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The Bryden Centre for Advanced Energy Research: building critical mass for marine and bio energy development in Northern Ireland, Ireland, and Scotland

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Named in honour of the late Professor Ian Bryden, the Bryden Centre is a new 'virtual centre of competence' designed to support industry-led applied/pre-commercial collaborative energy research that is focused marine renewable energy in Ireland, Northern Ireland, and Western Scotland. The west coasts of this region have many geographic, economic and demographic characteristics that combined represent a unique opportunity for the development of renewable technologies and should provide a distinctive competitive advantage in a global marketplace. However, a number of challenges have prevented regional industry from capitalising on this opportunity. Small enterprises at the forefront of the sector struggle to allocate resource to innovation, while research funding constraints can often limit knowledge exchange activities between researchers and businesses. Even more importantly, the region lacks critical mass in trained scientists and engineers capable of translating research into commercial success within these companies. Using a Doctoral Training Centre model, the Bryden Centre aims to address these challenges, building capacity and facilitating knowledge exchange across disciplines and across the region. In this paper, we discuss these challenges specifically associated with wave and tidal energy in Ireland, Northern Ireland, and Scotland, highlighting the state of the art for key research topics being progressed by Bryden Centre PhD researchers, including optimisation methods, operational device monitoring, energy storage, social licence to operate, and environmental impacts. We also discuss opportunities for information exchange and collaboration across the sector.

Keywords—**environmental impacts, energy storage, optimisation, regional development.** **Introduction**

MARINE renewable and bio energy represent an opportunity for energy generation in coastal regions, particularly in the North East Atlantic area. The Atlantic-facing coastlines of the UK and Ireland have many geographic, economic and demographic characteristics that, together, represent a unique opportunity for the development of renewable technologies and should provide a distinctive competitive advantage in a global marketplace. These include the tidal power sites at Strangford and the North Antrim Coast, the offshore wind activity in Western Scotland, and the potential for wave power generation in Donegal. Furthermore, the region can draw upon world leading research taking place within its research institutions. Indeed, these regions have been some of the earliest to adopt marine energy technologies. Nascent companies have received substantial support for development in this region, and support from the Scottish and Irish governments has enabled testing centres such as the European Marine Energy Centre in Orkney, Scotland, and MaREI at UCC and the AMETS test site of the West coast of Ireland, to become global focal points for marine energy development. Investment in marine renewable energy technologies in this region goes hand in hand with economic development. The UK and Ireland also have international presence and experience in marine engineering and offshore operations, providing expertise and opportunities for diversification into the marine energy supply chain. A survey by Renewable UK, cited in [1] suggested that of the £578M invested in marine renewable energy in the UK, over 77% was spent in the UK economy, representing a substantial boost for regional economic development. Even so, development of the marine energy industry in this region has not accelerated as predicted.

In Ireland, for example, the resources for offshore renewable energy are vast. Ireland's offshore territory is approximately 10 times its land mass. The Offshore Renewable Energy Development Plan (OREDP) [2] identified significant areas for the development of offshore wind, wave and tidal energy around the Irish coast. It estimated that the sector could develop up to 6GW of

ID 1607 track ESP (Economical, social, legal and political aspects of ocean energy).

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TABLE I
RESEARCH THEMES WITHIN THE BRYDEN CENTRE

THEME	SUB-THEME(S)	RESEARCH TOPICS
Marine Renewable Energy	Reducing the levelised cost of energy	• Advanced design and manufacturing • Modelling / resource assessment • Environment / marine life / habitat • Biofouling • Foundations & deployment
Bio energy	Bio-resources	• Algal biomass • Other non-food biomass sources
	Biogas utilisation	• Waste heat recovery
'Cross-cutting' Themes		• Economics • Supply chain • Community / localised energy systems • Life cycle analysis

ocean energy without an adverse effect on the environment.

Within the eligible region of Interreg VA funding, the North West coast of Donegal is of particular interest. Here there are vast resources potentially for offshore wind, tidal and possibly wave in the longer-term. In 2004 Ireland had one offshore wind farm of the Arklow Bank on the east coast. The Arklow Bank wind farm has an operating capacity of 25MW. At a similar time (2004) the UK had an offshore installed capacity of approximately 150MW.

Today the story is quite different: the UK is a world leader with nearly 8 GW of installed capacity of offshore renewable energy [3] while the development of capacity in Ireland has stalled. Ireland has been looking to Scotland and the rest of the UK for best practice, to help shape how offshore renewable energy is developed in the future. The forthcoming Maritime Area and Foreshore (Amendment) Bill 2013 [4] when enacted represents a substantial opportunity for Ireland to capitalise on its marine energy resources. The Bill has three main aims:

- to align the foreshore consent system with the planning system;
- to provide for a single Environmental Impact Assessment for projects; and
- to provide a coherent mechanism to facilitate and manage development in the exclusive economic zone (EEZ) and on the continental shelf, such as oil and gas projects and offshore renewable energy.

It is hoped that the bill, due to be enacted in late 2019, will allow Ireland emerge as a significant region for Marine Renewable Energy development in Europe. However, in Ireland, as in Scotland and the wider UK, the challenge of socially, politically, and environmentally acceptable governance of marine renewable energy development remains. Lange et al. [5] recognized that there is a need to address shortcomings in governance by exploring innovative approaches to collaboration and integration to facilitate and enable marine energies toward a more sustainable future.

Beyond appropriate governance, a number of challenges have prevented industry across Ireland, Northern Ireland, and Scotland from fully capitalising on the marine renewable energy opportunity. Foremost among these is the profile of the regional industry, with companies typically being small- or micro-sized enterprises. As is true for all industries, small enterprises in the renewables sector struggle to dedicate the resource needed to innovate. This is exacerbated by a lack of funding for research and innovation that would allow industry and research partners from across the region to collaborate on early-stage innovative concepts. In addition, there is a recognised gap between outcomes from existing research projects and commercialisation, 'the valley of death', that is indicative of industry and University partnerships not maximising the outputs of early stage collaborations.

PROFESSOR IAN BRYDEN
1958-2016

The Bryden Centre is named in honour of the late Professor Ian Bryden, who played an essential role in brokering partnerships and laying the foundations of this initiative. Professor Bryden was a well-known figure in the marine renewable energy field, having spent 35 years working in the field. He completed his PhD at the University of Edinburgh, as part of the wave energy group led by Professor Steven Salter. Between 2010 and 2013, Professor Bryden was a Professor of Renewable Energy at the University of Edinburgh, where he led the Institute for Energy Systems between 2010 and 2013. In 2013, he became Vice Principal of Research at the University of the Highlands and Islands, where he was responsible for developing the university's research in renewable energy and instigating numerous projects to bring renewable energy research capacity to the region, including the Bryden Centre

The final aspect of this is a lack of critical mass of highly-qualified scientists and engineers capable of translating research into commercial success within these companies. Evidence suggests that a mismatch between growth in the green economy and the development of a skilled workforce is resulting in shortages in managerial and technical professional disciplines essential to the development of renewable energy [6]. The new Bryden Centre for Advanced Marine Energy Research (or the Bryden Centre) aims to address these challenges.

The Bryden Centre was created to be a 'virtual competence centre' that supports industry-led applied or pre-commercial collaborative research on a cross-border, interregional basis. This research is focused on two specific forms of renewable energy: marine renewable energy and bio energy. These are considered to have the greatest sustainable potential & widest applicability across the Ireland, Northern Ireland, and west Scotland region. The remainder of this paper will specifically focus on the marine renewable energy aspects of the Bryden Centre.

I. The Bryden Centre for Advanced Marine energy and Bio Energy Research

The Bryden Centre was awarded funding by the European Union's Interreg VA programme, managed by the Special EU Programmes Board, and was officially launched on the 17th of January, 2018, in Belfast.

Using a Doctoral Training Centre model, the centre leverages existing R&D infrastructure at five research institutes, working with ~40 companies to award over 30 PhD industrially relevant studentships and 5 PDRAs, producing applied research outcomes with the potential for commercial exploitation and resulting in economic growth within the region. The project partnership includes: Queens University Belfast (coordinators), the University of the Highlands and Islands, the Letterkenny Institute of Technology, the Agri-Food and Biosciences Institute, the University of Ulster, Donegal County Council, and Dumfries and Galloway Council.

Fig. 1. The first Bryden Centre summer school at Queens University Belfast focused on a 'micro-MBA'.

A. *Developing a research agenda*

From the outset, the Bryden Centre has aimed to develop a research agenda that is led by the current challenges faced by the marine renewable energy industry. Businesses, industry bodies, regulators, and advisors are essential members of the Bryden Centre, contributing to the project's board, science and commercial advisory panel, and PhD studentships.

Each individual project was developed during a brokerage event that brought together academics, industry professionals, regulatory bodies, and other stakeholders in the industry. Across a two-day process, projects were refined and moulded to meet the research requirements of a PhD, while simultaneously addressing a pressing industry need. To ensure this requirement is met, each studentship has a supervisory team that is comprised of at least two academics based in different countries within the region, and a non-academic professional.

B. *PhD studentships and post-docs*

To date 32 PhD studentships have been awarded through the Bryden Centre, across 2 cohort intakes. In addition to carrying out research towards their PhD, students are required to attend annual summer schools (Figure 1) to develop business management and entrepreneurship skills (e.g. financial planning, market research), personal research skills (e.g. research methods, dissertation planning, scientific report writing, ethics, presentation skills), and additional technical skills (e.g. statistical analysis). Students are also required to engage in at least two weeks of seconded time with their industry partners.

The studentships are supported by a team of 5 post-doctoral researchers, who in addition to pursuing their own renewable energy-related research, act as informal research team leaders, providing student mentoring and support.

II. Bryden Centre Research: state of the art

Bryden Centre researchers and PhD students are carrying out a broad range of challenge-led and industry-led projects related to marine renewable energy and bioenergy in Ireland, Northern Ireland, and Scotland. While the most common subject areas are to do with engineering and interactions of development with the marine environment, students are also tackling energy storage, social acceptability, and marine spatial planning.

Specific marine renewable energy research topics include:

1) Device modelling & development

- Numerical analysis of floating offshore wind turbines to improve the accuracy of response calculations for floating wind turbines in extreme weather
- Modelling the dynamic response of floating solar PV arrays in nearshore locations
- Offshore wind turbine mechanical power electronic fault coupled diagnostic tool (or marine renewable energy & offshore wind power diagnostic tools)
- Fatigue assessment of offshore wind turbines using numerical modelling
- Investigating the feasibility of community scale tidal power generation

2) Environmental impacts

- New methods to address potential biases in vantage point survey data for quantification of seabird use of tidal environments
- Understanding how seabirds use tidal flow areas, focussing on how key species interact with tidal turbines at fine-scale resolution
- Assessing how organisms interact with tidal hydrodynamics across multiple trophic levels (top predators, fish, zooplankton) to inform consenting decisions for offshore renewable energy
- Understanding the collision risk of harbour seals with tidal energy devices
- Using Unmanned Aerial Vehicles (UAVs) to measure animal distribution in tidal-stream energy sites
- Passive acoustic monitoring and automated detection of gadoid fish species in marine renewable energy development areas
- Ecology and recovery of flame shells (*L. hians*) to disturbance
- Marine renewable energy device biofouling in relation to device noise and vibration

3) Optimisation

- Numerical modelling and optimisation of tidal energy devices, integrating building information modelling for lifecycle management
- Developing multidisciplinary optimisation methods for wave energy
- Engineering Modelling Methods to Support Outsourcing Decisions in Marine Renewable Energy

4) Energy storage

- Investigating lithium ion battery degradation using spectroscopic techniques
- Solid oxide fuel cells

5) Marine Planning & social license to operate

- Transitioning towards social acceptability of marine renewable energy in Ireland
- Developing new spatial models to optimise development siting and design

6) Economic viability

- Optimal integration of joint energy and power services to determine the true strike price of offshore wind to understand the full economic viability

Similar topics on modelling, development, energy storage, social license to operate, and economic viability are also being pursued in the bio energy field with in the Bryden Centre. In addition, students are pursuing research on reducing the emissions of biodiesel production, assessing the viability of new feed stock sources, and systems for energy recovery.

III. Opportunities for Knowledge Exchange & Innovation

The Bryden Centre is designed to be a resource, building capacity across the Interreg VA region to support and accelerate the development of marine renewable energy. PhD qualified individuals with strong links to the regional industry will build research and development capacity in a region otherwise poor in this area.

It is recognized that the marine renewable energy and bio energy industries and associated research needs will change and develop between 2018 and 2021, the duration of the Bryden Centre. To address emerging research needs, the Bryden Centre aims to work with non-academic partners to develop and carry out short feasibility studies which address a particular barrier to development or innovation need. For the industry, regulators, and their advisors, this represents a substantial opportunity to collaborate with a dedicated researcher on an individual topic, in return a commitment that the outcomes of the research (within reason of commercial sensitivity) are shared with the wider marine renewable and bio energy communities, to benefit the industry as a whole.

The Bryden Centre will also provide an incentive scheme supporting 100% of the salary cost of a three month (post-award) PhD graduate placement to 10 businesses. These placements should be focused on embedding new knowledge within the business and/or supporting commercialisation focused activities, contributing to economic competitiveness. A call for these industry placements will be released to Bryden Centre industry participants towards the end of the project's lifetime, in 2021.

IV. Legacy

The Bryden Centre aims to enhance the technical skill-base for marine energy and bioenergy across the region,

while simultaneously improving relationships between industry, academia, and other stakeholders to enable continued innovation in the marine energy sector. The doctoral training centre model equips students to enter the academe, business or government bodies with a holistic knowledge of the sector, developed through close interaction with the Bryden Centre network of partners. The network of participants in the Bryden Centre (students, PDRAs, lead scientists, businesses, and government regulators and advisors) is a key legacy of the project. Relationships built over the duration of the Bryden Centre represent pathways for further research, development, and knowledge exchange within and throughout the region as the newly PhD qualified scientists move into the workforce.

In addition, the newly formed alliances and the developed research capacity should facilitate the development and deployment of MRE technologies for a sustainable future on these islands.

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