



Circular
Economy



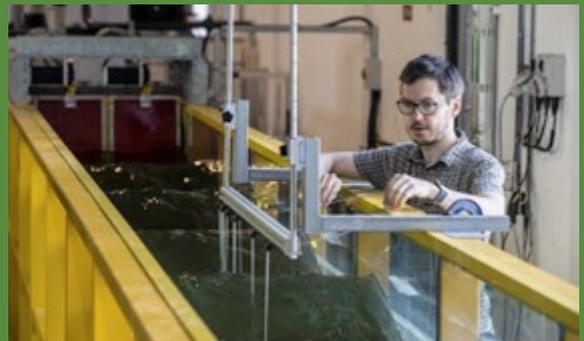
Healthy
Environment



Climate
Action

Environmental Research Institute

ANNUAL REPORT 2019



VISION

To enable a transition to a zero carbon, resource efficient and sustainable society.

MISSION

To generate new research knowledge for the understanding and protection of our natural environment, and develop technologies, tools, services and policy knowledge to facilitate a transformation to a zero carbon, resource efficient, and sustainable society.

The Environmental Research Institute is committed to the following five core principles:

Research excellence

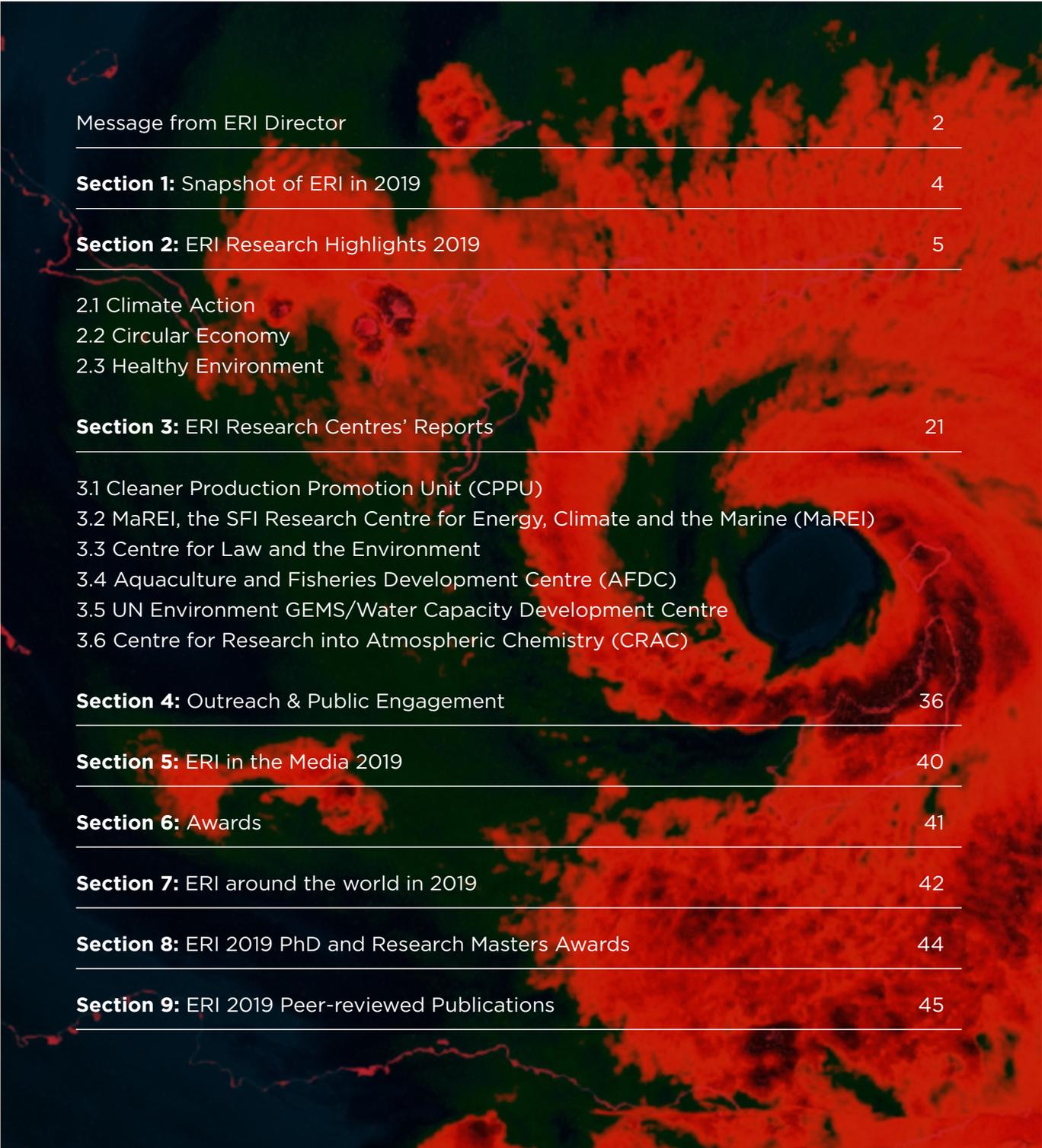
Interdisciplinary collaboration

**Research with impact –
Environmental, Societal & Economic**

**High quality postgraduate and
postdoctoral education and training**

Diversity and Equality

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Message from ERI Director

Welcome to the 2019 Annual Report from the Environmental Research Institute at University College Cork. The report is our yearly opportunity to take collective stock of the diverse research being conducted by the Institute's 400 researchers across 20 departments and 6 research centres, and reflect on how that research has made its impact upon the academic world and society. 2019 was the year where the urgency of environmental action was brought to our attention by young activists; the children and students protesting in schools and colleges, including here in UCC, held a light to the lack of action on climate change for the past two decades. However 2019 also showed signs of progress on climate change. We may be reaching a social tipping point on climate action with nine European citizens out of 10 asking for decisive climate action reflected in an electoral "green wave" across Europe and in Ireland. The European Union has committed to becoming the first climate-neutral continent by 2050 with a European Green Deal investment of €1 trillion. The confluence of social tipping points with significant decarbonisation investment means that, more than ever, we critically need our researchers to engage with societal stakeholders to co-produce action-oriented research.

The Institute is particularly proud of how its researchers and centres, through a range of research projects and initiatives, are working with communities, industry, policymakers and NGOs to produce a more sustainable planet. Our 2019 Annual Report highlights the diverse approaches with which Institute researchers are addressing sustainability challenges, many

of which crucially involve close collaboration with communities such as in the Imagining 2050 and MaREI Dingle Peninsula 2030 projects. Our Centres are to the fore in this regard. The Centre for Law and the Environment hosted a number of high profile events on Climate Law and Governance during the 2019 Law and the Environment conference and the UCC 2019 Community Engagement Week. The Centre for Research into Atmospheric Chemistry used the visual arts to raise awareness of air pollution on World Environment Day, and the UN GEMS Water CDC used citizen science to help reach SDG Goal 6. The Cleaner Production Promotion Unit hosted a highly attended public talk on "Citizen Engagement – Envisioning Energy Futures" to explore citizen preferences for low carbon energy pathways. It was wonderful to see our environmental, energy and climate research in ERI and MaREI profiled so extensively across TV, radio and on-line during Science Week culminating in key climate and energy scientists from MaREI meeting An Taoiseach Leo Varadkar to discuss how Ireland can lead the charge of climate change adaptation, mitigation and transition. The ERI was very pleased co-host a 2-day public workshop on "Cork - a Healthy City in a Changing Climate" in 2019 which identified key actions to mitigate the impact of our changing climate on our health and wellbeing in Cork City. We also had the largest scientific conference ever to be held in Cork in 2019 when Dr Cian Desmond hosted the 2019 Wind Energy Science Conference (WESC) in UCC.

We were delighted to receive the second round of funding for the SFI MaREI Research Centre for Energy, Climate and Marine in 2019; many congratulations to the MaREI leadership and operations teams in securing €19 million for another 6 years of research that will underpin Ireland's transition to a zero carbon economy. Since its establishment six years ago, MaREI has made a significant research contribution to the areas of energy transition, climate action, the marine and the blue economy. We were also very pleased to have the LiR National Ocean Test Facility in the ERI Beaufort Building officially launched by An Tánaiste, Simon Coveney in January 2019; LiR is proving to be a key piece of infrastructure for small to medium scale laboratory testing of ocean and maritime systems.

The Institute, its researchers and centres attracted a record €21.6M in research and operational funding in 2019. Research funding schemes have an average success rate of 20%, and our success in attracting

funding is a credit to the quality of our research and persistence of our researchers. In particular congratulations to Professor Colm O'Dwyer who received a prestigious Irish Research Council Advanced Laureate in 2019, and to Dr Gordon Dalton who was awarded €3.2M to explore a full suite of blue growth solutions for small islands in the MUSICA project. The Institute and its constituent centres were awarded 84 new research projects in 2019 bringing the current total to 252 active research projects worth over €77M. The Institute's researchers published 313 peer-reviewed publications and 27 postgraduates graduated under the supervision of ERI affiliated academics in 2019.

To ensure a voice for ERI schools and centres in the strategic direction of the Institute the ERI put in place an Academic Advisory Board in 2019 which will play an essential role in guiding the scientific direction of the Institute and implementation of strategy. Finally we

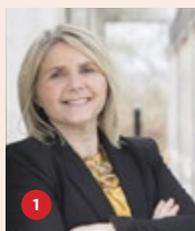
are very pleased to welcome new affiliated principal investigators from across a host of UCC schools and departments in 2019 including Dr Hannah Daly (School of Engineering), Dr Andrew Keane (School of Mathematical Sciences), Dr Kate Kiseeva (School of BEES), Dr Eoin McLaughlin (Department of Economics, CUBS), Dr Marguerite Nyhan (School of Engineering) and Dr Paul Holloway (Department of Geography). We are confident that these new staff will generate vital new research to support the Institute's challenges of climate action, healthy environment and circular economy.



Professor Sarah Culloty

Director, Environmental Research Institute.

ERI Management



1



2



3



4



5



6



7

1. Prof Sarah Culloty
2. Prof Jerry Murphy
3. Prof Brian Ó Gallachoir
4. Dr Paul Bolger
5. Dr Gillian Bruton
6. Dr Jimmy Murphy
7. Jeremy Gault

ERI Academic Advisory Board

Prof Sarah Culloty (Chair) Director of ERI (Head of SEFS)

Prof Jerry Murphy Deputy Director of ERI (Engineering)

Prof Brian Ó Gallachoir Deputy Director of ERI (Engineering)

Dr Paul Bolger Manager of ERI

Prof Ed Byrne School of Engineering

Dr Fiona Cawkwell Dept of Geography

Prof Eleanor Doyle Dept of Economics

Dr Niall Dunphy School of Engineering

Jeremy Gault Beaufort Bldg Operations Manager

Dr Clodagh Harris Dept of Government

Prof Justin Holmes School of Chemistry

Prof Marcel Jansen School of BEES

Dr Maria Kirrane UCC Green Campus

Prof Mary McCarthy Dept of Management and Marketing

Prof Owen McIntyre School of Law

Dr Pat Meere School of BEES

Dr John Morrissey School of Microbiology

Dr Ger Mullally Dept of Sociology

Dr Stephen Onakuse Dept of Food Business and Development

Dr Eilís O'Reilly School of Public Health

Dr Tom Reed School of BEES

Dr Áine Ryall School of Law

Dr Maria de Sousa-Gallagher School of Engineering

Prof John Wenger School of Chemistry

Prof Astrid Wingler School of BEES

SECTION 1 – Snapshot of ERI in 2019



405
RESEARCHERS



252
ACTIVE
PROJECTS



313
PUBLICATIONS



€21.6m
IN NEW
RESEARCH
FUNDING
IN 2019



84
NEW PROJECTS
IN 2019



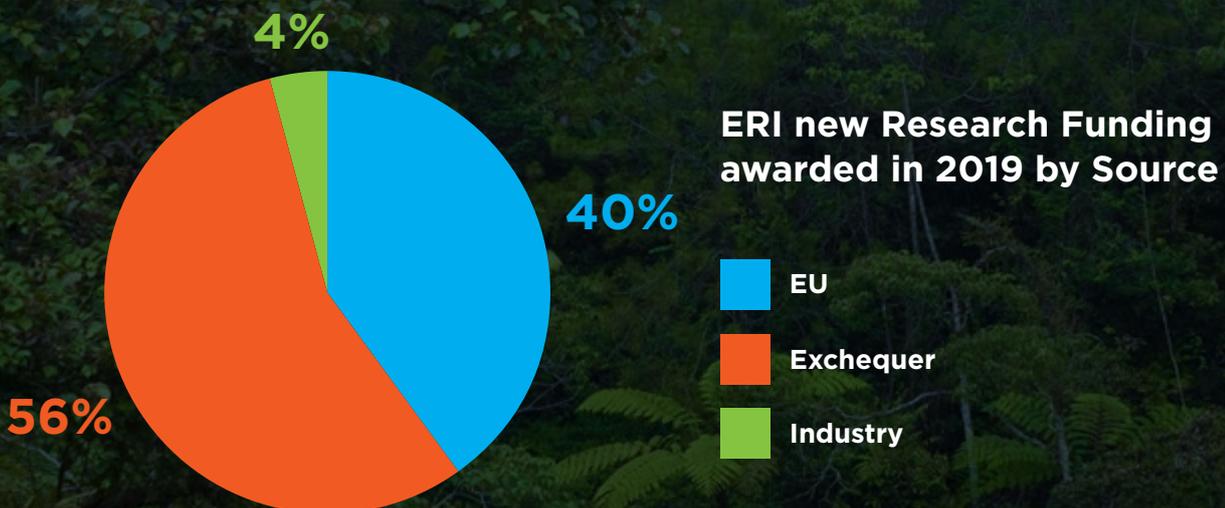
27
POSTGRADUATES
GRADUATED
IN 2019



€77m
IN ACTIVE GRANTS
IN 2019



91
AFFILIATED
ACADEMICS



SECTION 2 – ERI Research Highlights 2019

2.1 Climate Action

Climate change is one of the greatest threats facing humanity. The transition to a zero carbon and climate resilient society as committed to in the 2015 Paris Agreement is now underway. The ERI Climate Action challenge is focused on understanding, responding, adapting and living with climate change.

Launch of the Lir National Ocean Test Facility

The Lir National Ocean Test Facility (Lir NOTF) was officially opened by the Minister for Foreign Affairs and An Tánaiste, Simon Coveney, TD on January 18th, 2019. Housed in the ERI Beaufort Building in Ringaskiddy and managed by Dr Jimmy Murphy (MaREI, ERI, School of Engineering), Lir NOTF houses Ireland's only infrastructure for small to medium scale laboratory testing of ocean and maritime systems, including four wave tanks that can replicate real ocean conditions. Lir also offers a highly experienced team of researchers and operators, making it a vital piece of infrastructure in the MaREI Centre, securing Ireland's position as a global leader in Offshore Renewable Energy (ORE) and providing an invaluable resource for industry, researchers and state institutions. It is anticipated that Lir will become a vital enabler of Ireland's blue economy, allowing both indigenous and international companies to develop renewable energy systems that will ultimately have real impact in how we generate energy from our oceans. As well as renewable energy devices and systems, Lir can also be used to test oil and gas platforms, aquaculture cages, vessels, breakwaters and coastal protection structures, allowing the Lir facility to accelerate Ireland's marine sector development. The Lir NOTF represents a capital investment

of c.€10m, with infrastructure funded by HEA and Bord Gais (under PRTLTI), DCCAE and the Sustainable Energy Authority of Ireland and support from the IDA and Port of Cork. Additional funding was received from DAFM and subsequent capital and equipment awards from Science Foundation Ireland and the Marine Institute. Lir receives ongoing support from SEAI through their Ocean Energy Programme.



Record breaking numbers attend 2019 Wind Energy Conference in Cork



The Wind Energy Science Conference (WESC) held in June 2019 in UCC and organised on behalf of the European Academy of Wind Energy (EAWE) by Dr Cian Desmond of MaREI, ERI was the largest scientific conference ever to be held in Cork. With almost 900 delegates including some of

the world's leading wind energy scientists, the 4-day international festival of wind energy science had 700 talks across eight themes including topics as diverse as *Offshore Wind Energy* to *Artificial Intelligence and Big Data in Wind Energy*. WESC 2019 provided a multi-disciplinary open forum for discussion and exploration of the latest developments in wind energy science, highlighting emerging trends and forging future trans-disciplinary collaborations. Other highlights included a demonstration of a commercial floating wind energy platform, which is currently being tested at the Lir National Ocean Test Facility in the ERI Beaufort Building and a discussion with EirGrid on the challenges faced by grid operators when there is a high percentage of wind energy on the system. Dr Desmond's achievement in securing and organising the event was subsequently recognised by the Cork Convention Bureau, who presented Cian with the 'Academic Conference Award' for 2019 during their award ceremony in September.

Is climate change confusing our ecosystems?



Climate change has resulted in shifts in the timing of spring phenological events, such as leaf unfolding, flowering, leaf senescence, bird migration and insect activity, but differences in the responses of organisms can result in phenological mismatches, with potential negative impacts on biodiversity. A newly launched EPA project, PhenoClimate, led by Professor Astrid Wingler (School of BEES, ERI), Dr Fiona Cawkwell and Dr Paul Holloway (Dept of Geography, ERI), will use current and historic datasets, satellite technology and digital photography to determine the impacts of climate change on Irish biodiversity. The other side of the interaction between plants and our climate is, of course, the role played by plants in carbon sequestration, and in 2019, Professor Wingler, who specialises in molecular plant processes, was invited by the US Department of Energy's Pacific Northwest National Laboratory in Washington State, to present her research on the topic "*Regulation of resource allocation in annual and perennial plants – implications for growth, yield and carbon sequestration*", which highlighted the importance of investigating plant function for carbon fluxes between the soil and the atmosphere.

Award-winning paper examines link between enforcement and environmental outcomes

An emerging challenge in the field of industrial sustainability lies in encouraging firms to move beyond compliance in order to promote sustainable behaviours that drive environmental quality. In their role as an environmental regulator, the Irish Environmental Protection Agency (EPA) is striving to foster an environment which supports firms in changing their behaviour, so that they become proactive rather than reactive. To this end, the EPA approached a multi-disciplinary team of researchers in the ERI to examine the link between enforcement and environmental outcomes. The resulting interdisciplinary working paper, which was co-authored by Dr Ellen O'Connor (CUBS/ERI), Dr John Eakins (CUBS/ERI), Dr Celine McNerney (CUBS/ERI), Dr Stig Hellebust (School of Chemistry/ERI), and Dr Timothy Sullivan (School of BEES/ERI), won the Best Paper Award for the Corporate Social Responsibility Track and Best Overall Paper at the 2019 Irish Academy of Management Conference. Using data from the CSO business survey and the EPA annual reports, the paper measured the impact of current enforcement activities on compliance-based and on sustainability-based outcomes and suggested that "*emphasis should*



be placed on positive sustainable behaviour that is likely to be long-lasting and is more closely associated with the ultimate objective of environmental regulation". A separately prepared EPA report also authored by ERI researchers Dr Celine McNerney, Dr Ellen O'Connor, Dr Bernadette Power and Dr Paul Deane (MaREI, School of Engineering) investigated the effects of the EU ETS on competitiveness of Irish companies and found that, as well as access to finance, lack of internal expertise regarding emissions reductions inhibits greater uptake of and investment in emissions reduction technologies. It is hoped that the findings of this project will lead to policy interventions around these key areas to facilitate more rapid compliance in meeting our emissions targets.



Wave farms could help to prevent coastal erosion

As well as providing renewable energy, wave farms can help protect coasts against erosion by reducing the force of waves. Using computer simulations, a new study, conducted by Professor Gregorio Iglesias (MaREI, ERI, School of Engineering) and colleagues concludes that a wave farm off the south coast of Spain could indeed protect the coastline under higher sea levels, and cause the local beach to grow in size after storms. The EU-funded study is the first to explore how wave farms could affect coastlines under future sea-level rise. The researchers considered the effects of a hypothetical wave farm 500–750 metres off the coast of Playa Granada, a three-km-long beach in southern Spain which has suffered terminal erosion in recent years. The researchers simulated a wave farm's effects on wave heights and sediment movement in this location and suggests that such a wave farm could be more effective at protecting coasts under sea-level rise than traditional hard-engineering solutions such as seawalls or groyne (banks or walls that stretch out to sea from the beach). While the research team has not analysed the possible impacts – notably environmental – of enlarging beaches and changing the flow of sediments, it plans to explore the ecological effects of the wave farm in the near future.

UCC academic acts as key advisor to international Citizens' Assemblies

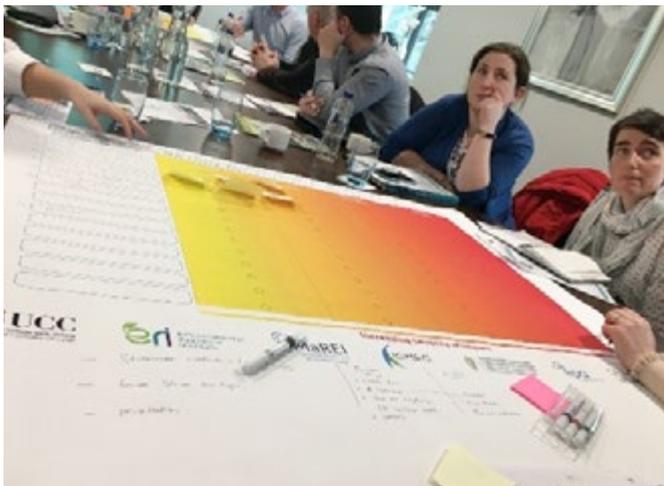
Since its establishment in 2016, the Irish Citizens' Assembly has come to be regarded as an international benchmark, with Irish participants increasingly consulted by countries wishing to adopt this model of assembly. Dr Clodagh Harris (Department of Government & Politics, ERI) was involved in the first Citizens' Assembly pilot, *'We the Citizens'*, in the subsequent Irish Convention on the Constitution (2012–2014), and in the more recent Citizens' Assembly (2016–18). In 2019, Dr Harris brought her considerable experience to bear as a member of the Research Advisory Group of the Scottish Citizens' Assembly, including meeting with Minister Mike Russell (MSP), Minister for Government Business and Constitutional Affairs, Scotland to advise on Citizens' Assemblies, and making an

invited contribution on *'The role of Citizens' Assemblies and reflections on the Irish Citizens' Assemblies'* to the Scottish Electoral Reform's Society public event *'What is the Scottish Citizens' Assembly?'* Dr Harris also prepared expert evidence on *'New ways to shape the future through setting the agenda'* for the National Assembly of Wales, advised the Extinction Rebellion UK's working group on Citizens' Assemblies, and participated in an expert Advisory meeting on Citizens' Assemblies with Minister Francois de Rugy (then French Ecology Minister). In addition, Dr Harris was invited to give key presentations *'Doing Democracy differently- lessons from Ireland's Citizens' Assemblies'*, to the Digital Enlightenment's Forum on *Democracy and the Media in the digital era* in Brussels; and *'Reflections on the Irish*

Citizens' Assemblies' to the *Democracy International/Mehr Demokratie* civil society and activist fact finding mission to Ireland.



Local authorities draw on adaptation guidance from Climate Ireland



The EPA/Department of Communications, Climate Action and Environment (DCCA/E)- funded Climate Ireland programme has been working to increase capacity within the Local Government sector to respond to the climate change impacts through the delivery of a series of adaptation action planning workshops held throughout Ireland in February 2019 with over 100 Local Authority representatives. These workshops were designed to support Local Authorities in de-

veloping adaptation action plans and implementation pathways in accordance with the requirements of the National Adaptation Framework (2018) and Local Authority Adaptation Strategy Guidelines (DCCA/E, 2018). In addition, at the invitation of the Association of Irish Local Government, Climate Ireland contributed to the development and delivery of training workshops entitled *'Climate Action – The Local Authority Response'*. These workshops were held in November 2019 with participation from all of Ireland's local elected representatives. The Cork City Council's Adaptation Strategy, which was published in 2019 benefitted from these consultations with the Climate Ireland team, as well as incorporating submissions from the ERI and School of Public Health academic, Dr Christie Godsmark.

On an international stage, Climate Ireland has been working to enhance the relevance of climate adaptation platforms to their users through the hosting of the 2nd International Climate Change Adaptation Platforms workshop in Dublin on October 10th-11th, 2019. Workshop participants included Climate Change Adaptation Platform experts from across Europe, Japan and Canada who were joined by representatives from Ireland's Climate Action Regional Offices, Local Authorities, Government Departments and State Agencies.



Energising the community to take climate action

The renewable electricity market in Ireland is about to fundamentally change for communities with the introduction of the new Renewable Electricity Support Scheme (RESS). As part of this new auction based scheme, there will be a ring-fenced capacity for 100% community owned projects from 2020 onwards. There will also be an opportunity for citizens to purchase and own shares in new renewable projects. ERI researchers have been engaging with communities on the ground to facilitate discussions on the implications of community energy, and provide expert guidance as part multiple of community-energy research projects in the Institute.

The newly launched Community engagement in wind energy: innovative approaches to achieving a social license (Co-Wind) project, led by Dr Bernadette Power (Department of Economics, CUBS, ERI), Dr Geraldine Ryan (Department of Accounting and Finance, CUBS), Dr John Eakins, (Department of Economics, CUBS, ERI) and Dr Ellen O' Connor (Department of Economics, CUBS, ERI) is an example of how research conducted within the institute will support community energy projects moving forward. Funded by the SEAI's Research, Development & Demonstration Funding Programme, the project will broadly identify public preferences for investment and benefit funds, and produce a community engagement toolkit which can be provided to communities as a resource informed by research.

Renewable energy developments present a viable business opportunity for community groups particularly those in rural areas. There is a role for researchers to equip the communities with the tools necessary to assess and develop these opportunities. A community energy project led by MaREI Research Fellow, Dr Cian Desmond, secured €300K in funding under the SEAI Energy Research Projects scheme to develop solutions that will help homes, businesses and communities in Ireland to deliver a cleaner energy future. The *'Support Tools for Community Renewable Energy'* is a multidisciplinary undertaking that will draw on expertise from across UCC including UCC spin out Exceedence Ltd based in the ERI Lee Road Building to deliver an online tool which will empower community groups to self-organise, plan, finance and develop their own renewable energy projects, run a first pass technoeconomic assess-



ment of the options, and raise project finance through crowd funding. The software will be co-developed with 3 rural and 3 urban communities to ensure that it meets their expectations in terms of functionality and transparency.

The Dingle Peninsula 2030 project is a novel transdisciplinary, community-based research project on climate action based in the Dingle Peninsula led by Professor Brian O'Gallachoir (MaREI, ERI, School of Engineering). At the project outset, researchers Evan Boyle, Connor McGookin and Clare Watson partnered with companies and community groups to co-design and co-develop pathways for reducing greenhouse gas emissions associated with energy and agriculture. This included the completion of a participatory mapping exercise, which enabled a wide spectrum of internal and external stakeholders to assist in delivering a range of goals as outlined by the participants, and to outline the supports required to successfully achieve these goals. This acted as a codesigned research intervention stemming from local discussions on the need to highlight the range of active stakeholders involved in a series of sustainability initiatives on the peninsula. Researchers also led the co-development of an energy master plan for the peninsula, and have been actively involved in a range of socioeconomic workshops across the peninsula. In 2019 the project underwent significant progress in delivering energy transition and climate action initiatives in a rural isolated region. While initially focussing on an ambassador programme with a series of energy efficiency technologies installed in their homes, the activity has evolved significantly through social diffusion into a wide-ranging engaged energy transition project, underpinned by MaREI engaged research and support.

Energy Policy and Modelling Group provide guidance on the challenges faced in meeting our climate targets



Deep decarbonisation of the global electricity sector requires improvements in model detail, size and complexity and transparency to facilitate an understanding of the global challenges ahead, particularly with regard to the large-scale interconnection of power systems. In 2019, MaREI's Energy Policy and Modelling Group at the ERI developed a new global hourly power system model entitled PLEXOS-World. This model is a first of a kind, allowing researchers to understand the detailed operation of most of the worlds power plants and to determine how the power system must change to align with the Paris Agreement. Researchers from the EPMG, Dr James Glynn and Dr Paul Deane, also contributed to several high impact publications in 2019, which serve to provide expertise for policy makers in the area of global energy transitions, most notably with regard to strengthening the EU response to energy poverty which was published in Nature Communications, and developing an inter-model assessment of direct air capture role in deep mitigation pathways which appeared in Nature Communications.

Energy resilience in the built environment

Taking climate action requires us to change the way we think about the relationship between energy supply and demand, ideally leading to the creation of a new, resilient and flexible energy system where energy supply and energy demand interact in real time to assure a clean, secure and affordable supply of heat and power to our homes, businesses and industry. The newly established Centre for Doctoral Training in Energy Resilience and the Built Environment (ERBE) will train innovative leaders with the necessary skills to transform the relationships between buildings and the energy system, providing sustainable, affordable, and healthy places to live and work. ERBE represents an exciting partnership between MaREI, University College London (UK), and the University of Loughborough (UK) that is funded through the SFI-EPSCRC 'Centres for Doctoral Training' (CDT) Programme. In order to deliver this training, a whole system multi-disciplinary approach will be implemented that draws on the skills of each ERBE partner, involving the training of 68 students across five separate intakes. Students are trained through a programme of taught courses and PhD research hosted by world-leaders in their field spanning the technical, social and economic aspects

of energy in the built environment, including: new and renewable energy systems; energy storage; smart controls; data analytics; socio-technical systems; people-centred design; human behaviour and energy economics. The ERBE project will be led by UCC PIs Professor Brian O'Gallachoir, Dr Dominic O'Sullivan, Dr Ger Mullally and Dr Ken Bruton and co-ordinated by Aoife Dunne.



Climate Action – New Principal Investigators



Dr Hannah Daly
(ERI, MaREI, School of Engineering)

Hannah has recently joined UCC as a Lecturer in Energy Engineering and a researcher in the MaREI Energy Policy and Modelling Group. A graduate of UCC for both her undergraduate degree (in Mathematical Sciences) and PhD (in energy policy and modelling), she is returning to Cork after 7 years abroad. Hannah's most recent appointment was with the International Energy Agency (IEA) in Paris, where she led the Agency's work on Energy Access and the UN Sustainable Development Goals, as well as being part of the World Energy Outlook report team.



Dr Andrew Keane
(School of Mathematical Sciences and ERI)

Andrew Keane has recently joined us as a Lecturer in Mathematical Sciences. Andrew completed his undergraduate studies in Australia and Germany before beginning a PhD at the University of Auckland in New Zealand. Upon completing his PhD in Applied Mathematics in 2016, he became a postdoctoral researcher at the University of Auckland. His research expertise lies in dynamical systems and applying its techniques to systems from various areas of application, in particular climate systems. Andrew is interested in the application of dynamical systems theory to areas beyond mathematics and actively embraces the cross-fertilisation between disciplines. So far he has studied systems in the context of neuronal networks, electro-chemical oscillators, climate systems, evolutionary robotics and control theory. Key topics of his research are climate dynamics, delay differential equations, bifurcation theory and coupled oscillators.

2.2 Circular Economy

A shift from a “take-make-consume” to a closed-loop economy where resources are kept in use for as long as possible is now an imperative for society and economy. The ERI Circular Economy challenge is focused on producing food and goods in a closed-loop approach with minimal or no waste.

ERI research advises industry leaders on sustainability challenges



Key to achieving the ERI strategic priorities are actions towards our targets of hosting inter-disciplinary teaching programmes/CPD for industry in key areas of expertise. Agriculture and food are critical sectors of the Irish and EU economy. Current agri-food systems are resource intensive relying heavily on non-renewable inputs and ERI research in this area focuses on opportunities for agriculture to become more ecologically sustainable, resource efficient and resilient by exploring the reuse of residues, nutrient management, reduction of waste, biological pest control, carbon sequestration, and new crop development. Bringing this research experience to bear, in 2019 the ERI contributed to several training events tailored to the Irish Agri-Food Industry. In conjunction with CUBS, Food Industry Training Unit (FITU) and sustainability consultants Brodie, the ERI hosted a leadership development programme for the Carbery Group on the topic of Sustainability in the Value Chain. The workshop

included contributions from the UCC Department of Management and Marketing, School of Public Health, School of BEES, MaREI, and UCC Green Campus and covered pertinent topics for the agri-food industry such as energy usage, ethical considerations in the supply chain, health and well-being and water and biodiversity. Following on from the success of this event, in November the ERI was invited by FITU to participate in the ‘The Sustainability Challenges Facing the Irish Dairy Industry’ event co-hosted by FITU, the School of Food and Nutritional Sciences and the Irish Co-operative Organisation Society (ICOS). This two-day training event on environmental sustainability, afforded a unique opportunity for Irish co-operative board directors and senior management to engage with the leading policy, industry and academic experts in the area of the environment with the objective of evaluating and developing solutions and approaches that will enable the Irish dairy sector to respond positively to the pressing challenges related to environmental sustainability.

The MaREI Centre continues to play a key role as academic partners providing consultation and guidance to numerous industries with regard to the field of renewable/green energy. In 2019, IBEC published their strategy for Carbon 2050 in conjunction with the Energy Policy and Modelling Group, which outlined the vision for what a low carbon economy could look like in the year 2050 and a roadmap for Ireland to pursue this ambition while also safeguarding our energy security and competitiveness. Additionally, Gas Networks Ireland also collaborated with MaREI to produce their Vision 2050 Report – setting out in detail the GNI strategy to achieve a net zero carbon gas network for Ireland.

Cleaning wastewaters using circular economy approaches

Professor Marcel Jansen (School of BEES, ERI) was awarded €1.1M to for a new circular economy project which treats wastewaters as well as recovering valuable resources. (Brainwaves). The project is funded through the Ireland Wales 2014-2020 European Territorial Co-operation (ETC) programme, a programme connecting organisations, businesses and communities on the west coast of Wales with the south-east coast of Ireland. Brainwaves is a collaborative project involving University College Cork and Aberystwyth University, as well as a range of other stakeholders. The interdisciplinary character of Brainwaves is underlined by the involvement of a range of ERI PI’s, including Dr Timothy Sullivan, Professor Edmond Byrne, Dr Alan Morrison and Professor Gavin Burnell. The funding success will enable the groups to significantly expand their research work on the circular economy, and specifically the use of duckweed (Lemna species) for water remediation. Duckweeds grow naturally on waste streams and contain high quality protein including essential amino acids, which can be used in animal feeds for the feed industry. This creates a “reduce, reuse and recycle”, full-circle use of nutrients, by using natural plant growth to create new nutrients to feed the agri-economy, and addressing pollution problems by minimising waste water.



ERI hosts circular economy workshop

Total global consumption exceeds the planet's regenerative capacity by more than 50% and there is broad consensus that an "absolute decoupling" of consumption from resource use and environmental impact is a necessary prerequisite for a sustainable society. A circular economy model provides a framework to achieve this shift while improving competitiveness, increasing security of supply and producing new business opportunities. The transition to a circular economy is one of the three global research challenges adopted by the ERI in its 2018-2022 Strategic Plan. The challenge, requires research efforts across fields of science, engineering, social sciences, business, economics, health, finance, law and humanities to ensure long-term sustainable outcomes. In January 2019, the ERI hosted a half-day workshop to highlight expertise and research projects in the circular economy area within the Institute, identify projects, ideas and collaboration opportunities internally, explore funding possibilities, and discuss how we can leverage our collective expertise, act strategically, and build capacity for circular economy research at ERI and UCC. The half-day programme included flash presentations from UCC staff across the Institute's affiliated schools and centres with a number of opportunities for networking and discussion. Some of the key discussion points that emerged from the workshop included leveraging our existing expertise in areas such as life cycle analysis, creating a database of theoretical projects, existing competencies and infrastructure which can be consulted when building multidisciplinary research teams along with the need for increased industry engagement and education as a means of addressing consumer perceptions and challenging societal norms.



The eco-innovative approach to healthy ageing

Prospects indicate that around the year 2040, the 65+ age group will be in the range of 24% to 45% of the population across the Atlantic Area regions. Malnutrition is a common problem in this age group mostly due to changes in eating habits, food choice and difficulties for meal preparation and intake. Healthy ageing requires a healthy diet, and seafood products provide essential nutrients not always accessible to older adults. With their valuable nutritional properties, marine resources can play a major role in healthier ageing. However, the efficient and sustainable use of marine resources poses some challenges which will be addressed by the newly launched InterReg project Seafood Age (Smart and eco-innovative SEAFOOD processes and products for healthy AGEing). The project aims to adopt circular economy concepts to generate ready-to-eat seafood for healthy ageing, produce novel eco-packaging and develop a smart label for better quality, safety and minimum food waste. As part of the project, Dr Maria de Sousa Gallagher (ERI, School of Engineering) will be developing eco-innovative packaging solutions towards better safety and minimum waste of seafood products while improving convenience for the older population. The project will establish a portfolio of best operation practices towards eco-innovative packaging to be piloted during the project; develop a ready-to-use kit for microorganism detection including spoilage and pathogenic bacteria; gather data for a microbial risk assessment of the packaged product along the cold chain; conduct a life cycle analysis of production processes; along with an evaluating the economic viability.

Biofuels key to closing the waste loop

Waste-to-biofuel biorefining is one of the key enabling strategies of the circular economy closing loops of raw biomass materials, minerals, water and carbon. The Biofuels and Bio-energy Research Group, led by Professor Jerry Murphy, are driving several new projects addressing this challenge. The EFACE (Electrofuels in the Circular Economy) project aims to increase energy efficiency from existing intermittent renewable electricity devices; create a more sustainable agricultural sector through the production of bioenergy; and deliver energy diversification and decarbonisation through the use of advanced transport fuels. The solution presented by the project is the assessment of a Power to Gas facility, which would introduce electrofuels to Ireland for the first time in the form of hydrogen, using electricity from wind turbines at times when demand for electricity is low. Addressing a different source of energy, another project titled BioWILL focuses on Integrated 'Zero Waste' Biorefinery utilising all fractions of willow feedstock for the production of bio-chemicals/materials and renewable energy. BioWILL will deliver a biorefinery model for willow in Northwest Europe, by producing high value salicylates from willow bark for medical applications and using the bark residue and willow pulp for safe food quality packaging material to replace fossil derived plastics; the end of life packaging will be used as a feedstock in a bio-energy anaerobic digestion system producing biogas suitable for grid injection. An industry collaborative research project called 'How to Achieve a Carbon Neutral Distillery' with Irish Distillers Ltd aims to identify potential pathways

to decarbonise the Irish Distillers' production facility located in Middleton Co. Cork. The focus of this research project is to identify alternative uses of by-products generated during the distillation process and explore the potential to convert these into renewable energy using anaerobic digestion to produce biogas which can then replace natural gas used onsite. Assessment of the utilisation of digestate (biofertilizer) remaining after the anaerobic digestion process is also to be conducted. Additionally, calculation of potential greenhouse gas emissions arising from the production of animal feed which may replace the current animal feed produced at the distillery will also be conducted.



Green Campus projects promote circular economy practices on campus



The newly launched Green Campus Living Laboratory Seed Fund led by Dr Maria Kirrane (UCC Sustainability Officer) is the most recent addition to the Green Campus initiatives striving to make sure that campus environmental and sustainability practices are research-informed. A number of the projects led by ERI PIs are focused on the circular economy. ReCircle, a demonstration of deposit-return scheme for reusable food

containers, led by Dr Niall Dunphy (Cleaner Production Promotion Centre, School of Engineering, ERI) aims to develop and demonstrate a tailored deposit-return scheme for reusable lunch boxes for takeaway food. Working with campus food services and other relevant stakeholders, this project will work to transfer the successful Swiss ReCircle social enterprise model to the UCC campus. The scheme will introduce purpose-designed reusable boxes that can be used as alternatives to the single use plastic containers or wrap currently provided. Boxes will be subject to a deposit or loyalty card system, with the deposits returned or accounts released on return of the box. The demonstration will be documented in a case study outlining the experiences of designing and implementing the system on campus. Similarly, another project titled Plastics free UCC: Exploring societal and marketing levers, aims to build upon the existing transdisciplinary capacity within UCC to develop a rigorous academic framework in seeking to understand the drivers, barriers and issues around a UCC Green Campus goal of a single-use plastics free campus by 2023. This project is led by Professor Edmond Byrne (School of Engineering, ERI) with contributions from Dr Claire O'Neill (CUBS, ERI), Dr Gerard Mullally (Dept of Sociology, ERI), Dr Niall Dunphy and Dr Maria Kirrane.

A new life for wind energy structures

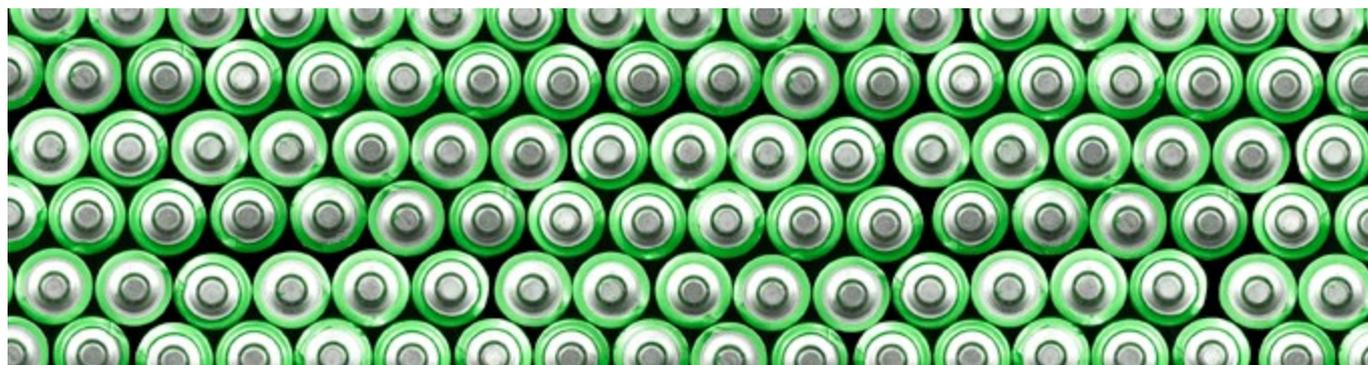
Given the 20-year lifespan of non-biodegradable blades in current wind turbines, many will need to be disposed of in the coming years. ERI researchers involved in the ReWind project are seeking an alternative to unsustainable disposal methods like landfilling and incineration. The project spans the disciplines of engineering, architecture, geography, sociology, and political science and is a collaborative effort between UCC and partners in Queens University Belfast and the USA. In UCC the ReWind team is led by Dr Paul Leahy (MaREI, School of Engineering, ERI), Dr Niall Dunphy (School of Engineering, CPPU, ERI) and Dr Ger Mullally (Department of Sociology, ERI). ReWind explores the blades potential reuse in architectural and engineering structures decreasing a major source of non-biodegradable waste. Now in its fourth year of research activity, the ReWind project team is sharing their findings for the benefit of others. In 2019, ReWind was invited to contribute at the WindEurope workshop “*Accelerating wind turbine circularity*” in Bilbao, to share their experience and best practice on regulation and current sector practices for decommissioning and recycling blades. In addition, Dr Paul Leahy was invited to give the keynote speech “*How sustainable are the technologies of the energy transition?*” focusing on end-of-life wind turbine blades at the International Conference on Power Science and Engineering 2019 in Dublin. A paper published by Dr Leahy and colleagues in 2019 in Transactions of the Institution of Mechanical Engineers, highlighted the role that the wind energy sector could play in the repurposing of offshore platforms formerly used for mining of oil and gas as offshore Power to Gas farms, converting wind energy to gas. Using a case study of the Kinsale Head gas platforms, the feasibility study concluded that the technology exists for a complete, end-to-end conversion process, entirely transforming renewable electricity from fluctuating sources, such as wind or wave power, to readily stored hydrogen or methane.



Energy storage solutions for a low-carbon society

ERI and School of Chemistry PI, Professor Colm O’Dwyer, was amongst 12 leading Irish researchers to be named an Irish Research Council Advanced Laureate in 2019. Each Laureate was awarded €1 million in research funding. The award programme is designed to address gaps in the Irish research and innovation landscape in frontier basic research. Professor O’Dwyer, who leads the Applied Nanoscience Research Group, received the award for his project *Battery performance in technicolor* – which will develop photonic material circuitry and 3D printed batteries for probing electrochemical energy storage mechanisms and cell performance. Taking inspiration from material structures in nature that reflect certain colours such as butterfly wings, beetle husks and peacock feathers,

this project will impose this type of ordered structure on new battery materials so that they can be monitored by carefully mapping out any changes in reflected colour to link it to specific details about how the material stores charge and behaves in a battery. This will allow researchers to screen new energy storage materials more quickly and help define the different conditions that are optimum for more sustainable materials in rechargeable batteries and other energy storage devices – whether it’s faster charging, longer lifetime, quick power delivery or higher energy. Developing the best rechargeable batteries using sustainable methods represents a major technological challenge for this new century as batteries will be central to how our society shifts away from fossil fuels.



Supporting climate-smart innovation in the dairy value chain in the Developing World

The EU funding programme Development-Smart Innovation through Research in Agriculture (DeSIRA) was founded in 2017 to foster innovation in agriculture through scientific knowledge, with a focus on activities that will also reduce poverty and vulnerability and support food security. In 2019 a series of projects were launched which signaled a new direction for this programme to address the SDGs through research and innovation for agricultural and food systems transformation in developing countries. Led by Dr Stephen Onakuse (CUBS, ERI), the CSARIDE project (Climate Smart Agriculture Research and Innovation Support for Dairy Value Chains in Eritrea) has the objective of promoting inclusive, sustainable and climate-relevant transformation of the Eritrean dairy value chain to enhance food and nutrition security, reduce poverty, create job opportunities for young people, and promote resilience to climate change while mitigating greenhouse gas emissions. This project represents a partnership between UCC, UCD, Teagasc, the Ministry of Agriculture in Eritrea, the National Agriculture Research Institute in Eritrea, Hamelmalo College, and various private

sector organisations. It will empower smallholder dairy farmers, facilitate private sector investment along the dairy value chain, and strengthen human and institutional resources of the public research and extension services to accelerate the impact of innovation at scale, particularly in the context of the severe climate change impacts expected in Eritrea.



Circular Economy – New Principal Investigators



Kate Kiseeva
(School of BEES and ERI)

Dr Kate Kiseeva joined the School of Biological, Earth and Environmental Sciences as a Lecturer in Geochemistry in 2019. Kate is an experimental petrologist with a strong background in geology and geochemistry. Many geological processes, such as magma genesis, the formation of mineral deposits, or the metamorphism of rocks, cannot be observed directly because they occur deep within the Earth. Although we may have rock samples brought to the surface by geological processes we can use our experiments to confirm, or discredit, the hypothesis that have been made about their formation. Therefore, as an experimental petrologist, Kate is using lab-based methods.



Eoin McLaughlin
(Department of Economics, CUBS and ERI)

Dr Eoin McLaughlin is a Senior Lecturer in Economics, Cork University Business School (CUBS). Prior to this appointment he was a Lecturer in Environmental Economics at the University of St. Andrews and was also a Leverhulme Early Career Fellow at the University of Edinburgh and University of St Andrews. He is currently a research affiliate of the Queen's University Centre for Economic History and a honorary fellow at the University of St Andrews. Eoin's research interests are in economic and financial history, particularly environmental economics, economic history, and historical demography. He has written extensively on topics related to economic indicators of sustainable development, and has been working on long-run empirical tests of economic theories of sustainable development. Another area that Eoin is working on is the relationship between food security, health and the environment using both anthropometric and palaeoecological indicators.

2.3 Healthy Environment

Our economic prosperity and well-being is underpinned by the quality of our environment and natural capital. The ERI Healthy Environment challenge is focused on protecting our natural ecosystems and providing a healthy environment for humans to live in.

Air quality project highlights the increasing risk of bioaerosols for human health

The need to measure the occurrence and real-time development of bioaerosols related to natural emissions and agricultural and waste-management activities has increased dramatically over recent years. This necessity is based on the undesirable effects that they are expected to have on human health as these particles are known to penetrate deep into the lung lining and also play a role in Earth's climate. For example, *Aspergillus fumigatus*, which is released from both composting and field harvesting activities, is an important airborne fungal spore pathogen known to cause life-threatening infections in immunocompromised patients. High levels of pollen can also be serious to those in the population who have "at risk" respiratory issues such as asthma. The OLBAS project, led by Professor John Sodeau (CRAC, ERI, School of Chemistry), investigated new methods for

detecting and quantifying bioaerosols and in 2019 published a report for the Environmental Protection Agency on their findings. The on-site campaigns carried out at a green-waste management facility in Ireland were the first to provide real-time data on bioaerosol emissions from these types of industrial activities. The results showed that the bioaerosol counts varied enormously depending on working activity, time of day/week and weather conditions. Monitoring data collected in the staff cabin showed that three major bioaerosol events occur each day, at opening time, lunchtime and closing time. Airborne grass pollen was also identified for the first time in real time by measuring its chlorophyll signal. The report went on to recommend that, based on these findings, indoor and outdoor locations likely to be associated with higher bioaerosol occupational risk

such as green-waste composting sites, farms with hay barns and food waste or associated agricultural facilities could be continuously monitored as a matter of course.

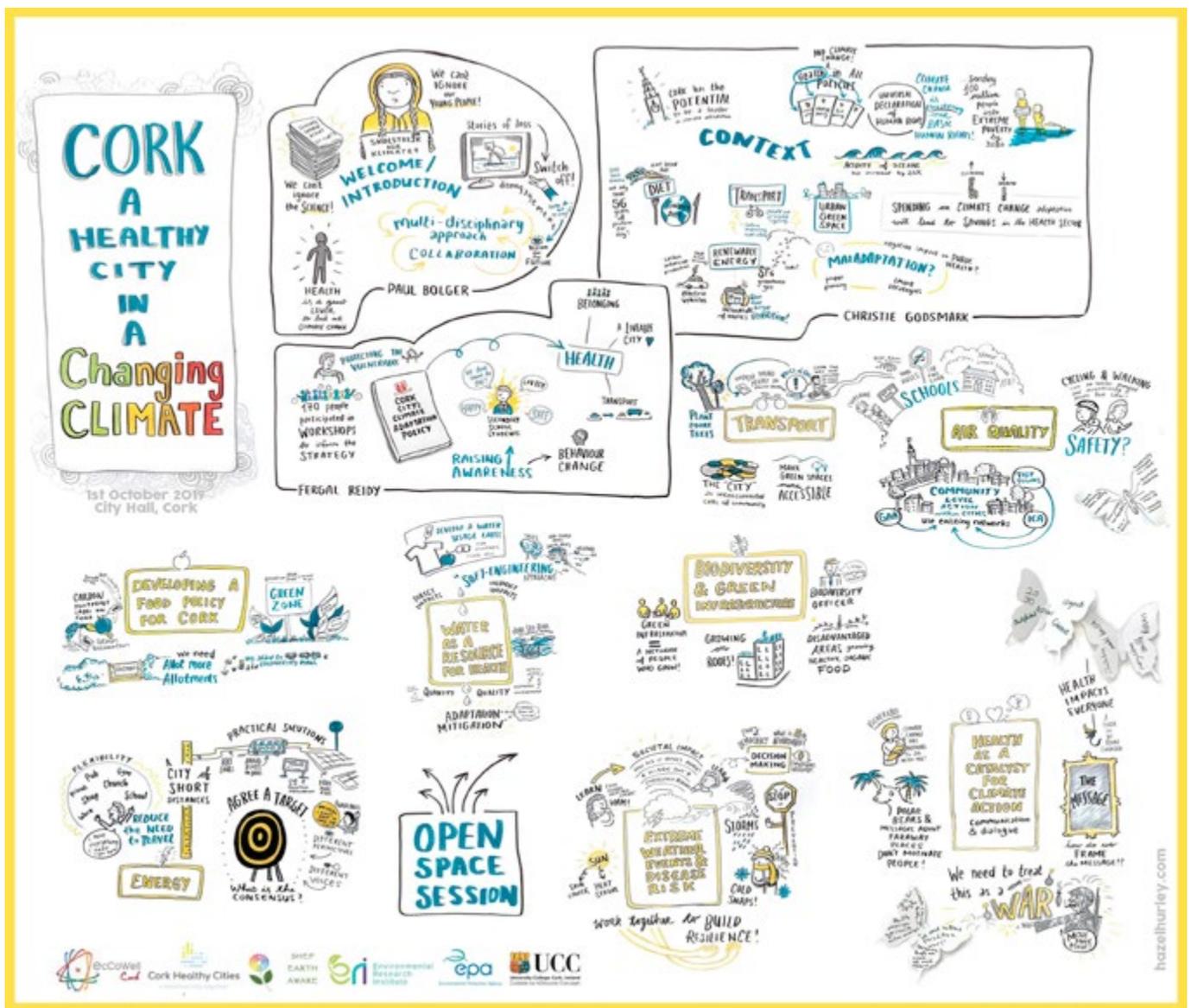


Groundwater a major global reservoir for antimicrobial resistant bacteria



Antimicrobial resistance is an increasingly serious threat to global public health that shows no signs of abating. In fact new modes of resistance are constantly evolving amongst bacteria, fungi, viruses, and parasites when they are exposed to antimicrobial drugs (such as antibiotics, antifungals, antivirals, antimalarials, and anthelmintics). This leads to increased

incidences of rapidly spreading strains of highly pathogenic microorganisms (such as the now familiar MRSA - methicillin-resistant *Staphylococcus aureus*) threatening our ability to treat common infectious diseases, resulting in prolonged illness, disability, and death. Identifying and understanding the sources and pathways for antimicrobial-resistant bacteria is critical. A 2019 study led by UCC School of BEES researchers Dr Jean O'Dwyer, Dr John Weatherhill and Luisa Andrade (with collaborators in Dublin and Canada) has revealed that almost a third of the studied groundwater sources harboured anti-microbial resistant bacteria. This study is the first systematic review and pooled analysis of antimicrobial resistant bacteria occurrence in global groundwater supplies, which are used as primary drinking water sources by 2.2 billion people worldwide and are recurrently linked to significant outbreaks of infection. Findings from the study leave little doubt that groundwater represents a major global reservoir for antimicrobial resistance; however significant additional research is required to establish environmental determinants and mechanisms mediating their occurrence.



Cork - a healthy city in a changing climate?

As climate change becomes increasingly accepted as a threat to public health, it is recognised that these health risks are likely to be unevenly distributed and will generally be greater for disadvantaged communities. In 2019, the ERI, in conjunction with Cork Healthy Cities, the Environmental Protection Agency, SHEP Earth Aware and EcCoWeLL Cork, hosted a 2-day public workshop to identify key actions to mitigate the impact of our changing climate on our health and wellbeing. ‘Cork a Healthy City in a Changing Climate?’ focused on the context and science of climate change with a specific emphasis on action at local level. The first day’s event was launched by Deputy Lord Mayor and Green Party Councillor Oliver Moran and consisted of a set of seminars presenting the science of climate and health aiming to stimulate discussion on the key public health considerations of climate mitigation and adaptation. Professor Ivan Perry of the UCC School of

Public Health set the scene for the subsequent presentations and discussions by highlighting the global significance of climate change as a threat to public health. The second day’s event provided a platform to explore and discuss the opportunities for action to promote health in Cork City in the context of a changing climate and to identify key inter-agency action areas for the implementation of the Cork City Adaptation Strategy and Cork Healthy Cities Action Plan. The approach provided an opportunity to hear briefly from key experts with presentations from ERI researchers across multiple disciplines including Dr Christie Godsmark, Professor Ivan Perry and Dr Janas Harrington (all from the School of Public Health), Dr Jean O’Dwyer (School of BEES), Professor John Sodeau and Dr Dean Venables (CRAC, School of Chemistry), as well as Fergal Reidy of Cork City Council, Kieran Lettice of Energy Cork, Finola McCarthy of LTI Horticulture Black-

rock, Dr Margaret Desmond of the EPA and Dr Ina Kelly, HSE. Topics discussed by each group included air quality, water quality biodiversity and green spaces, energy, extreme weather events and disease risk, health as a catalyst for climate action, food sustainability, mental health and active transport. Key actions such as the need for soft engineering solutions to combat flooding, a national smoky coal ban, solar powered bins and sustainable footprint labeling on products were identified by group discussion amongst members of the public, policy makers and research experts, collated. These actions will be embedded in the implementation of the Cork City Climate Adaptation Policy and the Cork Healthy Cities Action Plan 2020 – 2030 along with various local community development committees where they will contribute to the formation of new policy decisions.

Improving our understanding of the impact of microplastics in freshwater

Microplastics are plastic particles smaller than 5mm. These particles are widespread in seas and oceans, and their harmful effects on many different marine animals are well known. In contrast, we know relatively little about microplastics in fresh water: their sources, environmental fate, and biological impacts. Several large scale projects are currently working to develop monitoring technology for these plastic particles, as well as creating models to explain its spread and build-up in the marine environment. However, microplastics can vary greatly in chemical composition, size, shape and concentration, and may have different toxic effects under fresh water conditions. Therefore, more information is needed to identify those microplastics posing the biggest risk for fresh water species and the freshwater environment which is the central objective of the EPA-funded Impact of Microplastics project, led by Professor Marcel Jansen (School of BEES, ERI). The project is exploring the impacts of microplastics on Irish fresh water aquatic organisms and ecosystems. This knowledge can inform monitoring programmes and regulatory policy by identifying those microplastics that pose the biggest risks to the freshwater environment. In 2019, the project team held an intensive workshop on microplastics in the freshwater environment. A large group of scientists and students gathered at the ERI Lee Road Building to discuss advances in our understanding of microplastics and their potential impacts on the environment. Experts from Galway, Edinburgh, London, Wallingford, and Ostend (Belgium) presented their research, focussing on key issues in microplastics research such as the presence, detection, and fate of microplastics in freshwater and marine environments. A key message arising from the workshop was that while microplastics are now ubiquitous in

the freshwater, marine and terrestrial environments, understanding of the impacts of these microplastics on organisms, and trophic transfer between organisms, remains inadequate, and monitoring is still in its infancy.

Knowledge on trophic transfer of microplastics within ecological food webs is also scarce. In the marine environment, by-caught seals are a good source of data to monitor the incidence of microplastic pollution within coastal food webs. A 2019 study from Dr Emer Rogan (School of BEES, ERI) and colleagues examined the incidence and distribution of microplastics along the intestines of by-caught seals recovered from nets off the south coast of Ireland. The researchers found microplastics in the intestines of all of the seals, and noticed that the locations of microplastic retention overlapped with the location of parasite aggregations, posing a question - which requires further research - of whether microplastics may play a role in host-parasite interactions.



Sustainable Development Goal implementation in Ireland

In September 2015, UN Member States adopted the 2030 Agenda for Sustainable Development (“Transforming our World”). The 2030 Agenda is a plan of action for people, planet and prosperity and applies to both developed and developing countries. The centre piece of the 2030 Agenda are the 17 Sustainable Development Goals (SDGs). The 17 SDGs reflect the economic, social and environmental dimensions of sustainable development and aim to achieve human development goals without compromising the integrity and stability of the planetary system to provide for future generations.

The recently launched MaREI-based SDGs4I project (Identifying Interactions 4 SDG Implementation in Ireland) led by Dr Martin Le Tissier and Hester Whyte explores these global aspirations against national goals in Ireland to understand the nature of interactions between SDGs and targets - negative and positive - and their implication for coherent planning and efficient policy design in Ireland to reflect national context, perspectives and priorities. This EPA-funded project specifically addresses SDG Target 17.14 under Goal 17 (Partnerships for the Goals) calling on all countries to enhance policy coherence for sustainable development. As part of the project researchers will explore: integrating policy analysis to ensure that proposed policies, programmes and targets are supportive of nationally tailored SDGs; coordinating institutional mechanisms to create formal partnerships across sectoral line departments and agencies and; integrating modelling & tools to help clarify and articulate the interconnected system of goals and targets and to analyse and inform key policies, programs and projects for their impact on nationally tailored SDGs. The project focuses on how environmental features of the SDGs support social and economic goals in Ireland, and which SDGs are important in the context of national, regional and international responsibilities for Ireland.



Climate Change occurring too fast for some species to adapt

In wildlife, the most commonly observed response to climate change is an alteration in the timing of biological events such as hibernation, reproduction or migration (phenological traits). Changes in body size, body mass or other morphological traits have also been associated with climate change, but show no systematic pattern as confirmed by a 2019 Nature Communications study from Dr Tom Reed (ERI, School of BEES) and colleagues. The researchers extracted relevant information from the scientific literature to relate changes in climate over the years to possible changes in phenological and morphological traits. They also evaluated whether observed trait changes were associated with higher survival or an increased number of offspring. The findings contained both good and bad news for the species studied. On the one hand, the data shows that many species are changing in ways that increase survival and reproductive success. However, the models also show that this may not be enough for populations to stay in the game long term, because the rate of adaptive change is too slow. The fear

is that the prognosis for species of conservation concern, for which researchers had little data, could be even worse. It is anticipated that this analysis and the assembled data sets will stimulate further research on the resilience of animal populations in the face of global change and contribute to a better predictive framework to assist future conservation management actions.



UCC Green Campus climbs the international rankings



2019 was a very busy year for the UCC Green Campus Team. On April 14th and 15th, the university was host to the 2019 Annual International Workshop on UI Green Metric, which addressed the theme of “*Sustainable University in a Changing World: Lessons, Challenges and Opportunities*.” Over 100 international delegates from 30 different countries across the globe attended the three-day event. An Tánaiste, Mr Simon Coveney, who opened the event called on all universities to encourage and challenge each other do better, to look at innovation and to set example to all other institutions in the fight towards sustainability. In December 2019, UCC was, for the second year running, ranked 9th globally in the UI Green Metric Ranking.

Also in 2019, UCC was awarded its 4th Green Flag from An Taisce, on behalf of the Foundation for Environmental Education, and ranked number 1 globally for SDG12: Responsible Consumption and Production in the Times Higher Education’s new Impact Ranking. 2019 also saw the pilot UCC Green Campus Living Laboratory Seed Fund launched. The fund has supported one MSc. studentship and 5 demonstration projects on topics as diverse as behaviour insights on single-use plastic use, an “Open Arboretum” on campus, and a Swap Shop for international students.

Do nature documentaries work?

The increasing popularity of nature documentaries, such as Blue Planet, has sparked debate about their role in generating awareness of the natural world. A 2019 study from researchers in the School of BEES and the ERI tracked how nature documentaries transfer conservation knowledge by measuring audience reactions and engagement on Twitter and Wikipedia. Using the BBC’s Planet Earth 2 presented by Sir David Attenborough as an example, Dr Darío Fernández-Bellon and Dr Adam Kane looked at how Planet Earth 2 portrayed nature: what species appeared in the show, how much time on screen was dedicated to each, and what group of animals they belonged to. They then searched Twitter for 35,000 tweets with the hashtag #PlanetEarth2, to see if audiences reacted more to some species than others. By analysing the number of visits to Wikipedia pages of each species, they then assessed whether audiences were searching for further information on

each species. Finally, they looked to see if donations to two nature charities coincided with the broadcast of the show. The research, published in Conservation Letters demonstrated spikes in visits to a species page right after the broadcast; this spike was independent of how well or poorly known the species was beforehand. In fact, the researchers found that Wikipedia pages of species that were poorly known by audiences, such as Golden Mole, received little or no attention before the show, but Planet Earth 2 served to put them on the map, generating increases in public awareness which lasted for months. Although the research found changes in public awareness of species, the link with proactive conservation actions, such as donations, was not clear. Researchers suggested that associating a single unique charity with the show, may create a clearer ‘call to action’ for viewers in this regard.



The Anatomy of Ancient Animals

UCC researchers have discovered a new way to reconstruct the anatomy of ancient vertebrate animals by analysing the chemistry of fossilised melanosomes from internal organs. The 2019 study, published in the journal *Proceedings of the National Academy of Sciences of the United States of America*, was led by Valentina Rossi and her supervisor Dr Maria McNamara (School of BEES and ERI) in collaboration with an international team of chemists from the US and Japan. The team used cutting-edge synchrotron techniques to analyse the chemistry of the fossil and modern melanosomes using X-rays, allowing them to peer inside the anatomy of fossils and uncover hidden features. Until recently, most studies on fossil melanin have focused on the skin and feathers, whereas here the pigment is linked to visible colour. Unexpectedly, the new study also showed that melanin is abundant in internal organs of modern amphibians, reptiles, birds and mammals, and their fossil counterparts. This discovery opens up a new avenue for reconstructing the anatomy of ancient animals. In some fossils, researchers can identify skin, lungs, the liver, the gut, the heart, and even connective tissue. Additionally, this study suggests that melanin had very ancient functions in regulating metal chemistry in the body going back tens of millions of years. The team made the initial discovery of internal melanosomes in 2018 on fossil frogs. The advent of new synchrotron X-ray analysis techniques allowed them to harness the energy of fast-moving electrons to detect minute quantities of different metals in the melanosomes. The fossils are so well-preserved that even the melanin molecule can be detected.

Heat waves – at the dangerous intersection of climate change and public health

Heatwaves are becoming more frequent due to our changing climate. In addition to threatening the lives and health of vulnerable populations, heatwaves have cascading impacts in other areas of society, such as reduced economic output, strained health systems and rolling power outages. The Lancet estimates that in 2017, 153 billion hours of work were lost due to extreme heat. To reduce future risks posed by climate change, we need collective global action to scale up early warning systems for heat waves. Cities have a unique potential to adapt to changing heat risks through effective risk management at multiple levels within a city; connecting policies and incentives; and strengthening community adaptation capacity. In 2019, the Red Cross Red Crescent Climate Centre (RCCC) produced the RCCC Heatwave Guide, a report intended to provide a resource for cities to start planning for extreme heat. ERI researcher Dr Christie Godsmark (School of Public Health) was an expert reviewer for this report which provides information and recommendations for technical staff within city government including: working with partners to understand city-specific heatwave risks;

operational approaches to prepare for an imminent heatwave; response strategies to reduce human harm during a heatwave; and ways to learn from a heatwave that has just ended. Case studies from cities around the world are included in this guide to highlight effective urban heat adaptation strategies, including early warning systems, climate-sensitive designs and public information campaigns. Dr Godsmark's own research centres on the impacts of climate change and extreme weather events on human health and wellbeing with a particular

focus on vulnerable populations. Her most recent publication *Heat-health vulnerability in temperate climates- lessons and response options from Ireland* highlights the anticipated heat-health challenges in Ireland, and other temperate regions, through analysing vulnerable groups and systems, reinforcing the need to respond and advocate for the adoption of a "health and climate change in all policies" approach and the development of a public health-focused heat-health action plan.



Noise as pollution – human impact on the sensitive underwater world

Human activity in and around the world's oceans brings tremendous growth as part of the Blue Economy but also increases the demands and pressure which we are placing on this ecosystem, particularly with regard to biodiversity. Continuous, pervasive noise from shipping, construction, and offshore oil surveys can adversely affect marine species through the propagation of sound waves, threatening the environmental status of the ocean. ERI researchers are investigating the extent of this impact and working to develop solutions through improved monitoring and management. JONAS is an Atlantic Area funded project coordinated by the MaREI Centre, which strives to mitigate the threat to biodiversity from underwater noise pollution in the northeast Atlantic through networking with other projects, researchers, and industry professionals working on underwater noise projects. Having identified the need for more research on noise propagation and reception along with increased efforts to standardise terminology, measurements, techniques and ways of reporting, JONAS is poised to push this forward and support researchers, policy makers and industry in working together to reduce negative impacts of anthropogenic underwater noise.

Many cetaceans use sound to navigate, communicate and feed. They are, as such, vulnerable to acoustic pollution. In 2019 the MaREI-based KOSMOS surveys enabled large-scale analysis of effects of seismic surveys on cetaceans. While this has been done on single species or at very small spatial scales, this is the first time that significant impacts (80% reduction in sightings of baleen whales and 50% reduction in sightings of toothed whales) have been shown across multiple species.



Healthy Environment – New Principal Investigators



Paul Holloway
(Department of Geography and ERI)

Paul is a lecturer and researcher in the School of Geography with a background in Biodiversity; Geographic Information Science (GIS); Movement Ecology and Species Distributions. Paul's research interests lie in how GIS, geocomputation, and spatial analysis can be used to address a suite of geographical, ecological, and environmental issues in natural, urban, and agricultural systems. His primary research explores the long-standing issue of incorporating movement into future projections of species distributions, as well as looking at new methods and techniques (e.g. step-selection analysis) for analysing animal movement through different environments. He is also involved in using spatial statistics and participatory GIS to explore questions related to urban infrastructure, planning policies, agriculture, and epidemiology.



Dr Marguerite Nyhan
(ERI, MaREI, School of Engineering)

Dr Marguerite Nyhan is a Lecturer in Environmental Engineering in the School of Engineering. While conducting her PhD in Environmental Engineering in Trinity College Dublin, Nyhan was invited to Massachusetts Institute of Technology and was awarded a Fulbright Scholarship. Following this, she worked as a Post-Doctoral researcher at MIT and then at Harvard University. Later, she was recruited by the United Nations in New York, where she worked as a Research Scientist. With her background in environmental engineering, urban analytics and public health, Marguerite leads research in designing intelligent solutions for climate friendly, sustainable, healthy and livable cities of the future. Her work also focuses on the human health impacts of climate change, and in harnessing emerging technologies for humanitarian efforts and sustainable development work. Marguerite is also currently a Visiting Scientist at Harvard University.

SECTION 3 – ERI Research Centres’ Reports

Cleaner Production Promotion Unit



The CPPU conducts multi-disciplinary research on the sustainability of socio-technical systems; sustainable consumption; governance for sustainability; and the broader human aspects of sustainable development. The Unit is led by Dr Niall Dunphy (School of Engineering and ERI).

Addressing UCC’s climate impact

Continuing a long-standing collaboration, in 2019 CPPU and the UCC Buildings and Estates Office, embarked on an exciting new project addressing the university’s climate impact. With this project, CPPU’s Lauren Quinlivan and Dr Niall Dunphy are determining the greenhouse gas emissions (i.e. carbon footprint) associated with the university’s activities and using this knowledge to work with stakeholders devising a Climate Action Plan. The first part of the project involved the determination of the carbon footprint of the university’s activities using data from the 2017-18 academic year. The calculation of the carbon footprint followed the Greenhouse Gas Protocol Corporate Standard which represents an update of previous carbon footprints conducted by CPPU. A significant enhancement over previous studies is the inclusion of emissions associated with the university’s procurement of goods

and services which is often excluded from assessments due to calculation difficulties. The second part of the project involves working with key stakeholders in priority areas highlighted by the carbon footprint. Here, the researchers are engaging with stakeholder panels using a structured dialogue process to explore opportunities and challenges and to co-create measures to form the basis of a climate action plan.



Communities and energy in Austria

During September 2019, Dr Niall Dunphy and Dr Breffní Lennon, conducted extensive fieldwork in Ternitz, Lower Austria on communities and energy. This work was carried out as part of the SEAI funded *EnergyPOLITIES* project, in which citizen participation in the energy transition is being explored. This is being achieved through examining different examples of citizen participation and civic mobilisation around energy projects. The innovative participatory business model found in *PhotovoltaikProjekt Ternitz*, represents an exemplar of how the energy transition can be delivered with the support of local communities. Working closely with local partners, the researchers engaged with local citizens and the city council officials to examine the social dynamics that informed the development of the solar power project, and understand the lived experiences of those impacted by the development. The fieldwork was very productive and subsequent analysis and interpretation of findings offer fresh insights that is informing subsequent work.

Citizen Engagement – Envisioning Energy Futures

On 22 October 2019, Professor Evelina Trutnevyte from the University of Geneva gave a invited talk at the ‘Citizen Engagement – Envisioning Energy Futures’ seminar organised by the EPA-funded *Imagining 2050* project, with contributions from Professor Brian Ó Gallachóir, Dr Niall Dunphy, Dr Gerard Mullally, and Dr Alexandra Revez (all UCC). Professor Trutnevyte presented an overview of the use of Informed Citizens Panels as a research tool. These were used to explore citizen preferences of different low carbon energy portfolios in Switzerland. The process aimed to ensure that the panel had a foundational understanding of different energy sources and technologies. Findings highlight the value of the information led process in the selection of the low carbon portfolio, stability of knowledge regarding some energy sources over others, the value of energy autonomy, and exploring local specificities in the creation of preferred portfolios. The issue of national energy autonomy and ownership was stressed and all speakers agreed that this is a strong theme which drives greater acceptance of new energy portfolios.



MaREI, the SFI Research Centre for Energy, Climate and the Marine



MaREI is coordinated by the ERI and is Ireland's SFI Centre for energy, climate and marine research, development and innovation working across 12 Irish academic institutions and collaborating with over 50 industry partners. The Centre is led by Co-Directors Professor Brian Ó Gallachóir and Professor Jerry Murphy.



MaREI receives renewed SFI funding

Since its establishment six years ago, MaREI research has made a significant research contribution to the areas of the Energy Transition, Climate Action, and the Blue Economy, and has used this research to inform policy, support industry, and empower society. MaREI has helped over 75 energy, climate and marine companies to date in developing new technologies, from design through to demonstration and commercialisation; lowering their overall carbon footprint and energy bills; and in developing strategies to harness the opportunities associated with the Energy Transition, Climate Action, and the Blue Economy, including underpinning ESB's recent strategic plan to lead Ireland's transition to a low-carbon energy future. The Centre's research has underpinned energy and climate policies of the Irish Government and the European Union, particularly the EU decision in 2018 to increase its 2030 renewable energy targets. Through engaged

research and dialogue with communities, MaREI also supports the human and societal dimensions of the Energy Transition, Climate Action, and the Blue Economy.

On May 9th 2019, the Minister for Business, Enterprise and Innovation, Heather Humphreys TD, and Minister of State for Training, Skills, Innovation, Research and Development, John Halligan TD, announced an investment of €230 million in six SFI research centres as part of Project Ireland 2040. MaREI was amongst the successfully funded centres, receiving €19 million in funding. Key to MaREI's strategy for Phase 2 is the expansion of the Centre's institutional partner base from six to thirteen partners supporting a general move towards larger, more challenge-based projects within the Centre, and the forming of new industry partnerships to focus on emerging challenges such as the hydrogen economy and industrial efficiency.

Irish Government welcomes research insights from MaREI energy policy group



MaREI's research increasingly underpins energy and climate policies of the Irish Government, and in 2019 the Centre continued its engagement with policy makers at multiple levels. The Irish Government published the highly ambitious Climate Action Plan (CAP) during 2019, which explicitly cites MaREI research and guidance on climate adaptation and the web-based Climate Ireland platform. MaREI provided insights on climate mitigation from analysis results to the Government as the plan was developed. This policy document is the first to specify how Ireland can meet its mandatory EU 2030 emissions reductions targets. To mark Europe Day on May 9th, students from eight Irish Universities were invited to a special sitting of the Houses of the Oireachtas to give presentations on policy challenges facing the European Union. Connor McGookin, PhD student in the Energy Policy and Modelling Group gave an account of his research on supporting the energy transition to a low carbon future on the Dingle peninsula. Connor's SFI-funded project, Facilitating Ireland's low carbon transition through the development of new societal

and energy system frameworks, aims to overcome the obstacles slowing the rate of progress to a low carbon transition by encouraging more active stakeholder engagement. He highlighted three findings, namely that climate change mitigation ambitions must be stepped up, secondly that there is a huge public appetite for climate action and thirdly that local action must be adequately supported. Similarly, Dr Paul Deane, also of the Energy Policy and Modelling Group, presented to the Oireachtas Joint Committee on Climate Action in October as part of a discussion on Hydraulic Fracturing Exploration. The Joint Committee also incorporated research findings from a 2019 publication from Dr James Glynn of the Energy Policy and Modelling Group, calling for 5-10% CO₂ reductions per year with carbon budgets to a zero carbon energy system by 2050, into their proposal report entitled *'Forty ways to revolutionise Ireland's approach to climate change'*.

In an effort to ensure Ireland is at the forefront of adapting to a more climate resilient future, An Taoiseach Leo Varadkar hosted a Science Week meeting of key climate change experts and scientists to discuss how Ireland can lead the charge of climate change adaptation, mitigation and transition. Present at the meeting were Dr Barry O'Dwyer of the Climate Ireland project, Clare Watson and Professor Brian Ó Gallachóir, both of the Energy Policy and Modelling Group.

Another invaluable step in informing research outputs, and in enabling closer integration between research and policy has been the ongoing series of seminars, jointly organised by MaREI and the Evaluation and Audit Unit in the Department of Foreign Affairs and Trade, which aims to provide a forum for policymakers and wider stakeholders to discuss the challenges of system transition for policy, and build a common understanding of how such transitions can be implemented and evaluated.

Maritime Spatial Planning

Marine Spatial Planning (MSP) is a relatively new way of looking at how we currently use the marine area and planning how best to use it into the future. MSP strives to strike a balance between the different demands for using the sea including the need to protect the marine environment. This takes into account planning when and where human activities take place at sea and ensuring these activities are as efficient and sustainable as possible. MaREI's research strengths in the area of MSP are becoming increasingly recognised, as is evident by the 2019 appointment of Dr Anne Marie O'Hagan to join the Department of Housing, Planning and Local Government's Expert Group on Marine Protected Areas (MPAs), convened by Minister Eoghan Murphy. The Expert Group is comprised of three sub-groups and Anne Marie will lead the sub-group on 'legal, governance and political aspects' of MPAs. The group's work will include reviewing existing marine environmental protection measures and advising on the processes required for the creation of MPAs. It will also consider the gaps in existing legislation to underpin

such a network. This will assist Ireland in meeting its marine environmental protection requirements under EU and international law. Slightly further afield, Dr O'Hagan was also invited to join the Technical Committee of the European Wave and Tidal Energy Conference (EWTEC) in 2019. EWTEC provides a forum where those at the forefront of technology development in the sector meet, interact, present their latest knowledge and debate new ideas and issues pertinent to wave and tidal energy conversion, including those related to planning, socio-economics, consenting and the environment.





Tracking and rehabilitation of the Irish grey seal

The Marine Ecology Group (MEG) at MaREI conducts fundamental and applied research on key marine species across the food web, from plankton to top predators and contributes scientific knowledge to industry and to policy (advice on risk and mitigation, nationally and at EU level). The Group has internationally recognised and nationally unique expertise in monitoring sensitive marine species, particularly higher predators such as seabirds and marine mammals protected under national and EU conservation legislation. In April researchers from MaREI and the School of BEES fitted 10 grey seals from the Inishkea islands with GPS tracking technology, as part of a study on seal-fishery interactions. As apex predators, the behaviour and health status of seals is an important indicator of the condition of the entire ecosystem in which they exist.

The data gathered from this project will ideally help to answer key questions such as how seals are getting into fishing nets, how often they are getting caught, and what can be done to prevent this. Also contributing to this knowledge base is the SeaMonitor project which tracks rehabilitated harbour seals from the Exploris aquarium (Northern Ireland) to understand how well rehabilitated seals fare following release. Working closely with fishermen, the team are looking at key factors such as where the seals are travelling to in relation to fishing boats, and where the seals may be at risk of getting caught in nets. The next step is to feed that information back to relevant authorities, such as Inishore Fishery Forum and BIM in order to help conservation efforts and have maximum research impact.

Co-designing the sustainable development of Ireland's offshore wind resources

Under its Climate Action Plan, the Irish Government is aiming to have 70% of Ireland's electricity generated from renewable sources by 2030; a 2019 Government announcement heralded the fast-tracking of seven offshore wind projects in the Irish Sea under a new planning regime. Public perception of wind-farms has been historically contentious in Ireland particularly in rural areas, but it has been hypothesised that the placing of wind farms offshore has potential for less societal resistance. To test this, researchers from the EirWind project conducted the first National Survey on Public Perception of Offshore Wind Farms. Carried out by Ms Yvonne Cronin and overseen by Dr Valerie Cummins, the survey polled 1,154 people online and suggested that there is 'significant' support from the Irish public for the development of offshore windfarms in Irish waters. EirWind is a MaREI Centre industry-led collaborative

research project, using offshore wind as the catalyst for innovation and impact funded by industry partners and Science Foundation Ireland. The project utilises the concepts of Marine Spatial Planning (MSP) to develop a stakeholder engagement and data management framework for the study of strategic areas for the development of offshore wind, off Ireland's east, south and west coasts, and to assess impacts from the development of renewable energies offshore from a biological, environmental, infrastructural and sociological point of view. The areas covered by the survey included the experience of the Irish public with offshore wind farms to date but also also looked at issues of job creation, effects on wildlife and visual impact and whether people would be inclined to object to the development of offshore wind farms in their area.

Biogas gets an upgrade with green hydrogen

Ireland's plans to have 70% renewable electricity by 2030, much of which will be offshore wind, could prove problematic on an island system. Green hydrogen from offshore wind is a facilitator of renewable electricity, reducing curtailment and constraint and is a form of chemical storage. However, hydrogen use presents some unique challenges due to its low energy density impacting distribution, its flammability and the lack of industry take-up. In 2019, researchers in the Biogas and Biofuels group led by Professor Jerry Murphy made significant advances in the energy transition by demonstrating the potential for green hydrogen to upgrade biogas to renewable methane. Green hydrogen produced via electrolysis facilitates the greater use of variable renewable energy by reducing curtailment at times of high wind and low demand. The research published in 3 separate research articles, demonstrated that biological methanation can replace physio-chemical upgrading of biogas, increase energy output by 70% from a biogas facility, and lends itself to existing digester systems. A prototype of the sequential 'ex-situ' reactor system is under construction in the Biogas and Biofuels laboratory in the ERI Lee Road Building, due for completion in 2020.





Strengthening the EU response to energy poverty

Energy poverty describes the lack of access to modern energy services and is becoming a widespread problem across Europe, as between 50 and 125 million people are unable to afford proper indoor fuel for heating. According to the Energy Poverty Action initiative of the World Economic Forum, energy poverty is the manifestation of social inequality in energy consumption and access to energy is fundamental to improving quality of life and is a key imperative for economic development. A 2019 Nature Energy paper from Dr Paul Deane (Energy Policy and Modelling Group) and colleagues, described the extent of energy poverty in the EU and demonstrated how policymakers can strengthen the response to energy poverty. It revealed that the concept of energy poverty was not recognized in legislation until 2009, and only inadequate and fragmented level responses have been seen across some member states. It proposed four key areas for EU action including prescriptive measures encompassing financial support, disconnection safeguards, consumer engagement and energy efficiency. Secondly, the EU should establish a definition for energy poverty to develop a common basis from which member states can take action. Thirdly, additional data should be gathered, including improved detail on building stock related income and energy consumption data, and higher spatial resolution on affordability concerns. Finally, strategic coordination is required across social, consumer and energy policy, given its multidimensional nature and to avoid continue ineffective action.

Inter-model assessment of direct air capture role in deep mitigation pathways

The Paris Agreement has set ambitious objectives to keep global warming well below 2°C, and the scientific debate has recently focused on the pursuit of 1.5°C targets. Given the current level of CO₂ emissions and the delay of global mitigation efforts, large-scale removal of CO₂ from the atmosphere is likely to be needed. Concerns about the sustainability of biological strategies to achieve this end and the inevitable competition with food, water use, and ecosystems have led to a focus on alternatives to sequester carbon from the atmosphere. Direct Air Carbon Capture and Storage (DACCS) is a complementary technology; it can capture the CO₂ produced by distributed sources, is modular and does not have major water and land interactions while competing for geolog-

ical storage with other carbon sequestration options. Until recently, only a few modelling exercises had included CO₂ removal measures other than afforestation and bioenergy with carbon capture and storage, and never in an inter-model comparison. A 2019 study from Dr James Glynn (Energy Policy and Modelling Group) and colleagues became the first study to analyse DACCS using two global techno-economic models in an integrated assessment. This paper describes the critical issues related to energy consumption, and the costs and materials necessary for an extensive rollout of DACCS technologies in global mitigation strategies. The energy requirements for manufacturing the chemicals to remove carbon dioxide from the atmosphere are pro-

jected to be significant, and may limit the amount of installed DACCS. The benefits from DACCS technologies are linked to the rate at which its capacity can be ramped up; this rate will likely be very limited in the near-term. DACCS shows considerable potential. However, the indirect impacts of large-scale deployment will need to be studied further, as they are likely to be considerable. If we over-rely on DACCS and it doesn't deliver emissions removals at large-scale, then we will overshoot our Paris Agreement targets, possibly quite significantly. The paper concludes that DACCS is not an alternative to reducing emissions, and that we must continue ratcheting up the mitigation strategies that are already in place to complement these technologies.



Centre for Law and the Environment



The Centre for Law and the Environment is a centre of excellence for research, teaching and advocacy work relating to law and the environment. Based in the School of Law, the Centre supports and promotes a wide range of high-impact research activity in Environmental, Marine, Climate, Energy and Natural Resources Law. Although the Centre is rooted firmly in the discipline of Law, it is engaged in significant interdisciplinary research collaborations and extensive outreach and advocacy activity. The Centre is led by its Co-Directors Professor Owen McIntyre and Dr Áine Ryall.

17th Annual Law and the Environment Conference 2019

On 11 April 2019, the Centre for Law and the Environment hosted the 17th annual Law and the Environment Conference which comprised almost 40 presentations delivered by expert speakers from Ireland, Europe and beyond. Over 200 participants enjoyed presentations grouped into 13 specialist sessions and arranged around the overarching conference theme: The Role of Environmental Law in the Transition to Sustainability. The conference programme included three specialist sessions on Environmental Transitions and others on topics such as Circular Economy Law and Brexit and the Future of Environmental Law, as well as a keynote presentation by Mr Mike Asquith, Project Manager for Sustainability Transitions at the European Environment Agency. It also in-

cluded the now perennial sessions on Marine Environmental law, Contemporary Developments in Planning Law, Energy Law and Climate Law and Policy.

The 2019 event, which received generous support from the Environmental Protection Agency, the Marine Institute and Ronan Daly Jermyn Solicitors, has to date resulted in publication of 13 articles in peer reviewed journals including Energy Policy, Review of European, Comparative and International Environmental Law and the Journal of Energy and Natural Resources Law, as well as a dedicated Special Issue of Environmental Liability: Law Policy and Practice on the theme 'Transitions to Sustainability'.



Pictured above: *Speakers at the Annual Law and the Environment Conference.* (Photo credit: Pat Rice)

11th Annual Postgraduate Research Symposium on Environmental Law

In conjunction with the annual Law and the Environment Conference, the Centre hosted the 11th annual Postgraduate Research Symposium on Environmental Law, which saw presentations on leading-edge research delivered by 14 postgraduate researchers from a range of Irish, UK and European

universities. As always, this event provided an important platform for new research activity in the field, as well as an opportunity for the postgraduate researchers to interact with the speakers and participants gathered for the annual conference.

Selected Research Highlights 2019

The Centre supports and promotes a wide range of high-impact, frontier research activity in Environmental, Marine, Climate, Energy and Natural Resources Law. Applied research, with a 'real world' focus is the hallmark of the Centre's work to date.

During 2019, key publications included 'Environmental Rights – The Development of Standards'. Professor Owen McIntyre was co-editor of this important collection. Both Professor McIntyre and Dr Áine Ryall contributed individual chapters to the collection: 'The Human Right(s) to Water and Sanitation and the Relentless Development of Standards' and 'The Aarhus Convention: Standards Governing Access to Justice in Environmental Matters'.

In 2019, Centre PIs continued to publish their work in a wide range of national and international peer reviewed journals including: Irish Planning and Environmental Law Journal, Dublin University Law Journal, Water International and Environmental Liability: Law Policy and Practice.

Two researchers at the Centre were awarded the PhD in 2019: Dr Celia Le Lievre for her thesis on Sustainably Reconciling Offshore Renewable Energy Developments with Natura 2000 Sites: An Adaptive Management Framework and Dr Sharanya Basu Roy for her thesis on Regulatory Quality of Water Pollution Control: A Comparative Case Study of India and China.

Dr Ruby Moynihan was awarded an Irish Research Council Postdoctoral Fellowship (2019-2021) for a project entitled Moving Forward with the Ecosystem Approach: Integrating the Sustainable Management of Freshwater and Ocean Ecosystems. Rhoda Jennings was awarded an Irish Research Council PhD Scholarship (2019-2022) to support her doctoral research on The Role of Science in Environmental Policy and Law-making: A Critical Legal Analysis.

Professor Owen McIntyre was invited to join the UN Food and Agriculture Organisation (FAO) Expert Working Group on the emerging legal concept of 'Water Tenure', and was also invited by

the Agency for Science and Higher Education, Croatia to take part in the evaluation and reaccreditation of the Ph.D. Programmes in Human Rights, Society and Multi-level Governance, Faculty of Law, University of Zagreb, and in Maritime Law and Law of the Sea, Faculty of Law, University of Split.



UCC Community Engagement Week 2019

The Centre places significant emphasis on outreach and community engagement. On 10 October 2019, the Centre hosted a public event to mark UCC Community Engagement Week. The focus was on Climate Law and Governance, with an strong emphasis on engagement, advocacy and activism to promote climate action. Dr Maria Kirrane, Sustainability Officer, UCC discussed the role of educational institutions in leading climate action and specific activities underway at UCC. Youth activist Alicia Joy O'Sullivan, from Skibbereen, reflected on her experience representing Ireland at the UN Youth Climate Action Summit in New York. Dr Margaret Desmond, Climate Services, Environmental Protection Agency, focussed on the role of the National Dialogue on Climate Action in leading on climate change activities at the national and local level. Centre Co-Director Dr Áine Ryall explained recent developments in climate law, including climate litigation, as a mechanism to force urgent climate action. The event generated lively discussion around the challenges and opportunities involved in delivering climate action and the vital role played in this regard by local communities.

Pictured left: Dr Áine Ryall, Dr Margaret Desmond, Alicia Joy O'Sullivan, Dr Maria Kirrane (Photo credit: @UCC_civic)

Corporate Law Theory and Regulatory Practice

Professor Irene Lynch Fannon is associated with a group of progressive corporate law scholars who are interested in re-thinking corporate law, theory and regulatory practice to respond to the modern concerns with sustainable economic practise. In this context, building on the United Nations Sustainable Development Goals, these scholars focus on economic and market practise whereby economics and the market generally has to be understood in terms of sustainable and planetary boundaries as outlined in 'Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist'. In con-

tributing to scholarship in this area Professor Lynch Fannon has written recently on corporate tax in 'Apple Tax - The Core Issues' and on EU social market value theory and asserts that hidden beneath the corporate structure there are actors (management, shareholders and stakeholders) with motivations that are complex and which are impervious to current regulatory models, as discussed in the forthcoming publication 'The Corporation and the EU Social Market Economy: A Renewed Commitment'.

EU Environmental Law Events & Outreach

The Centre secured funding from the Department of Foreign Affairs and Trade Communicating Europe Initiative which enabled it to offer two public events to a wide audience, free of charge. On 28 June 2019, a seminar explored Recent Developments in European Union Environmental Law. Over 100 people participated in this seminar including lawyers, public authorities, regulators, Government officials, ecologists, NGOs, community groups, academics, students and members of the public with an interest in environmental law. The seminar explained recent developments in the law in an accessible manner. It also sought to explain the obligations on public authorities and the State in specific areas of EU environmental law, and the role of the public, including NGOs, in enforcing those obligations.

On 18 October 2019, the Centre hosted a major conference on Enforcing European Union Environmental Law. The conference was opened by Mr Simon Coveney TD, Tánaiste and Minister for Foreign Affairs and Trade and attracted a capacity audience. The Hon Ms Justice Marie Baker, now a Judge of the Supreme Court, chaired the conference. A number of themes relating to the enforcement of EU environmental law were ex-

amined including: the role of the EU Commission; EU nature law; enforcing the right to clean air; private enforcement of EU law; and the outlook for the future. The overarching aim was to interrogate how best to deliver an effective implementation of this complex and rapidly evolving field of EU law.



Pictured above: Mr Simon Coveney TD, Tánaiste and Minister for Foreign Affairs and Trade. (Photo: Rob Lamb photography)



Integration of Research and Teaching

Research-based teaching, at both undergraduate and postgraduate levels, is an important element of the Centre's activity. The Centre offers two innovative taught LLM programmes: the LLM (Environmental and Natural Resources Law) and the LLM (Marine and Maritime Law), in addition to a range of undergraduate modules in environmental law. Both LLM programmes incorporate clinical elements: the Environmental Law Clinic and Law of the Sea (Clinical) which is delivered in association with the Naval Service. The Centre's Co-Directors also contribute to the University Wide module on Sustainability.

During 2019, guest lectures, seminars and workshops were delivered at the

Centre by the Chief Justice of Ireland, the Hon Mr Justice Frank Clarke (Adjunct Professor, School of Law, UCC) and by leading practitioners and experts including: Joe Noonan (Noonan Linehan Carroll Coffey), Dr Fred Logue (FP Logue Solicitors), Dr Andrew Jackson (UDC Sutherland School of Law) and Darragh Page (Programme Manager, Environmental Protection Agency). These engagements enable our students to gain important insights into how environmental law operates in practice and underpin our commitment to experiential learning.

In November 2019, the Centre secured funding from the Higher Education Authority / National Forum for the Enhancement of Teaching and Learning

for a project on the theme Teaching Environmental Law for Policy Innovation and Impact. The aim of this project is to design, develop and test a series of innovative models of experiential learning in the field of environmental law and policy. The models are intended to be transferable to other areas of law and beyond the discipline of law. Dr Áine Ryall (Principal Investigator), Professor Mark Poustie, Professor Owen McIntyre and Cara O'Mahony are the programme team delivering this project.



Conference on Environmental Law Enforcement

Four members of the Centre contributed to a major conference organised by the Environmental Protection Agency (EPA) and the Irish Centre for European Law (ICEL) on the theme Environmental Law Enforcement: Emerging Challenges 2019 held in Dublin on 25 November 2019. The conference was convened by Dr Áine Ryall and Dr Tom Ryan (EPA). The Opening Address was delivered by the Chief Justice, the Hon Mr Justice Frank Clarke. The purpose of the conference, which attracted a capacity audience, was to explore the role of law and its enforcement in shaping

our approach to environmental protection. Professor Mark Poustie, Dean of Law UCC, presented a paper on the theme Tougher Penalties for Wildlife Crime: Experience from Scotland. Dr Áine Ryall spoke on the significance of the principle of effectiveness of EU law in the context of environmental protection and environmental law enforcement more generally.

Following an independent, competitive selection process, two PhD candidates based at the Centre were among the early career researchers selected to

present their work at the conference. Laurie O’Keeffe, PhD candidate, School of Law UCC, presented her work on A Critical Analysis of Enforcement of Sea-Fisheries Law in Ireland. Sarah Enright, PhD candidate, School of Law and SFI Research Centre for Energy, Climate and the Marine (MaREI), presented her work on Effective Marine Governance: The Evolving Role of Marine Protected Areas as a Legal Tool for the Conservation and Sustainable Use of Marine Biodiversity.



Above: Dr Tom Ryan (EPA); Dr Áine Ryall; the Hon Ms Justice Mary Laffoy; the Hon Mr Justice Frank Clarke, Chief Justice; Laura Burke (Director General, EPA); Dr John Temple Lang. (Photo Credit: Fennell Photography)



Above: Dr Tom Ryan (Director, Office of Environmental Enforcement, EPA), Sarah Enright, Laurie O’Keeffe, Edwin Alblas (UCD Sutherland School of Law)

Cork Environmental Forum Public Sector Award 2019

Dr Áine Ryall was honoured with the Public Sector Award at the Cork Environmental Forum Awards held on 27 November 2019. These awards acknowledge, honour and celebrate the outstanding actions of groups, organisations and individuals that are in keeping with the spirit of sustainable development and community resilience, including raising awareness on environmental sustainability. The award made to Áine Ryall recognised her outstanding public service, her influence

of future generations through her teaching and her outreach work which enables learning and networking across a wide and diverse community. Awards are made across the main pillars of the Forum: Public Sector; Business and Commercial Sector; Community and Voluntary Sector; Individual Category; and Sustainable Agriculture. Nominations are accepted from Forum members and members of the public.

Aquaculture and Fisheries Development Centre



The AFDC is a centre of excellence for aquaculture and fisheries research, based in the School of Biological, Earth, and Environmental Sciences, focusing on fisheries and fish population genetics, health of aquaculture species, and marine mammal research. The Centre is led by its Director, Professor Sarah Culloty.

Aquatic animal health and biology

The Aquatic Animal Health Group in the School of BEES and ERI and led by Professor Sarah Culloty specialises in ecological parasitology and immunology. Much of the group's research focuses on diseases of commercially significant bivalve shellfish (oysters, clams, mussels, scallops, cockles), but work is also ongoing on other groups (crabs, polychaetes, gastropods, tunicates). The group is heavily involved in collaborative research with numerous active partnerships across Europe and beyond, and recent research directions include the impact of potential climate change drivers on disease development in the marine environment and the impact of climate change on coastal communities that rely on the fishing industry.

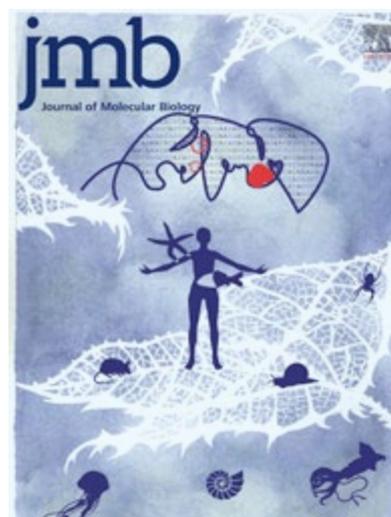
Oysters in particular are very sensitive to changes in climate and water quality, because they cannot move if a location becomes inhospitable. In this sense, oyster populations are sentinels of long-term climate fluctuations and climate trends, and more broadly of the 'health' of coastal ecosystems. In 2019, Dr Sharon Lynch participated in

the Native Oyster Restoration Alliance (NORA) technical writing workshop to develop a handbook and set of recommendation for monitoring the native European oyster, *Ostrea edulis*. NORA supports the protection and ecological restoration of the native European oyster, and its habitat in areas of its current or historical distribution. This handbook will support responsible restoration practice, in compliance with biosecurity and sustainability.

Another ongoing area of concern with regard to marine organism health is the transfer of invasive aquatic species through ships' hulls (biofouling). Professor Sarah Culloty completed an invited visit to Australia and New Zealand in autumn 2019 to take part in the 4th ANZPAC Workshop on Biofouling Management for Sustainable Shipping. Organised by Maritime Industry Australia Ltd., the workshop aimed to identify, promote and develop effective and practical biofouling management strategies that will ensure shipping and other maritime industries can continue to underpin trade, security and economic

development with minimal environmental impact. Professor Culloty spoke on the topic of disease and pathogen spread as an unintended consequence of the global economy.

Fish and shellfish are known to have a high content of selenium in their bodies. However, the role of selenium in the biology of these animals is virtually unexplored. In a 2019 publication in the *Journal of Molecular Biology*, Dr Sharon Lynch and colleagues characterized the oyster selenoproteome (collection of proteins within the animal which contain selenium) in detail and provided insights into selenium effects on gene expression regulation *in vivo*. This work paves the way for investigating selenium biology in oysters and other molluscs. Considering the importance of these species in the food industry and their high selenium content, this research will prompt further studies to identify the function of selenoproteins and other aspects of selenium metabolism in these species. Imagery from the research paper was chosen for the cover art of that issue (pictured below).



How climate change is impacting the lives of our native trout species



Little is known about why some fish migrate to sea and others do not - some brown trout make the decision to leave the river where they are born and head to the sea in search of more food, or mates, or to get away from unpleasant river conditions - conditions which will be made much worse by climate change. A key study from PhD student Louise Archer (under supervision from Dr Tom Reed) and colleagues in the

School of BEES and the ERI published in *Global Change Biology*, asked the question of how changes in water temperature and the amount of available food (both affected by climate change) influence the migration of brown trout. By rearing young of wild trout for two years under conditions of reduced food and increased temperature, and then recording the numbers of future sea-going migrants, the team found that food reduction increased the numbers of migrating fish, but warm temperatures had the opposite effect, where fewer fish chose to migrate to sea, instead remaining resident in fresh water. With conflicting pressures mounting, trout will become under increased pressure make complex decisions about whether they should migrate. The study noticed that fish choosing migration were smaller and in poorer condition than fish that remained in fresh water, indicating sea migration occurred when the fish urgently needed to consume more food. Understanding how climate change will affect migratory sea trout is crucial to successful management and conservation of the species, particularly since many sea trout populations have shown dramatic declines across Europe in recent years. This study sheds some light on this enduring question by highlighting how warming temperatures cause fewer fish to migrate to sea, with more fish remaining in fresh water to reproduce earlier. Worryingly, this research suggests that with climate warming, we may see further declines in sea-going trout.

Our top predators diet and the implications for Irish fisheries

Foraging is one of the most important components of individuals' reproductive success and survival in free-ranging marine mammals, the energetic costs of foraging are high; animals with high-energy requirements have the potential to considerably impact local prey populations and often play important roles in the structure and functioning of their ecological communities. Equally, factors affecting the prey, such as fishing industry practices and climate change, will impact on the predators foraging behaviour, ultimate diet and survival. In a 2019 study from PhD student Martha Gosch (under supervision from Dr Michelle Cronin, Dr Mark Jessop, and Professor Emer Rogan) and colleagues in the School of BEES, MaREI and the ERI, the diet of the grey seal was investigated to understand how top predators and their populations respond to changing ecological and environmental conditions, and to comprehend their functional roles in the marine ecosystem. Grey seals can move between feeding sites and so researchers used scat samples collected at contrasting habitats (shallower and deeper waters) in Irish waters to determine prey composition. Regional differences in the diet appeared to reflect regional differences in the physical habitat features, with seals foraging in deeper waters over sandy substrates showing a higher prevalence of prey species such as blue whiting and sandeels. Conversely, seals foraging in comparatively shallow waters had a greater contribution of seabed and groundfish species such as cephalopods and flatfish in their diet.

Considered internationally important commercial fishing grounds, Irish waters support many species of marine mammals. Against a backdrop of direct and indirect pressures on marine ecosystems, effective conservation of species and their habitat requires an understanding of the interactions that drive the functioning of an ecosystem. Rather than assuming predator diet is consistent across ecosystems, this study emphasises the importance of incorporating regional diet information when constructing fisheries and ecosystem-based models.



UN Environment GEMS/Water Capacity Development Centre



The UN Environment GEMS/Water Capacity Development Centre (CDC) provides global capacity development in water quality monitoring and assessment working on a programme of activities to support the Water Sustainable Development Goals. The Centre is led by its Director, Dr Debbie Chapman (School of BEES and ERI).

Training future professionals in water quality and monitoring

Through its global scoping exercise and bilateral discussions with the water and education sectors in developing countries, the UN GEMS Water Capacity Development Centre (GEMS Water CDC) identified a need for a flexible, advanced courses for individuals involved in water quality management throughout the world. In addition, the new UN Agenda 2030 Sustainable Development Goal for water (SDG 6) is leading to an increased demand for knowledge, understanding and capacity in water quality monitoring and assessment worldwide. To meet these needs, GEMS Water CDC developed the Postgraduate Diploma in Freshwater Quality Monitoring and Assessment in conjunction with the School of BEES, to enable the development of water monitoring expertise in countries through online learning. Students received online training in modules such as Freshwater Quality Monitoring using Biological and Ecological Methods; Freshwater Quality Monitoring using Particulate Material; and Freshwater Quality Monitoring in the Field and Monitoring and Assessment of Groundwater. The Postgraduate Diploma field course module was delivered by the GEMS Water CDC in April 2019 in Cork. It provided an opportunity to demonstrate and practice field sampling and monitoring techniques for freshwater quality assessment. During this intense week of fieldwork the Postgraduate Diploma students completed a series

of practical exercises on water sampling for chemical and biological analysis in rivers, lakes, reservoirs and groundwaters. This field course gave the students an opportunity to work in the field and laboratory as well as to interact with the Centre staff, colleagues from the School of BEES and the EPA. Some students have chosen to continue their postgraduate studies through an MSc. In Freshwater Quality Monitoring and Assessment; thirteen students are currently carrying out research projects in their home countries in Africa and the Caribbean on a wide range of projects.



The potential for Citizen Science to help reach SDG Goal 6

As the implementing partner for SDG Indicator 6.3.2 for Water Quality, GEMS Water CDC are involved in numerous activities contributing to the 6.3.2 methodology. In 2019 MSc student Lauren Quinlivan worked with GEMS Water CDC and the UCC Centre for Global Development to carry out a research project which explored the role for Citizen Science in achieving the goal. Lauren's research compared the measurements used for SDG Indicator 6.3.2 for ambient water quality with those collected by FreshWater Watch (Earthwatch's global citizen science project aiming to better manage and protect freshwater quality) in their Citizen Science monitoring programmes. By training a group of secondary school students to use the FreshWater Watch field kits to sample and analyse water from two different rivers in Kerry, Lauren was able to validate citizen science monitoring for SDG indicator 6.3.2. In addition, the Centre organised a Regional Support Meeting for SDG Indicator 6.3.2 in Zambia in April, in conjunction with the Water Resources Management Authority of Zambia (WARMA). Participants were invited to attend from Southern and Eastern African countries. The meeting was a follow-up to the SDG Indicator 6.3.2 Technical Expert Feedback Workshop, held in Dublin in October 2018 which aimed to establish a group of countries in the Southern and Eastern African region that experience similar challenges in reporting for the SDG Indicator 6.3.2. This interaction will build connections for the exchange of ideas; investigate novel approaches to data collection that are regionally relevant; and to identify potential for division of labour in the region.



6 CLEAN WATER AND SANITATION





Water Quality Monitoring Training Workshop, Vientiane, Laos

The Mekong River is one of the world's great river systems, flowing 4,909 km through six countries: China, Myanmar, Thailand, Lao PDR, Cambodia, and Viet Nam. The source of the river's great productivity is its seasonal variation in water level and the range of wetland habitats inundated. The Mekong River Basin's biodiversity is immense, even in comparison with other parts of tropical Asia. Its biodiversity is fundamental to the viability of natural resource-based rural livelihoods of a population of 60 million people living in the Lower Mekong Basin. The Mekong River Commission (MRC) is the only inter-governmental organisation that works directly with the governments of Cambodia, Lao PDR, Thailand and Viet Nam to jointly manage the shared water resources and the sustainable development of the Mekong River. As a regional advisory body governed by water and environment ministers of the four countries, the MRC ensures the efficient and mutually beneficial development of the Mekong River while minimising the potentially harmful effects on the people and the environment in the Lower Mekong Basin.

In collaboration with the MRC, in 2019 the GEMS Water CDC developed a training workshop for staff of the Environmental Management Division to support them in analysing trends in water quality over 10 years for the production of a water quality assessment report. Dr Debbie Chapman and

Katelyn Grant from the Centre travelled to the MRC secretariat in Vientiane, Laos to deliver the water quality monitoring and reporting workshop in February, 2019. The participants came from Viet Nam, Cambodia, Thailand and Laos and were already involved in environmental management activities in the Mekong River region particularly laboratory analysis of freshwater samples and the reporting of results. Many topics were discussed including different approaches for monitoring water bodies including physical and chemical parameters, as well as biological methods; data management and ways to review and evaluate an existing monitoring programme.



Centre for Research into Atmospheric Chemistry



CRAC is a leading national centre for atmospheric chemistry research carrying out laboratory, field and modelling studies to support clean air quality. The CRAC Centre Director is Professor John Wenger (School of Chemistry and ERI).

Visiting researchers welcomed as part of the EUROCHAMP 2020 project

The Horizon 2020-funded project, EUROCHAMP-2020, aims at further integrating the most advanced European atmospheric simulation chambers into a world-class infrastructure for research and innovation and ensure that Europe retains its premier place in atmospheric simulation chamber research. The project is composed of a coordinated set of networking activities, which deliver improved chamber operability across the infrastructure, as well as standard protocols for data generation and analysis. Trans-national access is provided to sixteen different chambers and four calibration centres, becoming the core of the project. CRAC's atmospheric simulation chamber, at UCC is part of the €9M European research project, and each year the Centre hosts research visits from colleagues as part

of the transnational access programme. In 2019, visiting researchers from Spain and Japan used the chamber to study atmospheric processes related to bio-fuels and night-time particle formation in polluted marine atmospheres. The latter topic involves some interesting interactions between the nitrate radical and iodine species which are common in the marine atmosphere, especially in regions with high occurrences of brown macroalgae, which release molecular iodine under oxidative stress conditions. These experiments contributed to the understanding of particle formation in polluted marine atmospheres, e.g. coastal cities. The formation of marine aerosols depends ultimately on the availability of new, nanometre-scale particles in the marine boundary layer, which were the subject of this inves-

tigation. As marine aerosol strongly scatters radiation there is an impact on visibility in coastal cities during dusk and dawn, and since particles also affect Earth's radiation budget, new mechanisms on particle production are important for improving our understanding of climate change.

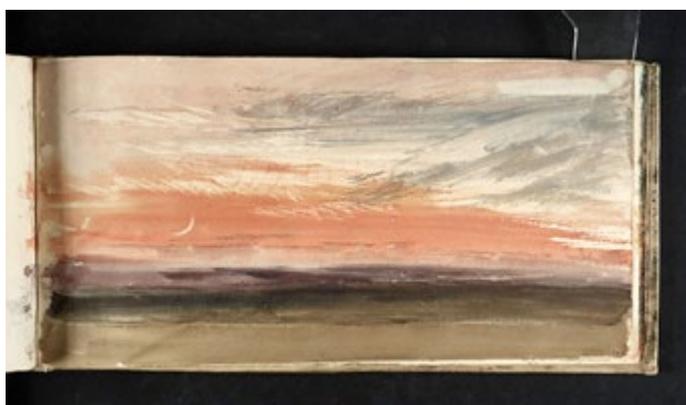
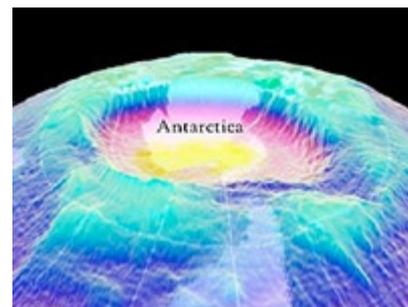


CRAC collaboration with Cork City Council to launch Ireland's first low-cost sensor network for monitoring air quality

Air pollution is responsible for over 1,200 premature deaths in Ireland every year. The pollutant impacting most on health is particulate matter (PM) which is composed of thousands of tiny particles suspended in air. The smaller the PM, the further it can travel into the body. For example, particles with diameters less than 2.5 micrometres (PM_{2.5}) can be breathed into the lungs and penetrate deep into the respiratory system. Some smaller particles can even enter the bloodstream. CRAC, along with colleagues in Cork City Council and CIT, monitor PM on a continuous basis as part of the national air quality network operated by the EPA. However, these moni-

tors measure PM in only four locations across the city. As part of wider plans to expand air quality monitoring in Cork City, CRAC teamed up with Cork City Council in 2019 to set up Ireland's first low-cost sensor network. Around 15 low-cost PM sensors have been deployed across the city as part of this pilot study, with the data reported in real-time on the PurpleAir website. From October to December 2019, a number of strong pollution episodes were observed and the new network enabled the extent of the pollution to be observed across Cork city for the first time. These pollution episodes peaked during the hours of 6pm to midnight and were caused by emissions of PM from the residential burning of solid fuels (peat, wood and coal) for home heating. The concentration of PM reached unhealthy levels on several occasions when dispersion of the pollution was limited by a strong temperature inversion and low wind speeds. These worrying findings prompted Prof John Wenger and Prof John Sodeau to renew their calls for government policies to tackle solid fuel burning and also further improve monitoring capabilities nationwide. CRAC continues to work with Cork City Council on air quality monitoring in the city and how this information can be used to inform the Air Quality Action Plan for Cork City, which is planned for 2020.





The Art of Air Pollution

Every year the United Nations organises World Environment Day in June to raise awareness of a particular area of environmental concern. In 2019, the theme was Beat Air Pollution and to mark the occasion the Centre for Research into Atmospheric Chemistry selected five iconic images that reflect our understanding of matters controlling air quality to raise awareness about air pollution in a user-friendly way. This mini-exhibition included images of China's Sichuan Province, where acid rain has attacked the Leshan Buddha monument; JMW Turner's "Red Sky and Crescent Moon" which shows a spectacular red sunset caused by the presence of volcanic

sulfate particles after the eruption of Mt Tambora in 1815; a satellite image obtained by the NASA Total Ozone Mapping Spectrometer (TOMS) depicting the hole in the ozone layer; the New Delhi smog; and the graffiti artist Banksy's famous Season's Greetings mural in Port Talbot, Wales. The environmental 'success stories' of increased awareness and action around acid rain and ozone depletion demonstrates that scientists, politicians and the general public are capable of aligning and acting for the same positive outcome. These past victories have provided hope that we can defeat the inter-connected worldwide problems of air pollution and climate change.

SECTION 4 – Outreach & Public Engagement



Science in the city

Cork is a city rooted in the tradition of bringing education, learning and discovery outside of the University walls and into the local community. In September, for the second year running UCC played host to European Researchers Night. Branded 'Cork Discovers', the city-wide event included demos, exhibitions, information stands and a careers café and welcomed members of the public of all ages to The Discovery Hall in UCC's Western Gateway Building. ERI researchers from CRAC, MaREI, AFDC, School of Microbiology and the School of BEES participated in this successful outreach event, coordinated by the UCC Office of the Vice President for Research and Innovation and UCC Academy.

Similarly, the ever-popular Cork Culture Night provides the opportunity to celebrate the established role of science, research and technology in Cork's cultural scene. The School of BEES, a favourite fixture in the Culture Night calendar, allowed visitors to get hands-on with specimens from their collections of mammals, sea creatures, plants, geological samples and fossils. With the additions of exhibits such as Meet the Scientist, the albatross photo booth, water testing demos and the chance to participate in a fossil dig, the School of BEES continued to offer a diverse and unique element to the Festival.

On a longer timescale, the 2019 Cork Science Festival consisted of a weeklong programme of events, during which

researchers from the ERI, MaREI and School of BEES featured at the Family Open day held in UCC's Western Gateway Building with an interactive booth containing demonstrations, activities and information for both parents and children on the topics of climate change, renewable energy, marine life, and air and water quality and ecology. In addition, PhD student Aoife Long and Dr Chen Deng (both of the ERI and MaREI Biofuels group) collaborated with Professor Jools Gilson from UCC department of Theatre, to develop a contemporary dance-based workshop on Renewable Gas. The Wise Movement workshop was held at the Firkin Crane theatre, which has the reputation of the leading centre for dance in Cork. The workshop was interactive, and participants were invited to learn about gas behaviour and processes through a series of movement exercises. Meanwhile, in more familiar surroundings, Professor Brian Ó Gallachóir (MaREI, ERI, School of Engineering) chaired an interactive public event *Listen to the Science* in response to the youth climate strike movement. Addressing questions, perceptions and misconceptions about the climate crisis and our transition to a low carbon future, the panel included Dr Hannah Daly, Dr Paul Deane and Dr Stephen Flood (all MaREI, ERI). Slightly further afield, in collaboration with the Dingle Hub, MaREI held three separate Climate Hack events in each of the secondary schools in the Dingle area, students were given a brief overview of the

energy challenges and asked to develop solutions using information sheets provided on electricity, heating and transport. The Dingle Hub have selected three ideas that will link up with initiatives seeking to improve public transport and investigate the potential for a community owned solar PV farm or anaerobic digester. MaREI also worked with a team from each school to prepare poster presentations for the launch of the Dingle Peninsula Energy Master Plan in February 2020. ERI and MaREI also supported the RTÉ/Oireachtas Youth Assembly on Climate Action, which was held in the Dáil as part of Science Week, and participated in the STEM South West secondary schools event which took place in November in Rochestown Park Hotel. Volunteers enjoyed a busy evening talking to future researchers about climate research, energy engineering, environmental law and marine ecology.





Science in the community

ERI researchers participated in the annual UCC Community Week in 2019, a week long programme of free public and community events that celebrates community engagement with UCC across the campus and beyond. Dr Niall O'Leary (ERI, School of Microbiology), hosted a visit from the 6th class students of St Mary's National School in Togher, to his laboratory to explore microplastic pollution associated with fashion and beauty. Dr Maria McNamara (ERI, School of BEES) held the popular Under the Microscope workshop opening up the world of microbeasts, fossils and crystals to young and old alike, and Dr Eoin Lettice (ERI, School of BEES) took visitors on a tour of UCC's tree collection as part of the UCC Open Arboretum Project. Meanwhile the Centre for Law and the Environment hosted an open event 'Climate Law and Governance' with an emphasis on engagement, advocacy and activism to promote climate action. Contributors included Dr Áine Ryall, Co-Director of the Centre for Law and the Environment, who spoke about recent developments in climate law, including climate litigation as a mechanism to force urgent climate action; Youth activist Alicia Joy O'Sullivan, from Skibbereen, Dr Margaret Desmond of the EPA and Dr Maria Kirrane, UCC Sustainability Officer.

Science for everyone

ERI researchers are constantly engaged in outreach activities designed to make science more accessible to new audiences by communicating concepts of societal importance without scientific terminology and jargon. In May, Angie Nagle (ERI, School of Engineering) participated in a Pint of Science and Aoife Long became a comedian for the night as part of the Bright Club Cork. Professor John Sodeau (CRAC, School of Chemistry) presented his public seminar 'Every breath you take: a talk about air pollution and climate change' as part of the Cork Life Long Learning Festival. Dr Jean O'Dwyer and Emma Critchley (both of BEES) got on their soapboxes as part of Soapbox Science Festival in July. Dr Dean Venables (CRAC, School of Chemistry) and Dr Eilis O'Reilly (School of Public Health, ERI) visited St Catherine's National School in Glasheen to speak about the risks of air pollution ahead of the #school-streets campaign in September, while Dr Christie Godsmark (School of Public Health, ERI) was guest speaker at the Taste of West Cork Festival, participating in the West Cork Forum on the topic of 'Facing The Challenges Of A Rapidly Changing World - Our Survival'. The Institute was also represented in force in the 2019 FameLab Ireland event in the Triskel Centre, Cork in February. Dr Karthik Rajendran, Aoife Long (both of MaREI, School of Engineering, ERI) and Arno Fricke (School of Microbiology, ERI) all took up the challenge to deliver a

non-specialist talk on their research topic in just 3 minutes. This global sci-comm event, funded by Science Foundation Ireland, is designed to inspire, motivate and develop scientists and engineers to actively engage with the public and stakeholders. In addition, Dr Paul Deane (ERI, MaREI, School of Engineering) and Dr Aine Ryall (ERI, Centre for Law and the Environment) contributed to the Perspectives on Climate Change panel as part of the Tralee-based Wild Mind Festival in April.

The Cork Social and Health Education Project (SHEP) is a non-profit organisation with an environmental arm in the form of the SHEP Earth Aware Group. Their vision of "a socially just world, where all people live in dignity, and where the integrity of the earth is honoured" is in line with SHEP's general style of experiential education. It involves helping people gain knowledge about what is happening to the planet and understanding how and why it is happening through inquiry and expert guidance. The ERI continues its collaboration with the Earth Aware group in 2019 by providing such guidance through public talks from Professor John Sodeau on the topic of 'Every Breath We Take', concerning the relationship between climate change, air pollution and public health, and Dr Christie Godsmark on the topic of 'Climate Changes Health - A call to action.'

MaREI researchers on the SCI:COM stage

SCI:COM is an annual national science communication event filled with talks, panel discussions, and networking. This year's theme examined creativity in science communication. For the first time there was also a poster session and MaREI's Hester Whyte and Aoife Deane presented a *Catching A Wave*, poster to explore ways of using an

art-science-technology approach for more impactful engagement and communication on ocean and climate change related science. Aoife Long (MaREI, ERI, School of Engineering) also hosted a breakout session about her experience entering the international Science Magazine 'Dance your PhD' competition.



An evening of weather and climate

In February, the ERI partnered with the Irish Meteorological Society, the UCC Astrophysics and Physics Society and the Irish National Flood Forum to host an evening of public talks on the topics of weather and climate. The event featured Met Eireann's Evelyn Cusack who spoke about the history of weather forecasting in Ireland, fellow Met Eireann colleague and UCC Graduate Dr Colm Clancy, who provided some insights into his work on numerical weather prediction. ERI speakers also contributed, Dr Lucia Hermida-Gonzalez (ClimATT, UN GEMS) who discussed her area of expertise - the human influence in extreme weather and climate events, and Dr Andy Ruth (Dept of Physics, CRAC, ERI) who explained how the sun generates and influences the Earth's weather. We also heard from a representative from the Irish National Flood Forum, Tadhg O'Leary who spoke about the efforts of the local community from Blackpool in Cork City who have taken initiative to protect their area - which is afflicted by periodic flooding- from the effects of extreme weather. The event was kindly sponsored by the EPA. On a similar theme,

Dr Paul Leahy (ERI, MaREI, School of Engineering) hosted a public lecture from Emeritus Professor Philip O'Kane in November on the topic of the Cork floods of November 2009 and the Lower Lee Flood Relief Scheme.



How and why life evolved colour

Dr Maria McNamara's (ERI, School of BEES) research focuses on the preservation of soft tissues in the fossil record and how this preservation provides unique insights into the biology of ancient animals, particularly with regard to appearance of colour and features such as skin and feathers. Several of her key recent findings relate to the preservation of structural and pigmentary colours in fossils and how this informs the evolution of animal communication strategies and physiology through

deep time. In 2019, Maria was invited to give numerous keynote addresses on this topic, including an invitation from the Smithsonian Museum of Natural History in Washington DC in March. Maria spoke to the gathered audience on the theme 'How and why life evolved colour' as part of the Smithsonian's Deep Time Symposium series which explores 'Life's greatest hits: key events in evolution'.





Science and the Sea

The Cork Harbour Festival is the annual celebration of Cork's unique maritime heritage. In recent years, the festival has expanded to celebrate and consider the ecological importance and renewable energy potential of our oceans, particularly the impact of human activities on marine biodiversity. In 2019, MaREI and the ERI hosted an interactive booth at the SeaFest portion of the Festival, on Kennedy Quay in Cork's port, showcasing marine-based research in the areas of renewable energy, bird and mammal biodiversity and plastic waste and informing the public about actions we can take to help protect our oceans, while Dr Tom Doyle (School of BEES, ERI) gave a public talk on the dangers of marine plastic pollution. MaREI's '3 for the Sea' event at Fountainstown

beach also played a part in Cork's Harbour Festival. Families learned about our marine environment, its amazing inhabitants, the threats posed by marine litter. A beach clean, rock pool exploration, marine themed arts & crafts, and hands-on activities for all ages were available on the day. On a similar theme but at a different seaside location, MaREI's The Sea+Me event took place on Dock Beach, Kinsale in September. MaREI also visited a number of schools during 2019 delivering workshops and talks on the theme of the Marine environment, and Aoife Deane, Communications & Public Engagement Manager also judged a student versus teachers debate on banning single-use plastics.

In 2019, MaREI collaborated with Port of Cork to deliver an educational initiative around marine litter which launched in January. Themed 'Maintaining a Healthy Harbour' the initiative aims to make school children aware of marine litter, its sources and impacts. Classes were encouraged to collect and use the marine litter and recycled items to create a 3D art project that would make people stop and think. Projects were exhibited at Port of Cork as part of Cork Harbour Festival and SeaFest. MaREI was also involved in an art initiative and subsequent exhibition called Tools of the Trade where primary school students created art pieces taking inspiration from 'tools' used by researchers and this was exhibited at Cork City Hall during SeaFest.

Climate Lab Seminar Series 2019

The ERI launched its 2019 Climate Lab Seminar Series in January with Dr Seán Healy, CEO of Social Justice Ireland, and Dr Catherine Kavanagh of Cork University Business School. Speaking on the topic of "Measuring Progress: Economy, Society and Environment in Ireland Today", Dr Healy discussed the measuring of real progress, taking into account the economic, environmental and social factors that so heavily influence our health as a society. Each year Social Justice Ireland marks the UN World Day of Social Justice on February 20th by publishing its Sustainable Progress Index which looks at Ireland's relative progress to date in meeting its responsibilities under the Sustainable Development Goals. In June, the ERI was honoured to host Dr Satyendra Prasad, the Ambassador of the Republic of Fiji to the United Nations. A former lecturer in development studies in UCC from 1995-1996, Dr Prasad returned to UCC to give a Climate Lab Seminar on the topic of climate change from the perspective of populations occupying islands. He highlighted the precarious position of the South Sea islands in particular, subject as they are to rising sea levels and extreme weather events and noted that smaller island countries look to Ireland to champion the needs of island nations in the United Nations assembly.

Losing Alaska film screening premiere

The ERI was delighted to be invited to take part in October's Cork Indie Film Festival screening of *Losing Alaska* presented in association with Cork Environmental Forum. The film tells the story of an Alaskan community suffering the effects of global warming, and this screening was followed by a Q&A and panel discussion with the film director Tom Burke, Cork Environmental Forum members and Dr Paul Bolger (ERI Manager) and Clare Watson (ERI, MaREI).





SECTION 5 – ERI in the Media 2019

January

The Government's proposed 'carbon cheque' scheme

Dr James Glynn,
The Hard Shoulder, Newstalk.

The future of offshore energy

Dr Jimmy Murphy,
Nationwide, RTÉ

April

Air pollution and climate change

Professor John Sodeau, RTÉ
Drivetime and Newstalk

UCC drives urgent Climate Action governance

Dr Áine Ryall, Irish Examiner

July

Atlantic puffin research

Dr Ashely Bennison and Dr Mark
Jessopp, Blue Planet UK

UCC study finds plastic in deep submarine canyon

Professor Andy Wheeler and
Dr Aaron Lim, Cork 96FM

Fight to ban GM feed imports in EU labelled 'scaremongering'

Dr Barbara Doyle-Prestwich
AgriLand

October

I live on the coast - is my home safe?

MaREI the SFI Research Centre for
Energy, Climate and the Marine,
The Journal

Frontlines: What are they doing to our trees?

Dr Eoin Lettice, Hot Press

Are our storms getting worse or is it that weather forecasters are better informed?

Dr Barry O'Dwyer,
Irish Independent

February

The dangerous emissions pathway

Dr Paul Deane, Eco Eye, RTÉ

Feathers came first: Dinosaurs beat the birds by 100 million years

Dr Maria McNamara,
Irish Independent

May

Let's get on the biogas bus and use eco-friendly fuel

Professor Jerry Murphy,
Irish Examiner

Climate Change is bad for your health and everything else

Dr Christie Godsmark,
RTÉ Brainstorm

August

Some animals can adapt to climate change—just not fast enough

National Geographic,
Dr Tom Reed

Lessons on climate action from the Rural Electrification scheme

Dr Fionn Rogan, RTÉ Brainstorm

Climate change: 'It's really hard to remain hopeful'

Dr Jean O'Dwyer, Irish Times

November

10 Things To Know

Dr Jimmy Murphy and
Dr Valerie Cummins, RTÉ One

Climate Action research

Professor Jerry Murphy and
Dr Clare Watson, the Blindboy
Podcast

Dangerous rise in air pollution levels as smoky coal ban flouted

Professor John Sodeau,
The Business Post

March

The local and community response to climate change

Evan Boyle, RTÉ Brainstorm

Sustainable fashion

Dr Eoin Flynn, RTÉ Drivetime

June

Conference at UCC attended by delegates for community ownership of wind farms

Dr Cian Desmond,
RTÉ News Six One

Societal consensus is key to Ireland's climate challenge

Professor Brian Ó Gallachóir,
Irish Times

Enniscorthy becoming Ireland's New Delhi, says expert

Professor John Sodeau and
Professor John Wenger, The Times

September

Major conference on climate change and health at UCC

ERI, Cork's 96FM

Kieran Hickey from UCC comments on new UN climate report

Dr Kieran Hickey, RTÉ Drivetime

Scientists issue jellyfish warning after more than 30 wash up on south-west coast

Dr Tom Doyle, Irish Examiner

December

Don't have a 'wasteful' festive period with these top ten tips for a sustainable Christmas

ERI, Breaking News.ie

A curious fly and 'illicit sex' gave humanity cheese and yoghurt 6,000 years ago

Dr John Morrissey,
The Conversation

Biodiversity loss an issue in Cork as well

Professor John Quinn, The Echo

UCC looks to maximise the value in waste

Professor Mary McCarthy, The Echo

SECTION 6 – Awards

Jeremy Gault to hold GEO Blue Planet Co-Chair

Congratulations to Coastal & Marine Systems Research Coordinator, Jeremy Gault (MaREI, ERI), on being selected as Co-Chair of GEO Blue Planet. GEO Blue Planet is the ocean and coastal arm of the Group on Earth Observations (GEO), a partnership of more than 100 national governments and participating organizations that envisions a future where decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations.

Professor Colm O'Dwyer receives IRC Advanced Laureate Award

ERI and School of Chemistry PI, Professor Colm O'Dwyer, was amongst 12 leading Irish researchers to each be awarded €1 million in research funding in April 2019. Professor O'Dwyer received the award for his project *Battery performance in technicolor* – which will develop photonic material circuitry and 3D printed batteries for probing electrochemical energy storage mechanisms and cell performance.

MaREI Directors awarded fellowships of the Irish Academy of Engineering

MaREI Directors and ERI Vice-Directors Professor Brian Ó Gallachóir and Professor Jerry Murphy (both also from School of Engineering) were formally elected as Fellows of the Irish Academy of Engineering in May 2019.

UCC Elmer Morrissey Prize

Congratulations to Dr Shane McDonagh (ERI, MaREI, School of Engineering) who won the UCC Elmer Morrissey Prize in April. The annual award of €1500 is presented to a UCC engineering student who demonstrates academic excellence, contributions to student life and an interest in improving their world. Shane is a recent PhD graduate of the Biofuels and Bioenergy Research Group.



School of BEES Best Presentation and Paper Awards

Congratulations to Alicia Mateos (School of BEES, ERI) for winning First Prize for Best Oral Presentation at the International Summer School on Emerging Micropollutants Removal from Wastewater in Finland, and to the 2019 Delap prize winners for best published paper, Dr Mohit Tunwal and Dr Emma Critchley from UCC School of BEES and the ERI.

Cork Environmental Forum award for Dr Áine Ryall

Dr Áine Ryall (Centre for Law and the Environment, ERI) won the Public Sector Award in the Cork Environmental Forum (CEF) Annual Environmental Awards 2019. The CEF award aims to acknowledge and honour the actions of groups, organisations and individuals around the county that have contributed to the health or richness of the Cork environment. Áine was also among 25 academics identified as “science-led game changers” by Silicon Republic, “25 Bright Sparks working to make our world a better place in 2020”.

Staff recognition award winners

Congratulations to the SEFS student-nominated staff teaching award-winner Dr Jean O'Dwyer from the School of BEES and the ERI, and to Professor Justin Holmes (School of Chemistry and the ERI), winner of the Staff Leadership Award.

Cork Convention Bureau Ambassador Awards

Two ERI researchers were recognised by the Cork Convention Bureau at their 2019 Cork Ambassador Award ceremony. School of Chemistry's Dr Eric Moore received a Special Recognition Award while Dr Cian Desmond (MaREI, ERI) was the winner of the Academic Conference Award for bringing the EAWE Wind Energy Science Conference to Cork.



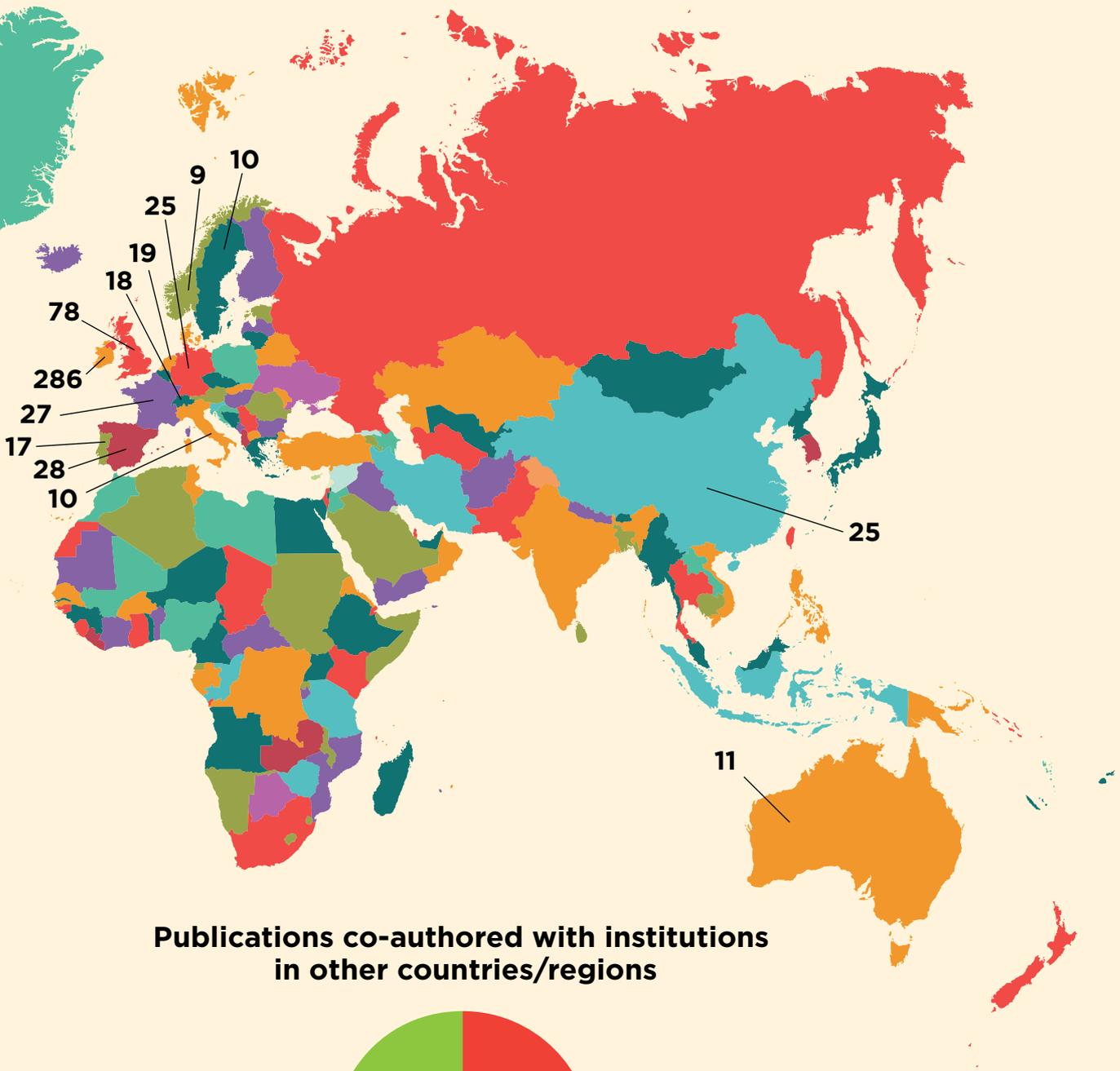
SECTION 7 - ERI around the world in 2019

The ERI has collaborative partnerships with over 500 national and international universities and companies, which result in hundreds of publications annually. The top 15 countries with which we produced the most publications in 2019 are highlighted here.

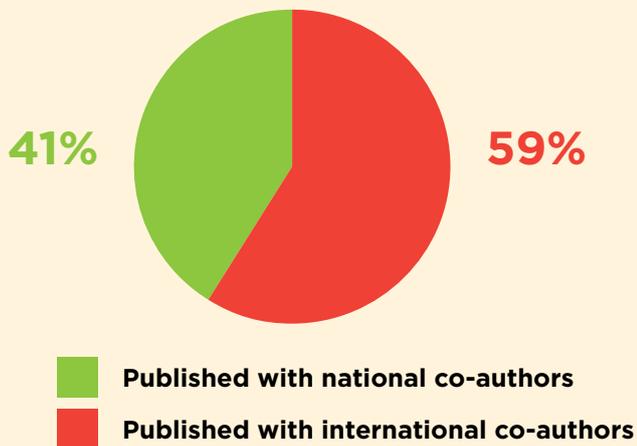
Top 15 countries

Ireland	286
United Kingdom	78
United States	40
Spain	28
France	27
China	25
Germany	25
Netherlands	19
Switzerland	18
Portugal	17
Australia	11
Canada	11
Italy	10
Sweden	10
Finland	9





Publications co-authored with institutions in other countries/regions



SECTION 8 – ERI 2019 PhD and Research Masters Awards

POSTGRADUATE		QUALIFICATION	SUPERVISOR(S)
Barker	Aaron	PhD (Engineering)	Professor Jeremiah D. G. Murphy
Basu Roy	Sharanya	PhD (Law)	Professor Owen McIntyre
Cao	Xi	PhD (Science)	Dr Eric Moore Dr Anna Maria Hogan
Critchley	Emma Jane	PhD (Science)	Professor John Quinn Dr Mark Jessop
Curtin	Joseph	PhD (Commerce)	Dr Celine McNerney Professor Brian Ó Gallachoir
Dennehy	Emer Regina	PhD (Engineering)	Professor Brian Ó Gallachoir
Flaherty	Sarah Jane	PhD (SPHeRE)	Professor Mary McCarthy Dr Alan Collins
Gaffney	Fiac Mark	PhD (Engineering)	Professor Brian Ó Gallachoir
Gallagher	Colm	PhD (Engineering)	Dr Dominic O'Sullivan
Gil Pulido	Beatriz	PhD (Science)	Dr Niall O'Leary Professor Alan Dobson
Gjørtz Howden	Julie	PhD (Law), Faculty of Law, University of Bergen, Norway	Professor Owen McIntyre (External Principal Supervisor)
Gkaragkouni	Maria	PhD (Science)	Professor Emer Rogan
Govi	Bianca	Master of Research	Professor Marcel Jansen Dr Niall O'Leary
Hennessy	Liam John	MSc (Commerce)	Professor Thia Hennessy Dr Robert Butler
Hinds	Stephen Michael	M Eng Sc (Elec.)	Dr Padraig Cantillon Murphy Dr Emanuel Popovici
Hynes	Austin John	Master of Research	Dr Patrick A Meere Dr Richard Unitt
Leahy	Kevin	PhD (Engineering)	Dr Dominic O'Sullivan
Le Lievre	Celia Andrea Clementine	PhD (Law)	Professor Owen McIntyre Dr Anne Marie O'Hagan
McDonagh	Shane	PhD (Engineering)	Professor Jeremiah D. G. Murphy
Negash Ghebregziabher	Kahsay	MSc (Commerce)	Professor Thia Hennessy Dr Stephen Onakuse Dr William P Marnane
Newman	Rebecca	PhD (Science)	Dr Ruth Ramsay O'Riordan
O'Donovan	Sarah Monica	PhD (Science)	Dr Claire O'Neill Dr Aidan Sullivan Dr David Clarke
Pye	Stephen	PhD (Engineering)	Professor Brian Ó Gallachoir
Reinhardt	Ingrid Carla	MEngSc (Process & Chemical Engineering)	Dr Denis Ring Professor Jorge Oliveira
Tanner	Sean Anthony	PhD (Commerce)	Dr Seamus O'Reilly Professor Mary McCarthy
Tesfay Okubazghi	Eskender	MSc (Commerce)	Professor Thia Hennessy Dr Stephen Onakuse
Yue	Xiufeng	PhD (Engineering)	Professor Brian Ó Gallachoir Dr Fionn Rogan

SECTION 9 – ERI 2019 Peer-reviewed Publications

1. Alialy, S., Gabriel, M., Davitt, F., Holmes, J.D. and Boland, J.J. (2019) *Switching at the contacts in Ge9Sb1Te5 phase-change nanowire devices*, Nanotechnology, 30, 33, 335706.

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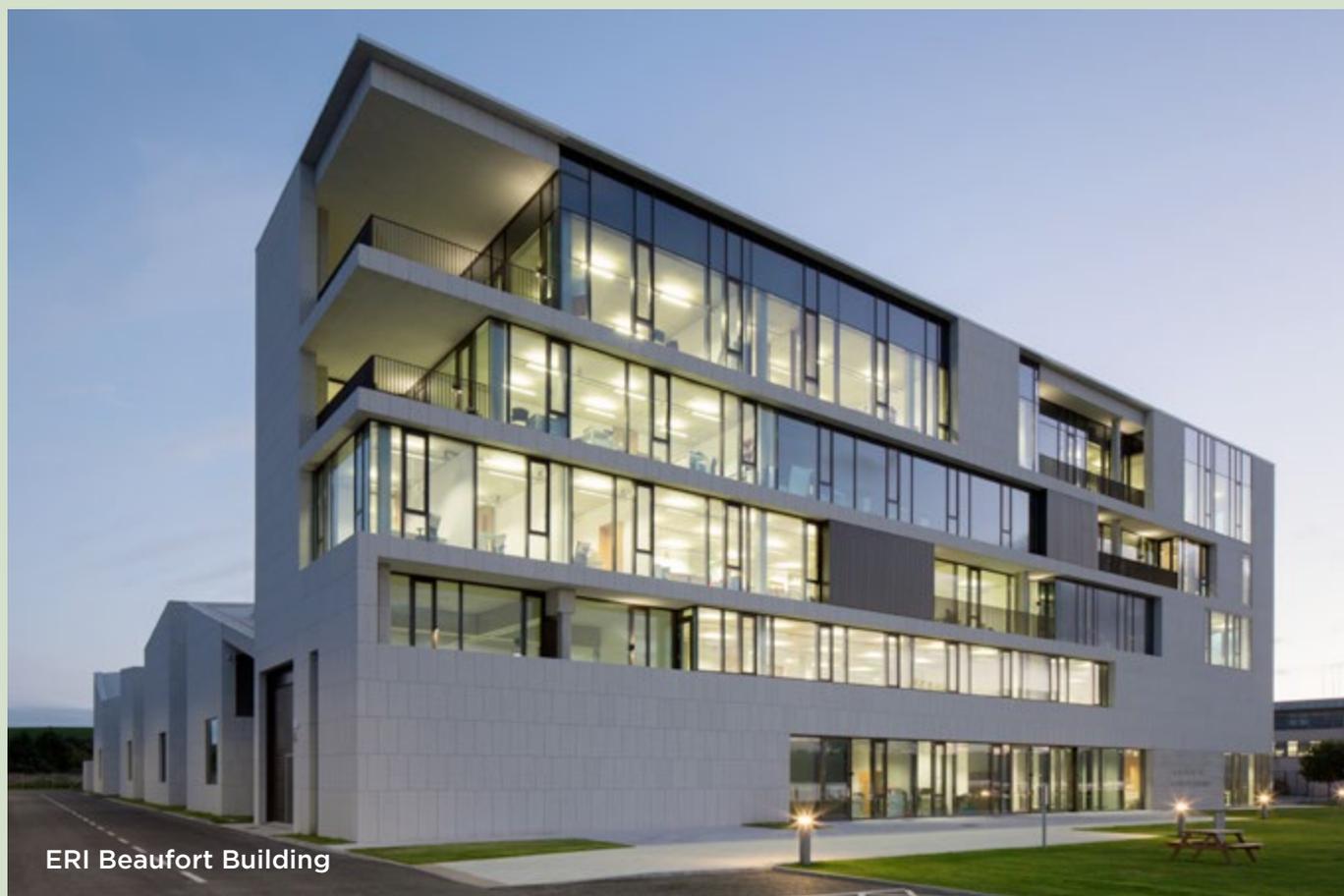
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Environmental Research Institute
University College Cork, Ireland
Phone: +353 (0)21 4901931
Email: eri@ucc.ie
Website: <http://eri.ucc.ie>