Title: Numerical modelling of a variable-porosity fence for tidal stream studies of the Pentland Firth

Supervisors: Prof. Alistair G. L. Borthwick, School of Engineering, The University of Edinburgh Dr Vengatesan Venugopal, School of Engineering, The University of Edinburgh

CASE partnership – Siquando Ltd
Company Director: Prof. Stephen Salter, Emeritus Professor of Engineering
Design. Address: Siquando Ltd, 5th Floor Quartermile Two, 2 Lister Square, Edinburgh EH3 9GL
Siquando Ltd is a small spin-off company from Edinburgh University founded by Stephen Salter. Income from patent royalties and consulting fees is used for research into various topics including renewable energy and climate engineering.

Primary supervisor contact email: alistair.borthwick@ed.ac.uk

Project background

Tidal stream energy is a natural resource which can provide major benefits to the UK. Estimates for the size of the tidal stream resource from the Pentland Firth, Scotland, vary over a wide range (1 GW mean – 18 GW peak) depending on assumptions about the fraction of flow which can be swept by turbine blades, the present flow losses, and the impedance of the flow source. Siquando Ltd is interested in the use of vertical-axis transverse flow turbines to extract power from 80% of the flow window rather than the 7% presently assumed. The project involves use of a novel analogy of a porous wall to represent the turbines within a numerical model of a single strait, followed by a model of modest resolution of the Atlantic, North Sea and English Channel but higher resolution of the Pentland Firth. Assessment will be made of environmental impact of large vertical axis turbines in the Pentland Firth. The project may indicate a very large, clean, predictable sustainable energy source (which can be exploited using vertical-axis turbines) and is aligned with the NERC's strategic research plan to help business, government and society to benefit from natural resources.

Key research questions

- How accurately can a porous wall simulation model energy extraction from tidal flows by close-packed variable-pitch turbines?
- What is the optimum fraction of flow swept by tidal stream turbines in the Pentland Firth in order to maximise power output without environmental degradation?
- What will be the effect of such large power extraction on the local environment (e.g. alterations to flow patterns, sediment erosion and deposition, etc.)?

Methodology: Programme of Research and Timetable

- Review of literature on tidal stream turbines in straits [Months 1-3]
- Development of a numerical model of tidal flow through a single strait, and investigation of the effect of a wall of adjustable porosity on water levels in the strait. [Months 3-12]
- Development of a numerical model of modest resolution of the Atlantic, North Sea and English Channel but higher of the Pentland Firth. [Months 12-24]

- Use of a porous wall simulation to model close-packed variable-pitch turbines in the Pentland Firth. [Months 18-30]
- Verification tests, including comparisons between predicted and measured flow velocity spectra and histograms. [Months 27-39]
- Assessment of environmental effect in the Pentland Firth {Months 30-39]
- Dissemination of findings through two journal and two conference papers. [Months 12-36]
- Write-up of PhD thesis working alongside Siquando Ltd. [Months 39-42].

Training

A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. The student would attend lectures on marine renewable energy at the University of Edinburgh. The student would also be encouraged to attend courses on digital mapping and ArcGIS given by EDINA. The School of Engineering requires all its doctoral students to attend a compulsory Health and Safety course, and to undergo training in research methods provided through the University's Postgraduate Transferable Skills Programme. The latter includes the Institute of Academic Development courses on Communication (including effective writing, conference preparation, writing a literature review, and writing for publication), Professional Development (including time management and goal setting), IT, Compass Programme (including communication skills, Scottish Parliament event), and Research Planning (including finding academic literature, how to be an effective researcher, managing your own research project, a PhD thesis writing workshop, practical project management, and presenting made easy.)

Requirements – Candidates should have at least an upper second class degree in Engineering, Mathematics, Physics, or Oceanography.

Further reading

Adcock T.A.A., Draper S., Houlsby G.T., Borthwick A.G.L. and Serhadlıoğlu S., (2013) The available power from placing tidal stream turbines in the Pentland Firth. *Proc. Roy. Soc. A,* 469: 20130072. Borthwick A.G.L. (2016) Marine renewable energy seascape. *Engineering*, **2**(1): 69-78.

A project summary

This project aims to assess the optimum fraction of flow swept by tidal stream turbines using the analogy of a porous wall within a numerical model of the Pentland Firth.