

THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY

advances

WALES



Celebrating the 100th issue of Advances Wales!

Advances Wales, 100 journals highlighting groundbreaking innovations in science, engineering and technology across Wales



Llywodraeth Cymru
Welsh Government

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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.

Advances Wales highlights groundbreaking innovations in science, engineering and technology across Wales.

Much has changed for Wales since we published the first edition of Advances Wales in 1993. That year we saw the Welsh Language Act become law, followed four years later by the devolution referendum.

The Senedd's law making powers were strengthened in a second referendum in 2011 and nine years later, the voting age was lowered to 16-year-olds in Welsh elections, the biggest extension of the right to vote in 50 years.

Just as the country has been on a constitutional journey, so have our science, technology and engineering sectors evolved, in many cases, out of all recognition.

This 100th edition of Advances is a milestone which considers some of our most frequently featured fields of endeavour over 30 years and looks at brand new Welsh developments in these same sectors.

The one constant has been our editorial mission. We seek to highlight the most interesting scientific research and innovations occurring in our universities, research organisations and businesses. A review of 99 editions confirms just what a smart place Wales is, proudly making its own contributions to a healthier, wealthier and more environmentally responsible world.



Vaughan Gething
Economy Minister
Welsh Government

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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.

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Advances Wales is designed and published on behalf of Welsh Government by Teamworks Design, The Maltings, East Tynhall Street, Cardiff CF24 5EA. Creative Design: Lee Gillum. Editor: Gwyn Tudor.

Opinions expressed in this magazine are not necessarily those of Welsh Government or its employees. Welsh Government is not responsible for third-party sources cited such as web sites or reports. ISSN 0968-7920. Printed in Wales by Harlequin Printing and Packaging, Pontyclun. Crown Copyright.

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www.teamworkdesign.com/clients/advances/

Breakthrough in the war on plastics



Happy Dolphin in Wrexham, North Wales, is launching an eco friendly, renewable patented material called Biodolomer, which is based on the chemical composition of egg shells. Calcium carbonate, in the form of chalk and plants, and protein.

This new material can be used to manufacture disposable packaging, plastic cups, cutlery and food trays, bottles and carrier bags. It is compatible with current plastic production lines and so requires no additional capital expenditure.

The material is fully compostable and creates no harmful pollution. While traditional compostable

shopping bags are typically made from corn starch, sugarcane or cassava and can only break down at high temperatures of 55C to 70C in specialist facilities, Biodolomer can break down naturally at ambient temperatures in the environment.

‘We would like to replace every, plastic “bag for life” with a true bag for life. Happy Dolphin bags are earth friendly, reusable and make massive savings on CO2 emissions. The Happy Dolphin carrier bag is home compostable and reusable many times and it replaces poisonous petroleum plastics. We are hoping that all supermarkets in Wales will trial the bags and this will offer consumers a greener choice.’

David Hughes
Founder, Happy Dolphin

 www.imnotplastic.info

Genomic selection accelerates biomass breeding programme

Aberystwyth University scientists have been given a boost to support their miscanthus grass breeding programme. The project has received a £2 million investment as part of the Biomass Feedstocks Innovation Programme.

Miscanthus is a highly productive perennial grass that requires very low inputs and is being bred by scientists at Aberystwyth as a biomass crop. It currently produces 12-15 tonnes of biomass each year even when grown on land that is less suitable for food production. This is harvested in spring and is sent to power stations to produce renewable electricity.

Researchers will use a technique called genomic selection in the breeding programme. Plant breeding is a process of crossing parent plants that have specific desirable traits in order to create offspring with improved traits. In the case of miscanthus, these traits include yield of biomass, ability to withstand drought and frost, and suitability for growing with low nutrient inputs.



However, miscanthus takes three years to mature in the UK, so when using conventional breeding there is a long delay before the team can select the most promising parents to cross. In genomic selection, genetic markers are identified across the genome that are associated with desirable traits. The markers are then used to identify and select plants predicted

to show the best traits while they are still only seedlings, thus speeding up the selection cycle from three years to one. This will help to develop new high-yielding plant varieties to provide sustainable biomass to help tackle climate change.

 www.aber.ac.uk

Supplying Finland's police with portable breathalysers

Every year there are around 273,000 alcohol-related deaths worldwide, among fatally injured road users. Breathalysers are a vital tool in the fight against drink driving.

Barry-based Lion Laboratories, who were featured in the first issue of *Advances Wales* in 1993, developed the very first electrochemical breathalyser. Technology, developed in Wales, which is now being used by police forces, border guards and prison services across the world and is set to be used by Finland's police.

In 1967, the British Government introduced the Road Safety Act which defined the maximum level of alcohol a person could have in his or her body while driving. It also introduced the roadside 'breathalyser' screening test to justify the arrest of a motorist on suspicion of driving with excess alcohol. Lion Laboratories were established in the same year, to meet the need for roadside breathalysers.

The principle of breath analysis is the evaporation of alcohol from the circulating blood into the air in the lungs during the breathing process. On its way around the body the blood picks up alcohol from drink a person has consumed. This blood is pumped through the lungs before flowing back to the heart. In the lungs oxygen



from the air passes into the blood and carbon dioxide and a small portion of any alcohol (if present), is expelled. The quantity expelled directly correlates to the amount of alcohol in the blood and it is this connection that is at the core of breathalyser technology.

The deal with Finland, to supply 250 portable infrared breathalysing instruments, will also see the company assist with their roll out and deliver full technical training to the country's law enforcement teams.

"Working with a spread of countries helps us to continually improve our products as they are developed to meet various international requirements."

Martin Slade
Head of Sales, Lion Laboratories

 www.lionlaboratories.com

IN BRIEF

Used nappies used for road surfaces

A stretch of road between Aberystwyth and Cardigan in West Wales has been resurfaced with a material that includes used disposable nappies as part of a green trial, with the hope that it could help road surfaces to last twice as long. The trial could also help offer a solution to the nappy waste problem, with about 140 million disposable nappies thrown into landfill annually in Wales. The nappies are shredded into fibrous grey pellets. The pellets are then added to bitumen to bind the asphalt road surfaces. This fibre replaces material that would normally have been imported into the UK from abroad. The process is an initiative between Ammanford based recycling company NappiCycle (featured in Issue 86) and Pura, which describes itself as an "eco-friendly baby care business". The company stresses that the roads infused with the new product smell of nothing worse than new roads!

Wafer firm plans new factory

Newport Technology company, SPTS Technologies (featured in Issue 86), is planning to build a new factory in the city on a brownfield site that could lead to the creation of 90 new jobs. The proposal would see the technology manufacturer move its official headquarters from its existing home. SPTS Technologies provides wafer processing solutions to the microelectronics industry. Its products are used in smartphones, tablet computers and games consoles. The company plans to build a three-storey manufacturing and research and development facility and administration office as it is outgrowing its existing site. The new factory will allow the company to increase its workforce from 360 to 450 employees. They are then planning a further expansion over the coming years that could accommodate a workforce of 650 employees.

University expertise backs UK's first 'hydrogen ecosystem'

Cardiff University researchers are supporting the UK's first 'Hydrogen Ecosystem'. South West England and South Wales are teaming up to lead the development of low carbon energy to help reach climate change goals. The Western Gateway partnership alongside the GW4 Alliance have unveiled a new strategy. Hydrogen is the most abundant element in the universe and has long been suggested as a potential energy solution to help the world decarbonise. It is currently being trialled as a potential low carbon energy source to power transport, distribution and shipping needs as well as to heat homes and decarbonise industry. Professor Roger Whitaker, Pro Vice-Chancellor for Research, Innovation and Enterprise, said: "Our research groups are investigating the use of hydrogen as a fuel, either directly or as a feedstock for conversion to ammonia. Examples include the use of green ammonia, the development of ammonia and hydrogen fuelled gas turbines, internal combustion engines, furnaces and drones, and fuels for HGVs, trains, aeroplanes and ocean-going vessels."

Wellbeing project will encourage active healthy living

Pentre Awel, a multi-million-pound development at an 83-acre site along the Llanelli coastline, will bring together life science innovation, community healthcare and modern leisure facilities in one location. As well as improving health and wellbeing, the project will create over 1,800 jobs and training/apprenticeship opportunities, and is expected to boost the local economy by £467million over the next 15 years. Pentre Awel is being delivered by Carmarthenshire Council in partnership with Hywel Dda University Health Board, Cardiff University, Coleg Sir Gar, the University of Wales Trinity Saint David, and Swansea University. It is part-funded by the Swansea Bay City Deal. Zone One (estimated full completion date summer 2024) will include a state-of-the-art new £27million leisure centre, a clinical delivery and research centre, and education facilities that will focus on health and care training. Later phases of the scheme will include a hotel, a range of social and affordable housing, assisted living accommodation and a nursing home.

New film studio for Anglesey

A new film and television studio is planned for Anglesey in North Wales. Aria Studios will have two fully soundproofed studio stages offering a total of 20,000 square foot of filming space and facilities for production companies based in the region, as well as for other companies within and outside of Wales. Established by Rondo Media and S4C Digital Media, the new studio will create employment for the creative sector as well as opportunities for other businesses, including accommodation, restaurants and catering. The plans also include training opportunities for careers in the film and television. Working in partnership with colleges, universities and training agencies the studio is intended to become a hub for talent and skills development.

Ship Shape named startup of the year

The best new Welsh businesses were named at the annual Wales StartUp Awards last month. The Awards celebrate the contribution that new entrepreneurial firms make to job creation, creativity and innovation, through the award of 26 categories.

Swansea-based venture capital search engine company, Ship Shape, were announced as the Fintech Startup of the Year. The search engine enables users to search for information and content published by potential investors including venture

capital firms (VC's), private equity firms, and family investors, as well as accelerators, incubators, universities and other support organisations.

While there are already databases on the market, a search engine has a number of important

advantages. Databases can store and retrieve large amounts of structured information, but they can require large and complex filters to find the information required by the user. These 'structured databases' also rely extensively on human analysts to maintain and classify the data as it is being saved. Search engines look through publicly available 'unstructured text' and then order results by relevance. This means they perform well in markets where large amounts of information are available in the public domain. Search engines also work well when the information required is constantly changing or being updated. The search engine can present relevant investor information alongside other online content, including social media and contact details. This approach helps to compress the research time required to draw up a shortlist and improve the chances of getting a good 'investor fit' when contact is made.



 www.shipshape.vc

Wild Oysters Project celebrates success

The Wild Oysters Project (featured in Advances Wales Issue 97, Restoring Native Oysters to Welsh Water) is celebrating this month, after finding over 27,000 marine animals living among their native oyster nurseries – indicating that the restoration project is helping far more than just oysters. More than 1,300 native oysters were returned to the waters of the River Conwy in North Wales as part of the Wild Oyster Project, which spans coastal regions across England, Scotland and Wales, and houses over 140 oyster nurseries and 4,000 oysters across three British Estuaries. Native oysters provide huge benefits to coastal waters by helping to clean seas, and their nurseries provide an important habitat for many species of marine wildlife, which has been demonstrated by these latest findings. The Wild Oysters Project is a partnership between ZSL (Zoological Society of London), Blue Marine Foundation (BLUE) and British Marine and has partnered with the School of Ocean Sciences at Bangor University.

Creo partners with robotic surgery leader

Chepstow-based medical devices firm Creo Medical (featured in Issue 87) has entered into a collaboration with the US firm and global leader in robotic assisted surgery, Intuitive. Creo Medical design and manufacture electrosurgical medical devices in the field of surgical endoscopy. Speedboat Inject, their flagship endoscopic surgery product, provides a minimally invasive alternative to traditional surgery, can avoid the need for general anaesthetic and reduce the usual side effects. This results in better outcomes and quicker treatment with patients often able to leave hospital on the same day. In turn this has benefits for hospitals and has freed up bed spaces and reduced waiting lists. Intuitive, the maker of the da Vinci surgical systems, is a global technology leader in minimally invasive care and a pioneer of robotic-assisted surgery. This multi-year collaboration will mean certain Creo products will be optimised to be compatible with Intuitive's robotic technology and will provide a framework to allow joint clinical studies.

SMTL supports World Bank project

The Surgical Material Testing Laboratory (SMTL), based at Princess of Wales Hospital in South Wales, has been invited to participate in a World Bank project to expand the production of basic medical devices and personal protective equipment (PPE) around the world. In support of the World Bank International Finance Corporation's (IFC) Global Health Platform, a Global Advisory Program on PPE has been launched. The programme's objective is to support the diversification of global supply chains and to work with manufacturers and governments in developing countries to increase the manufacturing and supply of quality PPE. A critical knowledge gap is the lack of laboratory testing capabilities and knowledge on technical regulations and standards across some countries. To address this a PPE Benchmarking Technical Guide and Laboratories Capacity Building project is being implemented by the British Standards Institution (BSI). BSI have invited SMTL to conduct training sessions on medical device testing for laboratories from Jordan, India and Vietnam.

Only way is up for vertical farming

The vertical farming project, Tech Tyfu, based at M-Sparc on Anglesey, is set to grow with the launch of a new accelerator programme. For two years Tech Tyfu has worked with growers in North Wales to develop fresh micro greens using sustainable, water-based hydroponic methods. Their success has seen the initiative scale-up to include more producers who will now receive further advice and guidance, cutting-edge equipment and ongoing business and marketing support. Vertical Farming is the process of growing food or other agricultural products within a controlled factory setting, without the resources associated with traditional agriculture such as soil and sunlight. Instead these resources are provided using artificial lighting and nutrient delivery systems. Vertical farming allows growers to control the growing environment, which can improve water and nutrient use efficiency, grow out of season crops and reduce pressure on the food supply chain, transport, packaging, and refrigeration costs.

Video game supports mental health

A Swansea University researcher has collaborated with Miracle Tea Studios to develop a way to help build psychological resilience in young people, utilising gamification of mental health interventions. The game, ACTing Minds, sets the scene for a deeply personal story about someone who recently lost his wife. Throughout the game, players learn they need to accept their loss and orient their lives toward what is meaningful to them. Players are drawn into the game dynamics, using gamification to reward behaviours that lead to increased psychological flexibility. Points are then awarded based on a scale of psychological flexibility. Dr Darren Edwards, Senior Lecturer at Swansea University, said: "We need to develop mental health interventions that are both accessible and engaging for young people. Building mental health skills and resilience early in life is crucial in reducing the overall mental health problems." The game has received excellent responses from users and is already being applied in mental health clinics around the world.

Innovation in medical genomics and genetics



From the first edition of *Advances Wales*, published in 1993, the value of extracting information from a patient's DNA was recognised and research was delivering new diagnostic methods for genetic diseases. Genetic advancements in research were regularly reported over the years even though The Human Genome Project (HGP) didn't complete the mapping of the human genome until April 2003. Fast-forward to today, the use of state-of-the-art genomics techniques in medicine to help diagnose and track disease and to support personalised treatments for patients is being used across the National Health Service (NHS).

Genomic sequencing as part of COVID-19 response

As part of the response to the COVID-19 pandemic, Public Health Wales have worked with partners to sequence and analyse every available SARS-CoV-2 sample from patients in Wales.

The work has fed into a project being led by the COVID-19 Genomics UK consortium. The team has sequenced COVID-19 cases looking for important viral changes, and tracking the spread of the virus in UK. The work has been carried out with support from the All Wales Medical Genomics Service and Cardiff University.

"A genome is effectively the blueprint containing the instructions to build an organism. In the case of COVID-19, genomics has enabled us to study the evolution of the whole virus: how it has changed over time, as well as examining changes in the individual parts that make up the virus."

Dr Thomas Connor
Bioinformatics Lead
Public Health Wales



Genetics service for mental health

People affected by mental health issues are now able to benefit from a new, psychiatric genomics service.

Patients and families referred by local mental health or genetics teams can now be offered a genetic test which could help pinpoint small alterations in their DNA known as Copy Number Variations (CNVs). While a person's experiences and environment have the greatest influence on their mental health, specialists believe that in a small number of cases, CNVs can also play a part. According to research, individuals with certain genetic alterations have a greater risk of developing conditions such as schizophrenia. Where such CNVs are identified the service can help patients to understand the results and offer interventions which might improve their quality of life.

Examples of people who might be considered for referral include: those with psychiatric disorders whose treatment is not proving to be effective; individuals worried about a family history of mental health disorders; or people with known genetic risk factors wanting advice about possible risks to future children.

It is hoped the work could also help identify more genetic alterations which may be linked to mental ill-health and to develop a greater understanding of how small changes in DNA can influence a person's susceptibility, thus paving the way for better care and treatments.

"We have a lot of experience in identifying these types of CNVs for more physical health disorders. So it's really exciting to be able to put this experience into giving access to mental health care for individuals who've struggled to access genetic testing in the past."

Dr Jade Heath
Clinical Scientist involved with the new service



Genetic screening to identify risk

Wales has become the first country in the UK to routinely screen all cancer patients being treated with certain types of chemotherapy, to identify their risk of severe side effects and help prevent this occurring.

An estimated 10% of patients prescribed fluoropyrimidine drugs, used for the treatment of cancer, can develop severe, sometimes

life-threatening side effects. These toxicities can be triggered by genetic variations in DPYD, the gene responsible for the DPD enzyme, which helps to break down the chemotherapy drugs.

Low levels of the DPD enzyme – predicted by the genetic test – can result in a build-up of these chemotherapy drugs, thereby making the side effects more severe. All health boards across Wales will routinely offer the DPYD test, following a successful pilot phase. The test will be offered prior to the start of chemotherapy with results available in as little as three working days. With such quick turnaround times, treatments can be adjusted accordingly leading to significantly improved patient outcomes.

Driving personalised medicine for cancer patients

A new genomic oncology diagnoses service in Wales aims to implement state-of-the-art technology which will enable oncologists to undertake rapid and extensive genomic analysis of cancer samples on an “unprecedented” scale. The service can be used to test for over 5 cancers, using gene sequencing to provide information on a patient’s prognosis and the likely effectiveness of each potential treatment.

In some cases the service will result in cancer patients being able to use alternative treatments, like taking tablets at home rather than receiving more aggressive treatments. Such medication can be more tolerable and improve a patient’s quality of life. The future aim is that all people with cancer will be routinely offered genomic testing.

“This genetic testing helps to provide clinical teams with the tools they need to identify the best treatments. It’s about introducing precision medicine for the benefits of patients, because we know that if we can target specific genetic changes in the DNA, we can switch off those signals which are telling the cancer cells to grow more effectively. Where we compare the newer anti-cancer targeted therapies with more traditional therapies, like chemotherapy, we know the outcomes are often better in terms of controlling the cancer and helping patients live for longer.”

Dr Samantha Cox
Velindre clinical oncologist

Whole Genome Sequencing

All Wales Medical Genomics Service has worked with partners to provide the UK’s first diagnostic rapid Whole Genome Sequencing (WGS) service for paediatric patients which is now available for patients who have a combination of serious health problems. The test is designed to reduce the child’s diagnostic journey by searching through their whole genome data to find a genetic cause for their health problems. Genomic DNA extracted from the child’s and parent’s blood samples is sequenced using next generation sequencing (NGS). Sequences are aligned to a reference human genome, and variants are identified, interpreted and reported to the child’s doctor.

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All Wales

Healthcare training in Virtual Reality



New innovations in health technology have always featured strongly in Advances but more recently digital technologies, that support both diagnosis and therapy, have become more prominent. The use of virtual reality (VR), which immerses the user in a virtual environment, and augmented reality (AR), which overlays computer generated sights, sounds and physical sensations onto a real world scenario, have been used to support new innovative therapies and to provide training safely in novel, effective ways.

AI and VR in health

Cardiff health technology company Rescape Innovation use Virtual Reality (VR) technology to provide immersive healthcare solutions to support pain management, anxiety/stress management, the patient experience, and communication.

The company has been working in collaboration with Swansea University and clinical partners at Cardiff and Vale University Health Board to develop and evaluate a new VR healthcare training platform.

The challenge was to develop three education modules, for the care of patients with a tracheostomy, a bronchoscopy session, and the insertion of an intercostal drain. Each of these procedures require significant expertise and practice but are difficult to train for using traditional educational methods.

The team used a combination of 360-degree video technology and avatar designed education sessions. Part of the project was to evaluate the modules across three healthcare sites, Cardiff and Vale University Health Board, Aneurin Bevan University Health Board and Cwm Taf Morgannwg University Health Board. In order to support the adoption and implementation of the new technology it was essential that the clinical education leads at these sites felt comfortable and confident in using the system.

Over 97% of the learners felt that VR was an educational tool that could impact positively on patient safety and that the technology was an effective tool for healthcare training. The project demonstrated that learners who were new to VR adapted to the system well with an average of just two attempts before the team members were independently adopting the training. All of the learners felt that training in a VR setting is an effective team training method for a range of clinical roles.

The team also learned valuable lessons from the way materials were presented and identified improvements that can be adopted for the platform. Orientation and support for early adopters of VR technology were key to successful implementation and provision of meaningful learning opportunities.

“The coronavirus pandemic caused significant challenges to the way that we delivered tracheostomy education, at a time where more patients than ever required a tracheostomy. Staff were redistributed to unfamiliar clinical environments and the health service was under unprecedented pressure. We have demonstrated that Virtual Reality has the potential to not only overcome those challenges, but to augment and improve existing training.”

Paul Twose
(Cardiff and Vale UHB)



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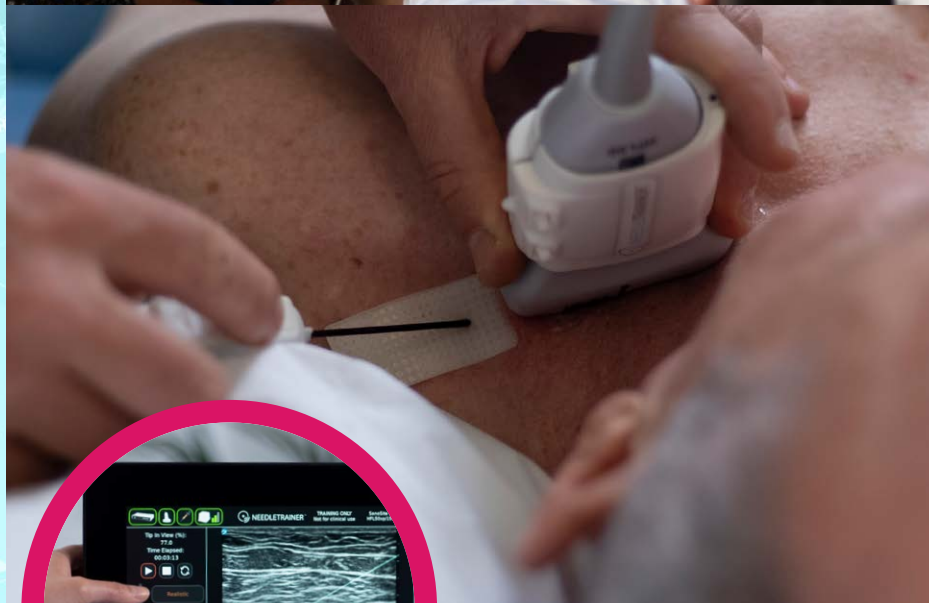
Cardiff

Classroom to clinic ultrasound training using real time virtual reality simulation

Based in Cardiff, Intelligent Ultrasound is a 'classroom to clinic' ultrasound company, specialising in providing real-time, Virtual Reality simulation for the ultrasound training market ('classroom') and artificial intelligence-based clinical image analysis software tools for the diagnostic medical ultrasound market ('clinic').

It has a range of real-time ultrasound education and training simulators that teach clinical ultrasound scanning skills. The company's newest technology, NeedleTrainer, combines simulated needle insertion with AI-based guidance tools to assist healthcare professionals to master ultrasound-guided regional anaesthesia in a safe environment during real-time scanning on real subjects. This technology helps trainees learn ultrasound scanning and develop hand-eye coordination for needle insertion, in a realistic simulation environment.

The product includes a blunt spring-loaded mock needle which can be safely pressed onto the skin of a volunteer whilst they are being scanned with an ultrasound machine. The software tracks the motion of the needle and ultrasound probe to superimpose a virtual needle onto the image in real time. This allows the learner to practise moving both the needle and the probe independently, to advance the



"While training and early clinical practice remained safe, as the trainee was always closely supervised, there were risks of needle misplacement. We needed a learning solution that would allow trainees to practice and develop this skill prior to injecting a real patient. Using human models allows trainees to learn about how to position the patient, and practise on different sides of the body, as well as different bodies, which all appear different under ultrasound. This product will allow students to practise in a highly supervised environment, with no risk, before moving to a patient-facing environment and then independent practice."

Sarah Harries
Head of School for Anaesthesia
HEIW Associate Dean

needle safely towards a target where local anaesthetic can be injected. Developing this skill prior to performing needle insertion or an injection on a real patient in a clinical setting has important safety implications such as reducing the risk of needle misplacement and tissue trauma.

The AI-powered software highlights key anatomical structures and supports users acquiring and interpreting the optimal ultrasound image.

Health Education and Improvement Wales (HEIW), who are responsible for postgraduate training of all junior doctors in Wales, have recently invested in the new NeedleTrainer technology. The platform was selected to provide safe learning opportunities for trainees and was considered to be the most realistic simulated training available.

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Cardiff

Hormone intelligence at your fingertips

Hormones are key to determining a person's mental and physical health but can be affected by lifestyle choices around exercise, nutrition and sleep. Female hormones have a significant effect on a woman's health, fertility and wellbeing. They are the most complex out of all the hormone networks and they change over a woman's life.

Perimenopause is a challenging time for many women as ovarian hormone production winds down. With increased life expectancy in recent years, women may live over a third of their life in menopause when ovarian hormones are very low. This situation can increase the risk of osteoporosis and cardiovascular disease.

Hormone Replacement Therapy (HRT) can improve quality of life for many women and reduce the risk of health problems. However, hormone concentration and biological response to hormones will vary with each woman and so a personalised approach is required to health management and can help women make more informed decisions about their own health management.

Forth, based in South Wales, have developed a biomarker tracking platform aimed at providing people with the information they need to manage their own health. Biomarkers are naturally occurring molecules, genes, or characteristics, found in the body, by which a particular physiological process can be

monitored. The platform measures and tracks key biomarkers which relate to good health. The company have combined medical, mathematical and technological expertise, through the use of artificial intelligence (AI) technologies, to analyse this data and deliver personalised hormonal information to women.

The mapping process starts when a woman takes a capillary (finger prick) blood test on day 14 and day 21 of her menstrual cycle and logs wellbeing metrics and menstrual cycle information. As soon as the second sample has been analysed in a UK accredited laboratory, graphs with an accompanying explanation and advice are provided through a mobile app. She can then monitor the effects of recommendations by repeating the process every 4-6 months.

"By using female hormone mapping throughout her lifespan, a woman can build up her own personal evolving hormone fingerprint. This enables women to make informed decisions about contraception, fertility and later whether and when to consider HRT."

Dr Nicky Keay
Chief Medical Officer
Forth



HORMONE

BALANCE

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Chepstow

Addressing global climate change for future generations



An important theme, featured in *Advances Wales* issue one and many times since, is the use of innovation to address global climate change and to protect the natural environment of Wales for future generations. In this issue we examine water quality and the legacy of mining in Wales and how it has presented an opportunity to treat water and extract valuable metals as a by-product. Equally important is protecting the environment into the future through the use of sustainable transport. Here we look at innovative solutions used to tackle technical challenges during the electrification of Wales' train network.

High value metals from waste water

X-Ray Mineral Services (XMS), a geoscience consultancy based in Conwy, North Wales, have developed Passive Leached Waste Metals (PLWM), a sustainable, low cost and low carbon remediation process for treating mine water. As well as cleaning mine water, high value "critical metals" can be extracted as a by-product of the process.

Once important contributors to the UK economy and employment, but now abandoned, metal mines have created a problematic legacy, causing pollution in many rivers and streams. When in use, mines were pumped to keep the underground workings dry, whereas after abandonment the pumps were removed and slowly the mines filled with water. Reacting with metal ore, the water forms acid solutions, rich in dissolved metal, which then finds its way to the surface. Mine water has polluted over 200km of river in Wales and 450 water courses in the UK with metals such as lead, zinc and cadmium. However, mine sites are often located in areas of natural beauty; they attract tourists and, as part of the upland landscape, are commonly protected in law for their unusual flora, fauna and ancient monuments. So maintaining the beauty of the land around the site is important for any remediation plan.

While many current remediation processes are too visually obtrusive for these sites and cannot work in remote, upland locations, PLWM is based on a gravity fed (minimising electricity use) water filter system. It has a small footprint and a carbon neutral filter media, derived from seaweed, which can be recycled in-situ and is deployed using a simple, robust, scalable skid mounted system.

The main advantage of this process is, while it recovers high value critical and base metals in a form easy to process and reuse, it removes the metals within minutes, which means there is no need to hold back large volumes of water to allow time for the treatment to work. As a result, extensive, and expensive, civil engineering works are not required and the visual impact and land requirements are minimised. The technology also has low energy demands to run the gravity fed filters meaning it can run without mains power in remote locations.

The filtered water produced can result in improved irrigation, livestock drinking water and the potential for leisure activities.

The team is now seeking to scale up the process to a 10,000L plant and run a trial site continuously for a year. The trial will provide critical performance data for subsequent commercialisation. They also intend to



improve the zinc capture performance and integrate chemical dosing. Integrated filter material recycling will be trialled at scale, capturing metals for offsite metal recovery, providing a circular economy route to metal supply and waste reduction.

"It's been great to work on a project that can potentially rectify the pollution legacy from metal mining and extract both bulk and the critical metals needed to drive the green transition within the UK."

Alex Finlay
R&D manager
X-Ray Mineral Services

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Conwy

Ingenious workaround to upgrade transport system

New trains throughout Wales will improve the experience of customers and provide a step change in decarbonising the transport network. The aim is to make the transport system more sustainable in light of the challenges of climate change and help to move towards achieving net-zero carbon emissions by 2030. However, a great degree of innovation and ingenuity has been needed across the network to make electrification of the lines work with the existing infrastructure.



Work underway to electrify the Core Valley Lines in South Wales involves putting up overhead lines above the tracks, which will then power new trains. The new trains have been designed to be powered by a combination of overhead electric power and batteries stored onboard. They will switch between electric and battery power as they travel along the line. This hybrid electrical operation will reduce the need for expensive and disruptive engineering works to raise bridges, lower tracks and adjust historic station canopies. The electrification of the lines will reduce noise, emissions and the use of fossil fuels and will be powered entirely from renewable sources.

Electrification is a major part of the new rail infrastructure in Wales but has required Amey Infrastructure Wales, who are carrying out the work, to propose an innovative solution in cases where bridges are too low to accommodate live overhead lines.

The infrastructure engineering works need to allow for the installation of the Overhead Line Electrification (OLE) but the network has around 100 bridges and other structures that lack the height needed for live overhead lines to pass safely through. Either demolishing the bridges and replacing them, or lowering the track, would increase the cost significantly, extend the engineering work programme and wouldn't provide low carbon solutions.

The innovative solution proposed involves discontinuous electrification and Permanently Earthed Sections (PESs) being used for bridges where clearance is too low to allow for full electrification. The new trains can switch to battery power to pass through the unwired or earthed sections before reverting back to overhead power on the other side of the bridge. Eliminating the electrical current in the PES section means that a structure too low to provide the necessary safety clearance can be retained without the need for modification. The PES approach is being used beneath 60 of these bridges.



This approach is possible because of the hybrid nature of the new light rail vehicles, which can switch easily between electric and battery power. As the trains approach the PES section, a beacon sends a signal to the onboard power system to stop drawing current from the overhead line and switch to battery. Once through the bridge, the train senses the available power and reverts to overhead electric mode.

However, where two listed footbridges threatened to disrupt electrification of the lines an additional ingenious workaround was needed. The use of a PES wasn't appropriate for two listed footbridges where Victorian latticework structures did not provide the necessary clearance. A structural assessment ruled out the option of lifting the bridges because they were simply too fragile. In

addition, Cadw (the Welsh Government's historic environment service) wanted to protect and preserve these listed structures.

Amev Infrastructure Wales, who are carrying out the work, came up with a new proposal – to simply make the area around each bridge wire-free. A beacon would prompt the train to drop its pantograph (apparatus mounted on the roof of a train to collect power through contact with an overhead line) and switch automatically to battery power. A second beacon would signal the train to raise the pantograph after passing under the bridge.

Unwired sections are also being used in areas where the installation of overhead cables would be disproportionately expensive such as the complex junctions and where the platform canopies are listed structures.

This simple-sounding solution was challenging to achieve. The engineers had to use a bespoke design model specially developed to simulate train and traction power systems. This tool allowed the team to analyse the movement of trains on the line and the state of charge (SoC) of their batteries at any given point. This was crucial, as the efficient operation of the trains depended on the availability of battery power when required. The PES and unwired sections would be an obvious drain. The model helped to establish that batteries could recharge effectively when regaining access to the live overhead line. A miscalculation could leave a train without charge in a 'dead' zone. Conversely, excessive charging and discharging would shorten battery life, adding to maintenance costs.

The resulting design resolves these issues, minimising the impact on battery life, while preserving the integrity of the listed footbridges and the line's Victorian heritage and potentially saving millions of pounds and man-hours.



Beyond the Core Valley Lines, areas where the network has not been electrified are to be updated with new diesel trains. These will be fitted with modern engines that will enable a 40% reduction in fuel consumption, an 84% reduction in Nitrus Oxide (NOx) and a more-than-90% reduction in harmful particulate emissions when compared to the current trains. These emissions not only contribute to climate change globally but can also be harmful for people living next to the railway. Removing older trains with high emissions and replacing them with cleaner, more efficient trains will minimise environmental impact overall and provide better air quality for line-side neighbours.

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Pontypridd

Information Technology comes of age



Information Technology has come of age since the introduction of Advances Wales. There have been many developments since the early advancements in computer power twenty five years ago. Today the use of big data, Augmented Reality (AR), Artificial Intelligence (AI) and machine learning are entering all areas of our business and leisure lives. Here we look at how new applications in data analytics, AR and the new world of the metaverse are presenting opportunities for innovation.

Equipping commentators with a digital toolkit

Today's sports and event commentators often still rely on handwritten notes and printouts of key information. Both of which present challenges when trying to keep up with fast paced dynamic sports where data organisation, accessibility and timely retrieval are all vital.

Former Cardiff City and Wales footballer Nathan Blake and sports agency Temporal Junction have been working with the University of South Wales to develop a digital interface that helps commentators to retrieve important player information, helping them to prepare, organise, and access facts and figures on upcoming sporting events.

The result is the 'Journo App', which supports commentators before and during a game. Instead of combing through numerous notes, websites and

fractured data sources, the app uses Application Programming Interfaces (APIs) to allow different websites to communicate with each other. Providing a single source of information and statistics about players, teams and fixtures, within a user-friendly interface that displays information such as player comparisons, goalscoring records, and team past performance. Commentators are also able to quickly capture notes via speech-to-text technology and they can record and input match events as they happen in a live timeline.

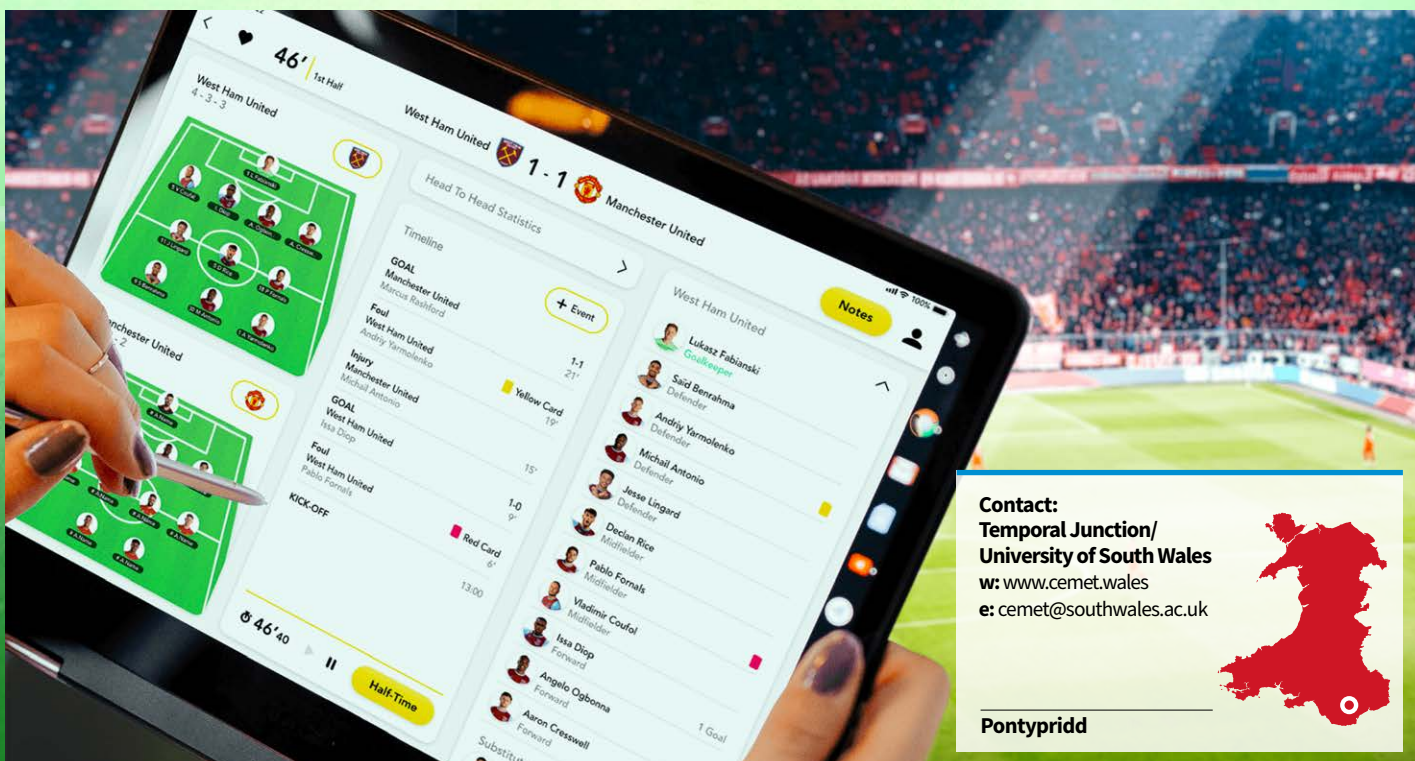
The team have developed a proof-of-concept app initially focussed on professional football, with plans for future development to incorporate other sports and events. The app allows commentators to dictate and capture contextually aware notes and view visualisation of statistical data, directly related to the fixture that is being played, the teams involved, and the players participating.

During the planning and development stages the company drew on the experiences of their

co-founder, to provide insight and to connect the development team to the community of sports commentators.

"I began working for the media in 2010. Most of my peers still worked with pens, pencils, felt tips, erasers and paper, which began to make me ask, 'Why is there no tech for this job?' and 'Is this the best and only way of doing things?'. Over time the tablet and laptop have become more prominent in sports broadcasting, but there was still nothing that could be deemed useful for all broadcasters. So, the idea of The Journo App was born in my head."

Nathan Blake
Former Cardiff City and Wales footballer and commentator



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Pontypridd

Delivering performance with the right data

Analytics company Talent Pathway iD (TPiD), from North Wales, was formed with the vision of transforming the way organisations and individuals use data and research to inform decisions about their strategies.

There is a vast array of personal and team performance data that managers and coaches can record, track and analyse, including physical performance, psychological wellbeing, tests, outcomes and lifestyle information. Athletes, coaches and managers need to understand which data points are most important to them to inform their participation, development, and performance strategies. To get this right, understanding how data from multiple sources and from multiple platforms interact is key.

TPiD has developed online software which uses machine learning and deep learning AI to analyse all data collectively. It provides athletes, coaches,

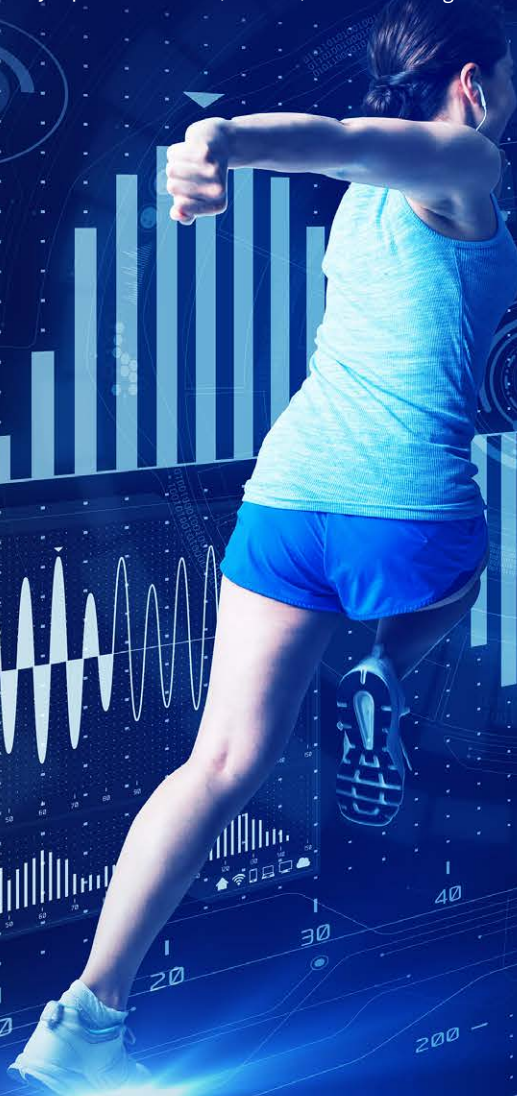
and managers, with intelligence and insights. The system ranks an organisation's data in order of the relative importance whilst simultaneously providing the best combination of results to meet the user's needs.

Following a recent collaborative project with British Canoeing, the company has shown that out of thousands of factors deemed important for developing elite talent, those who win gold medals can be separated from those who do not by as few as seven key factors. Similarly, out of six hundred developmental factors collected from developing weightlifters, a subset of five can be used to predict future success with over 90% accuracy. In addition to understanding how best to maximise the development of their high-performance talent, Canoe Wales have partnered with TPiD to better understand the well-being of their wider membership. The collection, analysis, and visualisation of the data is intended to help shape Canoe Wales' sustainable development and well-being objectives and to show how best to measure against performance to support achieving these objectives in the future.

The goal for future development is to analyse data in such a way that sport, can refine, reduce, and make their systems less onerous and more effective for athletes, coaches, and support staff.

“Rather than just collecting more data, TPiD's AI algorithms help users to intelligently interrogate, understand, and ultimately select the 'right' data. Using the system means understanding the whole picture is possible, which means the need for large data sets is reduced because the understanding of complex interactions becomes more refined and leads to more efficient athlete and coach participation, development, and performance strategies.”

Dr Dior Anderson
Founding Partner
Talent Pathway iD



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Anglesey

Games firm develops pets for the metaverse

Tiny Rebel Games, a company founded in Los Angeles and now located in Newport in South Wales, is building the Petaverse Network. Their goal is to develop an open standard for digital pets “to be with you wherever you live your digital life”. This concept has taken the proven idea of digital pets, pioneered in games like Nintendogs and Tamagotchi, and brings it up to date using nonfungible tokens (NFTs), to allow players to take ownership of their uniquely authenticated digital companions.

The pets are accessible through different digital devices (mobile, PC, Augmented Reality and Virtual Reality). Each pet is physically unique and has a set of personality traits which can

affect how they behave. Their open-access data also allows different experiences and games to reinterpret a pet’s visual appearance into a look which is more compatible with that experience.

The first variety of pets will be cats. The cats will be compatible with Augmented Reality-enhanced, mobile and browser platforms so the new owner will be able to view their pets in the real-world and to share moments through social media. A variety of additional games and apps are in the pipeline and open-access data will allow other development teams to access their code to create new experiences and games for the pets.

Susan Cummings, Founder of Tiny Rebel Games remembers playing with virtual pets on the Nintendo DS. She says: “There were 24 million people playing this game who loved them, bonded with them and played with them for countless hours and then Nintendo moved away from the DS platform and the pets were gone. Trapped on the bottom of a drawer

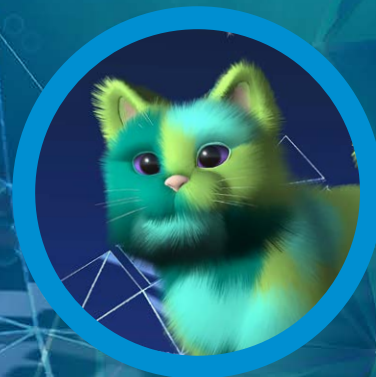


Augmented Reality (AR) uses a digital device’s camera to visualise, in real-time, a combination of real and virtual worlds. Positioning computer generated objects into the user’s real-world setting.

Virtual Reality (VR) is a computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using equipment, such as a headset or gloves fitted with sensors.

Metaverse is a term used to describe the network of 3D virtual worlds focused on social connection that is facilitated by the use of virtual and augmented reality interfaces.

forever. We’re trying to create these resilient pets that aren’t tied to specific games. This new concept will offer pets to bond with, train, and evolve, based on their specific DNA and the interactions users have with them. It lets us create and start with an infinite number of cats, what they look like, and also how they behave. The underlying DNA defines, for example, whether they’re curious, whether they’re agile or clumsy, and whether they’re fast or slow.”



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Newport

Reducing impact on the environment through Augmented Reality

Tarian Drums, based in Pontyclun in South Wales, manufacture bespoke drums working with clients from the very first design decisions to the final stages of the manufacturing process.

With environmental considerations at the heart of the company's ethos, the firm makes sure that environmental impact is considered at every step in the sales and production process. This includes the use of water-based finishes with lower VOC (volatile organic compounds), plastic free packaging and providing each client with the opportunity to have a tree planted in their name.

The Tarian team have worked with the Centre of Excellence in Mobile and Emerging Technologies (CEMET) at the University of South Wales to develop their own bespoke drum designer app complete with Augmented Reality (AR) capabilities. This would allow their clients to create and accurately visualise their drums as they want them whilst cutting out unnecessary travel and transport for both client and company.



The two organisations designed and developed an app that allows the user to experiment with designing a plethora of different drum sets, customising everything from wood type, lugs, hoops, heads and snares, to even their choice of finish – and at any point being able to switch lighting effects from a light “lab” setting to a dark “stage” to suit the user’s environment utilising AR technology.

It was also important to the team that the app was bilingual, accessible in Welsh and English, but through the development process they realised that some of the technical terms used by performers didn't have a direct Welsh translation. The terms for different types of drums, and parts of the instruments, had to be developed.

Experts at Y Termiadur Addysg at Bangor University, who provide standardised terminology for use in Welsh language education helped to give definitions to specialist terms used by drummers. This meant the percussionists using the app could design their perfect instruments using the language of their choice.

A new set of specialist words has been added to the Welsh dictionary as a result of the development of this app to help drummers design new instruments.

“The obvious example that arose during our work with Tarian was 'snare'. The English noun 'snare' originally referred to a string or wire-based trap that you would use to 'snare' small animals, but its use has been extended to also refer to a type of drum that uses wires on its underbelly to give it its distinctive sound. We couldn't just use the Welsh equivalent for 'snare' for the drum because the Welsh word is associated too strongly with the sense of 'trapping'. As it happened, we found that two Welsh terms were already in use for a 'snare drum'. We decided that the meaning of 'wire drum' ('drwm gwifrau') was more appropriate.”

Gruffudd Prys
Terminologist
Bangor University



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Pontyclun

Sustainable solutions for timber and packaging



With the strengths Wales has in natural resources it is no surprise that the use of biocomposites, and natural engineering products, have featured so often since the first issue of *Advances Wales*. As with many other areas of innovation, information technology is increasingly having an impact on design, manufacturing and the management of these materials. Here we see how efforts are being made to reduce the carbon footprint of timber use and how natural, biodegradable materials are being used to deliver novel packaging solutions.

Partnership creates carbon impact calculator

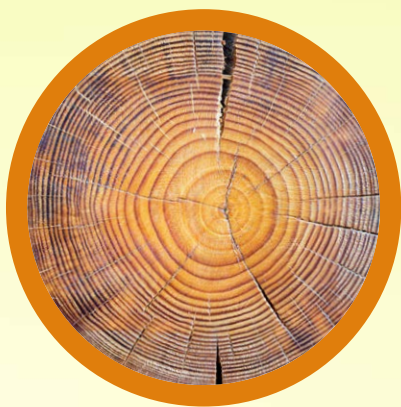
James Latham, one of the UK's largest independent distributors of timber, panels, and decorative surfaces, has partnered with the Biocomposites Centre at Bangor University to create a 'carbon calculator' to provide customers with transparency, knowledge and awareness of the carbon impact of its products.

The calculator details the footprint of the entire process, from the carbon contained within the wood's structure to the manufacturing process, delivery, and storage, with data provided for more than 70 per cent of the company's products.

The Biocomposites Centre is behind the development of the dataset used to calculate the actual carbon score, as well as supplying certification of the validity of the data used. Peer-reviewed independent data from a

manufacturer, such as an environmental performance declaration, will hold the highest accuracy scoring in the system, while publicly published yet unverified figures will hold a lower score. By certifying the accuracy and peer-acceptance status of the data, the calculator will ensure that the impact is understood and explained better than if rough estimations were used. This in turn will provide a clearer picture of the difference using more sustainable products can make.





This will benefit not only end users who will be able to research and select the most sustainable products, but it will also encourage suppliers to take greater steps to ensure resources and their carbon footprints are measured and peer-reviewed.

“With major industries like construction placing an increasing focus on carbon efficiency and footprints, as a distributor we need to be able to communicate directly and simply to all our stakeholders about the products we sell. Providing a clear message as to the level of confidence within the data will also help achieve two key aims of ours; encouraging those involved in the design process to use the most efficient products available, but also pushing the sector towards a higher standard of carbon measurement.”

Ewa Bazydło
Environmental and compliance manager
James Latham

Capping off work on eco-conscious paper whisky bottle

Consumers could soon be pouring whisky out of a paper bottle, with a sustainable packaging project nearing completion at Bangor University. Members of the university’s Biocomposites Centre have partnered with global green packaging consortium Pulpex to design a paper bottle for use by a number of global consumer packaged goods companies.

Made from sustainably sourced FSC-certified wood pulp, the bottles have been designed to balance functionality and quality with

recyclability, and the intention is to create a resilient container which will allow for a long-term shelf-life and simple mass production.

“Given the high carbon and energy cost which go into making even a single glass bottle, it is critical more sustainable methods of packaging are developed to reduce costs and the global carbon footprint. Working with industry is vital if we are to move forward to the next stage of innovation; the knowledge and support they bring is invaluable in helping us research and optimise the ideal makeup of the bottle as well as scale up testing to provide more comprehensive results.”

Dr Rob Elias
Director
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Bangor

Compound semiconductors delivers competitive advantage



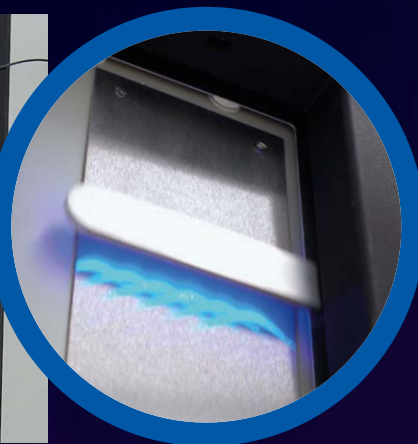
Since issue 2, *Advances Wales* has reported on innovation in the electronics and semiconductor manufacturing sectors. Modern electronic products, from computers to smart phones, use semiconductors. Eighty per cent of the world's semiconductors use silicon and the remaining twenty per cent are compound semiconductors, which combine two or more elements, for example, silicon (Si) and carbon (C) forming silicon-carbide (SiC).

Although compound semiconductors are more complex to manufacture, they outperform silicon in three key areas:

Light – Important for photonics applications such as optical fibre communications

Speed – Important for radio applications such as 5G and RADAR

Power – Important for power electronics for electric vehicles



LUSS - LED based Ultra-Violet exposure for Safe Surfaces

The LUSS (LED based Ultra-Violet exposure for Safe Surfaces) project brings together the South-west Wales site of Microlink Devices, design company Wide Blue and Compound Semiconductor Applications (CSA) Catapult to develop a novel disinfection product, for COVID-19, other viruses and bacteria, using UV LEDs.

This automated disinfection tool uses a targeted UV light source, emitted from an array of LEDs, to automatically disinfect surfaces between uses and help to reduce the spread of viruses and diseases. The technology delivers a cleaner surface that requires less manual cleaning.

Compound semiconductor technology, called UV-C LED, is at the heart of this cleaning tool. UV-C radiation has a disinfecting effect as it is absorbed by the DNA of microorganisms, disrupting the replication process.

The ultraviolet light spectrum can be sub-divided into UV-A, UV-B which naturally reach the Earth's surface and UV-C which is absorbed by the atmosphere. UV-C can, however, be generated artificially and is used for disinfection and

purification of air, water and surfaces. Using cost-effective, controllable and environmentally friendly UV-C light sources, that take advantage of developments in compound semiconductor technology, opens up opportunities for a wider range of commercial applications.

The potential uses for the technology developed in the LUSS project include healthcare and retail applications which have frequent touch-points and a higher chance of viruses spreading in public spaces.

ESCAPE - Silicon-carbide (SiC) power converters

Silicon-carbide (SiC) is considered to be the most promising compound material for semiconductor applications that require a large capacity, such as high frequency power converters used for the speed regulation of motors in electric vehicles. CSA Catapult and Microchip in South Wales have come together with 12 partners from across the automotive sector as part of the ESCAPE project, to provide a proof of principle of a 800V

SiC power converter. Project partners McLaren Applied, who develop advanced engineering and technology solutions for motorsport, are using SiC semiconductors to deliver faster vehicle charging. While Turbo Power Systems, who design and manufacture power conversion systems, have developed rapid charging technology for use in the UK. They are expecting to exceed production of 120,000 rapid and 60,000 ultra-rapid vehicle chargers by 2030.

"As the first of its kind, the ESCAPE project gives McLaren Applied a competitive advantage in the race to create a full UK supply chain for automotive power electronics."

Steve Lambert
Head of Electrification
McLaren Applied Technology

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Newport