Institution: Heriot Watt University

Unit of Assessment: 7 Earth Systems and Environmental Sciences

Title of case study:

Development of Marine Energy: Testing, planning and wider economic impacts in Orkney

1. Summary of the impact (indicative maximum 100 words)

The International Centre for Island Technology (ICIT) based at Heriot-Watt University's Orkney campus is a multi-disciplinary research team whose focus for over a decade has been research into the socio-economic and environmental barriers to the development of marine renewable energy, particularly in the Pentland Firth and Orkney Waters (PFOW) area and its establishment as a Marine Energy park. This has enabled 1.2GW of marine energy leases by the Crown Estates including an estimated £3billion of related capital investment, as well as the establishment of the European Marine Energy Centre (EMEC), which continues to maintain its impact on the development of marine renewable energy.

Research at the International Centre for Island Technology at Heriot-Watt University has led to a substantial boost to Orkney with £8.8m in Gross Value Added to the local economy, with the creation of 119 jobs (Biggar Economics, 2012) through a dozen spin-out companies.

2. Underpinning research (indicative maximum 500 words)

Research undertaken at ICIT had focussed on the impact of traditional energy activities and analysed the effect of different international legislation regimes would have on companies' management of abandoned platforms (e.g. Side 1997[1]). However, Early EU-funded research (*The Feasibility of Use of Tidal Currents in Orkney and Shetland for Generation on Electric Power*) on marine tidal energy by Bullen at Heriot-Watt (e.g. Bryden *et al*, 1998[2]) signalled potential turbine designs and the suitability of Orkney for marine renewables research, investigating the potential sites and leading to a feasibility study for a marine energy test centre. ICIT's contribution to the project was an analysis of the potential of the tidal resource at the Falls of Warness, Island of Eday, Orkney. The activity involved and strengthened ICIT's connection with the economic development directorate at Orkney Islands Council which enabled further development over the following years.

ICIT worked closely with EMEC for example undertaking analysis of the MetOcean data gathered at Billia Croo wave test site. Working with EMEC these analyses were made available to developers deploying at the wave site and inform them of the site conditions, which helped in device design, assessment and deployment.

Kerr and Johnson's research (e.g. **Kerr** 2006) on local authorities, planning policy and renewable energy applications was further developed through a Scottish Funding Council Strategic Research Development Grant, SRDG (MReDS, 2007-2013[G1]). These activities led to a developing engagement with Marine Scotland, and other stakeholders and to participation in the EU FP7 funded our "Monitoring and Evaluation of Spatially Managed Areas" (MESMA 2009-2013 [G2]) research programme. MESMA research is focused on development of a generic marine spatial planning framework to inform policy and practice in Europe and beyond. Data from twelve case studies in thirteen countries is employed and **Side**, **Kerr** and **Johnson** lead the case study of the Pentland Firth and Orkney Waters (PFOW) and in particular has been identified as an early example of development-led marine planning (e.g. **Johnson** *et al*. 2012[5]). They identified high, but frequently conflicting, priorities on marine planning, ranging from economic growth and job creation, to conservation and ecosystem-based management, and the potential obstacle to marine renewable energy developments that these may pose; specific examples include fisheries, community benefits and conflicts arising from EU conservation Directives (e.g. **Johnson** *et al*., 2013[6]).

The PFOW case study has established a close collaboration with Marine Science Scotland including the holding of joint workshops and public consultation. Underpinning research includes a digitalised planning framework model (e.g. for use by marine planners); development and evaluation of marine planning tools; a metadata portal and library; and a marine governance analysis and comparison across European countries.

Emerging from the SRDG, MESMA and related research on the EPSRC Supergen II [G3](**Side**) has been a growing concern over the impacts on the ecosystem of energy extraction (Shields *et al*. 2011[4]), which with the direct support and engagement of Marine Scotland Science has led now to 2 successful EPSRC Grand Challenge projects (TeraWatt, June 2012 - June 2015[G4]) and EcoWatt2050 (March 2014 - February 2017[G5]) with this focus. These projects provide data for field developers, informing EIAs (see also [G6]) and the consenting process as well as a range of monitoring and modelling studies being undertaken. They feed directly into the noise modelling methodologies being developed for a wave device developer (Pelamis) and collision monitoring methodologies adopted by a tidal turbine developer (Scotrenewables). Identification of deficiencies in noise monitoring technologies has led to a proof of concept proposal for an ambisonic hydrophone buoy, which will enable a cost efficient means to discriminate the spectral and directional features of underwater noise, and to a number of consultancy studies.

The work has also led to a close relationship with Crown Estate and its marine renewables leasing studies with the appointment of **Side** to the Crown Estate Operating Agreement Panel.

3. References to the research (indicative maximum of six references)

The references identified with * are the ones which best indicate the quality of the underpinning research.

[1]* Side, J. 1997. "The Future of North Sea Oil Industry Abandonment in the Light of the Brent Spar Decision". Marine Policy 21(1): 45-52. DOI: 10.1016/S0308-597X(96)00045-0

[2]* G Bryden, S Naik, P Fraenkel, C.R Bullen. 1998. "Matching Tidal Current Plants To Local Flow Conditions", Energy 23(9):699-709. DOI: 10.1016/S0360-5442(98)00021-8

[3] Osalusi, E., Side J.C. & Harris, R.E. 2009. "Structure of turbulent flow in EMEC's tidal energy test site. International Communications in Heat and Mass Transfer", 36(5):422-431 DOI:10.1016/j.icheatmasstransfer.2009.02.010

[4]* Shields, M.A., Woolf, D.K., Grist, E.P.M., Kerr, S.A., Jackson, A.C., Harris, R.E., Bell, M.C., Beharie, R., Want, A., Osalusi, E., Gibb, S.W. & Side, J. 2011. "Marine renewable energy: The ecological implications of altering the hydrodynamics of the marine environment". Ocean and Coastal Management 54(1):2-9 DOI: 10.1016/j.ocecoaman.2010.10.036

[5] Johnson, K., Kerr, S. & Side, J. 2012. "Accommodating Wave and Tidal Energy - Control and Decision in Scotland", Ocean and Coastal Management 65, 26-33. DOI: 10.1016/j.ocecoaman.2012.04.018

[6] Johnson, K., Kerr, S. & Side, J. 2013. "Marine renewables and coastal communities - experiences from the offshore oil industry in the 1970s and their relevance to marine renewables in the 2010s", Marine Policy 38, 491-499. DOI: 10.1016/j.marpol.2012.08.004

Grants

[G1] MREDS: Advancing Marine Renewable Energy Research Capacity in Scotland. (Scottish Funding Council Strategic Research Development Grant, Total £1.1M, 2007 – 2013, Lead: HWU-Side, Partners UHI & EMEC)

[G2] MESMA: Monitoring and Evaluation of Spatially Managed Areas (EU, FP7, £125k, 2009-2013, HWU Co-I: Johnson)

[G3] Supergen (EPSRC EP/E040136/1, £160k, 2007-2011, HWU Co-I: Side)

[G4] TeraWatt: Large scale Interactive coupled 3D modelling for wave and tidal energy resource and environmental impact (EPSRC EP/J010170/1, Total £980k, 2012-2015, Lead: HWU-Side, 6 partners)

[G5] EcoWatt2050: Impacts of Very Large Scale Arrays and their Regulation (EPSRC EP/K012851/1, Total £950k, 2013-2016, Lead: HWU-Side, 8 partners)

[G6] QBEX: Quantifying benefits and impacts of fishing exclusion zones around Marine Renewable Energy Installations (NERC NE/J012351/1, £17k, 2012-2015, HWU Co-I: Side)

[G7] Brahan Codar UK HF Radar Demonstration Project (Marine Scotland Science, £10k, 2012-2013, Lead: HWU-Johnson)

4. Details of the impact (indicative maximum 750 words)

Development of Marine Energy: Testing

A senior spokesperson from EMEC [**S1**] has stated that the "*very idea of a Scottish test facility for*

wave and tidal energy largely stemmed from discussions between HWU, industry and government (HIE). A combination of Heriot-Watt's presence in Orkney and ICIT's research into the local energy resource, and environment, helped single out Orkney as the preferred location for EMEC."

EMEC is the world's only accredited test facility for wave and tidal energy devices. It has attracted £36m of investment and employs 23 staff. Assessment by Highlands and Islands Enterprise has suggested a GVA for the County of £54m from marine renewables and £120M for Scotland as a whole. [**S1**] attributes this to there being a test centre in Scotland, so they are benefits to which EMEC (and indirectly therefore HWU) justifiably lays claim on behalf of the sector. He goes on to state that "*ICIT's presence in Orkney plays an important part in maintaining Orkney's undoubted high profile in the world of marine energy*".

OpenHydro was the first developer to use the tidal test site at the Fall of Warness off the island of Eday when its test rig and 250kW open centred turbine were installed. In 2008, the device was the first tidal turbine to be grid connected in Scotland and subsequently the first to successfully generate electricity to the national grid in the UK. Since 2008, over 15 companies (including E.On, Scottish Power, and Scotrenewables Tidal Power), have used the test facility at EMEC. Scotrenewables Tidal Power Ltd (SRTP) and associated companies in Orkney now employ over 25 people locally having raised over £17m capital in the development tidal turbine designs. Initial designs were developed through a Royal Society of Edinburgh Enterprise Award to an ICIT PhD student. The Fellow, now a senior company spokesman [S2] attests "*My research on the Heriot-Watt Campus provided the vital springboard in the field of marine renewables*". SRTP have developed an innovative floating tidal energy converter known as the Scotrenewables Tidal Turbine. Nine different scale models of the device have been tested extensively over the past 10 years both offshore and in laboratory environments. The culmination of this development work has been the construction of the 250kW prototype which weighs 100 tonnes and measures 33 metres long towards the end of 2010. The device was successfully connected to the national grid at the European Marine Energy Centre at the end of March 2011.

In March 2010, the Crown Estate announced 1.2GW of marine energy leases in Orkney waters and the wider Pentland Firth, which included an estimated £3 billion of related capital investment, A senior member of Orkney Islands Council [S3], observed that "*none of it would have happened without the foresight of Heriot-Watt University and its presence in Orkney*".

Development of Marine Energy: Planning, and socio-economic & environmental impacts

European legislators have adopted ambitious policy initiatives relevant for the oceans, seas and coasts, to be implemented in the next 10 to 20 years. These initiatives include the 2008 Marine Strategy Framework Directive (2008/56/EC), the 2009 Renewable Energy Directive (2009/28/EC) and more recently the Proposal for a Directive to establish a framework for maritime spatial planning and integrated coastal management (COM 2013:133). The MESMA Project deliverables and associated publications make an important contribution to the draft Directive. MESMA research is focused on development of a generic marine spatial planning framework to inform policy and practice in Europe and beyond. The Pentland Firth and Orkney Waters (PFOW). PFOW area is a UK designated 'Marine Energy Park' in 2012, and the Marine Spatial Plan is a pilot which sets the standard for all Scottish waters. A member Marine Scotland's Marine staff responsible for managing the development of the Plan [S4] notes the significant "*work put into the workshops and public consultation events during July 2013 [by ICIT] for the Planning Issues and Options and draft Environmental Report consultation papers for the Pentland Firth and Orkney Waters (PFOW) marine spatial plan. Our collaboration has worked well and we have benefited from our different but mutually complementary skills- the added dimension which HWU and the MESMA programme have brought to the preparation of the PFOW plan has been invaluable*."

The strength of ICIT's links with policy organisations in both the development of research and delivery of impact is recognised for example by senior staff in Marine Scotland responsible for Marine Energy development across the country [S5]. They pay particular attention to ICIT's "*willingness to increase their understanding of end-user needs*" and this has been instrumental in determining "*the extent of future marine renewables development, and clarify our understanding of*

the ecological impacts of these technologies".

Wider Economic Impacts in Orkney

"*Activity at the Orkney campus is predominantly research driven*" and accounts for "*nearly 6% of the Gross Value Added (GVA) of the Orkney economy and supports more than 2% of employment on the Islands*" (Biggar Economics 2012[S6]).

The Orkney campus has been a particularly significant source of start-up activity. A report commissioned by Highlands and Islands Enterprise in 2011 (Westbrook 2011[S7]) identified 10 active start-up companies that had been established by former students and staff at the Orkney campus. Taken together these businesses employ 90 FTEs, 88 of whom are based in Orkney. Through these spin-outs the Orkney Campus has contributed £8.8m in GVA to the local Orkney economy, with the direct creation of 119 jobs and rather more "*if the initiative in putting forward the initial case for a test centre, and its lobbying for EMEC to be located in Orkney was also quantified in terms of net additional employment in the islands*" (Westbrook 2011[S7]). The presence of such research activity in remote areas is a significant factor in the number and sustainability of this economic activity; "*if the Orkney campus did not exist, the founders of these businesses would probably be located elsewhere in Scotland in areas that may offer more employment opportunities and therefore fewer incentives to start-up independently*" (Biggar Economics 2012[S6]). In addition, most of these start-ups relate directly to the environmental/energy research developed at ICIT (including Scotrenewables, Aquetera, Xodus Aurora, North Isles Environmental Ltd., Credo Green, Opus Plus Ltd.) (Table 7.5 in Biggar Economics 2012[S6]).

Scotrenewables employs over 25 people having raised over £17m capital in the development of its tidal turbine. Scotrenewables [S2] confirmed "*Without ... the ongoing support from the Heriot-Watt research activity, the establishment of Scotrenewables Tidal Power and associated companies in Orkney would certainly not have been possible*".

Environmental impacts research has informed and led to the creation of specialist environmental consultancies such as Aquatera. Aquatera employs over 15 members of staff in Orkney and over 25% are Heriot-Watt graduates (www.aquatera.co.uk).

5. Sources to corroborate the impact (indicative maximum of 10 references)

[S1] Senior Spokesperson, Marine Energy Centre (EMEC) Ltd
Will clarify the role of HWU in establishing EMEC and the development of marine renewable energy using the facility since 2008.

[S2] Senior Manager, Scotrenewables Tidal Power Ltd (SRTP)
Will describe the importance of ICIT to marine renewables development and to enterprise creation in the region.

[S3] Senior Member of Orkney Islands Council will corroborate the importance of ICIT to marine energy leases.

[S4] A Marine Scotland Manager responsible for Marine Renewable Energy
The role of ICIT in driving the PFOW Marine Spatial Planning and Marine Energy Park Development.

[S5] Marine Renewable Energy Programme Manager, Marine Scotland Science
Will describe how ICIT work with policy and company interests to develop research to deliver impact.

[S6] Biggar Economics (2012). Heriot-Watt University, Economic Impact Study.
http://www.hw.ac.uk/documents/Heriot_Watt_University_Economic_Impact_Report.pdf

[S7] Westbrook S (2011) Orkney Renewables Centre: Economic Impact Assessment for Highlands and Islands Enterprise. A report for HIE by Steve Westbrook, Economist. Available on request.