

Hydrogen development in Wales

Baselining report into hydrogen activities and expertise in Wales

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Authors

michael.dolman@element-energy.co.uk

william.nock@element-energy.co.uk

simon.king@element-energy.co.uk

elementenergy

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1 Executive summary

This report provides a snapshot of the hydrogen-related activities and expertise that exist in Wales as of mid-2020. The list of initiatives is based on information available in the public domain and is therefore non-exhaustive as there are other projects and programmes under development which for various reasons have not yet been announced. Nevertheless, the range of projects and the depth of existing hydrogen experience in certain areas provides a solid foundation for further development of hydrogen for energy applications in Wales. What the future for hydrogen in Wales could look like and the actions required to capitalise on the opportunities that this growing sector presents is the subject of the *Hydrogen in Wales: A pathway and action plan for developing the hydrogen energy sector in Wales* report.

Based on the evidence compiled in this report, the following conclusions can be drawn:

- Wales is home to world-leading hydrogen research and development projects and facilities. Institutions such as Cardiff University (and its Gas Turbine Research Centre), Swansea University, and the University of South Wales (and its Hydrogen Centre) are highly active in this area and conduct wide-ranging research into hydrogen and related fields (e.g. ammonia).
- Wales also benefits from expertise in the safe generation, storage, transport, and use of hydrogen, mainly as an industrial gas in the South Wales area. There is a strong oil and gas presence in Wales, including strategically important infrastructure in both north and south Wales. The skills base in these and other industries need not be lost as they decline but can be redirected towards emerging hydrogen activities and at scale. If addressed quickly, this can help offset any shortfall in skills in a rapidly expanding hydrogen economy and place Wales at a competitive advantage.
- Furthermore, Wales is home to Riversimple, an SME that is designing, building, and testing innovative fuel cell electric vehicles. Other organisations with expertise in fuel cell vehicle design / integration are present in Wales (e.g. Huxtec, which has links to Hypermotive) and under the right conditions rapid expansion of the fuel cell vehicle manufacturing / integration sector in Wales could be envisaged. There may also be opportunities to attract investment in manufacturing / assembly plants in Wales for hydrogen-fuelled appliances, taking advantage of the existing skills base and to support the growth of indigenous SMEs as they diversify into hydrogen activities throughout the value chain.
- Numerous knowledge-based companies with hydrogen expertise have a presence in Wales, for example consultancy companies ranging from SMEs through to large organisations with an international presence. Further development of the hydrogen sector in Wales will provide new opportunities for such companies domestically, and the chance to benefit from export opportunities given the growing interest in hydrogen more broadly.
- There are several past and on-going trials of hydrogen in energy applications, specifically in the transport sector, with small-scale trials of fuel cell vehicles in the Neath / Port Talbot area (using the hydrogen refuelling station at the University of South Wales Hydrogen Centre at Baglan) and in Abergavenny (Riversimple RASA vehicles using a temporary, small-scale refueller).
- However, the overall level of real-world trials and deployment of hydrogen in energy applications in Wales remains relatively low. As is the case elsewhere in the UK (and beyond), the business case for hydrogen solutions has to date often been challenging, and the hydrogen energy sector is not yet fully commercialised. Therefore, hydrogen projects established over the past five to ten years have typically relied heavily on public funding. Despite the relatively low level of trials within Wales, technology demonstration activities that have taken place elsewhere have helped to develop the hydrogen sector to the point where further scale up, with associated technology cost reductions, can now be planned.
- While real-world deployment of hydrogen technologies is sparse, there is much on-going work exploring the role of hydrogen in meeting Wales' net zero target, and on feasibility studies seeking to develop

further technology trials and deployment. Such feasibility studies are not confined to one region, with activities in North, Mid, and South Wales identified in this study. There is excellent scope, therefore, to develop an all-Wales approach which connects Wales' plentiful rural and marine resource with end-use hydrogen applications at scale in its urban areas of population and industry. Wales' small size, strong infrastructure networks and ports, skills base and readily available internal markets can provide a platform for deployment of hydrogen and fuel cell technologies under a favourable policy environment.

- There is a growing consensus in Wales and internationally of the need for hydrogen in zero carbon energy systems. Indeed, there is a focus on hydrogen as a key facilitator in delivering economy-wide decarbonisation in projects such as Zero2050, HyNet and within the South Wales Industrial Cluster. For example, low or zero carbon hydrogen is required to decarbonise the industrial activities in South Wales, along with other measures such as efficiency improvements. However, as noted above, in general there is a lack of a commercial case for proceeding with deployment projects and large-scale roll-out is likely to be contingent upon further policy support and / or new regulation.
- There is also an increasing level of communication and coordination between organisations with a shared interest in the hydrogen sector. The establishment of HyCymru in February 2020 demonstrates the growing interest and this group provides a useful platform for on-going information exchange and dialogue. The Hydrogen Reference Group convened by the Welsh Government is another means of facilitating effective communication, and other specific groupings that will allow collaborative working are emerging, such as the South Wales Industrial Cluster.

The findings of this baselining study will be used to inform the development of a hydrogen pathway for Wales, which will set out a vision and action plan for Wales to take advantage of the opportunities that this emerging sector offers.

2 Introduction

2.1 Context

2.1.1 Global context

As Governments have accepted the need to completely remove CO₂ emissions from the energy system to meet the challenge of climate change, the role and importance of hydrogen becomes clear. Hydrogen offers promise as an energy vector that can be produced from a range of energy sources, act as a pre-cursor to the production of other fuels, facilitate increased harnessing of renewables, and provide long-term energy storage at scale. Although not a silver bullet to the energy and environmental challenges we face, hydrogen is becoming a key element in strategies to achieve net zero carbon emissions by public and private sector stakeholders around the world. This is evident from both the number and nature of the recent announcements relating to hydrogen. Examples include:

- The publication of the **European Hydrogen Strategy** on 8th July 2020 (1) – this was published alongside the EU Strategy for Energy System Integration as part of the European Commission’s “powering a climate-neutral economy” vision. The EU Hydrogen Strategy sets out a roadmap for renewable hydrogen production over the period 2020–2050, and includes a plan for 6GW of electrolyser capacity by 2024 and 40GW by 2030 to produce renewable hydrogen at an industrial scale. The European Clean Hydrogen Alliance, which will “*build up an investment pipeline for scaled-up production and will support demand for clean hydrogen in the EU*”, was launched on the same day. (2)
- **National hydrogen strategies along with public funding commitments in the billions of euros** published by several European countries, including France, Germany, the Netherlands, Norway, Portugal, and Spain.
- **Publication of national hydrogen strategies in several other countries around the world**, for example the Australian Government published its National Hydrogen Strategy in November 2019 which seeks to position Australia as a major player in this sector by 2030 (3). New Zealand’s Government also published its Green Hydrogen Strategy in 2019 (4). Last year also saw the release of South Korea’s Hydrogen Economy Roadmap and National Roadmap of Hydrogen Technology Development. (5)
- **Expansion of the Hydrogen Council** from 13 founding organisations in 2017 to >90 members as of July 2020.

There has been interest in hydrogen for energy applications for many years. Indeed, the concept of the “hydrogen economy” has been around for decades and the sector has seen a number of false dawns. However, there are several key differences now compared to previous hypes around hydrogen that combined mean the sector appears to be on the verge of scaling up:

- Commitments to net zero – with many countries around the world committing to decarbonise their economies, there is a recognition of a need for solutions for all areas of energy use. Based on currently available solutions, no single technology is suitable for all applications and for net zero to be achieved there is a need for hydrogen (or hydrogen-derived fuels) in several areas.
- Falling costs of renewables – advances in renewable energy, particularly renewable electricity, generation in recent years means that renewable energy is now available at costs far lower than previously seen. This creates an opportunity to produce low cost “green” hydrogen for use in multiple sectors / geographic markets around the world.
- Technology maturity – there has been a significant level of investment in research, development and demonstration activities in the hydrogen and fuel cells sector over the past two decades, leading to increased maturity of the technologies required at each area of the supply and use chain. While further

developments and innovations are expected, fuel cell technology has reached the point where it is ready for deployment at scale in certain applications.

In a 2017 report, the Hydrogen Council set out an “ambitious yet realistic” vision of the long-term potential of hydrogen and a deployment roadmap that would see hydrogen meeting 18% of final global energy demand by 2050. To achieve such a vision, the Hydrogen Council estimate that annual investments of \$20bn to \$25bn would be required, totalling c.\$280bn by 2030 (6).

2.1.2 UK context

The UK Government and the devolved administrations have committed to meeting the Net Zero target recommended by the Committee on Climate Change (CCC). This implies major changes in energy generation and use in all parts of the economy, and the CCC has identified hydrogen as being required for some applications (primarily industrial processes, long-distance HGVs, ships, etc.).

The UK has positioned itself amongst the leading early markets for hydrogen transport in Europe (e.g. being one of the few territories selected for early deployment of fuel cell cars, buses and vans from global OEMs and with ambitious plans for further fuel cell bus roll-out). This is largely a result of participation of UK-based organisations in demonstration projects and the existence of the UK H₂Mobility consortium, a partnership of industrial organisations with an interest in hydrogen mobility that works closely with the UK Government. The UK is also a global leader in developing the use of hydrogen for heat and industrial decarbonisation, with initiatives such as H₂1 North of England, HyNet, Acorn and the Zero Carbon Humber projects setting out visions for use of low carbon hydrogen at scale in major industrial clusters. It is worth noting that the HyNet project zone extends across North West England and North East Wales with CO₂ capture, transport and offshore storage, and hydrogen distribution and fuel switching.

There are significant pockets of hydrogen deployment activities elsewhere in the UK, notably in Scotland. For example, Aberdeen had until recently Europe’s largest fleet of fuel cell buses and is progressing with plans to scale up deployment of hydrogen technologies. Several projects have led to renewable hydrogen production and use in the Orkney Islands, and a new initiative (“Green Hydrogen for Scotland”) was recently announced through which a partnership of ScottishPower Renewables, BOC, and ITM Power is seeking to provide hydrogen production facilities and clusters of refuelling stations across Scotland, starting with a 10 MW electrolyser on the outskirts of Glasgow (7). In March 2020 the Scottish Government launched its Hydrogen Assessment Project, which is seeking to form a key part of the evidence base to inform Scotland’s strategic approach to hydrogen over the coming years (8).

As of mid-2020, there is no national hydrogen strategy in place in the UK. However, in June 2020, a group of organisations wrote an open letter to the Chancellor calling for a UK-wide hydrogen strategy to help unlock at least £1.5bn of private sector investment into the sector (9). The following month, the UK Government announced the launch of the Hydrogen Advisory Council, whose role is to *inform the development of hydrogen as a strategic decarbonised energy carrier for the UK*. (10)

2.1.3 Welsh context

In June 2019, the Welsh Minister for Environment, Energy and Rural Affairs accepted the CCC’s recommendation for a 95% reduction in greenhouse gas emissions in Wales by 2050 (relative to 1990 levels), and indicated the Welsh Government’s intention to go beyond this target and achieve net zero no later than 2050. Since then, the Welsh Government has consulted widely, published a series of measures being taken to tackle the climate emergency (11), and in July 2020 announced a “team Wales” approach covering the entire public sector to work towards realising a low carbon economy in Wales. (12)

The potential for hydrogen to play a role in meeting several of the Welsh Government’s strategic objectives in terms of reduced reliance on fossil fuels and maximising the role of renewable energy has been recognised for

some time. In 2017 the Welsh Government established the cross-sector Hydrogen Reference Group, a group with the aim of supporting the development of a hydrogen economy in Wales. Momentum around hydrogen in Wales built further with the launch in February 2020 of the Wales Hydrogen Trade Association, HyCymru, an industry trade association that seeks to support the initiation and delivery of hydrogen projects while promoting public interest in hydrogen and fuel cell (HFC) technologies. The involvement of a wide range of industrial organisations, including operators of the electricity and gas networks in Wales, signals the growing interest in exploring and developing hydrogen opportunities across the country, which can help meet key Welsh Government objectives to include the Wellbeing of Future Generations Act and Prosperity for All in keeping with Circular & Foundational Economy principles.

A unique selling point for Wales is the invention of the fuel cell by William Grove of Swansea in 1842. Grove's name is synonymous with fuel cells and his brand and appeal can play a strong role in marketing Wales and hydrogen to the world.

As this report demonstrates, Wales is also home to a significant number of organisations with an interest and expertise in hydrogen and fuel cell technologies, including academic and research centres, large industrial organisations, and innovative start-up companies. There have been several pre-commercial demonstration projects involving hydrogen in energy applications in Wales over many years, and the pipeline of potential opportunities has expanded significantly in recent months. However, there has to date been a lack of coordination of hydrogen-related activity at a national level in Wales, and an absence of an overall direction of travel. The Welsh Government therefore appointed Element Energy to summarise the existing hydrogen activities in Wales, to develop a pathway for hydrogen in consultation with a wide range of stakeholders, and to support the implementation of hydrogen projects in the early 2020s.

2.2 Project objectives

The overall objective of this study is to ensure that Wales is well positioned to take advantages of the opportunities (environmental, economic, social, etc.) available from the development of hydrogen energy applications across all sectors. Specific objectives of the study include:

- Collect a comprehensive evidence base of the projects and expertise in Wales relating to HFC technologies.
- Develop a pathway for implementing hydrogen projects that have the potential to provide benefits to Wales.
- Support and coordinate the implementation of hydrogen initiatives in Wales until at least March 2022.

2.3 Purpose of this report

This document summarises the existing and publicly announced hydrogen projects in Wales and highlights the areas of expertise that exist in this sector, which includes companies and academia currently based in Wales that could have a role in developing the Welsh hydrogen sector. This “baselining report” was prepared during summer 2020 with input from a wide range of stakeholders (from within Welsh Government, industry, and academia) and forms part of the evidence based for the *Hydrogen Pathway for Wales* that is under development and due to be published around the end of 2020.

If Wales does not swiftly develop initiatives and policies which advance hydrogen and create opportunities within both internal, Welsh markets and serve as a platform for large, external markets, it faces the prospect of losing economic and competitive advantage, when countries across the world and nations and regions within the UK are already advancing their own interests. This report sets the scene for putting forward quick-wins for Wales while also preparing a longer-term pathway to seize the emerging, large-scale opportunities.

3 Hydrogen activities in Wales

3.1 Overview

Wales benefits from a wealth of experience and expertise in hydrogen and fuel cell technologies, including academic and applied research, use of hydrogen in industrial applications, and innovative start-up companies developing new products. The figure below summarises some of the hydrogen activity in Wales as of mid-2020. A list of the companies and projects represented by the icons on the map is presented in the appendix, see section 4.

Although the scope of this study is limited to Wales, clearly Wales is well connected to its neighbours in the UK and Ireland. Cross-border hydrogen initiatives are already being planned, such as the HyNet project, which although largely based in NW England, extends into NE Wales. Major transport routes which form logical corridors for hydrogen refuelling stations include the M4 linking South Wales to the west of England and ultimately London, and the A55 in North Wales, which is also an important route for freight traffic going to / from Ireland via Holyhead.

The map below illustrates the known, public state of play in mid-2020. Other projects and activities, including those which are currently commercially sensitive, are emerging and these can be added to the database and map as they are confirmed. Options for presenting the information shown below on a website are being explored, which will provide the opportunity to show a live, dynamic picture of hydrogen activities in Wales.

Ferry links from Wales to Ireland, with hydrogen opportunities at the port and hydrogen mobility potential from the transport links

Inter-connector from Ireland and opportunities to import renewable energy, as well as offshore renewables for green hydrogen production



Links from Wales to hydrogen initiatives in the North West of England, including HyNet and Net Zero North West

Links across the Severn and the Western Gateway powerhouse, connecting Wales with hydrogen activities in Bristol and Swindon.

KEY

Existing hydrogen projects		Planned hydrogen projects	
Other projects of interest to hydrogen		Potential hydrogen commercial interest (manufacturing)	
Potential hydrogen electricity generation interest (power plants)		Potential / current hydrogen vehicle manufacturing / integration interest	
Potential hydrogen aviation / aerospace interest		Potential hydrogen interest (petroleum refineries)	
Hydrogen research facilities		Merchant hydrogen production sites	
Private hydrogen production sites			

Figure 1: Overview of hydrogen activities and expertise in Wales

For the purposes of this study, we categorise the hydrogen activities into the following:

- **Hydrogen energy application projects (existing)** – for example the University of South Wales’ Baglan hydrogen refuelling station (HRS), which has been refuelling Hyundai ix35 vehicles for the Mid and West Wales Fire Service since 2017, as well as the university developed ‘Tribid’ vehicle.
- **Hydrogen energy application projects (planned)** – the consultation carried out in this study revealed a wide range of projects where hydrogen is either expected to play a central role, or in which there is potential to generate / use hydrogen as a fuel. Planned projects are looking beyond the immediate use of hydrogen for industry and transport and aim to implement hydrogen in a larger integrated energy system with multiple end uses. The increased scale and breadth of these projects is encouraging and demonstrates the greater role hydrogen is playing in plans to decarbonise hard-to-treat sectors for a net-zero Welsh energy system by 2050.
- **Industrial hydrogen production** – existing hydrogen production plants where the gas is produced on site for captive markets. Two sub-categories are indicated on the map above; “private hydrogen

production sites” offer limited / no scope for supplying users beyond the existing customer(s), whereas “merchant hydrogen production sites” have the capacity to supply others beyond the existing customer base.

- **Research centres** – universities and associated centres of excellence with expertise related to the hydrogen sector.
- **Companies with hydrogen expertise or a potential interest in the hydrogen sector** – organisations that either specialise in the HFC sector, which have relevant expertise that is can be transferred to hydrogen technologies, or for which hydrogen could be relevant in the context of the energy transition.

The following sub-sections provide an overview of a selection of the projects / initiatives outlined in Figure 1. Note that the list of activities is not exhaustive and we have focused on projects for which information is available in the public domain. Given the growing interest in hydrogen as a clean energy vector, and the urgent need to take action to address the climate emergency in Wales and beyond, we anticipate a growing number of publicly announced hydrogen-related initiatives over the coming months and years.

3.2 Industrial hydrogen production

3.2.1 Air Products



Company Description

Air Products is a multinational producer of atmospheric and industrial gases. Air Products has been an active player in the emerging hydrogen energy market, particularly in California. Air Products also participated in several hydrogen transport demonstration projects with deployments in the UK (covering buses (CHIC project), and cars / taxis / vans (HyTEC, London Hydrogen Network Expansion, and HyFIVE)). The company currently operates a publicly accessible hydrogen refuelling station at Hatton Cross, near Heathrow airport. Air Products appears to be investing heavily in low carbon hydrogen solutions, as evidenced by the recent (July 2020) announcement of an agreement with ACWA Power and NEOM for a \$5bn electrolytic hydrogen production facility in Saudi Arabia (the facility is due to be equally owned by the three parties). The hydrogen produced at the 650 ton per day facility will be converted to ammonia to be transported around the world before dissociation to yield green hydrogen to be used primarily in the transport market. (13)

Welsh Industrial Sites

Air Products has an industrial gas production site including SMR hydrogen production at Llanwern, to the west of Newport, which supplies Tata Steel by pipeline.

3.2.2 BOC



Company Description

BOC, part of the Linde Group, is a global producer of atmospheric gases (primarily nitrogen, oxygen and argon) for the food and beverage, welding and manufacturing and automotive sectors. BOC has invested in developing hydrogen as a fuel over the last 25 years and provide solutions for production, storage, distribution and dispensing. BOC has experience in the design, deployment and operation of hydrogen refuelling stations in the UK, e.g. at the Honda plant in Swindon and in Aberdeen (for the Aberdeen hydrogen bus project).

Welsh Industrial Sites

BOC Gases has a major industrial site at Margam in Port Talbot, including SMR hydrogen production for pipeline supply to Tata Steel and Merchant supply from tube trailers filled on site. BOC also operate private SMR hydrogen sites at Newport supplying Eastman Chemicals and Barry supplying Dow Silicones UK Limited, as well as on-site hydrogen supply to Tata Steel as Trostre.

3.2.3 Cabot



Company Description

Cabot is a multinational corporation based in the USA, with three manufacturing locations in the UK (Glamorgan, Berkeley, Glasgow). Cabot manufactures speciality chemicals and performance materials for the transportation, infrastructure, environment and consumer industries.

Welsh Hydrogen Production

Cabot Carbon is a branch of Cabot that operate in Glamorgan, South Wales, specialising in the manufacture of inorganic chemicals. Cabot Carbon has on-site hydrogen production capacity.

3.2.4 DOW Silicones UK Limited



Company Description

DOW is a multinational chemicals company active in various markets from agriculture to construction, food and beverage and oil & gas. 3 sites across the UK (Leeds, Peak District and Cardiff). DOW may have a future interest in hydrogen opportunities as numerous sectors of their business (e.g. ammonia production) utilise hydrogen. Since 2018, DOW has been involved in the implementation of a 12 km dedicated hydrogen pipeline in the Netherlands in partnership with Gasunie, Yara and ICL-IP (14).

3.2.5 Eastman Chemicals



Company Description

Eastman Chemicals is a specialty materials company which manufactures chemicals, fibres and plastics. Eastman operates globally, with two locations in the UK (Essex and Newport).

Welsh Hydrogen Production

Eastman partnered with BOC Margam in 2015 to run and maintain their hydrogen production facility in Newport, which supplies hydrogen to their thermol production plant (15). The facility uses a steam methane reformer.

3.2.6 Vale



Company Description

Vale is a mining company focused on the mining of iron ore, Nickel, Manganese, Coal and Copper. The company also works in the logistics, energy and steel making sectors. Vale is involved in the SWIC project (see 3.5.9).

Welsh Hydrogen Production

Vale has a nickel refinery in Clydach. Located onsite is an SMR facility to produce hydrogen for use in the refinery kiln. (16)

3.2.7 Valero



Company Description

Valero is an international manufacturer of petroleum products and operates 15 oil refineries globally with a combined throughput capacity of 3.2 million barrels per day. (17) Valero acquired a refinery in Pembroke from Chevron in 2011, and this is one of the sites being investigated for decarbonisation opportunities as part of the SWIC project.

Welsh Hydrogen Production

Valero have existing internal hydrogen production as part of the refinery process in Pembroke (hydrogen is used for desulphurisation).

3.3 Hydrogen in energy applications – deployment activities

3.3.1 University of South Wales Hydrogen Centre (Baglan)



Overview

The Hydrogen Centre was opened by the University of South Wales (USW) (formerly University of Glamorgan) in 2008. The Centre has been used to build on the university’s research into hydrogen energy from SERC (Sustainable Environment Research Centre). The centre provides a platform for research and development of hydrogen production from renewable sources, storage and vehicle and fuel cell applications.

The centre aims to raise awareness of hydrogen as an energy vector and to engage with industrial partners in a consultancy or research and development role. The economic and social impacts, as well as potential hydrogen business cases, are also researched at the centre. (18)

Wales’ first public HRS was deployed by the University in 2008 as part of their Hydrogen Centre. The refuelling station, which as of mid-2020 offers 350 bar dispensing (see section 3.4.9), is used to refuel vehicles such as the ‘Tribid’ minibus developed by the university, as well as Hyundai ix35 FCEVs trialled by Mid and West Wales Fire Service in 2017 (19). There is also a HCNG (Hydrogen & Compressed Natural Gas) refueller deployed at the centre which dispenses mixtures of hydrogen and CNG to be used as a vehicle fuel.

The Hydrogen Centre has partnered with approximately 100 commercial partners for work on R&D activities including: high pressure hydrogen component testing, renewable hydrogen and oxygen production from waste water treatment and stationary fuel cell hydrogen energy storage applications.

Organisations Involved

University of South Wales – Hydrogen Centre funding, operation.

Mid and West Wales Fire Service – FCEV trialling.

Support for project shown by Neath Port Talbot Council, Welsh Government. (18)

Funding Details

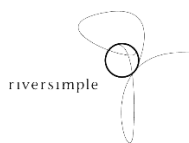
The Hydrogen Centre was jointly funded by the USW and the European Regional Development Fund. Estimated cost of £2.2M. (20).

Additional Comments

The USW is also involved in the SWIC project (see 3.5.9) and is bringing key learnings to the project from the work done at the Hydrogen Centre. University of South Wales form part of FLEXIS and offer a valuable point of contact when planning future hydrogen deployment projects.

A second hydrogen refuelling station opened at the USW Glyntaff Campus in 2011 adjacent to SERC laboratories (this HRS has since closed but hydrogen research continues at the Glyntaff site). The deployment received funding from the Department for Transport and has been used to support the Hydrogen Centre in its research on fuel cell vehicles. (21)

3.3.2 Riversimple at Abergavenny



Project Description

A temporary HRS is deployed in Abergavenny for the refuelling of Riversimple RASA vehicles. RASA vehicles are 2-seater fuel cell electric vehicles developed by Riversimple, a Wales-based company developing innovative, zero emission transport solutions. The HRS was deployed as part of the SWARM project (2015–2018). A 12-month user trial of 20 RASA vehicles was scheduled for mid-2020, but has been delayed to a phased rollout of vehicles starting with one vehicle to be delivered to Monmouthshire County Council in November 2020, Covid permitting. The trial will consist of one-month lease agreements with 280 retail consumers and two car sharing companies. Five public sector operators are trialling the car for a multi-month period. The project is intended to generate market interest in a small fuel cell vehicles and trial the design ahead of market launch. Riversimple has no stated plans to construct permanent hydrogen refuelling stations and intends to work with existing filling station owners for future rollout (22).

Project Status

A 12-month user trial of Riversimple vehicles is expected to start imminently. Expected launch of Riversimple RASA vehicles to market in 2023.

Organisations Involved

Riversimple (Project Lead).

SWARM consortium – Element Energy, PLANET GbR, Riversimple, Air Liquide Advanced Technologies, University of Birmingham, Coventry University Enterprises, Universite Libre de Liege, Jade Hochschule Wilhelmshaven, TÜV Süd AG, Service Public de Wallonie and Microcab. Involved in HRS deployment.

Funding Details

In addition to the refueller infrastructure costs, and other investment into the development and planned build of the trial cars for both Abergavenny and Milford Haven, £1.25M of UK Government through OLEV was awarded to support Abergavenny deployment of 20 vehicles.

In addition £2.8M was raised from crowdfunding across three different Riversimple crowdfunding campaigns as of July 2019 (23).

Additional Comments

Riversimple’s business plan is based on offering cars on an all-inclusive service basis. During 12-month trial customers pay a monthly fee and a low cost per mile charge. This approach for charging reflects the indicative production volume pricing that Riversimple aims to bring to market in 2022.

Provided market readiness by 2023, the main barrier to further deployment outside of Abergavenny area will be engagement with potential HRS owners and hydrogen suppliers.

3.4 Academic expertise, research projects and facilities

3.4.1 AMRC Cymru



Company Description

AMRC Cymru is a manufacturing innovation research centre, part of Sheffield University’s Advanced Manufacturing Research Centre (AMRC). The centre provides support to industry and the Welsh Government in their ambition to make Wales a centre for advanced manufacturing. Specialises in automation and digitalisation.

Locations

The AMRC Cymru centre opened in 2019 in Broughton, Wales.

Hydrogen Interest

As an industrial manufacturing researcher hydrogen is, and will in the future increasingly be, a key area of interest. AMRC Cymru has been consulted as a potential partner in the novel application of fuel cell systems for vehicles as part of the Ynys Môn Hydrogen Island Holyhead Hydrogen Hub project.

3.4.2 Cardiff University



Hydrogen Interest

Cardiff University is actively involved in hydrogen research through its materials and energy research unit, which focuses on the development of materials for energy applications such as hydrogen storage, fuel cells and catalysts. Researchers based at Cardiff also actively research ammonia for its potential as an energy vector and its potential synergies with long distance hydrogen transportation and recently announced their participation in the SAFE (Storage of Ammonia for Energy) project (24). The Cardiff University Centre for Integrated Energy Generation and Supply Research Group has also conducted numerous studies modelling the role of hydrogen within future integrated energy systems.

3.4.3 Bangor University



Bangor University hosts the Nuclear Futures Institute, which is developing world-leading capability in nuclear science and engineering. Although there are no active research projects, there is growing interest with co-generation of nuclear electrical and heat energy with hydrogen (25). Bangor University also hosts the National Research Network for Low Carbon Energy and Environment (NRN-LCEE). This is a pan-Wales initiative, funded by Welsh Government, which aims to promote collaborations and interdisciplinary research within Wales into

the sustainable use of natural resources for the provision of energy, water, food and other ecosystem services. The first phase of the programme ran from 2013-2019, with a £7 million investment from Welsh Government, which leveraged £33 million for Welsh research institutions. The second phase has commenced and is funded by the European Regional Development Fund, through the Welsh Government (26) (27).

3.4.4 FLEXIS project



Project Description

FLEXIS (Flexible Integrated Energy Systems) is a £24M research project aiming to develop and improve energy system research in Wales, looking at both the social impacts and technical challenges for energy systems. A number of work packages focus explicitly on hydrogen:

WP 1 – Integrated Energy Supply Systems. Extended in 2016-17 to include a demonstration area in the Swansea University Bay Campus (see Figure 2). This area houses Cardiff University’s Gas Turbine Research Centre which studies the effect of hydrogen mixtures on gas turbines (28), as well as the £7M Swansea Bay Technology Centre. The Technology Centre is a new build construction project which aims to be energy positive and use excess energy to produce hydrogen for fuel cell vehicles at the nearby Baglan Hydrogen Centre (see 3.3.1). Also within the demonstration area is Tata Steel Port Talbot Steelworks, a consumer of hydrogen.

WP 5 – Hydrogen Energy Storage. Builds on expertise of SERC (Sustainable Energy Research Centre) at the University of South Wales to research and develop grid scale hydrogen storage.

WP 6 – Sustainable Production and Purification of Hydrogen, Syngas, BioH2 and BioCH4

WP 7 – Hydrogen and Syngas (focusing on energy and transport sectors).

WP 15 – Energy Vectoring through Hydrogen. (29)

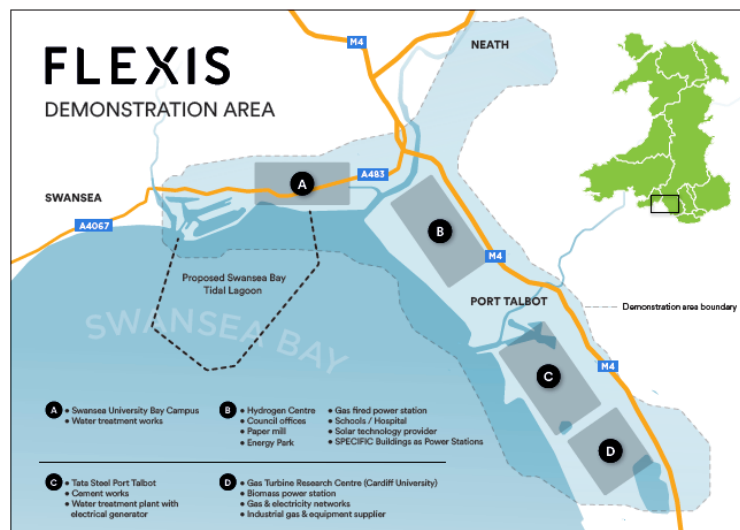


Figure 2: FLEXIS Demonstration Area (30)

Project Status

The project began in 2015 with a five-year timescale for delivery. Work is still ongoing.

Organisations Involved

The project is led by Cardiff University, Swansea University and the University of South Wales.

Collaborative partners include: Aberystwyth University, Bangor University and British Geological Survey.

Industrial partners include: Apex drilling services, Carreg Las, Central Mining Institute, Compound Semiconductor Centre, Egnida, Energybuild, GFZ, ITM Power, Kensa Heat Pumps, National Grid, NU Vision Energy, Port of Milford Haven, Siemens, SP Energy Networks, Tata Steel, TerraDat, Wales and West Utilities, Welsh Water and Western Power Distribution. (31)

Funding Details

Flexis received £15M in funding support from the European Regional Development Fund via the Welsh Government. (32)

Additional Comments

Broad scope of research activities conducted at FLEXIS in all areas of the energy sector, including CCS, smart energy grids, gases and energy storage. This project continued the collaborative work of the SEREN project and the LCRI (Low Carbon Research Centre), which also supported the WEST (Welsh Energy Sector Training) project. LCRI conducted research activities between 2009–2015. (33)

3.4.5 Gas Turbine Research Centre



The Gas Turbine Research Centre (GTRC), established in 2007 and based in Port Talbot (near Tata Steel), is a research institute which is part of Cardiff University. The GTRC *undertakes research in the field of novel combustion systems, components, and fuels, under elevated conditions of temperature and pressure.* The centre benefits from a suite of experimental facilities for testing combustion systems and investigating the combustion characteristics of traditional and alternative fuels. A key feature of the facility is the ability to examine flames within pressurised chambers, which simulate engine-relevant conditions.¹ The GTRC also has the capability to blend various fuels, for example methane and hydrogen, which is an area of interest and active research in the context of injecting hydrogen into gas grids. The GTRC has extensive expertise in the use of ammonia for hydrogen storage and for production of heat and power, including on-going research activities on ammonia combustion.

The GTRC has expertise in hydrogen safety and the facility includes a classroom environment for delivering training courses (e.g. courses on risks, hazards, and safety for employees at the adjacent steel works are provided at the centre).

With the growing interest in hydrogen and hydrogen-derived fuels in a range of energy applications, the GTRC is well placed to expand over the coming years.

3.4.6 HyHy Project



Project Description

¹ The GTRC has pressurised counter-flow burners, which are not commonly found in other research / testing facilities.

Research project to investigate the deployment of hydrogen supply and hybrid heating. The project aims to assess the role of hybrid heating in the transition to zero carbon heating in Wales and how it can enable carbon compliance with national targets. The analysis compares a hybrid approach to hydrogen-only / full electrification pathways.

The project will be modelling focussed and the key output will be a feasibility study on the deployment of hybrid heating in Wales. The knowledge gained from the project will be used to inform business plan development and results will be disseminated to policy makers.

Project Status

Start Date: November 2019

End Date: December 2020

Organisations Involved

Ofgem – Funding

Wales & West Utilities – Project Lead

Progressive Energy – Consulting

Funding Details

The project is wholly funded by the Network Innovation Allowance (£146,667).

Additional Comments

Expected to be used to develop business plans by Wales & West Utilities (and others) for hydrogen heating deployments.

3.4.7 Reducing Industrial Carbon Emissions (RICE)



Swansea University
Prifysgol Abertawe



Project Description

The RICE project is an initiative led by the Energy Safety Research Institute at Swansea University with the aim of working with local companies to test how CO₂ captured from industry CCUS can be used to make high value products and chemicals. In addition to this objective, production of electrolytic hydrogen is included in the technologies to be tested.

Work Packages involving hydrogen research include:

- WP 3 – Integrated Hydrogen Bioprocesses, looking specifically at the potentials for the treatment of wastewater.
- WP 4 – Variable input hydrogen & oxygen production from renewable energy.
- WP 5 – Heat, hydrogen and their efficiency.
- WP 6 – Heat to hydrogen, looking at the utilisation of waste heat from industrial processes
- WP 7 – Systems & Techno-Economic Analysis (34)

Project Status

The project began in 2018 and is now due to run until February 2022.

Organisations Involved

Collaborative partners include Swansea University, the University of South Wales, the Energy Safety Research Institute (ESRI) and the Sustainable Energy Research Centre (SERC).

Project partners include: Welsh Water, eCORP, Membranology, Tata Steel, Tarmac, Vale, Celsa Manufacturing, Hanson, British Glass, Valero, Eubia, Apache, Aberystwyth University, RE-CORD, Berkeley Lab, University of Chester, NUI Galway, CERTH, and Bio Energy International. (35)

Funding Details

RICE is a £9.2M initiative part funded by the European Regional Development Fund.

Additional Comments

The RICE project, in collaboration with the University of South Wales' George Ewart Evans Centre for Storytelling (GEECS), will take a holistic approach to reporting its findings and will include in its dissemination activities stories from the companies it is working with to try and generate an understanding of the effects of changing the energy environment from an SME perspective. (36)

3.4.8 Swansea University



Hydrogen Interest

The university, along with Cardiff University and the University of South Wales is a collaborating partner in the FLEXIS project (see section 3.4.4) and leads the RICE project with the University of South Wales. Swansea University also offers a Masters degree in fuel technologies, of which hydrogen is one of four research areas and is the lead on the Reducing Industrial Carbon Emissions (RICE) project.

The Energy Safety Research Institute (ESRI) at Swansea University has R&D activity in the development of power flexible, low-cost alkaline electrolysis and thermoelectric enhancement of water electrolysis. In 2018 it was reported that researchers at Swansea University had developed a process to convert plastic waste into hydrogen in partnership with the University of Cambridge, however, future research is needed into identifying and developing suitable catalysts (37).

3.4.9 University of South Wales



The University has conducted research into hydrogen since the mid-1990s via the Sustainable Environmental Research Centre (SERC). With an initial focus in fermentative biohydrogen production, SERC now has over 40 research staff and research students conducting a broad portfolio of hydrogen research, including; i) thermochemical, electrolytic and biological hydrogen production, ii) hydrogen storage material development and hydrogen energy storage modelling and experimentation, iii) hydrogen recovery and amplification from industrial process streams, hydrogen and CO₂ separation, and hydrogen / CO₂ processes for platform chemical development (CCU), Solid Oxide co-electrolysis of syngases, iv) hydrogen application for transport, heat and power, v) PEM fuel cell materials development, Solid Oxide fuel cells and Microbial fuel cells research. SERC also specialise in techno-economic and environmental analysis of hydrogen systems.

SERC are based at the University's main campus in Pontypridd and at the Hydrogen Centre in Baglan Energy Park in Port Talbot. The SERC labs at Pontypridd (Glyntaf) focus on earlier TRL research, whereas the emphasis at the Baglan Centre is on mid- to later TRL research and development.

Since opening in 2008, the Baglan Hydrogen Centre includes an active hydrogen refuelling station, fed by hydrogen produced on site by PEM and alkaline electrolysers and a small test SMR. While the hydrogen refuelling station currently only refuels vehicles up to 350 bar, an upgrade to allow 700 bar refuelling (the standard adopted by major car OEMs producing fuel cell vehicles) is planned. The Baglan hydrogen station has been used to refuel hydrogen vehicles in several ongoing FCV trials and plans are now in place to further upgrade the station capacity as part of an initiative that would also bring a new fleet of hydrogen-fuelled vehicles to the area. USW also installed a demonstration HRS at the Glyntaf campus in 2011 but is no longer operational, with the equipment relocated to Baglan.

SERC lead the IEA HIA BioHydrogen Task Group and are represented on the UK Government Hydrogen Advisory Council. The centre is a partner with Cardiff and Swansea University's on the FLEXIS and FLEXISApp projects and with Swansea University on the industrial research project RICE. (38) Together with Tata Steel, SERC initiated the South Wales Industrial Cluster and are the academic leads for the cluster.

The USW Centre for Automotive & Power Systems Engineering (CAPSE) is nationally recognised independent research, development, test and certification house and has conducted a number of hydrogen fuel cell drive train development and test projects with automotive industry partners.

3.4.10 Wrexham Glyndwr University



Wrexham Glyndwr University has close working links with local employers, including Airbus and JCB. The university offers undergraduate courses in Renewable and Sustainable Engineering and conducts research in advanced composites. As part of the work in advanced composites, Wrexham Glyndwr University has collaborated with Airbus, Coleg Cambria (higher education college in Wrexham) and Welsh Government to establish the Advanced Composite Training and Development Centre. Although this work is not currently linked directly to hydrogen, there are opportunities to expand this research to hydrogen related activities, including the development of advanced composites for hydrogen storage (39).

3.4.11 Other research activities

While the above listed activities highlight dedicated hydrogen research, many hydrogen-related research activities are undertaken in Wales' universities and which could be applied to support commercial activity, especially in partnership with Welsh companies and to attract inward investment. An audit of all hydrogen-related activities – whether explicit or, at this stage, tangential – is worthy of a dedicated piece of work in itself, in order to capture its full potential. We list below a selection of those which have been identified to date:

- Cardiff Catalysis Centre, Cardiff University
- Centre for Integrated Renewable Energy Generation and Supply, Cardiff University
- Nuclear Futures Institute, Bangor University (together with M-Sparc, Menai Science Centre)
- Marine Renewable Energy Research, Bangor University
- Materials Research Centre, Swansea University

It is also worth noting that Welsh academics are active in hydrogen and related activities outside Wales and could be attracted to base some of their activities here or to develop partnerships with Welsh-based academics should opportunities arise.

Furthermore, Wales' further education colleges should be included in any strategic planning for hydrogen in Wales. It is within these colleges, nurtured by schools, that the skills-base for deploying hydrogen technologies will be developed. There is a track record of developing skills for the solar, nuclear, oil, gas, electricity, steel and

other industries in Wales, many of which skills are complementary to and can be redirected towards the hydrogen sector.

3.5 Hydrogen in energy applications – planned projects

3.5.1 Dwr Cymru Welsh Water Cardiff Hydrogen Production



Project Description

Dwr Cymru Welsh Water is developing a project to produce hydrogen on-site at their Cardiff wastewater treatment works. Cardiff Council is interested in the project as a potential hydrogen end user for heavy waste vehicles, identified as a high carbon emitter in the council’s Low Emission Transport Strategy. (40)

Project Status

Dwr Cymru Welsh Water has conducted a *scouting study* and as of Q3 2020 is embarking on feasibility work that will consider details such as plant siting and outline design of the equipment. The project is targeting hydrogen supplies to the transport sector and the production plant could be operational by 2024 provided that sufficient demands for the fuel can be secured.

Organisations Involved

Dwr Cymru Welsh Water – Project lead

Costain – Funding application consultancy

Cardiff Council – Hydrogen end user

Additional Comments

The project has the potential to provide a novel sustainable hydrogen production method, as well as helping to achieve Cardiff’s clean air ambitions (41) through refuse vehicle operation.

3.5.2 Green Valley Energy – Trecwen, Haverfordwest



Project Description

Trecwn Valley in North Pembrokeshire is a 1,000-acre former Royal Navy Armaments Depot (RNAD) site. The site is managed by Renewable Developments (Wales) Ltd who plan to develop green hydrogen production facilities using local renewable energy generation from solar and wind. The site has existing rail infrastructure, and the project partners are exploring the potential for hydrogen fuel cell trains and aiming to develop the site into a ‘Centre of Excellence’ in the rail and road transport sectors.

Project Status

Each of the project participants is undertaking the necessary due diligence to establish a working relationship that will deliver an integrated provision of hydrogen powered trains in Wales. The landowners of the various parcels of land making up the footprint of the project are working with Renewable Developments (Wales) Ltd who are currently leading the project.

Organisations Involved

- Renewable Developments Wales Ltd – Project lead
- Manhattan Loft Corporation – Site landlord
- Eversholt Rail – Rolling stock company developing hydrogen fuel cell train with Alstom
- Alstom – Railway rolling stock manufacturer developing hydrogen fuel cell trains
- Statkraft – Renewable energy generator

Funding Details

Current project activities are being funded by the individual organisations involved.

Additional Comments

Renewable Developments (Wales) Ltd have ambitious plans for the Trecwn site to attract organisations and develop the hydrogen demand, production capacity and help to establish the site as a Centre of Excellence for the rail and road transport sectors.

3.5.3 HyNet North West



Project Description

HyNet North West will develop a hydrogen network, which will produce, store and distribute hydrogen to decarbonise the North West of England and North Wales. Together with carbon capture and storage (CCS), these technologies have the potential to reduce CO₂ emissions by 10 million tonnes every year by 2030 – the equivalent of taking four million cars off the road. A final investment decision on HyNet is due in 2023, this will be dependent on support from UK Government, regulatory approvals of pipelines for CO₂ and H₂, and subsea CO₂ storage in Liverpool Bay will also be required (42).

Project Status

HyNet North West is targeting 2025 for first operation. The project has hit its first major milestone by beginning the planning process for the pipeline infrastructure. The front-end engineering design (FEED) for the hydrogen production site and consents is currently underway (target to be completed by 2021). The hydrogen and CO₂ pipeline distribution network FEED and consenting is also underway (target to be completed by 2023). (42)

Organisations Involved

HyNet is led by Progressive Energy and Cadent, who are supported by a range of organisations based in the North West of England and North East Wales. This includes; Cargill, CF fertilisers, CPW, Encric, Eni, Essar, Istock Brick, Intergen, Jaguar Landrover, Johnson Matthey, Novelis, North West Hydrogen Alliance, Net Zero North West, Peel, Pilkington, SNC Lavalin, Solvay, Unilever, Uniper, University of Chester.

Funding Details

HyNet North West has received funding support from the Cheshire & Warrington Local Enterprise Partnership through their Local Growth Fund. HyNet has also been awarded funding from BEIS through the CCUS Innovation, Low Carbon Hydrogen Supply Competition and Industrial Fuel Switching programmes.

Additional Comments

The route of the hydrogen and CO₂ pipeline is currently being designed, this could provide low carbon hydrogen to industries across North East Wales, as well as infrastructure for CO₂ transport and offshore CO₂ storage.

3.5.4 Milford Haven Energy Kingdom (MH:EK)



Project Description

Milford Haven Energy Kingdom aims to explore what a decarbonised smart local energy system could look like for the Milford Haven Waterway. The project will explore the potential of hydrogen as part of a multi-vector approach to decarbonisation. Central to the project, and to achieving net-zero, is a commitment to engage with the community and local industry, providing insight and opportunities for growth. This is to be achieved via the design of a smart local energy system for the Milford Haven area to include: local renewable energy (solar, onshore wind, future offshore wind and biomass) and diversified markets for hydrogen across heat, power, transport and industry sectors. The project includes demonstration of hydrogen-ready features and technologies such as a hydrogen vehicle refuelling station for Riversimple’s fuel cell RASA cars as well as a hybrid heat pump and hydrogen-ready boiler demo for heating, allowing people to test real-world hydrogen vehicles and heating equipment. The project will gather detailed insight into the whole energy system around Milford Haven, to identify and design a future smart local energy system based on a truly multi-vector approach and comprehensive energy systems architecture (43) (44) (45).

Project Status

The two year project will run until Spring 2022. The project will create investable propositions and an ongoing business case to allow future design and implementation of a smart local energy system integrating local renewables and hydrogen for Milford Haven.

Organisations Involved (45)

Pembrokeshire County Council (Project Lead) – Project lead with a role in the provision of a hydrogen car refueller station, use of Riversimple RASA FCEV’s transport trials, stakeholder and investor engagement.

Offshore Renewable Energy (ORE) Catapult – Project manager with expertise in offshore renewable asset integration, stakeholder & investor engagement

Riversimple – Fuel cell electric vehicle provision together with trial & data recording.

Wales & West Utilities – Gas distribution system operator with smart hybrid heating trial experience and whole energy system modelling, design and integration capability.

Port of Milford Haven – Hosting of hydrogen refuelling and heating demonstrators, as well as industry stakeholder and investor engagement.

Energy Systems Catapult (ESC) – Principal lead for development of system architecture

Arup – Principal lead for design integration, commercial modelling, major energy facilities, households and buildings design development.

Formal support for the project has been received from: RWE (non-funded collaborator), Western Power Distribution (non-funded collaborator), Welsh Government Energy Service (supporter), Community Energy Pembrokeshire (supporter) and Simply Blue Energy (supporter).

Funding Details

The project is part-funded by the UK Government, with a £2.05M grant awarded under the UK Research and Innovation (UKRI) Prospering from the Energy Revolution challenge fund. A further £2.45M is being provided

in match funding by project partners (ORE Catapult, Port of Milford Haven, Riversimple Movement Ltd, Wales & West Utilities) (46) (47).

Additional Comments

The project includes a plan to create a carbon neutral zone in the Milford Haven Waterfront and the system is to be designed to enable the heat, transport, and power needs of local communities and tourists visiting the area to be met by renewable energy.

3.5.5 Net Zero North West



Project Description

The Net Zero North West partnership aims to become the UK’s first low carbon industrial cluster by 2030, and achieve net zero emissions by 2040. This project is on the border with Wales and has potential synergies with industry decarbonisation in North East Wales. The is an opportunity that presents significant economic benefits, both regionally and nationally. In addition to the decarbonisation focus, the partnership aims to create and protect high value-added jobs and to position the UK at the forefront of global industrial emissions reductions.

Project Status

The Net Zero North West initiative has gained support from a range of industries across the region, as well as local political support. The project is aiming to attract £4 billion in investment into a range of projects, some of these encompass regions of Wales, such as the HyNet project (48).

Organisations Involved

The Net Zero North West partnership includes: CF Fertilisers, Encirc, Essar Oil UK, INOVYN, the North West Business Leadership Team (NWBLT), Peel L&P Environmental, Siemens, Storengy and Tata Chemicals Europe.

Funding Details

The partnership supports the funding of decarbonisation projects across the region, including HyNet, which has received UK Government funding.

Additional Comments

The partnership focuses on decarbonisation of industry, where hydrogen will have a role. This is alongside renewable generation, carbon capture usage and storage, nuclear and smart grids (49).

3.5.6 Hydrogen opportunity in apartment



Project Description

Development of a 45no. apartment older persons development in Newport, South Wales. The project partners are exploring options to blend hydrogen with natural gas into the CHP unit to reduce GHG emissions from the onsite CHP system.

Project Status

The building development is currently in the construction phase and the potential use of hydrogen is being considered in the design for the combined heat and power (CHP) plant.

Organisations Involved

Hoare Lea, pobl and Ynni Glan are involved in the project development.

Funding Details

Current project activities are being funded by the individual organisations involved.

3.5.7 Port of Mostyn Tidal Lagoon



Project Description

The Port of Mostyn plans to build a £590M, 6.7km tidal lagoon from Mostyn to Point of Ayr in Flintshire. Eight turbines along the lagoon will be able to generate 298 GWh electricity annually and the lagoon will double as flood protection to the coastline.

Technologies that can offer opportunities to enhance the commercial and operational viability of tidal lagoons such as hydrogen production, battery storage and air liquid battery technologies are being investigated in terms of their feasibility of being incorporated in the Mostyn design.

Project Status

Mostyn plan to submit an application to the UK Government by 2022, to be approved the following year. Construction is estimated to take four years with the potential for energy production by mid-2027. (50)

Organisations Involved

The lagoon is being developed by Mostyn SeaPower, a subsidiary of the Port of Mostyn.

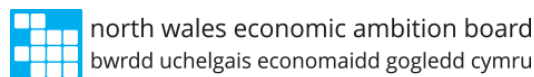
Funding Details

The estimated £590M capital cost of the project is expected to be part-funded by the Port of Mostyn, and public funding is likely required for the project to proceed (although no government funding details have been announced to date). Engagement with the UK Government to help guarantee a strike price has been quoted as being a potential method for financial viability. (51)

Additional Comments

The original plans involve electricity from the proposed tidal lagoon being fed into the national grid via the Connah’s Quay power station (c. 11 miles from the site). There could be potential to use some of the renewable electricity from the tidal turbines for hydrogen production, either at the Port or at the Connah’s Quay site, subject to confirmation of the technical and commercial viability.

3.5.8 Transport Decarbonisation Project: Deeside Hydrogen Hub



Project Description

The project aims to develop a hydrogen hub around the Deeside Industrial Park in Flintshire. The hub would act as a demonstrator project, with green hydrogen produced from renewable energy being used to decarbonise local transport networks by powering hydrogen fuelled vehicles such as buses and HGVs.

Project Status

An initial study commissioned by the North Wales Economic Ambition Board has highlighted the potential of producing green hydrogen to decarbonise regional transport networks. Feasibility studies will now be undertaken to assess the feasibility of green hydrogen production and the demand for hydrogen amongst local businesses and public sector partners.

Organisations Involved

The project will be developed by the North Wales Economic Ambition Board, a regional partnership established to support economic growth in North Wales. The Board will work closely with Welsh Government, Welsh Government Energy Service, Flintshire County Council, local businesses and regional stakeholders.

Funding Details

Initial studies were funded through the Welsh Government Smart Living Programme. Further feasibility work is being supported through the Welsh Government Local Transport Fund and will focus on developing a Strategic Outline Case. Potential funding partners and transport operators will be engaged as part of the next phase of work. Subject to the outcome from feasibility studies and a robust business case being developed, the project could also be supported through the North Wales Growth Deal.

3.5.9 South Wales Industrial Cluster (SWIC)



Project Description

The South Wales Industrial Cluster is currently a network and informal grouping of organisations representing a diverse set of industries including oil refining, paper, nickel, insulation, chemicals, LNG import, coin production, general manufacturing, steel and cement. The SWIC group also includes local energy generation and distribution companies. With its roots in the FLEXIS and RICE projects, the SWIC’s mission is to *develop a world leading, truly sustainable industrial cluster befitting the societal needs of 2030, 2040, 2050 and beyond*. SWIC was formed in response to the UK Government’s Industrial Strategy and Industrial Clusters mission *grand challenge*, and the SWIC covers a wide area across South Wales, from Newport to Milford Haven. The industrial cluster in the region currently produces 16 MtCO₂ per year (52). While exploring the potential for carbon capture, utilisation, and storage (CCUS) and supporting the initiation of a hydrogen economy in South Wales are within the scope of the SWIC, the initiative is not a “hydrogen” or “CCUS” project per se, rather the partners are investigating a range of solutions to achieve the overarching mission outlined above.

In 2020, SWIC secured UK Research and Innovation funding under the Industrial Decarbonisation Deployment and Roadmap projects initiative from the UK Government. There are two streams to this work:

- The **roadmap** project aims to identify the best options for cost-effective decarbonisation of industry in South Wales. In particular, the infrastructure required for development of a hydrogen economy will be examined, including large scale CCUS, transport and strategic opportunities for industry. SWIC was

one of six winners of the Industrial Decarbonisation Roadmap competition, and the first phase of work was undertaken in 2020. All six projects have the opportunity to bid for further UK funding to develop roadmaps for decarbonising major UK industrial clusters. (53)

- The **deployment** project focuses on a number of key industrial sites across South Wales. SWIC now has the opportunity to apply for further UK funding to *deliver, or support delivery of, significant emissions reductions in a UK industrial cluster by 2030.* (53)

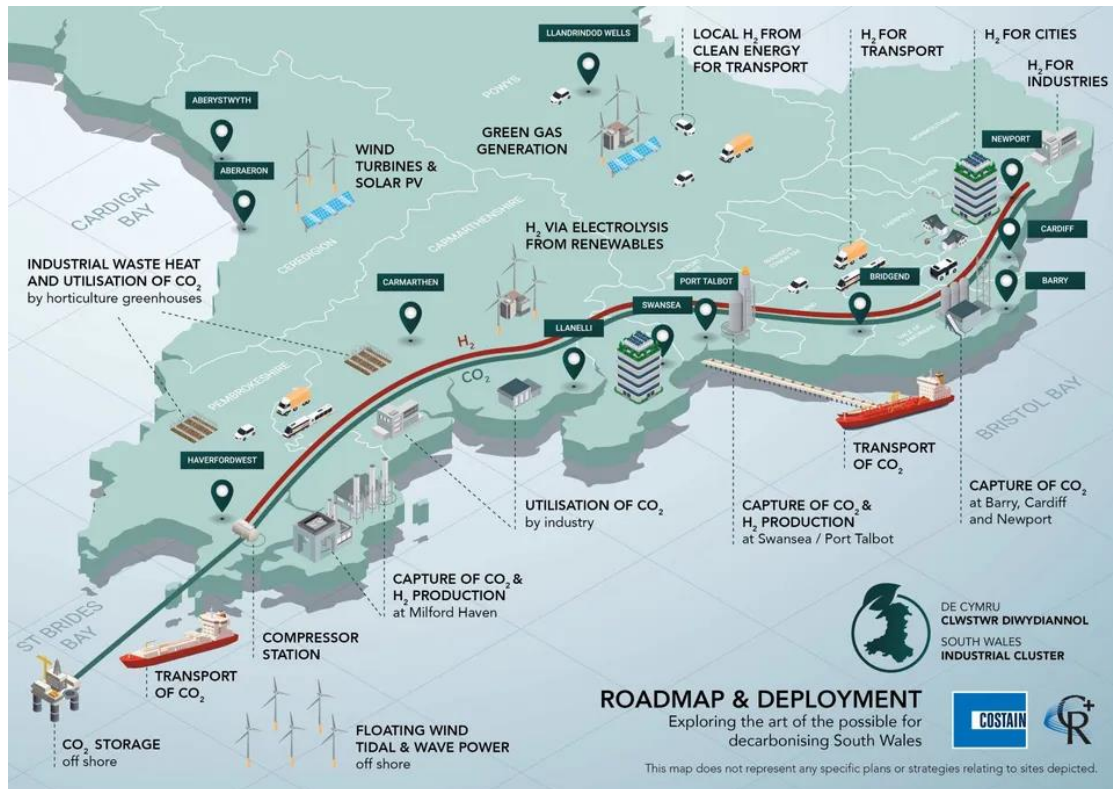


Figure 3: SWIC Roadmap (52)

Project Status

SWIC project planning began in 2018 between the University of South Wales and Tata Steel. The Roadmap Project planning is underway, with the expected rollout of technology throughout 2020s and the aim for a low – carbon area by 2030. The concept of a ‘hydrogen highway’ along the M4 has been circulated since 2010 (54).

Organisations Involved (as of July 2020) (53)

University of South Wales – Academic lead

CR Plus – Energy efficiency and project engineering consultancy – Roadmap lead

Costain – Construction engineering – Deployment lead

Roadmap project partners: RWE, Progressive Energy, University of South Wales, Celsa Manufacturing, Tata Steel, Port of Milford Haven, Vale Europe.

Deployment project partners: Tata Steel, Tarmac, RWE, Valero Energy, Progressive Energy, CR Plus, Capital Law, Flexible Process Consultants, University of South Wales.

Funding Details

Grant funding has been received from Innovate UK to further develop the roadmap and deployment projects. SWIC aims to secure a share of Industrial Decarbonisation Challenge Fund allocated by the UK Government, although there is expected to be significant competition for this fund from other UK industrial clusters. (55) (56)

Additional Comments

Broad project scope with an expectation for expansion. The deployment project is termed ‘phase one’ deployment as expansion beyond the four initially planned sites will be needed to create the net-zero industrial cluster.

As a first of its kind project in decarbonising Welsh industrial areas, financial viability will depend on UK Government funding and / or a suitable policy environment.

3.5.10 Ynys Môn Hydrogen Island, Holyhead Hydrogen Hub



Project Description

Development of the Ynys Môn Hydrogen Island project is being led by Menter Môn, a not-for-profit company focused on “*providing solutions to the challenges facing rural Wales*”. The Hydrogen Island aims to create a framework for hydrogen deployment on the island. Work to date has included engaging with stakeholders and assessing the potential hydrogen projects which can be developed as part of the Energy Island initiative. Following an initial feasibility study in 2019, a consultancy team comprising Ynni Glân and Element Energy was appointed to support with the development of a business case for creating a hydrogen hub on the island. As of mid-2020, the project proponents are seeking funding for further development activities and ultimately technology deployment in the early 2020s. (57)

Project Status

A ten-week Phase 1 feasibility study began in April 2019 to identify priority projects. This led to the Phase 2, Holyhead Hydrogen Hub, detailed study which reported on the development of a Hub (which could initially serve HGVs – over 300,000 passing through Holyhead each year – and other large vehicles) and assessed the business case in summer 2020, in preparation for development funding.

Organisations Involved

Menter Môn (Project Lead) – social enterprise providing solutions to socio-economic challenges by Ynys Môn communities.

Morlais – Menter Môn project, managing 35 km² seabed near Ynys Cybi with a potential for 240 MW tidal power generating capacity.

Funding Details

Funded by Menter Môn.

Additional Comments

Ynys Môn has high renewable energy potential (e.g. high wind power density, Morlais tidal project) which is underexploited (57). Final project scope could include renewable deployments to produce green hydrogen.

3.6 Other initiatives with a potential role for hydrogen

3.6.1 Global Centre of Rail Excellence



Project Description

The Welsh Government plans to develop a c.£150M Centre of Rail Excellence facility on the site of the Onllwyn and Nant Helen open case coal mine, on the border of Neath Port Talbot and Powys. The plans include two electrified oval tracks (one 4.5km long and one 6.9km long), a tunnel section, and platform for testing and training. The facility is also due to include storage for ~400 rolling stock units, a maintenance facility, a decommissioning facility and R&D innovation centre, education centre and office and training facilities. (58)

Project Status

A consultation seeking feedback on the project was run between July and October 2019. Proposals for the site were submitted in early 2020. Conversion work to the site is expected to be finished by 2023. (59)

Organisations Involved

Welsh Government (Project Lead)

Neath Port Talbot Council (Local Council)

Powys (Local Council)

Celtic Energy (Site owner)

Additional Comments

This facility provides opportunities for testing of hydrogen rail vehicles and the opportunity to expand the facility's capabilities to allow testing of hydrogen-fuelled trains is being considered.

3.6.2 Greenlink Interconnector



European Commission



Partners Group
REALIZING POTENTIAL IN PRIVATE MARKETS

Project Description

Greenlink is a proposed subsea electricity cable of nominal capacity 500 MW that is set to be built between National Grid's Pembroke substation and EirGrid's Great Island substation in County Wexford.

Project Status

The project is planned for commissioning in 2023. Pembrokeshire County Council gave planning permission approval in July 2020. (60)

Organisations Involved

Greenlink is being developed by Greenlink Interconnector Limited, which is owned jointly by Hudson Sustainability Investments and Partners Group. (61)

Funding Details

The Greenlink interconnector is partly funded as a European Project of Common Interest (PCI).

Additional Comments

The interconnector provides the possibility for imported renewably generated electricity to be used for hydrogen production, which could help deal with intermittency issues related to local renewable electricity production in both directions.

3.6.3 Heat and potential uses of hydrogen in homes

Project Description

Several innovative projects are proceeding as part of the Growth and Regional Deals and as part of the Innovative Housing Programme as well as the district heating scheme. Different technologies and sources of energy are being utilised and it may be that hydrogen, will form part of that mix once more trials have been undertaken and more certainty provided about decarbonisation of the gas networks.

Additional Comments

In the context of decarbonising homes, several reports to Welsh ministers from the Decarbonisation of Homes in Wales Advisory Group were published in 2019. (62)

3.6.4 Welsh Government bus & taxi zero emission target

The Welsh Government is aiming for 100% decarbonisation of the bus, taxi and private hire vehicle fleets by 2028 (63). This highly ambitious goal will likely require large investments in hydrogen mobility solutions for the heavier duty applications in particular, with approximately 9,100 buses and coaches registered in Wales (64), but which can also cascade down in scale to taxis and private hire vehicles.

3.6.5 Wind projects in Wales

There are several wind power development projects currently ongoing in Wales. Wind power generation is an area of interest for hydrogen development as hydrogen can provide solutions to grid connection issues in remote areas and intermittency issues, as demonstrated by the decisions to link new wind power deployment and hydrogen production deployment in the German and Dutch National Hydrogen Strategies (65) (66). Discussions with Welsh Government representatives during the course of this study suggest that network constraints are restricting further development of onshore wind in certain areas (e.g. mid-Wales and the Heads of the Valley area), and local hydrogen generation and use is being considered as a potential solution; and which can release the full potential of Wales' renewables including through the development of local ownership models as stated in Prosperity for All.

Total and Simply Blue Energy have this year revealed their partnership plans for a Celtic Sea floating wind farm, with the first deployment expected to be a 96 MW demonstration project for which an application for approval has already been submitted to the government. There are expected to be other deep-water deployment projects by the partnership to be developed by the 2030s. (67)

Although not specific to Wales, the Offshore Renewable Catapult (which has a presence in Pembrokeshire, see 3.5.4) released a report in September 2020 which identified a resource potential of 675GW of offshore wind available in UK waters, at or close to prevailing contract prices (68), which offers major opportunities for green hydrogen production. A significant proportion of this resource potential lies within Welsh waters. The report should be considered in conjunction with the ORE Catapult's July 2020 report on floating offshore wind constraint in the Celtic Sea (69).

3.6.6 Potential nuclear development

Wales has two decommissioned nuclear sites; Wylfa Newydd and Trawsfynydd, both of which are being considered for further development. Despite the recent withdrawal of Hitachi from the Wylfa site in September 2020, there is still potential for this site to be taken on by other nuclear developers. The Snowdonia Enterprise Zone Advisory Board has also identified the potential for Trawsfynydd to develop as a centre of excellence for

low carbon energy R&D. This has included the potential for locating the first of a kind development in the UK of a small modular reactor / advanced modular reactor (70). Welsh Government has recently set up a development company, Cwmni Egin, to take forward new developments at Trawsfynydd (71). The development company will also support the case for the thermo-hydraulic testing facility at Menai Science Park (M-Sparc) on Anglesey and work with the AMRC Cymru facility on Deeside.

The Nuclear Futures Institute (NFI) at Bangor University is also developing equipment to locate at the proposed national thermal hydraulic facility at M-Sparc on Anglesey. The national thermal hydraulic facility will facilitate research on the movement of heat and fluids in the reactor system during the conversion of nuclear energy into electricity (72). This could also support the co-location of hydrogen production with nuclear, utilising heat energy and electricity for water electrolysis to produce low-carbon hydrogen.

3.6.7 Zero2050 and Net Zero South Wales projects



Project Description

Zero2050 South Wales (herein referred to as the National Grid project) is a project led by National Grid Electricity Transmission to accelerate the transition to net zero in South Wales. It is a collaborative project with National Grid Gas Transmission, Wales and West Utilities and Western Power Distribution. The aim of the project is for partners to collaborate and develop plausible, optimised decarbonisation pathways for the whole energy system in South Wales (73).

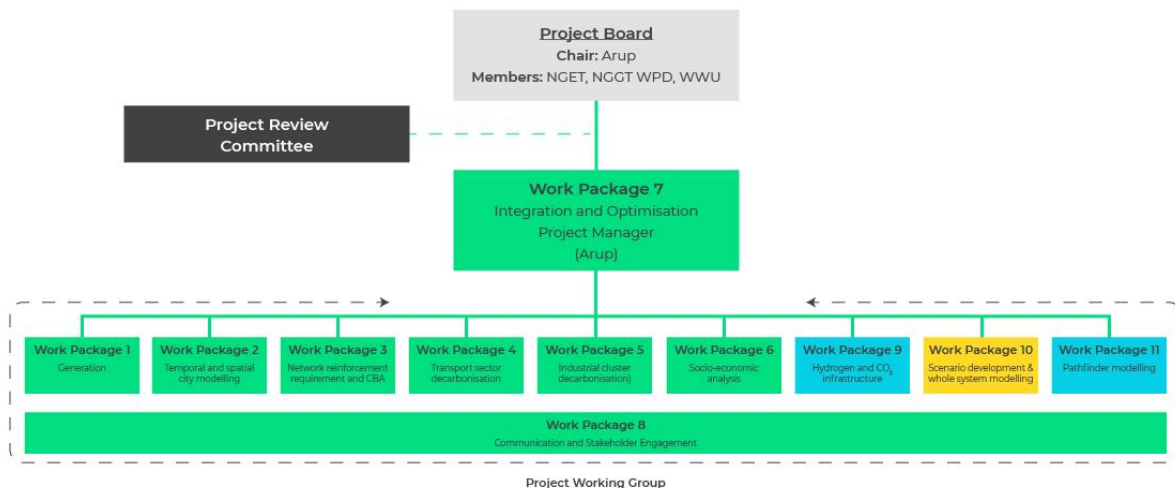


Figure 4: Overview of the project structure and governance for Zero2050 (73)

As the figure above shows, the scope of the project includes energy generation, temporal and spatial city mapping, network reinforcement, transport decarbonisation, and industrial cluster decarbonisation. Hydrogen is a significant feature in several areas of the project.

The Net Zero South Wales project (herein referred to as the WPD / WWU project) is a related project, shown by Work Package 10 in Figure 4, led by Western Power Distribution and Wales & West Utilities which aimed to understand the implications of the transition to net zero on distributed energy networks. The Network Innovation Allowance funded project explored the impact on network operation due to the decarbonisation of heat and transport, increase in renewable generation and the production, supply and use of low carbon gases (hydrogen and biomethane). Learnings from the WPD / WWU project will feed into the parent National Grid project. (74) (75)

Project Status

The WWU / WPD project ended in summer 2020 (76). As of July 2020, work was still ongoing for the National Grid project with an increased focus on a green recovery from the coronavirus pandemic.

Organisations Involved

National Grid Project

National Grid – Project Lead

Partners and affiliates: National Grid Electricity Transmission, National Grid Gas Transmission, Wales & West Utilities, Western Power Distribution

Suppliers: Arup, BMT, Digital Engineering, Cardiff University, Burns McDonnell, CR Plus, Progressive Energy

Review Committee: Welsh Government, South Wales Industrial Cluster, Department for Business, Energy & Industrial Strategy, National Grid Electricity Transmission, National Grid Gas Transmission, Wales & West Utilities, Western Power Distribution, Tata Steel, Siemens, Arup, Welsh Water, University of South Wales

WPD / WWU Project

Partners: Western Power Distribution, Wales & West Utilities, Regen.

Funding Details

The National Grid (Zero2050) and Net Zero South Wales (WPD / WWU) projects have been funded by the Network Innovation Allowance.

Additional Comments

Hydrogen is being studied in the generation, industry, cities and transport sectors of the National Grid project, as well as being explicitly mentioned as a low carbon gas of interest in the WPD / WWU project.

3.7 HyCymru

HyCymru (also known as the Wales Hydrogen Trade Association) was launched in February 2020 and brings together companies across the whole hydrogen value chain with the goal of unifying the effort to progress policy and innovation in this area. The partnership aims to achieve rapid hydrogen development in Wales through activities such as gathering market intelligence, helping to fund hydrogen projects, influencing policy developments and raising public awareness of hydrogen.

A list of HyCymru members with an overview of their work and interest in the hydrogen sector is provided in the appendix, along with an overview of companies not part of the association but which may have an interest in the further development of the hydrogen sector in Wales.

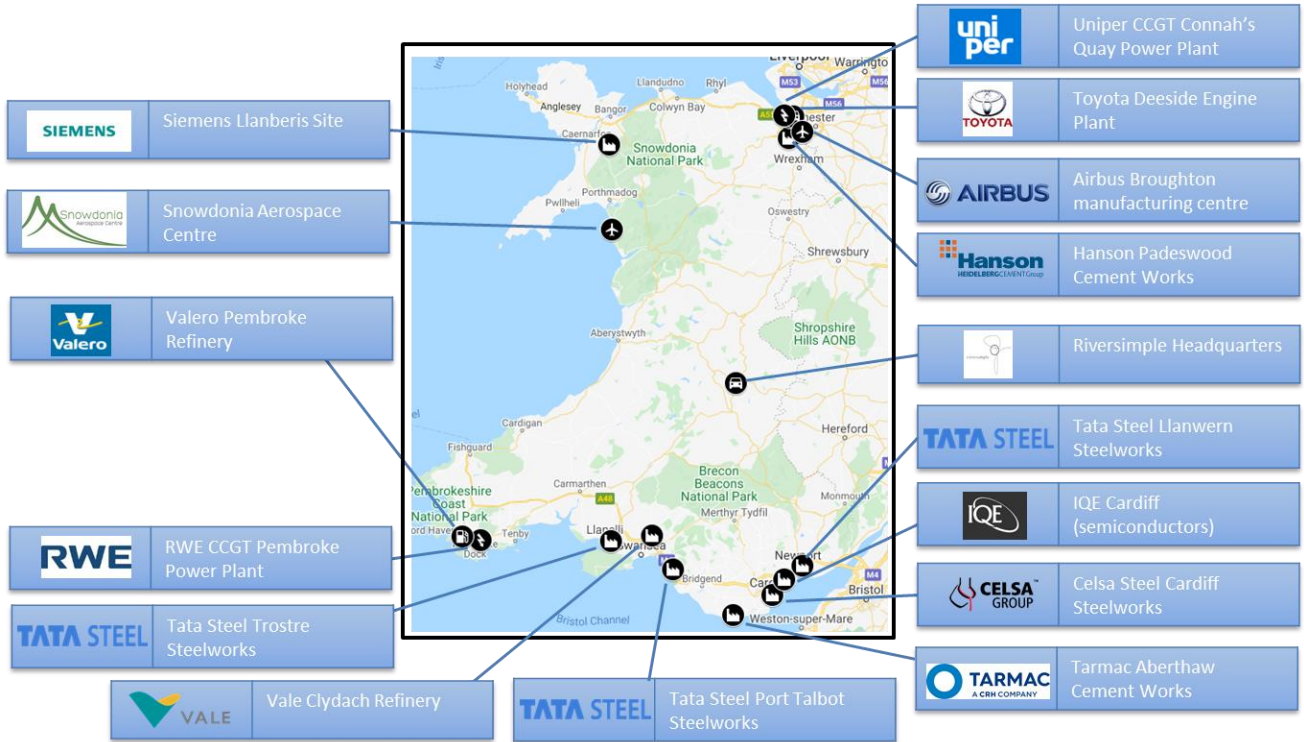
A membership drive by HyCymru is anticipated in late 2020 to reflect the national and international expressions of interest in their work. HyCymru has also established strategic relationships with the UK's other hydrogen trade associations and with organisations in the EU, including in Ireland, and further afield.



4 Appendix

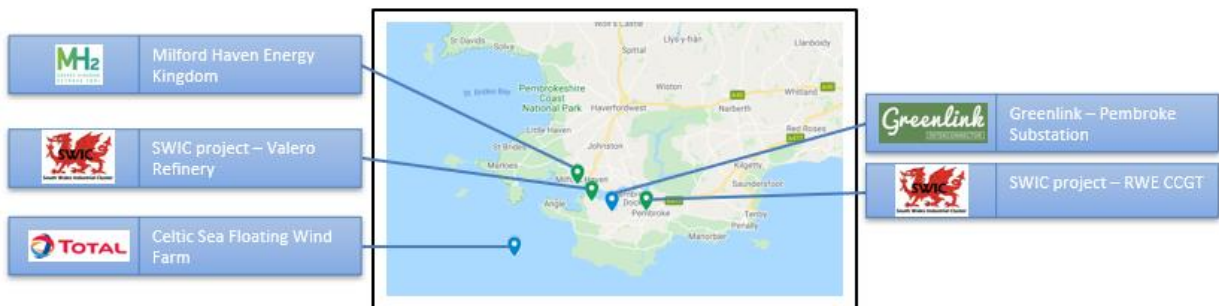
4.1 Hydrogen activities / interest in Wales: detailed mapping

4.1.1 Companies with an interest in hydrogen



4.1.2 Hydrogen projects and areas of interest

South West Wales



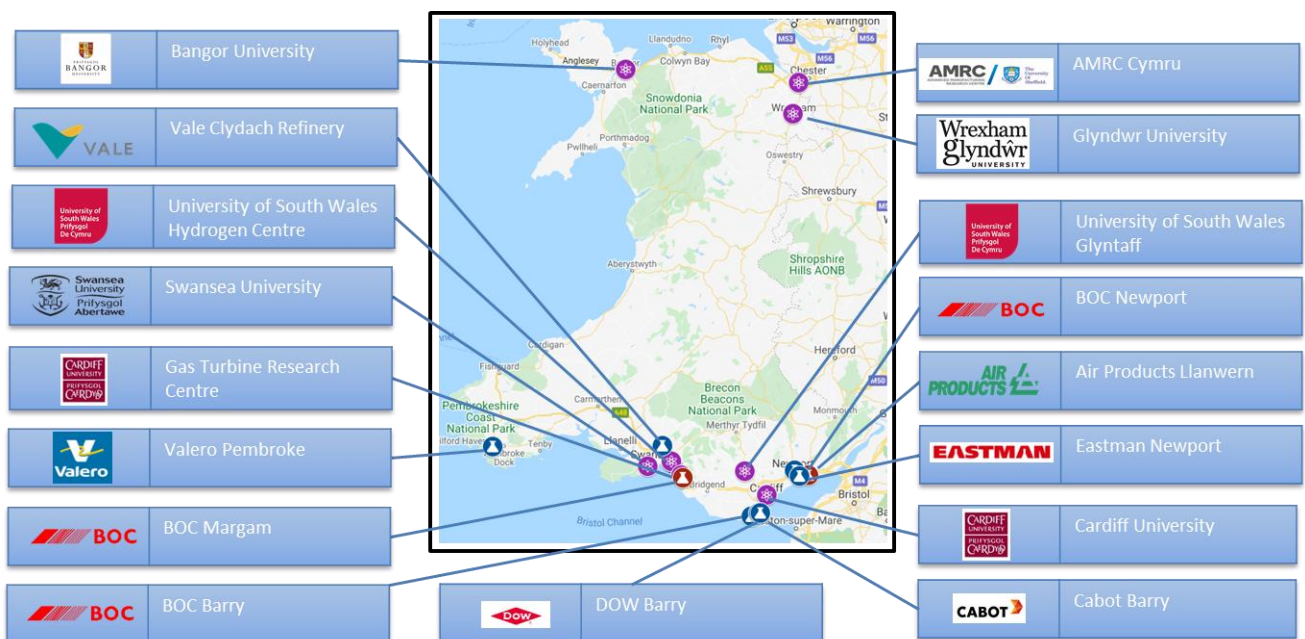
South East Wales



North Wales



4.1.3 Areas of hydrogen research and hydrogen production facilities



4.2 HyCymru members

HyCymru, the Wales Hydrogen Trade Association's, founding supporting organisations are listed below.

4.2.1 2G



Company Description

2G Energy AG is one of the leading international manufacturers of combined heat and power plants (CHP) for the decentralised generation and supply of electricity and heat using CHP technology.

The 2G product range includes CHP systems with an electrical output between 20 kW and 2,000 kW for operation with natural gas, biogas and other lean gases and biomethane. To date, 2G has successfully installed several thousand CHP plants in 55 countries. In the output range between 50 kW and 550 kW especially, 2G has its own combustion engine concepts with low fuel consumption, high availability and optimised maintenance requirements.

Locations

2G's headquarters are in Germany, and the company has presence across Europe and North America and Nigeria, with partners across Asia, Israel and Australia. In the UK, 2G has a location in North West England in Runcorn (77).

Hydrogen Interest

2G has developed a hydrogen gas CHP engine, capable of operating on 100% hydrogen. The hydrogen engine CHP is available from 115 to 360 kW, with electrical efficiency 37-40% and thermal efficiency >40% (78).

4.2.2 Acorn



Company Description

Recruitment specialists, providing services to a variety of sectors relevant to hydrogen including construction, industry & manufacturing, engineering and energy (specifically nuclear). IRP top UK recruiter of the year winner 2017 & 2018.

Locations

More than 40 locations across the UK.

Hydrogen Interest

Recruitment and skills development in the hydrogen sector.

4.2.3 Afallen



Company Description

Multi-disciplinary sustainability consultancy providing research expertise, project management and strategic development services. Afallen have previously led projects in social housing, industry and green spaces and were a Wales Start Up Awards Finalist in 2019.

Locations

Based in Penarth, Wales

Hydrogen Interest

Whilst not a hydrogen specialist, development of hydrogen in Wales would add to Afallen’s portfolio of expertise in sustainability and would be especially relevant to their work in the housing and industry sectors.

4.2.4 University of Sheffield / AMRC Cymru



See section 3.4.1.

4.2.5 Arup



Company Description

Arup is an independent firm of designers, planners, engineers, consultants and technical specialists offering a broad range of professional services across a range of sectors including energy, cities and transport. Arup has a global presence with offices in 33 countries.

Locations

16 offices across the UK, including Cardiff.

Hydrogen Interest

Arup maintains a key interest in hydrogen and has produced research reports and information booklets on hydrogen such as: *Establishing a Hydrogen Economy: The future of energy 2035* (79) and *Five Minute Guide to Hydrogen* (80). Arup is principal lead for design integration for the Milford Haven: Energy Kingdom project and project managers for Zero2050 South Wales.

4.2.6 BIA Energy Consulting



Company Description

BIA Energy Consulting are a specialist consultant to the micro-CHP (Combined heat and power on a household level). Launched in 2019 by Dr S. Cook.

Locations

Based in Caerphilly, Wales.

Hydrogen Interest

Prior to launching BIA, Dr S. Cook was an engineering researcher at Panasonic Cardiff and a key member in launching three generations of fuel cell boiler to the UK market. Hydrogen is a key area of interest for smart domestic heating schemes.

4.2.7 Capital Law

Capital Law

Company Description

Capital Law is a commercial law firm which works across a number of sectors, including providing services to energy and infrastructure projects. Capital Law has worked on several wind and solar projects, advising on procurement as well as operations and maintenance.

Locations

Based in Cardiff, Wales.

Hydrogen Interest

Capital Law is a deployment project partner in the SWIC project and offer a contact point for legal services for large scale hydrogen deployment projects.

4.2.8 Costain



Company Description

Costain is a strategic consultancy specialising in the clean energy and transport sectors, as well as providing services to oil, gas & hydrocarbon and defence.

Locations

Offices across England and Scotland.

Hydrogen Interest

Costain is a deployment project partner in the SWIC project. Costain has stated that they believe one of the most practical options to achieve clean energy growth is hydrogen (81).

4.2.9 Engsolve



Company Description

Engsolve is a multi-disciplinary consulting engineering company. Engsolve provides facilities support, engineering, HSE and project services expertise required by clients in developing small to medium sized projects and studies in the industrial, general engineering, manufacturing, utilities and energy-from-waste sectors.

Locations

Engsolve is based in Bridgend.

Hydrogen Interest

Engsolve has supported clients with the design and engineering of hydrogen projects, including waste-to-hydrogen plants and industrial hydrogen fuel cell installations. This includes piping and instrumentation diagrams, process line sizing, electrical single line diagrams and utility flow diagrams.

4.2.10 Industry Wales



Company Description

Industry Wales provides services and support to help grow Welsh industries. Host specialist aerospace, automotive, electronics, software and technology forums.

Locations

Based in Bridgend, Wales

Hydrogen Interest

General interest in Wales hydrogen industry development.

4.2.11 Institution of Mechanical Engineers



Company Description

The Institute aims to support mechanical engineers by providing events and webinars, access to journals and newsletters and magazines.

Locations

Based in London, UK

Hydrogen Interest

General interest in the development of engineering in the hydrogen sector.

4.2.12 POBL



Company Description

Pobl is a not-for-profit company who provide housing and community services. They help with home finding and support those who live independently, as well as investing in making homes more sustainable and cheaper.

Locations

Based in Newport, Wales

Hydrogen Interest

General interest in making homes more environmentally friendly and lowering utilities bills through sustainable schemes.

4.2.13 Protium



Company Description

Hydrogen and fuel cell specialist project managers, providing project design, funding and deployment expertise. Members of the UK and Scottish Hydrogen & Fuel Cells Associations, as well as Renewables UK Hydrogen Steering Group.

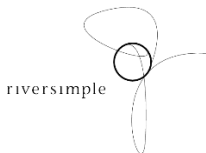
Locations

Based in London, UK

Hydrogen Interest

Specialists in hydrogen. A founding member of HyCymru.

4.2.14 Riversimple



Company Description

Riversimple is the designer of the RASA hydrogen fuel cell cars, which it aims to bring to market in 2023.

Locations

Based in Llandrindod Wells, Wales.

Hydrogen Interest

Manufacturer of highly efficiency, light-duty fuel cell electric vehicles (cars and vans) which will require suitable refuelling infrastructure and could create new demands for hydrogen (although the demands per vehicle are low due to the design and target operational profile).

4.2.15 Savills



Company Description

Savills is a real estate agent. Also offer services in areas such as consultancy, finance and energy. The energy team helps with the funding, planning, deployment and management of energy assets.

Locations

Based in London with numerous offices in the UK and globally.

Hydrogen Interest

General interest in the use of hydrogen in homes and larger developments.

4.2.16 SP Energy Networks



Company Description

SP Energy Networks is a branch of Scottish Power which operates energy distribution networks on behalf of electricity supply companies.

Locations

Customers across the UK including in Northern Wales. Based in Glasgow, Scotland.

Hydrogen Interest

SP Energy Networks are investigating pathways to zero carbon in the transport, heat and energy sectors including the deployment of hydrogen infrastructure in the Liverpool area and have launched the Zero Carbon Communities Initiative. (82)

4.2.17 Wales & West Utilities



Company Description

Gas network operator, with a gas network which supplies homes and businesses in Wales and South West England.

Locations

Based in Newport, Wales

Hydrogen Interest

As a gas network operator, an increase in hydrogen use would be a clear benefit to Wales & West Utilities with the potential for blending with natural gas and using existing gas pipelines in a hydrogen distribution network. Wales & West Utilities are involved in running the Net Zero South Wales 2050 project, as well as the HyHy Project and the Milford Haven Energy Kingdom.

4.2.18 Welsh Water



Company Description

Welsh Water is a not-for-profit utilities company supplying water to households and businesses. There is a focus within the company on environmental sustainability.

Locations

Welsh Water service most of Wales and Herefordshire.

Hydrogen Interest

Welsh Water is planning to produce hydrogen from their Cog Moors water treatment plant. Welsh Water is also involved as a project partner in the RICE project.

4.2.19 Ynni Glân



Company Description

Ynni Glân is a clean energy consultancy specialising in hydrogen fuel cells. Provides feasibility study, project development and project management services.

Locations

Based in Cardiff, Wales.

Hydrogen Interest

As a specialist hydrogen consultancy Ynni Glân is involved in the development of the Ynys Môn Hydrogen Island project and other fuel cell & hydrogen project activities primarily in Wales.

4.3 Other companies with a potential interest in hydrogen

4.3.1 Airbus



Company Description

Airbus is an airline manufacturer, with operating head office located in Toulouse, France and manufacturing plants across Europe and worldwide.

Locations

Broughton, Wales.

Hydrogen Interest

Airbus employs around 6,000 staff at its wing manufacturing facility in Broughton. The site assembles wings for Airbus commercial aircraft, including manufacturing, engineering and support functions, such as procurement and finance. Airbus recently announced three ZEROe concept zero emission commercial aircraft, which they target for use by 2035. (83) These aircraft would be fuelled by hydrogen and powered by modified gas turbines, with a fuel cell providing the electrical power load. Traditionally fuel on aircraft is stored in the wings, these concepts propose to use liquid hydrogen. Liquid hydrogen requires storage at -253°C and cylindrical storage tanks, which poses several technical and engineering challenges. There is potential for research and development into liquid hydrogen storage to be led by Airbus with expertise from the Broughton manufacturing and engineering facility.

4.3.2 Celsa Manufacturing



Company Description

Celsa is a global steel manufacturer. The Celsa Group spans Spain, the UK, Poland, Norway and France.

Locations

Steelwork site in Cardiff, Wales.

Hydrogen Interest

Celsa is a partner in the SWIC project. Also involved in the deployment of an electrolysis facility for use in Celsa Steel furnaces in Mo I Rana, Norway.

4.3.3 ENI



Company Description

Eni UK is a subsidiary of Eni SpA, an international energy company with 31,300 employees. Eni is committed to being a leader in the energy transition, and has reorganized into two distinct, but collaborating businesses; Natural Resources and Energy Evolution, to focus its move from an Oil and Gas Company to a company that embraces the need for change towards new, greener fuels.

Locations

Eni SpA operates in 66 countries across the globe. In the UK, Eni operate the Liverpool Bay Area (LBA) oil and gas fields in the East Irish Sea, with its onshore terminal at Point of Ayr, and its offices in Northop, Flintshire, Wales, and the Hewett Areas gas fields in the Southern North Sea. The LBA fields are expected to cease

production in the mid-2020s, which opens opportunities for re-use, including hydrogen generation, and carbon capture, utilisation and storage (CCUS).

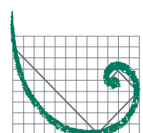
Hydrogen Interest

With a strong belief that natural gas will lead the way to meet the worlds net zero targets, Eni is committed to being a leader in CCUS, associated with Blue Energy from CCGT Power Plants and Blue Hydrogen from Steam Reformers. Eni are operating two projects in Europe; in Ravenna, Italy and in the Liverpool Basy Area. Eni are also participating with BP, Shell, Equinor and Total in the Net Zero Teeside Project.

Eni has been awarded the License for Storage of CO₂ in its Liverpool Bay depleted gas fields. The Liverpool Bay Area CCUS Project forms a part of the HyNet North West Project. The project aims to store up to 10MTCO₂/year by 2030, capturing the CO₂ produced from a number of industrial emitters (including refinery, fertiliser plant, cement plant) and from blue hydrogen production plants. The Liverpool Bay Area CCUS Project is looking to reuse pipelines, platforms and wells from the depleted Hamilton, Hamilton North and Lennox Fields for storage of the CO₂.

Eni UK is also undertaking pre-feasibility studies for blue hydrogen and blue energy generation at Point of Ayr.

4.3.4 ERM



ERM

Company Description

ERM is a leading global provider of environmental, health, safety, risk, social consulting services and sustainability related services. ERM deliver innovative solutions and help clients to understand and manage their sustainability challenges (84).

Locations

ERM have more than 5,500 people in over 40 countries and territories working out of more than 160 offices. This includes 8 offices in the UK, including London and Bristol.

Hydrogen Interest

ERM are developers of the Dolphyn green hydrogen project, where they are looking to deploy offshore hydrogen production integrated with offshore floating wind. ERM is deploying two demonstration units (2MW and 10MW) off the coast in Aberdeen, and are reviewing options for commercial scale deployment. ERM has been considering the options for future developments in the Celtic Sea, where there is strong potential for offshore floating wind and bringing hydrogen into Wales into Milford Haven and Port Talbot.

4.3.5 Fre-energy



Company Description

Having designed unique technology within the anaerobic digestion sector, Fre-energy manages the installation of waste anaerobic digestion plants from feasibility through to commissioning and provides ongoing operational on-site and remote technical support. Fre-energy has built twelve farm-based anaerobic digestion (AD) plants across the UK to process a broad range of feedstocks, from slurries and manures, abattoir arisings, through to manufacturing and hospitality food wastes. Ranging from 80kW to 500kW incorporating our unique waste AD technology and foam alleviation system, each plant is sized to suit the respective farm operations and meet the farms core strategic business objectives. All installations operate efficiently and contribute to reducing the farm business carbon footprint. Actively engaged in innovation, both independently and in collaboration with academia and industry in the UK and internationally, Fre-energy has received multiple Innovate UK awards for project funding and recognition for their innovative AD technology and contribution to waste valorisation.

Locations

Fre-energy’s head office is in Holt, Wrexham. Also the home of the pilot plant and subsidiary, Lodge Farm Biogas Ltd is a regulated Cat-3 ABP Licensed Food Waste AD facility. Fre-energy waste AD technology has a patent granted in the UK, Ireland, Europe, USA, Australia and South Africa.

Hydrogen Interest

Project Lead in the design and fabrication of an anaerobic acidification reactor for the production of hydrogen and volatile fatty acids. The initial lab-scale work, carried out by Fre-energy’s university partner based in India, identified that incorporating Fre-energy gas-mixing techniques significantly enhanced the operational process. Fre-energy have built a pilot plant on their site in Wrexham and are commencing further trials of this innovative reactor.

4.3.6 Hanson



Company Description

Hanson is a UK based building materials company which operates globally.

Locations

Quarries in southern and mid-Wales. There is a Hanson cement works in Padeswood.

Hydrogen Interest

No public engagement with hydrogen solutions has been demonstrated by Hanson, however, they could be a potential end user in Northern Wales if hydrogen is demonstrated to be a viable energy solution for building materials companies.

4.3.7 IQE



Company Description

IQE is a British semi-conductor company which manufactures advanced epitaxial wafers and provides wafer services to the semiconductor industry. A wafer is a thin slice of a semiconductor.

Locations

IQE are based in Wales and operate globally. UK locations in Cardiff and Milton Keynes.

Hydrogen Interest

IQE are a potential hydrogen end user (hydrogen is used as a carrier gas for wafer fabrication).

4.3.8 Puma Energy



Company Description

Puma Energy is a multi-national oil company, specialising in supply, storage, refining, distribution and retail of petroleum products. Puma Energy supplies around 50% of the UK’s import of bitumen products, for road and infrastructure developments.

Locations

Puma Energy operates in over 47 countries worldwide, mainly in Asia, Latin America and Africa. In 2016 Puma Energy purchased a disused oil refinery at Milford Haven, which is they have converted for petroleum storage and use as a distribution terminal. Puma Energy also operates a ship-to-truck loading operations centre in Cardiff.

Hydrogen Interest

Puma Energy could support hydrogen logistics and their majority shareholder, Trafigura, has invested in hydrogen projects and organisations, including H2Energy, which is supporting the hydrogen refuelling infrastructure for fuel cell truck deployments in Switzerland (85).

4.3.9 RWE



Company Description

RWE AG is a leading player in the field of renewable energy. RWE Renewables, the newest subsidiary of the RWE Group, is one of the world’s leading renewable energy companies. With its highly efficient power plants in Germany, the UK and the Netherlands, approximately 3,000 employees at RWE Generation use gas, hard coal, hydro power and biomass to generate electricity. The company’s gas fleet is the third largest in Europe. RWE will be carbon neutral by 2040, with clean, secure and affordable energy.

Locations

RWE owns a natural gas CCGT plant in Pembroke. Owned a coal-fired power plant in Aberthaw until closure in March 2020.

Hydrogen Interest

RWE is conducting research into the possible uses of hydrogen in the GET H2 project and through the installation of a 105-MW power-to-gas electrolysis facility in Lingen, Germany. RWE is also a partner in hydrogen research in the region of Groningen, Netherlands, and South Wales, UK. The Pembroke power plant is being investigated as to its potential use as an end user in the SWIC project.

4.3.10 Snowdonia Aerospace



Company Description

Snowdonia Aerospace LLP owns and maintains Snowdonia Aerospace Centre at Llanbedr Airfield, North Wales. The former RAF airfield is now operational for general aviation and has facilities for the testing and evaluation of unmanned air systems / drones. Snowdonia Aerospace Centre was also awarded funding from the UK Space Agency, along with B2Space (based in Newport) to develop a plan for a spaceport, this includes a research and development centre, training and facilities for a satellite launch.

Locations

Snowdonia Aerospace Centre is on the North West coast of Wales, within the Snowdonia National Park near the village of Llanbedr, Gwynedd.

Hydrogen Interest

Although specific hydrogen applications have not been identified by Snowdonia Aerospace, there are several companies based in the UK that are involved in developing hydrogen aerospace applications. This includes Reaction Engines who are developing the Synergetic Air Breathing Rocket Engine (SABRE), which is powered by liquid hydrogen. There are also companies looking to develop fuel cell powered unmanned aircraft systems (UAS), such as Intelligent Energy. Hydrogen refuelling infrastructure at the aerospace field could attract research and development aerospace activities at the site.

4.3.11 Tarmac



Company Description

Tarmac is a British building materials company. Focuses especially on sustainable building materials and construction solutions.

Locations

Sites across South Wales including a cement works at Aberthaw.

Hydrogen Interest

The company has previously demonstrated the potential for hydrogen to decarbonise cement and lime production (86). Tarmac is being investigated as a potential early end user for the SWIC project.

4.3.12 Tata Steel



Company Description

Tata Steel is a global steel supplier and manufacturer with a presence in Europe, India and South East Asia.

Locations

Wales manufacturing facilities based in Port Talbot, Llanwern, Flintshire and Trostre.

Hydrogen Interest

Steelworks are an area of interest for hydrogen, with the potential for decarbonisation of the steel production process by using hydrogen to replace coke furnaces. Tata Steel Trostre, Llanwern and Shotton are existing large end users, where hydrogen is used in the annealing process for steel coils.

Tata Steel are involved in several hydrogen deployment projects: the steelworks at Port Talbot is an initial deployment site for SWIC, whilst their Ijmuiden steelworks in the Netherlands are planning to offtake hydrogen from a 100MW electrolyser facility. (87)

4.3.13 Toyota



Company Description

Global vehicle manufacturer, specialising in light vehicles. Toyota offers a range of hybrid electric cars and produces the Toyota Mirai Hydrogen Fuel Cell Vehicle.

Locations

There is a Toyota engine plant in Deeside, Wales.

Hydrogen Interest

Toyota is one of the world’s leading manufacturers of fuel cell electric vehicles (FCEVs), and is supporting the development of the hydrogen transport sector in various markets around the world, including in the UK.

4.3.14 Uniper



Company Description

Uniper is a leading international energy company with around 11,500 employees and activities in more than 40 countries. With about 34 GW of installed generation capacity, Uniper is among the largest global power generators. Its main activities include power generation in Europe and Russia as well as global energy trading, including a diversified gas portfolio that makes Uniper one of Europe’s leading gas companies. The company is headquartered in Düsseldorf, being the third-largest listed German utility. Under its new strategy, Uniper aims to become climate neutral in its European power generation by 2035.

Locations

In the UK, Uniper operates a flexible generation portfolio of seven power stations, including Connah’s Quay in Flintshire, Wales and a fast-cycle gas storage facility in Cheshire. Connah’s Quay is a natural gas-fired, combined cycle gas turbine power station with a capacity of c.1.4 GW.

Hydrogen Interest

Uniper has announced its aim to be climate neutral, in its European power generation by 2035 and sees hydrogen use as essential in meeting Net Zero. A pioneer in the field of hydrogen the company has already trialled the manufacture of green hydrogen and its injection into the gas network in Falkenhagen and Hamburg (Windgas project). Hydrogen is an important element in decarbonising cross-sectors – power, industry, transport, and heat. And Uniper is working on collaborative cross-sector projects as well as exploring opportunities to integrate hydrogen into its existing assets. For example, Connah’s Quay power station could provide blending opportunities for hydrogen of up to 20% (blends of up to 20% H₂ by volume are feasible with

the existing technology). Connah’s Quay is also strategically located in the context of hydrogen production and use due to several factors:

- The site is located on the proposed route of the CO₂ pipeline from the HyNET project, which presents opportunities for Hydrogen production by SMR / ATR with CCS, as well as the new Hydrogen distribution infrastructure proposed under HyNet Phase 3.
- Excellent network connections – the site is connected to the national grid (400kV) and has access to renewable electricity from Welsh and Scottish offshore wind farms (via the adjacent 132kV substation and Western HVDC link), providing the option to produce green hydrogen.
- Proximity to other renewable electricity generation schemes – for example, the planned Port of Mostyn tidal lagoon is due to connect to the national grid at the Connah’s Quay site.
- Proximity to strategic transport links such as the North Wales Coast Line (North Wales Main Line railway), the A55 and the proposed route of the new North Wales link road (88).
- Access to land at the site which could be used for green and blue hydrogen production, subject to demand for the fuel developing.

4.3.15 Vale



Company Description

Vale is a mining company focused on the mining of iron ore, Nickel, Manganese, Coal and Copper. The company also works in the logistics, energy and steel making sectors.

Locations

Vale is based in Brazil. Vale has a nickel refinery in Clydach, Wales.

Hydrogen Interest

Vale is one of the partners in the SWIC and RICE projects. Their interest in hydrogen could be due to a number of factors, such as looking to expand their mining operations to mine for fuel cell rare earth metals, a desire to use hydrogen in their steel making operations or in their Clydach refinery.

4.4 Other interested parties

4.4.1 Hypermotive & Huxtec



Company Description

Hypermotive is a fast-growing SME focusing on fuel cell and battery integration and retrofitting for automotive applications. Hypermotive also manufactures wiring and electrical systems for applications across the automotive industry. (89)

Hypermotive has links to the automotive and low carbon energy consultancy Huxtec (Adam Huckstep is managing director of both companies). Huxtec is active in the hydrogen and fuel technical consultancy areas. (90)

Locations

Hypermotive is based in Leicestershire, UK

Huxtec is based in Newbridge, Wales

Hydrogen Interest

Hypermotive work in retrofitting hydrogen range extenders to electric vehicles, as well as prime mover complete fuel cell drivetrains. Hypermotive actively engage with European fuel cell manufacturers.

4.4.2 Menter Môn



Company Description

Menter Môn is a not-for-profit who work with businesses and communities to provide projects which contribute to a sustainable future.

Locations

Menter Môn operates on the island of Ynys Môn.

Hydrogen Interest

Menter Môn is the lead on the Hydrogen Island project and have a general interest in hydrogen in order to make Ynys Môn more sustainable. Menter Môn owns Morlais, a tidal energy company which is a potential supplier of clean energy for the Hydrogen Island.

4.4.3 Siemens

SIEMENS

Company Description

Siemens is an industrial manufacturer and home appliance supplier which operates globally.

Locations

Locations across the UK including Llanberis, Wales.

Hydrogen Interest

Siemens produces the Silyzer 300 PEM electrolyser, a 6 MW system able to achieve an efficiency of 80% (91). Siemens also partnered with the University of Oxford and Cardiff University in producing the Siemens green ammonia demonstrator at the Rutherford Appleton Laboratory.

4.4.4 Solid Power



Company Description

Solid Power is a manufacturer of stationary fuel cell systems and microCHP 'BlueGEN' units for applications in residential and small commercial building heat and power systems.

Locations

Fuel cell systems are marketed at Switzerland, Germany, Italy and Australia. Company is based in Mezzolombardo, Italy.

Hydrogen Interest

15 BlueGEN Fuel Cell Micro-CHP devices have been deployed in the Rhondda Cynon Taf region. (92)

4.4.5 Vattenfall



Company Description

Vattenfall is a leading European energy company and is working towards ‘fossil free living within one generation’. In the UK Vattenfall owns and operates renewable energy assets, including two onshore wind farms in Wales.

Locations

Vattenfall owns and operates renewable energy assets, including onshore wind farms in Wales at Pen y Cymoedd and Parc Cynog in South Wales.

Hydrogen Interest

Vattenfall is working on hydrogen projects, including the HYBRIT project in Sweden, which will produce fossil-free steel with green hydrogen used in the direct reduction of iron ore. The pilot scale plant is due to begin operation in 2025.

4.4.6 Western Power Distribution



Company Description

Western Power Distribution (WPD) operates an electricity distribution network which delivers electricity to approximately 7.9 million customers.

Locations

The WPD network spans the Midlands, South Wales and the South West.

Hydrogen Interest

Involved with Wales & West Utilities in the Net Zero South Wales project. Hydrogen will be of interest to WPD due to its potential synergies with energy storage and use in a flexible grid system. Western Power Distribution were the lead on the 2018-2019 Network Innovation Allowance funded ‘Heat and Fleet Viability Assessment’ which planned to explore the use of electrolyzers to generate hydrogen from excess local renewable energy, with the hydrogen then being used for building heating and mobility applications. (93)

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