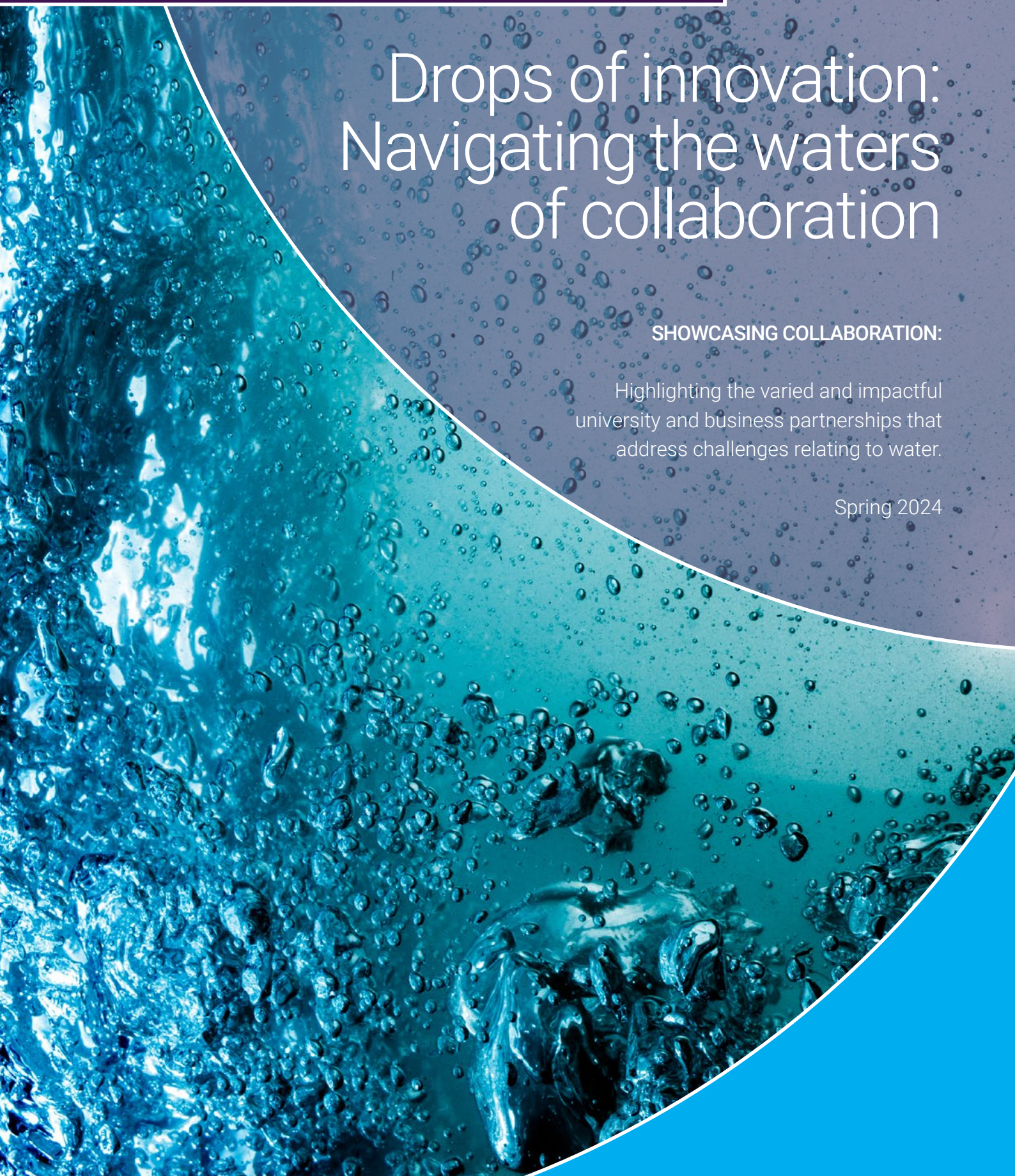
National Centre for Universities and Business

Drops of innovation: Navigating the waters of collaboration

SHOWCASING COLLABORATION:

Highlighting the varied and impactful university and business partnerships that address challenges relating to water.

Spring 2024



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Introduction

Joe Marshall
Chief Executive, National Centre for Universities and Business

Water is the life source of our planet: our bodies, plants and oceans are made of it. Climate change is altering patterns of weather and water around the world, causing shortages and droughts in some areas, and floods in others.

Water shortages are currently impacting four billion people – almost two thirds of the world's population. Two billion people live in countries where water supply is inadequate. UNICEF predicts that half of the world's population could be living in areas facing water scarcity by as early as 2025. The repercussions of inadequate water management are far-reaching, affecting not only the sustainability of our ecosystems but also posing direct threats to human and animal health.

In 2010, the UN General Assembly explicitly recognised the human right to water and sanitation. Everyone has the right to sufficient, continuous, safe, acceptable, physically accessible and affordable water for personal and domestic use. What's more, harnessing the power of our natural water resources, and ending our reliance on fossil fuels will allow the UK to reach Net Zero targets by 2050.

The importance of research and innovation into water preservation, purification and utilisation is therefore vital. It is more critical than ever to support, promote and cultivate innovation on the water projects.

We are very proud to share and celebrate some recent NCUB member collaborations between businesses and universities working on water projects. Utilising AI to detect flooding, innovating to cleanse water sources and working together to meet water energy goals, are just some of the projects that our members have been involved in.

In this booklet, NCUB presents ten collaboration case studies from across the country that demonstrate the vital role of collaboration in the world's water.

A collaborative project involving the University of Sheffield, Yorkshire Water and Siemens is using a cloud-based artificial intelligence (AI) system designed to detect blockages in sewers. The system has shown an almost 90 per cent accuracy rate in a recent trial.

Early identification of sewer blockages is essential to reduce pollution incidents affecting our rivers. AI algorithms can analyse vast datasets in real-time, enhancing our ability to predict and manage flood events more effectively. By employing smart sensors and monitoring systems powered by AI, we can detect and respond to pollution incidents swiftly, implementing targeted interventions to safeguard water quality. Using AI in water management strategies is already delivering a proactive and dynamic approach. It contributes to sustainable practices and allows us to be more resilient against the challenges of flooding and river pollution.

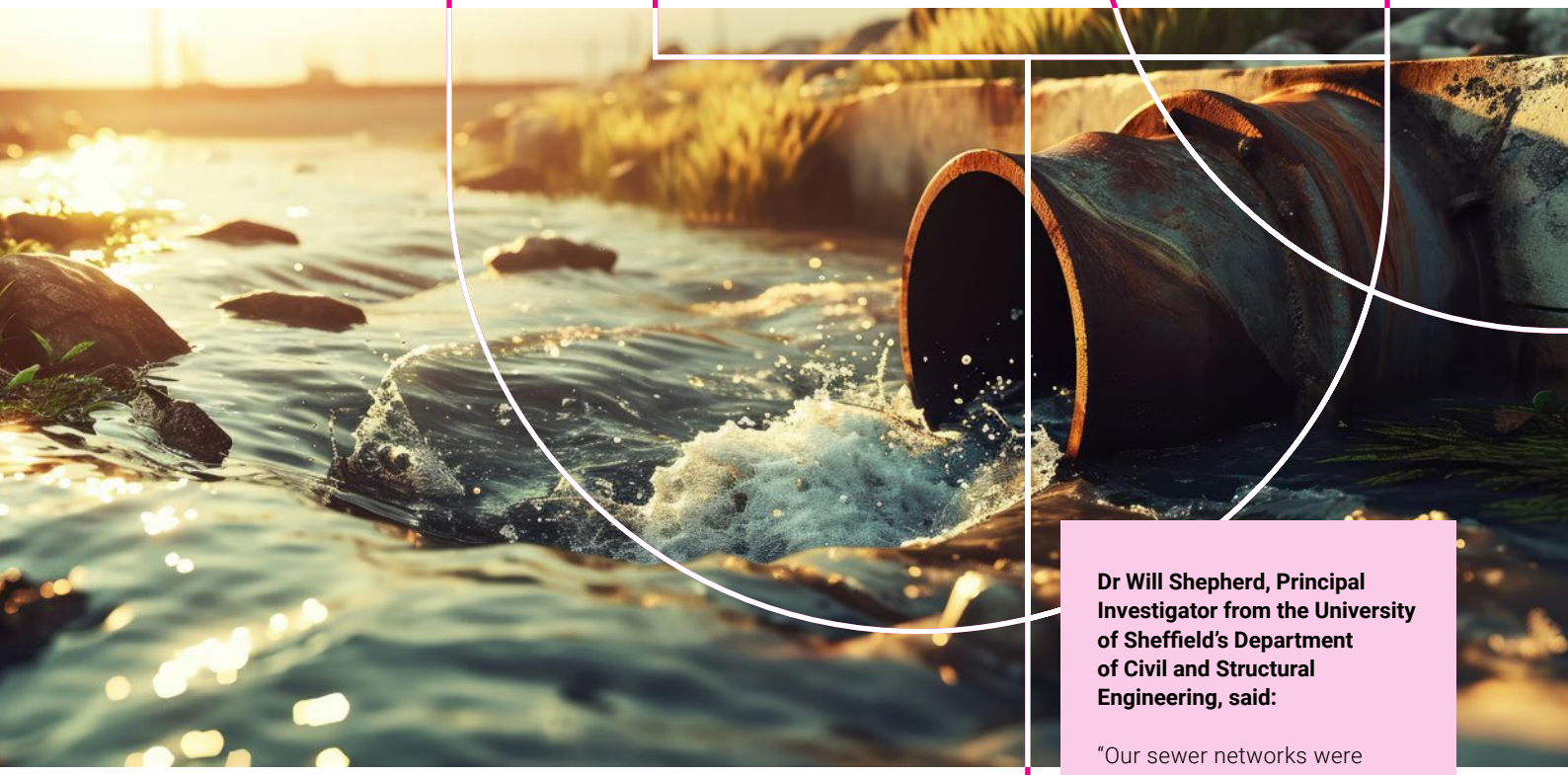
Using AI to reduce flooding and limit river pollution

Using a cloud-based AI system designed to detect blockages in sewers is a collaboration between the University of Sheffield, Yorkshire Water, and tech company Siemens. It is part of the 'Pollution Incident Reduction Plan' which focuses on early intervention to reduce pollution incidents by 50 per cent by 2025.

Sewers have 'combined sewer overflows' (CSOs) which let excess water spill out into a nearby water body when the pipes are full due to heavy rainfall, preventing downstream flooding. These spillages can also be caused by unexpected restrictions in the pipe, such as blockages, resulting in unnecessary pollution of our rivers and watercourses.

Sensors monitor water depth in the CSOs, and other parts of the sewer network, allowing real time understanding of performance. The quantity of sensors makes manual analysis infeasible, hence an automated system is needed.

The technique was originally developed by the University of Sheffield and Yorkshire Water to improve on their previous analytics technique. This project with Siemens and collaborating SME Mounce Hydrosmart Ltd has further developed the tool into a



commercial, cloud-based solution – the Siemens Water (SIWA) Blockage Predictor.

Analysis of 21,300 days of data by researchers at the University of Sheffield found the blockage predictor can provide up to two weeks' notice of problems within the sewer network and identify nine out of 10 potential issues - three times more successful than existing pollution prediction processes, while reducing the number of false positive alerts by 50 per cent.

The AI based solution predicts water depths using rainfall data and compares these to the measured depth using a Fuzzy Logic (FL) algorithm. The FL alerts the water utility of any unexpectedly high depths which could lead to a pollution incident. The aim is to identify developing blockages so that they can be removed before pollution occurs.

The integrated sensing, communication, analytics and reporting solution works by using sensors to feed water level data into the SIWA Blockage Predictor, an application on Siemens' cloud-based, open Internet of Things (IoT) operating system, Insights Hub.

The performance of the sewer network is analysed in real time and predicts problems like network blockages before they happen - enabling Yorkshire Water to quickly investigate the predicted blockage and prevent it developing into sewage pollution in the environment.

A new peer reviewed journal article presents an assessment of the SIWA Blockage Predictor for 50 CSOs over a two year 'historic' period and a six month 'live' period. The article also compares performance to the previous analytics solution. Across the full dataset, 88.4 per cent of confirmed issues were correctly identified, compared to 26.6 per cent for the previous solution.

Dr Will Shepherd, Principal Investigator from the University of Sheffield's Department of Civil and Structural Engineering, said:

"Our sewer networks were not designed to convey heavy rainfall to treatment, CSOs provide an essential relief valve when rain would otherwise cause flooding further down the network. Our focus here is on making them as environmentally friendly as possible by identifying blockages which would cause premature spills and hence pollution of rivers and watercourses."

Professor Joby Boxall, Professor of Water Infrastructure Engineering in the University of Sheffield's Department of Civil and Structural Engineering, said:

"The synergies of the collaborative partnership approach to this research was vital to success. It was important that the different needs and ambitions of each partner was mutually recognised and respected from the outset and that we built and maintained a high level of trust."

Advancing tidal stream energy to reach Net Zero goals

Delivering renewable energy using ocean tides will help us to meet the UK's Net Zero goals. Research co-led at the University of Strathclyde has been supported by a £7 million investment in this area. The team will look at how to cut carbon emissions and boost energy security using tidal stream power.

The CoTide project will bring together multi-disciplinary teams from Strathclyde and the universities of Oxford and Edinburgh. The group will work to make renewable energy generation from ocean tides cheaper, more reliable and scalable.

The CoTide project will develop integrated engineering tools and solutions, together with concept designs complemented by laboratory demonstrators.

Achieving the UK's target to reach Net Zero by 2050 requires the decarbonisation of all the nation's energy supplies and a huge expansion of renewable generation from the current 50GW to 120-300GW.

The powerful tides that surround the UK remain under-utilised but have huge potential as a source of greener power that could make a significant contribution to this goal. Unlike the wind and the sun, tides also ebb and flow at predictable times every day and so have the advantage of providing power that is both renewable and reliable.

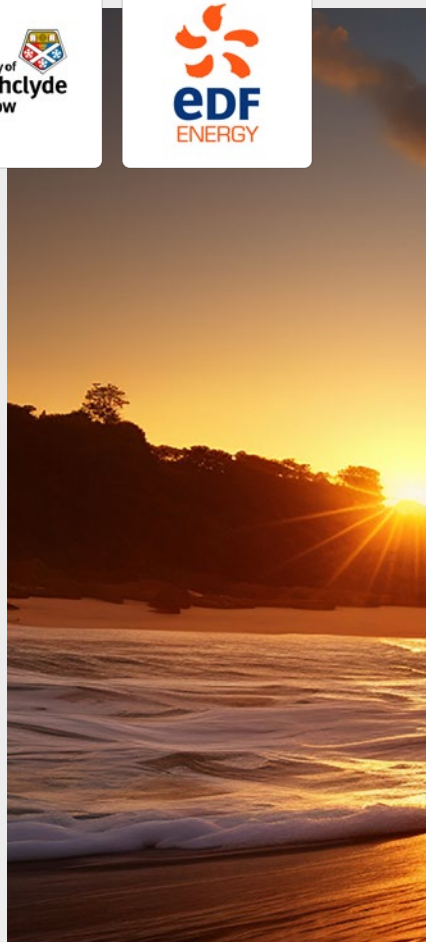
The CoTide researchers will work to ensure that the UK can take full advantage of this incredible resource by developing state of the art tidal stream turbine systems. Unlike more traditional tidal barrages and tidal lagoons that require turbines to be installed in structures such as dams or sea walls, tidal stream turbines are fixed directly at sea in the line of the strongest, most suitable tidal flows. They are cheaper to build and install and, crucially, have less of an environmental impact.

If fully developed nationally, these systems have the potential to generate in excess of 6GW, enough to power over five million homes, with an export market worth £25bn, supporting over 25,000 marine energy jobs.

But technical challenges remain, and tidal stream systems require careful

Tidal energy is created using the movement of our tides and oceans, where the intensity of the water from the rise and fall of tides is a form of kinetic energy. The consistent energy output of tides, driven by gravitational forces means it is a predictable and constant form of energy.

A collaborative project, called Co-tide, between the Universities of Strathclyde, Oxford and Edinburgh and 25 partner organisations including EDF Energy, is looking to harness tidal energy power.



design to maximise power while providing reliability in hostile marine environments characterised by corrosive seawater and unsteady loading caused by waves, turbulence and sheared flows.

To tackle this, the CoTide team includes a spectrum of expertise in all relevant areas, including device hydrodynamics, composites, rotor materials, corrosion, risk and reliability, environmental modelling, and system control and optimisation.

Together, the researchers will cooperate to develop and demonstrate holistic integrated tools and design processes that will significantly reduce costs by removing unnecessary redundancy and improving engineering solutions and processes.

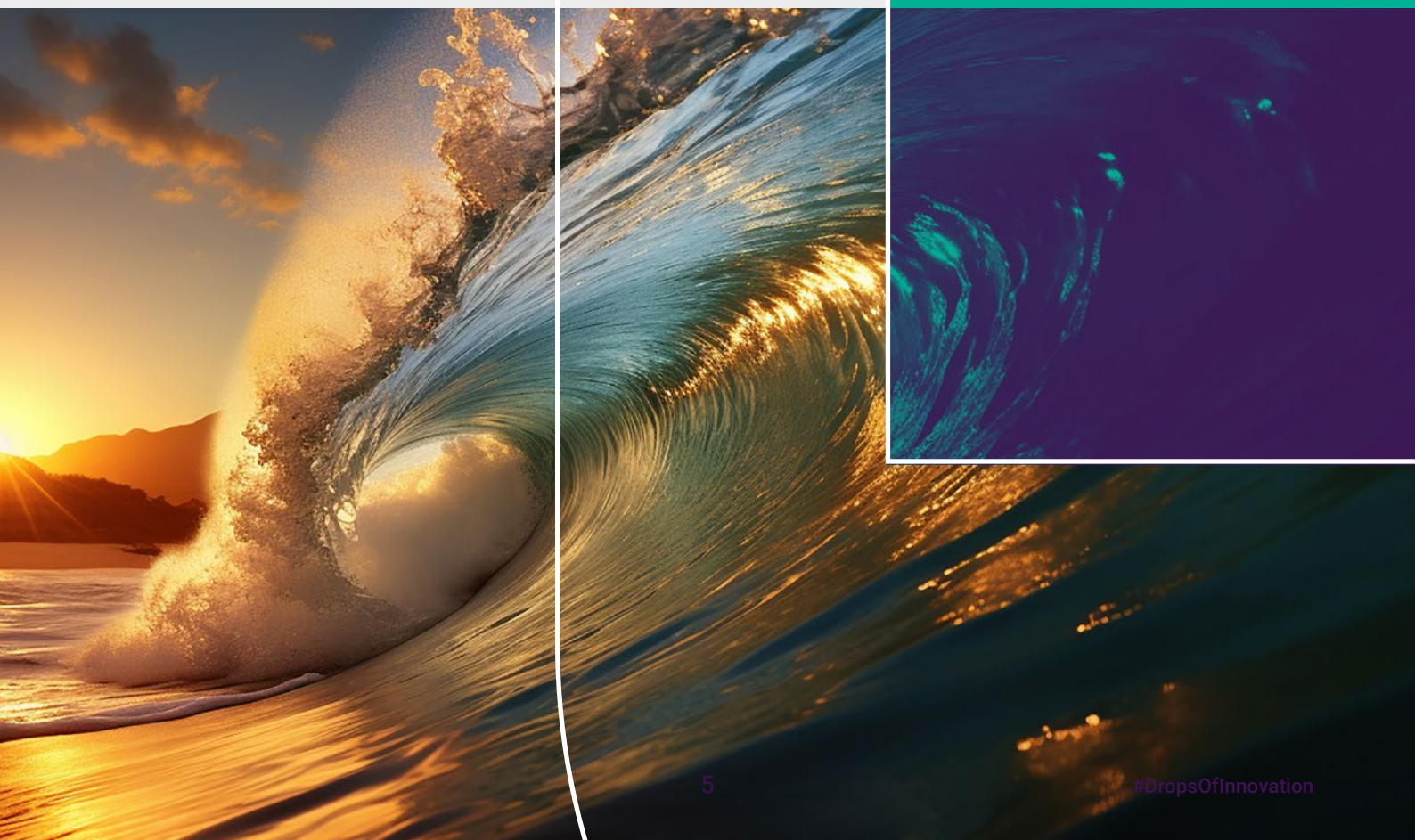
CoTide has 25 project partners, including EDF Energy Plc, the Health and Safety Executive, and global manufacturer Arkema International.

Sue Barr, Chair of the UK Marine Energy Council, said: "We are beginning to see real commercial traction for tidal stream projects. In order for tidal stream energy to become more competitive, we need real step changes in system performance, reliability metrics and scalability of the technology. This will require integrated tools which can be utilised by the sector to not only improve performance, but also increase confidence for investors and guarantors. The CoTide's project's collaborative and innovative scope provides a real opportunity for successful outcomes."

Professor Feargal Brennan, Head of Strathclyde's Department of Naval Architecture, Ocean and Marine Engineering, is the University's lead in the project. He said:

"Wind and Solar Power have to date become a phenomenal success and Tidal Stream is an opportunity to balance the variability of Wind and Solar power with clean, sustainable and steady power due to the predictable nature of the tides.

"The sea, however, is an unforgiving environment and the Strathclyde team will lead on the development of offshore structures and engineering materials in the marine environment that can resist the enormous forces that tidal currents and waves exert on tidal turbines and their supporting infrastructure. Another exciting opportunity is to develop a local industry to build and maintain tidal turbines and additionally provide employment and export opportunities."



We have relied on antibiotics to treat bacterial infections for nearly a century, and in that time the burden of infectious disease caused by bacterial pathogens has decreased dramatically. However we are now seeing an increase in antibiotic resistance, also referred to as antimicrobial resistance or AMR.

Over time these antibiotics have entered our waterways, passing from humans and animals through our waste. In collaboration with AstraZeneca, the University of Exeter is working to understand antibiotic resistance and the safe limits for antibiotics in river water.

Antibiotic resistance in our waterways

Antibiotics underpin modern medicine, allowing treatment and prevention of infections including those that occur during surgery, cancer treatment and childbirth. However, bacteria are developing resistance to antibiotics, allowing them to survive treatment. Bacteria do this by acquiring resistance through random genetic changes or by acquiring DNA from other bacteria.

AstraZeneca

University of Exeter

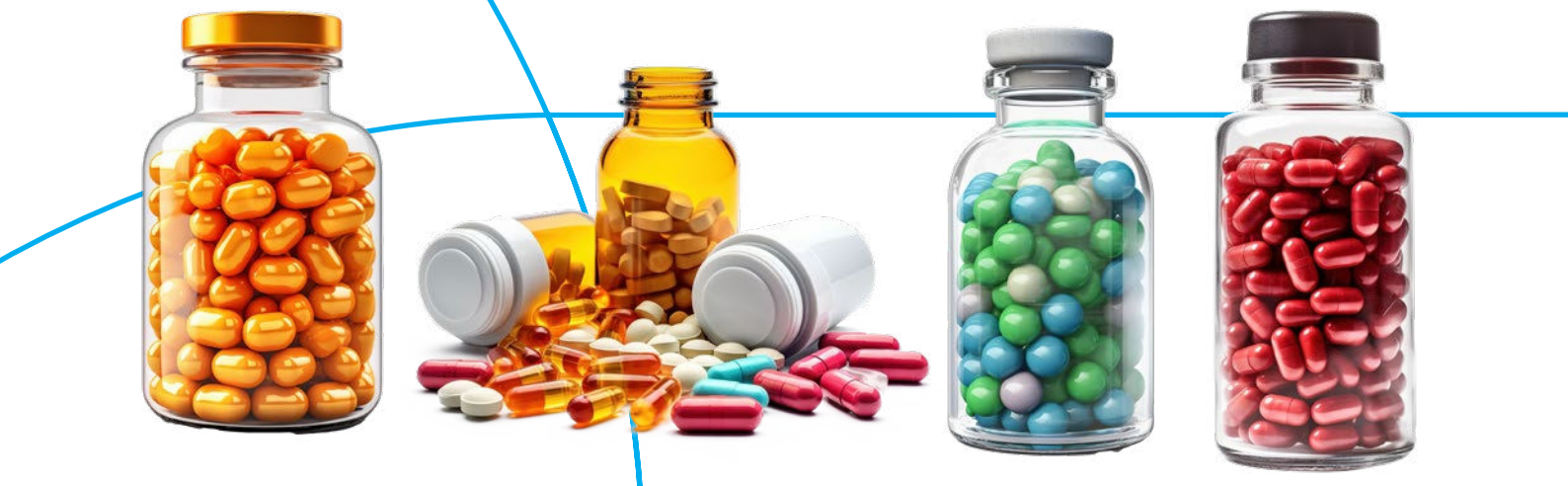
The World Health Organization cites antibiotic resistance as one of the most significant risks facing the world. Often referred to as a 'hidden pandemic', it threatens global health and development as it impacts on human, animal and plant health and also our environment, water safety and food security.

Indeed, latest research shows that in 2019, nearly five million deaths worldwide were associated with antibiotic resistant bacterial infections.

Most attention has focused on this process of antibiotic resistance evolution in patients, but resistance can also occur in bacteria living in or on animals, because most antibiotics produced are used in the livestock industry globally. Antibiotic resistance can also occur in the environment as antibiotics are produced naturally by microorganisms, and human activity introduces resistant bacteria and antibiotics to the environment.

Antibiotic resistance in our waterways

Recently, there has been a realisation that many of the antibiotics used in



human medicine and animal production are excreted in an active form. This then enters the environment through manure and sewage sludge application to land or through run-off from farmland and wastewater treatment plant discharges to rivers and seas.

Environmental concentrations of antibiotics are much lower than found in the human body during treatment of infection, but new data suggests that even at these low concentrations, antibiotics may still maintain their ability to contribute towards the antibiotic resistance crisis.

Working with AstraZeneca since 2012, researchers at the University of Exeter Medical School have worked to determine the ability of environmental antibiotic residues to contribute to antibiotic resistance. The collaboration also looks to establish new risk assessment tools to determine safe limits for antibiotics in river water.

The impact of the work

This work has attracted the attention of the Antimicrobial Resistance (AMR) Industry Alliance, the largest international consortium of pharmaceutical companies who have pledged to combat the AMR crisis, and has informed inclusion of antibiotics on the EU Water Framework Directive Hazardous Compound Watch List.

This led to the University of Exeter working with the Environment Agency as part of the Government's £19.2 million Pathogen Surveillance in Agriculture, Food and Environment programme. The team also advised the All-Party Parliamentary Group (APPG) on antibiotics, the United Nations Environment Programme and UK policy makers within the Environment Agency, Defra, as well as parliamentarians and industry.

The team continues to collaborate with the pharmaceutical industry and the Environment Agency on environmentally realistic mixtures of antibiotics, and how these may impact antibiotic resistance development.

This research is one theme of work on the environmental dimension of antibiotic resistance at the University of Exeter. Other themes include river catchment scale spread of antibiotic resistant bacteria and how different pollution sources and weather conditions contribute to environmental reservoirs of antibiotic resistant bacteria. There is also a work to quantify human exposure to these bacteria and the risk of environmental transmission in recreational water users.

This programme of research is one of the largest in the UK and globally, specifically focusing on antibiotic resistance in the environment, livestock and humans and the group have informed UK, EU and global policy on antibiotic resistance.

For more information on this work, contact William Gaze, Professor of Microbiology at The European Centre for Environment and Human Health, University of Exeter Medical School at W.H.Gaze@exeter.ac.uk.

Using ultrasound technology to remove forever chemicals

These chemicals are called Per- and poly-fluoroalkyl substances (PFAS) are a group of about 4,700 man-made chemicals used across a range of applications such as fire-fighting foams, waterproofing for clothes, and non-stick cookware such as Teflon, among others. Even everyday items like pizza boxes and dental floss include PFAS.

There's a type of synthetic chemical which has been so widely used over the last 70 years that its remnants can be found in 99 per cent of humans. Thee chemical has also been found in rainwater, soil and wildlife. Even low-level exposure to this pollutant is known to increase the risks of several cancers, including breast, testicular and kidney, birth defects and potentially around 800 other diseases.

The Guardian reported in 2023 that these "forever chemicals" have been detected in the drinking water sources at 17 of 18 England's water companies, with 11,853 samples testing positive.

Forever chemicals are incredibly stubborn to safely and sustainably dispose of. A collaboration between the University of Surrey and Arcadis, a global design, engineering and management consulting company, has found a way to destroy these chemicals and remove them from our water sources.

Forever chemicals

The properties of PFAS lead to unique behaviour and stability which were sought after commercial properties. However, these very properties also make them infuriatingly stubborn to safely and sustainably dispose of. Using conventional water or soil treatment technologies will not destroy them.

PFAS are surfactants – this means that they act like soap to help mix substances that would normally separate, like oil and water. They show remarkable resistance to typical pollution treatments, such as the use of ozone, bacteria or heating to temperatures of several hundred degrees.

Until recently, the only way you could truly destroy PFAS was only possible with incineration, which is expensive (especially for water-based pollution), highly polluting and often simply re-disperses the PFAS into the air.

Despite knowing the dangers and toxic nature of these substances since the 1950s, manufacturers were dumping waste PFAS into the environment until the early 2000s.

Destroying PFAS

Scientists around the world are now working on a different of ways to treat PFAS pollution. Teams are using new techniques such as photochemistry (destruction using light), plasma and electrochemical treatments. Some researchers have even tried grinding PFAS like wheat. However many of these methods ultimately produce smaller PFAS molecules that make further treatment even more difficult.

A team from the University of Surrey, in collaboration with Arcadis, have developed sonolysis (the use of ultrasonic waves to break down a substance) to treat PFAS.

The carbon-fluorine chain in PFAS molecules are hydrophobic, meaning when you put them in water they tend to congregate around any gas bubbles present. When you bombard them with high frequency soundwaves, these bubbles undergo extraordinarily fast cycles of compression and expansion, tens of thousands (even millions) of times per second.

This causes the bubbles to grow and then violently collapse under the next incoming soundwave. The collapsing gas momentarily reaches temperatures exceeding the surface of the sun and pressures around a thousand times higher than our atmosphere.

This method completely degrades PFAS into relatively harmless carbon dioxide and fluoride.

Next steps

The team hope to develop a large reactor capable of treating contaminated domestic water supplies or firefighting foams, as well as adapting the process for soil contaminations.

Legionnaires' disease is a severe form of pneumonia caused by the Legionella bacteria. The bacteria thrive in natural and artificial water sources, such as rivers and lakes, but can also multiply in man-made water systems like cooling towers, hot water tanks, plumbing systems, and air conditioning units. About 15 per cent of people who get Legionnaires' disease will die from the infection.

Staffordshire University is helping a local business, SAS Water, develop a game-changing new product to prevent the spread of deadly bacteria Legionella. If left undetected in water supplies, Legionella can grow to dangerous levels.

Monitoring water for deadly bacteria

SAS Water, based in Leek, is an industry leader in Legionella control with more than 30 years' experience of working with clients across private and public sectors including factories, councils, nursing homes, housing associations, hotels, spas and leisure centres.

What is Legionnaires' disease?
According to the NHS Legionnaires' disease is a lung infection you can get from inhaling droplets of water from things like air conditioning or hot tubs. It's uncommon but it can be very serious. You can get Legionnaires' disease if you breathe in tiny droplets of water containing bacteria that cause the infection.

It's usually caught in places like hotels, hospitals or offices where the bacteria have got into the water supply.

Now, the company has teamed up with Staffordshire University on a project which aims to transform the market for water safety.

Lizzie Ward, Managing Director of SAS Water, explained: "Each year, hundreds of Legionella outbreaks are discovered across the UK and can result in serious illness and death. Businesses have a legal obligation to understand and minimise the risk of Legionella and we provide a range of services to help them do this. We had an idea for a new product but didn't have the technical know-how to bring it to life. So, working with Staffordshire University seemed liked a fantastic opportunity."

"Staffordshire University has played an important role in developing this product which will help our business to stay ahead in Legionella prevention and ultimately protect people from this life-threatening disease."

Legionella risk is usually monitored through temperature checks and regular flushing of water systems. To improve accuracy and save resources, SAS Water is developing a sensor-based solution to automatically monitor water for the bacteria, using low powered, cutting-edge sensor technologies and a cloud-based management system.

SAS Water has accessed a range of funded support through Staffordshire University's Innovation Enterprise Zone including the use of state-of-the-art facilities, dedicated academic advisors and a graduate intern. After developing the product concept and a prototype, the company has entered a two-year Knowledge Transfer Partnership (KTP) with Staffordshire University to bring the product to market.

Philip O'Neil, Employer Partnership Development Manager at Staffordshire University, said: "SAS Water is a brilliant, forward-thinking company and this is the perfect example of knowledge transfer. You have a business with an idea for a project but lacking the internal expertise to deliver it. We have incredible knowledge within our academic teams. It's a fantastic way of driving businesses forward. We're very pleased to be working with SAS Water on this product which will not only benefit the business but will have a positive impact on society as a whole."

Small and medium-sized enterprises, large businesses, charities and public sector organisations are eligible to apply for a KTP with Staffordshire University and between 50 to 75 per cent of project costs will be covered by government funding.

Embedding innovation in water organisations

Cardiff University, Wales' biggest research university, and Dŵr Cymru Welsh Water (DCWW) launched a strategic partnership in July 2022, following a long-standing history of collaboration.

The Water Research Institute at Cardiff University maintains enduring partnerships with industry, academia, government, regulation and the third sector. Its collaborative approach involves co-designing and co-delivering impactful research and training to over 120 PhD students in business-relevant research. Together they share expertise on water-related issues through consultations and advisory boards and they organise frequent meetings and events.

Dŵr Cymru Welsh Water is one of these partner organisations. The strategic partnership agreement has delivered benefits across a range of projects.

DCWW provides essential water and wastewater services to over three million people across most of Wales, Herefordshire and Deeside.

The strategic partnership agreement sets out to invest in projects that have the potential to deliver ambitious outcomes at scale across strategic themes. The partnership looks to boost consultancy projects and research collaborations, leveraging significant external funding via sponsors such as the Ofwat Challenge fund, UKRI and Horizon Europe.

The partnership enables DCWW to tap into multiple areas of expertise, train and attract new talent, and tackle challenges through co-designed research. For the university, it provides opportunities to leverage funding and maximise the impact of researchers' work applied to real-world challenges.

Whilst strengthening a long-standing and mutually beneficial relationship, it also encourages future interactions to flourish by streamlining processes and breaking down more significant barriers, providing a platform for

The Embedding Innovation programme

Dŵr Cymru Welsh Water is owned by its customers. As a social enterprise, innovation is crucial to delivering lower costs, limiting environmental impact, and reducing risks. DCWW worked with Cardiff University to develop innovation capacity across the organisation. The result was a ground-breaking programme that has generated both immediate and long-term benefits.

The Embedding Innovation programme included knowledge transfer, exploration and practical innovation work-streams where participants developed company improvements. Cardiff University facilitated the process of embedding tools and methods throughout DCWW, guiding participants to produce an in-house innovation toolkit.

The programme allowed managers from across DCWW to pool their knowledge, test existing innovation processes.

greater impact, both in terms of research and the benefits for society.

The collaboration is led by Isabelle Durance, Professor and Director of Cardiff University Water Research Institute. Professor Durance said: "Our strategic partnership with Dŵr Cymru Welsh Water aligns to the efforts of the leading not-for-profit water utility and Cardiff University's internationally renowned work in water sciences. Together we are uniquely positioned to change the way we manage water, wastewater and our natural resources."

Tony Harrington, Director of Environment at DCWW, said: "We are in an environment where change is accelerating—certainly in the water industry—and that is accelerating the need for good science and innovations to underpin DCWW's investment strategies."

If you are interested in finding out more about collaboration opportunities with the Water Research Institute, please contact the team at water@cardiff.ac.uk.

Dŵr Cymru Welsh Water Resilience review

Extreme weather events, ageing water infrastructure and current population growth in the UK are factors likely to impact on UK water suppliers in the future. Working alongside academic partners, DCWW aimed to:

- Improve its understanding of the challenges it faces
- Improve resilience planning
- Inform a strategy to 2050

In this context, an interdisciplinary group of experts from Cardiff University worked with DCWW colleagues to identify and review potential drivers of major change across the social, technological, environmental, economic and politico-legal realms. It investigated scenario approaches for dealing with plausible futures. Priority research areas were also determined based on knowledge gaps and uncertainties.

This work contributed to the refresh of the DCWW 2050 strategy and supported the future resilience of DCWW's business. It enabled them to reflect on their Strategic Responses with an improved understanding of where DCWW were 'on track' and where they were 'at risk.'

Knowledge Exchange event

To mark the launch of the strategic partnership, over 50 staff from DCWW and Cardiff University attended a networking and knowledge exchange event, to ignite ideas for addressing current challenges and future research opportunities.

Interdisciplinary discussions generated over 24 ideas for collaboration. A growing Network Directory links over 70 colleagues from DCWW and CU pursuing collaboration opportunities. Network members can search for and connect with potential collaborators through the directory, as well as access resources to support joint projects.

Finding and using water - on the Moon!

Scientists have confirmed the presence of water molecules on the Moon's surface. This discovery challenges the earlier belief that the Moon is completely dry. Lunar water is considered a valuable resource for future space exploration. It could be used for drinking water, oxygen production, and could even be split into hydrogen and oxygen for rocket fuel.

NCUB members the Open University and Leonardo have formed part of a consortium that takes samples of moon water and other materials of high value for science and exploration.

The Open University is driving the search for water on the lunar surface, for scientific discovery and as a resource to support human exploration of the Moon and beyond.

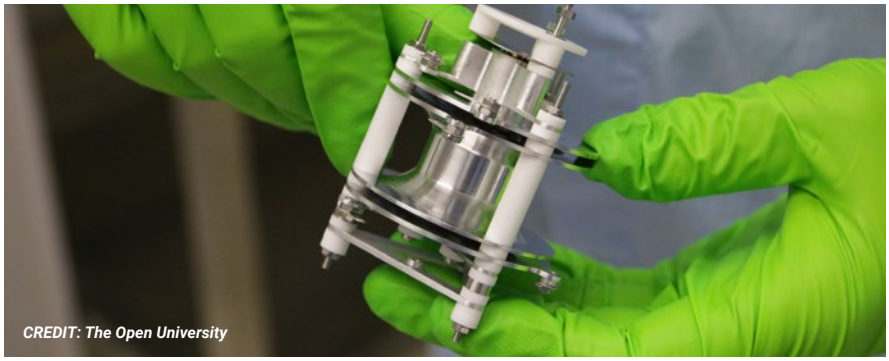
Around the world, a new fleet of spacecraft is being developed to land on the Moon, starting with robotic craft and leading up the first crewed missions to the Moon since Apollo 17 in 1972.

This renewed interest has been sparked by one thing: water. The legacy of the Apollo programme was seemingly that the Moon was a dry and barren place. But as research laboratories worldwide have developed ever more sophisticated techniques to analyse the 300 kg or so of rocks collected by the astronauts, a new picture is beginning to emerge.

Researchers, including at OU have found water locked deep within lunar rocks. And instruments on orbiting spacecraft have started detecting hints of water ice frozen at the cold lunar poles, and even traversing the warmer equatorial regions.

Water on the Moon is a prize attractive for many reasons. Scientists hope to understand how gases move around a planetary surface, eventually finding their way to cold regions at the poles where they become trapped and accumulate as a scientific treasure trove of ices that record the history of the process happening on the Moon over billions of years. And there are practical reasons too: if ice can be extracted and purified it could be used for drinking water and sanitation by astronauts in lunar bases, reducing the dependency of bringing supplies from Earth and enabling a more sustainable way of space exploration.

The OU has a long history of developing bespoke scientific instruments for space missions, from studying the atmosphere and surface of Mars to landing on a comet. Since 2011, OU has been



The Ion Trap Mass Spectrometer imaged above is a part of an instrument that will detect lunar volatiles

supporting the Europe's space industry to develop a flagship product for lunar exploration. 'PROSPECT' combines an Italian-led drill for collecting samples from below the Moon's surface, and OU's miniature laboratory for analysing the samples for water and other materials of high value for science and exploration.

The PROSPECT consortium is led by Italian prime contractor Leonardo S.p.A, to which OU is the major subcontractor. Leonardo S.p.A brings space closer to Earth for the benefit of citizens, institutions and businesses, covering the entire value chain of the space industry, from the manufacture of satellites and orbiting infrastructure, and the production of high-tech equipment and sensors, through to management of satellite services and propulsion and launching systems.

The Open University is contributing to these endeavours in various ways:

Cutting-edge laboratory research

The OU team applies cutting-edge techniques to analyse Moon rocks brought to Earth by space missions or as meteorites falls. This research has identified the primary source of water in lunar rocks and has improved our understanding of the formation of the Moon itself.

Building payloads for space missions

As part of the PROSPECT consortium, the OU's role is critical to the success of the mission. The Leonardo Head of Space said:

"ESA awarded a contract in January 2020 to Leonardo for a [further] EUR31,500,000 for the development of PROSPECT flight model. Again, OU is the major project collaborator […]. The research of OU into lunar samples, ices and volatiles and mini science laboratories has been very important for us. Our collaboration with OU has led to these two very important contracts for the company and has secured a role for us in a new and the growing market for lunar exploration missions which previously we had not been involved in. The employment of highly skilled staff is a significant part of the cost of a space product, and so contracts of this value secure many tens of existing and new jobs in our company and in the supply chain in the various countries that support our work on PROSPECT". OU also leads a diverse team of subcontractors on this project, ranging from UK company Airbus Defence and Space Limited, to UKRI STFC RAL Space, to a range of SMEs and micro-SMEs.

PROSPECT will fly to the South Polar region of the Moon on board a NASA-led spacecraft in 2026. And a simplified version of the instrument has already successfully operated on board the Peregrine Mission One spacecraft built by Pittsburgh company Astrobotic.

Practical technologies for ISRU

OU research and researchers continue to help define the global strategy for space exploration. And as the future emphasis shifts from finding water on the Moon to learning how to make use of it in a responsible and sustainable way, OU is developing techniques and payloads for the next generation of spacecraft. One example is a payload that will extract water and oxygen from Moon soil and rock, thus providing a source of life support anywhere on the Moon, without relying on finite polar ice reserves.

Down to Earth

Space research also brings benefits back down on Earth. The know-how gained through developing complex instrumentation to operate in the harsh environment of space, has been applied to terrestrial challenges ranging from keeping submariners safe at sea to the optimisation of new fragrances. Instruments used for planetary sciences are being applied by OU's scientists for the early detection of cancer, detecting adulteration in food and drink and the remediation of mining spoil.

Water re-use can help to relieve the pressure on water resources globally. However, chemical pollutants from industrial and domestic processes that end up in water make it unsafe to reuse and over two billion people globally still have no access to clean water.

Existing water treatment technologies tend to be energy intensive and costly, and some generate toxic by-products.

A new, low-cost, sustainable solution to remove pollutants from our wastewater is transforming how we clean our waterways, protecting both people and the environment. University of Birmingham researchers developed this innovative technology through their spin-out, Daphne Water Solutions (DWS) Limited. Now through industry collaborations, they are testing its use.

Using water fleas to clean our waterways

Barely bigger than a sesame seed, regulators have long used daphnia (water fleas) to find and set safe concentrations of chemicals in the environment. These tiny crustaceans can lie dormant for decades. Professor Luisa Orsini and Dr Mohamed Abdallah discovered that dormant strains from pre-industrial revolution can more efficiently filter and clean water than their contemporary counterparts.

A sleeping eco "giant"

In 2021, Professor Orsini and Professor Karl Dearn patented the process of using daphnia to remove persistent chemicals from wastewater, making it safe to reuse. Working with international innovation, consulting and project engineering company, Stopford Ltd., they gained insight into the water treatment industry and developed a business plan for their spin-out, Daphne Water Solutions Ltd (DWS).

Professors Orsini and Dearn and the DWS team, including Dr Iestyn Stead and Professor Robert Lee, built a prototype to introduce daphnia to wastewater treatment systems where they can thrive while filtering chemicals out of the water. This prototype has successfully run at Severn Trent's Resource Recovery and Innovation Centre in Spernal for the past nine months.

Water fleas are helpful because they remove a wide range of chemical pollutants spanning pharmaceuticals, pesticides and industrial chemicals, including "forever chemicals", a harmful group of persistent chemicals present in many everyday items we use. The water fleas' removal efficiency is as good, if not better than, existing treatment technologies, and the treatment system is significantly cheaper too. On

the technology, Professor Karl Dearn says: "Water fleas are remarkable for sustainability because they largely sustain themselves once introduced in wastewater. What makes the technology unique is the selection of strains from past environments based on their chemical tolerance and the retrofittable design."

Industry collaboration for a cleaner, healthier future for all

Severn Trent has been the first water company to support the testing of the daphnia-based technology. On enabling the testing of the technology, Severn Trent said: "We are pleased to have played a part in testing this pioneering technology, accelerating its market readiness, and to continue working with Daphne Water Solutions and the University of Birmingham to enable its scale up in commercial settings to comply with upcoming regulatory requirements and improve water quality for our customers."

The environmental health impact of the discovery and technology is high, as Dr Mohamed Abdallah notes: "Preventing emerging chemical contaminants from re-entering our waterways through wastewater effluents, substantially reduces environmental pollution and adverse health impacts."

Through DWS, Orsini and Dearn, together with Abdallah and others at the University of Birmingham, are working with other water companies and other businesses, including in overseas territories where the combination of climate change, less developed infrastructure and water scarcity hugely affects access to clean water. A state-owned water utility company in South Africa approached the University of Birmingham researchers and financed the first test trial of the technology in South Africa.

With 57 per cent of the world population projected to live in water scarce areas by 2050, industry and the public increasingly recognise the need to reuse water safely. Severn Trent continues to partner with University of Birmingham researchers and DWS, to generate new knowledge and research-based insights on nature-driven, circular solutions to emerging environmental challenges. With the University of Birmingham and DWS, they are part of the large consortium funded through Horizon Europe. Comprising 22 partners from 11 European countries, the consortium seeks to identify sustainable solutions to reduce plastic and other emerging contaminants in rivers.

On the significance of the research and innovation to industry, Professor Luisa Orsini noted: "It shows the growing need for sustainable, green solutions to solve environmental challenges such as the global water crisis. Regulation on chemical pollutants is becoming more stringent and public awareness of the consequences of pollution is growing. Our research and innovation can help businesses meet regulatory compliance and address water scarcity at affordable costs, while meeting sustainability commitments."

Distilling industry wastewater to create green hydrogen

Scientists at Heriot-Watt have developed a way to use the large amount of wastewater created in the distilling industry to produce green hydrogen. Producing green hydrogen currently consumes 20.5 billion litres of fresh water a year.

Wastewater from the distilling industry could be used to produce green hydrogen – a type of sustainable fuel – using materials developed by scientists at Heriot-Watt University.

Green hydrogen does not emit polluting gases either during combustion or during production. It is proving vital in replacing fossil fuels in those sectors that are more difficult to decarbonise, thus contributing to the fight against climate change.

Distilleries in Scotland alone produce an estimated 1 million litres a year of wastewater from the whisky distilling process. Globally, the distilling industry is thought to produce around 1 billion litres a year of wastewater.

Dr Sudhagar Pitchaimuthu, a materials scientist in Heriot-Watt's School of Engineering and Physical Sciences, explained: "It takes 9kg of water to produce every 1kg of green hydrogen. Meanwhile, every 1 litre of malt whisky production creates about 10 litres of residue. To help protect the planet, we need to reduce our use of fresh water and other natural resources. So our research focused on how to use this distillery wastewater for green hydrogen production with a simple process that removes waste materials present in the water."

Dr Pitchaimuthu and his team have developed a nanoscale material – a particle that is one in 10,000th the diameter of a human hair – to allow distillery wastewater to replace fresh water in the green hydrogen production process. The nanoparticle, called a nickel selenide, treats the wastewater and, in the team's research, produced similar or slightly higher quantities of green hydrogen from the wastewater, compared to the results from fresh water.

"About one billion litres of wastewater a year is produced from the distilling industry, so the potential of this process is huge," Dr Pitchaimuthu said. "Using industry wastewater means we can reduce the extensive freshwater footprint associated with green hydrogen production. Our research also shows how we can use the world's resources more sustainably to produce clean energy."

Hydrogen is a gas that, unlike fossil fuels, does not emit carbon when it is burned. Green hydrogen is generated using renewable energy. The electricity generated from renewable sources – such as wind or solar – is used to power electrolysis. This is the process which produces hydrogen by splitting water into hydrogen and oxygen.

Electrolysers – the devices used to perform electrolysis – only work with fresh water and typically fail because of the substances in wastewater. But Heriot-Watt's nanoparticle overcomes this challenge.

The next steps for the research team include developing their own electrolyser prototype and scaling up production of their nickel selenide nanoparticles. They will also be analysing the distillery wastewater to discover whether other materials of value could be salvaged from it, alongside hydrogen and oxygen.

The research was funded by Heriot-Watt's School of Engineering and Physical Sciences and completed in collaboration with the University of Bath's Department of Chemical Engineering and The Scotch Whisky Research Institute, which supports applied research across the Scotch Whisky production process.

Hydrogen and green hydrogen are key research areas at a new Global Research Institute for Net Zero and Beyond being developed at Heriot-Watt University. Called iNetZ+, the institute will bring together researchers from across the University and collaborate with industry, government and communities to address global sustainability challenges.

A water research collaboration spanning over 25 years

Northumbrian Water Group (NWG) and Newcastle University's longstanding research collaboration and shared research facilities are delivering extensive results - enhancing water and wastewater treatments, maximising the efficient use of water, and advancing techniques to generate energy from water.

Here we share some examples of what this long standing collaboration has achieved.

Research embedded across all levels

Research between NWG and Newcastle University occurs across all levels from undergraduate summer placements and industry internships, sponsorship of masters projects and post-doctoral researchers through to UKRI-funded Knowledge Transfer Partnerships (KTPs). One KTP was to investigate generating energy from wastewater, which on large, complex sewage treatment work. A new process optimisation method was developed during a research collaboration between senior lecturers from Newcastle University's School of Engineering, and the team at Northumbrian Water. The research was extended, with the employment of a KTP Associate, who has been working full time on the project since summer 2022.

Royal recognition for water research

These pioneering projects in water research with NWG have contributed to Newcastle University being awarded the Queen's Anniversary Prize for Higher and Further Education in November 2023 in recognition of its long-standing excellence in water research. Newcastle University's many partnerships not just with industry, but with governments and NGOs in water research are helping to mitigate long-lasting real-word impacts impact of floods and droughts and improve water quality and public health in communities across the world.

Pictured (l-r): Professor Chris Day, Vice-Chancellor and President; Professor Richard Dawson, Chair in Earth Systems Engineering and Director of Research, School of Engineering; Professor Stephanie Glendinning, Pro-Vice-Chancellor, Science, Agriculture and Engineering.

Prestigious Royal Academy of Engineering Fellowship for academic leading METZero

Jointly Newcastle University and NWG are at the forefront of Microbial Electrochemical Technology (MET) research and development. After years of pilot-testing and developing the technology and IP, the team now aims to advance it further through commercialisation.

The resulting spin-out company, METzero can help wastewater treatment plants increase their capacity and reduce the energy costs of treatment whilst also reducing their carbon emissions. It is hoped that METzero can complement existing treatment technologies and help bring the sector closer to net zero.

Dr Pavlina Theodosiou, the academic leading MetZero, was awarded a prestigious Enterprise Fellowship, by the Royal Academy of Engineering earlier this year, to support her as the company's CEO.

'FairWater' industry collaboration to reduce customer bills and carbon emissions

NWG and Newcastle University also collaborate on the FairWater project, alongside industry partners National Energy Action, Procter & Gamble and Northern Gas Network. A winning entry in the first round of Ofwat's £200million Water Breakthrough Challenge competition, the project was awarded £3.8m over four years.

The overarching aim of FairWater is to reduce household water consumption, particularly hot water, to help reduce bills for customers. The project focusses on driving improved water efficiency at the task-based level – by reducing time, frequency and intensity of water consumption for given tasks. Where appropriate, the possibility of re-purposing water will be explored, provided it can be executed without major household re-plumbing.

Within FairWater the project partners are working with manufacturers and industry-level organisations, to test and develop solutions or options that manage task-based water and energy use in the home. The desire is that every home will be able to access at least one option, appropriate to their needs.

The project uses specially recruited real home-owner properties and dedicated research facilities at the partner sites, which will have the effect of maximising the relevance and impact of the co-developed research findings. The home-owner properties will have a range of options for trialling interventions, new products and installed equipment, which can all be tested to see which are most relevant and significant for reducing household water use. The partner research facilities include:

- purpose-built Futures Close on the NGN's Low Thornley site, which has representative housing stock used for any experiments or trials considered too disruptive to deploy in real households,
- the Urban Observatory (UO) infrastructure hosted by Newcastle University, where its team of data scientists, investigate how best to use data to inform and guide customers on reducing water used

In addition to practical experiments, other interactions with recruited households include surveys, focus groups, interviews and diary recording exercises, adding another layer of information and knowledge on household water use habits, and the most effective methods for helping with reducing water use.

Chris Jones, Research & Development Manager, Northumbrian Water Group said "FairWater has been possible thanks to NWG's longstanding and multi-disciplinary partnership with Newcastle University. The project involves teams across business, social science, computing, geospatial and, of course, water. The success of FairWater relies on the trust and understanding between our two organisations and builds on the strong relationships that both NWG and Newcastle University have with the other project partners, essential for coping with the uncertainty and risk inherent in cutting edge research and innovation. Our collaborative research is steered by NWG's strategic ambition and the outcomes we aspire to for our customers and environment, focussed through NU's lens of internationally leading science to deliver both local and global impact."

Conclusion

This booklet highlights the varied and impactful university and business partnerships that address challenges related to water. As our planet faces the growing threat of water shortages and pollution, these collaborations underscore the critical role of research and innovation in finding sustainable solutions.

These projects demonstrate the power of collaboration and show the commitment of NCUB members to harnessing innovation for the benefit of wider society.

As we navigate the waters of climate change and environmental challenges, this booklet emphasises the importance of ongoing collaboration in shaping a more sustainable and resilient future. The diverse projects featured here exemplify the creativity, expertise, and dedication of UK universities and businesses to address pressing water-related issues.

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