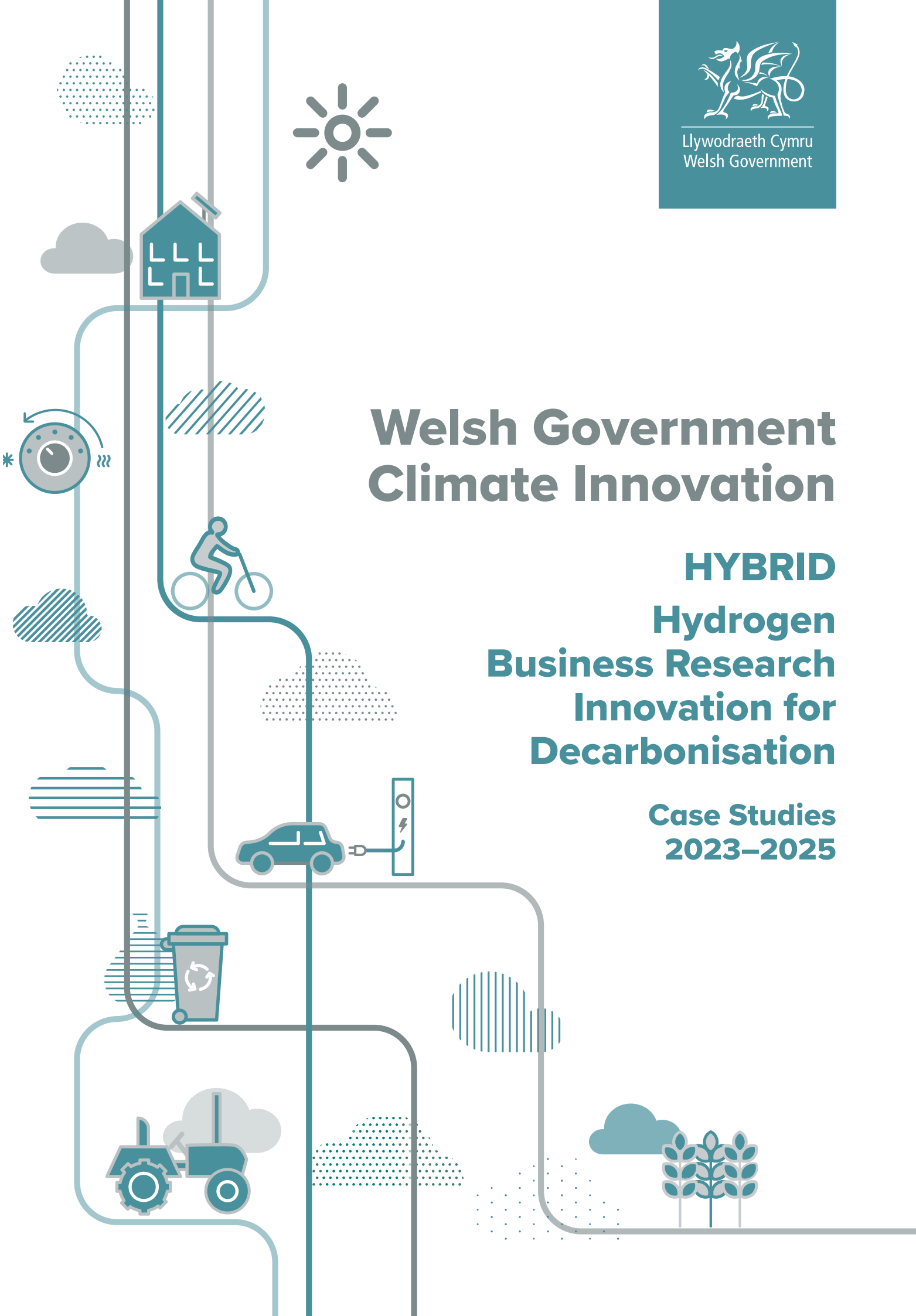


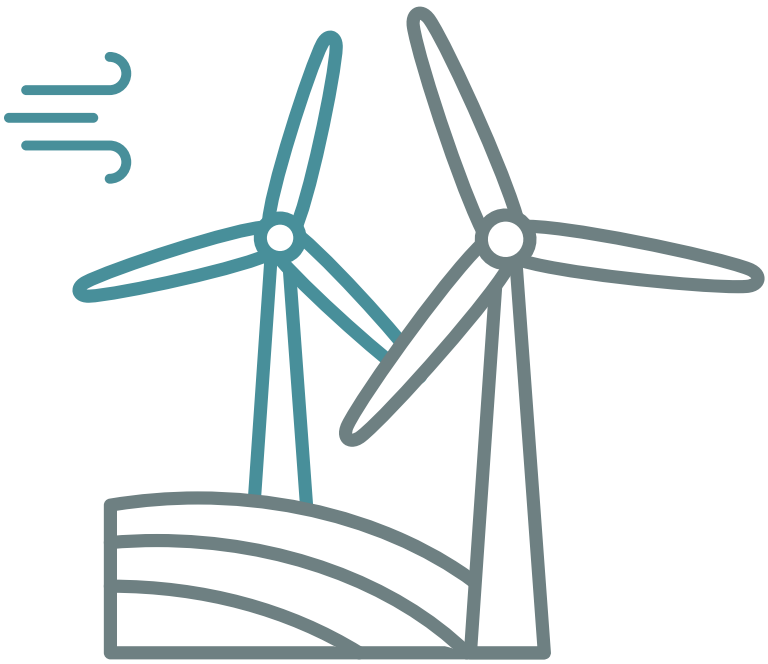
Llywodraeth Cymru
Welsh Government

Welsh Government Climate Innovation

HYBRID
Hydrogen Business Research Innovation for Decarbonisation

Case Studies 2023–2025

Contents



Foreword

I am delighted to share with you the second set of case studies from the Welsh Government's Climate Innovation HYBRID programme. These stories show in detail how we're finding new and innovative ways to tackle climate change across Wales.

We have invested £2.75 million into HYBRID, backing 30 projects between 2021 and 2025 across a wide range of sectors. These projects came up with new ideas and research to help Wales deliver on our Hydrogen Pathway, deliver benefits for communities and create opportunities for businesses.

HYBRID made it easier and quicker to use hydrogen energy, including through making more uses of Wales' unique renewable energy resources – a big win for making low-carbon hydrogen.

Every part of our economy has a role to play in cutting emissions. Wales Climate Week 2025 recently focused on sectors where hydrogen can really help, like farming, land use, marine, transport, housing and heavy industries. For hard-to-decarbonise areas, success depends on a few key things that these HYBRID projects tried out in Wales for the first time. This includes new tech and business models, building up skills, and using good data and monitoring for better decisions.

We have recently published our policy on making and using hydrogen, after asking the public what they think. Hydrogen now has a clear place in Wales' plans to cut emissions, backed by solid research and evidence. I'm excited to see even more hydrogen solutions and future projects that will hit our targets in Carbon Budget 3 (2026–2030) and help Wales grow greener. We're continuing to support hydrogen projects through our climate innovation work, and we'll use the lessons from HYBRID to help us do this.

The Climate Innovation journey is one we are all taking together. The next five years will really matter, as the choices we take now will shape Wales for 2030 and beyond. If we all work together and trial new innovative solutions as we have with HYBRID, we can build a country that's not just tackling climate change, but is also safer, fairer, more skilled, and better for everyone. I hope you find these case studies as inspiring and as valuable as I do.

Huw Irranca Davies MS
Deputy First Minister

Introduction

HYBRID

HYBRID was the Welsh Government Climate Innovation scheme's **Hydrogen Business Research & Innovation for Decarbonisation** SBRI programme (2021–2025). It supported innovation and research solutions to deliver the Wales Hydrogen Pathway and Net Zero Wales CB2 – 2021–2025. Programme investment was designed to speed up the deployment of hydrogen as a key energy vector, and help Wales meet our national commitment to achieve net zero emissions by 2050. HYBRID was delivered using the Contracts for Innovation pre-commercial framework (known as "SBRI" until May 2024).

After successful feasibility studies completed during Phase 1 during January–June 2023, the second demonstrator phase of HYBRID 2.0 ran from September 2024 to June 2025. The case studies in this brochure derive from both phases.

Overall Climate Innovation awarded £2.75m to support hydrogen deployment projects across Wales through the two iterations of the HYBRID programme.

Climate Innovation

HYBRID was delivered and managed by Welsh Government Climate Innovation.

The Climate Innovation scheme develops innovative new climate approaches and solutions with partners across government and civil society, to support a net zero well-adapted future Wales. Formerly called "Smart Living", it has since 2015 been helping to realise the Wellbeing of Future Generations Act (2015) and the goals and policies of our Net Zero Wales Carbon Budget 2 and its successors. Its programmes supply place-based and needs-led solutions for trialling in the real world, so that they can later be mainstreamed and rolled out at scale. Climate Innovation also promotes the development of a whole energy systems approach. Projects and challenges are usually delivered in partnership with Welsh local government and other public sector bodies. They also link into complementary Welsh Government climate action initiatives and other public and private investment in this important area.

Climate Innovation is continually refreshing its innovation agenda, deepening stakeholder engagement, developing more robust metrics, and ensuring both Welsh local and system-wide impact. It is adapting dynamically to future needs, government priorities, and the evolving climate innovation landscape in Wales. It also has a central role in acting to solve complex or "wicked" climate action around policy and delivery issues, engagement activity and focussed resource allocation.

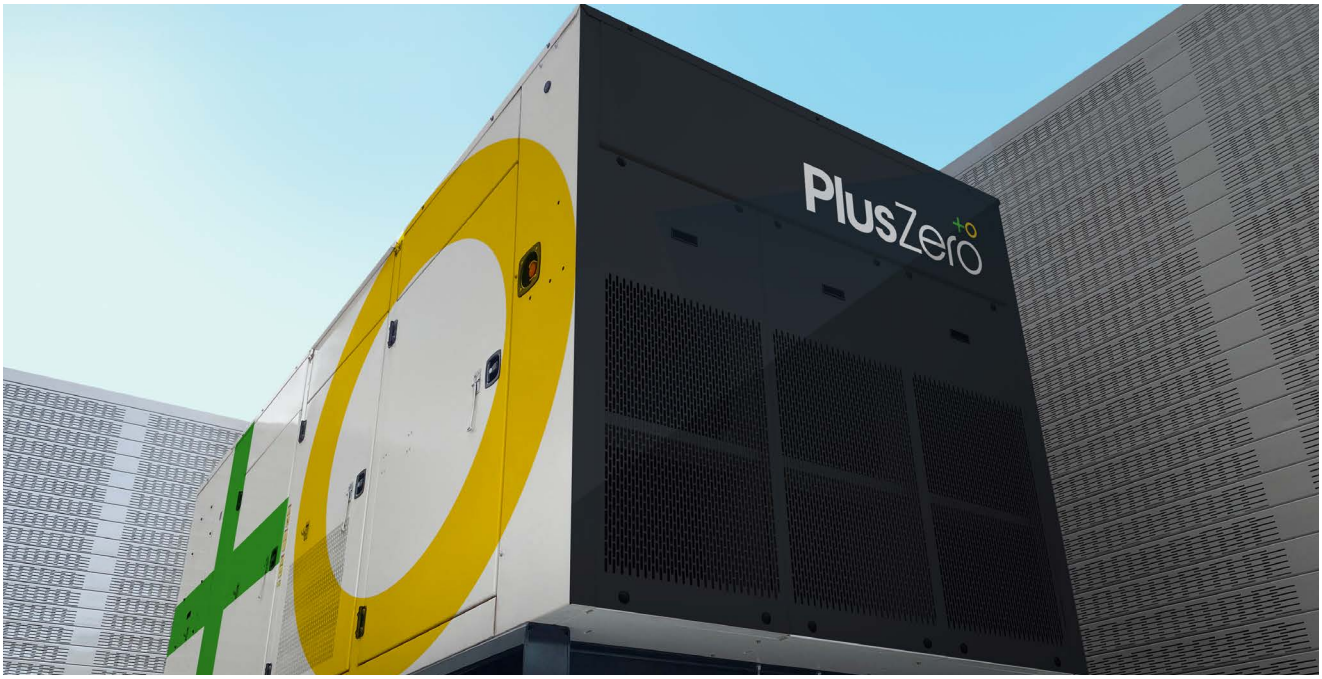
Contracts for Innovation Cymru

Since 2021 Climate Innovation has run several consecutive Contracts for Innovation (previously known as *Small Business Research Initiative* or *SBRI*) programmes with partners across Wales to deliver its innovation mission. Contracts for Innovation is the UK public sector's leading pre-commercial procurement framework which uses the procurement of research and development to support the creation of new products and solutions to address perceived unmet needs. Contracts for Innovation offers organisations and businesses in Wales[1] a unique opportunity to work directly with the public sector to develop new technologies and processes, helping to meet efficiency targets and improving public services. Contracts for Innovation is not limited to small businesses and is in fact open to any organisation, regardless of size or previous experience of working in a specific sector.

1. Contracts for Innovation Cymru https://www.contractsforinnovation.cymru/

1. HYBRID Feasibility Projects

PlusZero Ltd Green hydrogen generators offer clean alternative to diesel in Wales



A PlusZero hydrogen generator

PlusZero is replacing diesel generators with an innovative clean hydrogen-powered alternative through its Green Hydrogen Generators project, supported by the Welsh Government's Climate Innovation HYBRID SBRI programme. Targeting off-grid power in events, film and TV, and construction, the project supports Wales' decarbonisation goals.

The Green Hydrogen Generators project at a glance

Green hydrogen specialist, PlusZero, developed a zero-emission generator using hydrogen combustion engine (H2ICE) technology. Emitting no carbon and minimal pollutants, the solution supports both rural and urban use and contributes to a fairer, greener Welsh economy.

Delivered in May 2023, the team designed and tested a lightweight, low-cost generator in the 50–100kVA range, using a 2.5L petrol engine converted to run on 100% green hydrogen. Delivery partner ProDev Engineering, based in Carmarthenshire, led on engine selection, fuel system development and calibration.

Phase One – Feasibility

This phase focused on converting a petrol engine to run on hydrogen – offering a zero-carbon replacement for diesel. A hybrid element was planned but not delivered due to delivery partner issues.

With £48,000 in funding from the Climate Innovation HYBRID SBRI programme, PlusZero and ProDev Engineering developed and demonstrated a working prototype in just four months, showing hydrogen combustion's real-world potential.

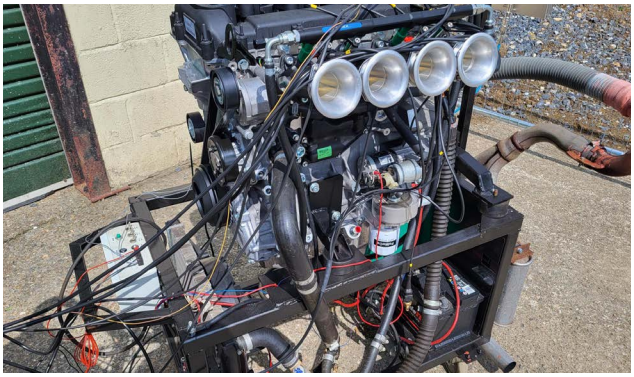
Key learnings

Hydrogen combustion engines offer a cost-effective alternative to fuel cells and batteries for medium-scale off-grid use. H2ICE systems use recyclable components, avoid rare earth metals and are simple to maintain and integrate into standard generator housings. Tests confirmed zero carbon emissions and low air pollutants – without complex emission controls.

Why South Wales?

South Wales provided access to skilled engineering partners and aligned with Welsh Government Net Zero 2050 targets. The project strengthened local supply chains and demonstrated the region's potential to lead in clean energy solutions.

David Amos, CEO of PlusZero, said: "This project shows hydrogen doesn't have to be expensive or experimental. We've adapted existing engine tech to create something practical and scalable. Partnering with ProDev Engineering proved the skills and supply chains already exist in Wales."



4 cylinder Hydrogen Internal Combustion Engine (HICE) test rig at Systemau Injan PlusZero Cyf.

Benefits

- **Clean replacement for diesel –** Enables zero-emission off-grid power.
- **Practical and familiar –** Uses modified petrol engines with accessible maintenance.
- **Supports Net Zero goals –** Reduces fossil fuel reliance in off-grid settings.
- **Delivers learning for Wales –** Shares insights on hydrogen engine development.
- **Builds Welsh supply chains –** Strengthens links with local manufacturing partners.

What happened next?

PlusZero and ProDev Engineering established Systemau Injan PlusZero Cyf. – a new joint venture company based in South Wales – to drive further developments. This included a single-cylinder hydrogen engine for portacabins manufactured by Neath-based Groundhog, supported by Innovate UK's New Innovators in Net Zero Industry programme. Commercial discussions are also underway with Merthyr Tydfil-based Quantum Gas Engines and portable buildings supplier Wernick Hire to scale deployment across Wales.

Get involved

Organisations interested in supporting or collaborating on hydrogen infrastructure projects in Wales are encouraged to get in touch. Whether you represent a local authority, energy developer or private investor, there are opportunities to get involved. The Welsh Government's Climate Innovation team can help connect you with relevant partners and projects which were part of the HYBRID SBRI programme and hydrogen deployment work it has supported in more recent initiatives.

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Menter Môn FerMônTation explores hydrogen-powered food production in Wales

A feasibility study from Menter Môn is helping Wales explore innovative new uses for hydrogen beyond energy and transport. Based in Anglesey in north Wales, the FerMônTation project assessed the potential for hydrogen-powered precision fermentation to produce food ingredients sustainably and reduce emissions across the supply chain. The study was delivered in summer 2023 with support from the Welsh Government's Climate Innovation HYBRID SBRI programme.

The FerMônTation project at a glance

FerMônTation explored whether hydrogen and carbon dioxide could be used in precision fermentation – a method that feeds microbes to produce protein-rich food ingredients without land-intensive farming. Led by Menter Môn, a social enterprise based in Anglesey and Gwynedd, the project was delivered in partnership with Lafan Consulting Group, a Welsh consultancy focused on sustainability and innovation, and the Centre for Process Innovation (CPI), a UK-wide tech innovation organisation. The study assessed the feasibility of the process in Wales, with a view to supporting food security and low-carbon growth.

Phase One – Feasibility

Menter Môn submitted its Phase One proposal in December 2022, aiming to explore how hydrogen could feed microbes in precision fermentation to create sustainable food ingredients. While hydrogen is better known for its role in energy and transport, its potential in food production remains underexplored.

The team secured £50,000 from the HYBRID SBRI programme to deliver a feasibility study. CPI provided technical insight into gas fermentation, while Lafan Consulting helped manage the project and engage stakeholders.

Key learnings

The study showed that hydrogen-based fermentation remains at a low technology readiness level. Key challenges include scaling up, managing hydrogen safely and navigating regulatory frameworks. However, the findings suggest that, with the right partners, Wales could lead in this emerging sector.

The project also outlined what equipment and infrastructure would be needed for a future demonstrator unit, giving a clearer picture of how to move the concept forward.

Why Anglesey in Wales?

Anglesey is already a centre of innovation in clean energy, with flagship projects such as the Morlais tidal scheme and the Holyhead Hydrogen Hub. Menter Môn's existing energy portfolio and strong local partnerships made the island an ideal base for the study.

FerMônTation aligns with Welsh Government priorities including Net Zero 2050, the Wales Hydrogen Pathway and the Well-being of Future Generations Act. It highlights a potential new use for green hydrogen, supporting both environmental and economic goals.

Benefits

- **Reduces emissions –** Sustainable food production with lower carbon emissions.
- **Improves food security –** Less reliance on imported food.
- **Supports green jobs in Wales –** Creates high-skill opportunities in biotech and clean energy.
- **Adds rural value –** Opens new pathways for diversification in Welsh agriculture.
- **Aligns with policy goals –** Supports Welsh Government decarbonisation targets.

What happened next?

While Phase One delivered a promising feasibility case, the project team is now seeking funding and partners to take the next step. This includes validating the findings through small-scale trials. Menter Môn is open to collaboration with service providers, fermentation specialists and investors to progress to Phase Two.

Get involved

Organisations interested in supporting or collaborating on hydrogen infrastructure projects in Wales are encouraged to get in touch. Whether you represent a local authority, energy developer or private investor, there are opportunities to get involved. The Welsh Government's Climate Innovation team can help connect you with relevant partners and projects which were part of the HYBRID SBRI programme and hydrogen deployment work it has supported in more recent initiatives.

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2. HYBRID Demonstrator Projects

HyPR project sets course for clean maritime future in Wales

Pembroke Dock, Milford Haven in Pembrokeshire. Site of the WG HYBRID programme HyPR project planning for hydrogen refuelling and onshore/offshore service craft and vehicle.

The Port of Milford Haven, in collaboration with a team of energy, engineering and innovation partners, is delivering the ambitious Hydrogen Port Refuelling (HyPR) Project – an initiative driving sustainable energy development by enabling hydrogen-powered maritime activity. The project is supported by Climate Innovation's HYBRID SBRI programme and contributes directly to the Welsh Government's decarbonisation targets for 2030 and 2050. HyPR offers a practical blueprint for how ports and local authorities can support future green growth.

The HyPR project at a glance

The project focused on enabling hydrogen-powered refuelling at the Port of Milford Haven to support vessels operating in the Celtic Sea – a key site for floating offshore wind (FLOW) developments. HyPR aimed to provide the foundation for future commercial refuelling by designing infrastructure that could eventually support widespread low-carbon shipping activity.

Located at Pembroke Port on the Milford Haven Waterway, the project investigated how renewable electricity – such as solar and wind – could be used to power hydrogen production and storage on-site. It also explored how hydrogen could be dispensed to both maritime vessels and quayside vehicles and equipment.

The work was delivered through a collaboration between the Port of Milford Haven and delivery partners Haush, Apollo, ERM Dolphyn and the Offshore Renewable Energy Catapult (OREC), with all of the companies having offices in Pembrokeshire.

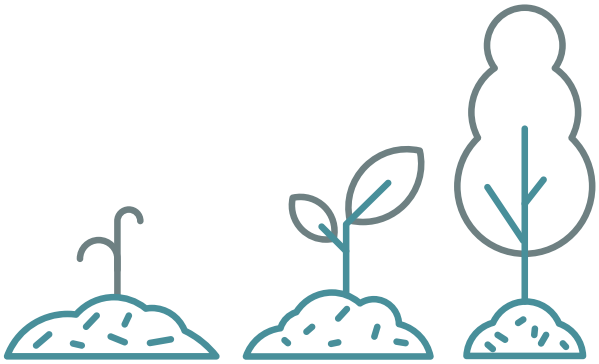
While the project focused on the port environment, its outcomes are intended to inform wider hydrogen and clean energy strategies across Wales.

Phases One and Two

Phase One of HyPR assessed how hydrogen refuelling could support vessels operating in the Celtic Sea and helped to forecast future demand linked to FLOW activity.

Building on this foundation, Phase Two focused on developing early-stage designs for hydrogen refuelling infrastructure in Pembroke Port. The work included a renewable energy feasibility study, initial layout designs for marine and quayside refuelling, business modelling and engagement with local stakeholders and potential end users. The Port of Milford Haven coordinated delivery, supported by a consortium of engineering and innovation partners.

Insights from earlier decarbonisation initiatives, including the Milford Haven: Energy Kingdom project and OREC's Clean Maritime Demonstration Hub, helped shape the project's direction.



Key insights about project development

The HyPR project brought together a wide range of organisations with specialist knowledge in hydrogen infrastructure, renewable energy, stakeholder engagement and maritime innovation.

The Port of Milford Haven led the delivery of the project, coordinating technical activities and hosting a staff knowledge transfer session to build internal awareness around hydrogen readiness. The Port also engaged with potential end users to explore how hydrogen produced on-site could be used or supplied to support their operations.

Haush, a renewable and hydrogen development company headquartered in Pembroke Dock, explored the commercial potential of refuelling infrastructure through a detailed business planning exercise.

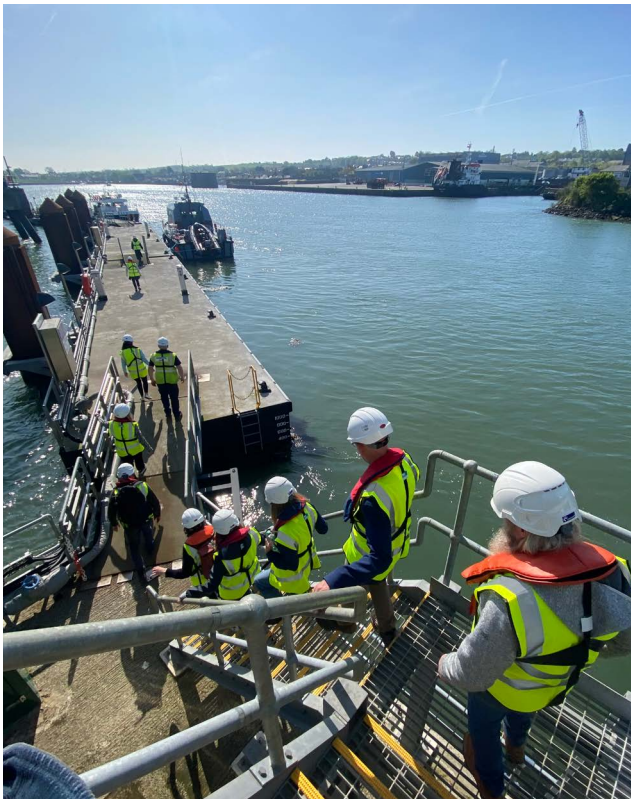
Apollo, a consultancy specialising in clean energy systems with offices in Pembroke Dock and North Wales, conducted a comprehensive assessment of the Port's renewable energy potential. This included evaluating solar and wind resources, energy storage options and the requirements for a smart grid interface.

ERM, the world's largest sustainability consultancy, with offices in Pembroke Dock, Cardiff and Bristol, developed outline designs for hydrogen refuelling infrastructure, covering both marine vessels and portside vehicles. These concepts will form the basis of future front-end engineering and construction planning.

ORE Catapult, a leading technology innovation and research centre for offshore renewable energy, led stakeholder engagement, raising awareness among potential hydrogen users

and preparing a final engagement report to be shared across the wider Climate Innovation and public sector network. Their previous work in maritime decarbonisation fed directly into the HyPR delivery model.

This collaboration laid the groundwork for future hydrogen refuelling at the Port by aligning technical design, renewable integration and real-world application in a single place-based project. You can find the latest presentation on the HyPR demonstrator by clicking on the following link: HyPR Phase 2 Webinar.



Stakeholder briefing visit to the HyPR trial site in Pembroke Dock.

Why Milford Haven?

Milford Haven is a nationally significant energy hub, handling around 20% of the UK's energy needs and supporting over 5,000 skilled jobs in Wales. Its location – closest to the Celtic Sea Development Sites – places it at the heart of upcoming FLOW activity, making it a natural base for hydrogen infrastructure that supports the construction and operation of renewable energy projects.

The HyPR project builds on the Port's existing strengths. These include well-established infrastructure for energy handling, transmission and logistics, as well as a skilled local workforce and an experienced engineering supply chain. The Port's close proximity to areas earmarked for FLOW development in the Celtic Sea enhances its strategic importance. In addition, it has a strong track record of innovation in energy transition and integrated system planning, positioning it as an ideal location to trial and scale new hydrogen technologies.

Jack O'Shea, Energy and Decarbonisation Manager at the Port of Milford Haven, said: "Milford Haven is already a key player in UK energy security and with further innovation we can continue to facilitate the secure transport of energy into and out of the UK as the energy mix evolves. HyPR demonstrates that we can lead positive change by building a practical, scalable model for clean maritime fuels."

Benefits

The HyPR Project offers several benefits for the community, businesses and public sector organisations in and around Milford Haven:

- **Support for port decarbonisation:** The project provides a model for reducing emissions from port activity and future vessel operations using hydrogen refuelling.
- **Enabling clean energy integration:** It explores how renewable energy sources such as solar and wind could power hydrogen production at the port.
- **Demonstration for public sector planning:** HyPR offers a replicable example of how ports and local authorities can work together to deliver early-stage hydrogen infrastructure.
- **Opportunities for Welsh businesses:** The involvement of Wales-based companies has helped strengthen local expertise in hydrogen, renewables and environmental engineering.
- **Contribution to net zero goals:** The project supports the Welsh Government's wider decarbonisation targets by trialling infrastructure that can be scaled to support clean maritime transport.

What's next for HyPR

The next stage of development will focus on producing detailed infrastructure designs for permanent hydrogen refuelling, while continuing to engage with maritime operators and logistics companies to build demand and assess commercial viability. Infrastructure will be phased in gradually, moving from initial feasibility and design to operational rollout. In parallel, findings from the project will be shared with local authorities, other ports and Climate Innovation partners across Wales to support wider adoption.

As Wales works towards its 2030 and 2050 decarbonisation goals, HyPR offers a clear example of how local innovation can lead the way in achieving national climate goals.

Get involved

Organisations interested in investing in, partnering on, or co-funding future hydrogen infrastructure projects in Wales are encouraged to get in touch. Whether you represent a local authority, energy developer or private investor, there are opportunities to get involved. The Welsh Government's Climate Innovation team can help connect you with relevant opportunities and partners, which were part of the HYBRID SBRI programme and hydrogen deployment work it has supported in more recent initiatives.

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Caerogen project explores green hydrogen opportunities in Caerphilly

Reed bed settling tanks at the Coed Top Caerogen trial site.

A place-based initiative in South East Wales explored green hydrogen could be produced using locally available resources. The Caerogen – Caerphilly Hydrogen Techno-Economic Assessment – project was supported by the Welsh Government's Climate Innovation HYBRID SBRI programme and aligns with national decarbonisation goals for 2030 and 2050. By combining renewable energy with treated water from combined waste streams – leachate from a disused municipal waste facility, water from road gullies and surface water – in a single, integrated system, Caerogen presented a practical example of how local authorities and partners can help deliver clean energy solutions in support of a net zero Wales.

The Caerogen project at a glance

Based at Coed Top Hill – a former landfill site near Nelson in Caerphilly County Borough – the project assessed whether green hydrogen can be produced using runoff water from a disused landfill site and surface water filtered through a reed bed, using renewable electricity from nearby solar and wind to power an on-site electrolyser.

The project trialled a water purification system using Multi-Effect Plate (MEP) technology, commonly used to desalinate seawater using waste heat. In Caerogen, the MEP system is powered by heat generated during hydrogen production, creating a closed-loop process – where outputs like waste heat are reused within the system – that improves efficiency and conserves drinking water.

Led by the University of South Wales, in partnership with Caerphilly County Borough Council (Caerphilly CBC), Alfa Laval and Challoch Energy, Caerogen explores how local infrastructure and natural assets can be used to support low-carbon hydrogen systems.

Phases One and Two

Phase One, completed in early 2023, assessed whether a hydrogen hub at Coed Top Hill was technically and commercially viable. The team explored local energy generation, potential hydrogen demand and the suitability of treated surface water for electrolysis – the process that splits water into hydrogen and oxygen using electricity. The findings were promising, confirming that the site could support a scalable hydrogen system.

Phase Two, delivered between late 2023 and early 2024, focused on demonstrating how the system could work in practice. The team modelled a closed-loop water treatment process using Multi-Effect Plate (MEP) technology, powered by waste heat from the electrolyser. The system was adapted for low-flow conditions and tested using site-specific water samples.

Additional activities included designing a site layout, conducting ecological and grid connection assessments and engaging with technology providers and future hydrogen users.

Key insights about project development

The Caerogen project brought together organisations with specialist expertise in hydrogen systems, water purification, energy integration and local planning – many of them based in Wales.

The **University of South Wales**, headquartered in Pontypridd, led the delivery of the project through its Hydrogen Research and Demonstration Centre based at Baglan Energy Park. The university coordinated all technical activities, managed engagement with stakeholders and provided core expertise in water treatment and hydrogen integration.

Caerphilly CBC, which owns the Coed Top Hill site, played a vital role in identifying local opportunities for hydrogen use, particularly around fleet decarbonisation. The council also supported site planning and helped shape the project's alignment with local net zero goals.

Alfa Laval, with UK operations and extensive experience in clean thermal technology, adapted its MEP system to purify water filtered through the reed bed using low-grade heat from the electrolyser. This was a key step in demonstrating a circular water and energy model.

Challoch Energy, which has its UK headquarters in Pencoed, Bridgend, supported energy system design and technical modelling. They ensured the energy flows between electrolysis and water treatment were optimised to create a feasible and scalable solution.

This collaboration brought local insight and global expertise together to test a new kind of hydrogen hub – one built around available infrastructure, resource efficiency and real-world applications.

Dr Stephen Carr, Caerogen project lead at the Sustainable Environment Research Centre (SERC), University of South Wales, said: "This project is about making hydrogen make sense for local areas. Coed Top gave us a unique mix – untreated surface water that isn't suitable for drinking, including runoff from a legacy landfill site, existing renewable energy and strong public sector interest.

The result is a model that shows how to do hydrogen differently – by reusing waste heat, using water that doesn't compete with drinking supply and thinking in systems, not silos."

Why Caerphilly?

Caerphilly CBC has the infrastructure, experience and ambition to support hydrogen development. The Coed Top site has existing water treatment in place and is well positioned for grid access, local transport routes and industrial estates. The council is already investing in renewable energy and vehicle decarbonisation, creating strong demand for low-carbon hydrogen.

Dr Carr added: “Hydrogen can be a key part of the wider shift to net zero – but it needs to work for the places where it’s produced and used. Caerogen shows how we can take what’s already there and build something that fits with the area’s energy, water and infrastructure in a responsible and scalable way.”

Benefits

The Caerogen project offers several benefits for the community, businesses and public sector organisations in Caerphilly:

- **Unlocking economic potential:** Caerogen opens pathways for future hydrogen markets and infrastructure investment in Wales.
- **Supporting local green jobs:** The project helps lay the foundation for employment in hydrogen production and clean energy systems.
- **Supporting fleet decarbonisation:** It enables hydrogen refuelling for council vehicles and other local heavy-duty users.
- **Demonstrating safe water reuse:** Treated surface water from a reed bed system is purified and reused for hydrogen production.
- **Reusing energy efficiently:** Waste heat from hydrogen production powers the on-site water purification system.
- **Enabling scalable design:** The modular closed-loop model developed at Coed Top can be adapted across other sites in Wales.

What’s next for Caerogen

The next phase of the project will focus on preparing the site for delivery and hydrogen production, including early engagement with the local community. This includes refining system designs, completing seasonal water flow assessments and building the business case for infrastructure investment.

The team will keep working with potential users and funders to plan how the system could be delivered. Caerogen will also share learnings with other Welsh local authorities, regional growth bodies and public agencies to support wider uptake of place-based hydrogen systems.

Get involved

Organisations interested in supporting or collaborating on hydrogen infrastructure projects in Wales are encouraged to get in touch. Whether you represent a local authority, energy developer or private investor, there are opportunities to get involved. The Welsh Government’s Climate Innovation team can help connect you with relevant partners and projects which were part of the HYBRID SBRI programme and hydrogen deployment work it has supported in more recent initiatives.

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Glossary

Term	Definition
Climate Innovation	A Welsh Government scheme developing innovative new climate approaches and solutions with partners across government and civil society, supporting a net zero well-adapted future Wales.
HYBRID	Hydrogen Business Research & Innovation for Decarbonisation. This is one of the Climate Innovation programmes.
Contracts for Innovation	This is the UK public sector's leading pre-commercial procurement vehicle which procures research and development to support the creation of new products and solutions to address perceived unmet needs.
Place-based	A concept and approach where interventions contribute to meeting local needs, matching the local contexts, addressing challenges and/or mitigating risks.
SLES	Smart Local Energy Systems. A concept for creating smart, locally integrated energy systems that are clean, cost-effective, and beneficial for local stakeholders.
SME	Small to medium sized enterprise, which reflects enterprises with ten or more employees and less than 250 employees.
TRL	Technology Readiness Level. This is a method for estimating the maturity of technologies.
Whole-systems approach	A concept and approach where there is interaction between different energy systems. Innovations are effectively connected in a smart and/or holistic system or have the opportunity to be.