Ocean energy numerical modelling and experimental testing facilities at the National University of Ireland, Galway

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Abstract

The Marine Renewable Energy Research Group (MRERG) at National University of Ireland, Galway, (NUI Galway) hosts an extensive suite of numerical modelling, experimental testing and real-world monitoring facilities for use in ocean energy research. Wave and tidal energy are the primary focus of the authors' research efforts with topics such as resource quantification, energy extraction, wave-structure interaction and hydro-environmental impact assessment currently under investigation.

Keywords: marine renewable energy, numerical modelling, scale testing, test facilities

1. Introduction

The Marine Renewable Energy Research Group at the Ryan Institute, National University of Ireland, Galway, hosts an extensive range of numerical modelling, experimental testing and real-world monitoring facilities for use in ocean energy research. These include: a coastal observing radar system, a tidal basin, a wave tank, structural testing equipment and a wide range of numerical models. These facilities are used to conduct world-class, cutting-edge research in the areas of wave and tidal energy, with the aim of facilitating the harnessing of these renewable resources in a sustainable and economic manner.

2. Coastal Observing Radar System

The coastal observing system (CODAR) - the only one of its kind in Irish or UK waters - consists of two high frequency radars that combine to provide real-time measurements of surface currents and waves. The system is currently deployed in Galway Bay; the two radar masts are located at Spiddal and Mutton Island giving coverage over most of the inner Bay (see Figure 1).

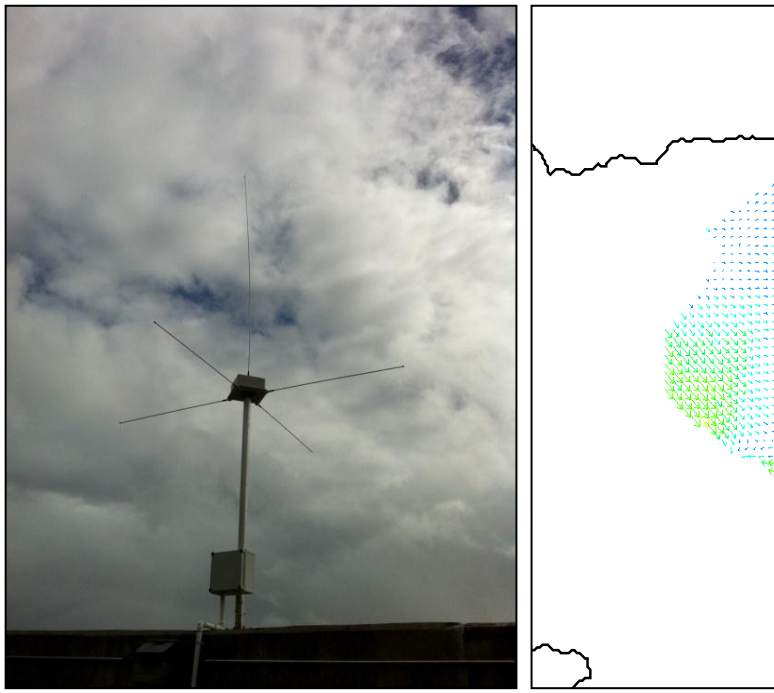

Figure 1: CODAR mast at Mutton Island and sample CODAR surface currents.

Applications of the radar system include:

- quantifying the available tidal / wave resource
- validating/improving numerical models (Figure 2)
- managing tidal / wave energy devices

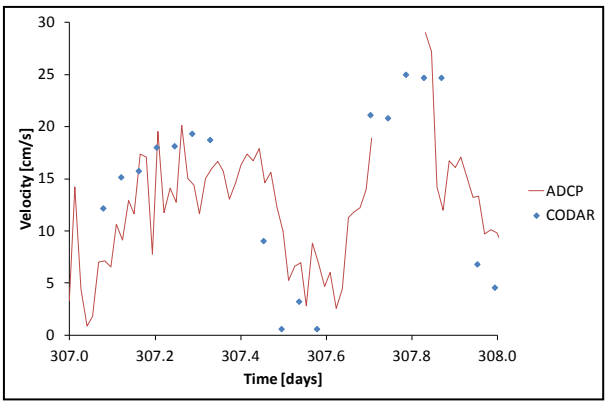

Figure 2: Surface current velocities recorded by Acoustic Doppler Current Profiler and by CODAR at a location west of the Inner Bay on 03/11/2011.

its kind in Ireland. During operation, water moves from the reservoir into the working area, and vice versa, simulating flooding and ebbing tides.

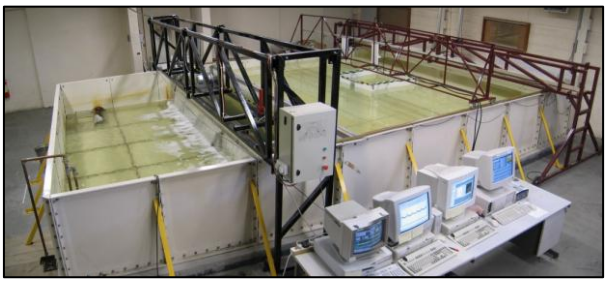

Figure 3: Tidal basin at NUI Galway.

The basin is instrumented with current velocity profilers and water level recorders to monitor the flow behaviour. Examples of research activities in the tidal/wave energy sector using the tidal basin include:

- assessing the hydro-environmental impacts of ocean energy extraction (Figure 4)
- optimising the configuration of tidal turbine farms
- validation of numerical models

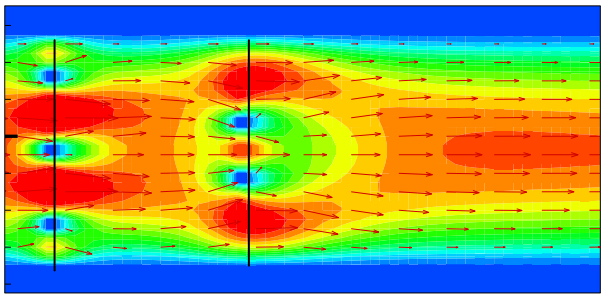

Figure 4: Output from a numerical model of a tidal turbine array (the blue squares) in a rectangular channel which was validated using the tidal basin.

4. Wave Tank

The wave flume (Figure 5) facilitates scale modelling of wave phenomena. The flume is 1m x 1m x 10m long and waves are generated using a stepper motor with a wedge-shaped plunger.

3. Tidal Basin

The tidal basin (Figure 3) reproduces tidal flows at laboratory-scale, allowing the testing of scaled physical models in tidal environments. It is the only facility of

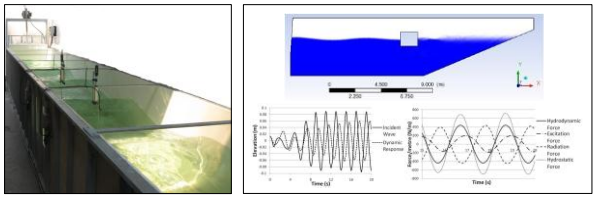

Figure 5: Wave flume at NUI Galway and numerical modelling of wave capture devices.

Some examples of research activities using the wave tank include:

- testing scaled prototype wave devices
- investigating wave-structure interactions
- validating/improving numerical models (Figure 5)

5. Structural testing Equipment

NUI Galway has a 375 m2 state-of-the-art high-bay Structures Research Laboratory, the largest of its kind in the Republic of Ireland. This laboratory is equipped with:

- facilities for full-scale tests to evaluate the static and dynamic performance of structural systems
- testing spaces that allow for a large number of configurations for testing small to large structural and mechanical elements and materials (Figure 6)
- servo-hydraulic testing machines with capacities ranging from 10 kN to 500 kN, as well as material fatigue testing machines and an impact testing machine
- state-of-the art data acquisition systems and sensors

Figure 6: Strong floor area (10m x 6m with anchor points at 500 to 1000 mm centres, each having a capacity of 500kN) and reaction frames in NUI Galway's Structures Research Laboratory.

Examples of recent structural testing research activities in the marine energy sector include:

- full-scale structural testing of composite and metallic ocean energy structures
- materials testing for the marine environment
- the application of composite damage mechanics and fatigue coupon testing results to improved finite element models of tidal turbine blades

6. Numerical Modelling

MRERG develop and use state-of-the-art numerical models for ocean energy applications. Computational fluid dynamic models are used to simulate the flow of water through, and around, energy devices, and structural analysis models are used to study the structural performance of wave and tidal energy devices. Examples of previous numerical modelling marine energy research applications include:

- assessing tidal and wave resources (Figure 7)
- investigating the hydro-environmental impacts of energy extraction
- improving the design and performance of energy devices (Figure 8)

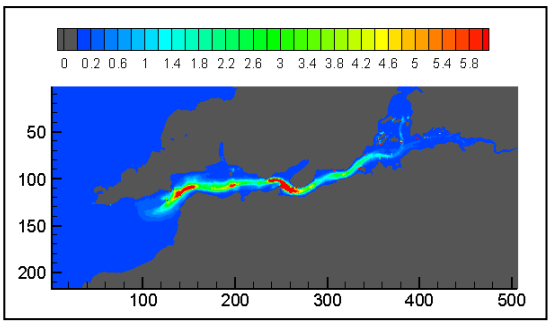

Figure 7: Output from a tidal flow model of the Shannon Estuary showing available tidal stream power in GWh/yr.

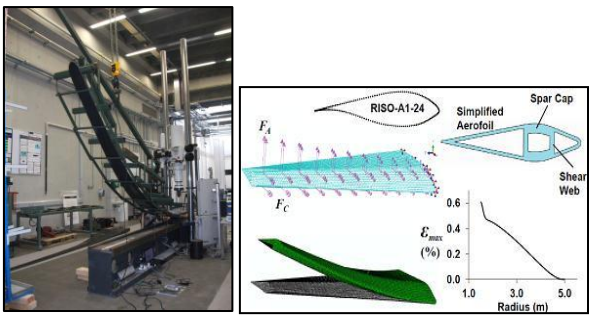

Figure 8: Physical testing and finite element analysis of a tidal turbine blade at NUI Galway.

7. Conclusions

The Marine Renewable Energy Research Group at National University Ireland Galway offer a range of facilities and expertise that are of use to the ocean energy sector. Using its existing modelling, testing and real-world observation facilities MRERG are actively engaged in a range of EU-, government- and industry-supported research projects. The Group is continuously adding to its suite of ocean energy test facilities and seeking new collaborations.

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