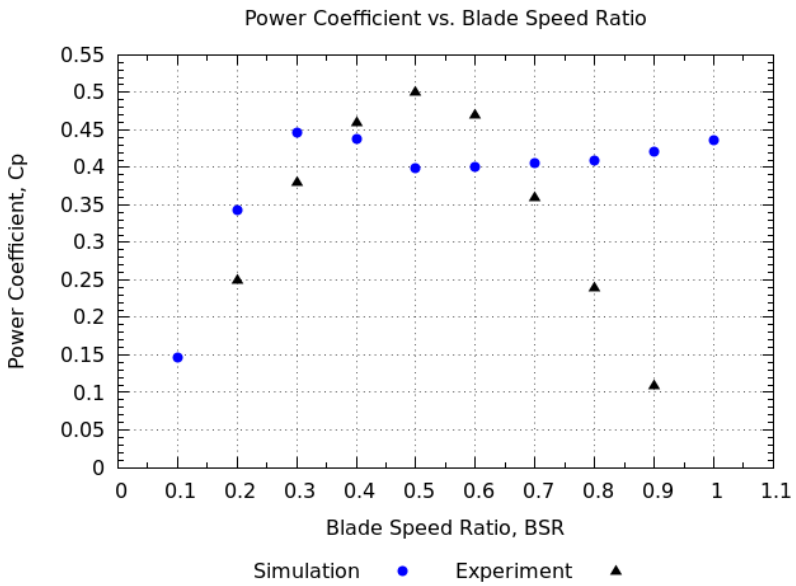


Figure : Torque generated power (Berry M, 2013)

Simplified CFD model

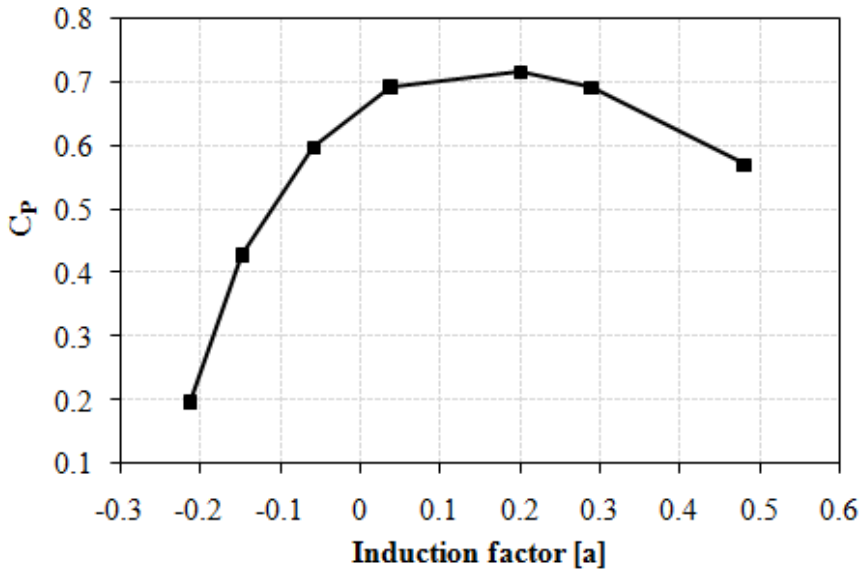


Figure : Total Energy extracted

Clusters of devices flow analysis

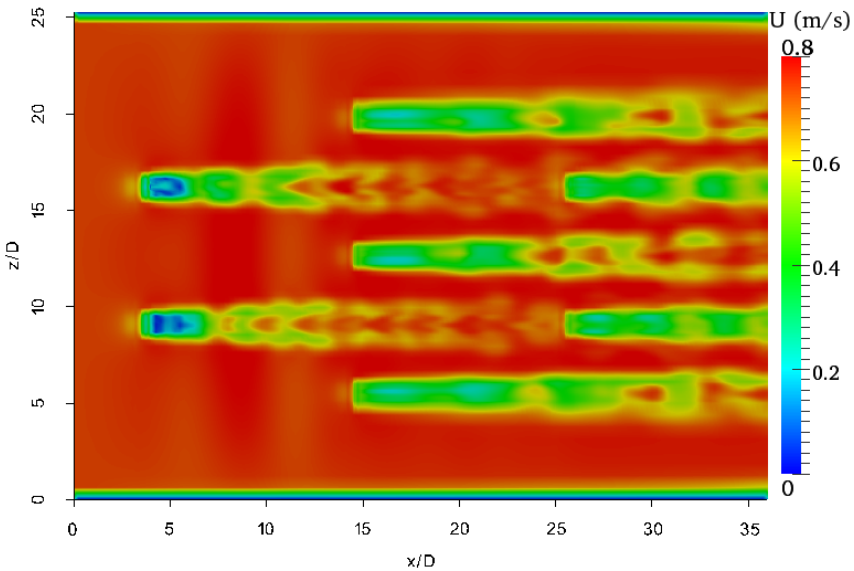


Figure : Staggered Configuration

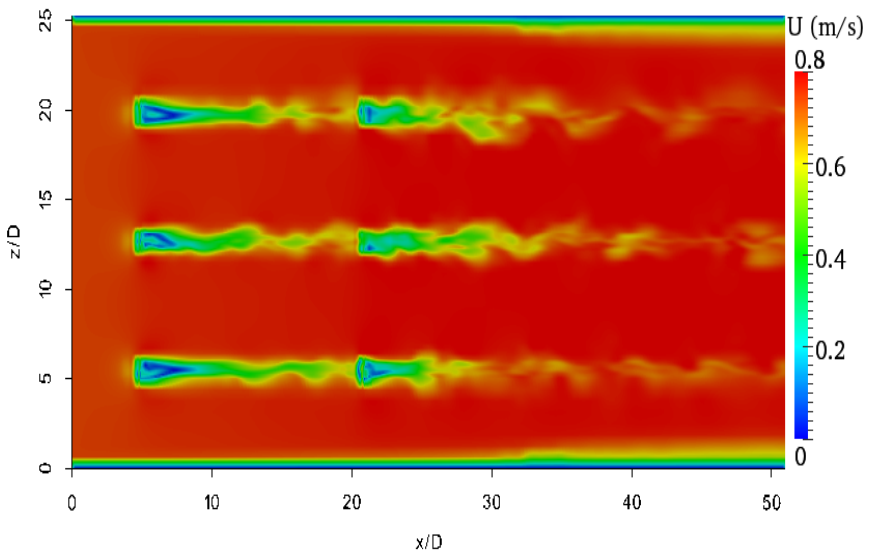
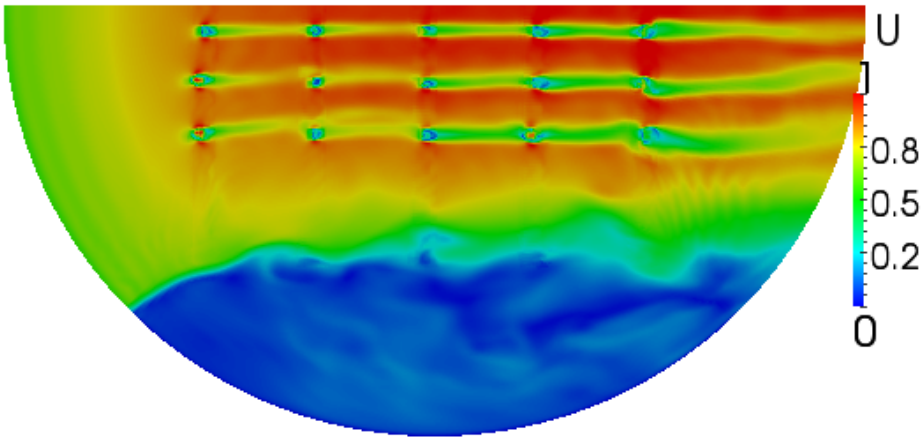


Figure : Tandem Configuration

Clusters of devices in the All Waters Facility

- Work in progress...
- The velocity contours shown below are prelimenary results



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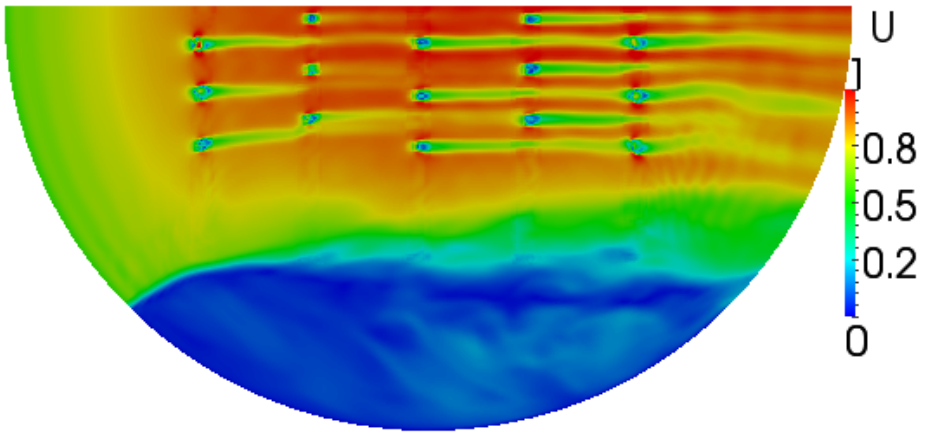

Figure : Staggered Configuration

Conclusion

- Most of the results discussed so far are prelimenary results with continous work and refinement underway to improve the results
- Analytical works are currently underway
- Preparations are nearly completed for experimental works on a single turbine