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advances WALES

CLIMATE CHANGE EDITION

How Welsh innovation is tackling climate change

Llywodraeth Cymru
Welsh Government

THE JOURNAL FOR SCIENCE, ENGINEERING AND TECHNOLOGY
advances WALES

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.

Climate change is without doubt the biggest challenge we have ever faced.

As a problem with no boundaries, it is every country's duty to deliver some of the solution, and Wales is proud to be making its contribution to the COP 26 goals. Well before COP 26, Wales was taking human caused global warming seriously and looking to improve the well-being of current and future generations. Indeed, back in 2015, we were the first country in the world to put into law our undertaking that future generations should have at least the same quality of life as we do now.

That's because we understand the importance of controlling climate change for the well-being of all the generations to come. This is the central message of our Net Zero Plan. We understand that there is no well-being of future generations if we fail to make a just climate transition over the next decade, and ensure that transition also tackles the inequalities existing in society.

As we continue our journey towards net zero, we need to seriously quicken our pace. This is why we recognise and promote innovation as a key driver to faster decarbonisation. For nearly 25 years, we've been featuring pioneering environmental research & development projects in Advances Wales, and many have now become mainstream products that are making a real difference.

Now, to mark COP 26, we've devoted this edition to the climate change agenda. We hope this will inspire universities, businesses, entrepreneurs and young people to ever greater advances which will help preserve this beautiful world we all inhabit for a short time and protect it for our future generations.

Julie James
Minister for Climate Change

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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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Three new low carbon projects set to go ahead

Three low carbon projects to reduce greenhouse gas emissions in agriculture are set to go ahead in North Wales.

The schemes, based at Coleg Cambria, will involve the use of pioneering technology to help the sector become more sustainable in the drive for net-zero farming, with the view for potential commercialisation in 2022.

The collaboration between M-Sparc, operated by Bangor University, and businesses will explore the potential for drones to identify on-land issues, such as weed growth, to help improve sustainability. The second phase of the scheme will involve research into how drones could communicate with a rover on the ground to target issues remotely.

Meanwhile, agricultural consultancy Promar International is developing a bilingual carbon footprint resource for farmers in North Wales, an online platform where they can input information, for example on the landscape, potential for tree planting and current meat and milk production systems. This data is then used to calculate their carbon footprint, with the results used to encourage best practice on a regional basis.

BioFactory Energy, an engineering and design company focusing on waste-to-energy technology, are developing a low-cost, modular Anaerobic Digestion system for small-medium Welsh dairy farms to reduce greenhouse gas emissions from slurry management.

A prototype plant is expected to be on-site in the new year to generate energy for the farm and improve slurry quality for spreading.

www.cambria.ac.uk
www.northwaleseab.co.uk.

Fuelling a greener future with hydrogen electric

A £600,000 hydrogen electric propulsion systems (HEPS) testbed, based in AMRC Cymru, is helping to accelerate efforts to decarbonise the transport sector by de-risking the assembly and production scale up of hydrogen fuel cells.

The Advanced Manufacturing Research Centre (AMRC) – a research and innovation centre working with advanced manufacturing companies – is heading the project, which will utilise 4.0 technologies and in-process inspection techniques to optimise the production process for fuel cells. Like battery electric vehicles (BEV), fuel cell electric vehicles (FCEV) run on a supply of electricity. However, whereas BEVs take hours to recharge to maintain supply, FCEVs use hydrogen, which can be refuelled in minutes. In addition, fuel cells emit only water vapour, making them a zero-carbon propulsion system.

"We want to support businesses who want to make the net zero energy transition to hydrogen electric propulsion systems by giving them a facility where they can use advanced manufacturing techniques to assemble and verify their product and then eventually integrate it in their vehicles."

Lee Wheeler
Hydrogen Technology Lead
AMRC Cymru

The project is specifically targeting the aerospace, energy generation, heavy automotive, off highway, public transport, and rail industries. With the production process for fuel cells extremely labour intensive, it intends to support small businesses looking to explore hydrogen technology.

Construction of the testbed is planned for January 2022, with the first assembly project set for April.

BAE Systems, GKN, Rolls-Royce and Toyota are helping to guide the project, alongside a group of smaller companies.

www.amrc.co.uk/facilities/amrc-cymru-wales

Low carbon growth project gets the green light

The £58.7 million Swansea Bay City Deal's Supporting Innovation and Low Carbon Growth programme, which aims to create a low carbon economy for the region, has been given the go ahead.

The programme, led by Neath Port Talbot Council with partners Swansea University and University of South Wales, aims to support the creation of 1,320 jobs in the green economy through seven interlinked projects to enhance infrastructure, research and development, and commercialisation. This includes; **Bay Technology Centre** – a self-sufficient, 'energy positive' building, with integrated renewable energy generation and storage, enabling the centre to generate its own energy; **South Wales Industrial Transition from Carbon Hub** – purpose-built facility and specialist equipment to decarbonise the steel and metal industry and supply chain; **advanced manufacturing production facility** – providing production units with open access to shared specialist equipment to support start-up companies and local business growth in the innovation and manufacturing sectors linked to energy and renewables; **property development fund** – gap funding for bespoke and speculative commercial buildings in the Port Talbot Waterfront Enterprise Zone area; **hydrogen stimulus project** – enabling a demonstrator to prove commercial viability of carbon-free hydrogen supply to fuel hydrogen vehicles; **air quality monitoring project** – test bed for new technology to acquire greater understanding of air quality and pollution levels to inform local action planning; **low emission vehicle charging infrastructure** – developing a strategy to decarbonise journeys in the Swansea Bay City Region and develop a pilot in the Valleys area of Neath Port Talbot.

www.swanseabaycitydeal.wales

IN BRIEF

Funding raised for Welsh hydrogen car manufacturer

Riversimple, a hydrogen car manufacturer, has raised £1.5 million from its crowdfunding campaign. The company will use the funding to build vehicles for customer trials that began earlier this year. Riversimple's first technology is a two-seater 'network electric' car powered by a hydrogen fuel cell. With the UK government planning to decarbonise cars by 2030, and demand for electric vehicles growing, it aims to diminish environmental harm. To function, hydrogen passes through a Proton Exchange Membrane in the fuel cell where it combines with oxygen to form water and electricity, which then flows to the motors in each wheel. As the car slows, this electricity floods into a bank of super-capacitors, which, unlike batteries, can take a huge charge very quickly. The only battery onboard exists to power the control units to start the car and turn on the lights before the fuel cell is switched on.

Hydrogen hub moves step closer

Plans for a hydrogen hub for Holyhead are now a step closer after funding was announced for the initial phase of the development. The benefit of hydrogen has long been known as a zero-emission fuel for transportation, a long-term energy store as well as for domestic heating. Seen as a first step, the proposals would see the production of hydrogen at Holyhead as well as a fuelling distribution centre. It will contribute to efforts to decarbonise the economy and tackle climate change, with the fuel potentially used to power HGVs and ships. The Hub is being developed by Anglesey social enterprise, Menter Môn, in partnership with Anglesey County Council.

Welsh science shows strength in sustainability

Welsh science has made considerable progress to meet the United Nations Sustainable Development Goals (SDGs), according to a report published in September. The SDGs were adopted by the UN in 2015 as a blueprint to achieve a more sustainable future. They are a collection of 17 global goals focusing on an end to poverty, coupled with strategies to improve health and education, reduce inequality, spur economic growth, and protect the planet. The report, "UN SDGs: Wales' Research Performance with UK and Global Comparators", shows that, among the SDGs, Welsh research is making a particularly strong contribution to those which relate to the planet such as SDGs 13, Climate Action, 14, Life below Water, and 15, Life on Land. Julie James, Minister for Climate Change, said: "At 130% above the world average, Wales had the joint highest overall citation impact of all of the comparators considered in the report making us a global leader in Sustainable Development Goals related research."

Green pilot seeks Denbighshire taxi operators

Denbighshire County Council is hosting the only North Wales pilot of a zero emission green taxi scheme, supporting efforts to de-carbonise the taxi fleet entirely in Wales by 2028. The pilot will operate a try before you buy initiative, allowing hackney licensed taxi drivers to try out an electric vehicle free of charge for 30 days, including free charging at specific locations in Denbighshire, vehicle licensing, breakdown cover and insurance. As part of the project, the associated charging infrastructure will also be installed.

Torfaen takes steps to cut carbon footprint

Torfaen council has taken significant steps to reduce its carbon footprint after investing in over 45 energy efficiency upgrades across the borough. Over the last five years, the council has implemented a range of decarbonisation and sustainability projects to help cut its energy consumption – and save millions of pounds – from street lighting upgrades, to LED lighting overhauls and the installation of numerous Building Energy Management Systems (BMS) in public sector buildings. One of its key focus has been to reduce the energy consumption within its schools – its biggest energy user, accounting for 34% of energy bills. The council has invested in numerous projects across 20 schools in the last five years, projected to save more than £156,000 and 847,000 kWh of energy a year – equalling 109 homes' electricity use for one year. The Council, which is on its way to becoming carbon net-zero by 2030, has further plans to improve its carbon footprint by investing in more renewable technologies.

Harnessing solar energy for EV charging

Dulas, a renewable energy installer and consultancy specialising in the wind, solar and hydro sectors, is embarking on a new project to install a solar-powered Electric Vehicle (EV) charging station at its head office in Mid-Wales.

The unit will provide a dual-station charging solution, combining energy storage technology with solar power. The installation will be a working testbed for the Machynlleth-based company – an experienced installer of Battery Energy Storage Solution (BESS).

Figures for March in the UK saw the highest penetration of new EV vehicles ever recorded, with the sales of battery electric and plug-in hybrid cars reaching 14% of the market. Meanwhile, the Government's plans to phase out the sale of new petrol and diesel cars by 2030 means that there could be as many as 10 million electric cars on the roads in the next decade.

Electrifying road transport will also place huge demands on grid supply, and added to this grid upgrades are costly, often requiring major changes to premises. By building a new onsite BESS using solar power, Dulas hopes to run a test-bed for a reliable and cost-effective charging solution that eliminates the expense of a grid upgrade or a change to the premises.

The EV charging station would have minimal or zero requirement for back-up grid power, while the project itself aims to provide proof of concept enabling Dulas to develop additional commercial solutions for both the EV charging market and the remote power market.

www.dulas.org.uk

Building zero carbon homes for Rhyl

With energy bills set to rise again, building the most energy efficient is becoming increasingly important in the UK. Creating Enterprise – a social enterprise based in North Wales – is investing over £1 million in a new factory to meet the growing demand for zero carbon homes. The 10,000 sq ft premises will be making the timber frames for energy efficient homes – with 50 already being built and another 100 on the order book. They will also be installing a machine to manufacture posi-joists for floor and roof structures. The technology, which has become more popular in recent years, combines the lightness of timber with the strength of steel webs, offering an alternative, eco-friendly structural flooring system through which cables and pipes can be threaded - supporting the vision for affordable, net zero carbon homes.

Graphene-based clean energy generation aboard ships

Marine technology company Grafmarine, whose R&D facility is based at M-SParc in North Wales, is looking to bring to market an integrated solar energy and storage solution for marine vessels that aims to reduce marine fuel consumption on ships by up to 10 per cent. The company has developed an innovative graphene-based technology platform using solar photovoltaic cells to create electrical power. It can be fitted to any vessel or structure and turn it into an energy generating surface. When a ship is stationary or in port, batteries can provide an alternative source of power, thereby reducing the fuel used by auxiliary generators. In certain situations, it will be possible for a ship to operate emission free when in port which will become increasingly important as port authorities implement strict airborne emission control regulations and demand for clean energy grows.

New Energy Strategy for North Wales

A new energy strategy has been launched to transform how energy is used across North Wales, which aims to bring the region a step closer to the government's net-zero carbon target for 2050 – for which an overall 55% reduction in energy related emissions is needed by 2035 across key sectors including transport, in homes, as well as commercial and industrial use. Helping to deliver the mission is the North Wales Energy Strategy Group, which has been established to develop, implement and coordinate the steps that need to be taken. The strategy aims to address current challenges including climate change, economic growth, and post COVID-19 economic recovery.

Expansion for green energy company Hafod Renewables

North Wales based Hafod Renewables, an expanding green energy company, is helping West Wales residents beat soaring energy prices. Hafod Managing Director David Jones explains: "The building boom coupled with expected hikes energy prices is fuelling interest in a range of renewable options, especially solar and air-source systems. These can easily be retro-fitted to older properties and can operate independently, or with solar making a lot of sense for people in rural areas unable to access mains gas."

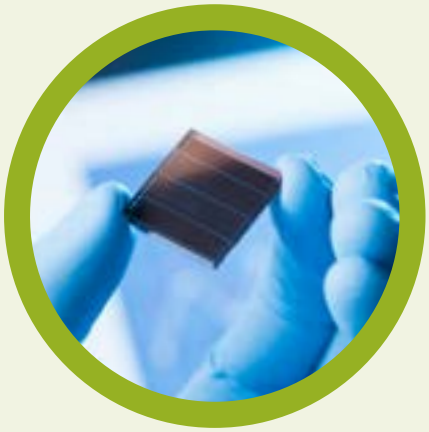
Funding boost for UK biomass production

It has been announced that 24 projects will receive funding of up to £200,000 to boost biomass productivity in the UK, through breeding, planting, cultivating and harvesting of organic energy materials. Biomass, which refers to sustainably derived plant material used as fuel to produce energy or to create products such as chemicals and bio-plastics, has a small but important role to play in the UK's commitment to eradicate its contribution to climate change by 2050. The funding recipients include Aberystwyth University, which has received over £160,000 for its 'Miscanspeed' project, through which it will demonstrate the latest technologies for planting willow and Miscanthus, the two perennial biomass crops that are best suited to UK conditions. The crops remove carbon dioxide from the atmosphere as they grow, making them a renewable and low carbon source of electricity, and can be harvested every one to three years. The project aims to make important contributions to meet net-zero climate targets.

A safer, greener way to make solar cells

Researchers at Swansea University's SPECIFIC Innovation and Knowledge Centre have found a way to replace the toxic, unsustainable solvents that are currently needed to make the next generation of solar technology.

Printed carbon perovskite solar cells are extremely efficient at converting light to electricity, as well as cheap and easy to make. However, a major barrier to the large-scale manufacture and commercialisation of these cells is the solvents used to control crystallisation of the perovskite during fabrication. They are made from unsustainable materials and are banned in many countries due to their toxicity and psychoactive effects.



SPECIFIC's researchers have discovered that a safer, greener solvent called γ-Valerolactone (GVL) could replace the current solvents without impacting cell performance. GVL is non-toxic, biodegradable, made from sustainable feedstocks, and suitable for use in large-scale manufacturing processes. There are also no legal issues with its use around the world.

The solvent problem has been a major barrier for new solar technology, not only restricting large-scale manufacture, but also holding back research in countries where the solvents are banned. The SPECIFIC team hope that their discovery will enable countries that were previously unable to participate in this research to become part of the community, accelerating the development of cleaner, greener energy.

Carys Worsley, who led the research as part of her doctorate, explained: "To be truly environmentally sustainable, the way that solar cells are made must be as green as the energy they produce. As the next generation of solar technologies approaches commercial viability, research to reduce the environmental impact of large-scale production will become increasingly important."

GVL's list of advantages could improve the commercial viability of carbon perovskite solar devices:

- It is made from sustainable feedstocks
- There are no legal issues in its use around the world
- It is suitable for use in large-scale manufacturing processes
- It is non-toxic and biodegradable

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Swansea

Developing quicker, safer technology for water disinfection

Using just hydrogen and air, scientists from Cardiff University have created a water disinfectant which is more effective at killing viruses and bacteria than traditional commercial methods as well as being more energy efficient and better for the environment.

Around 785 million people lack access to water, and 2.7 billion experience water scarcity at least one month a year. In addition to this, inadequate sanitation can lead to deadly diarrheal diseases, including cholera and typhoid fever, as well as other water-borne illnesses.

Over four million tonnes of hydrogen peroxide are made in factories each year and then transported in order to be stored and used for water disinfection. Stabilising chemicals are often added to stop the solution from degrading during transport and storage, but they ultimately reduce its effectiveness as a disinfectant.

Another common approach to disinfecting water is the addition of chlorine. However, chlorine is capable of reacting with naturally occurring compounds in water to form new compounds which, in high doses, can be toxic to humans. The ability to produce hydrogen peroxide at the point of use would overcome both the efficacy and safety issues that are currently associated with commercial water disinfection methods.

In a new study, scientists have discovered a potentially ground-breaking way to form hydrogen peroxide, using a catalyst made from gold and palladium that takes in hydrogen and oxygen. The study was led by Cardiff University's School of Chemistry and School of Pharmacy & Pharmaceutical Sciences, with researchers from Swansea University, Lehigh University, National University of Singapore and the University of Bath, as well as experts from Dwr Cymru Welsh Water.

The team tested the efficacy of commercially available hydrogen peroxide and chlorine, compared to their new catalytic method. Each approach was tested for its ability to kill Escherichia coli in identical conditions, followed by subsequent analysis to determine how exactly the bacteria were killed using each method.

They found that as the catalyst brought hydrogen and oxygen together to form hydrogen peroxide, it simultaneously produced a number of highly reactive compounds, known as reactive oxygen species (ROS). These were then responsible for the antibacterial and antiviral effect, rather than the hydrogen peroxide itself.

Results showed that the catalyst-based method was 10 million times more potent at killing the bacteria than an equivalent amount of the industrial hydrogen peroxide, and over 100 million times more effective than chlorine under equivalent conditions. The new method was also more effective at killing the bacteria and viruses in a shorter space of time compared to the other two methods.

The new, cleaner 'on the spot' water disinfection technology could present an opportunity to provide clean water for communities that need it most, more efficiently and with less impact on the environment.

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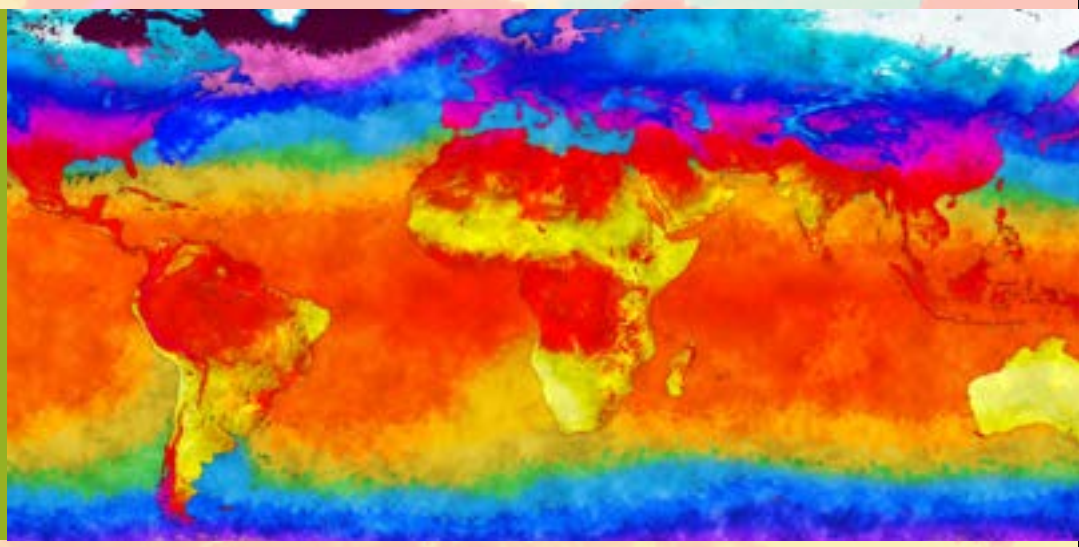
Cardiff

Research addresses future cooling challenges

Scientists at Cardiff University are exploring whether rising temperatures and the new 'working from home' culture might impact the UK's target of achieving net-zero carbon emissions by 2050.

Currently, up to 10 per cent of all UK electricity is used for cooling and air conditioning. But this is predicted to rise in the future, with a general temperature increase of 3-5°C for the average summer by 2080, and an increase in the number and frequency of hot spells. Demand for cooling is likely to rise in homes and commercial and civic buildings, such as hospitals, schools, offices and shops, if people are to remain comfortable in everyday life and work.



A new project called Flex-Cool-Store (Flexibility from Cooling and Storage) is investigating the impacts of this growth in demand for cooling. Researchers will also explore how the demand can be managed through the design of new, energy-efficient cooling systems that require little or no carbon.

Dr Carlos Ugalde-Loo, Principal Investigator for the project from Cardiff University's School of Engineering, explained: "Cooling decarbonisation has not previously received significant attention, but this is changing due to population increase and climate change. Summertime cooling of buildings is becoming increasingly important, particularly as more people choose to work from home, and the demand for better comfort levels increases. Significant reductions in emissions have already been achieved in the electric power sector, but progress has been limited in other areas, such as heating and cooling, which account for over a third of all UK emissions."

The Flex-Cool-Store project will lead to recommendations on how cooling can contribute to a sustainable, low-carbon and net-zero transition by 2050, and will inform the energy sector, government and individual consumers on the cooling challenges that lie ahead. The aim is to quantify how cooling will affect peak electricity demand and to determine what this means for the energy network. In particular, researchers will consider how the UK's power systems can be balanced with a surge in photovoltaic energy generation, expected during the summer months.

The team will study how cooling and electricity systems can be integrated with energy storage in buildings to maximise flexibility.

This work builds on the whole energy systems work undertaken at Cardiff University. The project brings engineering and modelling together while also exploring public perceptions towards the adoption of cooling technologies within households, buildings and communities via interviews and public workshops.

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Cardiff

Harnessing energy from the sun to tackle period poverty

Scientists at Cardiff University are developing a material for reusable sanitary towels that could kill bacteria when exposed to sunlight.

Reusable sanitary towels and period pants are eco-friendly, low-cost alternatives to single-use sanitary products. However, safe use often requires an elaborate disinfection and laundering regime.

A team from Cardiff University is now developing a special type of fabric that could be used in reusable sanitary towels or period pants. The material is infused with non-toxic metals acting as a catalyst, harnessing energy from the sun and producing compounds that are capable of killing bacteria, removing stains and neutralising odours. Sanitary towels or period pants made of the new material would be rinsed with water and then left to dry in the sun to kickstart the bacteria-killing process.

The reusable product is expected to be of huge benefit to people living in countries where access to single-use sanitary products is both costly and limited. Access to disinfectants and clean water is also at a premium in such countries, meaning there is currently a risk of infection with reusable products that already exist. This solution should provide a cheaper, safer, more energy efficient sustainable option.

> “Our overall goal is to create a catalyst-infused self-cleaning material that can provide a cheap and easy-to-use solution for use in reusable period products, improving the health of women in communities all over the world. Our initial results show the technology is already highly effective at rapidly killing bacteria in the presence of sunlight, so it is up to us now to optimise our process and create a product that is effective at reducing the likelihood of deadly infections.”
>
> **Dr Jennifer Edwards**
> Project Lead
> School of Chemistry
> Cardiff University

It has been found that unsanitary reusable products contribute to a high incidence of vaginal infections in low- and middle-income countries. This creates chronic discomfort and doubles the risk of miscarriage, which can prove deadly in communities with poor medical provision. In Nepal, for example, almost half of female agricultural workers have a vaginal infection at any one time.

Results of the research have already shown that non-toxic Photo Active Catalysts can harness energy from sunlight to produce chemical energy, in the form of bacteria-killing particles called reactive oxygen species. These can be created in significant amounts using the catalysts, and are effective at killing 99.9% of the bacterium Deinococcus radiodurans in just 15 minutes when exposed to UV light. The team has also shown that antibacterial activity only occurs under UV light and is ineffective in the dark, meaning that the materials are benign and less likely to cause possible irritation when worn under clothes.

The scientists are now exploring how this technology can be implemented into a suitable material inside a sanitary towel. At the same time, they are aiming to optimise Photo Active Catalysts so that they can be used against a broad spectrum of pathogens, as well as to reduce organic blood products and colour to provide a cheaper, safe and more eco friendly alternative to single use products.

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Cardiff

Using enzymes to make sustainable detergents, textiles and cosmetics

Scientists at Bangor University are collaborating with academic and industrial partners across Europe to make everyday consumer products more environmentally friendly.

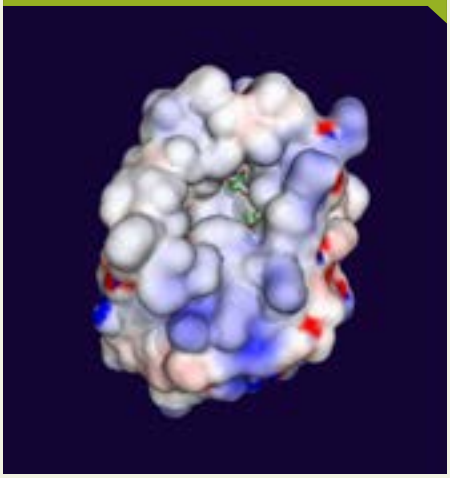
Complex formulas within everyday items such as detergents, textiles and cosmetics can cause environmental damage. Producing them creates a significant amount of carbon dioxide, uses vast amounts of energy and water, and discharges chemical products into the environment.

A promising way of alleviating this problem in industrial processes is by substituting chemical agents with enzymes. Using enzymes in liquid detergents, as well as in the processing of textiles and cosmetic ingredients, could reduce carbon dioxide emissions by 42 million tons per year according to recent estimates. Although enzymes that perform these activities already exist on the market, less than 10 per cent of current consumer products contain them, either because of their high cost or low performance.

Scientists from the Centre for Environmental Biotechnology at Bangor University are part of a multidisciplinary research consortium called FuturEnzyme, seeking to develop new, more environmentally friendly microbial enzymes that can be used in the manufacture of consumer products. The 16 academic and industrial partners involved in the project are led by the Institute of Catalysis at the Spanish National Research Council (CSIC).

Current enzymes are unable to cope with the formulation of higher environmental quality consumer products. It is therefore a priority to design smart technologies based on a new generation of enzymes with higher activity and stability and lower cost, that meet the demands of both consumers and industry.

The FuturEnzyme consortium will initially focus on detergents, cosmetics and sportswear already available. The work is not about designing new consumer products, taking years to get to market, but improving existing ones, making them more environmentally friendly, functional and sustainable by incorporating enzymes into the production process. These enzymes will be selected from a range of micro-organisms and microbial genomic libraries that Bangor University and other partners have sourced from previous collaborative research.



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Bangor

New insights into the Greenland Ice Sheet

Research from Aberystwyth University shows the Greenland Ice Sheet is under threat from surface microbes multiplying faster than they are washed away in a warming climate.

The Greenland Ice Sheet is the largest mass of ice in the northern hemisphere, covering an area seven times the size of the UK and up to 3 km (2 miles) deep. Its surface harbours a wealth of microbial life, including algae, which can change the ice's colour by photosynthesising and storing carbon during summer months. These carbon deposits are removed by natural wash-off by meltwater, but Aberystwyth University scientists have found that these deposits are increasing faster than they are being washed away.

They estimate that meltwater removes 37kg of carbon deposits from every square kilometre of the melting ice sheet each summer. The study suggests that every square metre of the ice sheet's melting surface is home to at least 1,500 million microbes that keep growing and multiplying, but that only 190 million of these microbes get transported to the streams that flow on the ice surface each day.

As a result, the ice sheet surface accumulates carbon, it experiences enhanced carbon exchanges, and may darken. A darker ice sheet reflects less sunlight back into space, meaning the sheet will melt more. This could contribute to climate change and rising sea levels.

The team analysed meltwater samples using a laser instrument called a flow cytometer to count the numbers of microbes present. They also used drones to map meltwater streams on the western Greenland Ice Sheet.

Dr Tristram Irvine-Fynn, lead author of the research paper, said: "The Greenland Ice Sheet surface is fascinating. We know that it simultaneously acquires and exports carbon, but many of the pathways and processes associated with it are still a mystery.

"Our analysis reveals that more microbes are accumulating on the surface than are being washed away. More microbes means more organic carbon. This could contribute to the darkening of the ice sheet surface, which will continue to increase as greater areas of ice habitat are exposed in the summer melt season."

The research also estimates, for the first time, how much microbial carbon is reaching the bed of the ice sheet. This gives an insight into another factor that affects climate change, because more methane is produced as more carbon is transferred from the sheet's surface to its bed.

The goal of the Nature Communications work was to highlight the slow transport of microbial biomass over the melting surface of the Greenland Ice Sheet given the regionally and globally relevant biogeochemical processes that occur there and to offer a novel evaluation of biomass that may be delivered to the ice sheet's bed beneath hundreds of metres of ice.

The next steps will be to work on a northern hemisphere assessment of microbe cellular carbon delivery from glaciers to downstream terrestrial and aquatic systems, the direct examination of how glacier melting may affect the microbial life that thrives on glacier surfaces and exploration of the limits to microbial life on Arctic glacier surfaces which are seasonally snow-covered and in winter darkness.

"The study's findings support the conclusion that far from being lifeless icy wastes, Earth's ice sheets teem with microbial life. As the climate warms, these microbes and their role in Earth's carbon cycle become intertwined with the fate of their icy habitats, and thus our future."

Dr Arwyn Edwards
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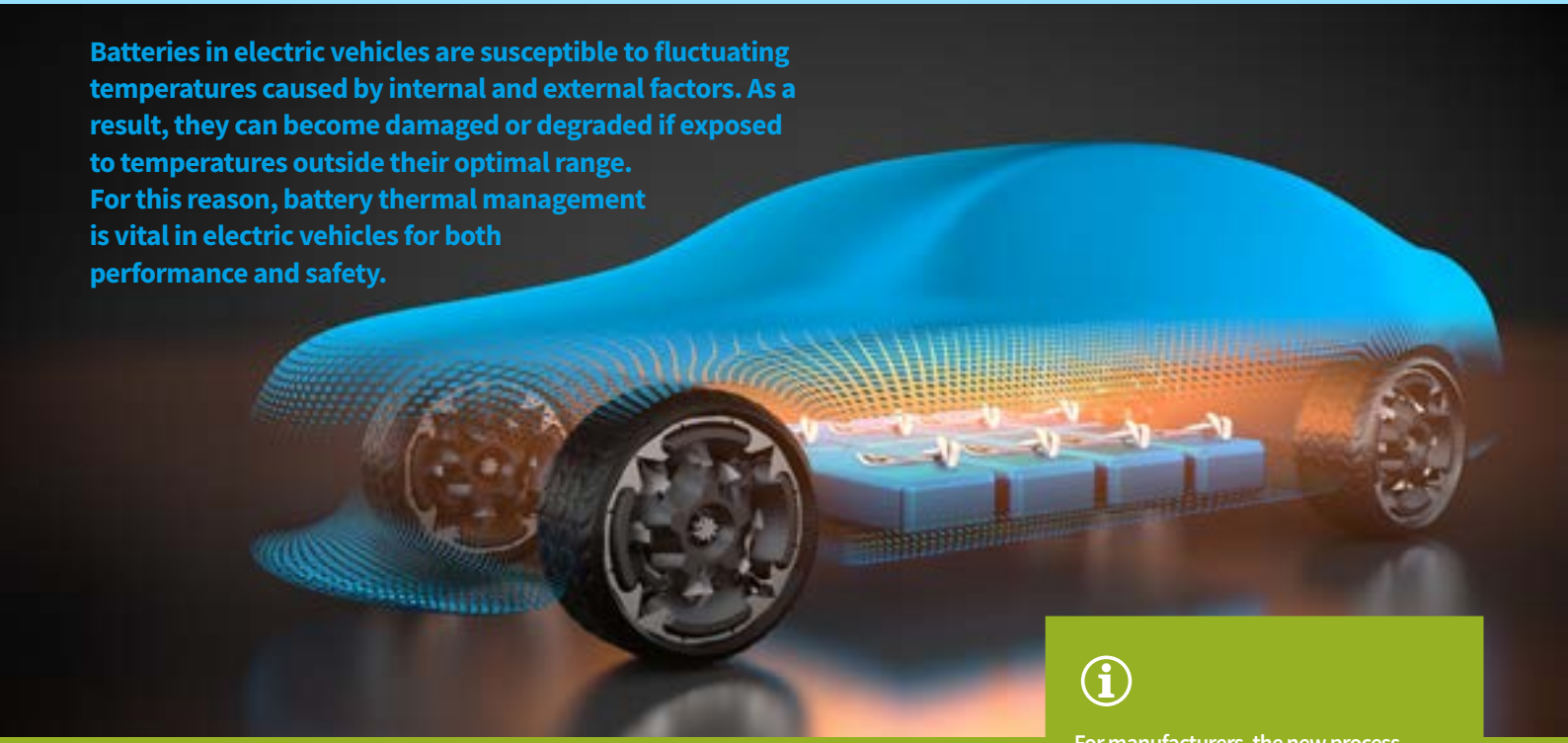
Aberystwyth

New process to make battery coolers for electric vehicles

Engineers at Senior Flexonics have developed aluminium battery coolers that will make electric vehicles more cost-effective.



Batteries in electric vehicles are susceptible to fluctuating temperatures caused by internal and external factors. As a result, they can become damaged or degraded if exposed to temperatures outside their optimal range. For this reason, battery thermal management is vital in electric vehicles for both performance and safety.

Heat exchangers ensure temperature control in battery electric vehicles, and these are commonly formed by joining aluminium components via a brazing process. The temperature range for these components is -40 to +60C. Brazing requires tight control of tolerances, significant amounts of heat energy and multiple processes.

To reduce both cost and environmental impact, engineers at Senior Flexonics have developed an aluminium heat exchanger cooled with water/glycol to be used in battery electric vehicles. Crucially, the tighter temperature range means that the aluminium components can be joined using cheaper adhesives, as opposed to traditional brazing. This project will contribute to carbon footprint reduction by using more energy efficient production methods and helping to make electric vehicles more cost-effective.

Initial activities involved testing to check the strength of several different adhesive options. Using empirical data, an FEA model was constructed to examine how the adhesives might respond in different conditions. Samples were then soaked in a number of fluids typically found in a vehicle. From this data, a single adhesive was chosen and a first heat exchanger was designed. After predictive trials proved successful, heat exchangers were manufactured and subjected to a full test programme, with long-term evaluation still ongoing.

Aluminium can expand when it is being brazed, due to the heat, which creates a restriction on the design of components. This problem does not exist with adhesives, enabling more complex forms to be joined and more efficient designs to be created. They can also be strong across a gap between components, allowing greater tolerances.

For manufacturers, the new process allows greater flexibility in how they control the temperature of their electrical components, as well as providing a lower cost solution which can then be passed on to the consumer. This kind of innovation will help electric vehicles to compete with the existing technology of Internal Combustion Engines in terms of price, and encourage the switch that is needed to reduce future emissions.

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Crumlin

Using recycled plastic in the medical sector

Vernacare (formerly Frontier Plastics) has created medical sharps containers manufactured from recycled polypropylene.

The company, which is part of the Vernacare Group, has incorporated recycled plastic into its Sharpsafe range of containers for the safe disposal of clinical sharps equipment, such as needles and blades. This will help to support the medical sector's ambitions to reduce its carbon emissions and its use of single-use plastic, whilst improving environmental practices and efficiencies.

A range of the company's sharps containers are now being manufactured using up to 20 per cent recycled materials whilst some accessories and products, including the eXchange range of black containers, use 100 per cent recycled materials. This means that over three years, more than 4,000 tonnes of recycled plastic will be used in the manufacturing process, saving around 2,500 tonnes of CO_2. Additionally, the recycled black polypropylene (rPP) is sourced from a Wales-based supplier, which has the extra benefit of reduced transport miles and a significantly shorter supply chain.

In initial trials, Vernacare sought to source the right grade of rPP which would perform to the same high impact strength and resistance to needle penetration. This was critical to ensure continued safe disposal of sharps to maintain infection control and safety in hospitals and other healthcare settings.

Sample pieces were injection moulded and tested to benchmark the material's impact strength and penetration resistance against the original, virgin resin. The testing identified two rPPs from post-consumer sources that closely matched the characteristics of the virgin resin – one natural rPP source and one black. Further product moulding trials were carried out, with both materials successfully passing quality control. More testing confirmed batch-to-batch consistency and conformance against specification.

The results of these trials enabled the move to full scale production using recycled materials. To support this change, the company has now introduced a factory-wide new material handling system, machine-side blending, and Quality Control test and validation equipment. The new containers will play their part in the fight against plastic pollution by keeping plastic in the economy and out of the environment.

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Blackwood

Bringing sustainability to bike production

Frog Bikes Manufacturing Ltd has innovated to make its business more sustainable and reduce its carbon footprint.

> "We are committed to reducing our emissions, and thanks to the extra skills in the business, we are now confident that we will reach net zero by 2050. We are continually working to integrate sustainability into each aspect of the business, but we understand it is an ongoing process. The decarbonisation project has put sustainability at the top of our agenda, and it's in all discussions down to the shop floor level. We hope to be one of the first bike companies producing properly green bikes."
>
> **Shelley Lawson**
> Director and Co-Founder
> Frog Bikes Manufacturing Ltd

The Welsh company, which manufactures lightweight bikes for children, had a desire to re-shore their bike frame building process, using recycled materials where possible, and to limit their carbon footprint. Their frames are currently manufactured from virgin aluminium in Asia, painted and then shipped to their factory in Mamhilad, Pontypool, where other bought-in parts such as brakes, gears, chains, seats and handlebars are assembled.

To meet their environmental goals, Frog Bikes enlisted the help of a dedicated specialist who could find ways of extending the useful life of their bicycles and components. This included studying the potential for reusing and remanufacturing components, increasing the number of uses for each bicycle, and possibly recycling materials when each bike reaches the end of its useful life.

In order to keep used bikes in operation for longer, the company also launched an MOT test pilot scheme, giving used bikes a 'health check'. The MOT inspection checks for damage, wear and tear, as well as potential repairs or adjustments on 20 key safety points around the bike, helping to keep children road-safe and in the saddle. The scheme has initially been rolled out to three bike stores in Wales, with plans for further expansion.

Changes at Frog Bikes will deliver carbon savings by using fewer new materials (especially aluminium) within the supply chain and by reducing the distance that materials are shipped around the globe. The company hopes to have all frame painting re-shored to South Wales by the end of 2021, and for the frames to be manufactured wholly in the UK by the end of 2022.

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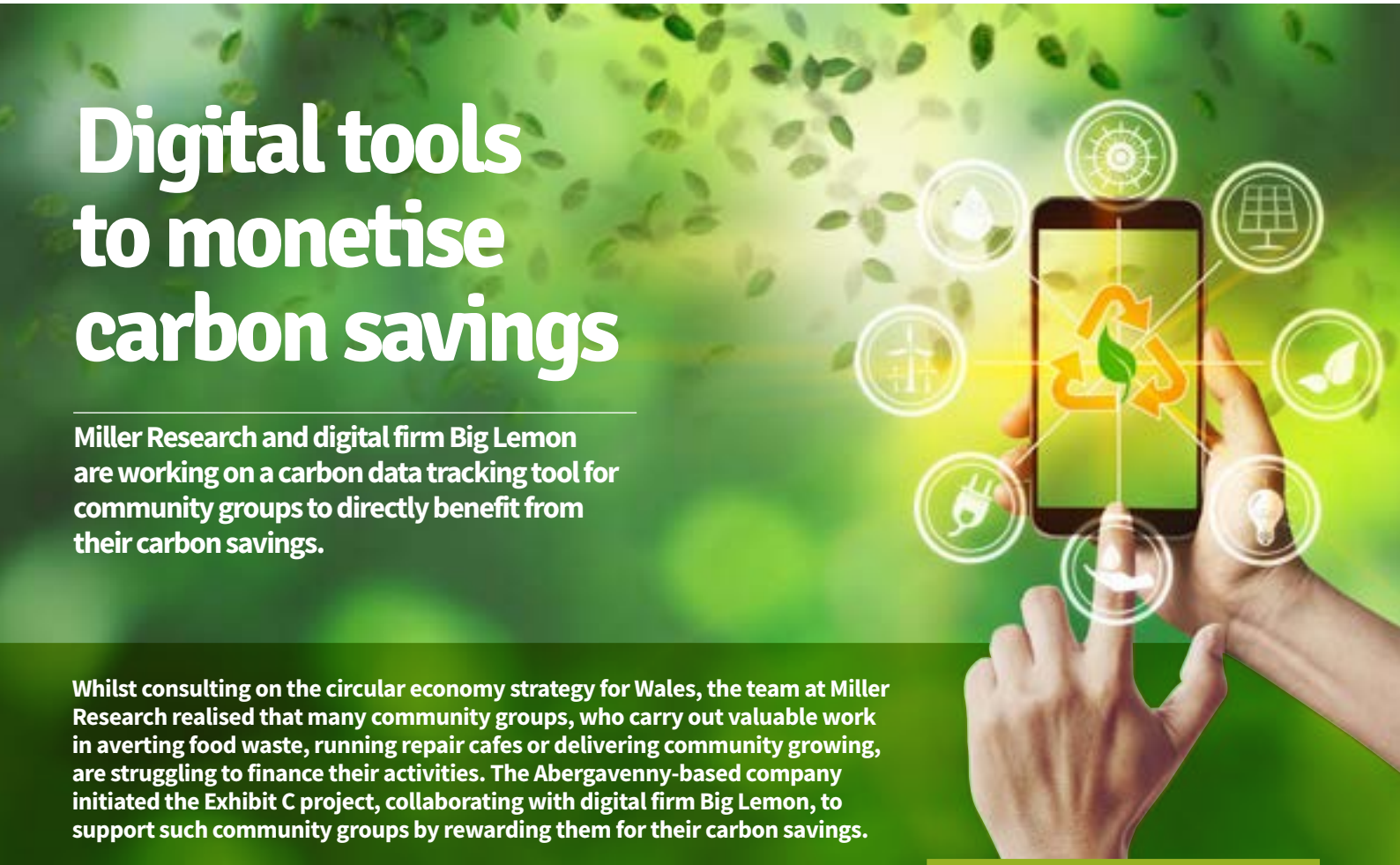
Digital tools to monetise carbon savings

Miller Research and digital firm Big Lemon are working on a carbon data tracking tool for community groups to directly benefit from their carbon savings.



Whilst consulting on the circular economy strategy for Wales, the team at Miller Research realised that many community groups, who carry out valuable work in averting food waste, running repair cafes or delivering community growing, are struggling to finance their activities. The Abergavenny-based company initiated the Exhibit C project, collaborating with digital firm Big Lemon, to support such community groups by rewarding them for their carbon savings.

Currently, few community or voluntary organisations are rewarded for their achievements, beyond a sense of fulfillment. Exhibit C emerged from a realisation that, in performing their core activities, many of these groups are saving substantial amounts of carbon through emissions averted and there was scope to monetise this untapped resource.

The project aims to provide a simple phone-based app for community groups to record their carbon savings, as well as a web-based platform which aggregates carbon data and creates individual carbon accounts for each group. These will then be aggregated and sold, either directly with corporate clients seeking offsets to meet net zero requirements, or through commercial traders. The proceeds will subsequently be recycled back into the community groups who created the initial savings.

Many carbon accounting models are highly complex, and require substantial resources to both measure and input carbon savings.

Given the nature of the target groups, the digital tools needed to have a simple user interface to maximise engagement. This has been achieved through carefully structured models for each activity, underpinned by continuous refinement through a machine learning approach that builds accuracy into the system. The team is currently investigating the incorporation of blockchain into the system in order to further build veracity and security.

Methods of accreditiing the audit models needed to be indentfied since there was none currently available. They are developing a Community Carbon Standard, which they aim to either build as a Welsh standard, verified by members and partners, or to be verified by an external certification body. Another challenge involved setting a price for carbon, as the current market for so-called 'charismatic carbon' is both volatile and low in price. A contract for setting the value of the carbon savings is currently in preparation.

The system is expected to have significant advantages over many offset systems, since it avoids issues of 'carbon colonialism' by funding community activities in the UK which can be visited and supported by offset clients. In addition, the model ensures that any investment is leveraged, because funds recycled go towards further beneficial work in communities and, in turn, greater carbon savings. Exhibit C is working with a range of community and corporate partners and expects to launch in early 2022.

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Cardiff

Welsh bioprocess expertise to tackle water industry emissions

A project involving the University of South Wales (USW) has been named among the winners of the inaugural OFWAT funded Water Breakthrough Challenge, aimed at tackling some of the biggest issues facing the water sector in England and Wales.

The consortium, led by Thames Water includes USW, Dwr Cyrmu Welsh Water, South West Water, United Utilities, Scottish Water, Yorkshire Water and Northumbrian Water, has been awarded more than £6m to decarbonise wastewater treatment – reducing nitrous oxide emissions and recovering resources including phosphorus and nitrogen which can be reused in agricultural applications.

The water industry consumes between two and three per cent of electricity produced in the UK – the same as around two million households – and approximately 55% of the energy consumed by a typical sewage works is largely due to aerobic wastewater processing. The project is developing solutions that will reduce the energy required for wastewater treatment.

Anaerobic digestion (AD) is a biological process that converts biodegradable material in the absence of oxygen by a consortium of bacteria and archaea from which a valuable biogas and nutrients can be recovered. AD has typically been deployed to treat sewage sludges within mesophilic temperatures. In this project, AD will be evaluated for deployment at ambient temperatures to treat sewage streams directly, avoiding the need for aerobic treatment and its related excess sludge generation, minimising treatment, energy use, transport and disposal requirements for sludges and avoiding related nitrous oxide emissions with a high greenhouse gas emission potential. The AD process will recover biomethane for use as an energy source and the nutrients will be recovered for multiple uses, including use agricultural products.

The UK has in recent years seen a significant deployment of AD technology used for treating sewage sludge and food wastes, and further deployment would be beneficial being a technology which supports resource recovery, net zero carbon and zero waste.

> “We have been at the forefront of R&D for anaerobic processes and recognise the importance that these bioprocesses can play in numerous sectors. The funding will enable the team to drive the novel concept integration and evaluate its impact in reducing society’s wastewater treatment energy footprint and in promoting sustainable resource recovery.”
>
> **Professor Sandra Esteves**
> Project Lead
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Treforest

The vital role hydrogen can play in a decarbonised energy future

Milford Haven Energy Kingdom explores the vital role hydrogen can play in a decarbonised energy future.

Milford Haven Energy Kingdom (MH:EK) is a two-year project, exploring what a decarbonised smart local energy system could look like for Milford Haven, Pembroke and Pembroke Dock. The Port of Milford Haven is already at the centre of the UK energy supply. The port today imports carbon – LNG and petroleum and Pembroke is the site of a gas fired power station. Coupled with plans in floating offshore wind this project will ensure the area is critical to the UK's net zero energy future. The team is exploring the potential of zero carbon hydrogen alongside renewable electricity to meet all of the area's future energy needs.

Central to the project, and to achieving net-zero carbon emissions, is a commitment to engage with the community and local industry, providing insight and opportunities for economic growth.The Project partners include: Pembrokeshire County Council, Port of Milford Haven, Wales & West Utilities, Riversimple, Offshore Renewable Energy Catapult, Arup and the Energy Systems Catapult.

Taking a multi-faceted approach, the team is investigating local renewable energy, including solar, onshore wind, future offshore wind and biomass to support the transition to zero carbon gas; while also developing business cases for accelerating towards a hydrogen economy for energy demands in heating, power, transport and industry. Hydrogen is a part of the energy system and it can ensure that renewable energy assets are maximised, producing green hydrogen during times of peak generation and thus storing energy for other applications. A key element of the project is delivering demonstrations through a consumer trial of hydrogen fuel cell vehicles and a world-first smart hydrogen hybrid heating system.

The team are gathering information into the whole energy system of today, around the Milford Haven Waterway, to help to identify and design the emerging and transformative energy systems of the future that will meet energy needs for heating buildings, power generation and fueling transport. They believe the project holds promise in showcasing the far-reaching benefits of zero carbon energy. It has the potential to lead the way and become the first of many Smart Local Energy Systems supporting our local communities, Wales and the UK in reaching the legislated target of net zero greenhouse gas emissions by 2050.

Hydrogen for Transport

"We've installed this pioneering hydrogen refilling station for fuel cell cars here at Milford Waterfront. It's a brilliant concept: an electrolyser that can use renewable electricity to create, store and dispense hydrogen. We also have two RASA prototype cars from Welsh firm Riversimple here on trial, showcasing the role that hydrogen can play in delivering zero carbon transport for all."

Hydrogen for Heat

"To demonstrate hydrogen as a heating solution, a world-first smart hydrogen hybrid heating system has been installed at the Port of Milford Haven's headquarters. It comprises smart controls, an air source heat pump powered by renewable electricity, and a hydrogen ready boiler. The boiler can kick in when the property needs a boost during cold weather, or if the local electricity network is constrained. The two big energy challenges we need to crack are the decarbonising of heating and transport, so these projects are important for proving the ability of hydrogen to play a crucial role."

Tam Bardell
Energy Development Manager
Energy Kingdom

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Milford Haven

Smart, data-driven solutions to decarbonise your home

Homes in the UK are a huge contributor to CO2 emissions. The Active Building Centre Research Programme (ABC-RP) is spearheading research into low and zero carbon buildings that will support the decarbonisation of the UK economy.

This multidisciplinary consortium of leading UK universities is developing innovative technologies and processes, and generating an evidence base to support the scale-up of decarbonisation activities. This will enable the buildings of the future and support the retrofitting of current housing stock with technologies to help achieve net-zero.

The ABC-RP, led by the team in Swansea University, is undertaking research across the Innovative Housing Programme and the Optimised Retrofit Programme. Pioneered in Wales, the programmes involve researchers working with social and private housing sectors to deliver their findings.

Taking a data-driven approach to decarbonisation, the ABC-RP is adopting open digital standards to enable the collection of energy performance data from buildings. This data provides insight into how in-home technologies perform in the real-world and is establishing an evidence base to inform future investments and improve the quality and energy efficiency of homes. While digital technologies and 'smart' solutions have become increasingly pervasive in recent years, the reality is that very little of the data collected is done so in a systematic manner, or used to improve how domestic buildings perform.

Currently systems within buildings operate independently and do not link to, or communicate, with each other. Coupled with a lack of standardisation, system integration is time- consuming and costly. ABC-RP has developed a data monitoring infrastructure, built using open source software and standards, to connect to building systems and securely and consistently collect data. The data being collected helps users to better understand how well these buildings are performing. It creates an Internet of Things (IoT) encompassing all the enabled devices in a home to capture insights into energy consumption on a device by device basis including, data on the internal environment such as temperature, air quality or humidity and renewable energy generation.

The infrastructure enabling the IoT is an efficient and scalable design for the secure messaging of data from in-home devices to a central data repository. It is incredibly flexible, both in terms of supporting a wide range of communication protocols and devices, and being deployable in a number of configurations. The infrastructure is continually optimised and is now built around a microservice infrastructure that consumes less power, is cheaper to run, and is easier for partners to deploy and scale. Importantly, adopting this infrastructure across the ORP and IHP has catalysed others within the supply chain to adopt more modern, open approaches

and improve their own products and services, for example developing capabilities to support IoT messaging, increasing the interoperability and security of their communications .

Properties using this infrastructure are showing the way in the decarbonisation and improvement in quality of housing. The use of technologies such as Intelligent Energy Systems, ground source Heat Pumps and building homes offsite using modern methods of construction, work together to optimise the energy efficiency of the property and comfort for the occupant.

- 40% of CO2 emissions globally are from buildings
- 35% of energy consumed in the UK is by domestic buildings
- 68m tonnes of CO2 emissions from domestic buildings
- 80% of buildings in use in 2050 have already been built
- Over 26m homes in need of retrofit to reduce carbon footprint

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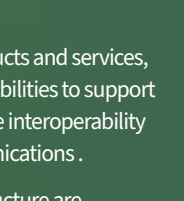
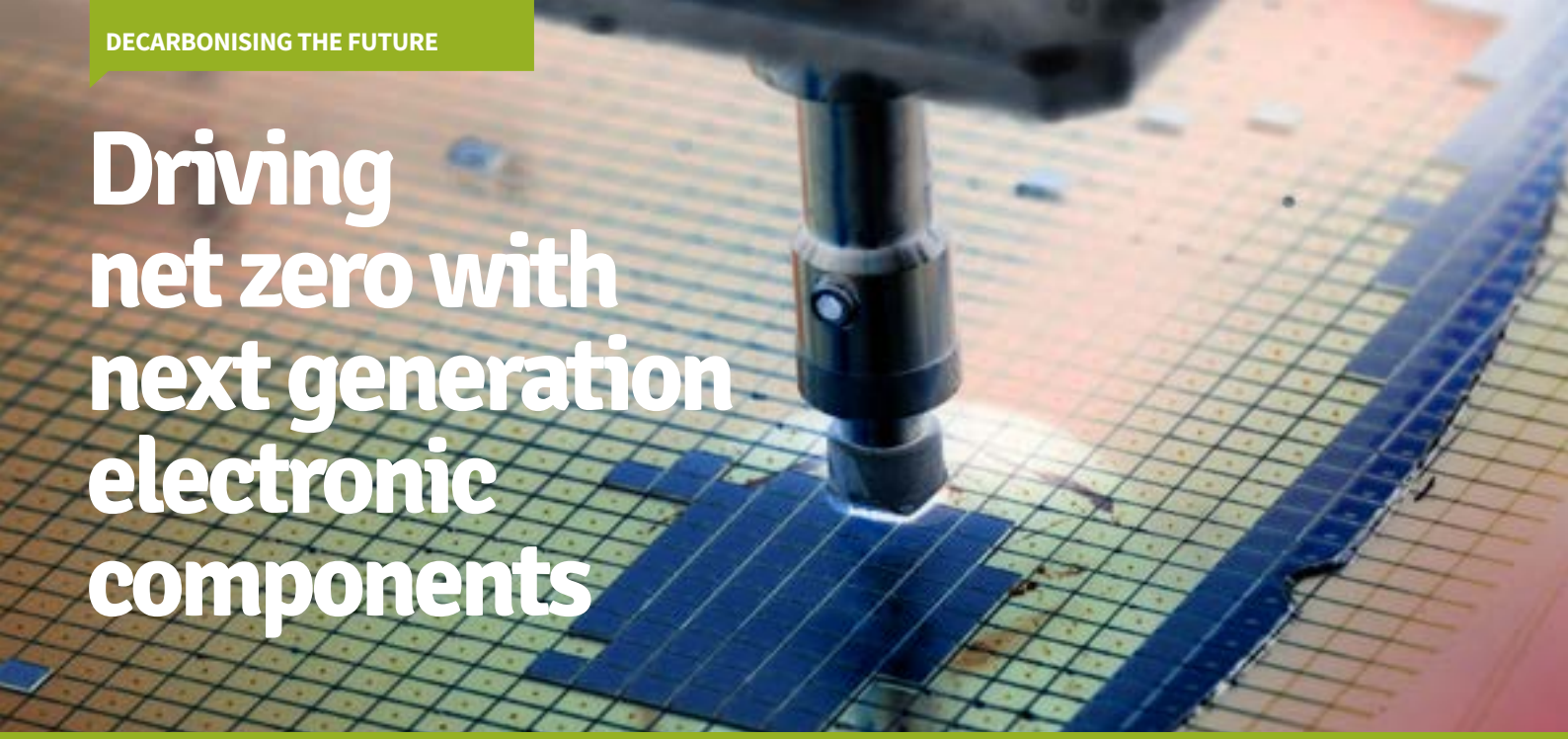


Swansea

Supporting Welsh developers deliver net-zero homes

Energy service and tech company Sero has launched a New Build Specification to support Welsh developers deliver net-zero homes.

The specification provides a roadmap relating to the design and fabric of the home, heating, and the use of renewables and smart energy technologies, covering social housing, privately owned and rented accommodation. The aim is to ensure houses can be truly net zero in operation (in line with the UK Green Build Council's definition) by the 2030s as the energy grid continues to decarbonise. The Welsh Government's latest Development Quality Requirements, "Creating Beautiful Homes and Places", requires all newly built social homes in Wales be fossil fuel free and meet the highest energy efficiency standards. As well as working with a number of social landlords to deliver zero carbon new homes, Cardiff-based Sero is also supporting the private sector and recently announced a JV agreement with Edenstone Homes Group to see the delivery of 6,000 zero carbon homes by 2030.



Driving net zero with next generation electronic components

Power electronics is an essential technology that enables many facets of modern life, from charging essential portable consumer products, such as smart phones and laptops, through to distribution of electricity in the grid, and efficient operation of electrical motors, pumps and fans in manufacturing machinery.

The demands of such applications require switching and voltage control components that reliably and efficiently operate at high temperatures, with long lifetimes and zero failure rates. The move towards electrification of transport, greater expectations on lifetimes of battery-operated consumer electronics, and the increasing use of renewables in the global energy mix opens new opportunities for innovation in a wide range of power electronics devices.

Currently, the majority of power electronics devices are manufactured from silicon semiconductors, which have evolved since the first silicon power transistors replaced vacuum tubes in 1950's. However, there are inherent limitations which arise from the material properties of silicon including operating temperatures limited to below 150C, and increasing losses at higher switching speeds and voltages.

Wide Band Gap (WBG) semiconductors are an emerging class of materials which are manufactured from compound semiconductors such as silicon carbide and gallium nitride. Such materials are delivering exciting innovations in power electronics applications across multiple industrial and clean energy devices, with vastly superior performance compared to silicon technology. Projected benefits include; elimination of up to 90% of the power losses that occur during ac power conversion, operation up to 10 times higher voltage than silicon-based devices and operation up to higher maximum temperature of Silicon-based devices, potentially >500C. This enables smaller, lighter systems with reduced manufacturing costs and lifecycle energy use, along with opportunities for servicing demanding new applications that will emerge as a result of the global transition to net zero.

The focus of the R&D is to make WBG-based devices less expensive than silicon devices by addressing current manufacturing challenges such as; increasing the diameter of the semiconductor wafers by integrating the new materials on low cost Silicon substrates; developing new techniques for the characterisation and quality control of WBG materials and devices; developing novel power device designs which exploit the WBG material properties; and working with the system industry to develop new packaging techniques for high-temperature operating environments enabled by WBG devices.

The Compound Semiconductor Centre (CSC) was founded in 2015 as a joint venture between Cardiff University and IQE Plc, with a mission to develop innovative new semiconductor technologies that will enable new applications. CSC has been working on WBG semiconductors since 2017, with multiple collaborative research projects with industrial supply chain partners in Wales, UK and the EU. Many of the projects are carried out with partners within the South Wales Semiconductor Cluster, a collaborative ecosystem based on common goals and a co-ordinated manufacturing supply chain.

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