

Session overview

Day 0: Tuesday 5th July 2022

Registration and Exhibitor setup		
17:00 – 19:00	Poster & exhibitor setup	Peter Lanyon
18:00 – 20:00	Early registration (optional)	Stannary Bar

Day 1: Wednesday 6th July 2022

Registration and Welcome		
08:30 – 09:00	Registration	Peter Lanyon
09:00 – 09:10	Welcome (Professor Lars Johanning)	Chapel
Session 1: Innovation across marine renewable energy (sponsored by EuroSWAC)		
09:10 – 09:40	Keynote (Kerry Hayes, Simply Blue Group)	Chapel
09:40 – 10:40	Presentations (4)	
10:40 – 11:00	Coffee break	
11:00 – 12:00	Presentations (4)	
12:00 – 13:00	Lunch	Peter Lanyon
Session 2: Tidal Stream Energy (sponsored by the Interreg TIGER project)		
13:00 – 13:30	Keynote (Sue Barr, Cambrian Offshore)	Chapel
13:30 – 14:30	Presentations (4)	
14:30 – 15:00	Coffee break	Peter Lanyon
15:00 – 16:00	Presentations (4)	Chapel
16:10 – 17:00	TIGER Panel session	
17:00 – 18:00	Poster and exhibitors networking event	Lower Stannary
19:30 – 23:00	Gala Dinner	Greenbank Hotel

Day 2: Thursday 7th July 2022

Registration and Welcome		
08:30 – 09:00	Registration	Peter Lanyon
09:00 – 09:15	Welcome (Professor Lars Johanning)	Chapel
Session 3: Wave Energy (sponsored by Marine-i)		
09:15 – 09:45	Keynote (John Chapman, Marine Power Systems)	Chapel
09:50 – 10:50	Presentations (4)	
10:50 – 11:10	Coffee Break	Peter Lanyon
11:10 – 12:10	Presentations (4)	Chapel
12:10 – 13:10	Lunch	Peter Lanyon
Session 4: Wind Energy		
13:10 – 13:40	Keynote (Matt Hodson, Celtic Sea Power)	Chapel
13:45 – 14:45	Parallel sessions: Presentations (4)	Chapel / LT 5
14:45 – 15:15	Coffee break	Peter Lanyon
15:15 – 16:30	Parallel sessions: Presentations (5)	Chapel / LT 5
16:30 – 16:45	Awards	Chapel
16:45 – 17:00	PRIMaRE chair handover and close	

Session detail

All keynotes and conference presentations will take place in the Chapel lecture theatre, with the exception of session 4b on Thursday afternoon, which will take place in the Peter Lanyon building lecture theatre 5. Coffee and lunch will be served upstairs in the Peter Lanyon building, where posters and exhibition stands are also located.

Wednesday 6th July 2022

Session 1: Innovation across Marine Energy

We are grateful to the EuroSWAC project for sponsoring this session. For more details on the project see the conference handbook or project website (euroswac.fr).

Session 1: Innovation across marine renewable energy (sponsored by EuroSWAC)		
Chairs: Paul Newman & Anna Young		
09:10 – 09:40	Keynote (Kerry Hayes, Simply Blue Group)	Chapel
09:40 – 09:55	Jamie Wheaton, Aleksandra Zawalna-Geer, Allen Alexander & Lars Johanning <i>The Evaluation of Marine Infrastructure from a Circular Economy Perspective</i>	
09:55 – 10:10	Daniel Coles <i>Impacts of tidal stream energy on supply-demand balancing in hybrid systems</i>	
10:10 – 10:25	Lowri Ch'ng <i>Modelling Tidal Turbine Biofouling Effects in a Wind Tunnel</i>	
10:25 – 10:40	Andrew Want & Rachel Nicholls-Lee <i>Quantifying the Impacts of Biofouling on Dynamic Subsea Power Cables used in Floating Offshore Renewable Technologies</i>	
10:40 – 11:00	Coffee Break	Peter Lanyon
Chair: Daniel Coles & Michael Togneri		
11:00 – 11:15	Ian Masters <i>Converging beam acoustic doppler profiler (cADP): First field trial results of a novel instrument</i>	Chapel
11:15 – 11:30	Anna Young <i>Barnacle: a probe for marine turbulence characterisation</i>	
11:30 – 11:45	Stephen Watson & Nicola Beaumont <i>The expansion of fixed and floating offshore windfarms: implications for ecosystem services</i>	
11:45 – 12:00	David White <i>Seabed friction for cables and foundations – measurement and estimation</i>	

Keynote: Kerry Hayes – Simply Blue Group



Kerry has a decade of experience working across the renewable energy sector with marine energy project developers, and a broad range of experience in supply chain development, stakeholder engagement, planning, consenting and energy policy. Kerry is passionate about increasing female representation in the renewable energy sector. She is chair of the RenewableUK Shadow Board, a regular conference speaker, mentor for students and professionals and holds guest lecturing posts at UK universities. Kerry has a BSc in Ocean Science and an MSc in Marine Renewable Energy.

Session 2: Tidal Stream Energy

We are grateful to the Tidal Stream Industry Energiser project (TIGER) for sponsoring this session. For more details on the project see the conference handbook or project website (www.interregtiger.com).

Session 2: Tidal Stream Energy (sponsored by the Interreg TIGER project)		
Chair: Ashleigh Henry & Lillian Lieber (TBC)		
13:00 – 13:30	Keynote (Sue Barr, Cambrian Offshore)	Chapel
13:30 – 13:45	Rebecca Fowell, Ophélie Nourisson, André Pacheco & Michael Togneri <i>Pairing non-simultaneous flow and load data on a tidal turbine through an oceanographic model proxy</i>	
13:45 – 14:00	Ed Mackay <i>Generalised IFORM: High-dimensional environmental contours from short datasets</i>	
14:00 – 14:15	Pimonpan (Peach) Phurappa <i>Innovative Multi-Turbine Control System for HydroWing Tidal Energy Technology</i>	
14:15 – 14:30	Hannah Mullings <i>Assessment of the spatial variation of fatigue loads due to both site and model data</i>	
14:30 – 15:00	Coffee Break	Peter Lanyon
Chair: Ian Ashton & Hannah Mullings		
15:00 – 15:15	Iain Fairley <i>Surface velocimetry for tidal stream resource assessment: a comparison of two methods across a range of sites</i>	Chapel
15:15 – 15:30	Lillian Lieber <i>Drones for tidal energy research</i>	
15:30 – 15:45	Rhys Gadd <i>Using an Agent based model (ABM) to predict 3D distribution and behaviour of forage fish around a Tidal Stream Turbine</i>	
15:45 – 16:00	Vahid Seydi, Lucille Chapuis, Gemma Veneruso, Sudha Balaguru, Noel Bristow & Dave Mills <i>Deep variational autoencoder to design one-class classifier on passive acoustic monitoring data to separate noisy clicks.</i>	
16:00 – 17:00	Ciaran Frost <i>Quantifying and comparing cost reduction drivers for tidal stream energy</i> Followed by TIGER Panel Session: <i>Cost reduction and innovation in the tidal stream sector</i>	

Keynote: Sue Barr – Cambrian Offshore



Sue is a Board member of Marine Energy Wales, Pembrokeshire Coastal Forum and a Non-Executive Director of Marine Power Systems. Sue also chairs the UK Marine Energy Council. Sue was the recipient of the 2018 SUT Award for 'Outstanding Contributions to Marine Energy' and was awarded Ocean Energy Europe's Vi Maris 2019 award for outstanding contribution to marine energy. Sue has played a key role in driving renewable industry development and policy in the marine area, both in the UK and internationally.

Session 3: Wave Energy

We are grateful to the Marine-i project for sponsoring this session. For more details on the project see the conference handbook or project website (www.marine-i.co.uk)

Session 3: Wave Energy (sponsored by Marine-i)		
Chairs: John Samuel & Jon Hardwick		
09:15 – 09:45	Keynote (John Chapman, Marine Power Systems)	Chapel
09:50 – 10:05	Jingru Xing, Liang Yang, Dimitris Stagonas & Phil Hart <i>Computational analysis of wave devouring propulsion with submerged hydrofoil</i>	
10:05 – 10:20	Tamer Abel Abdelmigid <i>Improved Short-term Significant Wave Height Forecasting Using Ensemble Empirical Mode Decomposition Coupled with Linear Regression</i>	
10:20 – 10:35	Bahareh Kamranzad <i>Prediction of long-term change of wave energy based on various wave parameters</i>	
10:35 – 10:50	Haoyu Ding & Jun Zang <i>Survival analysis of a wave energy convertor</i>	
10:50 – 11:10	Coffee Break	Peter Lanyon
Chairs: Jingru Xing & Ed Mackay		
11:10 – 11:25	Jon Hardwick <i>Uncertainty in Wave Modelling using a Bayesian Emulator</i>	Chapel
11:25 – 11:40	Rachel Nicholls-Lee <i>Development of a novel, robust, near-shore, wave energy converter for energy security in remote communities</i>	
11:40 – 11:55	John Samuel, David Simmonds, Keri Collins, Jon Miles, Deborah Greaves, Giovanni Malara, Felice Arena <i>Hydrodynamic Performance and Survivability of a U-shaped Oscillating Water Column Wave Energy Converter</i>	
11:55 – 12:10	Terry Griffiths <i>Observations and experiences in transitioning from PhD researcher to renewable energy engineer</i>	

Keynote: John Chapman – Marine Power Systems



John is Chief Engineer of Marine Power Systems. He has over 16 years' experience in marine renewables in both academia and industry, with experience in several high-tech renewable energy start-ups including tidal, wave and offshore wind renewables. With experience in Mechanical engineering and computational simulation, at MPS he has responsibility for technical system development of MPS' products.

Session 4a: Wind Energy parallel A (Modelling and Optimisation)

Session 4a: Wind Energy: Modelling and Optimisation		
Chairs: Bahareh Kamranzad & Rick Lupton		
13:10 – 13:40	Keynote (Matt Hodson, Celtic Sea Power)	Chapel
13:45 – 14:00	Lars Johanning, Kanchan Joshi & Justin Olosunde <i>A low carbon-cost choice decision tool to model the performance of Floating Offshore Wind (FOW) energy farms</i>	
14:00 – 14:15	Barton Chen <i>Assessment of the pathways to integrate floating offshore wind to the energy system</i>	
14:15 – 14:30	Emma Edwards, Edward Ransley, Scott Brown, Deborah Greaves & Martyn Hann <i>Physical modelling of floating offshore wind turbines and comparison to numerical results</i>	
14:30 – 14:45	Kevin Gauder, Mike Graham & Ian Milne <i>Effect of rotor resistance on the turbulent inflow in an atmospheric boundary-layer</i>	
14:45 – 15:15	Coffee Break	Peter Lanyon
Chairs: Ajit Pillai & Emma Edwards		
15:15 – 15:30	Tom Tosdevin <i>Extreme response modelling of a semi-sub FOWT</i>	Chapel
15:30 – 15:45	Pawel Manikowski, David Walker & Matthew Craven <i>Many-objective Optimisation of Offshore Wind Farms</i>	
15:45 – 16:00	Mathew Walter, Pawel Manikowski, David Walker & Matthew Craven <i>Explainable Optimisation of Offshore Wind Farms</i>	
16:00 – 16:15	Emilio Faraggiana <i>An efficient optimisation tool for floating offshore wind support structures</i>	
16:15 – 16:30	Rick Lupton <i>Frequency domain modelling of floating wind turbines</i>	

Session 4 Keynote: Matt Hodson – Celtic Sea Power



Matt is Celtic Sea Power's Chief Operations Officer. He plays a leading role alongside key partners in positioning, formulating, and delivering the strategy for the future of Floating Offshore Wind and the marine sector in Cornwall and Isles of Scilly. Matt is an experienced commercial and operational leader with over 30 years' experience across a range of sectors. Following an early career as a Merchant Navy Deck Officer his roles have covered Public Sector economic growth, Marine Operations/Marine Technology/ Marine Renewable Energy, Port Management, Marine Leisure, Shipping and Commercial Services.

Session 4b: Wind Energy parallel B (Cables, Anchors, Moorings & Dampers)

Session 4b: Wind Energy: Cables, Anchors, Moorings & Dampers		
Chairs: Tessa Gordelier & Philipp Thies		
13:10 – 13:40	Keynote (Matt Hodson, Celtic Sea Power)	Chapel
13:45 – 14:00	Rachel Nicholls-Lee & Philipp Thies <i>Improving understanding of the structural response of dynamic subsea power cables</i>	Peter Lanyon LT 5
14:00 – 14:15	Alan Crowle <i>A technical review of the installation of floating offshore wind turbines</i>	
14:15 – 14:30	Lars Johanning & Hailun Xie <i>A Hierarchical Metocean Data Selection Model for Fast O&M Simulation in Offshore Renewable Energy Systems</i>	
14:30 – 14:45	Anna Holcombe, Martyn Hann, Shanshan Cheng, Robert Rawinson-Smith, Scott Brown <i>Scale physical modelling of dynamic power cable for a floating offshore wind turbine</i>	Peter Lanyon
14:45 – 15:15	Coffee Break	Peter Lanyon
Chairs: Alan Crowle & Lars Johanning		
15:15 – 15:30	Rodrigo Martinez, Sergi Arnau, Callum Scullion, Richard Nielson & Marcin Kapitaniak <i>Floating anchors for offshore wind turbines</i>	Peter Lanyon LT 5
15:30 – 15:45	Tessa Gordelier & Ajit Pillai <i>Mitigating Anchor Loads for Floating Wind in the Celtic Sea: Assessing Shared Anchors and Mooring Design Philosophy</i>	
15:45 – 16:00	Faryal Khalid, Philipp Thies, Lars Johanning & David Newsam <i>Physical testing of a mooring damper for floating offshore wind application</i>	
16:00 – 16:15	Ignacio Johannesen & Edward Ransley <i>Passive motion reduction strategies for semisubmersible platforms for floating offshore wind turbines</i>	
16:15 – 16:30	David Christie <i>Wave Modulation by Offshore Wind Farms</i>	

Abstracts by session

Session 1: Innovation across marine renewable energy (sponsored by EuroSWAC)

Jamie Wheaton, Aleksandra Zawalna-Geer, Allen Alexander & Lars Johanning
University of Exeter, Penryn Campus

The Evaluation of Marine Infrastructure from a Circular Economy Perspective

EuroSWAC is a highly innovative project aimed at demonstrating the potential of the English Channel seawater for cooling, adapting an existing technology to the low depth and temperate climate of the Channel Area. SWAC (Sea Water Air Conditioning) technology exploits temperature differences between seawater and external air temperature to produce cooling by pumping cold water and transferring its cooling power to a secondary loop via a heat exchange station.

Amongst its various objectives (e.g., develop two UK SWAC demonstrators, provide blueprints for replication of SWAC installations along the Channel coastline), the EuroSWAC project also aims to explore the decision-making tools available when evaluating marine infrastructure from a circular economy perspective. The presentation demonstrates ongoing research into the technical optimisation of EuroSWAC as well as its ongoing assessment through a Life Cycle Sustainability Assessment, a methodology which measures the performance of an asset according to all three aspects of Circular Economy (i.e., environmental, economic, and social equity) from a cradle-to-cradle usage philosophy.

The study demonstrates how the optimisation of EuroSWAC according to circular principles can inform the technical, economic and environmental replicability requirements of future SWAC systems, in addition to the business decisions adopted by potential, future end-users.

Daniel Coles
University of Plymouth

Impacts of tidal stream energy on supply-demand balancing in hybrid systems

In the UK during August and September 2021, sustained lulls in wind power generation coincided with low nuclear power availability, resulting in increased reliance on natural gas for power generation. Due to low natural gas reserves, reliance on imported natural gas increased. High global natural gas demand led to significant increases in its wholesale price, resulting in a doubling of UK wholesale electricity price. These simultaneous events highlight the vulnerability of electricity systems when relying on established renewable power with high long-term forecasting uncertainty, such as wind, and imported back-up fuels with volatile pricing. In this research, we investigate the impacts of diversifying the mix of renewable power generators on energy system resilience and security. We focus on the addition of tidal stream energy, given its ability to provide reliable, periodic power production with short-long term predictability. The energy system on the Isle of Wight is considered to explore the 'optimal' mix of solar pv, tidal stream and wind power capacity that maximises supply-demand balancing in a partially isolated energy system that includes energy storage. Results show that through diversification, supply-demand matching is improved by up to 40%, relative to the adoption of a single power generation technology alone.

Lowri Ch'ng
Swansea University

Modelling Tidal Turbine Biofouling Effects in a Wind Tunnel

Biofouling is a common occurrence on submerged surfaces. Accumulation of organisms increases surface roughness and disturbs the flow around the surface. Detrimental effects on tidal turbine performance where a power reduction of up to 43% has been observed [1]. Vortex Generators (VGs) are flow separation control devices that are known to counteract the negative effects of increased surface roughness on wind turbine blades. This project firstly aims at modelling biofouling effects on a tidal turbine hydrofoil in a wind tunnel and secondly, examine whether VGs can control the disturbed flow. A 20% thick hydrofoil located near the root of a turbine was tested at a Reynolds number of 1 million, recording force balance measurements. Artificial algae were attached around the profile with and without VGs. The biofouled model showed a reduction in the lift gradient in the linear region and decreased maximum lift by 20%, while delaying stall by 2°. An increase in drag was observed for angles of attack tested with over 5 times at 0°. The addition of the VGs to the biofouled model increased drag in the linear region, while stall was further delayed by 2° leading to reductions in drag and increasing maximum lift by 8%.

References:

[1] Starzmann, R., Kaufmann, N., Jeffcoate, P., Guerra, M., Hay, A., and Pieroway, R. (2021) Effect of Fouling on the Performance. Proceeding of the 14th European Wave and Tidal Energy Conference. 5-9th September. Plymouth.

Andrew Want & Rachel Nicholls-Lee
Heriot Watt University - Orkney and University of Exeter - Penryn

Quantifying the Impacts of Biofouling on Dynamic Subsea Power Cables used in Floating Offshore Renewable Technologies

Floating offshore renewable energy (ORE) technologies are reliant on dynamic subsea power cables (dSPCs) passing through the water column to transmit electricity from the surface to the seabed. Hydrodynamic forces in the high-exposure environments targeted for many deployments increase the vulnerability of dSPCs to fatigue failure. dSPCs are costly to manufacture and repair, and maintenance 'down-time' may result in significant loss of revenue. The structural response of dSPCs will be impacted by increased loading and drag associated with biofouling from sessile marine organisms. Existing studies of biofouling in the oil and gas sector have limited application to ORE technologies, and current standards and guidelines used in the ORE sector provide only broad generalisations on biofouling that may be less relevant to smaller diameter structures, such as cables. Significant knowledge gaps exist on biofouling growth rates and seasonality concerning materials, components, and locations used in ORE. Using a multi-disciplinary approach, in situ biofouling studies in the sector are being used to capture quantifiable data necessary to understand expected loading consequences of marine growth on cable movement and buoyancy. Modelling dSPC responses to a range of biofouling scenarios may help assess economic impacts and provide mitigation guidance to the sector.

Ian Masters
Swansea University

Converging beam acoustic doppler profiler (cADP): First field trial results of a novel instrument

The measurement beams of conventional Acoustic Doppler Current Profilers (ADCPs) spread outwards and measurements rely on a statistical average and steady flow conditions to provide a “point” measurement of velocity and turbulence metrics. Therefore, there is a desire to build instruments that have inward pointing converging doppler beams. Following the Vectron (Dalhousie, Canada) and Edinburgh cADP instruments, we describe here the design and testing of a third cADP design.

The instrument is a triangular seabed frame, with three single beam ADPs positioned 10m apart. The design concept is lightweight and can be deployed and retrieved without use of a crane barge. Following discussion of the design process, and the experimental campaign to test the deployment system, data will be presented from the first 28 day deployment of the system. Data was collected from the 3 converging beams and from a co-located 5 beam diverging instrument. First results from this system will be presented on velocity and turbulence.

This work is part of the Selkie project, funded by the European Union's European Regional Development Fund through the Ireland Wales Cooperation programme.

Anna Young
University of Bath

Barnacle: a probe for marine turbulence characterisation

Most tidal site flow data are acquired with Acoustic Doppler Current Profilers (ADCPs). ADCPs, however, only capture low-frequency unsteady flow and miss entirely some of the flow structures that are most damaging to a turbine. An array of Acoustic Doppler Velocimeters (ADV, which take point measurements) could be used instead, since they can capture flow structures over the required frequency range. ADVs are, however, less robust than ADCPs and both devices are too expensive to be deployed in the numbers necessary to survey an entire site effectively.

The Barnacle had been developed in response to the need for a low-cost, accurate turbulence probe for marine use. The principle of operation is similar to that of the five-hole probe used in wind tunnel testing, with significant adaptations to use in the marine environment. The Barnacle uses pressure differences to calculate the speed and direction of the oncoming flow. The advantages of the Barnacle over Doppler-based devices are high frequency response, robustness and independence from seeding. In this talk, we will show the results of trials with the Barnacle alongside an ADV in Strangford Lough and discuss the relative merits of the two devices.

Stephen Watson (Presented by Nicola Beaumont)
Plymouth Marine Laboratory

The expansion of fixed and floating offshore windfarms: implications for ecosystem services

Globally, the deployment of offshore wind is expanding rapidly, with offshore wind capacity in UK waters expected to grow four-fold by 2030 (and potentially ten-fold by 2050). An improved understanding of the social and environmental impacts of this sector, and how they compare with those of other energy systems, is therefore necessary to support energy policy and planning decisions. This presentation will outline the ongoing work of the UKERC energy, environment & landscapes project (2020-2023) which will apply ecosystem service and natural capital approaches to understand the environmental implications of changes in the UK offshore wind energy system. The impacts of offshore wind development (including floating wind) on

ecosystem services will be assessed through a qualitative process of mapping ecological and cultural parameters informed and tested using existing case study data from UK offshore wind farms, particularly those collected as part of statutory monitoring. By reporting outcomes in societal terms, the approach will help facilitate communication with decision makers and will aid in the evaluation of trade-offs such as environmental net gain and the potential for co-location with other economic activities.

David White
University of Southampton

Seabed friction for cables and foundations – measurement and estimation

The sliding friction between cables, foundations and the seabed is an important input parameter that depends on the material properties of the contacting surfaces as well as their shape (i.e. the local bathymetry). In soft soil conditions, or on smooth rock, a friction coefficient as low as 0.1 may be appropriate, but much higher friction – corresponding to a coefficient of 1 or more – can be valid in other conditions.

This presentation will show some completed and in-progress research for seabeds ranging from very soft muds to hard rocks. It will include the development of new devices to measure the friction properties of seabed samples taken to the lab, as well as methods to measure the properties in situ. Emerging ways to estimate the effective seabed friction, allowing for the effect of consolidation of soft soils and ruggedness of rock will be discussed. There will be examples of successful innovations that have found use by industry, and examples where the idea has failed to gain traction (no pun intended) for one or other reason.

Finally, the application of this work to the stability design of cables and foundations in new frontiers of the UK's offshore renewables developments will be explored.

Session 2: Tidal Stream Energy (sponsored by the Interreg TIGER project)

Rebecca Fowell, Ophélie Nourisson, André Pacheco & Michael Togneri
Swansea University

Pairing non-simultaneous flow and load data on a tidal turbine through an oceanographic model proxy

Establishing a relationship between tidal current conditions and tidal turbine performance and loads is a critically important consideration for turbine reliability. Nonetheless, obtaining in-situ information is often challenging, and as a result both environmental and load data may be more sparse than desired. This study presents a method to make use of limited data sets by establishing a relationship between measurements of hydrodynamic variability and turbine power or blade strain variability, even when these measurements are not taken simultaneously. The method is tested on data from the deployment of a full-scale pilot tidal turbine in the Fromveur Strait: in situ velocity measurements and turbulence characteristics taken at times when the turbine was not installed were associated with power and strain measurements during the turbine's deployment via a Delft3D proxy. The data show that the variability of active power correlates well with turbulence kinetic energy (TKE) when comparing similar populations via the proxy. Examination of blade strain variance against TKE shows a weaker correlation, with fat-tailed distributions and extremely high strain outlier values present across all flow speeds.

Acceleration or deceleration of the flow influenced the power variability of the turbine, with larger standard deviations recorded across accelerating flows. No significant difference was found when comparing blade strain variance in accelerating and decelerating flows. We conclude that the proxy method studied can establish a population-level relationship between non-simultaneous environmental and load data, but that the accuracy and precision of this relationship depends on the amount of data available: this method is therefore only suitable where there is a sufficiently rich dataset.

Ed Mackay
University of Exeter

Generalised IFORM: High-dimensional environmental contours from short datasets

Design of offshore renewables requires understanding of the environmental conditions which they will experience during their deployment. Variables such as wind speed and direction; wave height, period and direction; and current speed and direction, all influence the response. Environmental contours are often used to define extreme combinations of these variables, usually in two or three dimensions. Contours are usually estimated by fitting a joint distribution model to observations, where the amount of data required scales with the number of dimensions, making estimation of high-dimensional contours infeasible in most cases. In this work, a method is presented for estimating environmental contours, which does not have this drawback. The method extends the 'Direct IFORM' method, based on projecting all observations onto lines at various angles to the origin and conducting a peaks-over-threshold analysis on the projected data, therefore utilising all observations for each angle. We show how this method can be applied in arbitrary dimensions, and consider computational aspects. Examples of the application of the method to derive contours of wind and wave and current parameters are presented.

Pimonpan (Peach) Phurappa
Inyanga Maritime Ltd and HydroWing Ltd

Innovative Multi-Turbine Control System for HydroWing Tidal Energy Technology

Hydrowing is a tidal energy converter housing two to four turbines from Tocardo BV on a wing-like structure which itself is retrievable from a seabed foundation. The Turbine Control Hub (TCH) is the centralised subsea power conditioning and control unit for all turbines on the same wing. Considering the well proven turbine characteristics and Tocardo's existing control strategies, a new control system within the TCH has been tailored/developed to enhance turbine nameplate power by 50% (Smart Overdrive control) and suit all HydroWing requirements. A simulation model was created using MATLAB Simulink. The model contains 4 subsystems including hydrodynamic, mechanical, machine torque & current, and speed controller. The use of MATLAB Simulink programme aids the graphical/numerical simulation of the control system development which illustrates and enables testing of behaviours of the HydroWing device under different operational eventualities. As a result of the research and development, the enhanced multi turbine control system is finalised covering all modes of operation – Normal operation, Optimal power operation and Smart overdrive. This work marks another crucial steps in HydroWing research and commercial development and is currently being integrated for next stage real environment demonstration in Q1 2023 before subsequent integration into HydroWing & Tocardo's commercial projects.

Hannah Mullings
The University of Manchester

Assessment of the spatial variation of fatigue loads due to both site and model data

The aim of this work is to assess the variation in turbine loads for a given flow condition. Analysis includes the use of site and model data from the European Marine Energy Centre (EMEC) in the UK and Le Raz Blanchard in France. This data enables the cross-comparison of fatigue loads for turbines located at various positions within a site, as well as at two different sites. Fatigue loads are quantified by using damage equivalent loads, utilising the fluctuating time history of blade loading for multiple samples over a number of tidal cycles. A blade element method is combined with a synthetic turbulence inflow, defined by velocity and turbulence datasets in order to calculate the unsteady blade loading. For a single design case, at one tidal site with two turbines with spacing of approximately four turbine diameters, a near surface turbine can experience a 5% difference of loads when considering a flood tide and 30% when an ebb tide is considered. The use of site data allows for an initial investigation into the impact of wave conditions on the fatigue loads, showing near surface turbines in a flood tide experience a 32% reduction in blade loading.

Iain Fairley
Swansea University

Surface velocimetry for tidal stream resource assessment: a comparison of two methods across a range of sites

Drone-based surface velocimetry is increasingly used in various fields due to the low cost of drones, ease of deployment, and lower health and safety risks compared to in-situ measurements. Surface velocimetry can provide two-dimensional maps of currents over a wide area and return the true surface current which acoustic Doppler current profilers (ADCPs) cannot, due to blanking distances. Our recent research has demonstrated the potential of large-scale particle image velocimetry (LSPIV) for tidal resource assessment by comparing LSPIV results to flow measurements from both ADCPs and GPS-equipped surface drifters across three sites (Ramsey Sound, Mumbles Head and the Inner Sound of the Pentland Firth); root mean square errors were $\sim 0.25\text{ms}^{-1}$ under favourable conditions. However, LSPIV accuracy depended on site bathymetry and weather conditions. To further explore this, experiments were conducted at three additional South Wales sites with potential for tidal stream energy extraction: Strumble Head, St Donats, and META, a tidal test location. There are times when wind-generated waves are the dominant signal in the imagery rather than current-advected turbulent structures. Therefore, an alternative approach, CopterCurrents, that considers the dispersion of surface gravity waves to estimate currents is being tested. This paper will compare both techniques at the six sites.

Lilian Lieber
Queen's University Belfast

Drones for tidal energy research

Placing ocean energy converters in our most dynamic coastal seas requires a better understanding of realistic flow interactions with devices and potential implications for marine life. Direct measurements of flow velocities and fine-scale turbulence (\sim meters) are often limited

by observational techniques, requiring innovation in the tools we have readily available. One such an innovation is the use of consumer-grade aerial drones in ocean energy research applications. In combination with other traditional sensors, such as acoustic Doppler current profilers (ADCPs), aerial drone imagery can provide quantitative measurements of flow velocities and turbulence structures very close to the water surface, a region of the water column where ADCPs cannot provide reliable measurements. Drones can therefore complement water column measurements during both inflow (affecting device performance) and downstream (wake signatures affecting downstream tidal turbine placement) assessments which is of particular relevance for the floating tidal turbine industry. Here, we present a study around the world's most powerful tidal turbine, the floating O2 device (Orbital Marine Power) installed at EMEC (Fall of Warness, Orkney Islands) to inform on both, industry-relevant flow measures and environmental interactions. Using a combination of drones, ADCPs and a broadband echosounder, our study aims to provide 1) direct engineering insight for the assessment of device performance and array spacing and 2) environmental characterisation, for a better understanding of the mechanisms underlying marine fauna (seabirds, fish) interactions. The project's vision is to prove a low-cost and robust data collection campaign to support the integration of various data streams, providing transferable knowledge and thus allowing for more transparency and flexible collaboration between industry and academia.

Rhys Gadd
Bangor University

Using an Agent based model (ABM) to predict 3D distribution and behaviour of forage fish around a Tidal Stream Turbine

There is a concern regarding how changes in local hydrodynamics as the result of tidal stream turbine (TST) arrays may affect foraging opportunities for piscivorous marine mammals and seabirds. The 3D behaviour and distribution of forage fish determines its availability to predators and understanding how TST alter school characteristics helps estimate impacts on foraging opportunities. However, previous methodologies used to study impacts of changing hydrodynamics on fish and top-predator populations around TST have struggled to comprehensively quantify school characteristics across the water column due to the turbulent nature of tidal stream environments and the high flows experienced there. To overcome challenges, and provide insights into potential changes in foraging opportunities, this study applies an agent-based model (ABM) approach to a high-fidelity simulated TST wake, estimating responses of forage fish to installations. Initial results will be presented, and indicate areas whereby foraging efficiency for top-predators may be altered, either from changes in school characteristics or anti-predatory responses. We therefore demonstrate the potential to simulate how fish and top-predators interact with a tidal turbine structure at a fine-scale, which can (once validated) be applied to understanding scaling concerns and providing a more accurate assessment of risks for legislators and planners.

Vahid Seydi, Lucille Chapuis, Gemma Veneruso, Sudha Balaguru, Noel Bristow & Dave Mills
Bangor University

Deep variational autoencoder to design one-class classifier on passive acoustic monitoring data to separate noisy clicks.

In this study, we design a new classifier based on a deep learning model to locate and identify important marine species around underwater tidal stream turbines in Wales by analysis of

passive acoustic monitoring (PAM) data. The research addresses concerns that operational turbines could cause direct harm to marine mammals and damage marine ecosystem function. Therefore, it is necessary to track the behaviour of individual species of concern around turbines. The proposed classifier is designed for the analysis of echolocation clicks present in PAM data. The problem is that only a very small percentage of recorded clicks are important. The majority of clicks in the labelled dataset are labelled as 'noise clicks' and this leads to the classifier facing a highly imbalanced dataset.

To address this issue, we design a one-class classifier using deep learning and variational autoencoder that separates noise clicks from relevant clicks of selected species. The proposed classifier model will be tested on PAM data collected in 2019 off Anglesey, where a tidal kite developed by Minesto was deployed. The results will be compared to those from an existing multiclass classification model and the effectiveness of our new classifier evaluated in terms of analytical speed and accuracy.

Ciaran Frost
Offshore Renewable Energy Catapult

Quantifying and comparing cost reduction drivers for tidal stream energy

Tidal stream energy is an exciting, emerging sector. While deployment has mostly been single turbines and proof of concept demonstration, the sector is on a cusp of a new revolution, with £20M generation subsidy per annum ringfenced by the UK Government through Allocation Round 4. Results, expected in April 2022, could see 30-40MW of new tidal capacity announced and commissioned as early as 2025, benefitting from existing site leases.

To secure future revenue support it is crucial that the industry maintains government support, demonstrating a fast but credible cost reduction trajectory, as it is currently more expensive than other renewable energy technologies. There are many innovations and drivers that could help the industry unlock lower levelized cost of energy (LCOE) and become cost competitive, however many of these are not yet implemented, with benefits not quantified.

This presentation will introduce the range of cost reduction drivers accessible to the industry, covering technological and financial innovations. Considering a baseline installation in 2021, we will show how these impact LCOE, quantifying the improvements and research areas that the industry should prioritise. We will also discuss the technology and site-specific nature of these innovations for projects being developed across the UK and France.

Session 3: Wave Energy (sponsored by Marine-i)

Jingru Xing, Liang Yang, Dimitris Stagonas & Phil Hart
Cranfield University & University of Cyprus

Computational analysis of wave devouring propulsion with submerged hydrofoil

Abstract of Computational analysis of wave devouring propulsion with submerged hydrofoil

Submerged flapping foils can convert wave energy directly into thrust. The thrust is generated from the wave-induced motion (surge, heave, and pitch). This thrust can be used for propulsion

or stabilising the floating system. Predicting the thrust generation and coupling with the dynamics of systems is challenging work. In this paper, we present an efficient 2D computational fluid dynamics (CFD) framework to explore the thrust generation of a submerged flapping hydrofoil in waves.

The wave devouring propulsion is demonstrated by a simulation of the passive-motion hydrofoil. The hydrofoil is placed in a numerical wave tank facing waves with the presence of the free surface. The pitching and heaving motions of it are restricted by spring-restoring forces. The numerical results are shown and discussed over a range of wave frequencies and wave heights. The effect of the spring stiffness is also discussed.

Tamer Abel Abdelmigid

Arab Academy for Science, Technology and Maritime Transport, Alexandria, Egypt

Improved Short-term Significant Wave Height Forecasting Using Ensemble Empirical Mode Decomposition Coupled with Linear Regression

Short-Term significant wave height (SWH) forecasting is imperative for improved real-time control of wave energy converters (WEC). Data driven techniques offer less computational burden than classical numerical forecasting methods and improved forecasting capabilities than statistical methods. However, deep learning techniques - even though offering state of the art accuracy in prediction - long training time prohibits its use in online forecasting, which is required in real time WEC control applications. In order to overcome this issue and maintain good forecasting accuracy, a combination of Ensemble Empirical Mode Decomposition and Linear Regression (EEMD-LR) is used to forecast the 1 Hr. SWH, with lag chosen using Bayesian optimization. Several National Buoy Database Center (NDBC) buoys were used to validate the model with state-of-the-art deep learning techniques, where the proposed technique outperformed many published methods. Additionally, it offered a short training time with less data required for training, making it a promising candidate for online forecasting and embedded real time WEC control systems.

Bahareh Kamranzad

The Hakubi Center for Advanced Research, Kyoto University

Prediction of long-term change of wave energy based on various wave parameters

Ocean renewable energy is one of the solutions to provide green energy and tackle the impacts of climate change. However, available ocean resources are affected by climate change, too. Therefore, assessing long-term changes in wave energy resources is essential in evaluating the sustainability of the resources. Recent studies also emphasize the importance of the stability of wave energy resources in detecting the suitable locations for wave energy extraction. In this research, we used 60 years of modeled wave characteristics (using Simulating WAVes Nearshore (SWAN)) with a re-analysis wind field (JRA-55) as the model input to investigate the link between the long-term change of wave power and different wave characteristics on a global scale. The link between the change of parameters was initially discussed for two 30-yearly periods. Then, the relationship between the decadal variation of different parameters and their dependency was investigated. The results indicate the linkage between the change of wave power and wave characteristics in different areas based on the dominant wave climate, and the obtained relationship can be used to predict future changes in wave energy resources.

Haoyu Ding & Jun Zang
Univeristy of Bath

Survival analysis of a wave energy convertor

The research on wave energy convertors (WECs) has attracted great interests, however, there are still many challenges remaining in the development of effective, reliable and economically viable WECs. Because WECs are always exposed to the harsh marine environments, survivability under extreme marine environments that cause extreme loads and large responses is one of the challenges that are needed to be addressed. OpenFOAM[®] has been proved to be an accurate and mature viscous flow model for simulating wave-structure interactions even under violent waves. This research aims to apply OpenFOAM[®] with RANS-based turbulence model to investigate the survivability of a CorPower WEC system as part of a joint EPSRC project. The focused waves generated by New Wave theory and based on JONSWAP spectrum are applied for the short-term survival analysis. Both translational and rotational motion responses of the WEC buoy are presented and discussed. The motion responses in time histories have a more obviously nonlinear form after the main crest of focused waves passed through the buoy. The viscous flow around the WEC buoy is also investigated in this research. Violent vorticities are observed downstream of the buoy over the following two wave periods after main crest passed.

Jon Hardwick
University of Exeter

Uncertainty in Wave Modelling using a Bayesian Emulator

Wave models are used to understand and predict the conditions experienced at offshore energy sites. Like all numerical simulations, wave models have uncertainties in their output caused by uncertainty about the various input data (which may themselves be model outputs), and uncertainty about how well the model simulates the real world. Understanding these uncertainties is important in order to hold confidence in the models accuracy. Classical uncertainty analysis requires a very large number of runs, impossible in large complex models. By substituting a much more computationally efficient mathematical model, known as an emulator, for the simulation, processing time can be decreased.

A methodology for constructing an emulator is demonstrated on a simple SWAN model. By using this Bayesian methodology on output from a small number of correctly designed runs a statistical approximation of the SWAN output is generated. Importantly this emulator provides not just an approximation of the output but a full probability distribution describing how close the emulator output is to the model. This provides results in a fraction of a second and can be run many thousands of times as is required for uncertainty and sensitivity analysis. This method can be applied to large models simulating real conditions.

Rachel Nicholls-Lee
University of Exeter

Development of a novel, robust, near-shore, wave energy converter for energy security in remote communities

Wave energy is relatively immature technology when compared to others in the offshore renewables sector. It is therefore essential that the costs associated with wave energy generation fall to a level which are comparable to other technologies for it to become part of the

global energy mix. Survivability of devices is key to ensure they can withstand the extremely aggressive environment inherent with wave sites. Creation of a device that is both simple, yet robust is integral to reducing the requirement, and hence cost, of major maintenance.

This work assesses the feasibility of a novel concept for a robust wave energy converter operating in the near-shore region. The converter uses a series of non-return valves, constrained by a tapered pipe, where the incoming wave builds up pressure in each compartment and finally drives a turbine onshore with the pressurised water. The device is ideal for remote communities to gain energy security and reduce dependence on imports. The device facilitates public engagement, and it is intended that locals are trained to perform maintenance tasks using low cost, readily available, parts. An initial numerical model has been constructed in ANSYS CFX and compared directly with small scale experimental tests with good agreement.

John Samuel, David Simmonds, Keri Collins, Jon Miles, Deborah Greaves, Giovanni Malara, Felice Arena
The University of Plymouth, & Mediterranean University of Reggio Calabria, Ital

Hydrodynamic Performance and Survivability of a U-shaped Oscillating Water Column Wave Energy Converter

The U-shaped Oscillating Water Column (U-OWC) is one of the wave energy converters (WECs) proved up to the pilot stage in the ocean due to its simplicity in operation and ability to integrate with coastal defence structures for producing clean energy and protecting the coast from erosion. Studies on U-OWC WEC widely pertain to optimising its geometries to increase the wave power absorption and evaluating wave loads on the system for its survivability separately, but the optimisation of its geometries in consideration with wave loads on the system has received lesser attention. Hence, in this study, a comprehensive experimental investigation was undertaken to understand the mutual benefits of studying hydrodynamic performance and wave loads on the U-OWC WEC. The effect of power take-off damping in different levels was studied subjected to wave steepness ranging from 0.01 to 0.06 with an interval of 0.01. The hydrodynamic performance is evaluated in terms of hydrodynamic efficiency, wave reflection, and run-up. The survivability of a U-OWC WEC is evaluated in terms of total wave force on the system and pressure distribution on different structural components.

Terry Griffiths
Aurora Offshore Engineering / The University of Western Australia

Observations and experiences in transitioning from PhD researcher to renewable energy engineer

In 2015 I left full time consulting engineering in the O&G industry to undertake a PhD at UWA in the Oceans Graduate School. My research journey evolved to focus on helping to translate oil and gas design practice and make it better suited and more applicable to subsea cables, which are of vital importance in the offshore renewables space. With colleagues, I also started a small boutique engineering consultancy to enable the outcomes of this research to be applied in practice to projects.

This journey has been anything but 'smooth sailing' but to date, Aurora Offshore Engineering has been able to contribute to over 7.4GW of new offshore renewable energy. Our latest project is helping roughly 1M homes to switch from Russian gas to renewables as their prime source of power. I hope that there might be some helpful observations to share on the translation of research into practice that might be of interest to the audience.

Session 4a: Floating Offshore Wind Energy: Modelling and Optimisation

Lars Johannig, Kanchan Joshi & Justin Olosunde
University of Exeter

A low carbon-cost choice decision tool to model the performance of Floating Offshore Wind (FOW) energy farms

The nascent global floating offshore wind industry to date has engaged global supply chains and pan-national port infrastructure to deliver the lowest Levelized Cost of Energy (LCOE) to support the demonstrator projects currently in operation or planned.

The UK Government has committed to a substantive future investment of 30GW of generation in the industry with a target to achieve 60% UK content for projects commissioning from 2023 onwards including a commitment to increased UK manufacturing but with a recognition that the majority of UK opportunity will probably be within the assembly, installation, operations and maintenance activities and final decommissioning of the planned farms

The University of Exeter has developed a tool to assess economic values and the environmental impacts of floating offshore wind (FOW) farms. The assessment is based on life cycle analyses, which include five development stages: pre-development, manufacturing, assembly and installation, operations, and maintenance (O&M), and decommissioning. The tool is designed to help stakeholders such as wind farm developers and policymakers to facilitate decision-making processes in FOW development. The tool is novel in approach by concurrently computing not only the whole life cost of energy production (LCOE) but the associated whole life carbon intensity of energy production and the lifetime return of energy generated as a ratio to the whole lifetime value of energy invested.

We deployed this tool to conduct a study to determine the effect of port location on key performance metrics. Several scenarios representing varied port-function combinations were built and simulated, using the tool, to provide a comparative analysis of the impact of the choice of port location on windfarm development strategy. The tool provides the flexibility and opportunity to determine what combination of manufacturing, assembly, installation, and servicing locations yields the optimal combination of low cost, low carbon, and highest energy yield.

Initial findings indicate that a high local content in terms of port infrastructure and local supply chain performing maintenance operations is competitive with globally sourced solutions in economic terms while simultaneously halving lifetime Green House Gas emissions.

Barton Chen
University of Exeter

Assessment of the pathways to integrate floating offshore wind to the energy system

Most of the offshore wind resources in the world are in deep waters, which are suitable for floating offshore wind technologies. To bring those power to shore could be challenging due to the long distance to energy users and the intermittent nature of wind power. Various pathways that convert wind power into different forms (e.g. electricity and hydrogen) and transmit in different ways (e.g. pipelines and vessels) are proposed to tackle the above issues. To find out the suitable transmission pathway of a system, not only the system cost but also the integration with the energy system should be considered.

In the Cornwall Flow Accelerator project, a tool is developed to estimate the energy costs of floating offshore wind systems with various configurations, such as electricity generation with electrical cables, hydrogen production with pipelines or vessels. The integration of the energy system is also investigated by considering the supply and demand in the regional and national

energy systems. The results can help policymakers and stakeholders to select and design a suitable transmission system for each floating offshore wind project.

Emma Edwards, Edward Ransley, Scott Brown, Deborah Greaves & Martyn Hann
University of Plymouth

Physical modelling of floating offshore wind turbines and comparison to numerical results

Physical modelling of Floating Offshore Wind Turbines (FOWTs) in laboratories is challenging due to the scaling mismatch between Reynolds scaling (important for wind effects) and Froude scaling (important for wave effects). To overcome this complication, we use a thruster to simulate Froude-scaled force from wind turbines on the structure in waves, using a real-time controller to replicate the changing force due to platform motion and unsteady wind. This procedure is an example of a Software in the Loop process [1].

To determine the thrust based on real-time platform motions, we use OpenFAST [2], a coupled aero-hydro-servo-elastic numerical model for FOWTs. For the hydrodynamic part of this code, HydroDyn, frequency dependent hydrodynamic coefficients are needed, as well as viscous drag coefficients. We show how to obtain these viscous drag coefficients from an experimental free decay test of the model. We use the open-source VoltturnUS-S [3] floating platform, with the IEA Reference 15 MW turbine [4], as a reference to build our experimental model. We compare results from the experimental free decay tests to the reference document, which uses computational fluid dynamics to obtain the viscous drag coefficients and OpenFAST to run the decay tests.

References

- [1] Azcona, J., Bouchotrouch, F., González, M., Garciandía, J., Munduate, X., Kelberlau, F., & Nygaard, T. A. (2014, June). Aerodynamic thrust modelling in wave tank tests of offshore floating wind turbines using a ducted fan. In *Journal of Physics: Conference Series* (Vol. 524, No. 1, p. 012089). IOP Publishing.
- [2] Web page <https://github.com/OpenFAST/openfast> (accessed Oct 15, 2022).
- [3] Allen, C., Viscelli, A., Dagher, H., Goupee, A., Gaertner, E., Abbas, N., ... & Barter, G. (2020). Definition of the UMaine VoltturnUS-S reference platform developed for the IEA Wind 15-megawatt offshore reference wind turbine (No. NREL/TP-5000-76773). National Renewable Energy Lab.(NREL), Golden, CO (United States).
- [4] Gaertner, E., Rinker, J., Sethuraman, L., Zahle, F., Anderson, B., Barter, G. E., ... & Viselli, A. (2020). IEA wind TCP task 37: definition of the IEA 15-megawatt offshore reference wind turbine (No. NREL/TP-5000-75698). National Renewable Energy Lab.(NREL), Golden, CO (United States).

Kevin Gauder, Mike Graham & Ian Milne
Imperial College London and The University of Western Australia

Effect of rotor resistance on the turbulent inflow in an atmospheric boundary-layer

The presentation will show new measurements of the streamwise turbulence intensity in the inflow of both a rotor model and porous disc analogues of actuator discs in a simulated 1:400 scale turbulent ABL in a wind tunnel. The turbulence length-scale to actuator disc diameter ratio covers a range of values from about 0.2 to 1.5. The results are compared with theoretical predictions based on interpolation between rapid distortion of turbulence theory which is appropriate for small length-scale turbulence and quasi-steady theory which is appropriate for large relative length-scales. The effect of the intensification by distortion of the streamwise

velocity component of the turbulence on increasing the buffet forces generated on the rotor are discussed, as is also the interaction with the relatively smaller length-scale turbulence involved in wake impact. The results and insights can ultimately assist in informing fatigue loading and control system design for both wind and tidal turbines.

Tom Tosdevin
University of Plymouth

Extreme response modelling of a semi-sub FOWT

The results of physical experiments investigating the extreme mooring and pitch responses of a semi-submersible floating offshore wind turbine (FOWT) using a 1:70 scale model of the IEA 15MW reference turbine and VolturnUS-S platform will be presented with a focus on the hydrodynamics under parked turbine conditions. A comparison of characteristic load predictions is made following different design standard recommendations by the IEC and DNVGL covering different design wave types and post processing methods. These design waves include constrained waves, solitary focused waves and long irregular waves. The post processing methods being compared are an average of maxima approach and the selectin of a high percentile. Constrained wave methods have the potential to speed up the design process by reducing simulation times, which would be particularly advantageous for physical experiments and high fidelity numerical models such as CFD. Constrained waves are permitted by the IEC for predicting characteristic loads for fixed offshore turbines but the extent to which they are suitable for floating devices is questionable and they are not yet recommended in the floating wind standards. In this work a method for characteristic load prediction developed as part of work package 4 of the Supergen project on floating offshore renewables is applied and it is concluded that in general characteristic responses related to pitch can be estimated well with solitary response conditioned focused waves but for response types where the low frequency surge is important, such as mooring loads, constrained focused waves need to be applied. The complicating effects of nonlinear wave development and viscous drift will be discussed.

Pawel Manikowski, David Walker & Matthew Craven
University of Plymouth

Many-objective Optimisation of Offshore Wind Farms

As energy prices are soaring, climate change is having a noticeable effect on the environment, and demand for fossil fuels increases in developing countries. Hence, the need for cleaner energy sources is higher than ever. Harnessing wind power at sea offers considerable potential to fill this need.

Optimisation of the wind farm typically focuses on two objective functions: minimisation of the cost and maximisation of the power output of the wind farms. While this can be solved using single or multi-objective optimisation, these approaches do not capture all of the nuances of wind farm modelling (i.e., extending the problem to many objectives allows a better understanding of the interaction of the objective functions like a number of wind turbines, length of the cables, area of the wind farm and more).

In our presentation, we will extend our research by introducing extra objective functions: minimisation of the area and length of the power cables and maximisation of the ratio of the power generated by the wind farm to nominal power output (i.e., wind farm efficiency).

Consequently, we will combine all of the objectives into one single problem in which they are optimised simultaneously. It is an example of an NP-hard problem that can not be solved analytically. Therefore, we will employ a well known many-objective evolutionary algorithm, namely NSGA-III. In addition, we use state-of-the-art visualisation tools to illustrate the trade-off between problem objectives, enabling practitioners to understand the consequences and benefits of specific design decisions.

Mathew Walter, Pawel Manikowski, David Walker & Matthew Craven
University of Plymouth

Explainable Optimisation of Offshore Wind Farms

Evolutionary Algorithms (EAs) have been used in various applications within wind farm modelling, and considerable benefits have arisen from nature-inspired optimisers. Many approaches to visualising the search process have been demonstrated. However, often these approaches result in practical but highly technical illustrations, which are informative to expert users of optimisation tools but are not accessible to problem owners in the wind farm design sector.

Recently the advent of eXplainable Artificial Intelligence (XAI) has shown the benefit of providing accessible visualisations. Population Dynamics Plot (PDP) were recently proposed, which provide a more accessible visualisation that illustrates the search process used by Multi-Objective Evolutionary Algorithms (MOEAs) to make them generally accessible to a broader audience – only then can nature-inspired techniques be widely adopted by the industry.

In this work, we use PDP to visualise the search history of MOEAs, optimising the Wind Farm Layout Optimisation Problem. The analysis considers the benefits of using the visualisation from both the traditional evolutionary point of view and the context of XAI. This gives decision makers an explanation of how final wind farm layouts are arrived at by illustrating the design decisions taken during the optimisation process.

Emilio Faraggiana
Politecnico di Torino

An efficient optimisation tool for floating offshore wind support structures

Floating offshore wind turbines (FOWTs) are a rapidly developing technology, but still, need to gain economic competitiveness to gain market acceptance. The reduction of the structural cost of the floating platform represents one of the main targets to obtain an optimal design in the initial design process. This paper proposes an efficient optimisation tool that could be applied to any floating wind turbine to optimise the main geometry design parameters. In this study, the OC3 spar buoy concept is considered as an example, where the stability and dynamic performance of the device are verified using hydrostatic and time-domain computations. The numerical simulations are solved using an in-house MATLAB code that uses Salome-Meca to create the mesh, Nemoh to calculate the hydrodynamic coefficients and an aero-hydro-servo Simscape model for the time-domain simulation. The main geometry design parameters of the buoy are optimised to minimise the buoy's structural cost while ensuring the spar's performance. The optimal design results demonstrate the hydrostatic constraints' significance over the dynamic ones as they mostly influence the feasible design area. The optimisation approach presented is particularly important as it is flexible and can be adapted to other platforms.

Rick Lupton
University of Bath

Frequency domain modelling of floating wind turbines

While detailed aero-servo-hydro-elastic simulation codes for modelling floating wind turbines (FWTs) are available, they achieve high accuracy at the expense of calculation speed. For conceptual design and optimisation, fast solutions are needed, and equivalent linearisation techniques combined with frequency-domain analysis offers to capture the complex behaviour of FWTs in fast, approximate models. We propose a harmonic linearisation approach to model the aerodynamic loading within a complete coupled model of a FWT. Two linearised models are derived from a coupled nonlinear model, using the OC3-Hywind FWT as a test case: the typical tangent linearisation derived by numerical perturbation of the nonlinear model and the harmonic linearisation yielding improved representation of the aerodynamic loads. Comparisons against nonlinear time-domain simulations from Bladed show that it is possible to create a frequency-domain model of a FWT, including a flexible structure, aeroelastic rotor loads and the effect of the control system, with reasonable accuracy. The biggest source of errors is the presence of additional harmonics caused by nonlinear interactions between loads at different frequencies, rather than inaccurate linearisation of the magnitudes of forces. The computational cost of the harmonic linearisation implemented varies, but in most cases is $\sim 10\times$ slower than the tangent linearisation and $\sim 100\times$ faster than the time domain solution.

Session 4b: Floating Offshore Wind Energy: Cables, Anchors, Moorings & Dampers

Rachel Nicholls-Lee & Philipp Thies
University of Exeter

Improving understanding of the structural response of dynamic subsea power cables

Subsea power cables are a critical infrastructure sub-system, operating in challenging offshore conditions. Subsea power cable failures often make up a substantial proportion of insurance claims in offshore renewable energy installations. New floating wind installations also have a demanding loading regime, which will require dynamic cables. With the recent announcement from The Crown Estate outlining a potential 4GW of floating wind in the Celtic Sea, improved understanding of the structural response and failure mechanisms of subsea cables is crucial.

Ongoing research seeks to improve the understanding of cable behaviour in dynamic applications. The overall approach couples global hydrodynamic load analysis along the cable with local finite element modelling of the cable cross-section to establish material stress and fatigue life. Investigation and interrogation of subsea power cables through numerical modelling is essential to predict the life expectancy of these complex composite structures. The models need to be carefully calibrated for each cable design and for different material compositions, which can only be achieved through highly instrumented physical component testing. This work compares physical and numerical test results from a subsea power cable, to characterise the overall properties of the cable illustrating the capability of advanced numerical modelling in future developments.

Alan Crowle

University of Exeter

A technical review of the installation of floating offshore wind turbines

Interest in floating offshore wind farms in deep waters is increasing, as an option for marine renewable energy. Existing floating wind projects demonstrate the feasibility of future commercial floating wind farms. To boost the competitiveness of floating offshore wind energy, it is important to identify the major cost drivers during the lifecycle, including the installation phase. Costs will be considered in the presentation into the optimum use of installation vessels.

Each type of floating substructure types exhibit quite different characteristics during transportation and installation. This presentation is a review of the state-of-the-art technical aspects of floating offshore wind turbine installation for different substructures types. An overview is first presented introducing the classification of floating offshore wind turbines, installation vessels, rules and regulations, and numerical modelling tools. Various installation methods and concepts for floating offshore wind turbines are critically discussed, including cable installation, wind turbine substructures and components. Opportunities and challenges of the installation methods of floating offshore wind turbines are identified.

Future developments in technical areas are envisioned in loadout, topside fit out, ocean tow and offshore installation are discussed. This review aims to guide research and development activities on floating offshore wind turbine installation.

Lars Johanning & Hailun Xie
University of Exeter

A Hierarchical Metocean Data Selection Model for Fast O&M Simulation in Offshore Renewable Energy Systems

The estimation of operation and maintenance (O&M) costs in offshore renewable energy systems entails significant complexity owing to the confounding effects associated with component reliability, vessel accessibility, as well as system availability. To quantify various uncertainties and enable realistic O&M simulations, many stochastic O&M assessment models were developed using Markov Chains Monte Carlo (MCMC) techniques. Such simulation approaches are inevitably subject to enormous computational cost due to the simulation of failure occurrence on a component level at each metocean timestep over the lifespan of offshore energy systems, i.e. typically 20 to 25 years.

In order to overcome the computational limitation and enhance the practicality of O&M stochastic simulation, in this study we propose a hierarchical statistical model to select the most representative metocean data from twenty-year record for each calendar month, and generate a composite metocean data file with one-year equivalent length. The proposed model includes two steps, i.e. the preselection to produce five candidate years and the refined selection to identify the final winner year from the five candidates. In the preselection stage, three statistical measurements are calculated between two time series in comparison, i.e. the Jensen-Shannon (JS) divergence, the difference of spectrum of data instances, and the difference of length of available metocean windows. In the refined selection stage, the cosine similarity is used as the sole selection criteria. As such, the proposed two-step selection model is capable of measuring the similarity between the metocean time series of each individual year and the collection of historical data from all individual years, for each calendar month, comprehensively by taking into account probability distribution, temporal synchronisation, as well as encapsulation of extreme conditions.

The yielded metocean file is subsequently employed to replace the twenty-year metocean data as the input for O&M simulation. Based on the empirical results from five configurations of wind farms, i.e. 2, 5, 10, 20, 30 turbines, the reductions of computational costs are between 95% and 98%, whereas the variations in terms of lifetime energy productions and O&M costs range from 2% to 4%, and from 0% to

5%, respectively, in comparison with the simulation results using twenty-year metocean data. Overall, the proposed model is particularly effective in reducing computational costs while reproducing the original results with a high level of confidence.

Anna Holcombe, Martyn Hann, Shanshan Cheng, Robert Rawinson-Smith, Scott Brown
University of Plymouth

Scale physical modelling of dynamic power cable for a floating offshore wind turbine

Dynamic cables have been identified as a technology area critically requiring further development for the floating offshore wind industry, particularly in terms of improving reliability. Dynamic cables must withstand hydrodynamic loading, floater-motion induced loading and can be subjected to costly mechanical failures such as fatigue damage.

In literature, studies have numerically modelled global loads and motions of dynamic cables attached to floating ORE devices, but very few have used a scale physical modelling approach. The aim of this work was to develop a methodology for scale physical modelling a dynamic cable attached to a floating offshore wind turbine, and to investigate the motion of the cable under regular wave loading.

Laboratory experiments were conducted in a wave tank with a 70th scale semi-submersible floating offshore wind turbine model and three catenary chain mooring lines. The cable was scaled in outer diameter and mass per unit length, using a rubber cord, and was set up in both catenary and lazy wave configurations. A motion tracking camera system recorded the position of markers spaced equally along the cable, to capture both the static and dynamic scenarios. The motion data of the cable and turbine will be compared to a numerical model.

Rodrigo Martinez, Sergi Arnau, Callum Scullion, Richard Nielson & Marcin Kapitaniak
University of Aberdeen, School of Engineering, National Decommissioning Centre

Floating anchors for offshore wind turbines

A set of detailed modelling studies are performed at the state-of-the-art, Marine Simulator at the National Decommissioning Centre (NDC) to study the feasibility of deploying novel self-floating anchors for mooring floating offshore wind turbines. Using the proposed approach, heavy-lifting cranes and large vessels can be avoided, in turn simplifying the deployment process and reducing installation costs. A small tugboat equipped with a simple winch, can tow the anchor and lower it to the seabed. The anchor has a 10 m square base, 4.5 m height and weight of 163 tonnes. Ocean conditions simulated include irregular waves with a JONSWAP spectrum with significant wave height up to 5m and peak period of 10s. An optimum winch speed of 0.35m/s is identified, at which working load range on the winch cable decreases from 80kN at the lowest winch speeds to about 30 kN. The sinking trajectory is similar at all winch speeds, however, the slower the descent, the further the anchor drifts. At the optimum winch velocity, the descent from the resting position under the stern to the seabed takes roughly 5 minutes. In addition, the anchor's yaw during the descent is below 10° at the optimal conditions.

Tessa Gordelier & Ajit Pillai
University of Exeter

Mitigating Anchor Loads for Floating Wind in the Celtic Sea: Assessing Shared Anchors and Mooring Design Philosophy

The floating offshore wind (FOW) sector has significantly advanced in recent years. The technical viability has been evidenced through multiple demonstration sites [1] and commercial scale turbines are now successfully in operation [2]. The Celtic Sea has been identified by the Crown Estate for both early commercial scale [3] and full commercial scale [4] FOW deployments. To date research has primarily focused on turbine and floating platform design, but in order to reduce the LCOE of this promising technology, research and innovation is required into the mooring and anchoring subsystems [5, 6].

The presented work uses high fidelity Orcaflex simulations of large scale 15 MW reference turbines [7] with a typical semi-submersible reference platform [8], applying bathymetric and environmental conditions representative of the Celtic Sea.

Results demonstrate that shared anchors offer substantial reductions in peak anchor load (maximum 67% reduction) by virtue of loading in opposing directions. The Celtic Sea's relatively shallow depths cause significant sensitivity to mooring footprint size; in chain catenary moorings increasing the footprint reduced the peak anchor load by 56%. The use of polyester and the novel Exeter Tether mooring are also shown to reduce peak anchor loads.

The study highlights the load envelope for consideration in the development of novel anchor solutions.

References

1. Ikhennecheu, M., et al., Corewind: D2.1 Review of the state of the art of mooring and anchoring designs, technical challenges and identification of relevant DLCs. 2020, H2020 - Grant Agreement 815083.
2. Durakovic, A., World's Largest Floating Wind Farm Starts Operating. 2021, offshoreWIND.biz: Online.
3. The Crown Estate, The Crown Estate to create new floating wind leasing opportunity in the Celtic Sea. 2021.
4. The Crown Estate, The Crown Estate develops proposals for floating wind in the Celtic Sea, outlining 4 GW opportunity, in Press Release. 2021.
5. Offshore Renewable Energy Catapult, Floating offshore wind: Cost reduction pathways to subsidy free, F.o.w.c.o. excellence, Editor. 2020, Offshore Renewable Energy CATAPULT.
6. UK Government (Department for Business, E.I.S. Floating Offshore Wind Demonstration Programme. 2021 [cited 2021 25/06/2021]; Available from: <https://www.gov.uk/government/publications/floating-offshore-wind-fow-demonstration-programme>.
7. Gaertner, E., et al., IEA wind TCP task 37: Definition of the IEA 15-megawatt offshore reference wind turbine. 2020, National Renewable Energy Lab.(NREL), Golden, CO (United States).
8. Allen, C., et al., Definition of the UMaine VoltornUS-S Reference Platform Developed for the IEA Wind 15-Megawatt Offshore Reference Wind Turbine, NREL, Editor. 2020, IEA Wind.

Faryal Khalid, Philipp Thies, Lars Johanning & David Newsam
University of Exeter

Physical testing of a mooring damper for floating offshore wind application

Innovative mooring components designed to dampen structural loads can reduce the risk and cost associated to mooring systems of floating offshore wind turbines. The Intelligent Mooring System (IMS) is one such active, hydraulic, nonlinear mooring component. It offers a combination of desirable stiffness characteristics; an initial compliant response that reduces loads on the structure and a stiffer response for more dynamic environments to reduce platform motion and ensure effective station keeping. A salient feature of the IMS is that through variation of the internal pressure, the stiffness of the system can be tuned to the prevailing environmental conditions.

This paper presents the results of the physical testing of a new double braided IMS at the

Dynamic Marine Component test facility and compares the stiffness and strength characteristics to a previous single braid prototype. The comparative analysis shows that the stiffness profiles of the double braid for the various configurations are consistent with the single braid design. Importantly, the use of a double braid results in a 50% increase of the tensile strength of the IMS. The investigation presented in this paper will aid in the design of a robust IMS for field-testing prior to commercial applications in floating wind installations.

Ignacio Johannesen & Edward Ransley
University of Plymouth

Passive motion reduction strategies for semisubmersible platforms for floating offshore wind turbines

In the case of floating offshore wind (FOW) technology, the motion of the whole platform is a key parameter of analysis that can have a big impact on the performance and lifespan of the device. Therefore, the response of the platform to the environment loads must be characterized and designed to be minimal.

In the present work, a numerical analysis of a passive motion reduction strategy for semisubmersible platforms for FOW is treated. The study is currently in an early stage, therefore, the efforts have been focused in the proper analysis of the effects of the current geometry solutions, i.e. heave plates. In the case of semisubmersible platforms, the main problem for FOW turbines relies on the pitch motion and acceleration. Therefore, the aim of this work is to improve and understand these strategies for heave and pitch motion. The open-source code OpenFOAM with a RANS based strategy will be used to solve the flow-structure interaction of this problem. The results of the used technique will be compared against experimental data from literature. In addition, a basic shape optimization routine based on potential theory for heave plates in pitch motion will be presented.

David Christie
Bangor University

Wave Modulation by Offshore Wind Farms

Large periodic arrays of offshore structures (such as wind farms) have the potential to modify the local wave climate, with the effect persisting over considerable distances. Reflection and diffraction can create areas of increased or reduced wave action, which can affect sediment dynamics and structural loading, and are particularly pertinent to the potential construction of hybrid wind-wave arrays.

Analytical calculations of wave scattering from arrays of impermeable vertical cylinders show array diffraction effects differ from simple superposition of independent single cylindrical wakes, but existing treatments have only considered small numbers of scatterers (up to six). Instead, numerical models based on empirical transmission coefficients have been adopted. The underlying assumptions for these models are not always clear, and they often predict large downwave energy reductions. We have developed a method for analysing much larger arrays, which is capable of modelling large offshore wind farms. We apply the method to calculate wave modulation by the 160-turbine Gwynt y Môr wind farm in North Wales, UK.

Posters

Posters will be displayed in the exhibition area in on the top floor of the Peter Lanyon building. Lunch and coffee break drinks will be served in this area, as well as drinks during the poster reception on Wednesday evening.

<p>Iestyn Evans Swansea University</p> <p><i>Including acceleration forces in a blade element momentum theory numerical model</i></p>
<p>Yan Naung Aye Newcastle University</p> <p><i>Mathematical Model for Flow-induced Vibration-Based Energy Harvester</i></p>
<p>Dr. Jonahtan Demmer School of Ocean Sciences, Bangor University</p> <p><i>Application of Lagrangian drifter data for marine renewable energy</i></p>
<p>Misha Patel University of Oxford</p> <p><i>Investigation of Low Order Parameters Affecting Tidal Stream Energy Resource Assessments</i></p>
<p>Eleanor Falch Bangor University</p> <p><i>Combining time-lapse photography and biologgers to understand population and individual-level activities of deep-diving seabirds in a tidal stream environment.</i></p>
<p>Sophie Crouch Bangor University</p> <p><i>Changes in the distribution and abundance of marine top-predators in the North Sea associated with present and future wind farm developments.</i></p>
<p>Ashleigh Henry Queen's University Belfast</p> <p><i>Investigating the use of tidal power as a baseload for offshore wind</i></p>
<p>Jon Miles Plymouth University</p> <p><i>Flow characteristics at Ramsey Sound relevant to tidal device deployment and recovery planning</i></p>
<p>Sulaiman Hurubi, Pablo Ouro, Timothy Stallard & Peter Stansby The University of Manchester</p> <p><i>The effect of sea-bed bathymetry on tidal stream turbine performance and wake recovery.</i></p>
<p>Miles Clark, Dr Amanda Smyth, Dr Luca Di Mare University of Oxford</p> <p><i>Optimal motion of flexible two-dimensional swimmers</i></p>

Luke Myers, Rodolfo Olvera
University of Southampton

Performance of winglets on the blades of horizontal axis tidal turbines

Michael Ridgill, David Christie and Simon Neill
Bangor University

Use of X-band radar for wave energy conversion resource assessment

Krishnendu Puzhukkil, Xinyu Wang, Jingyi Yang, Alistair Borthwick, Edward Ransley, John Chaplin, Malcolm Cox, Maozhou Meng, Martyn Hann, Robert Rawlinson-Smith, Siming Zheng, Shanshan Cheng, Zhong You, Deborah Greaves
University of Plymouth

Flexible Responsive Systems in Wave Energy: FlexWave

Matthew Riella, Christopher Broers
IDPortal Engineering

Aeroelastic Characterisation of an Innovative Wing Structure Design

Luke Evans
IDCORE, EMEC

Uncertainty Quantification in Tidal Energy Power Performance Assessment

Alyona Naberezhnykh, Ian Ashton, David Ingram
IDCORE, EMEC, Edinburgh University, Exeter University, Strathclyde University

Detection of intermittent turbulent structures in real tidal flows

Stephen C. L. Watson, Heather Baxter, Andrew Edwards-Jones, Nicola J Beaumont
Plymouth Marine Laboratory

Stakeholder perspectives for sustainable offshore wind farm upscaling and the implementation of environmental net gain policies in the UK

Ian Ashton, Sophie Corrigan, Ross Brown, Carly Daniels
University of Exeter

Seaweed Aquaculture around MRE Infrastructure?

Supporting organisations & Exhibitors

The PRIMaRE conference could not take place without the support of sponsoring organisations and exhibitors. We are very grateful to all our sponsors and encourage delegates to visit sponsor exhibitions in the upper area of the Peter Lanyon building during the conference.



Session 1 (Innovation across marine renewable energy) session sponsor: EuroSwac

Large cooling demand in the Channel Area in various sectors and global societal changes require a fundamental rethink of how Heating & Cooling can be produced at local level. Currently, almost all cold used in the Channel Area is produced by vapor-compression refrigeration, contributing to high CO₂ emission and releasing gases harming the ozone layer.

The EUROSAC is a highly innovative project (co-financed by the European Regional Development Fund, total budget of €3.9 million) aiming at demonstrating the ability of using the Channel seawater for cooling, adapting an existing technology to the low depth and temperate climate of the Channel Area. It involves eleven UK and French partners, from academic and industrial fields.

The SWAC (Sea Water Air Conditioning) technology is exploiting temperature difference between sea water and external air temperature to produce cold by pumping cold water and transferring its cooling power to a secondary loop via a heat exchange station.

Up to 10% of cooling needs and 5% of heating needs of the Channel area tertiary buildings could be met by shallow-water based SWAC by 2030, reducing electricity consumption for cooling by minimum 30%.

The project aims to develop two UK SWAC demonstrators (Brixham laboratory and National Lobster Hatchery) and provide blueprints for replication of SWAC installations along the Channel coastline. In order to advance the SWAC technology work will be direct to streamline EIA processes, enhance the technology aiming on cost reduction while identifying key market segments, and business models. In order to achieve this, a multigeneric optimisation approach has been proposed for a range of sites within the Channel to provide multi-solution for end users wanting to decrease their carbon footprint. Advances within the SWAC technology will be discussed and findings related to optimisation approach will be disseminated.



EUROPEAN UNION
European Regional Development Fund

Session 2 (Tidal Stream Energy) session sponsor: Interreg TIGER

The Tidal Stream Industry Energiser Project, known as TIGER, is the biggest ever Interreg project driving collaboration and cost reduction through tidal turbine installations in the UK and France. The TIGER project will drive the growth of tidal stream energy to become a greater part of the energy mix, with significant benefits for coastal communities.

The project will demonstrate that Tidal Stream Energy is a maturing industry, capable of achieving an accelerated cost reduction pathway, and will position the Channel region at the heart of the sector by addressing technology challenges; building the supply chain; switching on new sites; and installing new turbines.

The project aims to drive the growth of tidal stream energy by installing up to 8 MW of new tidal capacity at sites in and around the Channel region thus driving innovation and the development of new products and services. TIGER will make a stronger, more cost-effective case for tidal stream to become part of the energy mix in the UK and France by harnessing economies of scale via volume manufacturing and multi-device deployments. Coastal communities used as ports of deployment will benefit from knock-on investment and job creation.

The total theoretical tidal energy capacity in the Channel region is nearly 4 GW, enough to power up to three million homes. Proving that tidal energy generation can be cost-effective on a large scale could open the door for it to become the renewable energy of choice in coastal locations with strong tidal currents globally, helping the growth of clean, green energy generation and tackling the climate emergency. The project will install up to 8 MW of additional energy capacity, ultimately leading to a reduction of greenhouse gas emissions of ~11,000 tonnes per annum; investment in coastal communities, leading to an economic increase in GVA of €13 million per annum; and a tidal energy cost reduction towards €150/MWh.

The Tidal Stream Industry Energiser project (TIGER) is co-financed by the European Regional Development Fund through the Interreg France (Channel) England Programme. More information is available at www.interregtiger.com



Session 3 (Wave Energy) session sponsor: Marine-i

Marine-i is a pioneering business support programme that has been designed to foster innovation in Cornwall's marine technology sector. Part-funded by the European Regional Development Fund, the project brings together expertise from six Project Partners - the University of Exeter, University of Plymouth, Cornwall College Group, Cornwall Marine Network, Cornwall Development Company, and the Offshore Renewable Energy Catapult - to stimulate research and innovation, and help Cornish marine businesses exploit new market opportunities.

Lars Johanning, Professor of Ocean Technology at the University of Exeter, leads the programme. "Our goal is to help put Cornwall at the forefront of the marine tech industries of the future. These include marine energy, marine manufacturing, maritime operations and marine environmental technologies. We want to help businesses get to the stage where their new ideas can be demonstrated and commercialised – and to do this as quickly as possible."

To achieve this, Marine-i offers one of the most complete packages of innovation support ever designed for the marine sector. This includes business consultancy, research expertise, grant funding, access to some of the best testing facilities in Europe, and graduate support at a subsidised cost. Marine-i provides a bespoke package to marine businesses that is geared to their specific needs and delivered through one point of contact.

Since its inception in 2017, Marine-i has supported 131 local marine businesses with market-leading research, received grant funding for 51 projects, placed 16 graduates with local businesses at a subsidised cost, launched 23 new products into the market, and helped 27 new businesses relocate - or open new offices - in Cornwall. The programme runs until December 2022, so there is still a great opportunity for more local SMEs to benefit from its support.

Supergen



Offshore
Renewable
Energy

Exhibitor and presentation prize sponsor: Supergen Offshore Renewable Energy Hub

The Supergen Offshore Renewable Energy (ORE) Hub is a £9 Million Engineering and Physical Sciences Research Council (EPSRC) funded consortium of 10 UK leading universities. The Hub is tackling the fundamental engineering research challenges in ORE in order to provide research leadership to connect academia, industry, policymakers and the public, inspire innovation and maximise societal value.

The University of Plymouth leads the Supergen ORE Hub, with Co-Directors from the Universities of Aberdeen, Edinburgh, Exeter, Hull, Manchester, Oxford, Southampton, Strathclyde, and Warwick. The Supergen ORE Hub is one of several Hubs created by EPSRC to deliver sustained and coordinated research on Sustainable Power GENERation and supply. Find out more about the Supergen ORE Hub at www.supergen-ore.net



Exhibitor and poster prize sponsor: The Devon & Cornwall Joint Branch of RINA & IMarEST

IMarEST is The Institute of Marine Engineering, Science and Technology; the international professional body and learned society for all marine professionals. IMarEST is the first Institute to bring together marine engineers, scientists and technologists into one international multi-disciplinary professional body. The mission of IMarEST is *To be the international organisation of choice for all concerned with marine resources and activities, by providing professional leadership, upholding standards, and developing and sharing knowledge based upon integrity, quality and fairness.*

The Royal Institution of Naval Architects (RINA) is an internationally renowned professional institution whose members are involved at all levels in the design, construction, maintenance and operation of marine vessels and structures. Members of RINA are widely represented in industry, universities and colleges, and maritime organisations in over ninety countries.



Exhibitor: META (Marine Energy Test Area)

The Marine Energy Test Area (META) is a £2.7 million project managed by Marine Energy Wales that has developed a series of eight consented marine energy test areas in and around the Milford Haven Waterway alongside world class engineering facilities; to test devices, sub-assemblies, components and scientific instruments. The project's mission is to reduce the time, cost and risks faced by marine energy developers, in order to accelerate growth in the sector, whilst complementing the existing test centre network present across the UK.

META is easily accessible and therefore ideal for early stage technology developers, and is also a perfect base for research and innovation. Targeting Technology Readiness Level 4-6, the META sites are non-grid connected, ranging from sheltered quayside sites to open water sites with moderate to strong wave and tidal resource. META is part funded by the European Regional Development Fund (through the Welsh Government), the Coastal Communities Fund and the Swansea Bay City Deal and contributes towards Wales' plans to play a key role in a growing global market.