MaREI
Centre for Marine and Renewable Energy

MaREI Annual Symposium 2018

'Creating Collaboration Opportunities'

Book of Abstracts

12 & 13 June 2018

Western Gateway Building

University College Cork

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Directors' Message

We would like to take this opportunity to welcome you all to our annual MaREI Symposium.

The theme of this year's Symposium is 'Creating Collaboration Opportunities.' We want this to initiate and drive multi-institutional multi-disciplinary collaborative research in marine and renewable energy. For MaREI to succeed as a world class research centre we must leverage our impact and reach new audiences in the new national research priority areas of "decarbonising the energy system" and "sustainable living".

Since our creation in 2013 MaREI has grown to a centre with cumulative research funding of €55M with 200 researchers across Ireland, and 45 industrial partners. Our flash presentations will highlight the potential for collaborations while also celebrating our achievements. We see this conference as an opportunity to renew old acquaintances and to forge new friendships.

We hope that you can all join us for a relaxed bite to eat and some light entertainment on the Tuesday night.

Prof. Jerry D Murphy

MaREI Director

Prof. Brian Ó Gallachóir

MaREI Director

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Organizing Committee

Symposium Chair: Karthik Rajendran (UCC)

Committee:

MaREI Administrator	Tara Reddington	UCC
Marine Renewable Energy Technologies	Nguyen Dinh	UCC
Materials & Structures	Edward Fagan	NUIG
Observations & Operations	Clare Noone	NUIG
Coastal & Marine Systems	Tim O' Higgins	UCC
Bioenergy	Karthik Rajendran	UCC
Energy Policy & Modelling	Maarten Brinkerink	UCC
Energy Management	Kevin Leahy	UCC
Marketing & Communications	Dee O' Connor	UCC

Acknowledgements

The research presented at the Symposium, and outlined in this document, is enabled by the generous support of over 50 industry partners and the following funding bodies and programmes, listed alphabetically:

Atlantic Area INTERREG
Bord Iascaigh Mhara
COST – European Cooperation in Science and Technology
Department of Agriculture, Food and the Marine
Department of Communications, Climate Action and Environment
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Irish Research Council
JPI Climate
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Northern Periphery and Arctic INTERREG
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Science Foundation Ireland
Sustainable Energy Authority of Ireland

Programme

Day 1 - Tuesday, 12th June

10:00-10:05	**Welcome**	**Dr Karthik Rajendran, UCC Symposium Chair**
10:05-10:15	**Welcome Address by MaREI Directors**	**Prof Jerry Murphy & Prof Brian Ó Gallachóir**
	Energy Policy & Modelling (RA6)	**Chair: Maarten Brinkerink, UCC**
10:15-10:30	Overview	Dr James Glynn, UCC
10:30-10:35	Decarbonising the European power system in alignment with the Paris Agreement: A comparison of scenarios	Fiac Gaffney, PhD Student, UCC
10:35-10:40	Assessment of current GHG Projections and practices of Ireland	Dr Parveen Kumar, UCC
10:40-10:45	Capacity building and evidence-based policy support tools with LEAP	Tomás Mac Uidhir, PhD Student, UCC
10:45-10:50	Potential employment opportunities for Irish interconnectors	Dr Mitra Kami Delivand, UCC
10:50-10:55	A new hybrid approach for multi criteria assessment of technology opportunities in the energy transition	Dr Tarun Sharma, UCC
10:55-11:00	Assessing robust carbon mitigation opportunities for Ireland with MACCs and energy system analysis	Xifueng Yue, PhD Student, UCC
11:00-11:05	The Spark Project	Clare Watson, PhD Student, UCC
11:05-11:15	Case Study "Transition Dingle 2030"	Connor McGookin & Evan Boyle, PhD Students, UCC
11:15-11:45	Poster Session for Energy Policy & Modelling (RA6)	Ground Floor Atrium WGB - refreshments available
	Materials & Structures (RA2)	**Chair: Dr Edward Fagan, NUIG**
11:45-12:00	Overview	Dr Edward Fagan, NUIG
12:00-12:05	Inspection of Marine Renewable Energy Devices	Dr Michael O'Byrne, UCD
12:05-12:10	Composite Materials and Manufacturing for Energy Applications	Dr Noel Harrison, NUIG
12:10-12:15	Fatigue testing requirements for tidal blades	Dr Vesna Jaksic, CIT
12:15-12:20	Tidal turbine blade design, optimisation, and testing	Dr Edward Fagan, NUIG
12:20-12:25	Fabrication of Marine Composites by Additive Manufacturing	Heather O'Connor, PhD Student, UCD
12:25-12:30	Cost effective Marine renewable energy devices	Dr Ananda Roy, UL
12:30-12:35	Coupled and time-frequency analysis in reduction of system responses and uncertainties	Dr Nguyen Dinh, UCC
12:35-12:40	One-shot manufacture of tidal turbine blades using powder-epoxy	Michael Flanagan, PhD Student, NUIG
12:40-12:45	Next Generation Lithium Ion Batteries Using Nanowire Anodes	Prof Kevin Ryan, UL
12:45-13:15	Poster Session for Materials & Structures (RA2)	Ground Floor Atrium WGB - refreshments available
13:15-13:30	**Funding Opportunities for MaREI**	**Prof Brian Ó Gallachóir**
13:30-14:00	**LUNCH**	**Ground Floor Atrium WGB**
	Marine Renewable Energy Technologies (RA1)	**Chair: Dr Nguyen Dinh, UCC**
14:00-14:15	Overview	Dr Cian Desmond, UCC
14:15-14:20	Tidal energy test rigs development for ORPC as part of TAOIDE and tying in with the electrical test infrastructure in Lir	Dr Dónal Murray, UCC

14:20-14:25	Development and testing of an innovative wave energy device	Pierre Benreguig, PhD Student, UCC
14:25-14:30	Cost Reduction Analysis in Offshore Wind	Rachel Chester, Research Assistant, UCC
14:30-14:35	Real-time free-surface elevation forecasting for marine applications using wave spectrum information	Alexis Merigaud, PhD Student, NUIM
14:35-14:40	Multi-DoF modelling of a hinge-barge wave energy converter	Dr LiGuo Wang, NUIM
14:40-14:45	Wave energy resource of the Northeast Atlantic	Jelena Janjic, PhD Student, UCD
14:45-14:50	Influence of wave-current interaction on tidal current velocity field	Aleksandar Jakovljevic, PhD Student, UCD
14:50-14:55	Faster linear potential flow simulations with Nemoh	Dr Matthieu Ancellin, UCD
14:55-15:00	The Wave-Activated Sensor Power Buoy (WASP)	Thomas Kelly, PhD Student, DKIT
15:00-15:30	Poster Session for MRE (RA1)	Ground Floor Atrium WGB - refreshments available
	Observation & Operations (RA3)	**Chair: Dr Clare Noone, NUIG**
15:30-15:45	Overview	Dr Jana Preissler, NUIG
15:45-15:50	C-CAPS Video	C-CAPS Video NUIG
15:50-15:55	Mace Head: Climate and Air Pollution Research Facility	Dr Jurgita Ovadnevaite, NUIG
15:55-16:00	Air Pollution Sources in Ireland	Lin Chunshui, PhD Student, NUIG
16:00-16:05	Efforts towards remote sensing of wind, clouds and volcanic ash	Dr Praveen Pandey, NUIG
16:05-16:10	A Review of Current High Bandwidth Maritime Communication Technologies	Luke Robinson, PhD Student, NUIG
16:10-16:15	FPGA based BITW Security Solution for remote communication	Dr Muzaffar Rao, NUIG
16:15-16:45	Poster Session for Observations & Operations (RA3)	Ground Floor Atrium WGB - refreshments available
	Energy Management (RA7)	**Chair: Kevin Leahy, PhD Student, UCC**
16:45-17:00	Overview	Dr Nguyen Dinh, UCC
17:00-17:05	A robust prescriptive framework and performance metric for diagnosing and predicting wind turbine faults based on SCADA and alarms data with case study	Kevin Leahy, PhD student, UCC
17:05-17:10	Automating performance verification of energy conservation measures in industrial buildings	Kevin Leahy (presenting obo Colm Gallagher)
17:10-17:15	Effect of large scale and lifetime on offshore wind LCOE in Ireland	Dr Nguyen Dinh, UCC
17:15-17:20	Local energy storage in offshore wind farms in Ireland	Vaishnav Pushpoth, MEngSc Student, UCC
17:20-17:50	Poster Session for Energy Management (RA7)	Ground Floor Atrium WGB - refreshments available
17:50-18:00	**Day One Closing**	**Prof Jerry Murphy & Prof Brian Ó Gallachóir**
19:30	**Franciscan Well Brewery, Cork**	**ALL**

Day 2 - Wednesday, 13th June

	Coastal & Marine Systems (RA4)	Chair: Dr Tim O'Higgins, UCC
09:00-09:15	Overview	Dr Tim O' Higgins, UCC
09:15-09:20	Cetaceans in offshore waters: combining data from multiple sources to enhance our understanding of cetacean distribution in Irish waters	Dr Ailbhe Kavanagh, UCC
09:20-09:25	Climate Ireland: supporting national adaptation policy	Dr Barry O'Dwyer, UCC
09:25-09:30	Status of Ireland's climate	Dr Walter Camaro, UCC
09:30-09:35	Demand-weighted vulnerability study of Irish national transport network	Tiny Remmers, Research Assistant, UCC
09:35-09:40	Urb-ADAPT project: assessing climate change impacts and adaptation strategies in the Greater Dublin region	Dr Roberta Paranunzio, UCC
09:40-09:45	Future earth coasts: land and sea interactions in the coastal zone	Dr Shona Paterson, UCC
09:45-09:50	Historical legacy, geopolitical transformations, and effective governance of transboundary marine ecosystems	Sarah Twomey, PhD Student, UCC
09:50-09:55	Wild Atlantic mussels	Dr Gerry Sutton, UCC
09:55-10:00	Understanding the movement patterns of Irish seabirds	Ashley Bennison, PhD Student, UCC
10:00-10:30	Poster Session for Coastal & Marine Systems (RA4)	Ground Floor Atrium WGB - refreshments available
	Bioenergy (RA5)	**Chair: Dr Karthik Rajendran, UCC**
10:30-10:45	Overview	Dr David Wall, UCC
10:45-10:50	Closing the loop: Role of algae in an integrated circular bioenergy system	Dr Richen Lin, UCC
10:50-10:55	Biological methanation systems	Markus Voelklein, PhD Student, UCC
10:55-11:00	Energy recovery and pathogen inactivation with dry co-digestion of food waste and pig manure	Zhongzhong Wang, PhD Student, NUIG
11:00-11:05	Adsorption behaviour of biofuels using different adsorbents in model syngas fermentation broth	Peyman Sadrimajd, PhD Student, NUIG
11:05-11:10	Location-allocation optimization model for bio-SNG production system: The Republic of Ireland case	Alessandro Singlitico, PhD Student, NUIG
11:10-11:15	Optimising electrolyser size to produce hydrogen and reduce wasted electricity at wind farms	T.A. Gunawan, PhD Student, NUIG
11:15-11:20	A comprehensive ignition delay time study of C1-C3 mixtures over a wide range of pressures, temperatures, equivalence ratios, and dilutions	Dr Mohammadreza Baigmohammadi, NUIG
11:20-11:25	Computational chemical modelling as a fundamental tool for cleaner fuel and combustor design	Dr Ultan Burke, NUIG
11:25-11:30	Nuclear Magnetic Resonance Spectroscopy for the Analysis of Biofuels	Dr Andrew Ure, TCD
11:30-12:00	Poster Session for Bioenergy (RA5)	Ground Floor Atrium WGB - refreshments available
12:00-13:00	Brainstorming Session	MaREI Researchers
13:00-13:15	Feedback Session	MaREI Researchers
13:15-13:30	Closing Presentations & Awards	MaREI Directors & Centre Manager
13:30-14:30	LUNCH	Ground Floor Atrium WGB

	EPA Workshop	Chair: Prof Jerry Murphy
14:30-14:45	Introduction	Prof Jerry Murphy
14:45-15:05	Laboratory work on power to gas	Markus Voelklein, PhD Student, UCC
15:05-15:25	Power to gas modelling	Shane McDonagh, PhD Student, UCC
15:25-16:00	Why should EV's have all the fun?	Dr Karthik Rajendran
16:00-16:15	Tea & Coffee	Ground Floor Atrium WGB
16:15-16:45	Panel Discussion	Chair: David McDonnell
16:45-17:00	Closing	Prof Brian O Gallachoir
17:00	**END**	

Energy Policy & Modelling

Decarbonising the European power system in alignment with the Paris Agreement: A comparison of scenarios.

Fiac Gaffney[1*], Paul Deane[1], James Glynn[1], Brian O'Gallachoir[1]

[1] *MaREI Centre, Environmental Research Institute, University College Cork, Cork, Ireland*
*Corresponding author email: fiac.gaffney@ucc.ie

Abstract:

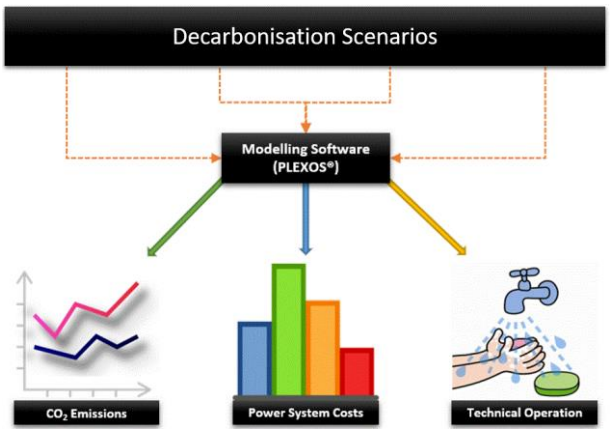
Decarbonising electricity generation is a key element in achieving the Paris climate agreement for limiting average global temperature rise to well below 2ºC. Multiple pathways involving varied levels of effort, technological development and policy support have analysed the roles of high levels of renewable electricity, low carbon nuclear power, increased energy efficiency, and carbon capture and storage on power system decarbonisation in Europe. However, the ratification of the Paris climate agreement demands a radical decarbonisation of the energy system and may require certain sectors within the economy to achieve negative emissions. Combining bioenergy with carbon capture and storage technology (BECCS) or the use of Direct Air Capture (DAC) offers the prospect of electricity supply with large-scale net-negative emissions. There are challenges and risks associated with both such as the provision of the biomass required, the storage of CO_2 and the financing of such plants, as today no plants have been built for electricity generation and tested at scale. In this article we replicate, simulate and compare different decarbonisation scenarios with high levels of variable renewables to more ambitious scenarios with negative emissions technologies (NETs) involving BECCS and DAC in terms of emissions, technical operation and total power system costs. Throughout the analysis a high temporal and technical resolution power system operation model is used to capture power system impacts. We also examine impacts associated with bioenergy resource availability in Europe, geological storage potential of CO_2 and the valuation of carbon costs in a system with net-negative emissions.

Keywords:

Power system decarbonisation; Negative Emission Technologies; Scenario comparison; Variable renewable energy.

Concept Illustration:

Comparing decarbonisation scenarios against a counterfactual (i.e. Reference scenario) using PLEXOS® integrated energy modelling software to investigate and evaluate the differences in CO_2 emissions produced, total power system costs and from a technical operation perspective.



Assessment of current GHG projections and practices of Ireland

Parveen Kumar[2*], Tomás Mac Uidhir[2], Fionn Rogan [1,2], Brian Ó Gallachóir [1,2]

[1]School of Engineering, University College Cork, College Road, Cork, Ireland
[2]Environmental Research Institute, University College Cork, Lee Road, Cork, Ireland
*Corresponding author email: parveen.kumar@ucc.ie

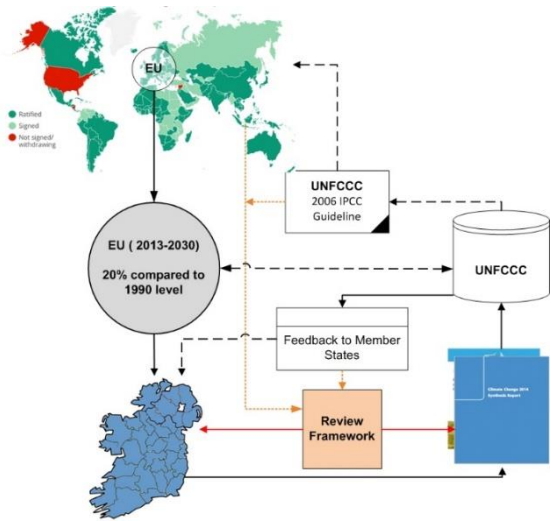
Abstract:

The Paris Climate Agreement was one of the crucial milestone in climate change negotiation to combat climate change globally. In the aftermath of the agreement, parties of United Nations Framework Convention on Climate Change (UNFCCC) have been submitting national plans, communication, and reports that highlight the progress to achieve their greenhouse gas (GHG) emission targets. The European Union, in particular, has been at the forefront of international efforts to achieve targets set by the agreement. In order to track efforts to achieve targets, Member States (MS) of EU have been submitting GHG inventories and projections. This is a complex process and MS are in constant negotiations to set their targets and ways to implement them. In Ireland, the Environmental Protection Agency (EPA) is responsible for preparing GHG emission inventory and projection to the UNFCCC under the EU Monitoring Mechanism. EPA compiles these inventories and projections with the help of partner organisation for different sectors. The modelling behind the GHG emission inventories and projections are based on many shared assumptions resulting in inconsistencies in terms of transference and quality of submission. There are significant uncertainties associated with ex-ante estimates against the ex-post quantifications of GHG emissions associated with policy measures. Therefore, a thorough assessment of Ireland's current GHG emission inventories and projection practices is essential to understand their effectiveness based on international best practices. To achieve this, we developed a review framework to include a combination of literature review of best practices and IPCC guidelines to assess current practices. This also involved assessing key assumptions, measures, models used, data sources, uncertainties assessment and quality control. Finally, the review framework will be tested on other countries and for Ireland. We anticipate that the results will highlight gaps in the current practices and helps in providing a feedback for further improvement of the GHG emission projections.

Keywords:

GHGs inventories and projections; transference; quality; ex-ante estimates; guidelines

Concept Illustration:



Capacity building and evidence-based policy support tools with LEAP

Tomás Mac Uidhir[2*], Parveen Kumar[2], Fionn Rogan [1,2], Brian Ó Gallachóir [1,2]

[1] School of Engineering, University College Cork, College Road, Cork, Ireland
[2] Environmental Research Institute, University College Cork, Lee Road, Cork, Ireland
*Corresponding author email: tomas.macuidhir@ucc.ie

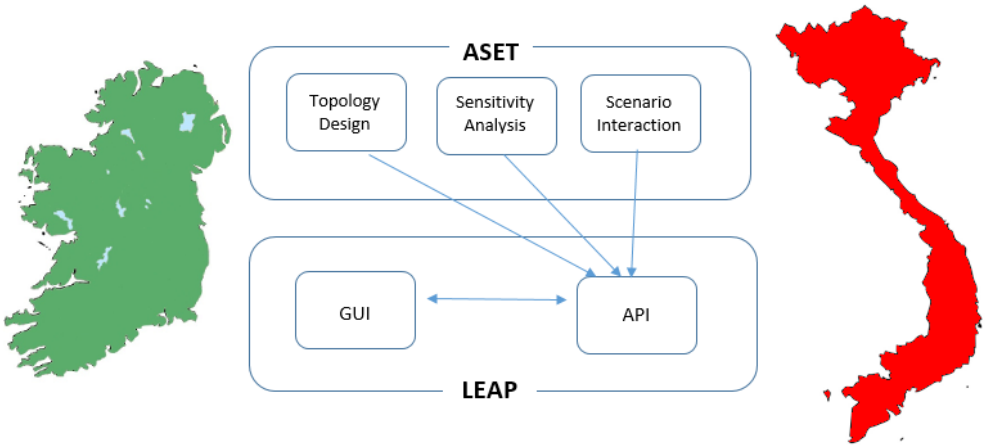
Abstract:

The Paris Agreement on Climate Change, agreed in 2015, marked a significant move from top-down approaches to effort sharing (e.g. Kyoto Protocol) on emissions reduction to bottom-up approaches based on Nationally Determined Contributions (NDCs). In the lead-up to the United Nations Climate Change Conference, 160 separate Intended NDCs representing 190 countries were submitted prior to the negotiations. This bottom-up approach prompted the urgent need for robust energy system modelling tools and methodologies to aid in the development of these NDCs and provide evidence-based policy support. The challenges faced by each signatory of the Paris agreement are unique, this paper develops a new methodology which answers this need through the rapid development of new Long-range Energy Alternative Planning (LEAP) models and provide new modelling capabilities and techniques which can support capacity building and foster institutional capacity. The modelling techniques have been informed/ guided by the requirement to develop a robust GHG inventory model for Ireland. This work has seen the amalgamation of multiple, sectoral specific models into one single coherent LEAP framework. These techniques are also being applied to develop a LEAP model for Viet Nam as part of the Vietnam Ireland Bilateral Exchange (VIBE) Programme, representing a practical application of the methodology.

Keywords:

Capacity Building, LEAP, COP 21, Paris Agreement, Evidence-based

Concept Illustration:



Potential employment opportunities for Irish interconnectors

Mitra Kamidelivand[1,2*], Fionn Rogan [1,2], Brian O'Gallachoir[1,2]

[1] *Energy Policy and Modelling Group, MaREI Centre, Environmental Research Institute (ERI), University College Cork, Ireland.*

[2] *School of Engineering, University College Cork, Ireland.*

*Corresponding author email: mitra.kamidelivand@ucc.ie

Abstract:

Investments are needed in electricity interconnectors to develop renewable energy systems. Many sectors benefit from this investment, especially in import-dependent countries where money can be saved by reduced reliance on imported fuels, in addition there will be a growth in green jobs. These green jobs are an opportunity for both the reduction of climate change impacts and the support of eco-friendly industries.

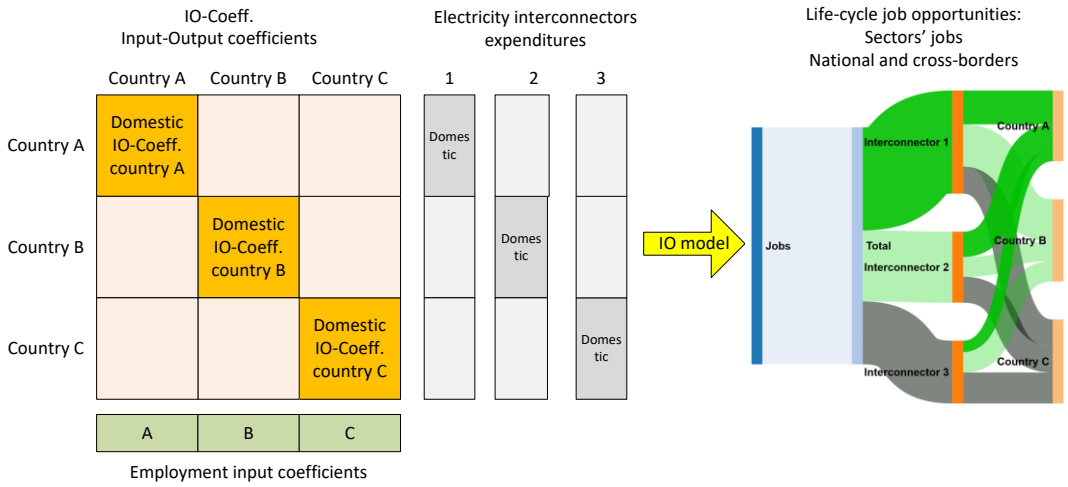
This study analyses the direct and cross-border job creations of investing €2.3b in the three Ten Year Network Development Plan (TYNDP) interconnectors for Ireland. An input-output simulation model is employed using the Exiobase, one of the most extensive environmental extended multiregional input-output (EE-MRIO) databases available. The investment in these interconnectors would potentially support 34,600 additional jobs across the world. This includes the direct jobs for the investors as well as the spill over jobs due to the trade with other countries. Direct jobs for Ireland would account for 3,900 of these jobs. The percentage distribution of the direct jobs in the energy, other manufacturing, and services sectors is 43%, 12%, and 45% respectively. Ireland's interconnectors would have considerable spill over jobs in the European and non-European countries. Among European countries, Poland (2,000), Great Britain (600), and Germany (500) have the highest share of the employment from Ireland's interconnectors. The non-European countries with the highest jobs from the interconnectors are Asia (2,000), America (1,700), Africa (1,300) and China (900).

One of the principal value chains predicted by the model is the amount and distribution of life-cycle job creation as a result of the interconnector investment. The model facilitates the identification of the potential key value chain winning and losing sectors in developing low carbon energy.

Keywords:

Extended multi-regional input-output; electricity interconnectors; life-cycle jobs

Concept Illustration:



A new hybrid approach for multi criteria assessment of technology opportunities in the energy transition

Tarun Sharma[1,2,3,*], Fionn Rogan[1,2,3], Brian Ó Gallachóir[1,2,3]

[1] Energy Policy and Modelling Group, Environmental Research Institute, University College Cork, Cork, Ireland
[2] School of Engineering, University College Cork, Co. Cork, Ireland
[3]SFI MaREI Centre for Marine and Renewable Energy, University College Cork, Co. Cork, Ireland
*Corresponding author email: tarun.sharma@ucc.ie

Abstract:

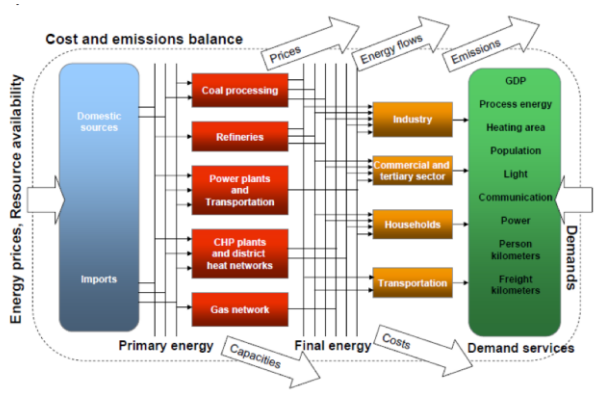
Multi criteria assessment (MCA) is widely used separately for assessments of scenarios and of technologies; in this paper we link the two. We use Irish TIMES[11] to track the transition of Ireland's energy system, exploring the results for individual technologies across scenario ensembles. The scenario ensembles are generated through variations across multiple dimensions, i.e., carbon budget, carbon capture technology availability year, etc and were informed by stakeholder consultation workshop. We rank technologies based on uptake in individual scenarios and then develop technology rank gradients across ensembles to quantify investment risk and technology robustness. We use these new attributes in combination with existing economic and technical criteria to conduct an MCA of technology opportunities. Finally, we undertake sensitivity analysis of the MCA weights using Monte Carlo simulation. This research demonstrates a new methodology and provides additional insights into technology opportunities associated with Ireland's low carbon energy transition and their resilience across a range of risk and economic criteria.

Keywords:

Technology opportunities; scenario ensembles; Multi criteria assessment

Concept Illustration:

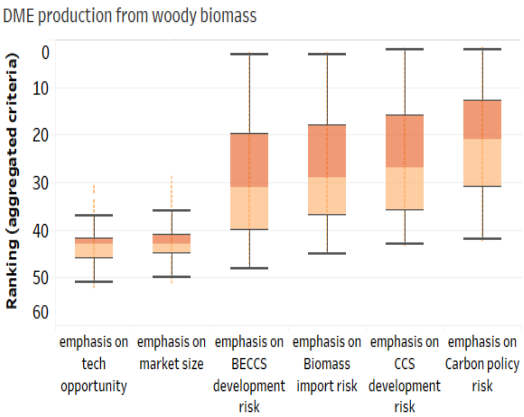
Energy system model



Scenario ensemble with variations along: Carbon budget, Biomass import, CCS development.

Identification and characterization (6 attributes: 2 return, 4 risk) of technology opportutnities.

Sensitivity analysis with weights in multi-criteria assessment



[1] It is a partial equilibrium model of Ireland's energy system, built with The Integrated MARKAL-EFOM system (TIMES), the techno-economic modelling tool developed by IEA-ETSAP which is a widely used energy systems model generator.

Assessing robust carbon mitigation opportunities for Ireland with MACCs and energy system analysis

Xiufeng Yue[1,2,3], Fionn Rogan[1,2,3,*], Brian O'Gallachoir [1,2,3]

[1]*Environmental Research Institute, University College Cork, Cork, Ireland*
[2]*School of Engineering, University College Cork, Cork, Ireland*
[3] *MaREI Centre, Environmental Research Institute, University College Cork, Cork, Ireland*
*Corresponding author email: f.rogan@ucc.ie

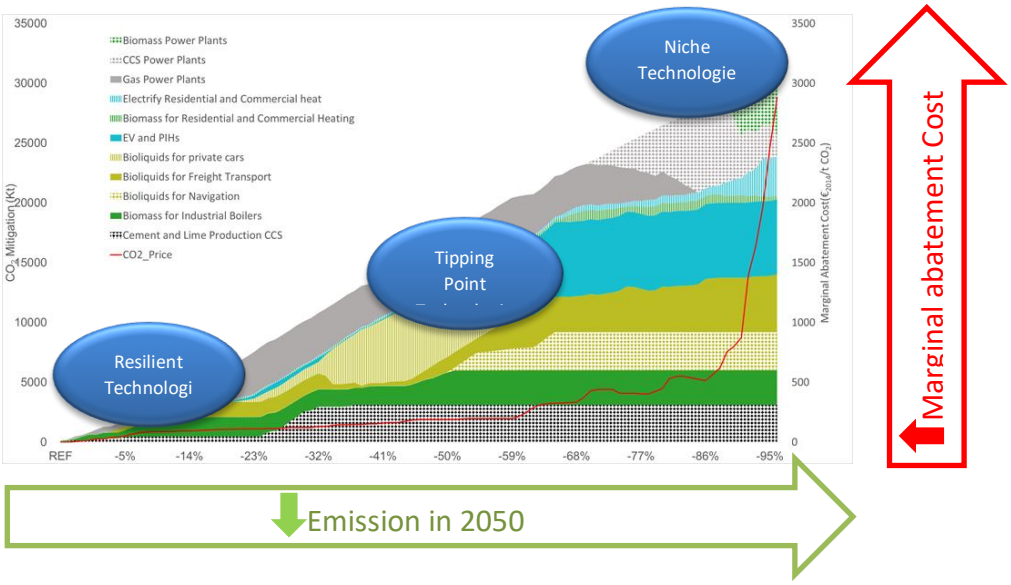
Abstract:

The European Union has an ambitious target to reduce greenhouse gas emissions to 80% below 1990 levels by 2050 to keep global warming within 2°C relative to pre-industrial levels. The more recent Paris climate agreement has a more ambitious target of limiting the temperature rise to well below 2°C. This study uses the Irish TIMES energy systems optimization models to analyse robust mitigation technologies with large number of scenarios. The relative cost efficiency of mitigation technologies in emission reduction are determined by the marginal abatement cost curves (MACCs). The MACCs describe the trade-off between economic feasibility and mitigation ambition. Key mitigation opportunities are ranked based on economic merit and classified in categories of cost effective resilient technologies, tipping point technologies that increase carbon costs significantly, and niche technologies that require further cost reduction to be competitive in an economically optimum scenario. The MACC scenarios are then compared with high renewable energy penetration scenarios to determine the difference in technology choices in energy system configurations that aim for high renewable penetration rather than carbon reduction. To incorporate uncertainties in model structure, the modelling to generate alternatives approach is used to explore alternative scenarios with similar cost levels but maximally different energy system setup. The uncertainties in parametric assumptions in technology costs are handled with Monte Carlo analysis. Technologies with high penetration levels under scenarios with various assumptions can be considered robust.

Keywords:

Energy system analysis, MARKAL-TIMES model, marginal abatement cost, modelling to generate alternatives, uncertainty analysis

Concept Illustration:



The Spark Project

Clare Watson[1] & Alan Gilsenan[2] *

[1] *Energy Policy & Modelling Group, Environmental Research Institute/University College Cork.*
[2] *Yellow Asylum Films.*

*Corresponding author email: clare.watson@ucc.ie

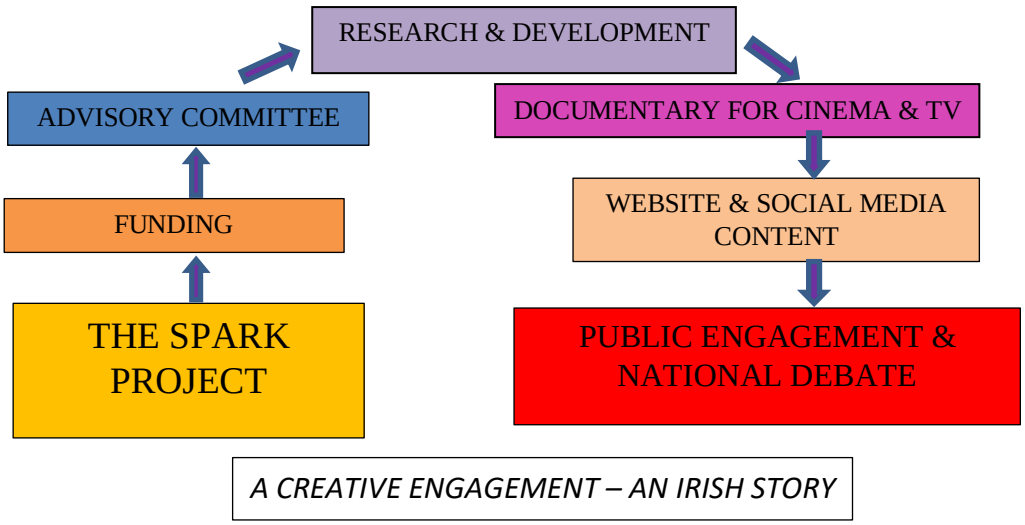
Abstract:

Today, in Ireland, it is broadly accepted that climate change is a reality and that its very existence challenges life on this planet. In a profound way, it is the ultimate existential threat. Yet, somehow, the very scale of the problem induces a kind of apathy or paralysis. It's truly global nature adds to our sense of powerlessness. THE SPARK PROJECT aims to bring a little informed hope and energy to the issue, by combining the best of academic and practical research with the production of a feature documentary of broad appeal, allied to a subsequent engagement campaign. The project aims are: to creatively, intellectually and emotionally engage and inform the broad Irish public about the complex challenges of climate change, energy transition & climate adaptation; to produce an entertaining, popular and stimulating cinema documentary film, alongside a public engagement campaign, aimed at a wide national audience; to empower the Irish citizenry in the face of the potentially disempowering force of climate change and energy transition; and to engage collaboratively with Irish State organisations and other bodies working in this field. The project will have three distinct phases: A detailed research and development period led by Clare Watson; the production and post-production of a 90-minute feature documentary, intended for cinema release across the country, followed by a broadcast on national television, directed by Alan Gilsenan; and a subsequent period of public engagement and education across the country, with a parallel but significant online presence in terms of a supporting website and social media campaign. The three phases should provoke a significant national debate. The clear intention of the project is to create output that will inform, provoke, entertain and move its audience, which will also be intellectually rigorous and scientifically sound.

Keywords:

Climate change; Documentary film; Public engagement; Stimulating; Entertaining

Concept Illustration:



New societal and energy system frameworks; case study "Transition Dingle 2030"

Connor McGookin[1,3*], Brian Ó Gallachóir[1,3], Edmond Byrne[2,3]

[1]School of Engineering – Energy Engineering, University College Cork, Ireland
[2]School of Engineering – Process & Chemical Engineering, University College Cork, Ireland
[3]Energy Policy & Modelling Group, MaREI Centre, Environmental Research Institute, University College Cork, Ireland

*Corresponding author email: connor.mcgookin@ucc.ie

Abstract:

An exciting project is emerging in the region of Ireland known as the Dingle Pensinsula; with a number of key agencies (such as the national distribution grid operator; ESB Networks) and local community representatives coming together to investigate how the region can transition to a low carbon future, as a learning template for national scale. Project motivation has emanated from a number of previous instances involving significant local mobilization in opposition to what could be characterised as 'green' infrastructural developments, including for example; overhead pylons associated with a North-South Interconnector or large scale onshore wind projects. These have highlighted weaknesses in current engagement practices, revealing significant gaps between energy industry and community imperatives. The project seeks to explore new approaches, which allow for greater community participation in the context of facilitating a low carbon transition (of energy and societal frameworks).

This research work will support the Transition Dingle project. Firstly, it facilitates the development of an energy map for the peninsula through building a spatial model using statistical data available from relevant statutory bodies. Then through engagement with key stakeholder groups (ESBN, Transition Dingle, local Tourism Board, etc.) it seeks to establish appropriate pathway scenarios. These scenarios will be used to generate predictions for potential future energy systems using metrics such as energy demand, CO2 emissions. This will facilitate the investigation of areas of commonality and potential conflict between the various pathways aimed at creating a single collaborative vision through recursive local engagement and scenario planning.

Keywords:

Regional energy balance, stakeholder engagement, scenario planning, societal transition

Concept Illustration:

Multi-stakeholder approach to the socio-technical transition to a low-carbon society on the Dingle Peninsula

Evan Boyle*, Prof. Brian Ó Gallachóir, Dr. Ger Mullally

Department of Sociology –University College Cork, Ireland
School of Engineering – Process & Chemical Engineering, University College Cork, Ireland
Energy Policy & Modelling Group, MaREI Centre, Environmental Research Institute, University College Cork, Ireland

*Corresponding author email:110365383@umail.ucc.ie

Abstract:

Transition Dingle Peninsula 2030 (working title) is an initiative aiming to transition a geographic region in the South West of Ireland to a low-carbon society by 2030. ESBN (the national distribution grid operator) have already launched a trial project which will see the company deploy a range of technologies to future proof the network. Alongside this the agriculture, transport and tourism sectors will be brought into the overall Transition Dingle Peninsula 2030 project. The project aims to work alongside community representatives/ organisations and state agencies to investigate how the region can transition to a low carbon future, as a learning template for national scale.

The purpose of my research project is to analyse the multi-stakeholder approach to the socio-technical transition to a low-carbon society on the Dingle Peninsula. In the past, approaches to transitioning have been implemented as either top-down (government led) or bottom-up (grassroots/community initiatives). Transition Dingle Peninsula 2030 has the potential to be a unique blend of both approaches, through collaboration and co-creation between different individuals/ organisations, with each having different goals, expectations and expertise. This research project will map the different individuals/ organisations involved in the Transition Dingle Peninsula 2030 project, to investigate how the multi-stakeholder network develops over time and will inform Transition Dingle Peninsula 2030's ambition, to create a robust multi-stakeholder network and increase social learning between different actors.

Keywords:

Socio-Technical Transition, Multi-Stakeholder Governance, Social Learning, Participation, Multi-Actor Perspective, Multi-Level Perspective, Social Network Analysis.

Materials & Structures

Inspection of marine renewable energy devices

Michael O'Byrne[1,*], Vikram Pakrashi[1], Bidisha Ghosh[2], Franck Schoefs[3]

[1] Dynamical Systems and Risk Laboratory (DSRL), School of Mechanical and Materials Engineering, University College Dublin, Ireland; Marine Renewable Energy Ireland (MaREI), University College Dublin, Ireland.
[2] Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Ireland.
[3] Université Bretagne-Loire, Université de Nantes, Research Institute of Civil Engineering and Mechanics (GeM)/Sea and Littoral Research Institute (IUML), CNRS UMR 6183/FR 3473, Nantes; IXEAD/CAPACITES Society, Nantes, France.

*Corresponding author email: michael.obyrne@ucd.ie

Abstract:

Marine Renewable Energy (MRE) devices typically operate in harsh and corrosive conditions, and for this reason, they are particularly susceptible to rapid ageing and deterioration. Inspections are therefore crucial to ensure that safety and structural integrity is maintained, and so that MRE devices can reach, or even surpass, their target lifespan.

An up-to-date description of the current status of underwater inspections for MRE devices is provided, including a detailed assessment of the state-of-art of underwater Non-Destructive Testing (NDT) tools. While the monitoring of MRE devices has historically been based on recurrent visual observations and assessments of structural condition, recent research efforts have centred on developing effective methods and reliable tools for acquiring, managing, integrating and interpreting structural performance data at a minimum cost while reducing the unreliable human element. Such efforts are particularly valued for underwater inspections where data must be conducted in a limited timeframe and the cost of adapting NDT tools for underwater deployment can be exorbitant in many cases. This study provides an overview of these recent advances and addresses many practical considerations. Special attention is given to the importance of adopting efficient on-site collection practices and how this can help when it comes to integrating inspection data into the decision-making process. To demonstrate this, we show how an image-based NDT system can be used to extract 3D shape information of marine growth colonized underwater components and consequently fed into a Computational Fluid Dynamics (CFD) environment where fluid-structure interaction analysis is carried out. The information gleaned from such an analysis is useful for engineers. This demonstration also illustrates how NDT tools can often be readily exploited to a greater potential.

Keywords:

Underwater Inspection; Non-Destructive Testing; Image Processing; Marine Renewable Energy Devices

Concept Illustration:

Composite materials and manufacturing for energy applications

Noel Harrison [1,2,3,4] Tomás Flanagan[5]

[1] *Mechanical Engineering, College of Engineering & Informatics, NUI Galway, Ireland*
[2] *Ryan Institute for Environmental, Marine and Energy Research, NUI Galway, Ireland*
[3] *I-Form Advanced Manufacturing Research Centre, Ireland*
[4] *IComp Irish Composites Centre, Ireland* [2]
[5] *ÉireComposites Teo., Indreabhán, Co. Galway, Ireland*
*Corresponding author email: noel.harrison@nuigalway.ie

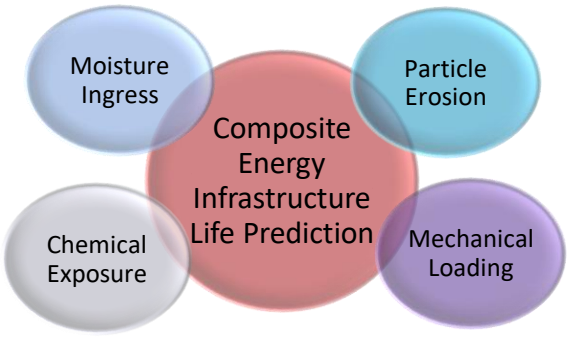
Abstract:

The European Union has set a target of an 80% reduction in carbon emissions by 2050 (EC 2050 Low-Carbon Economy Roadmap), which will see a drastic reduction on the reliance of fossil fuel combustion. In order to deliver this, renewable energy, in the form of composite wind, tidal and wave energy devices, will replace a major portion of fossil fuel-based electricity generation. Understanding long-term in-service material behaviour, optimising material selection and improving manufacturing processes represent some of the key challenges for developing sustainable long-term composite energy infrastructure. As the renewable energy sector, particularly tidal and wave, moves from demonstrator site stage to full service infrastructure, the degradation of these structures in the hostile marine environment, and limitation of their operating life are only now being determined. The immediate requirement is to develop materials and processes for tidal turbine plant that has decades of operational lifetime. Material ageing in the marine environment is mainly attributed to moisture ingress and is driven by both chemical- and mechanical-based mechanisms. Chemical-based mechanisms, due to hydrolytic degradation, and mechanical-based ageing attributed to stress-based mechanisms also reduce the long-term durability of marine-based composite structures and structural designers are faced with significant challenges when making quantitative predictions of component life-cycle. Currently tidal turbine blades and designed within the DNV-SE-0163 "Certification of tidal turbines and arrays" standard. In the prototype certification section of this document, there is a requirement for testing to "…reduce uncertainties through the collection of data on long term degradation effects and to quantify the design margins." This research will see the design and calibration of accelerated degradation tests, computational models and life predictive tools to advance the understanding of fundamental composite degradation and ageing mechanisms, improve manufacturing processes and increase the uptake of composite materials in renewable energy infrastructure.

Keywords:

Renewable Energy, Material for Energy, Composite Manufacturing, Finite Element Modelling,

Concept Illustration:



Fatigue testing requirements for tidal blades

Vesna Jaksic[1,*], Conchúr Ó Brádaigh[2]

[1] *Sustainable Infrastructure Research & Innovation Group (SIRIG), Civil, Structural & Environmental Department/Cork Institute of Technology.*

[2] *Materials and Processes, Mechanical Engineering/The University of Edinburgh.*

*Corresponding author email: vesna.jaksic@cit.ie

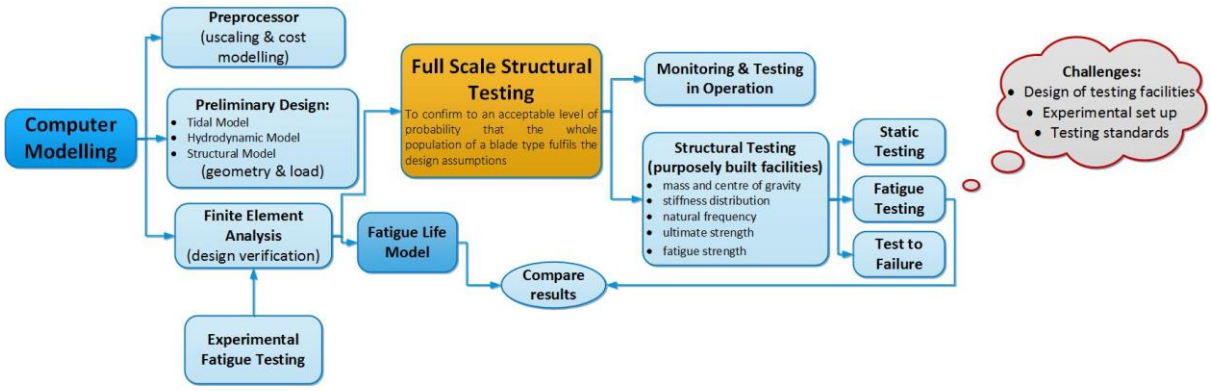
Abstract:

Capital cost reduction and structural reliability of blades are the key factors in tidal turbine development. In that regard, up to now, the research has been primarily focused on two aspects of tidal blade (TB) design improvements. Firstly, the possibility of replacing Glass Fibre Reinforced Polymers (GFRP) with Carbon Fibre Reinforced Polymers (CFRP) in the design of TB structures in order to reduce weight and cost has been studied. It has been found that simple upscaling of the TB will only lead to an increase of the blade mass (i.e. cost), imposing additional loading on the blade root, reducing the hydrodynamic efficiency of the blade, and reducing the turbine energy productivity. Hence, the mass of the blade can be significantly reduced by changing the geometry of the spar and employing CFRP instead of GFRP in its design. Secondly, the optimisation of the blade mass can be further improved by the use of realistic saturated material properties, thus avoiding the overly conservative design safety factors. With this in view, the fundamental fatigue design of GFRP has been developed with the aim to estimate and compare the immersed life of Stall-Regulated (SR) and Pitch-Regulated (PR) tidal turbine blades. The experiments have shown that the fatigue life of TB is extensively dependent on a strain-stress level experienced by the blade, regardless of the material. In addition, the SR blade will have a shorter life span than the equivalent PR turbine blade. However, the TB designs need to be subject to full scale testing in order to verify the computational analysis and address the lack of industry knowledge in area of TB failures. This will require three stages of TB testing: static, fatigue, and test to failure. Some of the testing challenges include applying the loads near blade root, no standard for design load cases, blade high natural frequency, etc.

Keywords:

Tidal blade, Fatigue testing, Glass Fibre Reinforced Polymers, Carbon Fibre Reinforced Polymers

Concept Illustration:



Tidal turbine blade design, optimisation, and testing

Jamie Goggins[1,3], Sean B Leen[2,3,4], Oscar De La Torre[1,3], Suhaib Salawdeh[1,3], Colm Walsh[1], Gerry Hynes[1], Edward Fagan[1,3] *

[1] Civil Engineering, School of Engineering, NUI Galway.
[2] Mechanical Engineering, School of Engineering, NUI Galway.
[3] Centre for Marine and Renewable Energy Ireland (MaREI), Ryan Institute, NUI Galway.
[4] I-Form Advanced Manufacturing Research Centre, Ireland
*Corresponding author email: edward.fagan@nuigalway.ie

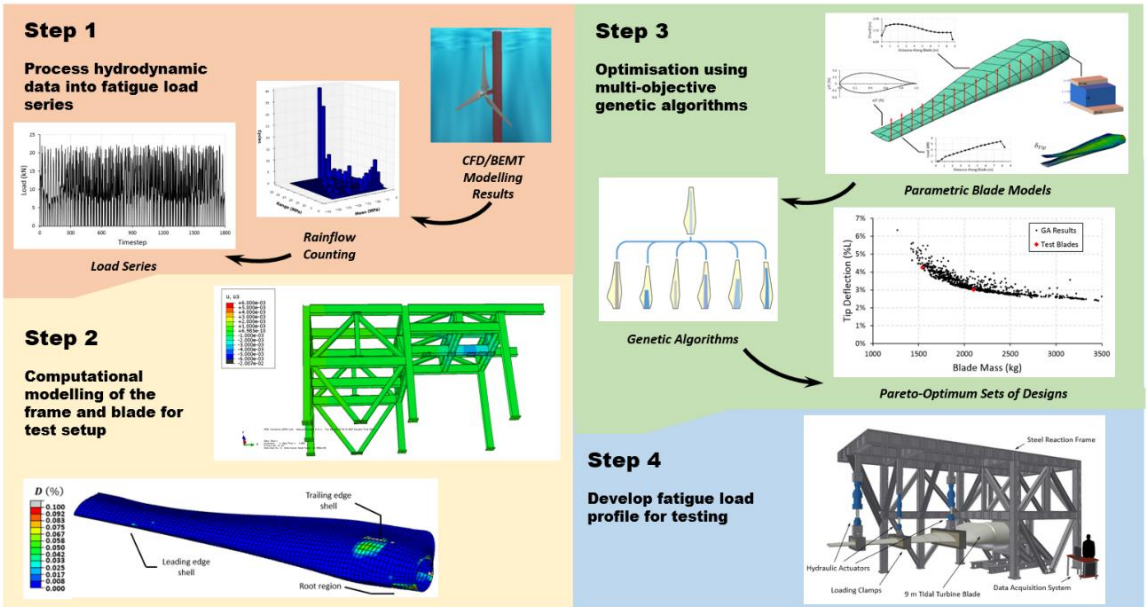
Abstract:

The successful development of the tidal energy market requires a significant reduction in the levelised cost of energy (LCOE) for the devices in the coming years. One way of achieving the necessary cost reductions is through optimising the structural design of components such as the blades of tidal turbines, reducing the up-front capital costs as well as the long-term maintenance costs. At NUI Galway a design methodology has been developed that incorporates aspects of hydrodynamic modelling, structural modelling, materials and manufacturing design and full-scale structural testing. The methodology draws on years of experience in these domains at NUI Galway and is supported by the MaREI funded Heavy Structures Test Cell. The tidal turbine blade design, analysis and testing methodology is broken down into four steps (illustrated in the graphic below): (i) CFD or BEMT (blade element momentum theory) hydrodynamic models are used to determine the dynamic loading on tidal turbines and the loads are processed into fatigue load series for further structural analyses, (ii) computational modelling of the structural response of the blade and the loading frame is performed to aid in the design and analysis of the test setup, (iii) optimisation is performed using parametric blade models and multi-objective genetic algorithms to determine an optimal structural design and (iv) full-scale structural testing of blades is performed, incorporating the loading and structural responses determined in the previous steps. The iterative design, analysis and optimisation methodology is encapsulated in an automated blade modelling code called BladeComp.

Keywords:

Tidal turbine blades; Composite materials; Finite element modelling; Optimisation; Structural testing.

Concept Illustration:



Fabrication of marine composites by additive manufacturing

Heather O' Connor[1*], Denis Dowling[1]

[1] *School of Mechanical and Materials Engineering, Belfield, UCD*

*Corresponding author email: heather.oconnor@ucdconnect.ie

Abstract:

Fibre-reinforced polymer composites (FRPC) are used in marine energy applications such as wind-energy turbines and tidal devices, due to their high strength to weight ratio and durability. The fabrication of FRPC, using additive manufacturing (AM) could help to significantly reduce the time and cost of production and allow the fabrication of more customisable designs. However, reduced mechanical performance of AM fabricated composites compared with conventional techniques has to-date, limited the use of AM technology for these applications. One of the factors causing this reduced performance is the presence of voids within the matrix. This issue is addressed in conventional composite fabrication by carrying out the process under low pressure conditions, removing the air. The aim of this study is to evaluate the mechanical properties of AM fabricated FRPC under low-pressure printing conditions.

Initial printing studies were carried out in the absence of fibre using fused deposition modelling (FDM), in a vacuum chamber (1 Pa), as well as at atmospheric pressure. Acrylonitrile-butadiene styrene (ABS), polylactic acid (PLA) and polyamide 6 (PA6) were investigated. Only minor differences in chemical functionality were observed between parts printed under the two processing pressures. Under low-pressure conditions however, it was observed that the ABS, PLA and PA6 exhibited an increase in Ultimate Tensile Strength of 9%, 13% and 42% respectively. This was attributed to the reduction in porosity of the printed part and the reduction in heat loss at the printed polymer surface. PA6 FRPC parts were then printed using a polymer coated continuous carbon-fibre filament. The printing studies were carried out under both atmospheric and low-pressure conditions. Based on SEM and nano-CT examination, it was concluded that the low-pressure printing conditions significantly reduced composite porosity. A significant enhancement in the interlaminar shear properties of the carbon-fibre PA6 composite was also achieved. Future work will build on these results, investigating the fabrication of glass and Kevlar reinforced composites and PEEK based composite via FDM, under low-pressure.

Keywords:

Additive Manufacturing; Material Extrusion; CFRP; Low-Pressure Printing

Concept Illustration:

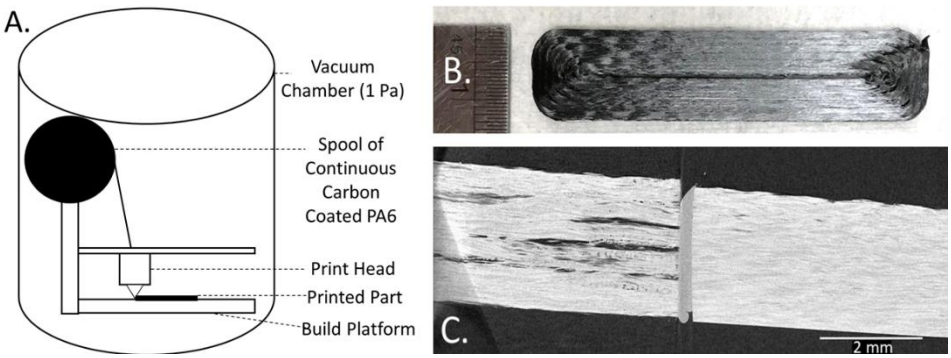


Figure 1: A. Schematic of FDM printer within vacuum chamber, B. Printed Carbon-fibre PA6 Specimen, C. CT scan of CFRP printed under atmospheric conditions, exhibiting high porosity (left) and printed under low-pressure conditions, exhibiting less porosity (right).

Cost effective marine renewable energy devices

Ananda Roy[1], Walter Stanley[2] *

[1] *IComp; University of Limerick.*
[2]*School of Engineering; University of Limerick.*
*Corresponding author email: Walter.Stanley@ul.ie

Abstract:

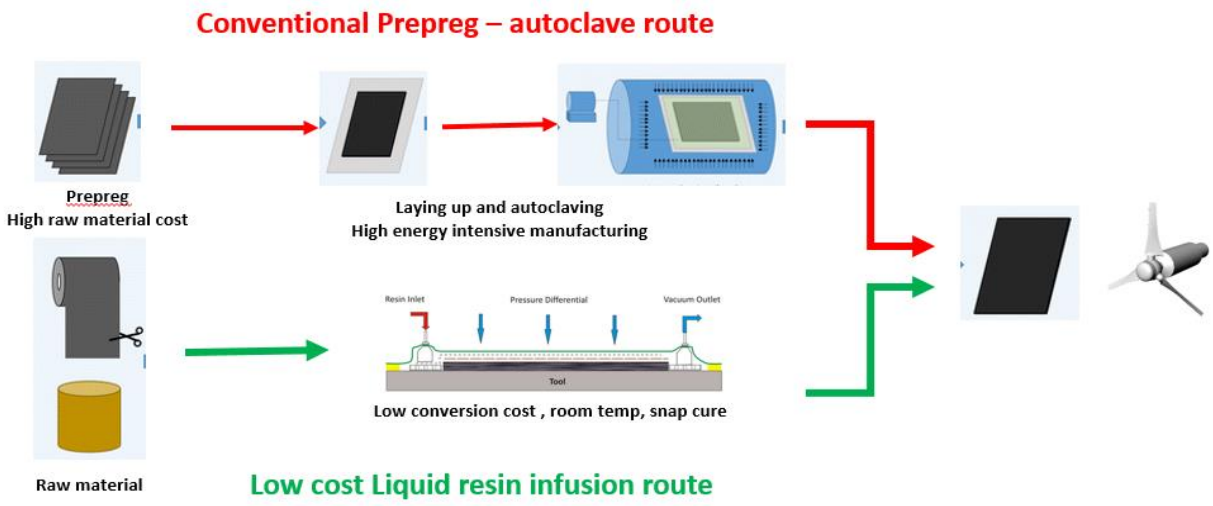
A new liquid thermoplastic resin has recently been introduced into market for manufacturing composite materials using standard room temperature infusion techniques (such as Light RTM). This will allow manufacturing of cost effective recyclable thermoplastic composites suitable for large marine structures.

One of the big challenges currently faced by the Marine Renewable Energy (MRE) industry is the overall high cost of the associated materials, manufacturing techniques and installation procedures. The present research will address the issue of the very high costs associated with aerospace grade materials used for MRE devices and their manufacturing technologies, that can be preimpregnated format type. Along with the liquid thermoplastic resin, the present work also focuses on the suitability of using cost effective, snap cure thermosetting resins for manufacturing marine structures. All of this aforementioned technique can reduce the material as well as the manufacturing costs. An investigation into the performance of the resulting composite materials over time in a saline environment has been carried out.

Keywords:

Acrylic matrix resin, snap cure, saltwater

Concept Illustration:



Coupled and time-frequency analysis in reduction of system responses and uncertainties

Van Nguyen Dinh[1, *], Biswajit Basu[2]

[1] *MaREI Centre for Marine and Renewable Energy, ERI, University College Cork, Ireland*
[2] *School of Engineering, Trinity College Dublin, Ireland*
***Corresponding author email:** nguyen.dinh@ucc.ie

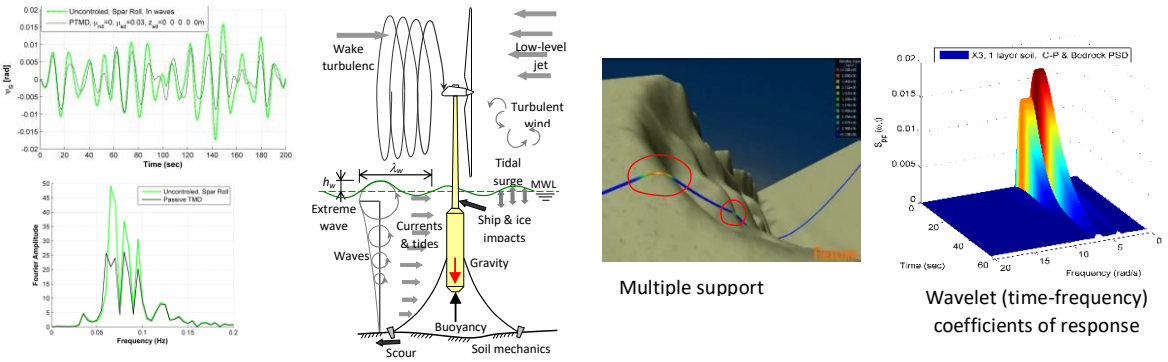
Abstract:

Most of systems consist of a number of elements and are subjected to multiple and simultaneous actions from the environment. The response by each element depends not only on its properties and the actions on it but also on the properties of and the actions on the other elements. The action from waves on marine structures is physically influenced by sea currents [1]. In a floating offshore wind turbine (FOWT), the vibration of the blades, nacelle, tower, and platform elements are interacted in all degrees of freedom and in all inertial, dissipative and elastic components [2, 3, 4]. In multiple support structures, there are differences and time-variations in both amplitudes and frequency content of the excitations and the properties of soil at each support [5]. In practice, when each element is designed, manufactured and installed by a separate contractor, a recent industry uncertainty is that how system risk is allocated to. The coupled analysis [1-5] and time-frequency analysis using wavelets [5] have been implemented highlighting the significant contribution of such interactions. The coupled modelling is used in the development of control measures for reducing responses of FOWT systems [2, 3]. This suggests a number of opportunities open to various systems in onshore, offshore, and subsea environments.

Keywords:

Coupled analysis; Time-frequency; Control; Floating offshore wind turbines; Multiple supports

Concept Illustration:



Multiple support

Wavelet (time-frequency) coefficients of response

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One-shot manufacture of tidal turbine blades using powder-epoxy

Michael Flanagan[12*], Noel M. Harrison[3], Jamie Goggins[1], Tomás Flanagan[2]

[1] Civil Engineering, National University of Ireland Galway, Ireland
[2] Engineering Department, ÉireComposites Teo., Indreabhán, Co. Galway, Ireland
[3] Mechanical Engineering, National University of Ireland Galway, Ireland
*Corresponding author email: m.flanagan15@nuigalway.ie

Abstract:

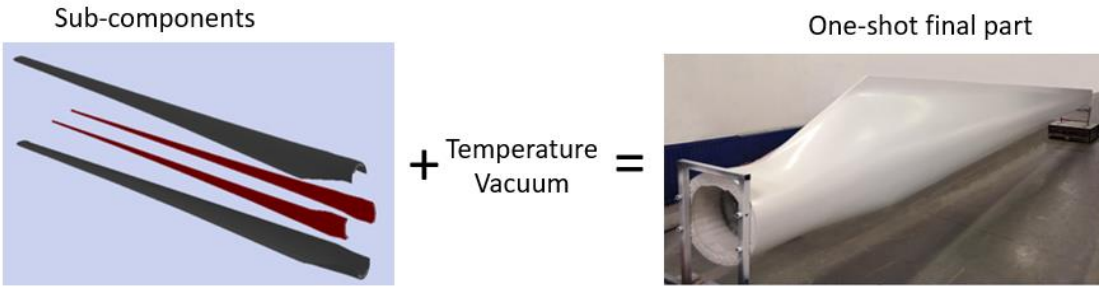
This work looks at a new method of manufacturing tidal turbine blades. Currently tidal blades are typically manufactured using traditional materials and manufacturing techniques. These techniques involve manufacturing sub-components and gluing the components together to form the final part. The current work looks at a one-shot manufacturing method where the entire structure is cured in one cure-cycle. The process has been used in the manufacture of commercial wind turbine blades and is currently being used in the development of tidal turbine blades and boat hulls. The process is made possible by the use of heat-activated powder-epoxy materials. Unlike traditional epoxy materials used in composite manufacture, powder epoxy can be formed into its final shape without polymerising the epoxy. In the new process, the sub-components are initially formed by laying up the part and applying vacuum pressure and heat. The fully formed sub- components are then assembled together and cured to form the final part. Using this process has several advantages over traditional processes. The whole blade is polymerised in one-shot eliminating glue-lines and consequently resulting in an increase in strength. The powder epoxy material does not give off volatile organic compounds during cure. The mechanical properties and moisture absorption of powder epoxy composite materials has also been found to be superior to composites manufactured using the traditional vacuum assisted resin transfer method.

Keywords:

Keywords; Powder-epoxy, Out-of-autoclave, Glass fibre, Tidal power

Concept Illustration:

The concept is illustrated below using a commercial wind turbine blade as an example



Next generation lithium ion batteries using nanowire anodes

Kevin M. Ryan*, Tadhg Kennedy, Hugh Geaney

Bernal Institute and Department of Chemical Sciences, University of Limerick
*Corresponding author email: kevin.m.ryan@ul.ie

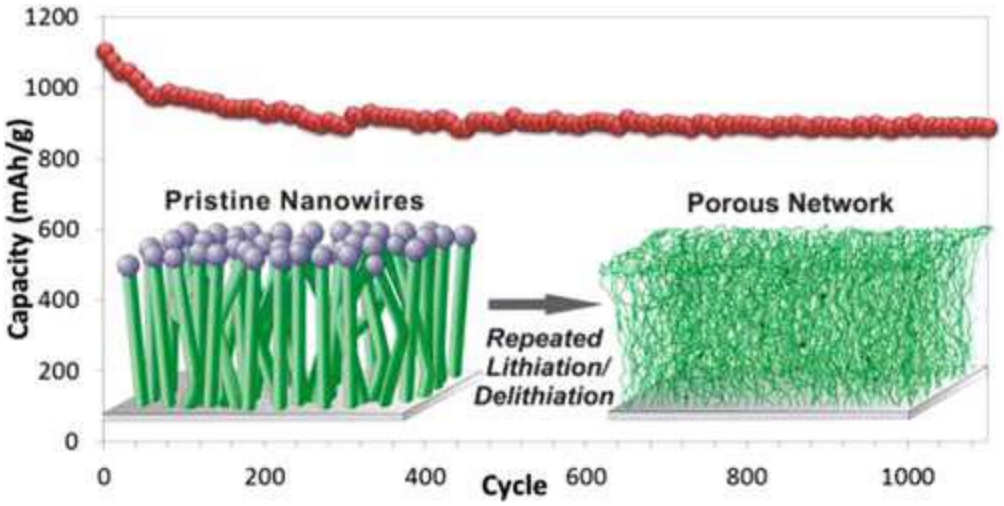
Abstract:

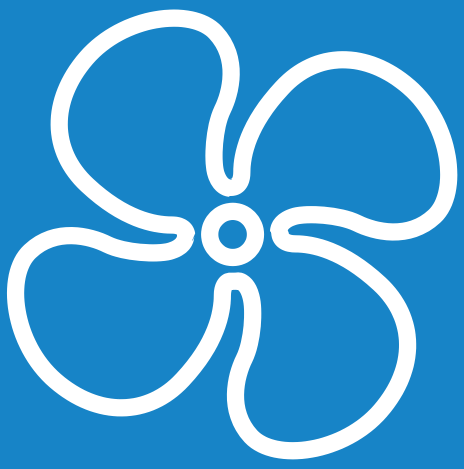
Lithium based batteries are the dominant power technology for mobile computing, telecommunications, power tools and emerging electric vehicles with a market worth 15 Bn in 2014. The energy density achievable with current Li-ion battery technology is a major limiting factor to continued advances in mobile power applications for current markets and is the bottle neck for the emergence of the electric vehicle market. As the power requirements of devices scales, the weight of battery in the device needs to increase or the else the battery has a greatly diminished range between charges limiting commercial viability. Ultimately, there is need for a higher capacity battery that can be achieved at a smaller weight and volume than is currently attainable. A doubling of the energy density is needed to allow for electric vehicles with 500 Km range in this emerging market or would allow halving of the battery weight for the same energy output for lighter mobile phones lap-tops and power tools. Ultimately, progress towards this goal is a materials chemistry challenge requiring novel battery compositions of higher capacity anodes and cathodes in a cell configuration that is safe reliable and cost-effective to produce. Recently, we developed silicon and germanium nanowire based anode materials that have multiples of the capacity of graphite anodes and could retain this capacity for over 1000 cycles (schematic) that represents a major development in this research. Critical to this advance was an understanding of the changes that occur in this material during cycling and its optimisation to achieve almost zero cycling losses

Keywords:

Lithium ion batteries, energy storage, silicon and germanium nanowires

Concept Illustration:





Marine Renewable Energy Technologies

Tidal energy test rigs development for ORPC as part of TAOIDE and tying in with the electrical test infrastructure in Lir

Dónal Murray[1*], Gillian Madden[1], Kevin Leyne[1]

[1] *Electrical Group, Offshore Renewable Energy Group, MaREI Centre, Beaufort Building, Environmental Research Institute, University College Cork, Ringaskiddy, Co. Cork, Ireland.*

*Corresponding author email: donalbmurray@ucc.ie

Abstract:

TAOIDE stands for The Technology Advancement of Ocean energy devices through Innovative Development of Electrical systems to increase performance and reliability. TAOIDE is a €3.2 million EU H2020 project that runs from November 2016 to October 2019 and consists of 5 partners. The project is aiming to improve the Rivgen® device, which is an offshore renewable energy system from the tidal and river-energy device developer, ORPC. Ultimate project goals are to develop a complete power transfer system from prime mover to electrical grid with normal maintenance intervals of greater than five years, and availability of greater than 98%. The improved design to be tested will comprise of a fully-seawater flooded, "wet-gap" generator, bearings and seals from SKF, commercial off-the-shelf power converters with control design help from Fraunhofer IEE, and maintenance procedures and protocols designed with the help of Letterkenny Institute of Technology. UCC and MaREI are coordinating the project and will develop and implement hardware and software validation testing. This will involve the creation and testing of two test rigs in Lir:

1. A bearings and seals test rig
2. A 55 kW low speed, high torque, wet-gap generator test rig

The generator test rig will also test the system power converters, the controls implemented through a supervisory controller, as well as SKF's condition monitoring hardware and software for sensor data handling. Grid integration, power converter testing, and power quality analysis will be carried out with the help of the Lir microgrid. Support from all in MaREI and experience and coordination with the 4 other electrical test rigs in Lir (the linear and rotary test rigs, as well as the medium and high-speed rotary emulators) will be crucial to success.

Keywords:

TAOIDE; Tidal energy; Power-Take Off (PTO); Microgrid, Testing, Test Rig.

Concept Illustration:

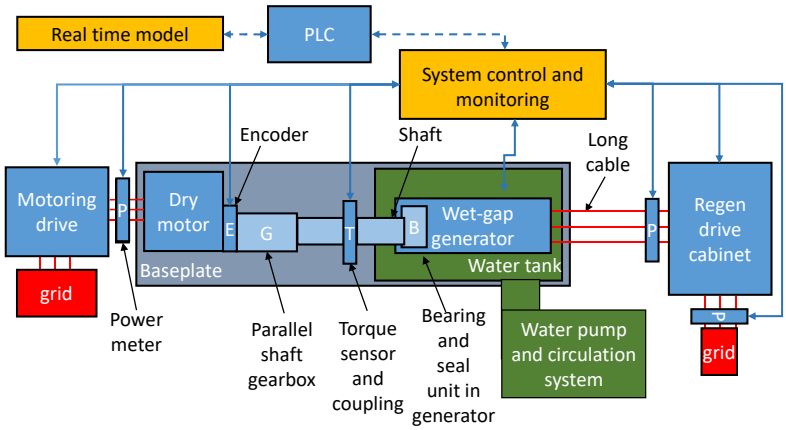


Figure 1: 55 kW low speed, high torque, wet-gap generator test rig

Development and testing of an innovative wave energy device

Pierre Benreguig[1]

[1] *ORE group, MaREI Center, University College Cork.*
*Corresponding author email: Pierre.Benreguig@ucc.ie

Abstract:

Oscillating Water Column (OWC) devices are one of the most promising wave energy devices and have been extensively studied and in some cases tested at full size in real ocean conditions.

A conventional OWC device generates a bidirectional air flow through a self-rectifying turbine located on top of the chamber and opened to the atmosphere. The turbine is connected to a generator which produces electricity. Self-rectifying turbines are a type of turbine that rotates in a single direction in bidirectional airflow. However, their efficiency is lower than the efficiency of unidirectional turbines and they produce high noise due to their high rotational speed and the atmospheric discharge.

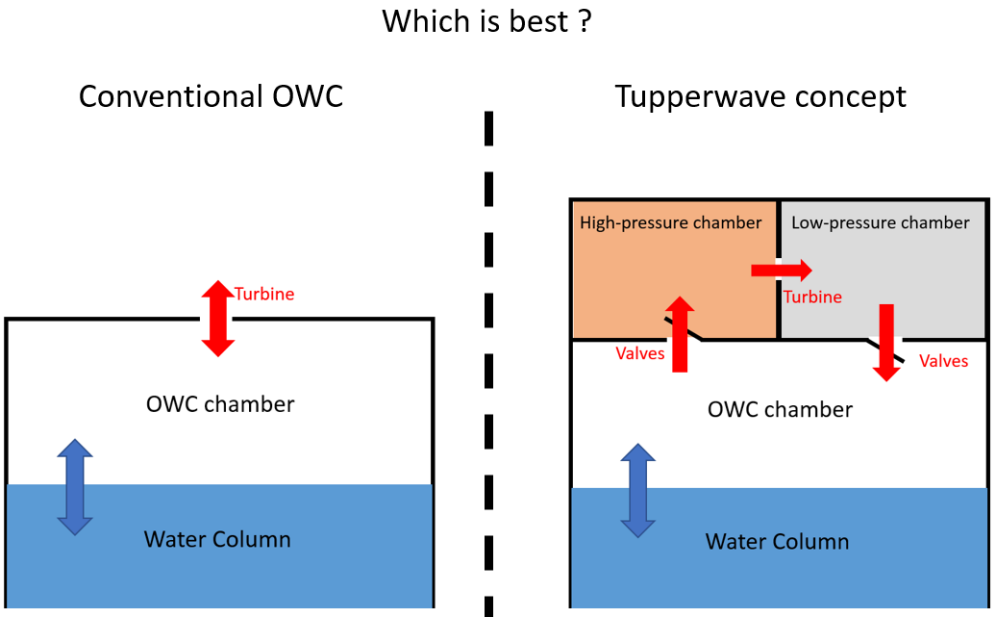
This research project involves the design of the Tupperwave concept: closed circuit OWC that generates a unidirectional air flow which can be converted into electricity via a unidirectional turbine. The principle is based on the use of unidirectional valves and of two additional chambers above the water column. One chamber gathers pressurised air while the other gathers depressurised air. The resulting air flow between the two chambers is harnessed by a high efficiency unidirectional turbine. The closed air circuit avoids atmospheric pressure discharge and is therefore less noisy.

The objective of the project is the comparison between the conventional OWC and the Tupperwave concept in terms of power production and power quality. This involves time domain numerical modelling as well as the physical testing at model scale in wave tanks.

Keywords:

Wave energy; Oscillating Water Column; Tank testing; Numerical modelling

Concept Illustration:



Cost reduction analysis in offshore wind

Rachel Chester*, C. Desmond, F. Devoy McAuliffe, B. Flannery, F. Judge, K. Lynch, J. Murphy

Ocean Renewable Energy Group, MaREI Centre, Beaufort Building, Environmental Research Institute, University College Cork, Ringaskiddy, Co. Cork, Ireland

*Corresponding author email: rachel.chester@ucc.ie

Abstract:

The offshore wind industry has successfully established itself over the past decade with 15.8 GW of installed capacity in Europe at the end of 2017. This progress surpassed predictions, with the industry achieving strike prices as low as €49.90/MWh in 2016 for Denmark's Krieger's Flak. However, in the current climate of low wholesale power market costs, the industry needs to continue in its cost reductions in order to sustain investors and wean itself away from governmental subsidies. Cost reductions need to be driven by a combination of innovative technology and efficient supply chain methodologies.

The economic viability of an offshore wind farm is strongly dictated by its site location, and therefore, a financial model developed during LEANWIND has been used to examine the impact of implementing new technologies and strategies. The financial model is a probabilistic simulation tool that runs through multiple iterations of a projects lifecycle (installation, operation and maintenance (O&M) and decommissioning) and employs Monte Carlo simulation to consider unknown stochastic elements such as weather. This tool was used during LEANWIND to assess the impacts of innovative technology and operational strategies, and to identify where time and cost savings can be made. Key findings highlighted the potential of using self-erecting turbines at sea, reducing the need for expensive heavy lift vessels by utilising a float-out installation strategy, and, most significantly, the higher than predicted cost of fully decommissioning an offshore wind farm.

An adapted financial model will be employed during the EirWind project. An optimisation of site specific scenarios will be conducted to identify the most suitable technology and operational strategies to reduce cost. The results will aid decision-making and reduce future development costs on site locations around Ireland.

Keywords:

Offshore Wind, LCOE, Financial Modelling, Project Lifecycle

Concept Illustration:

Real-time free-surface elevation forecasting for marine applications using wave spectrum information

Alexis Mérigaud[1, *], James Herterich[2,3], Jason Flanagan[4], Frederic Dias[2,3], John V. Ringwood[1]

[1] *Centre for Ocean Energy Research, Maynooth University*
[2] *UCD School of Mathematics and Statistics, University College Dublin, MaREI Centre, Dublin, Ireland*
[3] *UCD Earth Institute, University College Dublin, Dublin, Ireland*
[4] *ICHEC, NUI Galway, Galway City, Ireland*
*Corresponding author email: alexis.merigaud.2015@mumail.ie

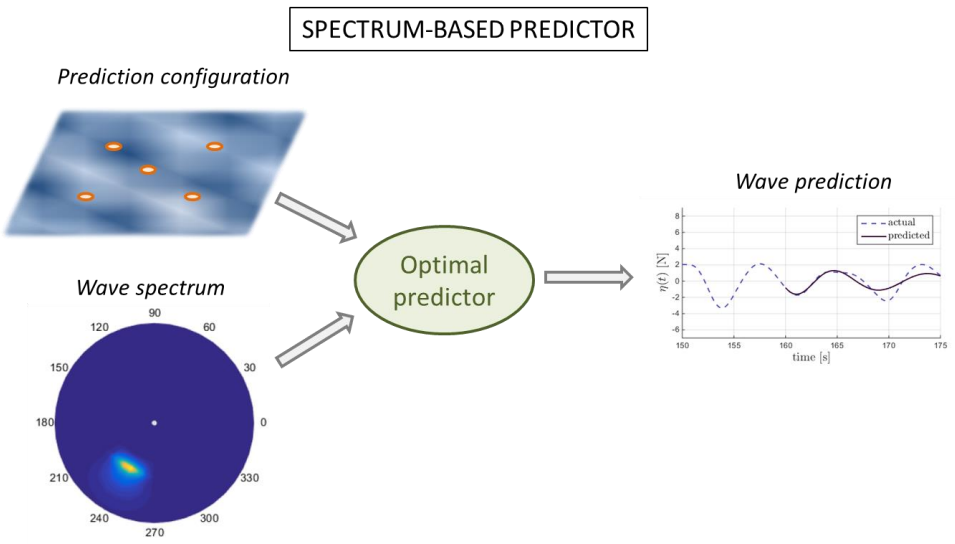
Abstract:

Real-time prediction of free-surface elevation is necessary for a variety of applications, such as offshore operations and wave energy converter control. Assuming a Gaussian wave field, the wave spectrum can be used to calculate the statistically-optimal predictor, for a given prediction configuration (i.e. for a given combination of measurement instants and spatial locations, relative to the instants and locations where and when the wave is predicted). More specifically, the optimal predictor is linear, and its coefficients need only be updated as the wave condition evolves, e.g. every 30 min. This approach is termed *spectrum-based prediction* (SBP). In this work, the validity of the SBP theoretical framework is tested against real-sea wave data, which originate from a measurement campaign using an acoustic Doppler current profiler (ADCP), and consist of free-surface elevation time series, at the corners and centre of a 25m-by-25m square. The directional wave spectra, corresponding to the sea states where the time series are provided, have also been calculated. The empirical SBP accuracy, obtained by applying the SBP in the real-sea time series, is assessed in various sea conditions and prediction configurations, and compared with the theoretical SBP accuracy, evaluated based on the wave spectra. Although the ADCP measurement layout is clearly not ideal for the purpose of wave forecasting, empirical results are physically and statistically consistent, and show good agreement with theoretical results, thus supporting the relevance of the SBP framework. Using real directional spectra, it is also investigated how a different measurement configuration could improve the prediction accuracy.

Keywords:

Wave elevation forecasting, time series, wave spectrum, Gaussian processes, ADCP

Concept Illustration:



Multi-DoF modelling of a hinge-barge wave energy converter

LiGuo Wang*, John Ringwood

Centre for Ocean Energy Research, Maynooth University.
*Corresponding author email: Liguo.Wang@mu.ie

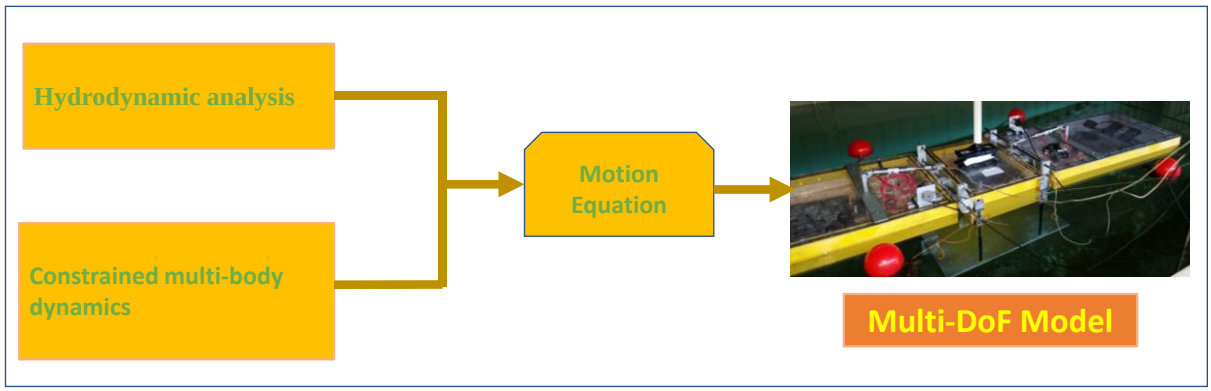
Abstract:

In this study, we extend a mathematical model of a multiple-body wave energy converter consisting of three hinged barges and a damping plate, which is an important step to provide a basis for model-based control design. To model the array of multiple bodies linked by hinges or by rigid connection, the methodology treats all bodies as free-response units in a hydrodynamic model, then incorporates all the constraints representing the hinge connection and the rigid connection in a formulation of motion equation. The hydrodynamic problem is solved based on linear potential flow theory, and the constraints are corresponding to the hinge connection between barges and to the rigid connection between central barge and the damping plate. The mathematical model allows the analysis of wave induced response of the central barge in surge, heave and pitch modes, also allows the computation of rotation of fore barge and aft barge relative to the central barge. The performance of a hinge-barge wave energy converter in terms of power production is investigated using this model.

Keywords:

Wave energy converter; Hinged barge; Multiple body; Damping plate

Concept Illustration:



Wave energy resource of the Northeast Atlantic

Jelena Janjic[1,*], Sarah Gallagher[2], Emily Gleeson[2], and Frederic Dias[1]

[1]School of Mathematics and Statistics, University College Dublin (UCD).
[2]Met Éireann – The Irish Meteorological Service.
*Corresponding author email: jelena.janjic@ucdconnect.ie

Abstract:

Our group in UCD studies the wave energy resource of the Northeast Atlantic using a numerical wave model WAVEWATCH III. With the help of meteorologists from Met Éireann, Sarah Gallagher and Emily Gleeson, we obtained the high-resolution winds to feed our model and produce high-quality results. We looked at the past wave energy resource of the Northeast Atlantic and the influence of climate change on the wave extraction processes by the end of the 21st Century [1,2]. We looked in depth of different aspect of the wave energy in three locations near important marine testing sites (The Atlantic Marine Energy Test site, the European Marine Energy Centre, and the French marine test facility SEM-REV) [3]. Our newest study looks at extreme waves, defined as waves of larger than expected amplitude, in the waters off the west coast of Ireland. These extreme events can manifest as transitory waves of great height, or as prolonged sea states of great energy. The force of waves during these events can pose a threat to the effective and safe management of offshore operations. Though both manifestations of extreme waves bring more energy, Wave Energy Converters (WECs) are very sensitive to these situations, especially if they are deployed in unsheltered locations. An excess of such energy could be disastrous to a WEC, leading to fatal structural damage, component malfunction, mooring system failure and more. Therefore, the knowledge of extreme sea states or individual waves is essential for WEC design, deployment and operation [4].

Keywords:

Wave energy resource; Northeast Atlantic; WAVEWATCH III; Wave Energy Converters.

Concept Illustration:

References:

[1] Janjic, J., Gallagher, S., and Dias, F., 2017. "The Future Northeast Atlantic Wave Energy Potential under Climate Change". In Proceedings of the 27th International Ocean and Polar Engineering Conference ISOPE, San Francisco, CA, USA, June 25-30, 2017, pp. 199–206. ISBN 978-1-880653-97-5; ISSN 1098-6189.

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[3] Janjic, J., Gallagher, S., Gleeson, E., and Dias, F., 2018. "Wave energy extraction by the end of the century: Impact of the North Atlantic Oscillation". In Proceedings of the ASME 2018 37th International Conference on Ocean, Offshore and Arctic Engineering (OMAE2018) in Madrid, Spain from June 17-22, 2018 (accepted).

[4] Janjic, J., Gallagher, S., and Dias, F., 2017. "Case study of the winter 2013/2014 extreme wave events off the west coast of Ireland". Advances in Science and Research, Special Issue: 17th EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017 (in review).

Influence of wave-current interaction on tidal current velocity field

Aleksandar Jakovljevic[1], Martin Dumont[2], Frédéric Dias[1, *]

[1] *School of Mathematics and Statistics, University College Dublin, Ireland.*
[2] *Bureau Veritas, Triangle de l'Arche, Paris, France.*
*Corresponding author email: aleksandar.jakovljevic@ucdconnect.ie

Abstract:

We consider the influence of Wave-Current Interactions (WCI) on the tidal energy resource through changes in the velocity field of tidal currents [1]. In order to investigate this, we have run three models: SWAN (stand-alone), ROMS (stand-alone) and COAWST (two-way coupled ROMS and SWAN model). The research area of our studies is Alderney Race, France, an area with strong currents, which has a strong potential for tidal turbine deployment. The time period used for the simulations was March 2008, when a strong storm hit the Alderney Race area and produced significant wave heights (Hs) of up to 7 m and a Stokes drift near the surface close to 0.3 m/s. Furthermore, in order to see the extent of the influence of large waves on current parameters, two virtual storms with larger waves have been generated by magnifying the wave energy spectrum and changing the frequency of the spectrum of the real storm in March 2008. The 3D and the barotropic velocity field were analysed in order to see if the WCI in the waters of Alderney Race during storm conditions can cause a significant increase or decrease of the current speed and through which mechanisms [2]. This study also investigates the Turbulent Kinetic Energy (TKE) in order to portray the turbulent conditions in the area of interest which are important for resource characterisation and device design.

Keywords:

Tidal current turbines, Storm conditions, Alderney Race, Wave-current interactions

Concept Illustration:

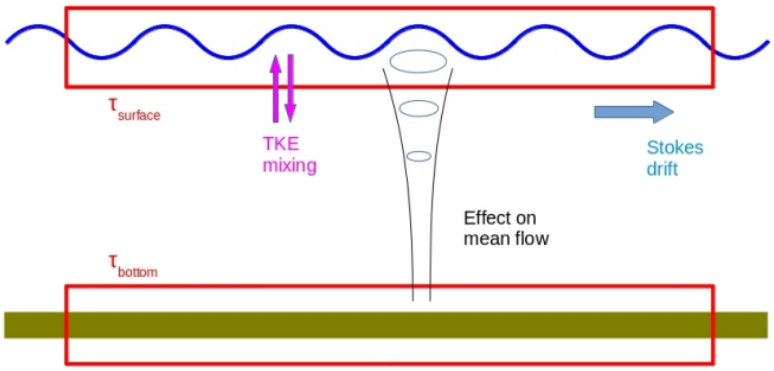


Fig. 1. Wave-current interaction. The upper red rectangle indicates changes in the surface boundary layer, the lower rectangle indicates the effects in the bottom boundary layer. In between, there are effects on the mean flow.

References:

[1] Jakovljevic, A., Paboeuf, S., and Dias, F., 2017. "Impact of wave-current interactions on tidal current turbine performance in storm conditions". In Proceedings of the 12th European Wave and Tidal Energy Conference EWTEC, 27th Aug – 1st Sept 2017, Cork, Ireland, pp. 774:1–11. ISSN 2309-1983.

[2] Jakovljevic, A., Dumont, M., and Dias, F., 2018. "Effect of wave-current interaction on strong tidal current". In Proceedings of the ASME 2018 37th International Conference on Ocean, Offshore and Arctic Engineering (OMAE2018) in Madrid, Spain from June 17-22, 2018 (accepted).

Faster linear potential flow simulations with Nemoh

Matthieu Ancellin* and Frederic Dias

School of Mathematics and Statistics, University College Dublin
*Corresponding author email: matthieu.ancellin@ucd.ie

Abstract:

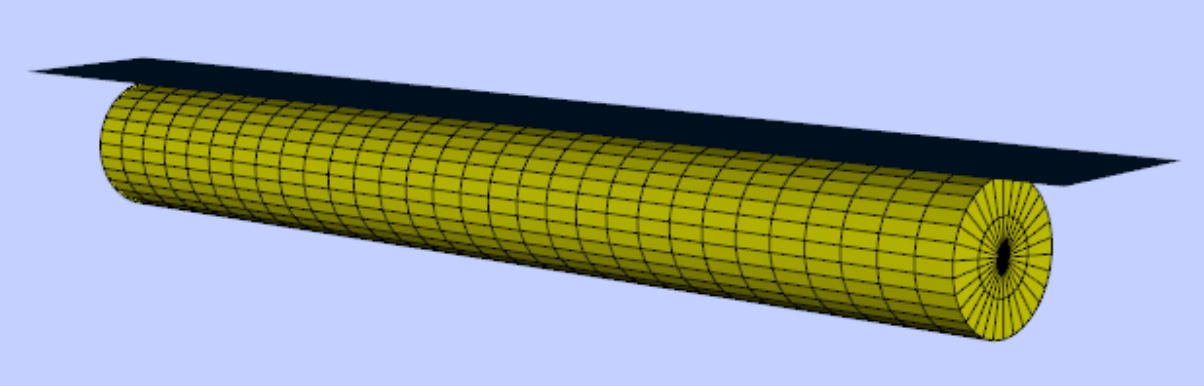
The interaction of floating bodies with water waves can be simulated with the linear potential flow theory, discretized with the Boundary Elements Method (BEM). Although this approach is already one of the fastest methods available for this kind of problems, it can still be too expensive for some cases such as the simulation of large farms of Wave Energy Converters (WECs).

Using as a basis the open source BEM solver Nemoh [1], we looked for some optimizations of the code to speed up the computations. Various algorithmic improvements have been implemented in a development version of the code (https://github.com/mancellin/capytaine). The symmetries of the domain offer some possibilities to mathematically reduce the complexity of the problem [2]. Finally, the use of iterative methods such as the method of reflections [3] is being investigated for the simulation of large sparse arrays of WECs.

Keywords:

Linear potential flow, Boundary Elements Method, Wave Energy Converter

Concept Illustration:



References:

[1] Babarit and Delhommeau, *Theoretical and numerical aspects of the open source BEM solver NEMOH*, Proceedings of the 11th European Wave and Tidal Energy Conference (EWTEC 2015).
[2] Ancellin and Dias, *Using the floating body symmetries to speed up the numerical computation of hydrodynamics coefficients with Nemoh*, Proceedings of the 37th International Conference on Ocean, Offshore and Arctic Engineering (OMAE 2018), to appear.
[3] Laurent, Legendre and Salomon, *On the method of reflections*, https://hal.archives-ouvertes.fr/hal-01439871/

The Wave-Activated Sensor Power Buoy (WASP)

Thomas Kelly[1,*], Thomas Dooley [1], Brendan Walsh[1]

[1] *Centre for Renewable Energy at Dundalk IT (CREDIT), Co. Louth, Ireland*
*Corresponding author email: thomas.kelly@dkit.ie

Abstract:

In order to assess the viability of locations for proposed wave energy farms, and design optimal wave energy converters and wave farm layouts, wave farm developers will need knowledge of local wave regimes. Furthermore, with the increasing occurrence of extreme weather events, coupled with rising sea-levels as a results of climate change, local authorities will also require knowledge of wave regimes in order to design effective coastal protection measures. Wave conditions at a location may be measured using existing buoys such as the range of wave rider buoys made by Datawell BV. However, such devices are expensive, and the aim of the work described herein is to develop a low-cost, self-powering buoy to measure wave conditions to meet the needs of both developers and local authorities. The proposed device, christened the Wave-activated Sensor Power Buoy (WASP) will comprise a floating body with a centre moonpool. The relative motion of the water level in the moonpool to the buoy will be used to drive a bidirectional turbine in the manner of an oscillating water column, which will be used in conjunction with a generator to recharge an on-board battery pack. The sea-state can be estimated from measurements of the variation in pressure within the air above the water column for a suitably calibrated buoy. Mathematical techniques to accurately estimate sea-sates including inverse transfer functions, neural networks and numerical estimators, each of which is currently the subject of further investigation. Calibration of the WASP will take place in a suitable test facility such as SmartBay. Proof of concept testing in SmartBay using an off-the-shelf buoy is scheduled for late 2018.

In the accompanying presentation, results from the tank testing of a scale model of the WASP and estimates of wave spectra made from measurements taken from the model, are presented, and discussed.

Keywords:

Sensor Buoy; Wave Measurement; Coastal Protection; Wave Energy; Resource Assessment

Concept Illustration:

Figure 2. Scale Model of the WASP

Results from the LEANWIND Project (Logistical Efficiencies And Naval architecture for Wind Installations with Novel Developments)

Fiona Devoy McAuliffe[1*], Katie Lynch[1], Jimmy Murphy[1]

[1] *Marine Renewable Energy, University College Cork.*

*Corresponding author email: f.devoymcauliffe@ucc.ie

Abstract:

Led by University College Cork, the LEANWIND project comprised 31 partners (52% from industry) and received €15million in funding. Focusing on current and future industry challenges, the project (2013-2017) addressed the logistics of deploying, installing and operating wind turbines ranging from 5-10MW in transitional water depths (40-60m) to deep sites (>60m) using fixed or floating substructures. The main objective was to provide cost reductions across the offshore wind farm lifecycle and supply chain through the application of lean principles and the development of state of the art technologies and tools.

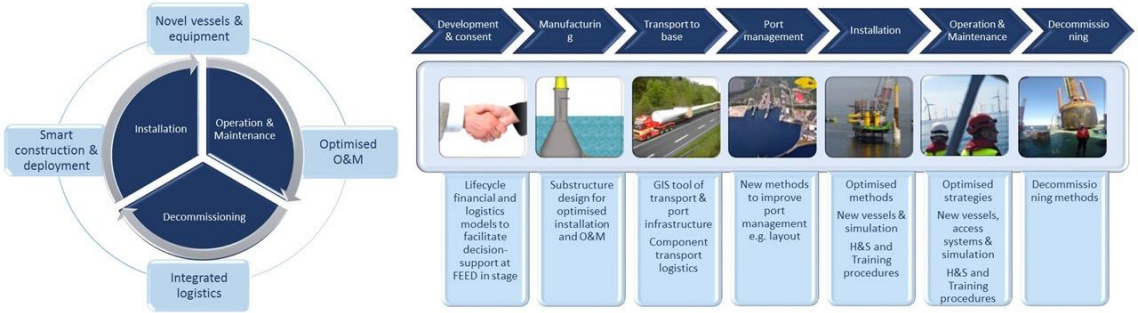
LEANWIND produced a large range of novel solutions including adaptations for fixed substructures and a new floating concept, which streamline deployment to minimise costs and installation time; purpose-built installation and servicing vessel concepts to address the increasing market demand; a range of decision-support models and recommendations for optimised O&M strategies; a remote presence device and condition monitoring software to reduce the need for human intervention and maintenance costs; and vessel simulation technologies to assess designs and mitigate the risks associated with new installation and O&M strategies. A set of logistics tools and a full lifecycle financial cost model were developed to assess project innovations and demonstrate their potential cost savings. For example, when compared to the current industry standard, the novel LEANWIND fixed foundations and floating platform achieved LCOE reductions ranging from 13-18%.

At every stage, LEANWIND sought to ensure the industry relevance of research, assessing the technical and non-technical impact of results to facilitate market uptake. Many project results are already being used by industry and a number are expected to become commercial products including the simulator tools, vessel concepts and remote presence device. Therefore, LEANWIND will help industry achieve and maintain their cost-reduction aspirations in the larger farms and more extreme sites planned in the future.

Keywords:

Offshore Wind; Installation; Operation and Maintenance; Logistics; Financial Assessment

Concept Illustration:



Direct interconnection of marine renewable energy (MRE) devices

Cathal O'Donnell [*], Joseph Coleman , Daniel Toal

CRIS - Centre for Robotics & Intelligent Systems, University of Limerick.
* Author email: Cathal.W.ODonnell@ul.ie

Abstract:

The goal of direct interconnection of Marine Renewable Energy (MRE) devices is to increase reliability and reduce costs for offshore power systems by reducing the amount of high failure rate components placed offshore. This is achieved by removing the back to back converter from each generation source in favour of a single, directly connected, stiff, frequency wild bus. This requires each unit to be spun up and synchronized with the bus before being connected. Once the device is connected the overall farm frequency, which is optimised to prevailing farm conditions, dictates the operating frequency of the unit.

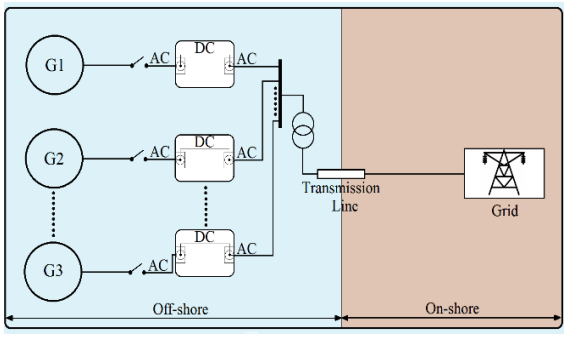
This single, non-grid compliant bus is then transmitted back to shore where it is then placed through back to back converters for connection to the grid. By placing the back to back converters on-shore there are reductions in repair times and costs associated with maintaining the power electronics. There is also greater scope for building in redundancy on-shore as space and civil engineering challenges associated with placing this at each generation unit are reduced or even removed completely leading to cheaper more reliable offshore power.

The direct interconnection technique is also a prime candidate approach for integrating subsea High Voltage Direct Current (HVDC) power transmission to shore. As the offshore bus is converted to DC for transmission it is hoped that power quality of the overall farm will be increased compared to traditionally connected farms. Circulating currents within the farm and harmonics on the frequency bus are isolated from the grid making the farm appear to the grid as a single large energy source rather than numerous small generators providing varying levels of power.

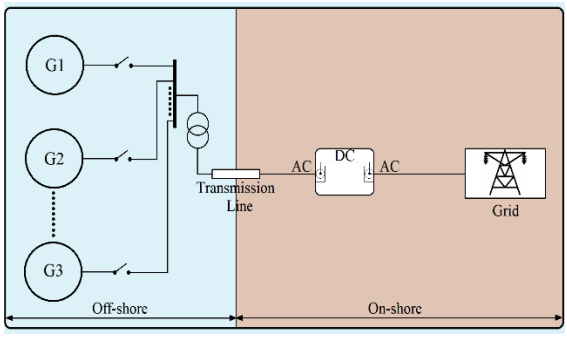
Keywords:

Direct Interconnection, Marine Renewables, MRE Devices, Marine Power Transmission, Marine Energy Reliability

Concept Illustration:



Indirect (Standard) Interconnection



Direct Interconnection

Observation & Operations

Mace head: climate and air pollution research facility

Jurgita Ovadnevaite*, Darius Ceburnis, Jana Preissler, Damien Martin, and Colin O'Dowd

School of Physics & Centre for Climate and Air Pollution Studies, Ryan Institute, National University of Ireland Galway.

*Corresponding author email: jurgita.ovadnevaite@nuigalway.ie

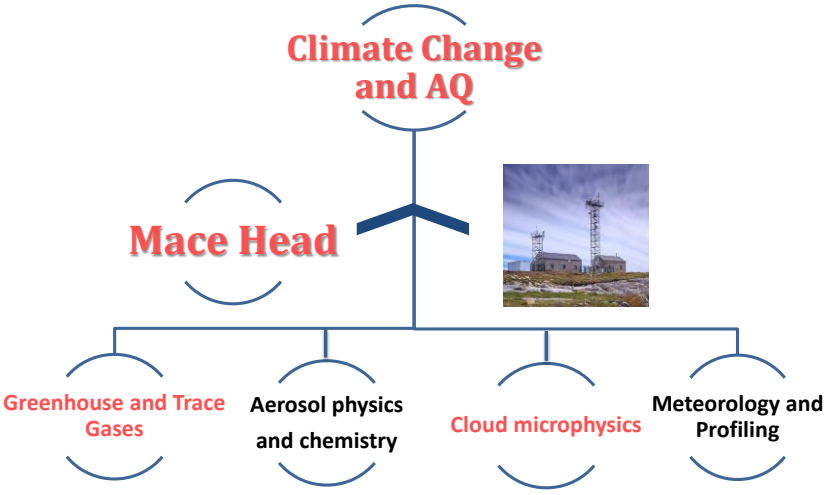
Abstract:

The Mace Head atmospheric research station, located on the west coast of Ireland (53° 19.5' N, 9° 54' W), is one of the most important facilities for atmospheric composition observations both locally and globally. Mace Head is a member of a number of global, regional and national networks, contributing data and analysis to a wide range of archives. In particular, Mace Head is a World Meteorological Organisation (WMO) Global Atmosphere Watch (GAW) atmospheric composition and climate research station and a European Monitoring and Evaluation Programme (EMEP) supersite aimed at solving transboundary air pollution problems. Mace Head is operated by the National University of Ireland Galway's School of Physics and the University's Ryan Institute Centre for Climate & Air Pollution studies. C-CAPS is at the forefront of driving an agenda of 'common issues' across Air Pollution and Climate Change problems in return for win-win solutions. At Mace Head, this strategy is implemented in an operational system StreamAIR, integrating highly-sophisticated research instruments, atmospheric models, and real-time Air Pollution and Essential Climate Variable data. Real time data include all main greenhouse gases (CO_2, CH_4, N_2O, Halocarbons, ozone and water vapour) as well as the cooling agents (aerosols) and also cover aerosol physical (SMPS's, APS, CPC), chemical (filters, Aerosol Mass Spectrometers), water uptake (CCNC, HTDMA), and radiative effects (nephelometers, aethalometers) as well as impacts on cloud microphysics (ceilometers, cloud radar), encapsulating both the direct and indirect aerosol climate effects. Basic meteorological products include wind speed, direction, precipitation, visibility, and UV radiation while a microwave radiometer (HATPRO) is deployed to provide vertical meteorological profiles and the Doppler LIDAR is used for the horizontal and vertical wind profiles. In summary, the scientific programme at Mace Head covers the research into sources, transformation, and sinks of atmospheric constituents affecting air pollution, climate change and ozone destruction.

Keywords:

Mace Head; Climate change; Air pollution; Cloud microphysics

Concept Illustration:



Air pollution sources in Ireland

Chunshui Lin, Jurgita Ovadnevaite, Darius Ceburnis, Colin O'Dowd [*]

[1]*School of Physics & Centre for Climate and Air Pollution Studies, Ryan Institute, National University of Ireland Galway.*

*Corresponding author email: colin.odowd@nuigalway.ie

Abstract:

We have shown that under polluted conditions, carbonaceous (organic matter and black carbon) aerosol prevails over historic inorganic species like sulphate and nitrate, contributing from 60% to 90% to the PM1 mass. Carbonaceous compounds are known to be diverse in source and nature resulting in more complex challenges in terms of measuring its contribution to PM in regulatory Air Quality networks, and in determining of their main sources. Consequently, effective pollution control strategies cannot be developed without sophisticated source apportionment of organic matter. AEROSOURCE project was initiated and deployed to overcome this deficit through the enhancement of the national transboundary air pollution network with 3 sophisticated aerosol mass spectrometer nodes delivering real-time carbonaceous PM data and enabling the application of subsequent source apportionment – in effect a pilot next-generation AQ monitoring network. The success and power of the next-gen network became evident after 3 months of operations when it provided real-time composition during unexpected and surprisingly frequent, extreme pollution events in south Dublin. These events, occurring during cold, stagnant conditions led to PM1 mass concentrations reaching 300 μg m^{-3}, of which 70% was from organics, and approximately 90% when considering carbonaceous PM as a whole. Moreover, it was shown that 52-70% of the PM_1 mass arose from <13% of the households that consumed peat (9-12%) and wood (<1%) for heating purposes. Similar results were observed for other locations, where peat emissions dominated the aerosol composition during winter months. The newly developed AQ network, coupled with sophisticated fingerprinting techniques, can better inform emission reductions policies via ensuring that the most appropriate air pollution sources are targeted. Finally, our results suggest that even modest increase in the consumption of solid fuels will have a disproportionate impact on the frequency of extreme pollution events.

Keywords:

Aerosols; source apportionment; solid fuels; Air pollution;

Efforts towards remote sensing of wind, clouds, and volcanic ash

Praveen Pandey[1, *], Thaize Baroni[1], Jana Preissler[1], Colin O'Dowd[1]

[1]*School of Physics & Centre for Climate and Air Pollution Studies, Ryan Institute, National University of Ireland Galway.*

*Corresponding author email: praveen.pandey@nuigalway.ie

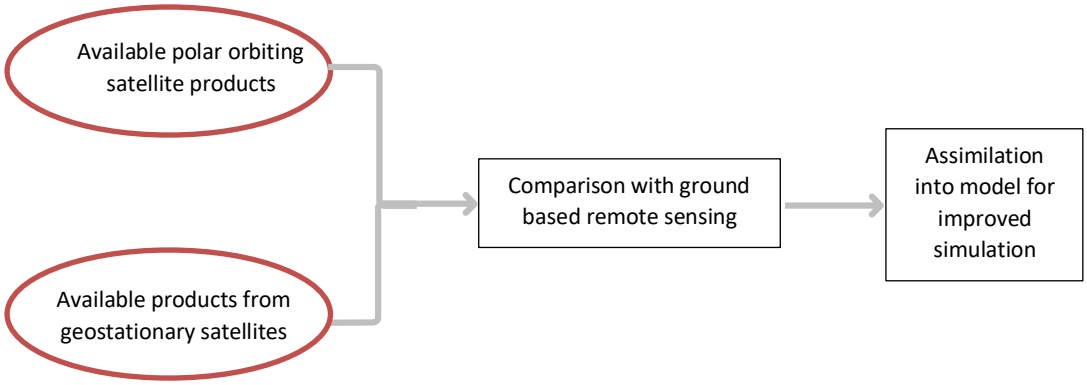
Abstract:

Remote sensing techniques play a vital role in the understanding of the atmosphere. A continuous monitoring and detection of various atmospheric parameters are possible using satellite-based remote sensing approach. This study shows the aspect of using various satellites, polar-orbiting and geostationary, for studying wind, clouds and volcanic ash. Initial efforts are put to understand the available products that can thereafter be used with ground-based remote sensing instruments for validating the model-based simulation results. The focus is over Ireland and its surrounding. Sentinel 1 that has a Synthetic Aperture Radar (SAR) -level 2 ocean product- is used to monitor wind parameters. The backscatter coefficients from the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) is put to use due to its usability in the detection of volcanic ash. The Spinning Enhanced and Visible Infra-red Imager (SEVIRI), which is a geostationary satellite that has a 12-channel imager, will also be used for volcanic ash detection. SEVIRI will also be used for the detection of the cloud physical properties.

Keywords:

Satellite remote sensing, clouds, wind

Concept Illustration:



A review of current high bandwidth maritime communication technologies

Luke Robinson[1,2,*], Thomas Newe[1], John Burke[2], Gerard Dooly[1], Joseph Coleman[1] and Daniel Toal[1]

[1] *CRIS – Centre for Robotics and Intelligent Systems, University of Limerick, Limerick, Ireland.*
[2] *CIL – Commissioners of Irish Lights, Dun Laoghaire, Co. Dublin.*
*Corresponding author email: luke.robinson@ul.ie

Abstract:

This presentation gives a review of high bandwidth maritime communication technologies. High bandwidth maritime communication technologies can broadly be divided into two main areas – commercially available systems and research based systems. A detailed review of the current technology in each area is undertaken. Several commercially available systems use satellite communications technologies. A number of these systems are reviewed and bandwidth, latency and cost comparisons are made. Point to point links, another commercially available technology, is also discussed and similar criteria are used for their comparison, including range and bandwidth.

As well as commercially available technologies, several novel methods of maritime communications are reviewed that are current research topics in the marine communications field. Many of these show interesting possibilities, such as evaporation ducting and tropospheric scatter. The main mode of operation of each technology is discussed, and the possible performance for each in terms of range and bandwidth is compared. Issues and challenges that need to be overcome for the technologies to be viable in the marine environment are also discussed.

The aim of this presentation is to provide the reader with a deeper knowledge of what technologies are currently available to facilitate high bandwidth maritime communications, and how they compare under a number of key performance metrics. In addition, an overview of new technologies that are currently under research is provided, and the potential benefits these technologies could bring to maritime communications and the technological issues in doing this is discussed.

Keywords:

Maritime communications; Satellite communications; Troposcatter; Evaporation ducts

FPGA based BITW security solution for remote communication

Muzaffar Rao*, Thomas Newe, Edin Omerdic, Daniel Toal

Centre for Robotics and Intelligent Systems (CRIS)
Department of Electronic and Computer Engineering
University of Limerick, Limerick, Ireland
*Corresponding author email: muzaffar.rao@ul.ie

Abstract:

The development of marine communications and remote inspection capabilities are necessary to maximise operational time for offshore marine and renewable energy infrastructure, with a view to economic energy production and minimising risks while protecting the environment. High bandwidth real-time marine communications for control purposes is a difficult and expensive problem to address and, in many cases, when security is required then military grade services need to be utilised. These services are expensive and beyond the reach and cost benefits for most offshore marine and renewable energy infrastructures. This research activity is about development of secure core for marine communication. The targeted Marine application consists of a control station and ROV. In this application the ROV is controlled and monitored through the Internet using a remote-control station. To secure the communication between the control station and the ROV an FPGA based BITW (Bump in The Wire) architecture is introduced. A BITW architecture is an implementation approach that places an information security device/mechanism outside of the system that is to be protected, thereby facilitating secure communications without existing system hardware modifications. The BITW security solution proposed here is suitable to use in applications where existing network interface devices do not support security checks or services. Existing solutions to marine communications do not address the security issues. The BITW security solution introduced the simplest and cost-effective solution to secure the high bandwidth real time marine communication. This solution is cost effective because the secure core proposed can be inserted into the existing system using a BITW technique.

Keywords:

FPGA, BITW, communication security

Concept Illustration:

(a) Insecure Communication between control station and ROV

(b) Secure Communication between control station and ROV using BITW technology

Figure 1. BITW security solution

StreamAIR operational forecast modelling

Clare Noone*, Rong-Ming Hu, Liz Coleman, Tomas Grigas, Jana Preissler, Jurgita Ovadnevaite and Colin O'Dowd

School of Physics & Centre for Climate and Air Pollution Studies, Ryan Institute, National University of Ireland Galway.

*Corresponding author email: clare.noone@nuigalway.ie

Abstract:

At StreamAIR our operational forecasting models include multi-scale nested high resolution (25 km, 5 km, 1 km) meteorological forecasting, air pollution forecasting and volcanic ash forecasting. All models are evaluated in real time with in-situ measurement data at Mace Head Atmospheric Research Station. We have found the meteorological forecasts to be in good agreement with measurements at Mace Head, particularly for the wind speed and wind direction parameters.

Current ongoing studies include air pollution forecasting using the WRF-Chem model to simulate heavy organic aerosol episodes in Urban areas and meteorological forecasting using the WRF nested models to investigate and forecast Low-Level Jet events (LLJs). LLJs are local maxima in the wind speed profile, which can cause stress on wind turbines. The WRF-ash model is used to forecast volcanic ash episodes like the 2010 volcanic Icelandic eruption which caused widespread disruption to European air travel.

In summary, our operational forecasting models can be used to develop custom products for relevant industries, for example low-level jet detection for the Wind Turbine Industry and 3-D ash and turbulence forecasting for the Aviation Industry. Our forecasting products can also be applied to early warning system for extreme weather events such as snow storms and hurricanes.

Keywords:

Weather Research and Forecast (WRF) Modelling, StreamAIR Mace Head, Air pollution, Low-Level Jets

Using innovating technologies to support climate Science: A StreamAIR web app case for visualizing the WRF model output

Tomas Grigas*, Liz Coleman, Clare Noone, Rong-Ming Hu and Colin O'Dowd

School of Physics & Centre for Climate and Air Pollution Studies, Ryan Institute, National University of Ireland Galway.

*Corresponding author email: tomas.grigas@nuigalway.ie

Abstract:

By using open source web technologies, we implemented a user-friendly StreamAIR web app, which allows the users to access the 4 days WRF model output. We produce WRF model forecasts daily and our models run on a powerful HPE machine with 144 cores of Intel Xeon CPUs and 2TB of RAM.

Currently, the visualisation of StreamAIR includes the forecasts of several air quality and meteorological variables: temperature, rain precipitation and snow forecast, relative humidity, wind speed, wind direction, air quality index, NOx, SO2, PM2.5 and PM10.

We successfully developed a StreamAIR web app as a test case and "warm-up". The case shows an enormous potential to develop other custom products for relevant industries such as wind turbines (low-level jets) and aviation (3-D ash and turbulence).

Keywords:
StreamAIR, innovation, web app, nuig, c-cap

Marinised unmanned aerial systems for marine renewable energy infrastructure inspection with satellite and maritime communication systems.

Oran Dolphin-Murray[1], Prof. Daniel Toal[2], Dr. Joseph Coleman[3], Dr. Thomas Newe[4]

[1] *CRIS - Centre for Robotics & Intelligent Systems, Dept. Electronic & Computer Engineering, University of Limerick, Limerick, Ireland.*

*Corresponding author email: oran.dolphin-murray@ul.ie

Abstract:

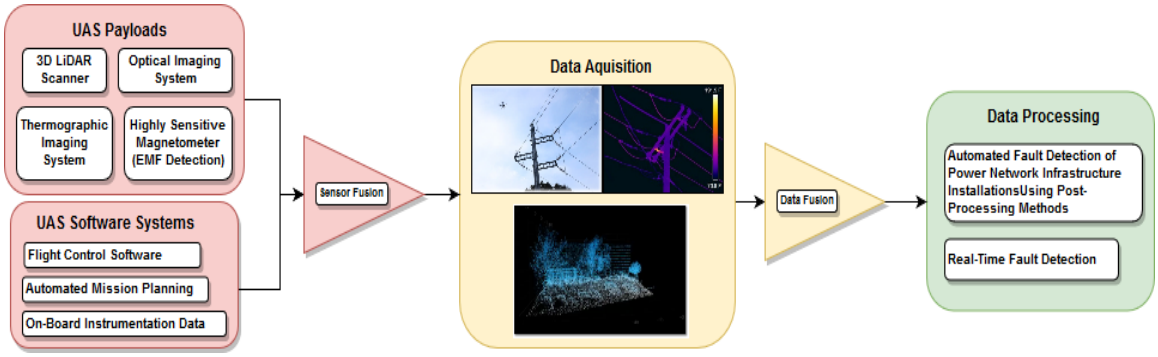
Offshore Marine Renewable Energy (MRE) installations pose significant challenges for operation, inspection and maintenance, especially more so than onshore renewable energy installations. Some of the existing barriers to MRE installations are: vastly increased cost of having human presence for monitoring / inspections / maintenance, deployment in an area of difficult natural characteristics (increased wind / waves / rain) and a reduced existing infrastructure in the vicinity of the MRE installations (remote power and communication networks). This project is intended to research and develop a long-range (20km) high endurance (2 hours of flight time) Unmanned Aerial System (UAS) capable of performing remote infrastructure inspection with the capability of detecting and reporting faults. The UAS will be able to perform its duties in the difficult environmental conditions seen in the maritime environment, along with the capability to land and take-off from a ship.

In parallel with the development of the long-range high-endurance UAS, the applications of payloads suitable for use on a UAS is to be investigated. These payloads include, but are currently not limited to, 3D LiDAR scanners, optical & thermographic imaging systems. By integrating these payloads into a single UAS platform, it is possible to build an accurate, real-time and detailed model of an MRE installation. This advanced model of an installation will pave the way for the implementation of automated fault detection with the possibility of investigating real-time fault detection. Real-time fault detection would reduce the requirement to store large amounts of data for post-processing and as a result would ensure significant cost reductions in the inspection of utility infrastructure. Due to the current state of MRE infrastructure in Ireland, the project is linked with ESB and as a result, much of the testing of the UAS capabilities will be done on the pre-existing onshore power network infrastructure.

Keywords:

Unmanned Aerial Systems; Infrastructure Inspection; Automated Fault Detection; LiDAR;

Concept Illustration:



Remote presence monitoring/control of MRE:

Infrastructure and installed robotic and sensor systems

Petar Trslic[1*], Daniel Toal[2], Edin Omerdic[3], Gerard Dooly[4]

[1] *CRIS – Centre for Robotics and Intelligent Systems, Department of Electronic and Computer Engineering, University of Limerick.*

*Corresponding author email: petar.trslic@ul.ie

Abstract:

Marine renewable energy (MRE) installations offshore will have significant challenges for operation, inspection, repair, maintenance and intervention activities beyond those for onshore renewable energy farms. They face challenges beyond those in offshore oil and gas, in scale of the individual installation, i.e. the plant is unmanned, and MRE must be located in areas of strong waves / current / wind. MRE installations must rely more on remote monitoring and control with limited human intervention in the field to achieve long-term commercial viability.

The main goal of the project is developing offshore modular garaging system for an inspection class remotely operated vehicle (ROV), which will incorporate smart tether management system (STMS). Purchase of the essential hardware, both electrical and mechanical, for the small scale, dry test rig has been conducted and small-scale rig has been developed during the year 2017. Having tested all key components and concepts of the system on the bench, we proceeded to design a full-scale STMS and this is now in fabrication. Speed and position controller of the STMS has been modelled and bench tested on a microcontroller. The precise tether feed rate speed and position will assist further development of the automatic tether management system based on ROV position relative to the garage.

Keywords:

Marine Renewable Energy, Smart Tether Management System, Long term ROV deployment

Detection of wind profiles on the Irish west coast

Jana Preissler[1, *], Minttu Tuononen[2], Yang Shu[3], Colin O'Dowd[1]

[1] *Centre for Climate and Air Pollution Studies (C-CAPS), School of Physics, National University of Ireland, Galway.*
[2] *Finnish Meteorological Institute, Helsinki; Vaisala Oyj, Vantaa; and Department of Physics, University of Helsinki, Helsinki, Finland.*
[3] *School of Science and Engineering, Reykjavik University; and Icelandic Meteorological Office, Reykjavik, Iceland.*
*Corresponding author email: jana.preissler@nuigalway.ie

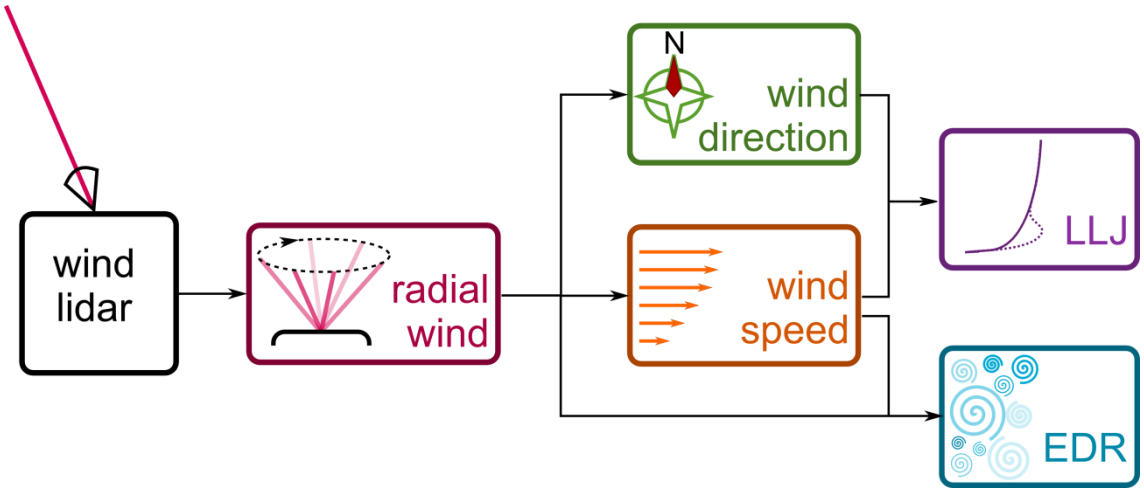
Abstract:

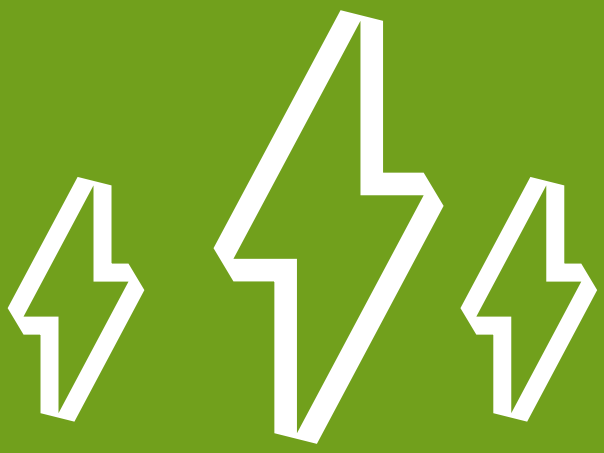
Horizontal wind speed and direction at different altitudes are crucial factors in planning and implementing wind farms, both on land, and off-shore. We use Doppler wind lidars to detect radial wind, from which vertical profiles of horizontal wind speed and direction are derived. Further products are low level jets (LLJs), and eddy dissipation rate (EDR). LLJs are local maxima in the wind speed profile. Those spikes in horizontal wind speed can cause strong wind shear in lower altitudes of the atmosphere, which might cause stress on wind turbines. Another source of stress on wind turbines is atmospheric turbulence. With wind lidar data we can calculate EDR, which is a measure for atmospheric turbulence. It quantifies the rate at which energy dissipates in the atmosphere. Two Doppler wind lidars are operated in Ireland, one at Dublin airport and one at Mace Head, Co. Galway. We focus here on measurements from the coastal site Mace Head, representing the crossing point of marine and terrestrial conditions.

Keywords:

wind profiles, low level jet detection, turbulence, coastal atmosphere, atmospheric boundary layer

Concept Illustration:





Energy Management

A Framework and Case Study on Wind Turbine Fault Prognosis through SCADA data

Kevin Leahy [1,2,*], Colm Gallagher [1,2], Peter O'Donovan[1], Ken Bruton[2,3], Dominic T.J. O'Sullivan[1,2]

[1] *School of Engineering, University College Cork, Ireland*
[2] *Science Foundation Ireland MaREI Centre, Environmental Research Institute, University College Cork, Ireland*
[3] *Department of Mechanical, Biomedical and Manufacturing Engineering, Cork Institute of Technology, Ireland*

*Corresponding author email: kevin.leahy@umail.ucc.ie

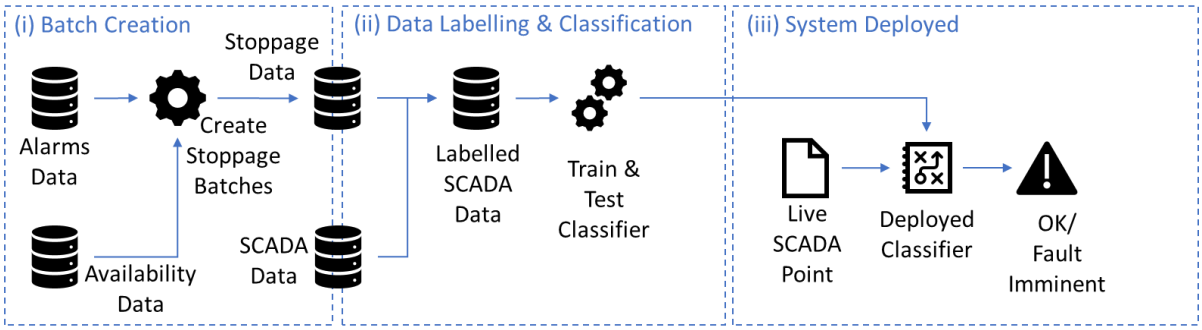
Abstract:

Using 10-minute wind turbine supervisory control and data acquisition (SCADA) data to diagnose or predict faults can be an attractive way of gaining the benefits of predictive maintenance without needing to invest in extra hardware. Classification methods have been shown to be an effective tool to enable this. In order to use these methods effectively, the historical data must be accurately labelled with the periods and reasons for fault-related downtime. Maintenance logs can be used to achieve this, but the unstructured nature of these mean it can be a highly tedious and time-consuming process. Labelling data by way of the historical alarm system logs can also work, but there are significant issues with the volume of alarms generated and false alarms which complicate these efforts. This work presents a prescribed framework for (i) automatically identifying periods of faulty operation using rules applied to the turbine alarm system, (ii) using this information to perform classification which avoids some of the common pitfalls observed in literature and (iii) generating alerts based on a sliding window metric to evaluate the performance of the system in a real-world scenario. The framework was applied to a dataset representing a wind farm in the South East of Ireland. Precision and recall scores of .16 and .49, respectively, are achieved. Although these raw classification scores are quite low, the sliding window metric compensated for this and showed that 71% of faults can be predicted with an average of 30 hours' notice, with false alarms active for 122 hours of the year. The metric parameters can be adjusted to drastically reduce the false alarm rate at the expense of missing some faults.

Keywords:

wind turbines; scada data; fault prognostics; machine learning; random forests

Concept Illustration:



A machine learning supported solution for measurement and verification 2.0 in industrial buildings

Colm V. Gallagher[a,b,*], Kevin Leahy[a,b], Peter O'Donovan[a,b], Ken Bruton[b,c] Dominic T.J. O'Sullivan[a,b]

[a] *Intelligent Efficiency Research Group, School of Engineering, University College Cork, Cork, Ireland*
[b] *MaREI Centre, Environmental Research Institute, University College Cork, Cork, Ireland*
[c] *Department of Mechanical, Biomedical and Manufacturing Engineering, Cork Institute of Technology, Cork, Ireland*

*Corresponding author email: c.v.gallagher@umail.ucc.ie

Abstract:

The European Union's Energy Efficiency Directive is placing an increased focus on the measurement and verification (M&V) of demand side energy savings. The primary objective of M&V is to quantify the performance improvement achieved with minimal uncertainty, thus maximising confidence in the energy conservation measure (ECM). This is only achievable if an accurate, consistent and transparent energy model of the building, and the equipment within it, can be constructed. This energy model is constructed pre-ECM. Most often this is a regression model and it is deployed following the implementation of an ECM to normalise post-ECM consumption to pre-ECM conditions. M&V is currently undergoing a transition to practices that employ automated advanced analytics to verify performance, referred to as M&V 2.0. This offers the opportunity to effectively manage the transition from short-term M&V to long-term monitoring and targeting, hence ensuring savings persist beyond the traditional M&V lifetime.

A challenge is faced in the complex energy systems in industrial buildings that can make M&V a resource intensive task as many variables impact on performance. An automated software solution that utilises advanced machine learning techniques to simulate the energy system and evaluate performance in real-time has been developed. A performance deviation detection system is incorporated to enable exception reporting, thus ensuring early identification of performance degradation. The benefits of the proposed M&V 2.0 approach are demonstrated using case studies in Irish manufacturing facilities. Accurate M&V provides a detailed insight into the performance of energy systems and can be used to inform both design and operations in buildings.

Keywords:

Performance verification, M&V 2.0, energy efficiency, machine learning, data-driven energy modelling, industrial buildings

Effect of large scale and lifetime on offshore wind LCOE in Ireland

Siddharth Joshi[1], Eamon McKeogh[1,2], Van Nguyen Dinh[2,*]

[1] *School of Engineering, University College Cork, Ireland*
[2] *MaREI Centre for Marine and Renewable Energy, ERI, University College Cork, Ireland*

*Corresponding author email: nguyen.dinh@ucc.ie

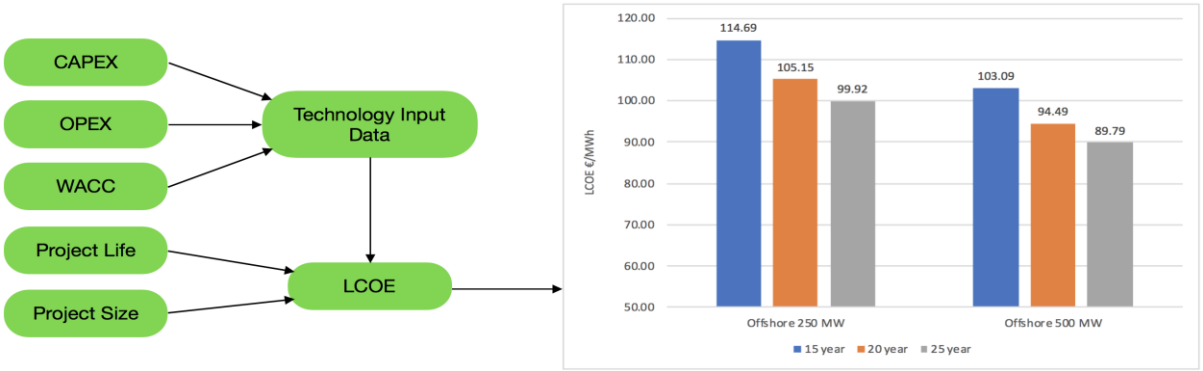
Abstract:

Offshore wind energy possesses a number of properties enabling significant cost reduction such as higher wind speed and full-load hours per year and longer lifetimes. The total potential amount of offshore wind development in Ireland is 34.8 GW – 39 GW without likely significant adverse effects on the environment [1]. The reliance on natural gas for around a half of the country's electricity generation while the UK currently supplies 40-50% of Ireland's gas demand makes Ireland energy security an issue. The development of offshore wind is therefore inevitable. The levelised cost of energy (LCOE) of offshore wind in Ireland is investigated in this study [2]. In the analysis, CAPEX expenditure is assumed to be spent in first year only and there is no staggered schedule. Variable CAPEX and OPEX have not been used for simplicity [2]. The actual generation of the plant is based on load factor for the plant and not on a simulated schedule, weighted average cost of capital 8.75%. Two deployment scales of 250MW and 500MW and three lifetimes of 15 years, 20 years and 25 years are considered in the analysis. All the values for the calculation are based on 2015 prices. The LCOE of the 250MW scale are €114.69/MWh, €105.15/MWh, and €99.92/MWh respectively. Those of 500MW scale are €103.09/MWh, €94.49/MWh, and €89.79/MWh respectively. Both deployment scale and project lifetime are seen to have a significant effect on reducing offshore wind LCOE that are able to bring that cost to less than €90/MWh [3]. Further analysis needs to be done to incorporate curtailment, and capacity limitations posed by electricity transmission grid in Ireland.

Keywords:

Offshore wind; LCOE; Large scale deployment; Lifetime; Ireland

Concept Illustration:



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[2] S. Joshi, "Opportunity identification of new energy market strategies for Ireland," MEngSc. Preliminary Report, University College Cork, 2018.
[3] S. Joshi, E. McKeogh and V. N. Dinh, "Market opportunities for offshore wind energy: a case study of Ireland" (Accepted) in The Fifth International Conference on Offshore Energy and Storage, Ningbo, China, 2018.

Local energy storage in offshore wind farms in Ireland

Vaishnav Pushpoth[1], Eamon McKeogh[1,2], Van Nguyen Dinh[2,*]

[1] *School of Engineering, University College Cork, Ireland*
[2] *MaREI Centre for Marine and Renewable Energy, ERI, University College Cork, Ireland*

*Corresponding author email: nguyen.dinh@ucc.ie

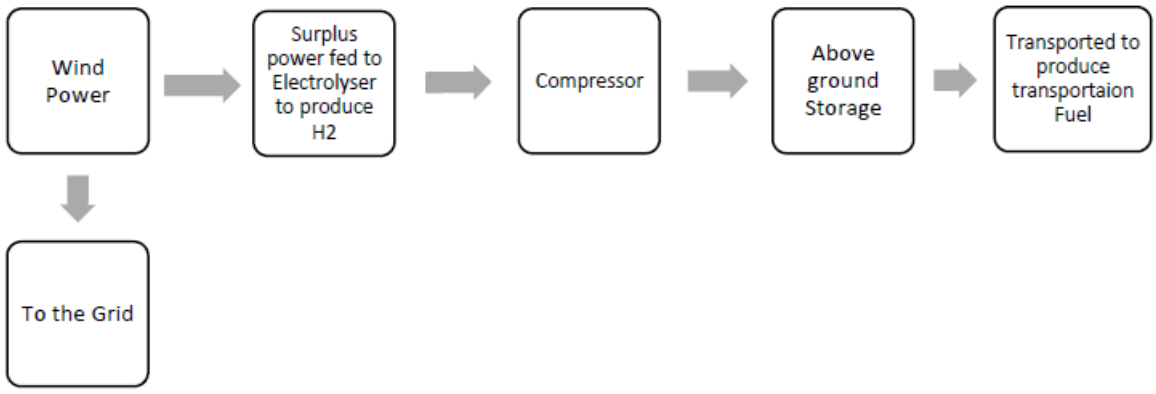
Abstract:

The deployment of wind energy is constrained by wind intermittency that lessens the value of wind-generated electricity to a significant extent [1]. As wind is an intermittent source of energy and power generation during periods of low electricity demand can be expected. This leads to curtailment of wind, which is detrimental to both the wind generators and the utility. Energy storage is being looked at in this study [2]. Several energy storage technologies including pumped storage systems (PSS), compressed air energy storage systems (CAES) and hydrogen have been reviewed. Offshore windfarms are always of some tens or hundreds of MWs of installed power. The storage power plants required must exhibit a charging/discharging ability approximately equal to the windfarm's nominal power and a total energy capacity, which can be between 1% and 3% of the total annual electricity production of the windfarm. This means that for an offshore windfarm with a nominal power of 100 MW and a capacity factor of 40%, a storage capacity of about 3,500 MWh (1% of annual production) is required. This, in turn, implies a large CAES or a PSS. The development of a local storage model for offshore wind farm by using the curtailed wind energy for hydrogen production is therefore proposed in this study [2,3]. The power production data of an existing wind farm (Irish Arklow Bank Phase 1) have been collected and scaled up and the curtailed wind is being modelled [2]. The model also looks at the use of hydrogen to produce renewable gaseous fuels for transportation. A cost-benefit model will be finally developed.

Keywords:

Offshore wind; Energy storage; Hydrogen; Renewable fuels for transportation

Concept Illustration:



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Coastal & Marine Systems

Cetaceans in offshore waters: combining data from multiple sources to enhance our understanding of cetacean distribution in Irish waters

Ailbhe S. Kavanagh[1*], William Hunt[1], Mark Jessopp[2,1]

[1] *Marine Ecology, Coastal and Marine Systems, MaREI Centre, University College Cork*
[2] *School of Biological, Earth and Environmental Sciences, Environmental Research Institute, University College Cork*
*Corresponding author email: ailbhe.kavanagh@ucc.ie

Abstract:

Irish waters are a geologically diverse region, rich in natural resources and biodiversity, which support over 20 species of cetacean (whales and dolphins). Despite over 7,000 hours of survey effort focused on examining the distribution of cetaceans in Irish waters, the spatial coverage is patchy, with large areas such as the Porcupine Seabight poorly surveyed. This reduces our knowledge of the distribution of rare and vulnerable species and compromises our ability to manage anthropogenic activities such as the development of Marine Renewable Energy sites. The KOSMOS project aimed to collate existing datasets, identify critical gaps in survey coverage, and implement a new data-acquisition programme to fill these data gaps. Under the programme, approximately 1,200 hours of additional survey effort were collected from vessels of opportunity in offshore waters. In addition, we identified a significant source of data in the form of marine mammal observer sightings from seismic surveys. Notably, these surveys were often located in poorly surveyed waters, however, the data need to be corrected for the effect of seismic surveys on the occurrence of cetaceans. Despite this, the combination of these datasets has resulted in the collation of over 16,000 hours of cetacean survey effort, covering almost all Irish waters. The dataset highlights the importance of the Porcupine Basin to many protected cetacean species and increases our understanding of the potential scale of impacts from offshore activities. Such information will supply environmental impact assessments with real data and will contribute to the effective management of anthropogenic activities in Irish waters.

Keywords:

Cetacean surveys; cetacean distribution; offshore waters; seismic surveys; anthropogenic activities

Concept Illustration:

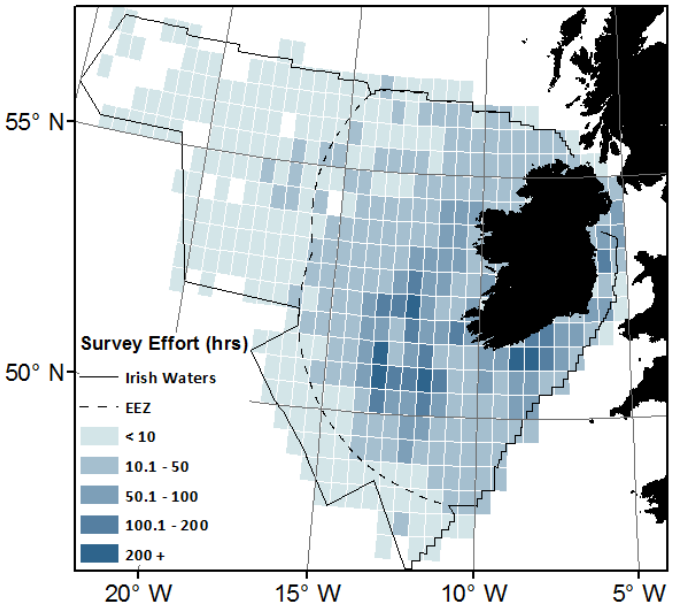


Figure: Distribution of survey effort for cetaceans on a 0.5° x 0.5° grid

Climate Ireland: supporting national adaptation policy

Barry O'Dwyer[1], Mohammad Hashemi[1], Tiny Remmers[1], Hester Whyte[1], Jeremy Gault[1]

Coastal and Marine Systems, MaREI Centre, University College Cork, Cork

Abstract:

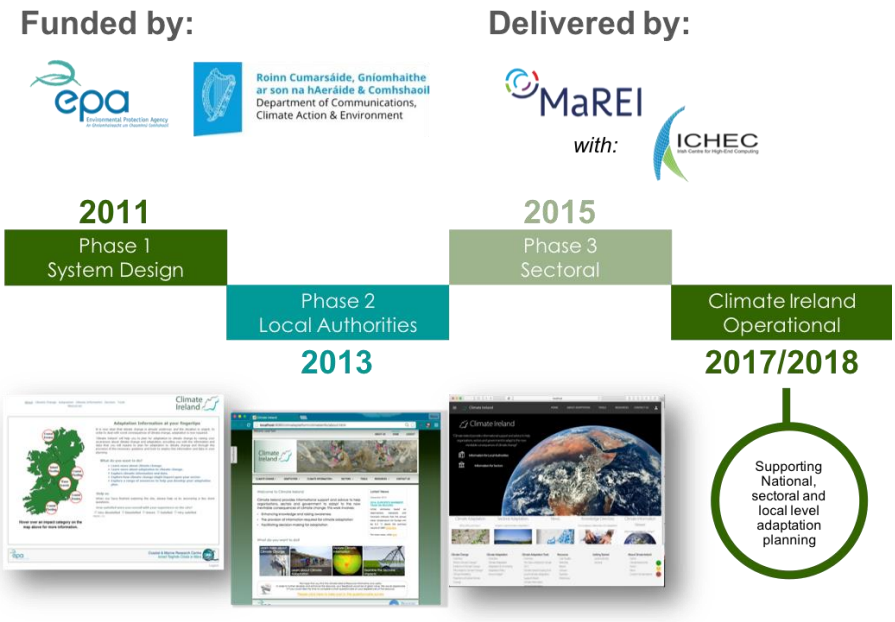
Adapting to climate change poses a significant challenge for decision makers in Ireland. In the context of planning for a future that includes projected climate change, relying on records of past climate is no longer adequate and it is essential that decision makers now consider how human-induced warming may affect key climatic parameters and the impacts of these changes for Ireland. Arriving at an understanding of current and future climate change impacts at this scale is a major challenge and requires consideration of a wide range of potential impacts, where and when these may occur and the consequences of these for different elements of Ireland's society, environment, and economy.

Adopting a phased approach to development (2011-2017), the EPA/DCCAE funded project 'Ireland Climate Information Platform' (ICIP) has made substantial progress in addressing the challenges described above. The first 'Discovery' phase of development provided a one stop online source of climate and adaptation information and data for Ireland, demonstrating the potential of ICIP to serve as a key resource for supporting the analysis of climate impacts, vulnerability, and adaptation options (http://www.climateireland.ie). ICIP Phase 2 further developed the ICIP Phase 1 resource and was specifically targeted at supporting Local Authorities in the development of their adaptation strategies. For example, the *Local Authority Adaptation Support Tool* was developed through ICIP Phase II to facilitate climate adaptation decision-making amongst Ireland's local authorities. ICIP Phase 3 built upon the ICIP Phase 2 resource and was specifically targeted sectoral decision-making for climate adaptation. For example, the Sectoral Adaptation Guidelines, online tools and supports developed through ICIP Phase 3 have been employed by national sectors in the development of their adaptation plans. Recently, through the NAF (2018), ICIP is recognised as a key national support for the development of Ireland's adaptation response at national, regional, and local scales.

Keywords:

Climate adaptation; adaptation planning; one stop shop

Concept Illustration:



Status of Ireland's climate

Walther Cámaro García[1], Jeremy Gault[1], Barry O'Dwyer[1, *]

[1] *MaREI Centre for Marine and Renewable Energy, Environmental Research Institute, University College Cork, Haulbowline Road, Ringaskiddy, Co. Cork, Ireland.*

*Corresponding author email: walther.camaro@ucc.ie

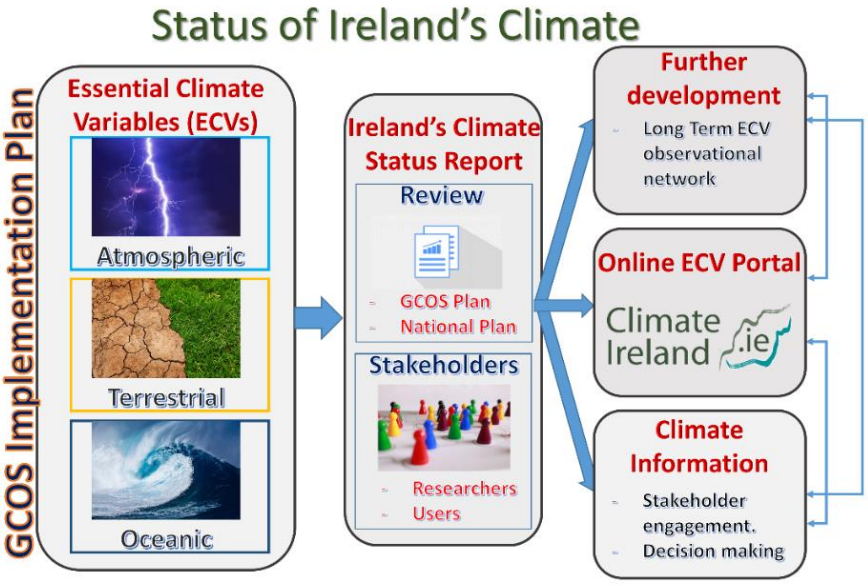
Abstract:

Ireland's climate is changing, and these changes are consistent with regional and global trends which display rapid changes in many aspects of climate. High quality climate observations are required in order to understand the characteristics of current climate and to assist avoiding adverse consequences of future climate changes. In this context, the Global Climate Observing System (GCOS) was established in response to the need to have a dedicated international programme for the dissemination of climate observations. During the last decade, GCOS have developed and updated a Climate Observation Implementation Plan which specifies 54 Essential Climate Variables (ECVs) that are key for sustainable climate observations. On this basis a number of assessment have been undertaken during the last decade which aim to highlight the state of Ireland's climate, the most recent assessment for Ireland, in 2012, provided a first Status Report with a comprehensive assessment of 40 ECVs for atmosphere, marine and terrestrial environments that are identified as being relevant for Ireland. Following the last report recommendations, a new report status will now be produced. Consequently, the initial phase of the assessment will be aimed to review the status of GCOS implementation and National Action Plans. Then, a second phase will be defined by the interaction with researchers and users to document and report on the Status of Ireland's Climate. Finally, a report will be produced with the current status of Ireland's Climate situation. A set of recommendations for the future development of a sustainable long term ECV observational network will be included in the report. In addition, an extensive programme of stakeholder engagement to promote the uptake of climate information in decision making will be implemented. All the datasets and relevant information will be integrated in an online ECV Portal via which users can access the data products and metadata.

Keywords:

Essential Climate Variables (ECVs), GCOS implementation plan, Stakeholder, Climate Change Indicators (CCIs)

Concept Illustration:



Demand-weighted vulnerability study of Irish national transport network

Tiny Remmers[1*], Barry O'Dwyer[1], Tim O'Higgins[1]

[1] *MaREI Centre for Marine and Renewable Energy, Beaufort Building, Environmental Research Institute, University College Cork, Ringaskiddy, Ireland.*

*Corresponding author email: tiny.remmers@ucc.ie

Abstract:

Transport networks play an essential role in human societies, not only for daily commuting and goods transport, but also as emergency responses systems for people and critical infrastructures. Consequences of disruption vary from increased travel time and cost to interruptions of services such as electricity and water supply. These consequences are often more important in rural areas due to the sparsely distributed critical infrastructures and the lack of alternative options for travel. Since the state of the network will influence user's travel behaviour, transport vulnerability is often measured as reduced accessibility or network degradation.

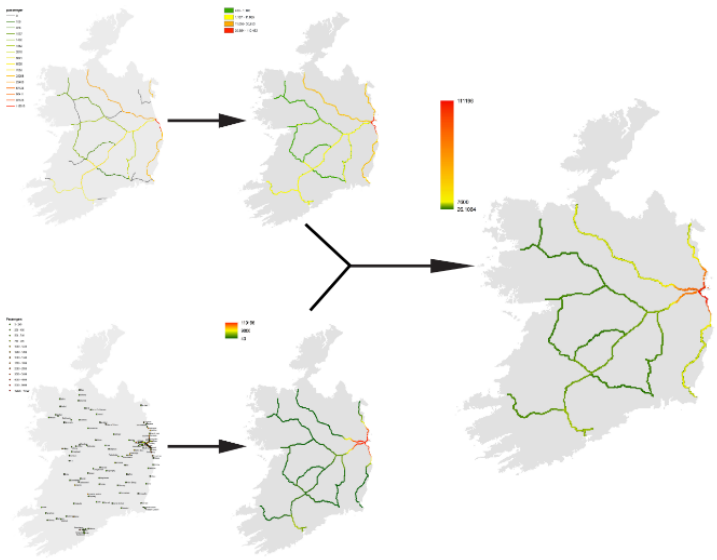
Traditionally, two methods have been used to investigate network vulnerability; topological vulnerability studies and system-based vulnerability studies (SBVS). The latter are considered to be more useful for planning and policy purposes. SBVS rely on demand and supply datum and has can depict socio-economic impacts of a transport network's degradation. In this study, datum from the National Transport Authorities (NTA), Transport Infrastructure Ireland (TII) and the Central Statistics Office (CSO) were used to create a demand-weighted vulnerability map of the national transport network in Ireland. Passenger density (passengers per km^2) maps were developed for the national roads and the railway network to illustrate the local importance of transport segments. The density unit was selected to fully represent the importance of nodes, highlighting connectivity and accessibility of the Irish national transport network.

In Ireland, the transport network is likely to be affected by projected increases in storminess and intensity of extreme weather events due to climate change, but also by an increase in remoteness resulting from rural depletion. As a complementary part of this study, it would be interesting to conduct a node-based vulnerability study in rural areas, to assess transport network vulnerability due to remoteness, as well as spatially investigating the impact of climate change projections on the current transport network.

Keywords:

Transport network vulnerability; Passengers weighted density; Connectivity; System-based vulnerability study

Concept Illustration:



Urb-ADAPT project: assessing climate change impacts and adaptation strategies in the Greater Dublin region

Roberta Paranunzio[1], Paul Alexander[1], Barry O'Dwyer[1, *]

[1] *Climate Change and Adaptation team, MaREI Centre, Beaufort Building – ERI, University College Cork.*
*Corresponding author email: roberta.paranunzio@ucc.ie

Abstract:

Recent scientific outcomes suggest that climate change is likely to cause shifts in the pattern and intensity of extreme events worldwide, in some regions increasing the exposure of populations to climate risks. This is especially so for urban areas, with expected growing population based on future scenarios. To better manage climate change risks at the urban scale, long-term planning and strategies are needed. Projected sea level rise will put large areas at risk because of growing soil anthropization, whereas impervious surfaces limit rainwater drainage into the ground, thus worsening floods. Urban Heat Island (UHI) effects leads to increased energy needs that further contribute to the heating and exacerbate physiological heat stress. The EPA-funded project Urb-ADAPT supports the assessment and management of key urban climate impacts, focusing on the Greater Dublin Region. An integrated approach, that merges (current and projected) climate data with socioeconomics and population information, is the basis for the development of a Climate Vulnerability Index (CVI) at the local and regional scale. The project is based on two key strands: i) temperature i.e., heat exposure and ii) water i.e., coastal inundation and pluvial flooding exposure. So far, the Heat Vulnerability Index (HVI) for the period 2020-2050 under different Representative Concentration Pathways (RCP) has been developed. Based on a Principal Component Analysis (PCA), four components, representing four aspects of heat vulnerability, have been identified, including: i) socioeconomic, ii) environmental, iii) demographic/urbanicity and iv) social isolation components. Overall, vulnerability to heat varies spatially in the Greater Dublin Region, with the highest HVI in the more urban areas i.e., city centres and Dublin suburbs. Works on the flooding and coastal inundation vulnerabilities are still in progress. These outcomes will represent, along with HVI, the basis for the development of multi-level climate adaptation and mitigation strategies in conjunction with the relevant stakeholders.

Keywords:

Urban areas, Climate Change, Vulnerability, Adaptation

Future earth coasts: land and sea interactions in the coastal zone

Shona Paterson[1,2*], Martin Le Tissier[1,2], Hester Whyte[1,2], Jeremy Gault[2,1], Valerie Cummins[1,3]

[1] *Future Earth Coasts*
[2] *MaREI Centre for Marine and Renewal Energy Ireland/UCC*
[3] *Biological, Earth & Environmental Sciences*
*Corresponding author email: shona.paterson@ucc.ie

Abstract:

Future Earth Coasts (FEC) builds on over 20 years of scientific experience and applied research through the Land-Ocean Interactions in the Coastal Zone (LOICZ) project of the former International Geosphere Biosphere Programme and the International Human Dimensions Programme. As a global network of coastal scientists and practitioners from all disciplines of the natural and social sciences, engineering, law and the humanities, who are dedicated to the sustainable development of our coastal zones, we directly contribute to and engage with international treaties and frameworks such as the 2030 Agenda for Sustainable Development, the COP21 Paris Agreement, and the Sendai Framework for Disaster Risk Reduction.

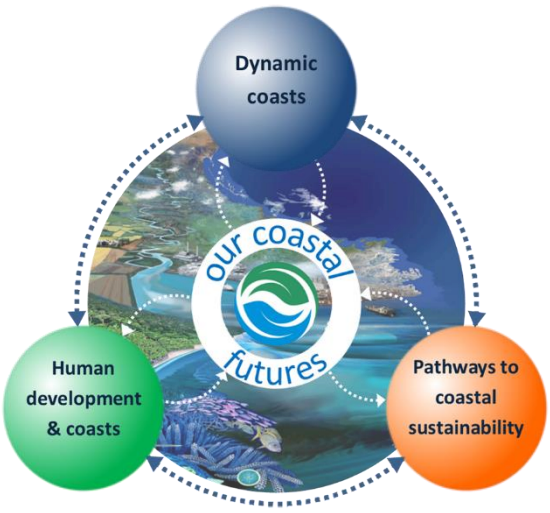
The establishment of a scientific and technological community from all disciplines for the co-design and co-production of knowledge that will engage with policymakers, business, industry and other stakeholders is a critical step for the success of FEC. Therefore, one key part of the FEC approach has been the facilitation and coordination of three international networks: the pan-African Ocean Acidification Network (OA-Africa), the Circum-Arctic Coastal Communities Knowledge Network (CACCON) and Lagoons for Life.

FEC supports numerous projects and researchers within MaREI and beyond in order to help build capacity and achieve research outcomes. In the last year, we have worked closely with the Earth Observation Group, the Governance Group, and Communications Team of UCC-MaREI as well as supporting three master's students from the Erasmus Mundus Masters course.

Keywords:

Sustainability, coasts, solution-oriented, capacity building, network development

Concept Illustration:



Historical legacy, geopolitical transformations, and effective governance of transboundary marine ecosystems

Sarah Twomey[*1,2], Valerie Cummins[1,3], Cathal O'Mahony[1]

Coastal and Marine Systems, MaREI Centre, Environmental Research Institute (ERI), University College Cork.
[2] Department of Geography, University College Cork.
[3] School of Biological, Earth and Environmental Sciences, , University College Cork.
*Corresponding author email: s.twomey@ucc.ie

Abstract:

Regional seas and shared marine waters present challenges in terms of management. Typically, these environments are bordered by numerous maritime jurisdictions, accommodate multiple sectors and activities, and are subject to differing governance arrangements. Governance sets the stage within which management occurs and effective governance is key to dealing with conflict and escalating pressures on the marine environment. Actions taken by one country can negatively influence the quality and availability of environmental resources in neighbouring jurisdictions. Transboundary, or cross-border, cooperation is a fundamental governance consideration. This research demonstrates that conflicts arising from complex socio-political transboundary marine ecosystems pose insights to a level of uncertainty in governance, that seldom align with conceptual frameworks for best practice. It adopts a case-study approach for engagement with a range of stakeholders in North-West Europe and South Asia (i.e. Lough Foyle, Ireland and Northern Ireland/United Kingdom; Palk Bay, India and Sri Lanka) and employs a qualitative, meta-analytical framework and timeline mapping technique. This enables an holistic, balanced and analytical synthesis of diverse sectoral conflicts involving disputed and contested maritime boundaries from two cross-border bays in ex armed-conflict zones. This toolkit can be deployed to inform the governance of transboundary marine ecosystems in other conflict settings going forward. Policy recommendations and future governance options are sensitive to the wider post-colonial historical context and current geo-political realities.

Keywords:

Transboundary; Geopolitics; Marine Governance; Historical Geography; Disputed Borders.

Concept Illustration:

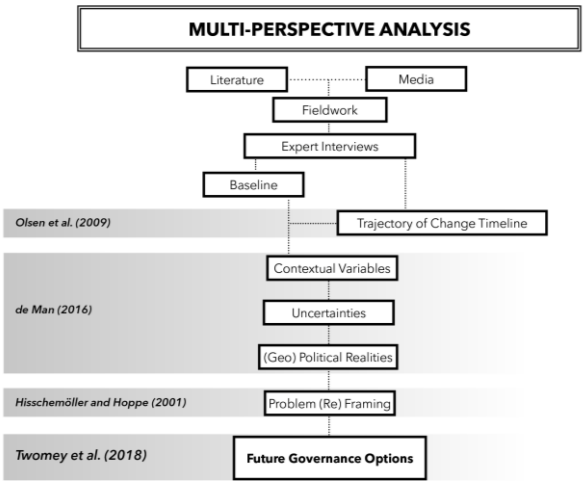


Figure 1: Conceptual framework for meta-analysis and production of future governance options for conflicts arising from complex socio-political transboundary marine ecosystems.

Wild Atlantic mussels

Gerry Sutton[1] and Tim O'Higgins[1]

[1] *MaREI Centre for Marine and Renewal Energy Ireland/UCC*

*Corresponding author email: gerry.sutton@ucc.ie, tim.ohiggins@ucc.ie

Abstract:

The Wild Atlantic Mussels (WAM) project is a multidisciplinary project funded by Bórd Iascaigh Mhara designed to explore the potential for upscaling sustainable development of mussel aquaculture in Ireland. Currently national production of mussels makes up approximately 10,000 tonnes and €7.5m Ireland and it is confined to inshore waters Recent international innovations in production techniques have illustrated the possibilities of scaling up production to offshore waters and there is clear potential for similar innovation in Irish waters to meet the needs of national and European ambition for Blue Growth. As a native species, with naturally occurring spat falls and positive environmental consequences, mussel culture offers several advantages over other aquaculture sectors.

WAM takes a holistic approach to investigate the political, social, financial, technical and environmental dimensions of the expansion of offshore mussel culture with the aim of identifying the most suitable locations and techniques as well as establishing social and political support.

Technical feasibility will be demonstrated based on field trial of an innovative subtidal mussel farm installation, which will be used to obtain growth rates and measure environmental parameters. National scale feasibility will be assessed based on systematic spatial analysis of ocean climate and site suitability using national data sets of physical, biological, and regulatory data layers and incorporating satellites derived data products.

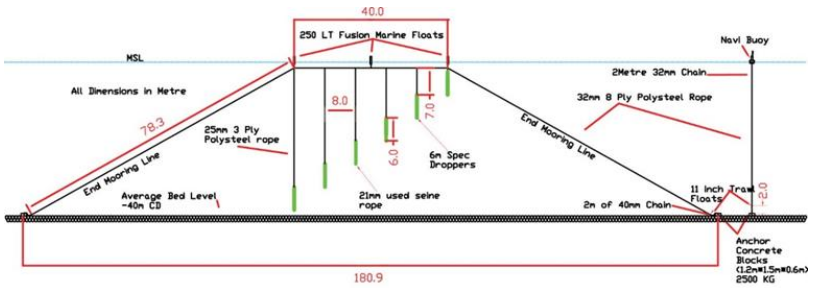
A synthesis of the potential for mussel aquaculture to enable simultaneous achievement of economic and environmental policy targets will be developed as a policy brief to garner political support, this will be accompanied by a public consultation to promote social awareness of the environmental benefits and industry participation.

Monte Carlo simulation will be used to assess multiple economic and financial risks based on Bio economic modelling incorporating biological, environmental, and engineering and market data to develop reliable probabilities of success to support informed investment choices.

Keywords:

Aquaculture, Mussels, Policy, GIS

Concept Illustration:



Typical Cross Section & Plan Detail
Scale 1:1000

Understanding the movement patterns of Irish seabirds

Ashley Bennison[1], John Quinn[2], Mark Jessopp[3, *]

[1] *Marine Ecology Group, Coastal and Marine Systems, MaREI Centre, University College Cork/School of Biological Earth and Environmental Sciences, University College Cork.*
[2] *School of Biological Earth and Environmental Sciences, University College Cork.*
[3] *Marine Ecology Group, Coastal and Marine Systems, MaREI Centre, University College Cork/School of Biological Earth and Environmental Sciences, University College Cork.*
*Corresponding author email: Ashley.bennison@ucc.ie

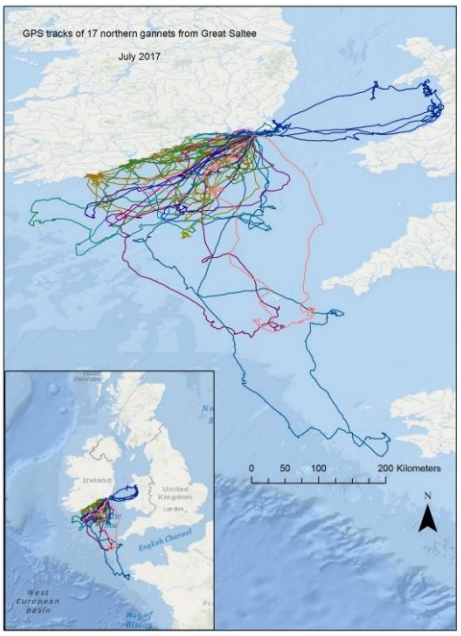
Abstract:

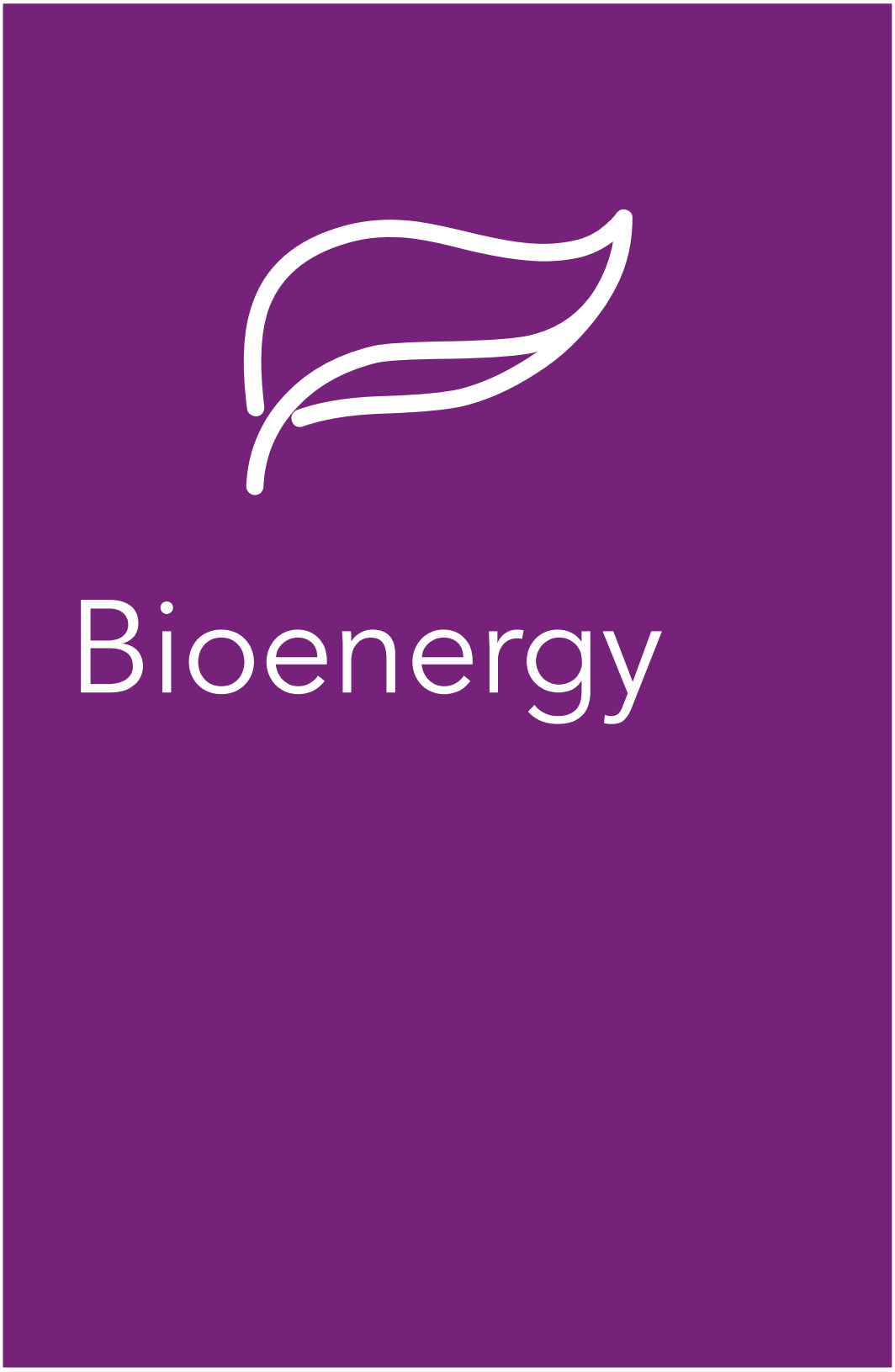
Under the EU Birds & Habitats directive, EU member states are required to ensure adequate protection of habitat and conservation management of all wild birds in the European Union. During the breeding season, many seabirds travel long distances at sea whilst searching for food. However, when considering the importance of areas for bird populations, individual behaviour must also be considered. At sea, mortality risks for seabirds are highest when interacting with the ocean surface, often when foraging for prey. In addition, mortality events may occur due to fisheries bycatch, oil contamination, or as a result of increased strike risk from marine renewable devices. Here we present the results of a northern gannet (***Morus bassanus***) tracking study that took place on Great Saltee, County Wexford, in July 2017. 17 individual gannets were tracked using a combination of GPS loggers, time depth recorders, and accelerometers. Gannets travelled a maximum of 246km from the colony and an average 377km during each foraging trip. Hidden markov models were developed to interpret behaviour and three key behavioural states were identified: travel, rest, and search behaviour. The proportion of time spent in each behavioural state was considered and key foraging areas throughout the Celtic Sea are identified. Outputs from this research will be used to form recommendations for the conservation management of Irish seabirds in Irish waters.

Keywords:

animal behaviour, marine ecology, seabirds

Concept Illustration:




Bioenergy

Closing the loop: Role of algae in an integrated circular bioenergy system

Richen Lin[1, 2*], Jerry Murphy[1, 2]

[1] *Bioenergy & Biofuels research group, MaREI Centre, Environmental Research Institute, University College Cork, Cork, Ireland*

[2] *School of Engineering, University College Cork, Cork, Ireland*

*Corresponding author email: richen.lin@ucc.ie

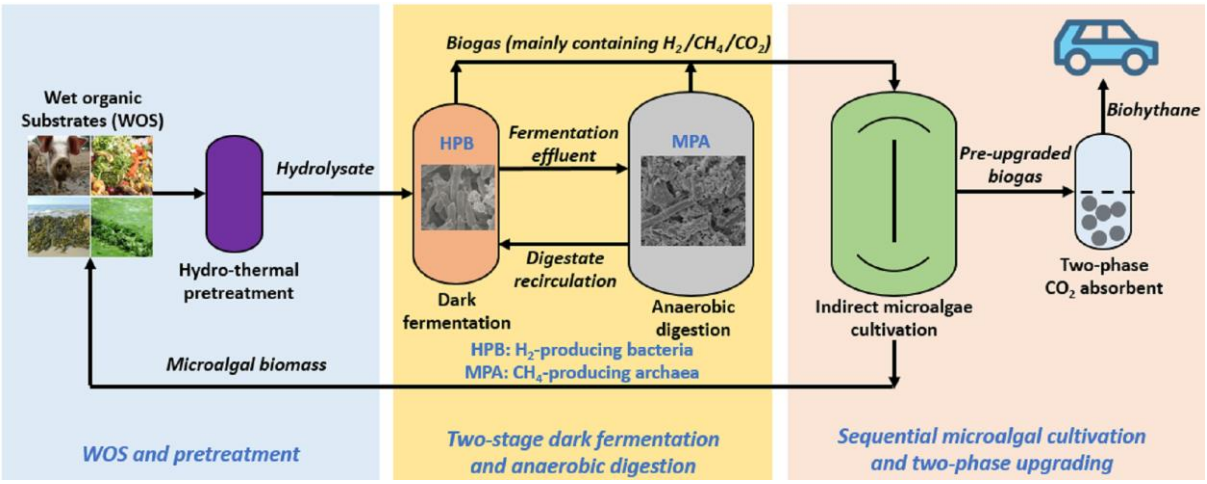
Abstract:

The production and use of advanced biofuels (such as biohydrogen and biomethane) with improved sustainability have been encouraged for future energy systems. The abundant resources of substrates, which can be characterised as second (agricultural and municipal residues) and third generation (algae) feedstocks, offer a huge potential for the production of advanced biofuels. Biological hydrogen and methane production offer a sustainable route and offer a technology platform with significant potential for integration. However, the overall bioenergy recovery in practice can be limited by several restrictions, including: lower substrate hydrolysis; lower activity and efficiency of microbial communities; and sub-optimal bioreactor configuration. These restrictions necessitate the development of comprehensive strategies aimed at enhancing the overall energy output. Here, we propose a circular bioenergy system for biohythane (biohydrogen + biomethane) production with reuse of CO_2. The novelty of the concept lies in the coupling and optimisation of technologies such as hydro-thermal pretreatment, dark hydrogen fermentation, anaerobic digestion, biogas upgrading through carbon capture by microalgal cultivation and system analysis and optimisation. The product of the integrated system is renewable gaseous transport biohythane with zero emission of CO_2 from the system. The integrated system includes the concepts of cascading bioenergy and circular economy comprising of: (1) Hydro-thermal pretreatment; (2) Dark hydrogen fermentation; (3) Anaerobic digestion; and, (4) Indirect microalgal cultivation. The overall reaction can be summarised as $C_6H_{12}O_6 + 18H_2O \rightarrow 12H_2 + 6CH_4 + 12O_2$ with zero emission of CO_2.

Keywords:

Circular economy; Dark fermentation; Anaerobic digestion; Algae; Biohythane.

Concept Illustration:



Biological methanation systems

Markus Voelklein[1], Jerry Murphy[1,2,*]

[1] *Bioenergy & biofuels research group, Environmental Research Institute, MaREI Centre, University College Cork, Cork, Ireland.*

[2] *School of Engineering, University College Cork, Cork, Ireland.*

*Corresponding author email: Jerry.murphy@ucc.ie

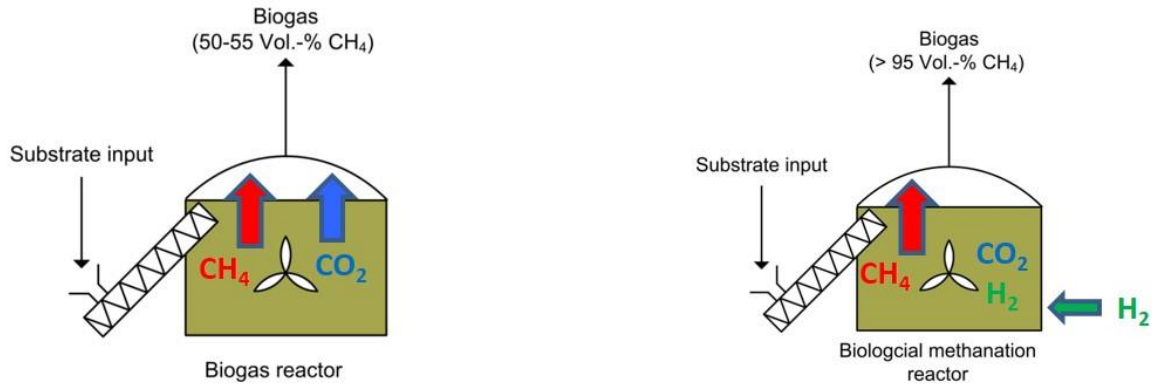
Abstract:

Anaerobic digestion has become one of the dominant renewable energy technologies for all kinds of wet organic residues, energy crops and manures. The methane content of the produced biogas can be further enriched in a so called biological methanation process. Microbes consume externally injected hydrogen (an equimolar amount of four times hydrogen to the produced carbon dioxide) and generate biomethane of natural gas quality. The bottleneck of the process is the low solubility of the injected hydrogen. It limits the conversion of carbon dioxide and hydrogen to methane. To facilitate the hydrogen gas to liquid transfer in this study, a ceramic gas diffuser was installed in a 5-litre lab scale methanation reactor. To enhance contact between the gases and the microbiological community, a gas pump continuously recirculated the gases through the bacterial bed. Batch, continuous and sequential upgrading strategies were investigated and analysed for its upgrading potential. The batch process exposed the microbes to the injected gases for a recurrent 24-hour period. In contrast, the continuous injection of gases into the reactor system steadily displaced the upgraded biogas. The sequential approach allowed an incremental upgrade of biogas until ideally a complete methanation is reached. A correlation between high hydrogen injection, high methane production rate and diminishing conversion rates of carbon dioxide to methane were observed. Conversion rates of 45 to 96 % were achieved at methane production rates between 0.5 and 8.5 L/L/d. This translates to a 10-fold increase of methane productivity compared to biogas production in conventional digester systems.

Keywords:

Biological methanation; power-to-gas; hydrogen; methane

Concept Illustration:



Energy recovery and pathogen inactivation with dry co-digestion of food waste and pig manure

Yan Jiang[1], Peadar G. Lawlor[2], Gillian E. Gardiner[3], Xinmin Zhan[1, *]

[1] *Civil Engineering, College of Engineering & Informatics, National University of Ireland, Galway, Ireland*
[2] *Teagasc, Pig Development Department, Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork, Ireland*
[3] *Department of Science, Waterford Institute of Technology, Waterford, Ireland*
*Corresponding author email: xinmin.zhan@nuigalway.ie

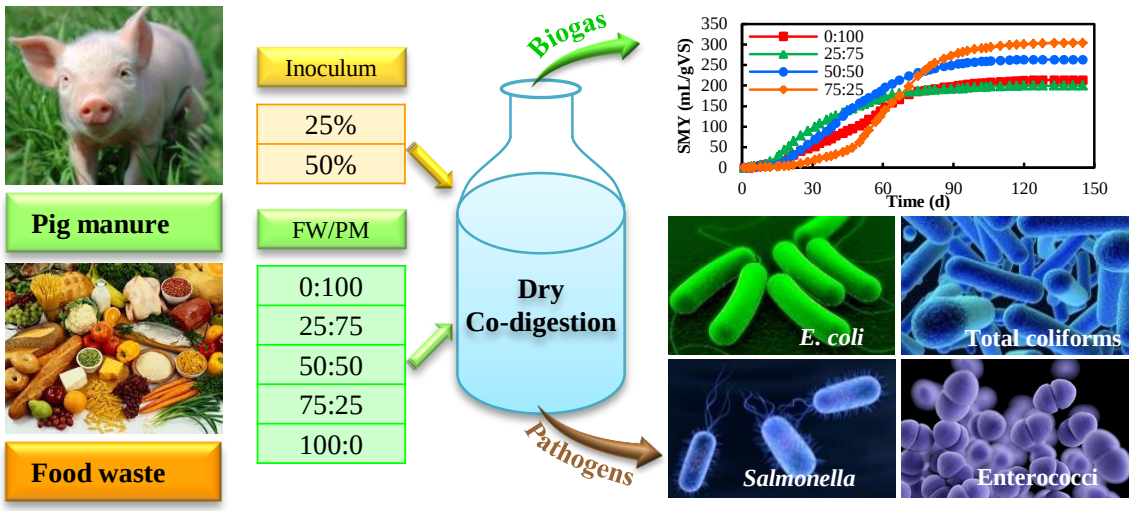
Abstract:

Dry co-digestion provides an effective solution for management of food waste (FW) and pig manure (PM) by producing methane-rich biogas, optimizing carbon to nitrogen ratio (C/N), reducing reactor volume, avoiding high cost of liquid digestate management and decreasing energy consumption for heating. Batch dry co-digestion of FW and PM was conducted at various inoculum rates and FW/PM ratios in laboratory-scale digesters to assess the optimal operation conditions, methane production kinetics and pathogen inactivation in dry co-digestion systems. The total solid (TS) content was set at 20%. The results showed that at preferable operation conditions, an average specific methane yield (SMY) obtained was 252 mL/g VS_{added} (volatile solids). Total VFA was the main inhibition factor for methane production ($P<0.001$), and the total VFA concentration was suggested to be < 20.0 g/L to avoid methane production inhibition. Dry co-digestion of FW and PM can effectively inactivate the enteric indicator bacteria. For example, *E. coli* and total coliform counts decreased to below the limit of detection (LOD, 10^2 CFU/g) within 7 days, enterococci decreased to below the LOD within 31 days, and *Salmonella* was completely eliminated within 6-7 days.

Keywords:

Dry digestion; *E. coli*; total coliforms; enterococci; *Salmonella*

Concept Illustration:



Adsorption behaviour of biofuels using different adsorbents in model syngas fermentation broth.

Peyman Sadrimajd[1, *], Samayita Chakraborty[2], Eldon R. Rene[2], Piet N. Lens[1]

[1] *Department of Microbiology, School of Natural Sciences, College of Science, National University of Ireland Galway, University Road, Galway, H91 TK33, Ireland.*

[2] *The Environmental Engineering and Water Technology Department, UNESCO-IHE Institute for Water Education, Westvest 7, 2611 AX, Delft, The Netherlands.*

*Corresponding author email: p.sadrimajd1@nuigalway.ie

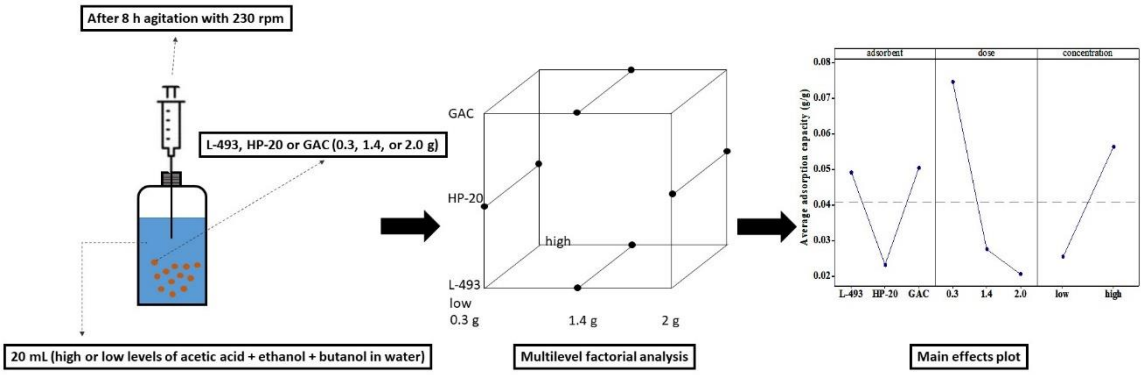
Abstract:

Syngas fermentation is an effective method to produce butanol, ethanol, and volatile fatty acids. This study investigated the adsorptive capability of two resins, Dowex Optipore™ L-493 and Diaion® HP-20 to selectively separate acetic acid, ethanol, and butanol from single (water as solvent) and multi-component systems. Granular activated carbon (Norit® 1240w GAC) was also tested to compare the performance of resins with commercially available GAC. In single-component solutions, the maximum acetic acid, ethanol, and butanol adsorption capacities were 41, 145, and 198 mg/g, respectively, using 1.5% (w/v) Dowex Optipore™ L-493. In the case of multi-component solutions, the maximum butanol adsorption capacity was 127 mg/g using 1.5% (w/v) of Norit® 1240w GAC. Dowex Optipore™ L-493 was found to be a suitable adsorbent for the recovery of butanol from syngas fermentation broth, due to its specificity and high adsorption capacity. A multi-level factorial analysis was conducted to study the effect of acetic acid, ethanol, and butanol concentrations, adsorbent dose, and type of adsorbent on the adsorption capacity of the different adsorbents. For ethanol and butanol in the multi-component system, their initial concentration was found to have the most significant effect ($P<0.05$) on the adsorption capacity of the adsorbent than the linear and interaction effects of the other parameters investigated.

Keywords:

Syngas fermentation; Adsorption; Multi-level factorial analysis; Butanol; Dowex Optipore L-493

Concept Illustration:



Location-allocation optimization model for bio-SNG production system: The Republic of Ireland case.

Alessandro Singlitico[1,2,3], Jamie Goggins[1,2,3], Rory F.D. Monaghan[1,2,3,*]

[1] *College of Engineering and Informatics, National University of Ireland, Galway.*
[2] *Ryan Institute for Environmental, Marine and Energy Research, Galway.*
[3] *MaREI Centre for Marine and Renewable Energy, Galway.*
*Corresponding author email: rory.monaghan@nuigalway.ie

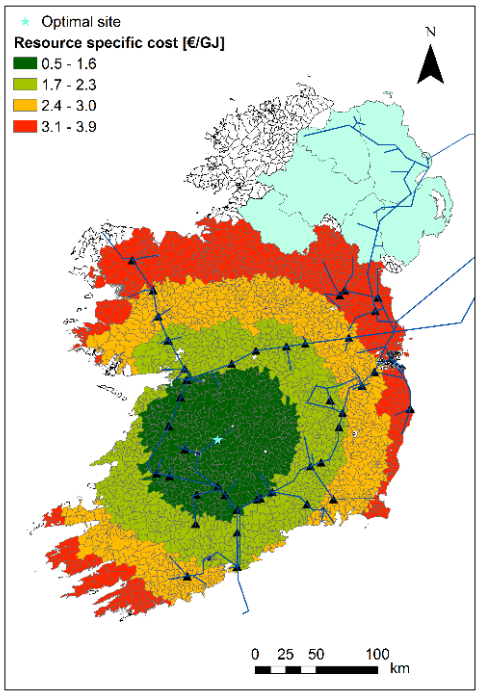
Abstract:

Decarbonisation of the gas network is a major target for six gas transmission systems operators (TSOs) that, in 2015, declared the aim to establish a 100% CO_2-neutral gas supply by 2050. The GoBiGas demonstration plant, developed by the Chalmers University of Technology (Göteborg, Sweden) is paving the way to large scale production of synthetic natural gas (SNG), up to 100 MW, through gasification and methanation. The aim of this work is to find the size and site of the process that minimizes the levelised cost of the energy (LCOE) of the bio-SNG produced. The Republic of Ireland is used as a test bench, considering its biomass resources distribution by electoral division, road networks and 42 above-ground injection points on the gas transmission network. The SNG production is simulated through thermodynamic models of each stage of the biomass-to-SNG conversion process, providing energy and mass balances, and a pinch analysis to evaluate heat integrations. A techno-economic assessment delivers a relation between size and capital and operational expenditures, and a geographical information system (GIS) algorithm, based on the location-allocation model, provides the cost of transportation. The algorithm iteratively calculates the LCOE of each possible configuration, selecting finally the site and the size with the minimum LCOE of the bio-SNG produced. The model used in this work represents an opportunity for TSOs to evaluate the integration of bio-SNG production systems on existing gas grids, and its profitability considering site-specific conditions.

Keywords:

SNG; Geographic Information System; Techno-Economic Assessment; Supply Chain Optimization.

Concept Illustration:



Cost-Effective Hydrogen Production from Curtailed Renewable Power

T. A. Gunawan [1,2,3,*], Rory F.D. Monaghan [1,2,3]

[1] *College of Engineering and Informatics, National University of Ireland Galway.*
[2] *Ryan Institute for Marine, Environmental and Energy Research, National University of Ireland Galway.*
[3] *MaREI Research Centre for Marine and Renewable Energy Research, Galway.*
* Corresponding author: t.gunawan1@nuigalway.ie

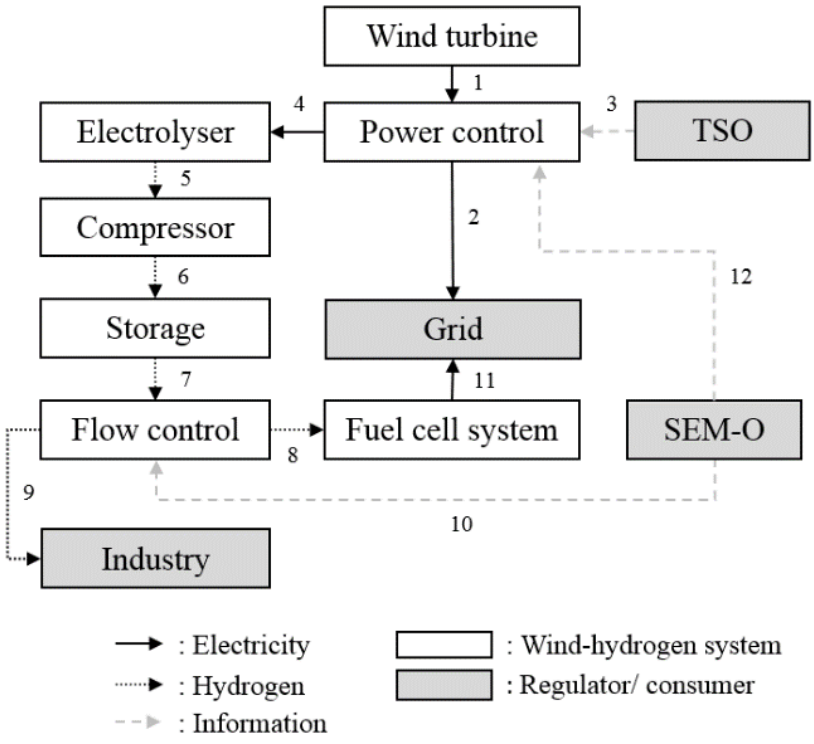
Abstract:

Hydrogen (H2) has potential to be a reliable energy storage technology in the future. It can be produced from various renewable energy sources and be transformed into some energy products like electricity, vehicle fuel, synthetic natural gas (SNG), and other valuable chemicals. This usability will increase penetration of renewable energy, reduce emissions, and enhance energy security. In Ireland, wind energy is the most favourable renewable energy source, sharing more than 20% of total electrical consumption in 2015. Not all of the available wind energy from wind farms can be transferred into the grid, due to curtailment or constraint. This wasted energy is known as dispatch down (DD) and potentially to be stored as hydrogen. The aim of this paper is to reduce DD by implementing a wind-hydrogen system (WHS). Levelised Cost of Hydrogen (LCOH) is used as an economic metric to analyse the system economic and technical performances. The most essential unit in WHS which affects LCOH is electrolyser, due to its cost contribution to almost half of total WHS capital expenditure (CAPEX). Therefore, sizing on suitable electrolyser capacity becomes necessary prior to the WHS development.

Keywords:

wind energy, hydrogen, energy system, wind-hydrogen system, energy storage

Concept Illustration:



Block diagram of proposed wind-hydrogen system

A comprehensive ignition delay time study of C_1-C_3 mixtures over a wide range of pressures, temperatures, equivalence ratios, and dilutions

Mohammadreza Baigmohammadi[1], Henry Curran[2,*], Andrzej Pekalski[3]

[1] *Combustion Chemistry Centre (C³), The Ryan institute, National University of Ireland Galway, Ireland*
[2] *Combustion Chemistry Centre (C³), The Ryan institute, National University of Ireland Galway, Ireland*
[3] *Shell Global Solutions, United Kingdom.*

*Corresponding author email: henry.curran@nuigalway.ie

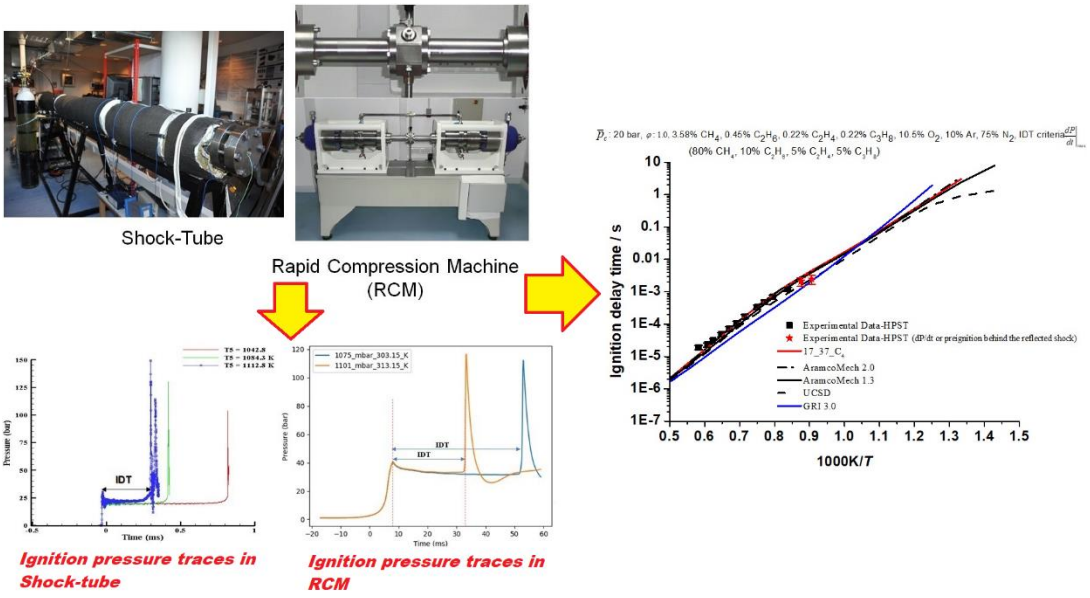
Abstract:

In this study, an extended experimental database for the ignition delay time (IDT) characteristics of various compositions of C_1-C_3 gaseous hydrocarbons including various alkanes and alkenes such as CH_4, C_2H_6, C_2H_4, C_3H_8, and their blends has been developed over a wide range of pressures (1~40 bar), temperatures (700~2000 K), equivalence ratios (0.5~2.0), and dilutions (75~90%). In this way, twelve different mono-, bi-, tri-, and tetra-fuel(s) compositions including CH_4, C_2H_4, C_2H_6, C_3H_8, (CH_4/C_2H_4), (CH_4/C_2H_6), (CH_4/C_3H_8), (C_2H_4/C_2H_6), (C_2H_6/C_3H_8), (C_2H_4/C_3H_8), (CH_4/C_2H_4/C_2H_6), and (CH_4/C_2H_4/C_2H_6/C_3H_8) have been considered. Also, the diluent (N_2 and Ar) concentrations have been varied from 75% to 90%. In order to reduce the experimental matrix, and simultaneously cover the wide range of studied parameters, the experiments have been designed using a Taguchi L_9 matrix. All of the high temperature and low temperature experimental data have been attained using a shock-tube and a rapid compression machine, respectively. Furthermore, modelling results using various chemical mechanisms including AramcoMech 2.0, AramcoMech 1.3, UCSD, and GRI 3.0 have been compared with the experimental data.

Keywords:

Experimental; Ignition delay time; Alkane; Alkene; Chemical mechanisms

Concept Illustration:



Computational chemical modelling as a fundamental tool for cleaner fuel and combustor design

Ultan Burke[1], Kieran P. Somers[1], Henry J. Curran[1,*]

[1] *Combustion Chemistry Centre, Ryan Institute, National University of Ireland Galway.*
*Corresponding author email: ultan.burke@nuigalway.ie

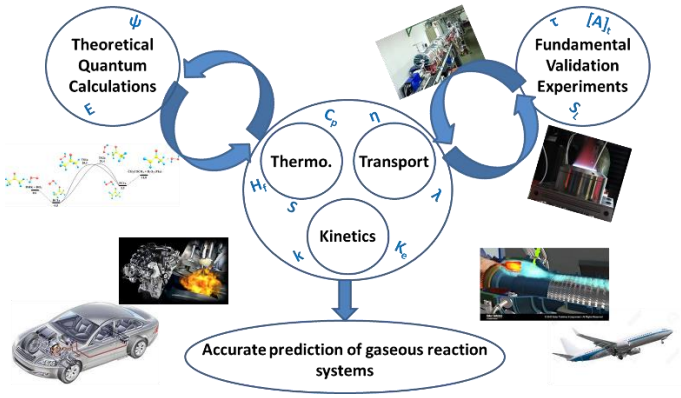
Abstract:

In order to overcome the considerable challenge of simultaneously, reducing our carbon footprint while still supplying enough energy to meet demand, we must understand the underlying physical processes producing our energy currently. From this perspective, we aim to accurately understand chemical oxidation of hydrocarbons under temperature/pressure/mixture compositions associated with modern combustors. Combustion technologies such as gas turbines, internal combustion engines and stationary combustion engines contribute considerably to the global energy production infrastructure. A wide variety of fuels are burned in these reactors and the fuel composition has an important effect on their efficiency and emissions. It stands to reason that, if we can understand the combustion kinetics (oxidation kinetics), we can design optimal fuel blends and combustors. Fundamental research into the chemical reactions which control the oxidation of these fuels helps us develop detailed computational models, which are used both industrially and academically in the design process. They are validated using experimental data taken in quasi ideal chemical reactors e.g. shock tubes, jet–stirred reactors and rapid compression machines. Of particular interest in the development process, are the reactions governing the smaller hydrocarbons and hydrogen. The reason being, that during oxidation of any hydrocarbon, these species will be produced as intermediates and will always impact the rate at which the fuel and oxidiser is converted to carbon dioxide and water. The C_4 model (containing species and reactions for all hydrocarbon molecules with up to four carbon atoms) has 458 species and 2604 gas-phase reactions. Our development of these models has led to the continual improvement in the efficiency of combustors and helps identify operational temperature/pressure/mixture compositions which can limit pollutant emissions. Moreover, the ever improving accuracy of our models opens up the possibility of bespoke fuel design. This method can expedite the process of using alternative biofuels in modern combustors.

Keywords:

Computational chemical modelling, fuel design, biofuel

Concept Illustration:



Nuclear magnetic resonance spectroscopy for the analysis of biofuels

Andrew D. Ure[1], John E. O'Brien[2], Stephen Dooley[3, *]

[1] *School of Physics, Trinity College, The University of Dublin.*
[2] *School of Chemistry, Trinity College, The University of Dublin.*
[3] *School of Physics, Trinity College, The University of Dublin.*
*Corresponding author email: stephen.dooley@tcd.ie

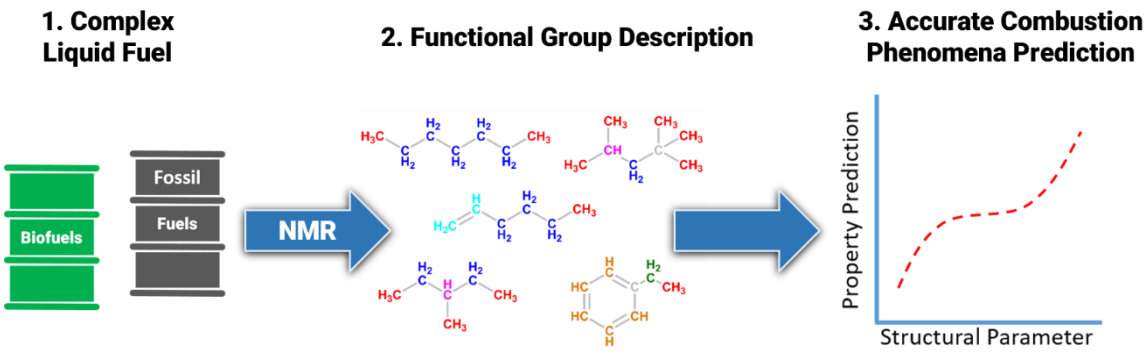
Abstract:

Dwindling fossil fuel reserves and environmental concerns have led to a surge in the development and implementation of bio-derived synthetic alternatives to conventional petroleum derived fuels. For aviation, currently, the use of synthetic paraffinic kerosenes (SPKs) such as Shell-SPK, hydro treated renewable Jet–SPK (HRJ-SPK) and alcohol to jet SPK (ATJ-SPK) in conjunction with archetypal jet fuels (*e.g.* Jet-A) as 'drop-ins' to form blends is being extensively investigated. Presently, the blending ratio is limited to 50 vol% due to a lack of understanding of how these synthetic fuels behave in the aviation turbine combustion process. Currently, engineering performance indicators such as research octane number (RON), motor octane number (MON), cetane number (CN) *etc.* are the legal metrics that relate fuel quality to device operating characteristics. These parameters are measured by approved experimental test procedures. However, alternative fuels, and even their blends, can lie outside the historical experience-base that exists for petroleum-derived gasoline, diesel and aviation fuels. There is now concern that this can manifest in a weakening of the effectiveness of the existing correlations relating the engine performance to the fuel performance indicator as both the fuel identity and the engine design change. Therefore, it is important that new techniques that are capable of reliably characterising fuels that emerge. We propose that to achieve this, we must understand the fundamental chemical processes that dictate the behaviour of fuels during combustion, rather than simply measuring the measuring the outcome (*i.e.* RON, MON, CN *etc.*). It follows that an accurate description of the chemical composition of these fuels on a molecular level will be required for this purpose. We will demonstrate that ^{1}H NMR spectroscopy can provide the requisite chemical structural information to ultimately yield quantitative structure property relationships capable of predicting fundamental properties of these fuels.

Keywords:

Combustion phenomena, alternative fuels, NMR spectroscopy

Concept Illustration:



Power-to-Gas:
Levelised costs, market interactions, and carbon intensity

Shane McDonagh[1], Jerry D. Murphy[1*]

[1] *Biofuels and Bioenergy Research Group, ERI-MaREI, UCC*

*Corresponding author email: jerry.murphy@ucc.ie

Abstract:

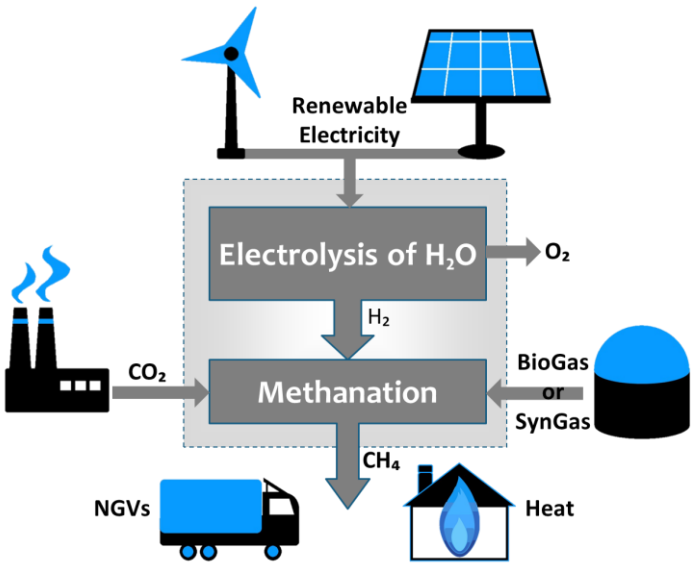
Power-to-Gas has been mooted as a means of producing gaseous transport fuel, whilst providing ancillary services to the electricity grid as a form of small scale (>10MW) energy storage. As a relatively new topic in energy research there are many gaps and much uncertainty in the literature. This work explores the likely costs, their contribution to the levelised cost of energy (LCOE), and a sensitivity analysis of system costs for a range of times. The LCOE was found to be €107-143/MWh (base value €124) in 2020, €89-121/MWh (base value €105) in 2030, and €81-103/MWh (base value €93) in 2040. As electricity cost dominates the LCOE (56%) and run hours are a function of such, interaction with the electricity markets is then analysed. The concept of consuming grid electricity is explored with the goal of economically optimising the Power-to-Gas plant modelled as a large purchaser, particular interest was given to the effects on curtailment. It was found that bidding more for electricity produced a more economic system, as did integrating more variable renewable generation into the mix. Within these optimisation controls the carbon intensity of the gas produced is examined and synergies were between environmental and economic optimisation found. Although Power-to-Gas derived gaseous transport fuel does not meet the criteria for advanced biofuels in the examined 2030 electricity mixes under the EU Renewable Energy Directive (Recast), it contributes to RES-T targets and has positive externalities for power producers and grid operators.

This abstract is based upon the work of three papers. One published, one due for publication, and one yet to be submitted.

Keywords:

Power-to-gas; Sensitivity analysis; Energy storage; Hydrogen; Methane

Concept Illustration:



Recovery of nutrients and volatile fatty acids from pig manure using two-stage bipolar membrane electrodialysis (BMED)

Lin Shi[1] and Xinmin Zhan[1,2,*]

[1] *Civil Engineering, College of Engineering and Informatics, National University of Ireland, Galway, Ireland.*
[2] *Shenzhen Environmental Science and New Energy Technology Engineering Laboratory, Tsinghua-Berkeley Shenzhen Institute, Shenzhen 518055, China.*
*Corresponding author email: xinmin.zhan@nuigalway.ie

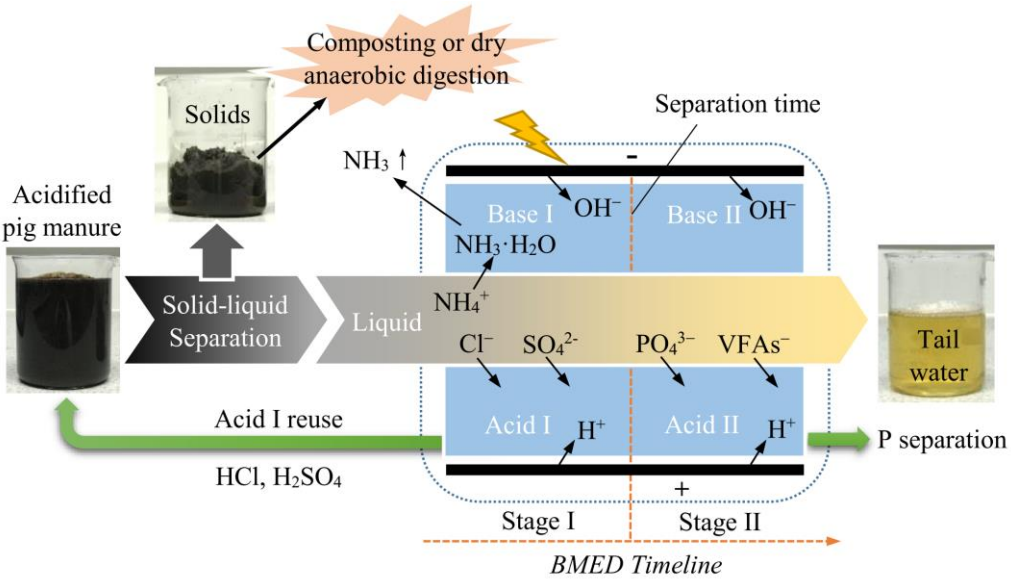
Abstract:

Animal manure should be regarded as a resource rather than a waste as it contains abundant nutrients (nitrogen and phosphorus) and organic matter. In this study, a laboratory-scale bipolar membrane electrodialysis (BMED) system was set up to assess the recovery of ammonium (NH_4^+), phosphate (PO_4^{3-}) and volatile fatty acids (VFAs) from both synthetic and real pig manure hydrolysate for the first time. Synthetic hydrolysate was used as feed first to investigate the ionic migrations in the BMED system. After 5.5 h of operation, 52% of NH_4^+ migrated to the base compartment, and 98% of PO_4^{3-} and 95% of VFAs migrated to the acid compartment. A BMED model was established to quantify the ion flux balance in the membrane stack. It substantiated that the low recovery efficiencies of NH_4^+ and the impurity of acid solution were primarily caused by the undesired diffusion of ions through bipolar membranes. Subsequently, a novel two-stage BMED operation based on the "inflection point" of voltage was developed to minimize the NH_4^+ loss and separate PO_4^{3-} and VFAs from the acid compartment. Through this operation, the recovery efficiency of NH_4^+ increased to 78%, and 75% of PO_4^{3-} and 87% of VFAs were separated from Cl^- and SO_4^{2-} in the acid compartment. Finally, real pig manure hydrolysate was tested and the variations of ions in the BMED were consistent as those using synthetic wastewater. This study demonstrates that it is feasible to recover valuable nutrients and VFAs from pig manure hydrolysate using two-stage BMED technology.

Keywords:

Pig manure; Bipolar membrane electrodialysis; Nutrients; Volatile fatty acids; Two-stage operation.

Concept Illustration:



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Tel: **+353 (0)21 486 4300**

Email: **marei@ucc.ie**

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