ISSUE 94 • AUTUMN 2020

THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY

advances WALES

New process to clean up pharmaceutical pollutants

Researchers at Swansea University have developed a new method to detect and remove water pollutants that come from everyday pharmaceuticals

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Advances Wales showcases the latest news, research and developments in Welsh science, engineering and technology. This edition and past editions can all be viewed online.

THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY
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We are delighted to welcome you to the 94th edition of Advances, a key publication supporting the innovation ecosystem in Wales.

Innovation is a very loaded word. It means different things to different people and has a myriad of definitions. We like the following: **"Innovation is the creation of something that improves the way we live our lives."** (Barack Obama)

At the Innovation Advisory Council for Wales (IACW), we know that innovation is a broad spectrum and there is a vital role for SME, Public Services and Third Sector innovation. Sometimes it is about adapting and adopting new technologies to solve problems across the whole of our economy, society and natural environment. The quote from Barack Obama is at the heart of our work, because it emphasises that innovation is a means to an end, rather than an end in itself.

Covid-19 has changed all of our lives and triggered much innovation in the public and private sectors in Wales. Challenges have been met and complex problems have been addressed which many assumed could not be solved. We have seen rapid deployment of digital technologies in our public services, ingenious scaling of ventilator and PPE production, and midnight oil being burnt to find an effective Covid-19 vaccine.

In this edition of Advances, you will find examples across the full spectrum of innovation, all of which will improve the way we live our lives. This edition is issued in Wales Climate Week. Profound change is needed to meet the challenge of climate change, and the net zero imperative can only be met by the best science, as well as the brightest and most inclusive innovation. We believe that the innovation spurred by the current pandemic is an inspiration for what is possible and what we can all do to create that stronger, greener future.

Claire Durkin and David Notley
Co-Chairs of the Innovation Advisory Council for Wales

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Advances Wales is a quarterly technology journal produced by Welsh Government to showcase new developments in science, engineering and technology from Wales.
Advances raises the profile of the technologies and expertise available from Wales in order to facilitate collaborative relationships between organisations and individuals interested in new technologies and innovation.

Editorial Board: Delyth Morgan, Lucas Brown, Sarah Brajer-Hughes, Simon Cooper, Gareth Browning, Marcia Jones, Clive Thomas, Richard Johnston.

For information on how to contribute features contact the editor, Sophie Davies tel 029 2047 3455
email: advances@teamworksdesign.com

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Funding boost for climate change research

Three major climate change research projects involving Aberystwyth University scientists have been awarded additional funding of £3.9 million.

The Ecostructure, Acclimatize and CHERISH projects address pressing questions to help coastal communities on both sides of the Irish Sea adapt to climate change and other challenges.

The Ecostructure project facilitates greater use of nature-based solutions to enhance the ecological value of artificial coastal structures along the Welsh and Irish coasts. As part of the project, existing eco-engineered interventions from around the world have been tested in the Irish Sea, and new designs have been created and attached to artificial structures such as sea defences to investigate their role in providing new habitats for marine life. The additional funding will allow the team to conduct larger scale trials of their nature-based interventions, moving further towards implementation at a commercial scale.

Meanwhile, researchers on the Acclimatize project have been working to improve the quality of bathing waters along the west coast of Wales and the Irish Sea. They are developing novel approaches to safeguard public health protection through risk prediction and the regulation of sea bathing waters.

Researchers from the Ecostructure team attaching specially-designed experimental tiles to natural and man-made sea defences in Borth near Aberystwyth to create new habitats for marine life.

Picture courtesy of Prifysgol Aberystwyth University

The CHERISH research project focuses on capturing the effects of climate change on coastal heritage, led by the Royal Commission on the Ancient and Historical Monuments of Wales. The researchers are using cutting-edge technologies to analyse coastal and island archaeology and maritime heritage sites most affected by climate change, coastal erosion, storms and rising sea levels.

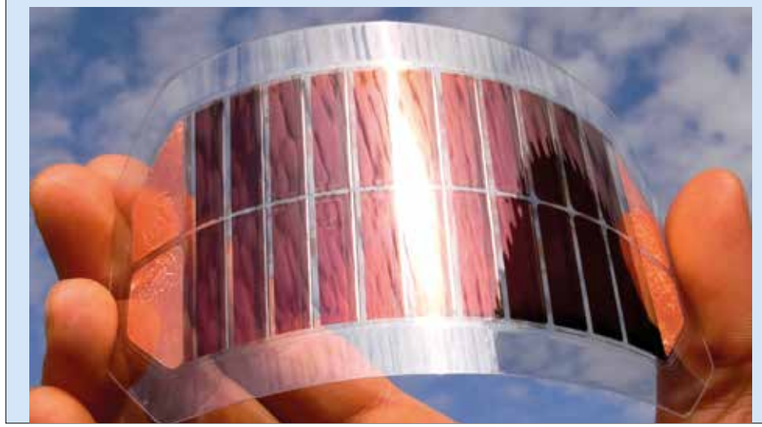
www.aber.ac.uk

Welsh scientists advance solar technologies

Researchers at Swansea University have been awarded a grant of £6 million to drive next-generation solar technology into new applications.

The grant brings together three research groups from Swansea University, Imperial College London and Oxford University to advance organic and perovskite solar cells into applications that current solar technologies are not suitable for.

These next-generation photovoltaics show great promise as their performance competes with current technology, but they have the advantages of being flexible, lightweight and cheap to produce. They can also be printed directly onto products during manufacture.



Such properties make them suitable for new applications that will be critical to advances such as: 5G, which requires ultra-lightweight sources of power for pseudo-satellites and high-altitude unmanned aerial vehicles; the Internet of Things, for which sensors and computing devices are increasingly embedded into everyday objects; and zero-carbon buildings and vehicles, which could use their roofs, walls and windows to generate power.

Led by SPECIFIC Innovation and Knowledge Centre at Swansea University, the team will use the grant to deliver the fundamental science and engineering to underpin the development of these promising solar technologies. They will also develop low-carbon, low-cost manufacturing methods that will enable the technologies to be produced at scale, and create prototypes to demonstrate how they can provide solar power in new applications.

www.swansea.ac.uk

Research to unlock the power of ammonia

Cardiff University scientists are working towards the large-scale generation of electricity from ammonia, thanks to new funding of almost £3 million.

Ammonia, a compound commonly used as a fertiliser, has recently shown promise as a fuel because it can be burnt in an engine or used in a fuel cell to produce electricity. It is thought that ammonia could form the basis of a new renewable energy storage and distribution solution, as it does not produce carbon dioxide when it is burned, can be created using energy from renewable sources and can be easily stored as a bulk liquid.

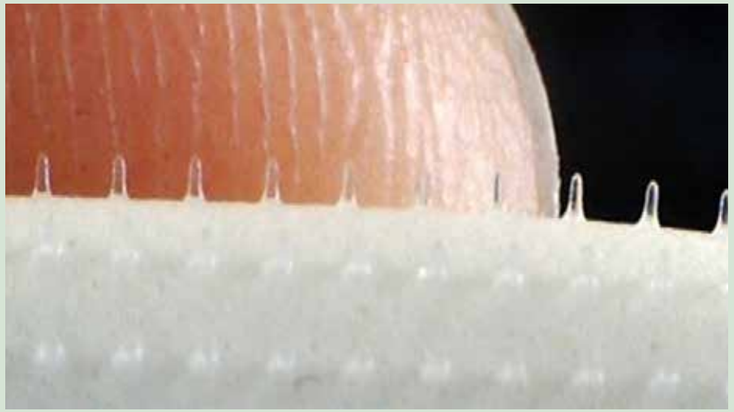
The research team at Cardiff University has already created the world's first demonstrator which turns electricity, water and air into ammonia and stores it in a tank, before later combusting it in a bespoke engine to generate electricity, all without producing any carbon emissions. A £1.9m project is now addressing the issues of scale by improving the system so that it can cope with large-scale power generation.

Meanwhile, a larger project called FLEXnCONFU is exploring the use of ammonia blends. The £11.5m project, from which Cardiff University secured a further £1m for ammonia combustion research, is aiming to reduce carbon dioxide emissions by designing innovative, carbon-free solutions to back up more traditional energy generating systems. The aviation industry is just one area that has shown interest in ammonia, with Cardiff University researchers already engaged in an exploratory project to test the viability of ammonia as a sustainable aviation fuel. Similarly, the team has research proposals in the marine sector, in heating and cooling applications for domestic appliances, and in large furnaces to support UK industry.

www.cardiff.ac.uk

Developing microneedle skin patches for vaccines

A new way to deliver vaccines through microneedle skin patches is being tested by Innoture, whose R&D department is based at Swansea University's Institute of Life Sciences.



The COVID-19 pandemic is giving extra urgency to the search for vaccines and new ways of delivering them. Traditional hypodermic needles can be frightening and painful for children and adults alike. Microneedles (tiny needles which have more in common with transdermal patches than with hypodermic needles) could improve patient compliance and therefore yield better health outcomes.

Innoture's next-generation transdermal delivery system has the potential to improve the patient experience and reduce the burden on the NHS and other healthcare systems.
The patch is designed to be painless and minimally invasive for patients to self-administer, reducing the need for people to attend a clinic. For healthcare professionals, this would also shorten consultation or appointment times and potentially remove the need for cold-chain storage.

The new research will develop and test technology for delivering a vaccine dose via the skin. It will also test a simple and secure disposal process, which would allow the patches to be administered at home.

www.innoture.co

IN BRIEF

US deal for Cardiff medtech firm

Alesi Surgical has struck an exclusive deal with Olympus to distribute its Ultravision surgical smoke control system in the US. Surgical smoke is a gaseous byproduct of tissue treated with electrical surgical devices for cutting, cautery and other uses. If not properly managed, surgical smoke can be hazardous to the health of people working within the surgical suite. In the US, Ultravision is cleared for use in laparoscopic and open surgery. Clinical research has shown that it improves visibility, prevents the release of surgical smoke into the operating room, reduces patient CO2 exposure and facilitates "low pressure" laparoscopic surgery. Dominic Griffiths, CEO of Alesi Surgical, said: "Given the immense resources and expertise of Olympus, this exciting partnership will greatly accelerate the ability of US hospitals to access Ultravision so that it can provide its benefits to staff and patients."

Algae could be key to safer sunscreens

Swansea University researchers have teamed up with the Natural Products Factory skincare firm to explore how algae could be used to create the next generation of sunscreens. The ALG-SUN project, led by the University's Biosciences Department, has been awarded funding from the Algae-UK (Proof of Concept) Scheme. The team believes that microalgae could hold the key to developing new, natural sunscreen products that do not damage the environment and are proven to be safe for use on the skin. Microalgae protect themselves from damaging solar ultraviolet radiation with a group of sunscreen compounds called mycosporine-like amino acids (MAAs). However, there is a major challenge in obtaining MAAs in sufficient quantity and purity to confirm their effectiveness on the skin and to make algal sunscreens commercially viable. This project will see the partners working together to try to overcome these commercial barriers.

Funding boost for marine renewable energy

The SEACAMS2 partnership between Bangor University and Swansea University has received £1.5m of EU funding, enabling their work to continue until 2022. This will extend research and innovation that supports the development of marine renewable energy in Welsh waters. Professor Lewis Le Vay from Bangor University commented: "Wales is well-placed to be a world leader in the development of low-carbon energy generation from its coastal and offshore waters. This new funding is an exciting opportunity to maximise the benefits of SEACAMS2, which since 2015 has been helping to unlock the potential of marine renewable energy through collaborative research partnerships with the Welsh renewables industry. We are now working to deliver a range of additional collaborative research and innovation projects that can help support growth in the marine economy during this critical period for economic recovery."

North Wales roll-out for cancer detection tech

New technology capable of detecting lung cancer in its early stages is now available for patients across North Wales. Electromagnetic Navigation Bronchoscopy (ENB) uses GPS-like technology to create a 3D map of the lungs. This map then helps doctors to guide a catheter through the lungs' most complex airways. It is a minimally invasive procedure that allows doctors to diagnose and prepare to treat cancerous lesions using a single procedure, as quickly as possible. Glan Clwyd Hospital is the first district general hospital in Wales, and only the second in the UK, to use the new technology. Dr Daniel Menzies, Consultant in Respiratory Medicine, explained: "Up until now it has been difficult to get an early diagnosis, sometimes because of the location of the cancer in the patient's chest. With this new piece of equipment, it can detect lung cancer in its early stages, sometimes before other symptoms have become evident. This means there is potential for earlier treatment and a good outcome for the patient."

Seabed rights for floating offshore wind farm

The Crown Estate has awarded Blue Gem Wind with seabed rights to develop Wales' first floating offshore wind farm. The 96 MW Erebus floating wind demonstration project will be located approximately 44km off the Pembrokeshire coastline. Seabed rights will allow Blue Gem Wind (a joint venture between Simply Blue Energy and Total) to progress with environmental assessments and surveys, and seek planning consent for the project through the statutory processes. Hugh Kelly, Project Managing Director, said: "This first project in Wales will begin to unlock the significant potential of floating wind in the Celtic Sea. It is the first of the stepping-stone projects required to launch a new chapter in the development of offshore energy in the South West; a new industry that can deliver significant benefits for the local supply chain and the coastal communities of Wales and the wider UK."

Bringing clean water to the poorest communities

Technology developed by Carmarthenshire-based Hydro Industries (which featured in Advances Issue 92) has been sent to Bangladesh, in order to provide safe drinking water for communities currently reliant on contaminated sources. The company's purification systems are being deployed to some of the world's poorest communities as part of a global partnership to meet one the most critical sustainable development goals of the United Nations. Two thousand people in Morrelganj are currently reliant on contaminated water from a local canal, in which scientists have revealed dangerous levels of bacteria, parasites, e-coli and, in some cases, arsenic. Hydro's pioneering electro-coagulation technology can process large volumes of water at low energy, while removing pollutants at an economically sustainable cost. The ambition is to expand this initial programme beyond Morrelganj to other communities in Bangladesh and elsewhere.

Welsh companies join fintech programme

Three Welsh firms have been chosen to join Tech Nation's fintech growth programme. Coincover from Cardiff protects the contents of digital wallets, providing deposit protection, crypto key storage and recovery, lost key protection, cryptocurrency wills and cryptocurrency theft cover. Credas from Cardiff (which featured in Advances Issue 85) provides a combination of biometric facial recognition, document authentication, client engagement, data capture and eSign technologies to a range of sectors. Moneyshake from Newport has developed price competition technology which, rather than one-dimensional static comparison, allows product providers to bid for its customers' business in unlimited volume and in real time. Over the next 12 months, Moneyshake will add multiple finance options to its platform, with the aim of creating the UK's first competitive car finance marketplace.

Welsh firms chosen for net zero programme

Three Welsh companies have been selected to join Tech Nation's Net Zero programme. This initiative is the first of its kind, designed to support promising scaleups that are contributing to the UK reaching its goal of net zero greenhouse gas emissions by 2050. Route Konnect from Cardiff (which featured in Advances Issue 89) makes traffic more predictable and eco-friendly by creating smarter junctions and predicting the amount of vehicles and people. Sero from Cardiff is changing the focus of the housing industry to decarbonisation, and supports housing providers and their residents to reach net zero by sitting at the intersection of home comfort, construction and energy. Surple from Newport (which featured in Advances Issue 92) seeks to help businesses make smarter energy decisions, with their energy management software analysing data from buildings and providing actionable insights to users. The cohort also includes companies that are building electric vehicles, creating vertical farms and animal-free dairy products, and improving manufacturing and recycling supply chains.

New spinout develops diagnostic tests

A spinout company called i-Omics Limited has been set up to take research from Aberystwyth University to the wider public by creating diagnostic testing systems and technologies. Using biomarker "fingerprinting", researchers at the University's Institute of Biological, Environmental and Rural Sciences (IBERS) have been able to accurately pinpoint the presence or absence of a disease, as well as its impact on the patient or animal. Their research has focused on developing clinically useful biomarker identification and testing for major chronic diseases that impact on an aging human population. A parallel strand of work has targeted important animal diseases. They are also developing a novel point-of-care diagnostic system, which will enable patient-clinician interaction and diagnosis without the need for clinical face-to-face consultations. i-Omics Limited will help to move the science out of the lab and into the hands of clinical practitioners.

Semiconductor research facility progress

Work is underway on a new £30m research facility which will play a key role in the world's first compound semiconductor cluster in South Wales. The Centre for Integrative Semiconductor Materials (CISM), based at Swansea University's Bay Campus, is due for completion in 2022 and will provide research and innovation support for the CSConnected Cluster. The cluster is a growing network of regional semiconductor industry partners, including tech firms such as IQE, SPTS Technologies, Microchip and Newport Wafer Fab, along with Swansea and Cardiff Universities. Chris Meadows, Director of CSconnected, commented: "Wales has built an envious position as a global powerhouse of advanced semiconductor capabilities that is driving next generation technologies. The Centre for Integrative Semiconductor Materials is a welcome addition to the CSconnected family that will play a critical role within the cluster, complementing and greatly enhancing the technology offering from across our region."

Producing sustainable packaging from agricultural waste

Researchers from Bangor University are creating sustainable food packaging from maize to reduce post harvest losses.

Post harvest losses are caused by fresh produce spoilage during transportation from the farm to the market, which typically results from the use of sub-optimal packaging materials. These losses have a significant impact on food security, as well as farmer incomes, in East Africa. In Uganda's fruit and vegetable sector, it is estimated that 30-40 per cent of fresh produce is wasted through post harvest losses, rising to 60 per cent for tomatoes.

The Stoverpack project involves researchers from Bangor University's Biocomposites Centre collaborating with UK company NER Ltd, as well as Ugandan partners Makerere University, Musa Body Machinery and Oribags Innovations. The project seeks to address issues around post harvest losses of fresh produce in Uganda by manufacturing sustainable packaging from maize stover residues, creating a new value chain for this waste material.

Among the population of Uganda, 84 per cent of people live in rural areas of the country and 82 per cent of the workforce are employed in agriculture. However, around 41 per cent of the population is undernourished. Women are highlighted as being especially food insecure, despite the fact that they comprise a majority of the agricultural workforce.

Maize is the country's most important cereal crop, providing a significant portion of the calories consumed in both rural and urban areas. This crop is grown in every part of the country and provides a direct source of income for many households, traders and millers. Increasingly, maize has become a major non-traditional export cash crop, particularly benefitting smallholdings (small farms). It is therefore extremely important to many households for both food security and income.

Once maize has been harvested for its grain, residues such as stalks and leaves are left behind, and this is known as maize stover. It is typically ploughed back or left in the fields as crop mulch, or used as fuel and livestock feed. There are currently no higher value outlets for maize stover, but a proportion of this material could be diverted from more traditional uses without affecting soil fertility.

The Stoverpack project is exploring the feasibility of a commercial facility in Uganda that will use maize stover to produce pulp moulded packaging for eggs, tomatoes, and other fruit and vegetables. By establishing novel pulping and packaging technologies, the project aims to reduce waste, boost farmer incomes and create new jobs in the biobased packaging sector.

The resultant sustainable packaging is expected to reduce post harvest losses during transportation, thereby improving food security. It will also offer consumers the opportunity to purchase produce in packaging that is made from an alternative to conventional plastics. There will be an additional focus on integrating female-led smallholdings into the new supply chains (harvesting, storing, processing and converting maize stover into packaging) and on providing training and new job opportunities for female agricultural workers in partnership with the Ugandan industry and academic partners.

Contact:
Bangor University
w: www.bangor.ac.uk
t: 01248 388072
e: adam.charlton@bangor.ac.uk

Bangor

Growing microalgae from organic waste

Scientists at Swansea University have developed novel techniques to cultivate microalgae using food and farm waste.

Microalgae are microscopic photosynthetic microorganisms found naturally in oceans and lakes. A team from Swansea University has now developed new methods of growing microalgae from organic waste, which in turn can be used to generate animal feed and other sustainable products.

Sites that treat food and farm waste typically use a process called anaerobic digestion. This converts waste into biogas, used for energy, and produces a nutrient rich digestate, most of which is returned to land as a biofertiliser. However, there are strict limits on how much of this can be used on agricultural land due to pollution risks. These restrictions increasingly result in excess unwanted digestate, which can be difficult and costly to store or dispose of in a safe way.

The ALG-AD project, led by Swansea University's College of Science in collaboration with partners across Europe, is using the nutrients in digestate to cultivate microalgae, which are rich in protein and other useful compounds. Three pilot facilities have been established across North West Europe – at Langage AD in the UK, Innolab in Belgium and Cooperl in France. Despite differences in location, quality of digestate, operating procedures and design, all three facilities are now successfully growing microalgae.

Researchers have developed processing and cultivation techniques which maximise the nutrient uptake from digestate and prevent the nutrients from otherwise going to waste. The resultant algal biomass can be used to generate sustainable products. Analysis has so far indicated that the microalgae grown in this way are even richer in proteins than the commercially grown equivalent. Therefore the team is keen to explore the market potential of this biomass as an animal feed ingredient.

The aim is for the new approach to be adopted by sites across North West Europe, which is a densely populated and intensely agricultural area. This will not only reduce the pollution risk from nitrates spread on land, but will also provide a locally cultivated, sustainable alternative to soya. The team is also developing decision support tools and best practice guides to help others develop and adopt the new technology.

"Microalgae already form an essential part of the planet's ecosystem, and our work is exploring innovative ways in which these amazing photosynthetic microorganisms can provide solutions to global challenges."

Professor Carole Llewellyn
Swansea University

Contact:
Swansea University
w: www.swansea.ac.uk
e: l.t.hall@swansea.ac.uk /
c.a.llewellyn@swansea.ac.uk

Swansea

Advances
AGRICULTURE & FOOD

New traceability and big data technologies to ensure sustainable palm oil

Scientists from the University of South Wales have been working with partners, including Imspex Diagnostics, to develop new methods of ensuring that sustainable palm oil is used in supply chains.

Palm oil-derived products are found in about half of all items in the average UK supermarket, and the oil is used daily for cooking by over one billion people – mostly in Asia. The market for palm oil is expected to continue expanding, due to an increasing global population and greater demand for the oil to make cleaning and healthcare products, such as liquid soaps.

Due to concerns about the environmental impact of palm oil, regulators in Europe (including the UK) require that imported oil is only sourced from genuine certified producers which comply with all environmental and sustainability criteria. However, it can be difficult to distinguish between 'good' certified palm oil and 'bad' oil that has been fraudulently labelled as certified. Unfortunately the good and bad oils look identical, even down to their basic molecular composition.

Scientists at the University of South Wales have been working with Imspex Technologies, also based in South Wales, in an effort to address these challenges. Imspex has developed a proprietary gas-chromatography ion-mobility-spectrometry (GC-IMS) system, which enables rapid and cost-effective screening of large numbers of samples using automated sampling and sophisticated data analysis. This technology enables identification of tiny traces of volatile compounds, meaning it could be possible to find a unique chemical 'fingerprint' of oil samples that can be linked to their point of origin. In the case of palm oil, the technology could allow for detection of bad oil versus the certified good oil.

The researchers obtained a range of palm oil samples from partners in Malaysia and analysed them to determine the composition of volatile compounds. GC-IMS is predominantly a rapid screening technique, in which the identification of compounds is not essential and the identification database is relatively small. To check this, compounds that had been provisionally identified using GC-IMS were compared with more sophisticated data to assess the accuracy of identification. This successfully demonstrated that the rapid screening method was accurate, and scale-up studies are now in progress.

In another part of the research, it was necessary to address the huge amounts of raw data being generated during the screening of large numbers of samples. This required the integration of advanced chemometrics and machine learning tools, in order to generate predictive models that would simplify and speed up the analytical process without sacrificing accuracy. To achieve this, the Welsh team partnered with colleagues at Warwick University's School of Engineering to compare the accuracy of five different classification models.

Each of the models performed with averages of 96 per cent accuracy, although one achieved 98 per cent. These analytical methods for verifying the geographical provenance of palm oils will have positive implications within the industry and will strengthen the safety of international supply chains. The new approaches could also be applied to other food and non-food products in the future to ensure product sustainability and consumer safety.

Contact:
The University of South Wales
w: www.southwales.ac.uk
t: 01443 482266
e: denis.murphy@southwales.ac.uk

Pontypridd

Developing a fertiliser to reduce the need for pesticides

The University of South Wales is working with industrial partner RecoTech Ltd to develop an advanced slow-release fertiliser.

Advances
AGRICULTURE & FOOD

The new multi-functional soil conditioner is rich in nutrients and can be delivered exclusively to plant roots, without excess leaching into soil or groundwater. Initial laboratory work and field-scale trials were conducted in the spring and summer of 2020 by researchers at the University of South Wales' Sustainable Environment Research Centre (SERC) and RecoTech Ltd. SERC brings together experts from biology, engineering, chemistry and physics in a single academic team, combining their resources and skills in order to address major energy and environmental R&D challenges.

Initial field-scale trials indicate that the new soil conditioner can increase crop yields with less use of pesticides, insecticides and fungicides. The material is intended to alleviate nitrate pollution and soil degradation whilst helping to restore degraded soils.

The soil conditioner is produced from digestate, a by-product of anaerobic digestion processes for biomethane production. This has been a key research area for SERC and the University for several decades. Digestate consists of a mixture of materials and liquids produced by the digestion process and is rich in organic and mineral nutrients. It is already applied to agricultural land as an organic fertiliser, but the window for land application is limited by crop requirements and weather conditions.

In addition, excessive application of digestate leads to excess minerals permeating into groundwater, contributing to soil degradation, nitrate pollution, water contamination and the decline of aquatic ecosystems. These are significant global public health issues, since they are also caused by conventional soluble mineral fertilisers, which have been routinely applied to land excessively as part of intensive farming practices for the last 50 years. Annually, there are 450 million tonnes of synthetic soluble mineral fertiliser produced worldwide, causing the degradation of billions of tonnes of soil every year.

The new soil conditioner embeds and retains the nutrients and organic matter of digestate within a bio-available substrate, which binds the nutrients and enables their slow release to land. Over time, the material slowly decomposes, enabling targeted release of nutrients to crops and therefore preventing excess release into soil and groundwater.

The substrate can also enhance plants' resistance to pests and pathogens. Once taken in by the crop, beneficial elements become deposited in the plant structures and inhibit aphids from penetrating cell walls. This in turn prevents sap leakage and associated fungal diseases, and leads to improved yields through better photosynthesis and greater resistance to disease. In addition to functioning as a fertiliser, the soil conditioner could potentially lessen the need for application of insecticides, fungicides and pesticides.

> *"Research and field-scale trials conducted so far have shown the material can be made using commercially available equipment and materials that are already routinely applied to agricultural land. The soil conditioner has been shown to have significant potential on a range of crops including spring barley, potatoes, maize and sugar beet. Future work and field trials scheduled for the autumn and winter of 2020-21 will focus on further optimisation and modification of the soil conditioner, to enable easy land application using existing farming machinery."*
>
> **Dr Christian Laycock**
> Lecturer in Electrochemistry
> University of South Wales

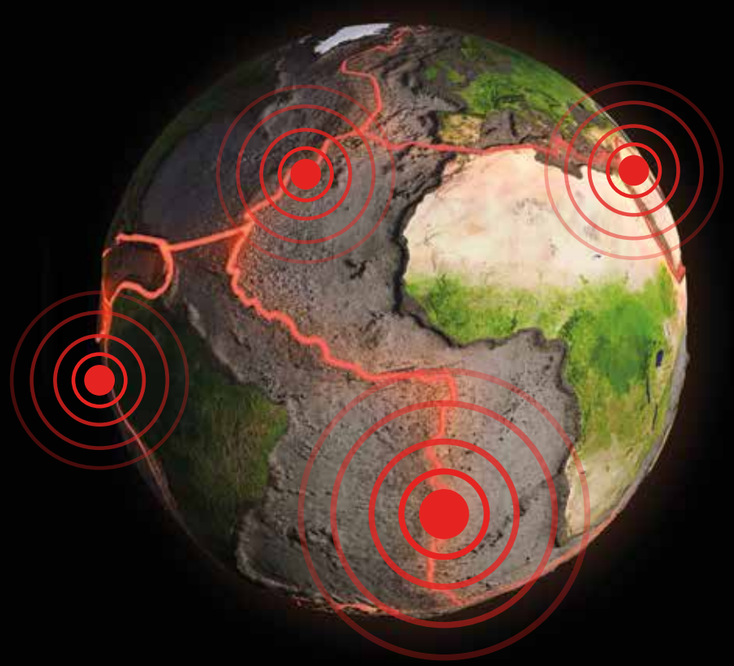
Contact:
The University of South Wales
w: www.southwales.ac.uk
t: 01443 482266
e: christian.laycock
@southwales.ac.uk

Pontypridd

New discovery to help forecasting of earthquakes

Scientists from Cardiff University have gained new insight into why earthquakes are less likely to occur in certain areas, which could help seismologists to make more accurate forecasts.

The Earth's outer layer is made up tectonic plates that shift over the underlying asthenosphere, rather like floats on a swimming pool. Stresses begin to build up where these plates meet and are relieved at certain times either by earthquakes, where one plate slips beneath the other at a rate of metres per second, or by creeping, where the plates slip slowly past each other at a rate of centimetres per year.



For a long time, scientists have been trying to determine what causes a particular plate boundary to either creep or produce an earthquake. It is commonly believed that slip at the juncture of an oceanic and continental plate is caused by a weak layer of sedimentary rock on the top of the ocean floor. However, new evidence has suggested that the rocks deeper beneath the surface in the oceanic crust could also play a part.

A team of scientists from Cardiff University's School of Earth and Ocean Sciences and Tsukuba University in Japan looked for geological evidence of creep in rocks along the Japan coast. They specifically examined rocks from oceanic crust which had been deeply buried in a subduction zone, but through uplift and erosion had become visible on the Earth's surface.

Using state-of-the-art imaging techniques, they were able to observe the microscopic structure of the rocks which make up the oceanic crust and use these structures to estimate the amount of stress that was present at the tectonic plate boundary. Their results challenge a long-held assumption that subducting oceanic crust is far stronger than subducting sediments and show that, where hydrated, the crust is actually far weaker than previously assumed.

The team discovered specific conditions that occur along the ocean floor where two tectonic plates are more likely to slowly creep past each other, as opposed to drastically slipping and creating an earthquake. The findings suggest that where fractures lie on the ocean floor, sufficient water is able to enter those fractures, hydrate the oceanic crust and trigger the formation of weak minerals which, at the junction of two plates, helps them to slowly slide past each other.

These new findings have the potential to help scientists understand the size of stresses at plate boundaries, and determine whether earthquakes are more likely or less likely to occur in certain areas. This, in turn, could contribute to solving one of the greatest challenges that seismologists face – the ability to forecast earthquakes with enough precision to save lives and limit damage.

Contact:
Christopher Tulley
Cardiff University
w: www.cardiff.ac.uk
e: tulleycj@cardiff.ac.uk

Cardiff

Trial to optimise electric vehicle charging

Researchers from Swansea University are taking part in a groundbreaking project to find more efficient ways of managing energy consumption.

The introduction of electric vehicles has changed the energy landscape. Electric vehicle owners typically put them on charge in the evening when they get home from work, which poses a problem as it coincides with peak demand for electricity. As a result of this, more fossil fuels are burnt to keep up with demand, causing environmental damage and increasing energy bills.

Since the existing grid infrastructure is under increasing pressure, researchers are now looking into smarter ways to manage how energy is used. SPECIFIC at Swansea University has teamed up with Evergreen Smart Power, Tonik Energy, myenergi and the Energy Systems Catapult for the Flexibly Responsive Energy Demand (FRED) project, which is exploring Demand Side Response (DSR) and its place in a future, low carbon energy system.

DSR is a method of reducing energy use at peak times so that there is less of a strain on the National Grid. It involves shifting the time of use for certain electrical loads, for example electric vehicle charging, from times when electricity is expensive or generated by fossil fuels to times when it is cheaper or dominated by renewables. This is important because it makes greater use of the large renewable capacity that the UK now has (largely wind and solar PV),

effectively reducing the cost of electricity from these sources. It also reduces the quantity of fossil fuels burned and their associated CO2 emissions.

This approach can be used in the home as an intervention to alter consumption patterns in real-time, at times of stress on the main electricity system, or in response to network operator price signals. Consumers can use this to, for instance, decrease their energy consumption by switching off non-essential services. They can also use it to reduce their bills by using appliances when electricity prices are low, and optimise renewables by charging batteries when there is a lot of solar or wind energy. These measures are beneficial for both consumers and the electricity network.

While industrial DSR is reasonably well established, opportunities for domestic application have not yet been fully explored. The FRED project seeks to demonstrate how Evergreen Smart Power's platform works with myenergi's devices to control domestic heating and vehicle charging in a way that can benefit both consumers and the grid. The project aims to find ways of maximising DSR capabilities and rewarding customers for being more flexible in how they use energy at home. It also intends to obtain real-world data on the potential of domestic DSR and measure consumer engagement against different approaches.

SPECIFIC's Active Building design principle integrates renewable energy technologies into buildings for heat, power and transport. It uses an intelligent system to control and release solar energy to wherever it is needed – within the building, to electric vehicles or the grid. The extensive systems and monitoring that are already in place, combined with engaged users and a fleet of electric vehicles, made SPECIFIC's Active Office an ideal place to trial the Virtual Power Plant platform and test different ways of controlling and modifying energy demand.

Contact:
Swansea University
w: www.swansea.ac.uk
t: 01792 606867
e: info-specific@swansea.ac.uk

Swansea

Advances

New process to clean up pharmaceutical pollutants

Researchers at Swansea University have developed a new method to detect and remove water pollutants that come from everyday pharmaceuticals.

A team of biochemists have developed a single process for separating and quantifying a wide range of pharmaceuticals and chemicals from personal care products that are found in most bathrooms and can end up in wastewater sludge and blood plasma. The new method will speed up understanding of the pollutants that are released and could help reduce the negative effects they have on the environment.

Pharmaceuticals can have adverse effects on animal populations across the world. For example, research has found that diclofenac, a non-steroidal anti-inflammatory, has caused multiple species of vulture in Asia to become critically endangered. Meanwhile the female contraceptive pill has caused the feminisation of male fish, which has led populations to decrease rapidly in recent years. There are also concerns that sludge used in agriculture could impact on human health too.

The Swansea team has pioneered a new process that uses a sample preparation method, called QuEChERS, with mass spectrometric detection.

Using this process, they were able to detect, extract and quantify a range of pharmaceutical compounds and personal care products from a variety of sources, such as wastewater sludge. Previously multiple extraction methods were needed to do this, making the new process more efficient in terms of time and resources.

"Many people don't think about what happens to drugs like paracetamol, ibuprofen and aspirin once they have taken them. Like any foodstuff, they are excreted from the body and end up in a wastewater treatment plant. It was previously thought that pharmaceuticals were degraded during the treatment process, but research has shown this isn't the case. And of course this becomes a problem as the treated wastewater is released into water courses such as rivers and streams, while 80 per cent of treated sludge is also recycled back onto agricultural land as fertiliser and potentially onto future food crops."

Dr Rachel Townsend
Swansea University

The team could then get a clearer picture of the factors controlling how antimicrobial resistance develops and spreads in the community.

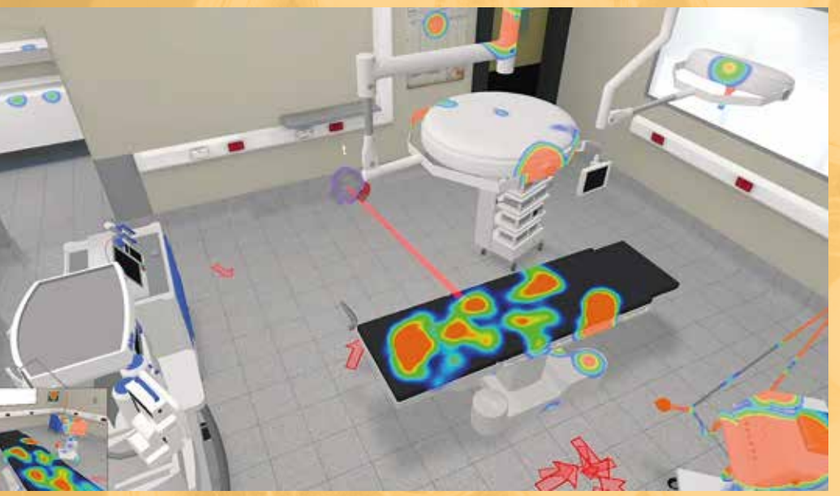
With enough research and data, changes can be made to the wastewater treatment process to ensure that everyday pollutants are degraded or removed, helping to safeguard water quality, the environment and health.

Contact:
Dr Rachel Townsend
Swansea University
w: www.swansea.ac.uk
t: 01792 602829
e: rachel.townsend@swansea.ac.uk

Swansea

Building a sustainable operating theatre of the future

Welsh partners are collaborating on the Future Theatre project to make hospital operating theatres more sustainable.



Hospitals use a relatively large amount of energy and produce more than five million tonnes of waste each year. The operating theatre environment contributes around 20-30 per cent of a hospital's carbon footprint.

There is an increasing need for buildings to transition towards a zero carbon environment and hospitals are no exception. To address this need, a variety of Welsh partners (Cardiff University, Cardiff & Vale University Health Board, University of Wales Trinity Saint David, Cenin Renewables, Medtronic, Nuaire and BIPVco) have come together to create a modular sustainable operating theatre.

The project will be focused around the specific needs of a general operating theatre, while also incorporating a low energy design. It will include efficient mechanical services for heating, cooling, ventilation and lighting, as well as building-integrated renewable energy generation and energy storage.

The team is working on two options, a single and double theatre, with supporting spaces. The modular design will ensure a rapid build programme, and the theatres will be transportable if needed elsewhere. The challenge is to produce a sustainable, energy-efficient operating theatre that meets the current comfort, safety and working environmental needs of hospital buildings for both patients and staff.

To ensure all needs are met, the project team is using 3D virtual reality simulations to evaluate the new theatre design, since COVID-19 has prevented face-to-face consultations. Building on an earlier stage using simple, low-tech, real scale models, the team has developed the architectural design and gained early feedback from key clinicians using navigable 3D web-based simulations. These 3D models will later be translated into fully immersive VR environments, so that clinicians can experience the new theatre space firsthand and evaluate spatial organisation and clinical workflow before the final specification and construction.

New ways to improve waste handling and minimise waste production, including anaesthetic gases, are also being considered. Theatre staff are working together to focus on architectural construction, design features and ergonomics, and anaesthetics and waste. The ultimate aim is to provide a model build that could be rolled out across NHS Wales, significantly reducing the carbon footprint of hospitals.

As a result of discussions around the Future Theatre project, some more sustainable decisions are already being made within the NHS.

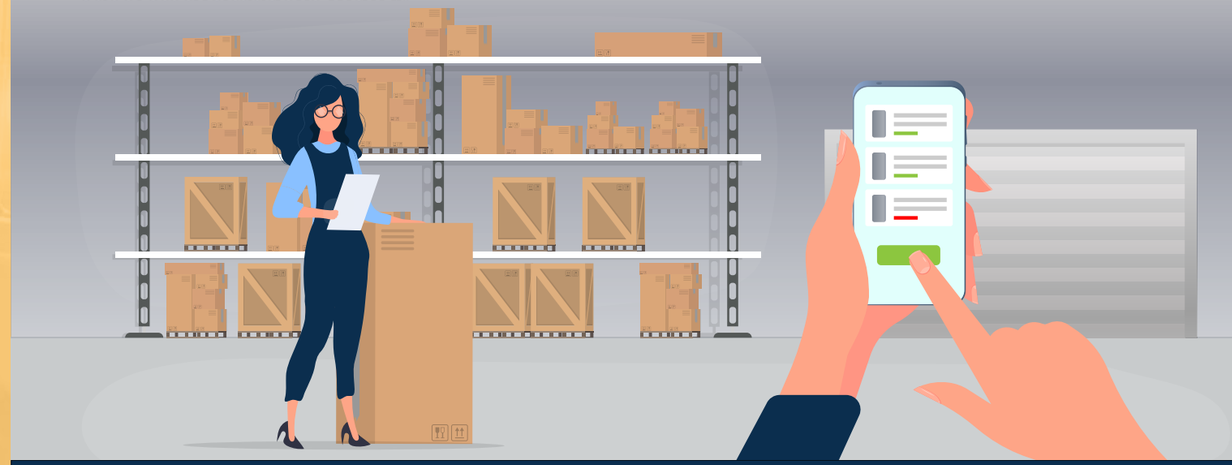
> *"It was agreed by Cardiff & Vale UHB Anaesthetic Consultants that we would remove the Desflurane vaporisers from the back bar of our anaesthetic machines. Compared to baseline data, we now save a recurring £8K per month and the department is able to reinvest 50 per cent of savings into equipment for the department. There is also the environmental saving of 80 tonnes of CO2 per month, which equates to around 350,000km in an average car each month."*
>
> **Fiona Brennan**
> Consultant Anaesthetist
> Cardiff & Vale UHB

Contact:
Cardiff University
w: www.cardiff.ac.uk
t: 029 2184 8288
e: accelerate@cardiff.ac.uk

Cardiff

Digital tools to help companies plan for the future

Aforza has developed a platform that enables consumer goods companies to predict and therefore avoid out of stock situations with AI.



Out of stock situations can be difficult for consumer goods companies to forecast. The process often involves gathering large amounts of data from a wide range of sources and entrusting people with the task of analysing it, which can be overwhelming and also comes with the risk of human error. This year, the COVID-19 pandemic has made the landscape even more unpredictable than usual, resulting in companies struggling to plan for sudden rises and falls in demand.

Cardiff-based company Aforza has produced digital tools that use AI to help consumer goods companies better plan for the future. Making use of big data and machine learning, one tool allows companies to see out of stock situations coming in advance. It automatically suggests when companies should be visiting retail outlets and placing new orders in order to keep products fully stocked on the shelves for their customers. Order processing can be optimised so that teams and deliveries can be sent to suitable outlets at the right times, cutting down on non-essential trips.

The platform can also guide large companies on how to better distribute items throughout all of their stores by identifying product gaps and opportunities at similar stores. It generates these insights by analysing various data sources, including order history and trends across different products and stores. These insights are constantly advancing through machine learning and can respond quickly to unexpected events and trends.

In addition to predicting demand, many companies struggle with the order capture process which, in turn, slows down the restocking process and is highly error prone. Traditionally, consumer goods companies capture orders via pen and paper, and then manually enter orders into their systems afterwards. This is primarily due to many storerooms, warehouses and retail basements having poor mobile reception. For this reason, Aforza has built its mobile systems to run entirely offline, meaning that users can go anywhere to check stock levels, receive AI predictions and place orders.

By moving processing, AI and data capture to mobile devices, the focus is shifted away from centralised data management into a future where field teams are actively providing feedback and new data insights. This influx of field data can enhance the AI predictions of the platform. Some companies also have large amounts of data that is collected and never used, but AI tools are able to put this to use.

Contact:
Aforza
w: www.aforza.com
t: 01442 780183
e: info@aforza.com

Cardiff

Creating an innovative telescope to meet new challenges

A team from Glyndŵr Innovations has designed an ultra-lightweight telescope to deliver high resolution images from high altitudes.

The Gwyliwr telescope has been developed to meet the operational requirements of newly emerging HAPS (High Altitude Pseudo Satellites) platforms, which are a new generation of UAVs (Unmanned Aerial Vehicles). These solar powered UAVs can operate at altitudes above 20km, providing an uninterrupted view of a chosen area for months at a time.

While the core design of the telescope is one dating back over a hundred years, the challenge was to design a system using new materials and manufacturing techniques, creating a rigid, lightweight structure that would be able to perform on a platform flying at the edge of space. The Precision Optical Systems Group at Glyndŵr Innovations is a specialist engineering team involved in the design and fabrication of precision and complex optical systems, including optical telescopes and instrumentation. Capabilities also include the polishing of large mirrors and lenses up to 1.8m in diameter.

The first step was to create an optical design, i.e. the design of the shape and size of the mirrors and other lenses that would provide the ground resolution imaging required. A lightweight structure was then needed to support these optics in place, because the positioning and alignment is critical for the operation of the system.

Mass was considered a key element of the structure and a weight of less than 3kg for the whole system was desirable. In order to achieve this, performance investigations were undertaken to select from a range of materials and assembly methods, which included research into the properties of composites and lightweight alloys. Thermally stable materials were important, as the operating environment of the unit can range from 30˚C to -60˚C. The team also had to create a structure that would maintain the position of the optics in relation to each other during temperature changes. This was achieved by selecting materials that complement each other in their thermal expansion.

During the design process, the team used FEA (Finite Element Analysis) to verify the structural and thermal behaviour of a 3D model developed in software, before the assembled unit was environmentally tested. The final system has a mass of less than 2kg and can fit in a space envelope of 375mm. It has been tested to perform in the required conditions and has produced high resolution images taken over very long distances (11.5km) though ground atmosphere providing a nominal resolution of 12cm.

The optics in the system were specially designed to be lightweight. Using an advanced design and manufacturing process, a mass reduction of 70 per cent was achieved by light-weighting it, which involved machining away back of the mirror to remove material without reducing its structural integrity.

The telescope has already received two awards for product innovation and has led to new projects working with companies including Airbus and Qinetiq. Currently the team is undertaking further development of the telescope with an industrial partner, to create a LIDAR based system that will provide added functionality.

Normally a light aircraft, helicopter or satellite is required to provide imaging over a defined area. HAPS provides a new medium to achieve this surveillance, since it can fly for longer over a particular area. The Gwyliwr telescope was specifically designed for this platform, and applications expected to benefit from it include defence and security, fire detection, search and rescue, agricultural monitoring and 3D cartography.

Contact:
Richard Hazelwood
Glyndŵr Innovations
w: www.glyndwrinnovations.co.uk
t: 01745 535100
e: r.hazelwood@glyndwr.ac.uk

St Asaph

Crab shell material to enhance PPE

Pennotec is developing a material derived from waste crab shells for use as a virucide on PPE and other medical devices.

North Wales-based Pennotec is working with experts at Bangor University to develop a unique coating with long-lasting virucidal properties. The team aims to produce coatings for PPE and medical devices, which could prevent the spread of coronavirus by destroying any virus that comes into contact with the coated materials.

The company has previously developed natural product formulations that incorporate chitosan, a polymer with natural antimicrobial properties derived from crab shells, for applications including water purification. Medical materials are a new area for them, and they are collaborating with chemists at Bangor University's BioComposites Centre on modifying chitosan to create virucidal coatings for the healthcare sector.

Chitosan is a natural derivative of chitin – a sustainable fibre resource found in the cell walls of fungi, the cuticle of insects, shells and the exoskeleton of crustaceans. Chitin is the second most abundant polymer in nature after cellulose and its healing properties have been known for a long time, but it is still relatively underexploited commercially.

Unlike chitin, chitosan is soluble. It also has antimicrobial properties, adheres selectively to biological surfaces (e.g. to tumour cells) and is biodegradable. However, its great commercial potential is mainly due to its chemical properties, because it can be modified chemically or enzymically in order to enhance its natural properties, generate entirely new functional properties or confer chitosan-like properties onto other chemicals.

The team of scientists are seeking to develop unique coatings with long-lasting virus-destroying properties, which could prove useful in the fight against COVID-19. Bangor University's BioComposites Centre has a track record of modifying chitosans, underpinned by its work on smart food packaging which involves attaching antimicrobial compounds to the surface of materials.

Pennotec has also formed a collaborative partnership with virology experts and clinical laboratory facilities at Cardiff University. This collaboration will evaluate the virucidal properties of chitosan-treated products against the COVID-19 associated coronavirus, SARS-CoV-2.

Contact:
Pennotec
w: www.pennotec.com
t: 01766 810345
e: enquiries@pennotec.com

Pwllheli

Smart valve technology to digitise water networks

iVapps is using innovative technology to improve monitoring and control of water distribution grids.

Water utilities are facing risks from increasing demand, exacerbated by issues such as aging infrastructure and climate change. Despite the increasing demand for water, losses within distribution networks are high. Clean drinking water can be lost in the distribution network before it reaches consumers' taps, and the UK is estimated to lose billions of litres of water every day from leakage.

Research suggests that leakage is occurring in many cases due to the 'blind' (i.e. non-digitised) operation of grids at local levels, leading to an unbalanced supply and increased pressure, which in turn can lead to pipe bursts and equipment failure. One way to combat these issues is through the deployment of sensors across the grid for data capture and communication, thereby forming smart networks. This provides opportunities to monitor asset health, prevent failures in aging water infrastructures and optimise systems. For example, the measurement and control of pressure can reduce pipe leakage by 20-40 per cent and reduce bursts and customer interruptions by 40 per cent.

A disruptive smart technology developed by iVapps, based in St Asaph, seeks to improve the monitoring and control of digital flow networks. The company's rapid exchangeable smart telemetry cartridge and valve solution aims to revolutionise the pipeline industry, through digitisation of the pipeline networks and connection to the Internet of Things. The technology enables the user to measure temperature, flow, turbidity and pressure, all from within the telemetry or valve cartridge, facilitating real-time monitoring and control. It can also be integrated with the user's individual sensor requirements and existing data platforms.

Sensors allow real-time data to be captured, digitising pipelines and allowing the user to operate in ways that they previously could not. This includes being able to react quickly to adverse events, in order to minimise or prevent issues such as leakage and contamination. Data also allows the user to study, model and visualise large complex systems in order to develop innovative solutions.

The current industry practice involves permanent or semi-permanent telemetry installations, which require system shutdowns and potentially long periods of disruptions at a significant cost. In contrast, the iVapps smart solution enables the user to service, calibrate and repair (and introduce future sensor technologies and data requirements) in ten minutes, without any need to disable or shut down the pipeline.

> *"Water is probably the world's most precious natural resource. Without it, there would be no life, and according to a UN assessment, around two-thirds of the world's population currently do not have a sufficient supply. Research now suggests that leakage from water supply and distribution networks accounts for around 80 per cent of total water loss, impacting on supply and resulting in substantial economic loss due to the energy required to extract and supply the water. We believe our solution represents a fundamental step change in managing water. Through a combination of leak technologies, network digitisation and disruptive mechanical engineering, our smart technology provides a technological leap forwards in the monitoring and control of digital flow networks."*
>
> **Nigel Roberts**
> National Manager UK/Europe
> iVapps

Contact:
iVapps
w: www. ivappstech.com
t: 07538 087 998
e: sales@ivapps.io

St Asaph

New genetic link to schizophrenia discovered

Cardiff University researchers have identified new mutations in a gene that provides novel insights into the causes of schizophrenia.

ISSUE 92

Wastewater provides insight into Covid-19 infection rates

Scientists at Bangor University are investigating what sewage can reveal about Covid-19 infection rates in different areas around the UK.

ISSUE 93

Modifying wood to improve durability and sustainability

Lignia Wood Company is working with Bangor University to develop unique forms of durable, sustainable timber.

ISSUE 92

Adapting a UTI test to diagnose coronavirus

The University of South Wales is developing a rapid diagnostic test for Covid-19 with help from the Welsh NHS and industry partners.

ISSUE 93

Discovering a new drug to treat inflammatory bowel disease

Compton Developments have discovered a drug which has successfully reduced inflammation in laboratory models of inflammatory bowel disease.

ISSUE 92

Restoring seagrass in the fight against climate change

A significant seagrass restoration project has marked a major milestone by planting over 750,000 seagrass seeds in Wales.

ISSUE 92

Digital platform enhances capabilities of coronavirus test

A platform created by Bond Digital Health will enhance a new Covid-19 test with digital connectivity and data capture technology.

ISSUE 93

Improving silage efficiency in Wales

Researchers at Aberystwyth University's Institute of Biological, Environmental & Rural Sciences (IBERS) are contributing to a project that aims to reduce silage losses in the agricultural industry.

ISSUE 92

Collaboration leads to new life-saving ventilator

Experts from Swansea University and University of Wales Trinity Saint David have collaborated to design a new ventilator for patients with severe coronavirus.

ISSUE 93

Using dried blood spot testing technology for Covid-19

A Welsh collaboration has developed a low-cost test for Covid-19 antibodies using dried blood spots.

ISSUE 93

Improving the accuracy of global weather forecasts

Researchers at the University of South Wales have been helping NASA to increase the accuracy of their weather predictions.

ISSUE 92

Digital platform to manage energy consumption

Surple has developed energy management software to help organisations make smarter energy decisions.

ISSUE 92

T cell test to help understand Covid-19 immunity

Indoor Biotechnologies is developing a new type of test for Covid-19 which can identify the presence of virus specific T cells in blood.

ISSUE 93

Groundbreaking research into the brain post-limb amputation

Psychologists at Bangor University have discovered how limb amputation drives changes in the way that both sides of the human brain work together.

ISSUE 92

Blood oxygen monitors developed for Covid-19 patients

Researchers at the University of South Wales have developed an innovative blood oxygen monitor, after supplies of this key device became limited as a result of the Covid-19 pandemic.

ISSUE 93

Databank enables vital health data research

An extensive health data resource built by Swansea University is being used to inform vital research into Covid-19.

ISSUE 93

New system to detect cyber-attacks on smart devices

Researchers at Cardiff University have developed a novel system capable of detecting and classifying cyber-attacks on smart devices in the home.

ISSUE 92

New technology to disinfect ambulances

A team from Swansea University is developing a disinfection technology to decontaminate public spaces from Covid-19.

ISSUE 93

Leading the way on lung ultrasound to manage Covid-19

Research from Cardiff University is being used globally to inform pioneering use of lung ultrasound in the management of Covid-19 patients.

ISSUE 93

Innovative technology to treat water

Hydro Industries has developed technology to purify dirty water, making it safer and cleaner.

ISSUE 92

Natural flavour enhancer for salt reduction in foods

Scientists at Aberystwyth University have developed a flavour enhancing food product which can be used to significantly reduce the salt content of pre-packaged meals and snacks.

ISSUE 92

Detecting coronavirus with breath analysis technology

A breath analysis device developed by IMSPEX Diagnostics is undergoing trials to determine its ability to detect coronavirus.

ISSUE 93

Developing new testing for UTIs

Researchers at University of South Wales are developing a diagnostic test capable of detecting the bacteria causing urinary tract infections.

ISSUE 92

Biocidal face masks to tackle the global shortage

Hybrisan is developing a new generation of face masks for frontline workers.

ISSUE 93